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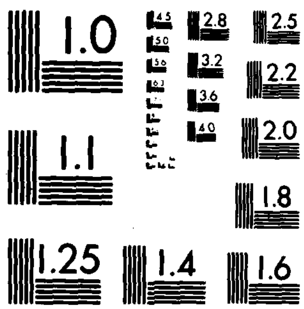

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THE EXPERIENCE OF SOVIET MEDICINE IN WORLD WAR II

1941-1945

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U. S. BOARD ON GEOGRAPHIC NAMES TRANSLITERATION SYSTEM

Block	Italic	Transliteration	Block	Italic	Transliteration
А а	*А а*	A, a	Р р	*Р р*	R, r
Б б	*Б б*	B, b	С с	*С с*	S, s
В в	*В в*	V, v	Т т	*Т т*	T, t
Г г	*Г г*	G, g	У у	*У у*	U, u
Д д	*Д д*	D, d	Ф ф	*Ф ф*	F, f
Е е	*Е е*	Ye, ye; E, e*	Х х	*Х х*	Kh, kh
Ж ж	*Ж ж*	Zh, zh	Ц ц	*Ц ц*	Ts, ts
З з	*З з*	Z, z	Ч ч	*Ч ч*	Ch, ch
И и	*И и*	I, i	Ш ш	*Ш ш*	Sh, sh
Й й	*Й й*	Y, y	Щ щ	*Щ щ*	Shch, shch
К к	*К к*	K, k	Ъ ъ	*Ъ ъ*	"
Л л	*Л л*	L, l	Ы ы	*Ы ы*	Y, y
М м	*М м*	M, m	Ь ь	*Ь ь*	'
Н н	*Н н*	N, n	Э э	*Э э*	E, e
О о	*О о*	O, o	Ю ю	*Ю ю*	Yu, yu
П п	*П п*	P, p	Я я	*Я я*	Ya, ya

*ye initially, after vowels, and after ъ, ь; e elsewhere.
When written as ё in Russian, transliterate as yё or ё.

RUSSIAN AND ENGLISH TRIGONOMETRIC FUNCTIONS

Russian	English	Russian	English	Russian	English
sin	sin	sh	sinh	arc sh	$\sinh^{-1}$
cos	cos	ch	cosh	arc ch	$\cosh^{-1}$
tg	tan	th	tanh	arc th	$\tanh^{-1}$
ctg	cot	cth	coth	arc cth	$\coth^{-1}$
sec	sec	sch	sech	arc sch	sech^{-1}
cosec	csc	csch	csch	arc csch	csch^{-1}

Russian	English
rot	curl
lg	log

[List of acronyms and their expansion used in this book].

AGLR - army field hospital for minor casualties
BMP - battalion medical station
DMP - division medical station
EG - evacuation hospital
EP - evacuation point
FEP - clearing station of a front
FGLR - field hospital for lightly wounded
GBA - army base hospital
GBF - base hospital of the front
GLR - hospital for light casualties
KEG - clearing hospital
KhPPG - mobile surgical field hospital
MEP - local evacuation station
MSB - medical battalion
MSR - motorized medical company
ORMU - separate medical reinforcement company
PMP - regimental medical station
PPG - mobile field hospital
RPM - company medical aid station
SEG - clearing and evacuating hospital
SEL - epidemiological laboratory

podrazdeleniye - unit lower than a USSR regiment

chast' - unit the size of a regiment comprising a number of podrazdeleniye

THE EXPERIENCE OF SOVIET MEDICINE
IN WORLD WAR II

1941-1945

VOL. 1

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Iosif Vissarionovich Stalin

THE EXPERIENCE OF SOVIET MEDICINE
IN WORLD WAR II, 1941-1945, Vol. 1

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FOREWORD

The brilliant victory won by the Soviet Union in single-handed combat with German Fascism and its vassals and subsequently the battle won over the Blitzkrieg threat of the crack troops of Japanese imperialism are indisputable proof of the great superiority of the Soviet social and state structure; these victories have shown the whole world the invincible power of our Socialist motherland, the moral and political unity and ardent patriotism of its people, its indissoluble connection between the front and the rear.

Our beloved teacher and wise leader of the Soviet people, I. V. Stalin, in his presentation on February 9, 1946 pointed out to a group of constituents in the Stalinskiy region of Moscow that the victory of the Soviet Union means, "... that the Soviet domestic structure is really a people's structure which has grown from the inner core of the people and which uses its tremendous strength; the Soviet social structure is a completely viable and stable form of organization for society." Victory also means that "... our Soviet state structure has been victorious and our multinational Soviet state has withstood the tests of war and shown itself to be viable."

During World War II, the noble humanism of the Soviet Army, the army liberators who rescued mankind from Fascist enslavement was fully disclosed in all its grandeur. The Soviet Army joined battle for justice; the war which it conducted was a war of justice, a war of liberation, a war of responsibility.

The new military science created by the genius of the greatest of its leaders - Generalissimo I. V. Stalin - was the immovable basis for broad operative and tactical plans and brilliant solutions which led the Soviet troops from victory to victory. The Stalin military science predetermined completely new principles of organization of certain types of troops and services, their functions and problems in different conditions of military circumstances; it created outstanding concepts as to their interaction and designation in the complex structure of modern armed forces.

The medical service of the Soviet Armed forces was no exception to this.

We will discuss in detail how the Soviet Army, in its essence and meaning, basically differs from armies in the capitalist state and how the medical service of the Soviet Army in the content and volume of the problems it handles differs from the medical service from any bourgeois army. The basis for this difference is the relationship of the individual and the soldier to his serious military work, his selflessness and valor, and often the blood which he sheds to achieve victory. The very essence of the Soviet Socialist state is the strong, constant and pervasive concern with the condition of each Soviet person, his health and most important his life. In the conditions of Soviet acti ty of war this concern did not weaken but on the contrary, the responsibility of public health organs increased for the protection of the health of the population; their duties increased and they became most active in seeing that the forms and methods of prophylactic and therapeutic work were available in the difficult circumstances of wartime. The public health organizations must provide all of the modern equipment for prophylaxis, diagnosis and treatment to the armies; they must mobilize all forces, energies and knowledge of medical workers to fight for the most complete recovery to health of person who are sick or wounded in wars.

In armies of capitalist countries, the organization of assistance to the sick and wounded is dictated by considerations which are about humans. The content and volume of health to sick and wounded in capitalist states is subject to such factors as the number of human resources, the duration, complexity and cost of treatment, the race or national affiliation of the patient.

Soviet medicine attempting to aid the sick and wounded most fully and rapily restores them to health, uses all capabilities, all methods and means which are at the disposal of modern medical science. This is an expression of the immovable moral principles of the Soviet man, the law which says that the most valuable capital resource of the Soviet state is its people.

The great pilot of the Soviet state, I. V. Stalin, in his historic speech broadcast on radio on July 3, 1941 speaking of the most important problems for providing needs of the front, called on the Soviet people to organize wide assistance to the wounded. This call by its beloved leader received a warm response in the hearts of the Soviet people. The public health organs day to day successfully assisted the entire Soviet people, to prevent the occurrence of infecttion and mass disease at the rear and at the front and, moreover, to fully solve the problem of medical and sanitation care for the civilian population and treatment of the wounded and sick soldiers. Medical workers in the Soviet nation for the entire duration of World War II conducted stressful, steadfast and demanding work to save human life and restore health to each of the sick and wounded soldiers. Their brilliant work was rewarded with outstanding results: the percentage of invalidism and mortality among wounded and sick was very insignificant and the number of sick and wounded returned to service was amazingly high - unparalled in the history of wars.

These achievements of Soviet medicine become exceptional factors if one looks at the health records of the Russian Army during World War I in 1914-1918. In spite of the fact that in this war the possibilities of returning the wounded to service due to the character and severity of wounds were greater than in World War II, the number of wounded returned to duty in the Russian Army varied in limits of

40-45% and in any case did not exceed 50%. In the Soviet Army during World War II, more than 72% of the wounded were returned to duty.

This is explained by the basic difference in social and political structure of the Soviet Union and prerevolutionary Russia, the deep basic difference in organization and activity of Soviet public health institutions from the structure and activity of these same separate institutions in Tsarist Russian which were to protect the health of the population.

Soviet military medicine is an inseparable part of the unified system of Soviet public health, and indissolubly connected to it. The activity of the medical service of the Soviet Army always, and in all relationships, is controlled by the party and the government. The treatment evacuation service in the Soviet Army was carried out not only by its medical service but all public health organs and the entire Soviet people participated in it. One of the widespread forms of this section was the efforts of workers, primarily women, in the treatment facilities and also the patronage of hospitals by industrial enterprises, Soviet institutions, trade unions and other public organizations. This all-people assistance played a large role in improving organization of treatment of sick and wounded soldiers, in particular, their care and consequently, in the final analysis, the number of favorable results for wounded and sick was increased.

In the army of prerevolutionary Russia there was not and could not be one of these conditions facilitating an increase in effectiveness in treatment and evacuation assistance as was true in the Soviet Army. Public assistance to the sick and wounded in Tsarist Russia cannot be compared with the all-people concern for sick and wounded troops in the Soviet Union. This difference is not just quantitative. For the Soviet people the direct personal participation in assisting sick and wounded soldiers was a natural expression of patriotic duty and love for its army. In prerevolutionary Russia the participation in public forces in the treatment and prophylactic care of the army was dictated primarily by attempts of certain society circles of trade and industry bourgeois and by a certain part of the intelligentsia to prevent catastrophic losses of army personnel - losses to a great degree caused by the incapability of the Tsarist government in their duties to provide prophylactic treatment to the army and organized treatment of sick and wounded.

In the Soviet Army, concern for the sick and wounded is the duty not only of workers in the medical service but also for all personnel of the army and its command. Daily attention of all personnel in the army to the needs of the medical service was apparent in the years of World War II as one of the most important factors; thanks to this, treatment and evacuation assistance was given - organization to carry the wounded from the battlefield, deliver them to the appropriate stages for evacuation and treatment conditions; because of this, in the Soviet Army an incomparably high level was achieved, much more so than in the armies of other countries who participated in the first and second World Wars. One should particularly emphasize the high perfection of organization for removing the wounded from the battlefield; this was done by the medical service at any time in any conditions, often under enemy fire.

When taking all measures for treatment and evacuation care of sick and wounded, the medical service always was met with assistance by the party and government, always felt the keen attention of our great Stalin. One of the remarkable expressions of limitless Stalin concern for man was the order by the Supreme High Command on August 23, 1941 on presentation to public health workers and stretcher carriers of awards for removing wounded from the field of battle along with their weapons. This edict on the rescue of wounded troops for the first time in history put these military achievements on a par with other military decorations.

World War II brought mass heroism to the Soviet people. In an edict on February 20, 1942, the great chief commander I. V. Stalin wrote: "the Red Army has a noble and elevated goal for the troops bringing it again to victory. This particularly explains that the

World War is giving birth to thousands of heroes and heroines who are ready to die for the freedom of their Motherland."

The personnel of the medical service of the Soviet Army had the same expectations, thoughts and feelings which resulted in mass heroism in troops of the active army, at the front, and led millions of persons at the rear to heroic labor. Therefore it is natural that among the workers of the medical service of the army and even more than among those who, due to the character of their obligations more often than others, are subjected to the dangers of combat; these include stretcher bearers and health workers who carry the wounded from the battlefield; there are many brave heroes among them referred to in the edict by the Supreme Commander.

Thanks to the heroic effort of health workers who are the primary link in a system of treatment and evacuation care, the wounded, in the shortest possible time after injury, were carried from the battlefield and delivered to the evacuation stages where they could be given first aid.

Thus, even at this stage of treatment and evacuation assistance, one could detect a characteristic for all activity of the medical services of the Soviet Army: a combination of high organization and individual valor of personnel. The demanding stressful work of all personnel in the medical service at subsequent stages of treatment and evacuation care, the precise and purposeful organization of the system for treatment and prophylactic care was a part of the decisive factors thanks to which the medical service of the Soviet Army solved imcomparably complex problems facing them in World War II with bravery.

It seems that among the personnel of the medical service in the Tsarist army there were persons who tried in every way to improve prophylactic care of the army and who devoted themselves to the care of wounded and sick. However, in distinction from what occurred in the Soviet Army, their activity occurred in conditions of a random organization for the medical and public health service and their efforts directed at improving treatment and prophylactic care in the army could not in any way significantly change matters because they did not have the cooperation of the government and army command.

In conditions of Soviet activity, the creative search for medical workers directed at improving treatment and prophylactic care of the army always was a concern of the party, the Soviet government and the army command.

Always improving methods and means for assisting the sick and wounded, the Soviet physicians achieved significant success in the treatment of combat injuries which physicians in the armies of capitalist countries considered as unnecessary.

The numerous factual materials presented in our "Works" which characterize, for example, aid to persons wounded in the central and peripheral nervous systems, the face, jaw, eyes, thoracic and abdominal cavities, blood vessels, etc. attest to the exceptional achievements of Soviet medicine.

Insofar as one can judge from evidence published in the foreign press, medical, and particularly, surgical assistance rendered to the wounded in the Soviet Army during the second World War for various wounds and illnesses was more highly perfected than that care given in armies of capitalist countries. Soviet physicians for the entire duration of World War II, besides the well-known and generally used methods and equipment for surgical treatment, wisely used new methods developed by Soviet scientists for diagnosis and therapy, in particular, new methods of surgical intervention for various combat injuries and new modifications of operative interventions made earlier. All of the new methods which were effective and gave favorable results in diagnosis and therapy were quickly made available to all treatment institutions of the army. This widespread and remarkable adoption of improved achievements of medical science in practice, along with their obligatory use for appropriate indications, is an outstanding feature of the public health system in the Soviet government where the use of science is to serve the people and to satisfy its needs. In bourgeois states the science generally and medicine in particular is a service meeting the demands of the leading groups of capitalists and their servants. Discoveries and improvements in the field of diagnosis and therapy are used in bourgeois countries for purposes of commercial enterprise and personal enrichment; secrecy often surrounds them and their broad practical use is artificially prevented by various enterprises. Therefore, if the achievements of medicine in the armies of capitalist countries during the second World War were used, then it was only episodic or for experimental testing and were limited to conditions which are very foreign to the true meaning of medical science.

In the Soviet Army the organization of treatment and prevention for wounded and sick is constructed on the basis of the foremost Soviet military and medical science. Here the structure of medical institutions, the methods for their operation and system for administration of them are included; this provided giving primary qualified medical care, particularly, surgical in direct proximity to the field of battle - in regions of combat activity for regiments and divisions - and also the most specialized treatment appropriate to the character of the wounds or diseases. The Soviet Army put as its goal a broad network of specialized field and evacuation hospitals with qualified personnel and the necessary medical equipment.

Materials for organization of the medical service in the armies of capitalist countries during the second World War are evidence that qualified surgical care in them is given only at a considerable distance from the battlefield and that evacuation of wounded and sick and their treatment in specialized hospitals has a very limited character.

The organization of specialized treatment of sick and wounded is possible only with well trained personnel and, particularly, an adequate number of highly qualified physician specialists who have theoretical knowledge and practical experience.

To carry out stage treatment with evacuation it is necessary to have railway, vehicle and aviation transportation, specially equipped for evacuating sick and wounded; considerably larger field and evacuation hospitals are needed than during the transportation system for treatment of sick and wounded.

Soviet medicine, for the entire World War II, had at their disposal personnel and the necessary equipment for organization of treatment of wounded and sick and also for anti-epidemic care of troops and population.

One of the conditions planned in the life support system for treatment by stages with evacuation is epidemic prevention among troops. In the troops of active armies in capitalist countries, infectious disease was widespread and often had an epidemic character. Mass infectious disease affected the civilian population and troop personnel including the wounded soldiers and officers. In the troops of the Soviet Army during World War II, there were no epidemics and the disease rate from infectious diseases had a sporadic character; the number of infectious diseases both in absolute numbers and relative to other diseases and wounds was very insignificant. Therefore, the evacuation of the wounded and their treatment in specialized hospitals was carried out for the entire World War II in strict accordance with the character of the wound without any of the limitations involved with concerns of an epidemiological character.

To prevent the occurrence and development of infectious diseases it is always important how well the sanitation and hygiene anti-epidemic service operates and how precisely and irreproachably the scientifically based anti-epidemic measures are conducted as well as how correctly organized treatment and prophylactic care is conducted relying on highly qualified clinical instruction. One of the main sources for the spread of infectious disease is the sick person; the timely discovery of patients with epidemically infectious diseases, quick hospitalization of them in treatment institutions and hygienic treatment of the focus are therefore the most important elements in anti-epidemic protection. Both of these factors - the public health hygiene measures and timely diagnosis and treatment - were organized in a coordinated way when conducting anti-epidemic work in the Soviet Army.

It has obvious from what has been presented that the prevention of epidemic diseases can be successful only under conditions where systematic and actually combined participation of treatment-prophylactic and sanitary-hygiene institutions for public health is in effect; the patients must not be a source for the existence and material advancement of physicians as is the case for all capitalist countries and on the contrary, when the entire system of public health is a government operation, there is centralized control and it is subject to the interests of the workers. These conditions which exist only in the Soviet Socialist system of public health predetermine the achievements of Soviet medicine in the field of prophylaxis of epiemic diseases both in the prewar years and during World War II.

* * *

The Communist Party has always considered protection of the public health tremendously important. The Bolshevik Party gave a great deal of attention to the socialist principle of constructing a state system of public health even before the Great October of the socialist revolution. In particular, these questions were discussed at the Congress II of the RSDRP (Russian Social Democratic Worker's Party [1898-1912]) in 1903 and at the sixth Prague Party Conference in 1912. The basic hypotheses which determine the activity of public health organs were formulated in the program confirmed by the VIII Congress of the party. The actual realization of these hypotheses began after the victory of the Great October socialist revolution. Under the administration and with the direct participation of the great leaders of the revolution, V. I. Lenin and I. V. Stalin, a government system of public health which was greatly improved was constructed in the socialist beginning. The success of Soviet medicine during World War II was due to the preceding period in building the people's public health; the basic principles described in the party program were confirmed in the Great Charter of the Soviet State - in the Stalinist Constitution.

The creator and organizer of the Soviet State, V. I. Lenin, in July 1918 signed an historic directive on the formation of a People's Commissariat of Public Health.

A center on administration of public health which combined all of the work of the medical service of the civilian and the Red Army was created for the first time. The main military and public health administration by that tremendous organizer of Soviet public health, Z. P. Solov'yev, for the first time became part of the People's Commissariat of Public Health. The close connection with the People's Commissariat of Public Health was retained in the military public health administration of the Red Army and later on when it was included in the People's Commissariat of military and naval activities.

In the years of foreign military intervention and civil war, V. I. Lenin and I. V. Stalin were daily concerned with questions of military medicine and expressed their great concern for the sick and wounded troops of the Red Army. This was reflected, in particular, in the creation of certain special organizations intended for improving care of sick and wounded Red Army personnel and commanders.

Comrade Stalin directly leading the military activities of the front in the Civil War paid particular attention to health care of the troops and organization of the evacuation and treatment of the wounded.

In the difficult conditions of the Civil War, blockades and intervention, assistance of the party and cooperation of the broad masses of workers made it possible for Soviet public health, in spite of the lack of medical personnel and provisions for treatment and prophylactic equipment, to overcome disdorder threatening the very existence of the young Soviet Republic in the organization of treatment and prophylactic care of the population and to lay down the basis for public health care and prevention of epidemics and other mass diseases.

The development of Soviet public health and the improvement of treatment and prophylactic care of workers developed in parallel with the industrial power of the Soviet Union and improvement of activity of its entire state apparatus. It is generally accepted that the construction, unexpected in its rate and dimensions, occurred in the years of prewar Stalinist 5-year plans, and that the face of the country was changed in these years, its industry was developed, its agriculture converted and established.

These circumstances were the most important attempts in the construction of Soviet public health including overcoming conditions thanks to which the Soviet Union during the first days of World War II were capable of active defense and the Soviet public health could provide the army and the population treatment and evacuation assistance. It is particularly due to this preliminary and long-term preparation of the country along with the entire national and people's public health that made it possible for the Soviet Union to achieve victory. As I. V. Stalin pointed out in his pre-election speech of February 9, 1946, it would be a mistake to think that one could achieve such a historic victory as the Soviet Union did in World War II, "... without preliminary preparation of the entire country for active defense. It would be no less erroneous to propose that this preparation could be carried out in a short time period, over three or four years."

The positions presented above show that in the years of prewar Stalinist 5-year plans which converted the Soviet Union into a strong industrial power with change in peacetime to mechanized agriculture, in the cities, workers villages and agricultural areas, the construction of various types of institutions for national public health were set up on an unparalleled scale. The enormous territory of the

Soviet state was covered with a thick network of outpatient clinics, dispensaries, hospitals and clinics, sanitoriums, children and women's consultation clinics; in the center of the country and on its periphery numerous public health epidemiological institutions, treatment and diagnostic, public health and nutrition institutions and other laboratories and clinics were set up. A number of cities not only in the European part of the Soviet Union but also in Siberia and in the national republics and oblasts were enriched with new medical higher institutions, middle medical schools, scientific and research institutions, institutions for improving qualification and requalification of different categories of medical workers, home for public health education, etc. In the capital of the Soviet Union, in Moscow, a centralized publishing house for medical literature was set up.

One of the very first central problems of Soviet public health in the years of prewar Stalinist 5-year plans was an increase in medical (hospital) investment which had been extremely inadequate in Tsarist Russia and which did not satisfy at all the needs of the population. In accordance with this, a grandiose construction of hospitals and clinics took place, both general purpose and specialized. By 1941 the number of hospital beds, in comparison with 1913, had increased by more than 5 times. During the Stalinist 5-year plans, a large number of hospitals were set up where there had been none or only isolated units in prerevolutionary Russia; some of these were like none in any other country. All of the treatment institutions organized by Soviet public health were equipped with modern means for diagnosis and therapy. The network of outpatient clinics, polyclinics, dispensaries has grown more and more; in comparison with 1913, their number has increased by more than ten times.

First aid stations existed in prerevolutionary Russia only in nine large cities; their personnel consisted of 1-2 field workers and a few public health workers; they had no connection with scientific and clinical institutions. In the Soviet Union at the beginning of World War II, there were thousands of first aid stations and many of these had been set up at scientific-research traumatology institutions, institutions for emergency aid and large clinical hospitals under whose direction they conducted operations. This played an important role during World War II because certain problems of traumolotolgy even in peacetime had been solved scientifically and practically; the circle of medical workers who had been trained in this field had been expanded.

Due to the development of public health aviation, the possibility of rapid first aid by highly qualified personnel had become almost commonplace.

In prerevolutionary Russia in 1913 there were 4367 agricultural medical sections; in the Soviet Union by the beginning of 1941 this number had been increased to 14,431. Moreover, in agricultural localities, a network of regional and district hospitals, maternity homes, field worker and midwife posts had grown up. Many treatment and prevention village institutions provided constant scientific and practical direction and consultation assistance for medical institutions, large city hospitals, different scientific and research institutes and clinics.

In semi-colonial outlying districts of the Russian empire, which became in the Soviet Union colorful national Soviet Socialist Republics, a whole network of treatment and prophylactic institutions were set up basically only after the Great October socialist revolution; under Tsarism, the local population was almost completely devoid of medical assistance.

A special directive signed by V. I. Lenin converted the sanatoriums and health resorts which had been a part of the government to public health areas for the people. In the years of the prewar Stalinist 5-year plans, along with expansion and reconstruction of health resorts already existing in the European and Asiatic parts of the Soviet Union, a series of new health resorts were set up, some of which in climate and quality of the therapeutic baths were as good as any of the Caucasus and Crimea famous resorts. By the beginning of 1941 in the USSR there were more than 3500 sanatorium resort institutions and 13 resort recreational institutes; hundreds of new mineral sources and deposits of therapeutic mud have been discovered. Along with setting up new resorts and good climate stations, throughout the entire territory of the Soviet Union where natural conditions were favorable, many sanatoriums and rest homes with outstanding equipment were constructed. Besides the public health organs, in the construction of new rest homes and sanatoriums, the trade unions were particularly active as well as different government institutions and public organizations, factories, plants and kolkhozes (collective farms).

Many of the best sanatoriums and rest homes were especially designed for serving personnel of the Soviet Army and the Navy.

A widely branching network of treatment and prophylactic institutions, in particular, the general (mixed) and specialized hospitals, made it easier during World War II to deploy evacuation hospitals and create an adequate hospital base at the rear with an abundance of rest homes and sanatoriums; this made it possible to provide special assistance to the sick and wounded, to improve hospital treatment and also to provide the personnel needed only in rest homes or for treatment in sanatorium resort conditions.

In prerevolutionary Russia the lack of investment in beds for treatment of patients was combined with the extreme limitations in the production of treatment and diagnostic equipment; the medical industry hardly existed and a large part of medications, medical equipment and instruments came from outside the country's borders.

The domestic chemical-pharmaceutical and medical-instrument factories created during the years of Stalin's 5-year plan almost completely freed the country from foreign imports and provided the needs of the population and treatment institutions for medications, objects for proper care of patients, surgical instruments and medical equipment.

Unification of Soviet public health provided an uninterrupted connection between civilian organs and institutions of public health and the military-medical service in providing medical treatment to wounded and sick soldiers of the Soviet Army and to accomplish the government plan for sanitation and anti-epidemic measures. This unification made it possible to freely maneuver the medical teams and the material and technical equipment depending on the complex conditions and to opportunely use the scientifically based methods for prophylaxis and treatment. Here the workers in practical medicine were directed by instructions developed at scientific research institutions in the country, taking into consideration different conditions or practical activity.

A decisive factor in successes and achievements in Soviet medicine which were brought forward during peacetime and particularly during the years of World War II is the prophylactic aspect which is the basis for scientific and practical activity of civilian and military public health organs.

The prophylactic approach to medicine is possible only in a socialist structure. For truly scientific materialistic medicine, there is the unconditional position that sources of disease are in the environment surrounding man. Conversion of this environment in the interest of workers, active systematic removal of unfavorable everyday production climate and other factors which cause disease is essentially the basic problem of public health. Solution of this problem predetermines prevention of disease.

The party and the government always directed activity for an active conversion of the environment of Soviet man in order to create the most favorable conditions for his multi-faceted physical and spiritual development, for improving his material well being and for protecting his health.

However, successful solution of the problem of maintaining the health of the population would be impossible if the people's public health did not involve the active participation of the workers themselves. Through their activity, the organs of Soviet public health with an outstanding thread, have formed a constant connection with the broad mass of the population. All of the preventive and treatment measures of public health organs are accomplished with the active participation of Soviet society and the workers themselves; this is one of the outstanding features of the Soviet socialist system for protecting the health of the population. The lively and active assistance of the population in the efforts to improve sanitary and hygienic conditions in everyday life and in production, physical education of the next generation, protection of mothers and children, improvement in sanitation education and also the accomplishment of the most important prophylactic measures has been one of the most important prerequisites for success in Soviet public health in the prewar years and has facilitated overcoming such difficulties in treatment and prophylaxis for the army and the population as has occurred during World War II.

Assistance to the population by organs of Soviet public health has been expressed in different organization forms. The commissions of public health of local soviets of deputies of workers, soviets of coworkers from therapeutic institutions and general public health representatives have played an important role in the years of prewar Stalinist 5-year plans.

Even in the first years of peacetime construction at plants and factories, in kolkhozes and sovkhozes, in apartment buildings, in higher institutions of training and in schools, in Soviet institutions, etc., units for the Red Cross Society and the Red Crescent, set up by a school for mass training for first aid and sanitation and hygiene training of the population were created; later on the number of such units was increased sharply. Many thousands of Soviet persons became fully knowledgeable and were part of the "prepared for sanitation defense" of the first and second degrees. Tens of thousands of sanitary assistants and workers were trained in the prewar years; during the war they gave aid to wounded and sick soldiers, worked in hospitals and clinics and replaced medical workers at the rear who were called into the army. Thousands of persons who became soldiers in the Soviet Army had received first aid training and knew how to guard against disease, how to behave in field conditions and how to prevent the spread of infection.

While one of the most important conditions providing achievements in Soviet medicine and in the prewar years during World War II was cooperation of the population with the public health organs in conducting sanitation and hygienic measures and the progressively developing public health education of the mass of workers, just as important was training of highly qualified and devoted teams of medical workers.

From the first days of construction of Soviet medicine before the organs of public health, the problem of training a large number of medical workers in different categories and specialties had arisen; they were not only to be trained in their own fields but also in the most important problems and goals of Soviet medicine to be capable of accomplishing work in these and practical activity itself. Training of this type of worker required not only increasing the number of medical institutions and expanding them but also a basic reorganization of the entire system of medical training.

Therefore it is natural that the party and the government for all of the prewar years and the years of the war devoted particular attention to training teams of physicians and average medical personnel; the demand for this personnel increased steadily. At the XVII Congress of the party, Comrade Stalin in his report pointed out that falling behind in training of medical teams was not permissible. This instruction from our great leader and teacher resulted in a number of organizational measures; as a result of this, the network of medical institutions increased and the level of medical training improved.

At the beginning of the first world war in Russia, there were 15 higher medical institutions of learning which graduated no more than 1500 physicians each year. At the beginning of World War II in the USSR, 74 state medical institutions existed which trained 115,000 students.

In prerevolutionary Russia, all of the higher institutions for medical training were concentrated in a few large cities in the European part of the nation; in the entire territory of the Asiatic part of the empire, there was only one medical institution at the Tomsk university. Under Soviet power, new medical institutions were organized not only in the large centers of the Russian federation, but also in the capitals and other cities of the union and autonomous republics which permitted training national physician teams.

In 1913, in Tsarist Russia, there were 24,000 physicians; in the Soviet Union on the eve of World War II, their number exceeded 140,000.

The Soviet state has devoted a good deal of attention to training average medical workers; in 1913 their number amounted to 47,000 and in 1941 this number had increased to 473,000.

Besides accomplishing measures for a quantitative increase in physician teams and an improvement in their qualifications, the party and state from year to year has carefully trained a new type of doctor - the Soviet doctor whose idealistic and moral aspects are unthinkable in any other social and political conditions besides those existing in the Soviet socialist state. The inseparable characteristics of the spiritual aspect of the Soviet physician put together even in prewar years are the result of the devotion of the socialist mother country and the work of Lenin and Stalin, the high humanity, the constant striving for expanding specialized knowledge and training in ideals, the purposefulness, high mindedness and skill overcome any difficulties in carrying out the high obligations of the physician to protect the health of the population and treat the sick. These qualities are combined with outstanding concepts as to the meaning of Soviet medicine and skill in using all modern achievements of medicine in practical activity and in turn fruitfully turning theory into practice.

The victory of socialism in the USSR has led to an unprecedented flowering of science in general and medical science in particular and has opened unlimited possibilities for the development of scientific and research activity. The communist party, the Soviet government and Comrade Stalin personally have shown and are showing a constant concern about the development of Soviet science and the adoption of its achievements in practice for improving the level of material wellbeing, education and health of the Soviet people. In the words of our great Lenin: "Earlier all human skill, all its genius, gave one person the benefit of technology and education and others were deprived of necessary education and development. Now all of the marvels of technology and all of the achievements of education have become an achievement for the entire people."

In prerevolutionary Russia, except for the Petersburg Institute of Experimental Medicine founded in 1890, essentially there were no scientific research institutions involved with training in medical problems. The scientific and research work was carried out almost exclusively in medical schools and the equipment necessary for scientific research was very scarce; the personnel quantitatively was very inadequate.

In the USSR, even long before World War II, scientific and research institutes were created in very different branches of theoretical, treatment and prophylactic medicine. Many of these were intended for developing new branches of medical science or studying such fields as would be difficult or even impossible in capitalist states.

As a result of research conducted in prewar years in a number of scientific research institutes, for example in institutes of neurosurgery, traumotology, hematology and blood transfusion, etc., Soviet physicians have acquired knowledge thanks to which even in the first days of the war it was possible for them to assist the wounded; this was possible for medical services in the armies of capitalist countries only as a result of experience accumulated directly during the war.

In 1932 the All-Union Institute of Experimental Medicine was created and during World War II, in 1944, the Academy of Medical Sciences of the USSR was organized; it was named the Center for Scientific Medical Thought in the country.

At the beginning of World War II, in the Soviet Union, there were more than 200 medical scientific research institutes where more than 20,000 scientific coworkers worked.

Surrounded by the attention of the party and the government and constantly directed by them, Soviet medicine even long before World War II was forward looking and progressive. Based on the teachings of Marx, Engels, Lenin and Stalin, in its creative quest for a unified scientific peaceful view with dialectical materialism, Soviet scientists again solved problems which were urgent for the Soviet people. The scientist-physicians created scientific bases for constructing Soviet medicine and enriched teams of its workers with knowledge which would be necessary in day to day practical activity. This connection between Soviet science and actual practice, combined with the high ideals of the scientific quest, with the Bolshevik party is irreconcilable for any idealism and pseudoscientific theory of bourgeois science.

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It is apparent from what has been presented above that after the Great October socialist revolution, the medical service of the army was set up with basically new beginnings.

In the army of prerevolutionary Russia, there were a few talented physicians who made a large contribution to military and medical science and to the organization of the military medical service and treatment for the wounded. One of the founders of the Russian therapeutic school was M. Ya. Mudrov; at this time he was the first

Russian professor who created a course for miltary medicine. The brilliant Russian surgeon N. I. Pirogov proved the superiority of Russian military field surgery in world science. The tremendous importance of N. I. Pirogov in military medicine is shown not only by his works directly on questions of military field surgery but also by the fact that he was the first to formulate organizational principles for activity of military-medical services, to outline the basis for constructing the system of treatment and evacuation care for wounded and sick, their assignment, transportation, the amount of aid at different stages of evacuation, etc.

The most important representatives of different branches of medical science - S. P. Botkin, N. V. Sklifosovskiy, N. A. Vel'yaminov, A. P. Dobroslavin, F. F. Yerisman, G. V. Khlopin, V. A. Oppel', S. P. Fyedorov and many others - directly participated in organization of assistance to the sick and wounded and the treatment and prophylactic care of the troops. All of them, expending a tremendous amount of effort, added to the reorganization of the medical service of the Tsarist army and, undoubtedly, their activity produced various improvements in giving assistance to the sick and wounded soldiers. However, these improvements were of a partial and temporary nature and efforts to accomplish any kind of significant basic innovations encountered resistance or, in the best case, indifference in reactions from the higher command of the army and indifference for the people by the government. Only after the victory of the Great October socialist revolution were all of the barriers removed which interfered with the basic organization of the medical service in the army and opened up possibilities for providing, in strict accordance with the needs of modern science, and establishing continuous communication between the general government system for the people's public health.

Soviet scientists critically studied the scientific inheritance from the past and having done this, introduced much that was new into the concept of basic problems of physiology and pathology, into the understanding of the origin, course and prevention of a number of diseases and the pathogenetic mechanism of traumatic injuries, in particular, wounds. These new concepts made it possible for Soviet science to enrich practical medicine with effective methods and methods and means for diagnosis and therapy.

The idealogical content of Soviet medicine was particularly important for the correct interpretation of the essence of different pathological processes and, consequently, for the selection of the most expedient methods of therapy for diseases and injuries. Having mastered and developed these scientific viewpoints of I. M. Sechenov, S. P. Botkin and particularly that of I. P. Pavlov created on the basis of the studies of I. M. Sechenov and S. P. Botkin, a new completely scientific materialistic physiology, Soviet scientific medical thought turned to a deep dialectic understanding of processes occurring in the organism both in normal and in pathological conditions.

For Soviet medicine there is an indisputable understanding of the fact that each local limited process in the organism is, at the same time, part of the process of the whole. The concept that the organism and its unbroken interaction with the environment is a single whole and that the central nervous system plays a leading and regulating role in all functions of the organism is also irrefutable.

Pavlov created, creatively developed and widely put into practice the natural scientific objective method of studying the vital functions of the whole organism in natural conditions for its existence. Using this method, I. P. Pavlov enriched science with his remarkable studies on physiology of higher nervious activities, on creative innervation, the physiology of blood circulation, digestion and other sections of physiology.

As a result of experimental and clinical studies of the reaction of the organism under the effect of environmental factors, the leading role of the central nervous system in all processes of vital activity of the organism and in all its functions both normal and in pathology became completely indisputable.

Developing the neurogenic theory of I. M. Sechenov and S. P. Botkin, I. P. Pavlov, on the basis of his own remarkable originality, precision and scientific achievements in experimental and clinical observations, concluded that "... the nervous system ... is an amazing complex and precise instrument of interrelationships, connections of many parts of the organism to each other and the organism as a complex system with an infinite number of external effects."

The continuity of the studies of Pavlov and its connection with different clinical disciplines has made it easier and expanded the possibilities for further creative development of his ideas. For instance, Soviet scientists used them for interpreting certain pathological processes, in particular, those which to a considerable degree are urgent in war time conditions (shock, contusion-commotion syndrome, etc.) and also for development of new methods and means of therapy (for example, treatment with sleep, treatment by artificially operating certain links in the nervous system, etc.).

The significance of Pavlov's studies for Soviet medicine is also determined by the fact that their high idealogical content is combined with the practical activity of the physician. Constantly striving to connect the physiological principles found by him with the clinical manifestations or the "physiology and medicine understood in a deep concept as inseparable," I. P. Pavlov looked at disease as the collision of the organism with any kind of unusual environmental conditions involving a breakdown in equilibrium between the organism and the environment - an equilibrium regulated by the nervous system, mainly by the cortex of the brain. Any disturbances in vital activity of the organism continuously and constantly involve normal physiological processes. Consequently, to understand disease and to develop a concept of its occurrence and developement, it is necessary to take into consideration the physiological principles which control functions of the organism.

These positions of the scientist I. P. Pavlov correspond to concepts of Soviet physicians as to disease both in the complex process and in any other stages encompassing the entire organ and system of the organism, the entire organism as a whole. This concept of illness is undoubtedly a denial of the view held by bourgeois scientists that it is a mechanistic reaction essentially of a virus cellular pathology separating the whole organism into the total of cellular territories and separating pathology from physiology.

Guided by a method of dialectic materialism, the creative development of ideas of I. P. Pavlov and the selection of those which are urgent for Soviet public health made it possible for many Soviet scientists even in prewar years to carry out a number of studies newly illuminating the importance of practical problems of clinical and preventive medicine. During World War II, the principles of physiological studies of I. P. Pavlov were used for solving certain problems of military pathology.

The broad knowledge of I. P. Pavlov could be used for studying different diseases of the nervous system, in particular psychoneurosis. In armies of capitalist countries, this type of patient, as a rule, makes up a considerable percentage. In the Russian army during World War I, with very incomplete data at a number of evacuation posts, from 38 to 44% of the wounded and sick suffered from psychoneuroses and neuroses. There is evidence of a significant spread of this type of disease during World War II in the English, German and particularly among the American troops.

In the Soviet Army during World War II, the total number of persons sick with psychoneuroses and neuroses, even including very light forms of these disorders, was very insignificant.

A large number of neuropsychic patients in the prerevolutionary Russian Army eloquently discussed the low level of health conditions for the population in Tsarist Russia and, consequently, those social and everyday political conditions to which he was subjected and which at the present time are even more pronounced in modern capitalist countries. The low percentage of neuropsychological patients in the Soviet Army is evidence of the achievements of prewar years of the Soviet people and brilliantly characterizes the high political and moral state of the Soviet troops.

For the treatment of those few patients with neuroses and psychoneuroses who were encountered in the Soviet Army, new methods and forms of therapy were successfully used; these were developed by Soviet scientists on the basis of the creative development of these scientific concepts of I. P. Pavlov in this area. The section of this "Work" which discusses characteristics of nervous diseases presents what is new and what has been devloped in Soviet science on interpretation of the origin of psychoneuroses, the mechanism for their development and their clinical manifestation and indicates how this concept was used as the basis for developing therapeutic measures whose effectiveness was later confirmed in practice.

The mastery by Soviet scientists in their scientific practical activity of the ideas of I. P. Pavlov, like their further development, fully met the essence of Soviet medicine and its requirements. Moreover, it was a clear expression of the basic principles of Soviet science - its attention to the actual needs of the people, high Bolshevik ideology, the spirit of innovation, continuous struggle against indifference to idealism.

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One of the characteristic properties of Soviet science is the multiple forms of creative search and their broad scope. Thanks to the fact that our government always created all of the necessary conditions for the development of any branch of science including the development of medical disciplines, Soviet scientists could conduct research in very different fields of medical knowledge. This is basically why the attention of Soviet scientists primarily has been turned to problems which are directly important to the new Soviet public health and its basic approach - to prevent disease. In the years of the prewar Stalin 5-year plans, such disciplines as epidemiology, bacteriology, microbiology, parisitology, helminthology and a mixture of these sections of medical knowledge were all broadly developed.

Studies of Soviet scientists in these fields were improved by significant achievements. For instance, the nature of certain infections was successfully established and the biology of their pathogens was studied; methods of contamination for a number of infections and invasions were made more precise and new means for therapy and prevention were developed or those previously known were improved.

Scientific studies in the field of epidemiology and in new sections of preventive medicine for them were combined with scientifically based, planned and wide scale practical measures conducted by public health organs. Along with these, there is the basic unswerving improvement in health of the population: living and eating conditions were improved; the circle of general health measures and treatment was expanded; in particular, assistance to the ill at home was improved; a number of areas in hospitals and santatoriums was increased; the capability of outpatient clinics, dispensaries, rest homes, preventive rest homes, dietectic dining halls, etc. was increased. Studies in physical exercise and sports involving a wider and wider segment of the population are extremely important for training the organism and improving its resistance to infection.

As a result of the interaction of all these factors, the health of the population has improved immeasurably; the total number of infectious diseases in the territory of the Soviet Union has dropped sharply and certain infections have completely disappeared. For instance, even before World War II, such diseases as smallpox, cholera and plague were eliminated. In prerevolutionary Russia, these infections almost always developed in certain foci and often had epidemic flareups, particularly in the south and southeast.

From year to year the number of other infections has decreased. The disease rate from typhoid fever in recent prewar years, in comparison with 1913-1914, decreased by 4 1/2 times (in the army by more than 10 times); the sickness rate from paratyphyoid fever decreased by 5 times, dysentery by 4 times, etc. Recurrent fever in the Soviet Union in 1939-1940 was encountered very rarely and sickness from typhus as observed only in isolated episodically occurring cases. The course of infectious diseases has become very light. The death rate has dropped sharply from certain children's diseases, from typhoid fever, paratyphoid fever and particularly from dysentery.

Epidemics were the unavoidable companion of all past wars affecting the civilian population and the army. In the army they often caused greater losses than from wounds; many wound patients died not from the wounds but from the infections.

In the first World War, infectious diseases which at times took on the character of significant epidemic flareups were observed in all of the fighting armies. In the Russian army the epidemics essentially never stopped; from the armies the epidemics spread to the rear of the country which was encouraged by the system of evacuation of infectious patients (to hospitals in the deep rear) and inadequate preventive measures in transportation.

Although not one of the foreign armies who participated in the second World War published evidence of infectious diseases, there is a basis for believing that in the armies of all the capitalist countries, the epidemic diseases were very widespread.

The Soviet Army and the civilian population throughout World War II did not know any epidemics and if infectious diseases occurred, these were only isolated cases; their total number was insignificant. To prevent the occurrence and spread of infectious diseases seemed possible because even in the prewar years a high level of sanitation and hygienic care in the country had been achieved. Prophylactic measures set up on a strictly scientific basis were conducted strictly before the war and particularly during the war both among the population and in the army in transportation.

Correct organization of the treatment and evacuation assistance to the army, a carefully thought out and conducted system for preventive measures and early hospitalization of infectious patients in special hospitals provided localization of the infection and stopped the possibility of its spread to troop personnel and the civilian population. Moreover, no other country had such difficult and complex conditions for fighting as the Soviet Union did due to the temorary enemy occupation of a broad expanse of territory and movement of many refugees deep into the country.

As was already mentioned above, the high level achieved by Soviet public health in sanitation and hygiene for the population and the army in peacetime and for the entire extent of the war, was due to a great degree to the attention of Soviet science to the problems of prevention.

In Tsarist Russia there were almost no state institutions working on scientific development of hygiene questions. In the Soviet Union, it is being accomplished on a governmental scale by many well equipped scientific research insitutes and laboratories. Literally there is no department of sanitation or hygiene, no single problem of nutrition or protection of the organism from different production or climatic dangers which has not been the object of research at Soviet scientific institutions. On the basis of these studies, standards and sanitation and hygienic requirements have been developed which are obligatory for planning and constructing industrial enterprises, communal institutions, transportation methods, new cities and worker villages. Particular attention was devoted to scientific studies in the prevention of occupational diseases and also to questions of nutrition and water supply for the population. Methods of cleaning up settled areas and questions of disinfection, deactivation and rat extermination have been broadly studied.

World War II presented high demands for organs and institutions of public health in relation to sanitation and hygienic care of troops and the population, particularly those involved in defense work. These requirements primarily involved questions of nutrition and water supply which as a result of the sharply changing conditions of wartime, took on particular practical significance.

Daily medical monitoring of the food supply for troops, food products and preparation of food, prevention of avitaminosis and food toxicoinfection, the conduct of measures for purification and decontamination of water in combat conditions, and also observations of a number of other sanitation and hygiene requirements were accomplished by a special hygiene service comprised of teams of hygienists and specialists. To a significant degree, this facilitated providing sanitation and hygiene favorable conditions for troops and the population during World War II.

Besides the broad development of questions of preventive medicine, Soviet science steadily worked on studying problems of clinical medicine, in particular, surgery.

The Russian surgical school, even at the end of the last century and the beginning of this century, was recognized by worldwide science as one of the most progressive and original. Such scientists as I. V. Buyal'skiy, F. I. Bush, N. I, Pirogov, N. V. Sklifosovskiy, S. P. Fedorov, V. A. Oppel' et al. were known far beyond the borders of Russia and their research and practical activity was used as an example and object for study and inspiration for many surgeons in foreign countries.

After the Great October Socialist Revolution, sugery like other sciences, had great possibilities for creative development.

Even in the prewar years, Soviet surgeons worked on urgent problems of military and field surgery and traumatology. By studying different questions of traumatology, in particular the development of the most modern methods and means for different types of trauma, they worked not only with special scientific research institutes of traumatology but also institutes of emergency aid and the appropriate clinics and departments in large hospitals. The broad development of first aid stations which usually operated under the administration of the treatment institute mentioned were assisted greatly by this research; in this way they participated in the scientific studies we have already mentioned above. In these same hospitals where emergency aid is given for trauma, also scientific observations are made of burns and frostbite.

The experience acquired by Soviet traumatologists in peacetime and scientific studies in the field of neurosurgery and blood transfusion are no less important. Neurosurgery, the problems of blood transfusion, and also diseases of the blood and circulatory organs have not been studied in any country as broadly as they have in the Soviet Union and not one country has such a quantity of special institutions, institutes and stations conducting scientific work in these fields and giving the appropriate treatment as in the Soviet Union. Scientific practical knowledge and questions of neurosurgery and blood tranfusions accumulated up to the beginning of World War II, to a significant degree, determined the multiplicity and success of neurosurgical aid to the wounded and the broad use during wartime of blood transfusion and blood replacement fluids.

In the successful treatment of wounds and their complications, massive transfusion of blood and blood substitutes played a tremendous role indeed. The expansion of indications for hemotransfusion as a method of combating loss of blood and also as a hemostatic means and method for stimulating therapy during various complications of wounds and a number of diseases is the great contribution of Soviet medicine. Transfusion of blood being accomplished at the troop stages of evacuation was extremely valuable (at the regiment and battalion medical aid posts).

The prerequisites for broad adoption of blood transfusion in actual treatment of wounded in wartime conditions were created by Soviet scientists back in peacetime. Methods for long storage and care of blood and also setting up conditions for its transport and methods for transfusing it were all developed by them.

Such a broad use of hemotransfusion during World War II required, naturally, a tremendous quantity of blood. The problem of a continuous supply of blood to the army medical for transfusion was solved by our people. Tens of thousands of Soviet people, grasping their high patriotic duty, primarily women, became donors and many times gave their blood for the sick and wounded soldiers.

The school of Soviet neurosurgeons created before World War II directed by outstanding Soviet scientists and surgeons A. L. Polenov and N. N. Burdenko developed methods of treatment for wounds and damage to the nervous system, in particular the brain and spinal cord. At the beginning of the war, Soviet neurosurgeons organized well trained teams capable of scientific and method direction of the practical activity of neurosurgeons. This made it possible for the medical service of the Soviet army during World War II to organize branch specialized neurosurgical assistance, on a broad scale in a number of cases in many forms and according to the complexity of operative intervention, unprecedented in the history of wars. It is possible to truthfully say for many of those wounded or hurt in the skull, brain or spinal column who would have been considered inoperable cases in the armies of the capitalist countries or who would have been operated on only as an experiment, the Soviet physicians continuously and successfully used operative intervention as well as other treatment methods.

The experience of Soviet neurosurgeons generalized in the "Work" is indisputable evidence of how troops with skull and brain wounds and wounds of other parts of the nervous system could be saved, avoiding the expectation of severe invalidism and who could be restored to a greater or lesser degree to normal functioning of the organism.

There is no more brilliant illustration of the achievements of Soviet medicine than surgery of gunshot chest wounds; many methods were developed on the basis of intervention used in peacetime for various diseases and traumas. A stable complex combatting of shock in which the A. V. Vishnevskiy's vagosympathetic blockage is a primary method, early aspiration during hemothoraxi, suturing of the open pneumothorax, combating suppurative complications using active aspiration and operative methods, original methods of eliminating bronchial fistulas, all of these produced very favorable results reducing significantly the death rate and complications and also restoring health to the wounded as much as possible.

In the prerevolutionary Russian army, surgical assistance to persons with jaw and face injuries was hardly effective; among these wounds there was a high percentage of death and invalidism. Thanks to the attention which Soviet public health devoted in the prewar years to the prevention and treatment of diseases and damage to the jaw, face and oral cavity and also concern as to training teams of stomatologists in the Soviet Army during World War II, a specialized stomatologic assistance program was organized. As a result of this, the death rate and invalidism rate from wounds to the face and jaw were decreased and severe deformities of the face in this category of wounds was almost completely eliminated. Soviet medicine achieved these same favorable results in treating gunshot damage to the eyes. Scientific studies in opthamology in the Soviet Union achieved considerable successes. The work of V. P. Filatov is particularly notable; he enriched the leading medical science with effective methods for treating not only certain severe eye diseases but also surgical and internal diseases of the eye. Training an adequate number of opthamologists who had worked in different branches of scientific and practical treatment institutions for the eye, Soviet medicine during World War II was organized for wounds damaging eyes to offer specialized assistance beginning in the army region and ending in the deep rear.

Also one should remember the very favorable results of treating wounds to the ear, throat and nose; therapy for injury to these organs to a great degree was developed in prewar years in many institutes and clinics who studied problems of otorhinolaryngology. In particular a great deal which was new was introduced into plastic surgery. The presence of an adequate number of teams prepared in the prewar years made it possible to organize special hospitals and to give qualified assistance to the wounded.

In all of the armies of the capitalist countries who participated in the first and second World Wars, evacuation and treatment of the wounded with damage to soft tissue and bones of the hands and feet (if these injuries were not combined with wounds of the internal organisms, large tubular bones, nerves and vessels) were not given the required attention. Such wounded were evacuated in the general course and treated on a par with more severe wounds and those needing long-term treatment. In the Soviet Army during World War II, the organization of evacuation and treatment of this category of wounds for the first time in history of wars was set up on the basis of the achievements of traumotology and the laws of physiology of the organism of movement. Along with this, they took into consideration the special features of the course of wounds in soft tissue which include wounds of the extremities particularly. These wounded remained in the military, army and front regions. To treat them, special hospitals were set up in which complex therapy was used including surgical and physical therapy methods for treatment, therapeutic physical education and labor processes.

It is difficult to enumerate all of the successes which surgery achieved in treating various types of wounds and injuries during World War II and which were the result of work by Soviet scientists in the prewar years. We cannot even begin to mention all of the achievements, the complete and broad solutions to problems of transportation and treatment immobilization of wounded, the use of gypsum bandages proposed even by N. I. Pirogov, the application of secondary sutures, the use of antiseptic equipment for local treatment of wounds and prophylaxis of wound infections by combining surgical treatment of wounds and the injection of serum. The position established in peacetime of the primary infection of any gunshot wound and the dependence of the course of the wound process on timely treatment and qualified first aid was an important prerequisite for organization of the whole system of treatment and evacuation care of the wounded.

Soviet medicine achieved successes in treatment of internal diseases never before achieved in the history of wars. Of the soldiers and officers hospitalized as a result of disease of the internal organs, 90.6% were returned to duty. This success was the result of achievements of Soviet public health in the field of training teams of clinicians and therapists and also the broad development of scientific research on internal diseases particularly those affecting wound diagnosis and methods of treatment of those diseases whose development or occurrence can be involved with wartime conditions. The system of evacuation and treatment of sick soldiers and officers which was developed during World War II was also based on the achievements of internal medicine and was extremely important.

The study of the nature and clinical practice of internal disease was developed on bases created by the Russian therapeutic school founded by M. Ya. Mudrov, S. P. Botkin, G. A. Zakhar'in, A. A. Ostroumov et al.

Due to the unlimited possibilities for creative work available after the Great October Socialist Revolution, the Soviet scientist therapists enriched science in internal diseases with numerous studies recognized by all leading medical thought. Scientific search by Soviet therapists, in particular, Professors V. P. Obraztsov, M. V. Yanovskiy, N. D. Strazhesko, S. S. Ziminitskiy, G. F. Lang, M. P. Konchalovskiy, M. I. Arinkin et al. was directed at solving questions of pathogenesis, clinical practices, diagnostics and therapy of diseases of the cardiovascular system, the digestive and respiratory tract, diseases of the blood and circulatory organs, ulcer and hypertonic disease, etc.; a large number of studies were also conducted on problems of tuberculosis, dysfunction of the glands of internal secretion and rheumatism. A characteristic trait of many of the scientific works was the attempt to give the practical physician more precise and available methods in ambulatory and polyclinical circumstances and the means for wound diagnosis and effecttive therapy of different diseases.

This approach to scientific research activity and achievements in the field of early diagnosis of diseases and the etiology and pathogenetic therapy made it possible to create during World War II an advantageous system for evacuation and treatment of patients depending on the character of the disease. Sick soldiers and officers were treated, as a rule, at battalion medical posts, at the army and front therapeutic hospitals. In the army therapeutic hospitals complemented by specialists and therapists and equipped with the very necessary diagnostic and treatment, made the final clinical diagnosis and determined the approximate time period and location for treatment. When indicated, the patients were sent to the appropriate hospitals in the early days of their disease. Patients with severe chronic diseases requiring long-term treatment were evacuated to hospitals at the deep rear.

For infectious diseases treatment was conducted on location in the region of the disease where inspected field mobile hospitals were in existence. Evacuating infectious patients was done only in cases where military circumstances made it necessary.

Starting with studies of the organism as a whole, the role of the nervous system in regulation of vital functions of the organism and development and course of pathological processes, Soviet medicine paid particular attention to observations for the occurrence and course of diseases of internal organs in the wounded. As a result of these observations made during World War II, new data were obtained on the special features for the occurrence and course of diseases of internal organs in the wounded. A special section in this "Work" deals with this question.

The active study of different problems of therapy continued throughout World War II and naturally, particular attention was devoted to the special features of the occurrence and course of diseases which were involved with conditions of military circumstances. Our progressive scientists, therapists and physiologists, who had created the basis for organization in the army of a specialized therapeutic service, obtained, thanks to the presence of this service, broad possibilities for making scientific observations during World War II. As a result of these observations, certain new data were available on etiology, pathogenesis, diagnostics, clinical treatment and therapy of diseases of internal organisms in soldiers and officers of the active army and also on the occurrence and the course of internal diseases in the wounded. The results of scientific studies carried out by Soviet therapists during the war had a serious, theoretical and practical value for internal medicine and the special features of military field therapy. Many diseases in general were studied in wartime (hypertonic disease, ulcers, certain diseases of the liver, etc.) and many new facts were obtained. The development of clinical disciplines in the Soviet Union took place in parallel with the development of theoretical departments of medicine and were based on the achievements of the latter. Clinical disciplines and disciplines of theoretical (physiology, pathological physiology and pathological anatomy) were developed in close cooperation; this is a necessary conditions for scientific progress in these sections of medical knowledge.

In many capitalist countries up until now, the possibility of pathologoanatomical observations were limited in view of the fact that disclosing them was not obligatory even in cases where there was treatment in state or municipal treatment institutions. In a number of the armies of capitalist countries, the pathologoanatomical service was completely nonexistent. In Soviet conditions, pathological anatomy can be developed just like any other science. Soviet pathologoanatomists, on the basis of studies of a large number of cases, have made more precise and expanded concepts on the connection between the character and special features of clinical course or trauma with the damage to the organs and system established by discovery. Often a method biopsy used in Soviet treatment institutions makes it possible to make diagnosis of the disease more precise and to conduct effective therapy. Testing the primary assumption by pathologohistological studies of the organs and tissues removed during operations is very important for this concept. Such verification is made in the practice at Soviet hospitals.

Scientific achievements of pathological anatomy, on the one hand, and training of teams of pathologoanatomists in prewar years on the other, made it possible to organize a pathologoanatomical service during World War II. The pathologoanatomical service played an important role because its observations permitted eliminating flaws in the treatment evacuation care of wounded and sick and facilitated improving it during combat action by the troops.

Soviet pathologoanatomists during World War II, besides large operative work, conducted a number of pathologoanatomical and pathologohistological studies on the wound process, wound substance, shock, traumatology (gunshot) osteomyelitis, bone and joint wounds, wounds of the bood vessels, combat trauma of the organs of the thoracic cage, the abdominal cavity, etc. Systematic study of the causes of fatality during evacuation beginning on the battlefield is extremely important. The results of these studies are discussed in a special section in this "Work."

For instance, Soviet public health as was already noted above, met World War II prepared and capable of providing the population and the army with multifaceted expediently organized and scientifically based treatment and prevention assistance. This preparation was due to the fact that during the Stalinist 5-year plans, the Soviet Union had made leaps forward with the assistance of our Motherland, according to the words of Comrade Stalin, to be converted from a backward country to a leading country, from an agrarian to an industrial nation. In the ranks of the public health organs, there is a branch network of treatment and diagnostic and prophylactic institutions equipped with the very necessary equipment for therapy and diagnosis and also scientific research institution laboratories in all departments of medical knowledge. These scientific institutions provided the possibility for developing these and other urgent problems. It is most valuable that Soviet medicine produced teams. All of the treatment and preventive institutions of the front and the rear, including the qualified specialists needed, were set up for all categories of medical workers trained to take on their obligations and without limit, to do their duty for their Motherland. Self disciplined, coordinated and purposeful work by personnel in the medical service of the army truly gave it its position in the ranks of other services and gave it the recognition and esteem of army personnel and the entire Soviet people.

Greeting the head surgeon of the Soviet Army, N. N. Burdenko in May 1943 to present a high governmental award, M. I. Kalinin in his introduction said: " ... this award means that the medical service of our Red Army stands side by side with the aviation and artillery services, that the medical workers in the ranks of the army are as necessary as the soldiers and the commanders."

The successes achieved by Soviet public health during World War II did not produce in the workers or particularly in the physicians self satisfaction or laziness. Like all of the Soviet people, Soviet physicians always worked for higher quality in their work. Striving to improve the treatment and prevention care of the sick and wounded, they constantly sought for new ways and means for diagnosis and therapy, struggled to deepen their understanding of different problems of pathology, in particular, military, and themselves established improved forms of organization in the medical service in the army and treatment assistance to wounded and sick.

The party and government required constant improvement in care of wounded and sick and provision of sanitary and hygienic care in the army. From the first weeks of the war, attention of the workers in public health was devoted to the necessity for scientific research work in the army and at the rear, the necessity for constantly using all of the most valuable achievements in medical science in practical activity. The physicians of the medical service of the army throughout World War II in the complex combat circumstances showed skill not only in using the achievements of medicine to analyze and generalize their own practical experience, but also proposed new even more innovative methods for scientifically based effective prevention and treatment-evacuation assistance. Not only scientific workers especially involved in study of these and other problems of military pathology, but also the rank-and-file physician of the treatment institutions, starting with systematic observations and critical evaluation of the methods used for assistance to the sick and wounded, constantly sought for new improved methods of diagnosis, therapy and prophylaxis. Constantly observing in the specialized hospitals the more or less identical diseases or wounds, physicians often noted small well-known or even unknown special characteristics for the course of a pathological process, making the existing concept of it even more precise.

A special reflection of the active practical and scientific research activity of the physicians was the medical conference. These conferences held often in military conditions were set up regularly and attracted the attention not only of the army medical workers but also of the command. Urgent problems of treatment and prophylaxis for care of the army were considered at them; all of the low-value or arguable care was constantly made scientifically based and more effective. The materials of the conferences and observations of individual treatment prophylactic institutions were generalized in special reports and the achievements of the entire army and all of Soviet public health were generalized.

Experience acquired by Soviet medicine in World War II is unparalleled in history. Its multifaceted study is of exceptional value for the further development of medical science and the practice of public health.

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The great leader and teacher of the Soviet people, Generalissimo I. V. Stalin, on February 23, 1946, proposed subjecting the scientific development of material of prophylaxis of disease in troops and treatment of the sick and wounded on its basis to generalization of the experience of tens of thousands of physicians and the multiplicity of treatment institutions at the front and rear. In accordance with this proposal, the Council of Ministers of the USSR, on March 26, 1946, adopted a resolution on "scientific development and generalization of experience of Soviet medicine during World War II, 1941-1945." This historical decree clearly reflecting the concern of the party, the Soviet government and Comrade Stalin personally for the further flowering of Soviet medical science, development of medical teams and improvement in activity of Soviet public health posed the following problem to the workers of Soviet medicine, to generalize the experience of the war years and to create this "Work."

The decree adopted by the Council of Ministers of the USSR on publishing a multivolume work entitled Opyt sovetskoy meditsiny v Velikoy Otechestvennoy voyne 1941-1945 gg. [Experience of Soviet Medicine in World War II 1941-1945] met with a lively response from all medical societies, particularly the direct participants in the war - physicians who had worked in the treatment and prophylactic institutions in the front and rear.

The factual material which must be studied, analyzed and then generalized, in order to form the basis for this "Work" was extremely varied in content and large in quantity. This material was not exhausted by charts in the forward region, by histories of diseases, operational journals, records of pathologoanatomical and histological studies, proposals by physician commissions, records of scientific conferences, various types of questionnaires and explanatory reports for them, acts of epidemiological and sanitation-hygienic studies, etc. Besides these documents, a number of physicians during the war accumulated many personal observations. A large number of scientific research works on military pathology and on sanitation-hygiene and epidemiological care of the army and also descriptions of cases of wounded and sick have already been published. The tremendous quantity of pathologoanatomical and pathologohistological preparations, photographs, microphotographs, X-rays and electrocardiograms, and also models of different types of instruments, equipment, tools, diagnostic, treatment and prophylactic equipment, models of different santitation-hygiene conditions, etc. created during the war and used in practice were found in the military-medical museum, at scientific research institutions involved in the treatment of sick and wounded troops in the Soviet Army and in certain large hospitals.

The decree by the Council of Ministers of the USSR to publish this "Work" took place on March 26, 1946, ten months after the end of the war with fascist Germany. The factual material which is tremendous in volume and which characterizes experience of Soviet medicine in World War II at the time of publication of the Council of Ministers decree had not yet been studied in any detailed and scholarly way. This circumstance predetermined two stages for compilation of the "Work." Each of these stages was of independent scientific value and required great effort, energy and persistence by many scientific workers in different specialities.

The first stage of scientific research work on generalizing the experience of Soviet medicine in World War II envisaged the selection and multifaceted study of the actual material - its statistical processing, classification according to nomenclature, nosology and content, systematization of facts according to the section of military pathology and prophylaxis to which they belonged, evaluation of the material studied from the point of view of identification of them to others similar in character.

The second stage of the work was a direct generalization of the experience of Soviet medicine on the basis of developing the primary documents for the wounded and sick and the study of the reports of medical institutions, the personal experience of physicians and other materials characterizing the circumstances of prophylactic care of troops and treatment of sick and wounded. The authors and the editors of the volumes of this "Work" were required to give a critical evaluation of existing concepts of military pathology, methods of treatment of the wounded and prevention of complications and diseases and they wish particularly to establish the presentation of those methods of treatment of sick and wounded which in wartime were the most effective and which could be adopted on a broad scale for Soviet public health. Moreover it was necessary to precisely indicate those problems which required further study.

The compilers of the "Work" had to complete scientific research work unparalleled in its scale, complexity and intent.

Problems of this type were not and could not be organized into one of the single reports made earlier as to the activity of military medicine. All of the existing characteristics of activity of the medical service during the war in Tsarist and foreign armies could not be even a remote example for studying the experience of Soviet medicine in World War II. In all of the well-known reports, documentation is given for isolated facts but from this no scientific generalization of experience accumulated during wartime has been made. Moreover, in army conditions in capitalist countries, any kind of truthful analysis of the activity of the medical service during the war is impossible and nonexistent or it would be some kind of stern judgment of the capitalist structure itself limited and distorted in function and use for institutions and organs of public health.

Activity of the medical service in Tsarist Russian, the USA, England, France and Germany during some of the wars in the 19th and 20th centuries was reflected only in very sparse reports, statistical surveys and monographs.

What do these reports represent on the basis of which sources they come from?

Tsarist Russia in the 19th and at the beginning of the 20th centuries underwent several wars. The activity of the medical service in this period is reflected in reports on just the Russian-Turkish War of 1877-1878 and the Russo-Japanese War of 1904-1905. A military medical report on the Danube and Caucasus armies for the Turkish War of 1877-1878 was published nine years after the end of the war. The three volumes of this report are in the activity of the medical service of the Danube army and two volumes are on the Caucasus army. The report presents different edicts, circulars and directives for directors of the public health service from military unions and other official persons and also directors of the sanitation service organs; the activity of hospitals and rest homes is described, official statistical data is reported on disease rate and death rate among soldiers and officers and, finally, characteristics of the sanitation condition of Russian soldiers and enemy troops is given.

The report does not contain the medical characteristics of separate forms and types of wounds and nosologic groups of diseases although they can involve wartime conditions. In the report there is no description of the methods and forms of treatment and evacuation care and prevention under any actual conditions but only a list of existing measures without an evaluation or analysis of any of them. Such incompleteness and limitation is typical not only of this report. In 1914, that is, ten years after the Russo-Japanese War, the main military sanitation administration published a report in one volume entitled Voyna s Yaponiyey 1904-1905 gg. Sanitarno-statisticheskiy ocherk [The War with Japan 1904-1905. Sanitary-Statistical Characteristics]. The sources for compiling this report were the reports by physicians in military chast' and soyedineniye and the leaders of medical institutions and administrations and also certain reports on soldiers and officers who had died in treatment institutions and other documents of a similar nature. All of these documents were incomplete because the medical statistical calculation was poorly made, did not include the entire army and was organized not at the beginning of the war but later on. Thus, Sanitarno-statisticheskiy ocherk [Sanitation-Statistical Characteristics] on wars with Japan characterizes even less the activity of the medical service and the treatment-evacuation and prophylactic care of the army than the report on the war with Turkey 1877-1878.

Throughout World War I, 1914-1918, the social organizations which participated in assisting the sick and wounded and the preventive care of the army, at times published brief reports on some specific aspect of the activity of these organization (All-Russian Union of Zemstvo [Elective District Council in Prerevolutionary Russia], the union of cities). These reports were published with a small number of examples intended primarily for a narrow circle of liberally minded social activitists.

In the USA in 1888, that is, 23 years after the end of the Civil War, a 6 volume work was published entitled The History of Medicine and Surgery During the Civil War Between the Northern and Southern States of America 1861-1865. Three volumes discussed internal diseases and three partial and general questions of military-field surgery. When compiling this work, only records of commanders and leaders of the medical (sanitation) services of military podrazdeleniye, chast' and soyedineniye were used as well as that of leaders of the military and military-sanitary institutions. The most important documents of the medical type were histories of diseases, operation journals, etc.; their discussion was not generalized.

In the period from 1921 to 1929, an official report entitled Medical Service of the USA Army During the World War consisting of 15 volumes was published. In eight volumes of the report, there was a description of the structure of the Central-Military medical administration of the USA army and the medical administration of the expedition forces, organization of the medical service at organizational posts and also the structure and organization of military hospitals. Besides this, general and particular questions were laid out of medical supply and a system of special training of personnel of the medical service; a description is given of the medical care for certain combat operations. Seven volumes discuss different combat injury and disease encountered in the army of the USA during the war and medical statistics and documentation; general and particular questions of field military surgery are presented in only one volume. The basic materials used for compiling this report were official instructions, reports by leaders of the medical institutions and statistical reports.

In this report, although it is distinguished to a definite degree from reports mentioned above, also attention is given to the lack of correspondence between the volume of information on questions of organization and equipment of the medical service on the one hand and the descriptions of military injuries and aid for them on the other. This lack of correspondence can be understood if one considers that when compiling this report as in all the others discussed above, the history of the disease, the acts of pathoanatomical discovery, operational journals and other documents were not studied and analyzed; these could have given a real understanding of certain types of combat injury and disease, their manifestation and course, their care and outcome.

In England, the activity of the medical service is discussed only for the Crimean campaign of 1854-1856 and the first World War 1914-1918. A report entitled Medical and Surgical History of the British Army During the Crimean Campaign of 1854-1856, was published in two volumes after the end of the war; the characteristics of certain forms and types of disease and combat injury are not contained in the report. The report entitled History of the Great War (1914-1918), based on official documents was started in 1921. Four volumes of this work discussed the general questions of medical service, two the diseases during wartime, and two the military-field surgery; two others discussed questions of hygiene and sanitation. The main sources for the compilation of these reports is not the primary documents on wounds and diseases as much as it is the reports of treament institutions and administrative organs, official statistical data, pathologoanatomical reports, different hospital journals, instructions and other materials of a like nature.

In France, not a single official report characterizing activity of the medical service during wartime has been published. There are only monographic descriptions belonging to isolated authors which are not devoid of interest but which do not give any kind of exhaustive scientific development of the main questions of medical care and concepts as to its state during wartime. Some information on prevention and particularly on treatment-evacuation of armies can be found in different types of reports which were published by large hospitals working in peacetime and in wartime; this information in no way can make up for the lack of a generalized report on medical and sanitation care of troops during wartime.

Of the reports published in Germany on the activity of the medical service during the war one should mention: Report on the Military-Medical Service During the War of 1870-1871 (publication completed in 1890), Administration of the Physician's Care During World War I 1914-1918 in nine volumes, published in 1921-1922 and a collection of articles published on different questions of military injury, disease during wartime, injury from war gas, etc. and finally, A Report on the Medical Surveys of the German Army in the World War of 1914-1918 in three volumes published between 1934 and 1938. Of the two latter publications on the war of 1914-1918, the first Administration... does not give a concept of the treatment and prophylactic care of the army in all its complexity or it is unsystematic and out of sequence and applies not to the entire treatment and prophylactic care but only to certain elements of it. The second publication Report... is full of official documentation, contains much statistical data and information on organizations and structures of the medical service, but has very little on characteristics of separate types of military injury and disease and their treatment.

As was already noted, all of the reports without exception on operation of the medical service of the army during wartime, published in different countries and discussing different wars, contain the results and selections of report data and statistical dispatches of leaders at medical institutions and also partial or compiled statistical tables. However, all of the statistical information, even that of a compiled character, are not a scientific statistical generalization: in the first place, they do not encompass all of the identical high-quality indices and touch only on the larger or smaller parts; secondly they are not subjected to a single principle but are constructed on very different bases and characteristics and are presented without connection to the actual combat circumstances in which the initial data were obtained. No single report is based on materials of scientific processing of the primary documents for the sick and wounded, that is, history of diseases, evacuation documents, operation and bandaging journals, reports of pathologoanatomical discoveries, etc. Moreover, only a multifacted thorough study of these materials could give an objective scientific report on circumstances for treatment of the wounded and sick and its special characteristics and also the course of various combat injuries and diseases and their outcome.

In accordance with this, the compilers of reports could not successfully establish the true causes for defects in organization of treatment and evacuation care of troops in wartime nor scientifically generalize and discuss the positive experience acquired. Even a few achievements which existed in different fields of treatment and prevention are not substantiated; they are not adopted into the practice of the medical service and were not an obligatory example used for improving the quality of medical work in the future. This meant that identical mistakes were repeated war after war, both of an organizational character and those occurring directly when treating the sick and wounded.

The editorial board of this work Opyt sovetskoy meditsiny v Velikoy Otechestvennoy voyne 1941-1945 gg. [Experience of Soviet Medicine in World War II 1941-1945], put out to correct this problem could not use the principles and methods of compilation of reports and the development of materials on medical care in armies used by compilers of any of the reports published earlier.

The editorial board of the "Work" selected an independent method and created its own method for processing and generalizing the materials which characterized the activity of Soviet medicine in World War II. Not only the character and content of the initial data itself is involved but also the use of the "Work."

The Council of Ministers of the USSR in its resolution considered publication of the multivolume work entitled Opyt sovetskoy meditsiny v Velikoy Otechestvennoy voyne 1941-1945 gg. [Experience of Soviet Medicine in World War II 1941-1945] in four parts: section I - Surgery, section II - Therapy, section III - Epidemiology and Hygiene and section IV - Pathology of Gunshot Wounds. Principles were laid down in the government decree to guide development of the material and favorable conditions were set up opening up possibilities for processing scientific research work and successfully publishing the "Work." Considerable means were available making it possible to collect, systematize and process a tremendous number of primary documents on sick and wounded (medical charts from the front region, patient histories, etc.) and other basic materials. The editorial board was set up as a structural organization which directed processing of the documents and preparation of them for publication. The Ministry of Public Health of the USSR and the Chief Military-Medical Administration conducted measures to provide the editorial board and the compilers of the "Work" with all the necesary conditions for fruitful work.

The decision by the government called for a deep and thorough study of a tremendous amount of experience accumulated by Soviet doctors to be used for the further development of theoretical and practical medicine. In order to meet all of these requirements, the decree of the Council of Ministers of the USSR pointed out the necessity for "bringing the most important scientists, specialists and rank-and-file physicians who participated in health care of troops and treatment of sick and wounded soldiers and officers both at the front and in the rear to the development of these materials for generalizing the experience of the war." A conference was set up on scientific works generalizing the experience of World War II for these purposes and means were made available for rewarding the best work.

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The work was divided into sections according to the government request for the structure of the published "Work."

The first section entitled Surgery consists of 15 subsections which show the multifaceted experience of Soviet surgeons in the field of treatment of wounds and the prevention of complications from wounds.

General questions of military field surgery are presented in the first section. In the other sections, clinical manifestations of wounds and injuries of various localizations and different special features are presented in the other sections and their manifestations depending on injury to various parts of the body, organs and systems. In accordance with this, wounds of the skull and brain, neck and face, eyes, nose and throat, chest, spine and spinal cord, stomach, pelvis and abdominal cavity, soft tissue and bone extremities, joints, hands and feet, vessels, and peripheral nerves are all organized separately.

All of the sections are set up according to a unified plan with insignificant changes according to localization of the wounds or injuries. In accordance with the plan in the first chapters of each of the surgical sections, questions of general character are considered: the frequency, significance and outcome of wounds and injuries described in the section in past wars; evolution of clinical-anatomical and therapeutic concepts as to wounds and injuries and an evaluation of their concepts; classification of the trauma studied and their frequency in difficult periods of World War II, depending on the character of the combat operations.

In subsequent chapters a description is given of the pathologoanatomical changes and their peculiarities caused by the character of the injury and its location; the clinical treatment is described in detail as well as the course, complications and diagnostics (in particular, the capabilities and methods of different stages of evacuation), principles and forms of evacuation. At many areas characteristics for therapy of the wounds and their complications are reported - the volume and content of treatment and preventive measures at evacuation stages, methods and means of operative and conservative treatment used during wartime, particularly those which were proposed and adopted in practice directly during the war and, finally, evaluation of the effectiveness of each of the methods and means and also the course of their use in different conditions.

The concluding chapters present a description of the outcome and aftereffects of wounds and injuries and also the characteristics of frequency of certain types of results, their relationship to quality and timeliness of treatment and particularly surgical measures at the early (leading) stages of evacuation and, finally, analysis of the outcome and in certain sections, in particular, invalidism.

In the reports problems are presented which come up in war in relation to injuries described in the section, the completeness and success of solving these problems and the approach for further studies are indicated. In certain sections, the content of the chapters is somewhat different from that indicated above but the general plan remains unchanged and questions which are not considered in one of the chapters are found in another if, in general, they are to be discussed in a unified plan for the sections.

The main positions or characteristics on pathology, clinical manifestations, methods of treatment, results, evacuation, etc. are illustrated by reports from the histories of patients, pathologo-anatomical reports, electrocardiogram readings, roentgenological and laboratory studies and also multiple photographs and X-rays. The materials giving the basis for generalization are presented in the form of statistical tables, schematics and diagrams.

The second part of the "Work" entitled Therapy consists of 11 sections including diseases of the internal organisms and nervous system which are characteristic and also bone and infectious diseases which were apparent in personnel of the army during the war.

The section on diseases of internal organs in the wounded is particularly important. The problem of interaction between diseases of internal organs and wounds has attracted attention from clinical practitioners and specialists in the field of pathological physiology for a long time but essentially it has never been fully studied; a few observations have usually been made on isolated patients. In view of the new concepts which were created by Soviet physicians as a result of studying this problem, the presence of an interconnection between the wound and the disease related to it and between the disease and the wound relating to the patient are undoubtedly true. Moreover, these concepts have resulted in understanding which connections are very fine and that they can be captured only with a thorough constant observation of the persons in whom the wound and disease are combined.

The constant and direct association which was established between surgeons and therapists from the very beginning of World War II, the obligations on the part of the physician-therpist in work at surgical hospitals solidly based in every day practice for observation of the wounded by the physician-therapist, regular exchange of experience between surgeons and therapists at different types of scientific conferences and conventions, all of this has made it easier to have the observations presented above and have made it possible to accumulate a large amount of actual material and select the most important information on the manifestation and course of internal diseases when combined with wounds.

The material generalized in Opyt sovetskoy meditsiny v Velikoy Otechestvennoy voyne 1941-1945 gg. [Experience of Soviet Medicine in World War II 1941-1945] is the basis for solving a number of questions affecting interaction of diseases of the internal organs and wounds and makes it possible to discover the special features for the occurrence and course of diseases of internal organs which, in a number of cases, apparently are due to the wounds. One should note that these same problems to various degrees are considered in some of the sections of the parts entitled Surgery and Therapy according to the wound or disease which is discussed in a given section.

In the sections of the part entitled Therapy, a number of diseases of the respiratory organs, the cardiovascular system, the liver, stomach and urinary organs, tuberculosis of the lungs and diseases involving breakdowns in general nutrition are all discussed. In accordance with this, pathogenesis of diseases is studied in detail and concepts existing earlier as to the origin and pathogenetic mechanism of various diseases are discussed as well as the modern views of them; also the special features of etiology and pathogenesis are discussed which were noted during the war and which can be connected to combat conditions.

In all of the others except for differences characterized above and the therapeutic sections compared with sections in the Surgery part, the plan in order of presentation and the basic elements of the content of the sections of these two parts are all identical.

The third part entitled Work - Epidemiology and Hygiene contain generalization of experience in the most important questions of antiepidemic and hygiene care of troops at the front and in the rear. In this part we are talking about the epidemic condition of troops in different times in World War II, about the organization of antiepidemic care of troops, about prevention of special infections, about hygiene of nutrition, water supply and field placement of troops. Besides this, the method and techniques of antiepidemic and hygienic work in troops in different periods of the war and in different sanitary-tactical conditions are discussed and the special features of epidemiology of the most infectious diseases are characterized as well as the measures used for prevention of these diseases and combat of them.

In the fourth section of the "Work" entitled Pathology of Gunshot Injury, the mechanism for action of the injurious shell is discussed[1], the significance of the wound process and the pathology of complications which develop at different evacuation stages. In this part also an analysis is given of complications and diseases which occur as the result of wounds; the outcome of them is considered depending on the severity of the damage, the time period they are removed from the battlefield, instructions of the medical aid,

[1]To a well-known degree this question is also considered in certain sections of the part entitled Surgery.

the physician, surgical and specialized assistance, the time when diagnosis is established and the time of hospitalization of the wounded, the character of the military operations, the sanitation-tactical circumstances, conduct of preventive measures and, finally, the time of year and climatic conditions.

From these brief characteristics for the structure of the "Work" and content of its parts and sections, it is obvious what a broad circle of questions it includes, what a large amount of material is found in it and what a contribution Soviet physicians have made to medical science on the basis of this scientifically generalized experience of work in the years of World War II. Also it is very important that in this "Work" a very valuable personal experience of wartime participants is generalized. The latter was provided so that the editorial board of the "Work," in accordance with decrees by the government, ordered on April 10, 1946 a competition for the best scientific work in generalization of the experience in World War II and involved authors who had not participated before in scientific and literary work giving all possible assistance.

The Soviet medical society has actively responded to the decree of the government for preparing the "Work." In the competition 454 works were entered, of which 344 were on surgical themes. The competition commission has presented awards to the authors of the best works of 147 first, second and third prizes; moreover, 158 works were adopted for use in compilation of the "Work." Articles presented to the competition reflected the activity of medical science of the army in its completeness - beginning with the medical service of the regiment and ending with medical institutions in the deep rear. In 12% of the works submitted, the activity of the medical service in combat regions was reflected; in 21% of the army and in 29% of the front. The competition made it possible to select and use materials and observations belonging not only to famous scientists and directors of actual military and civilian medicine but also to the rank-and-file physician. Moreover, thanks to the character and content of the work presented, the competition made it possible to discover problems requiring particularly careful presentation in the "Work."

Scientific processing of the experience of Soviet medicine in the years of the war preceded the multifacted preparation work made by a large collective of physicians and coworkers of the Military-Medical Museum and also authors and editors of the "Work." It amounted to systematization, study and analysis of the history of the diseases and different official documents which reflect organization of the medical care and methods for treatment-evacuation and antiepidemic work in different periods of World War II.

With the participation of specialists and statisticians, an ordered and unified system of processing histories of diseases selected from all the treatment institutions at the front and rear was established; the number of patient histories necessary for the processing was established; indices were adopted for studying certain pathological form and methods of correct calculation of these indices were selected.

The system for processing histories of disease included selection and systematization of the histories of the patients at treatment institutions, transfer of data obtained when studying histories of the diseases to specially developed charts for general and fundamental characteristics and also subsequent processing of information selected by computer methods.

Statistical data obtained as the result of developing charts for general characteristics made it possible to determine the average arithmetic values according to a certain type of wound and to study them in relation to each other, in relation to isolated types of health loss during the years of the war and also according to the character of the weapon involved. Similar indices were obtained in relation to the diseases.

Processing of the data of the chart on fundamental characteristics was used as the basis for determining the special charteristics of the course, frequency of complications, success in treatment and outcome according to a specific type of wound or disease.

In all about 200 separate types of combat injuries and diseases were studied. After the appropriate statistical processing, more than 14,000 tables were compiled containing about 4 million indices characterizing wounds and diseases according to various characteristics.

In order to provide verification of the results of processing history of diseases, daily monitoring was established which was carried out at all stages of the work. Moreover, each editor used the consultation of a specialist-statistician; jointly with him, a precise count of the indices was made and calculation of their correct use. Each section after repeated statistical testing and proofreading by the editor for each section and by the editor of the part, all members of the editorial board for the "Work" reevaluated it and then it was considered by a group of colleagues.

The tremendous valuable experience of Soviet medicine accumulated during World War II was the military-medical literature. Publication of this literature thanks to the unlimited assistance of the party and government, was carried out widely during the war and after its completion.

This literature was selected by the editorial board of this "Work" and is presented in the bibliographical index.

A certain concept as to which rich materials belonging to Soviet medicine should be generalized for the experience of the war can be found in the information on the military-medical literature published during the years of the first World War and during World War II. For instance, on the general question of organization and sanitation in 1914-1918, 53 works were published and in 1941-1945 (in incomplete data) - 890; on the question of military-surgery, respectively, 859 and 9544. On military-field therapy in 1914 to 1918 only isolated articles were published (precise data does not exist) and in 1941-1945 this type of literature was published with 1523 titles. On the question of military hygiene and antiepidemic protection of troops, there were, respectively, 95 and 495 titles. In general in 1914-1918, 1007 works were published and in 1941-1945, 12,452.

The editorial board of the "Work" when processing the questions studied in the "Work" widely used broad and varied materials from the Military-Medical Museum. The editorial board had available not only histories of patients, reports, dispatches, data of calculations and reports and other medical documents but also a systematized photographic record containing more than 30,000 negatives, collections of pathologanatomical preparations for more than 6500 examples among which there were hundreds of unique and a tremendous number of exhibits (more than 30,000) collected at the front in the war. Such rich collections made it possible to accompany the "Work" with very clear illustrated material.

In compiling the multivolume (Work) about 1700 persons participated including the most important scientists of the country, outstanding activists in civilian and military public health and, moreover, many hundreds of young scientific workers and practical physicians in different specialities who worked during wartime in hospitals and other treatment and diagnostic institutions of the army. Among the authors of the "Work" about 50 active members and corresponding members of the Academy of Sciences USSR, the Academy of Medical Sciences USSR and the Academy of Sciences of the Union Republics participated; 43% of the authors and editors of the "Work" have scholarly degrees of doctor of medical sciences, ~~24~~ 27% have degress of candidate of medical sciences.

The persons compiling the "Work" have experience in work in medical institutions of military, army and front regions, in treatment institutions of the rear of the country and in the administrative apparatus of the military-medical service. For instance, of the total number of compilers for the volumes Surgery, 7.2%.

worked in the central apparatus, in the treatment institutions of the existing army (troop, army, front) - 60.7% and, in military-medical and civilian institutions for treatment at the rear of the country - 32·1%; for authors and editors of the section entitled Therapy these numbers are respectively 7.0%, 51.6% and 41.4%.

These data are evidence of the fact that in the "Work" multi-faceted experience is reflected both in the famous scientists and in the rank-and-file physicians.

The basis for the scientific processing of the material was the study of primary documents on the wounded and the sick including those who, with the requirements of medical science and statistics, make it possible to develop a fully valuable and well founded generalization in relation to all of the questions studied. All of the numbers and positions are based on study of the history of the patients, the charts of the front region, the acts and reports of different types of studies and other primary documents on wounded and sick. When compiling the "Work" also reports and dispatches were carefully studied in order to discover the combat, sanitary-tactical and medical circumstances which had to be analyzed and correctly used with the data obtained. This made it possible to establish the effect of different factors on the course and outcome of wounds or diseases, to trace the development during wartime of methods of treatment-evacuation and antiepidemic care and to establish certain principles which are particularly important both for theoretical medicine and for medical care of combat troops.

The editorial board, authors and editors of the work entitled Opyt sovetskoy meditsiny v Velikoy Otechestvennoy voyne 1941-1945 gg. [Experience of Soviet Medicine in World War II 1941-1945] fulfilled the task given them by the party, the government and the great leader of the Soviet people, Comrade Stalin, with full responsibility and discharge of duty. They hope that this work will be a great contribution to theoretical and practical Soviet medicine and will facilitate further development of medical science.

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SECTION ONE

GENERAL QUESTIONS OF MILITARY-FIELD SURGERY
(WOUNDS, FROSTBITE, BURNS)

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CHAPTER I

GUNSHOT WOUNDS

General Concept

In modern wars the overwhelming majority of loss is due to gunshot wounds from weapons. The projectiles required for damaging personnel and structures differ greatly; the variation and force have had a constant tendency toward increase. The methods for directing the projectiles at their target are also varied. Along with the simple hand grenade complex firing devices and mechanisms are used. The distance for inflicting damage has increased steadily for modern weapons. Moreover, in the last decades, projectiles are becoming more and more widepread which move through the air or water requiring special mechanisms which are included in the projectile. These include torpedoes, mines with jet engines and aircraft projectiles used by the Germans.

The damaging effect of all types of firing weapons used depends on the kinetic energy which the wounding body has at the moment of contact with tissue.

Wounds from cold weapons (sabers, lances, even bayonets) in the past war were insignificant and had practically no importance. A cold weapon played an important role in the hand-to-hand combat in battles in the time of Suvorov and Kutuzov, not to mention wars of ancient times. But even N. I. Pirogov noted that "even in the Crimean War one rarely saw significant wounds from a cold weapon." In the wars of this century, the frequency of wounds caused by a cold weapon continued to decrease. In the Russo-Japanese War of 1904-1905, the frequency of wounds with a cold weapon in the Japanese army reached 3.0%. In the first World War 1914-1918, the frequency of wounds with cold weapons in the German army decreased to 0.6%, in the second World War, for 1939-1941, to 0.02%.

In the Soviet Army in World War II, these wounds also occurred only in 0.02%. Their frequency during various combat operations varied from thousandths of percentages to 0.2%. For instance, the percent of wounds with cold weapons, in relation to all wounds, during the Battle for Stalingrad equaled 0[1]; during the Orlov-Kursk operation - 0.1; the Byelorussian operation - 0.02; the operation on the Visla-Oder - 0.07; the Berlin operation - 0.2.

The percentage of bullet wounds is decreasing and of artillery is increasing. Wounds from fragments of mines and hand grenades are apparent as we see in Table 1.

These changes in the character of combat during direct contact with the enemy are explained particularly by the broad use of hand grenades and shooting from supports because automatic weapons do not require time for reloading and are always ready for action.

Moreover, from the surgical point of view, wounds with a cold weapon, other conditions being equal, usually are not as serious as gunshot wounds. N. Pirogov once wrote: "But all these wounds (that is, from cold weapons) disappeared before the multiplicity of damage caused by seiges of the tremendous previously unheard of gunshot shells." All of the difficulties of surgical treatment and therapy once more are involved with gunshot wounds, not with wounds from a

[1]These data were introduced only for the period for eliminating the 6th German Army from the area around Stalingrad.

Table 1. Distribution of wounds according to the type of wounding weapon in different wars

	(a) Ружейные пули	(b) Артиллерийские снаряды	(c) Мины	(d) Ручные гранаты	(e) Вторичные снаряды
	(i) процент ранений				
(f) Русская армия, 1904—1905 гг.	78,6 [1]	21,4 [1]	—	—	—
(g) Французская армия, 1917 г. (позиционная война)	11,6	55,9	0,9	10,3	21,3
(h) Французская армия, 1918 г. (маневренная война)	14,7	53,9	0,3	6,7	24,4

Key: (a) Rifle bullets; (b) Artillery shells; (c) Mines; (d) Hand grenades; (e) Secondary projectiles; (f) Russian Army, 1904-1905; (g) French Army, 1917 (position warfare); (h) French Army, 1918 (mobile war).

[1] According to Kaminsky and Novosel'skiy

(i) percentage of wounds.

cold weapon.

Wounds of the so-called secondary projectiles, that is, rocks, fragments of frozen earth, bits of metal, wood and glass, etc. during explosions of artillery shells, mines, bombs from aircraft, etc. hardly differ at all from gunshot wounds and from the surgical point of view can be combined with them (Fig. 1).

In this way, gunshot wounds have become the center of attention for the modern physician in wartime. Both in their properties and special features, as well as in their frequency, they occupy first place in modern combat field surgery.

If one takes into account all of the means for damage which were used in World War II by the German military forces and their satellites, and also the ballistic properties of the different types of shells used, then one can begin to understand the severity of their effect on tissue of the human body.

Firearms were begun to be used in combat practice more than 500 years ago; in that time the technology of firearms has made

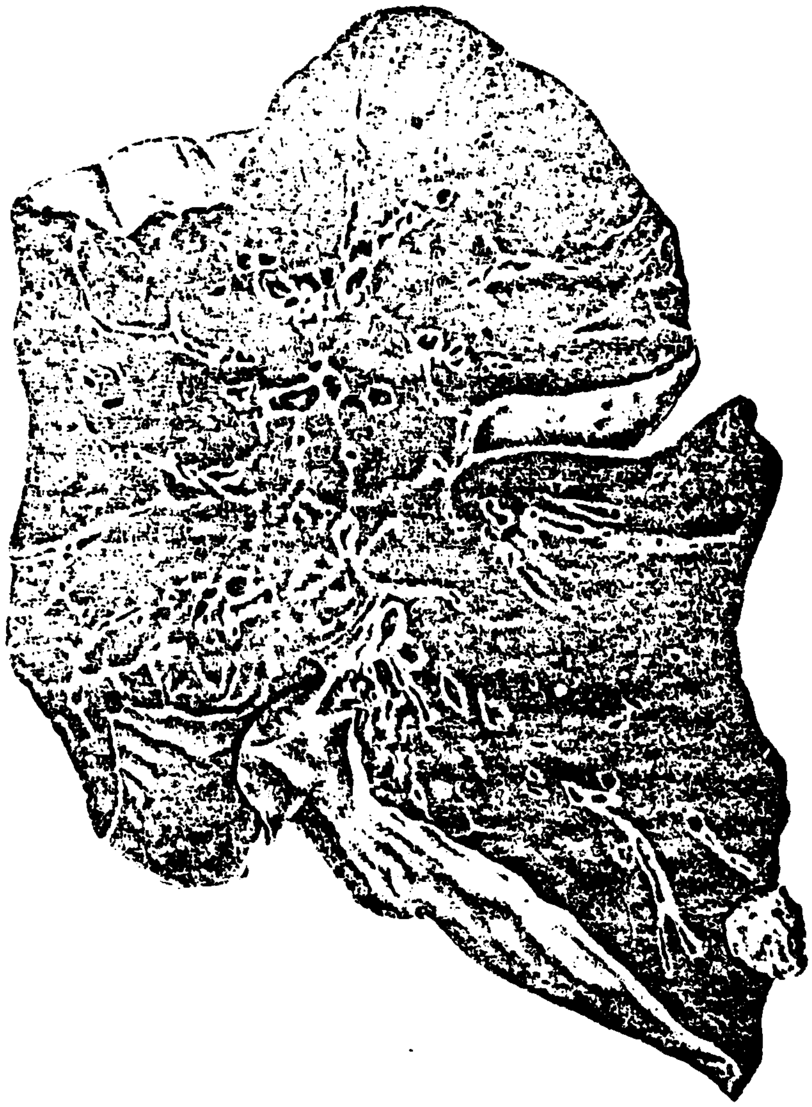

Fig. 1. Wound from a secondary projectile. Rock in the lung. Speciman VMM No. 3531/388. (Artist: S. A. Moiseyeva)

tremendous advances. Physicians, even with their very first acquaintance with firearm wounds, have attempted to study their peculiarities starting with the clinical course of the wounds and their tendencies toward complications during the healing period.

The first mention of a gunshot wound, more precisely, about the removal of a bullet was written and dated August 2, 1445 (Brunner) and according to other data - 1444; the first such description of a special tool for probing bullets in the wound was given by the surgeon Pfolspeund in 1460.

Obviously the fact that there is a foreign body in the wound attracted attention first and was the basis for characteristic types of wounds. However, then a good deal of attention was directed at another property of gunshot wounds: the course of a gunshot wound was comparatively more severe than other wounds and the tendency toward complication was observed not only when the bullets or fragments remained in the wound but also when they passed through the body. It took a good deal of time and effort to discover the cause for damaged tissue in gunshot wounds. It is understood that their study could give valuable results when scientists, along with clinical observers, started to experiment in this way. This question was discussed in many works both in our country and abroad. Among the works of the Russian authors, one should mention the studies of K. K. Reyer, M. M. Rozanov, Ye. V. Pavlov, V. A. Tule, I. N. Kochetov, A. A. Glebovich, A. A. Opokin et al.

The first experiments on the passage of a bullet (spherical) through different media were conducted in 1830 by Dyupyuitren.

Eighteen years later (1848) N. I. Pirogov tested Dyupyuitren's data on models and on corpses and approved his conclusion that with the passage of bullets through a medium, the outgoing aperture always is larger than the ingoing and there is a definite principle under impact of the bullet on concave or convex surfaces. On the basis of these tests and also subsequent observations in Sevastopol both with sperical and conical bullets, N. I. Pirogov considers the use of data obtained on wooden or felt models used as the person as being incorrect.

Modern studies in which all possibilities of modern equipment were used, particularly photography and roentgenography of the test shell in flight with passage through an experimental medium (water, solution of gelatin, etc.) or through tissue of an experimental animal, have the most value for understanding the character of damage to tissue; these studies have been conducted in modern times. Photographs of single frames were made in one millionth of a second, movie film from 2000 to 7000 frames per second at a rate of shell flight from 338 to 1300 and more meters per second; this corresponds to the initial speed of the bullet for a modern weapon. It has been known since long ago that along the wound channel with gunshot wounds, a significant contusion of the tissue occurs but now a metal body (sphere or bullet) passing through tissue has been successfuly photographed and the force of impact has been calculated precisely.

A steel ball weighing 0.439 grams, flying at a speed of 1157.8 m per second develops an impact energy equal to $29.02\mathrm{X}10^{8}$ergs. Inasmuch as the breakdown which occurs in the tissue depends on the one hand on speed, shape and mass of the wounding projectile and on the other hand on the physical properties of the tissue being damaged, a combination of these many factors and the conditions for their interaction involves a tremendous variety of wounds.

In all perforation wounds as well as nonperforation which penetrate even the muscle layers, the force of impact and the speed of movement of the projectile is much greater than those caused by the characteristic properties of gunshot wounds.

The kinetic energy with which the injuring body passes into the tissue, as a result of the resistance of the latter with nonperforated wounds drops to 0 and with perforated wounds it is expended only partially and its fragments are carried outside by the wounding body.

Observations of the effect of the projectile when firing were made for steel balls, bullets and irregular shaped fragments; here the flight of the projectiles, besides the tests on anesthetized animals, were also studied on models of different shapes with solid and elastic walls made of water or a solution of gelatin. It would seem that under the effect of the impact, at the moment of penetra n of a foreign body into the medium, the strong wave occurs from compression of tissue (or the solution) in front of the projectile; this sharply deforms the model. At the same time, behind the foreign body a sort of cavity is created which then shifts along the course of the wound channel. However, these deformations are very short term, lasting for thousandths of a second increasing and disappearing spontaneously.

In the short time that a bullet passes through a body of an experimental animal, two to three waves are observed.

Even N. I. Pirogov comments that the bleeding and other symptoms of damage can be detected far from the wound channel; moreover, one should expect this with wounds from modern bullets and fragments which have a much higher flight speed than during the time of N. I. Pirogov.

Preparations by a pathologoanatomist, in particular, studies by A. V. Smal'yannikov on amputated extremities and corpses shows the presence of the smallest fragments of damaged femur bone as far away as the entire length of the spinal column and also the smallest of hemorrhaging as a result of this explosion of bone fragments.

Studying the results of the experiments mentioned above, one can state on the basis of morphological data, that with gunshot wounds trauma causes noticeable changes far from the limits of the actual contact of the wounding projectile and the tissue. However, the morph logically determined results of wounding are observed essentially less than one could expect on the basis of experimental data. Obviously here the short term of the effect measured in the smallest parts of a second are important. It is much more difficult to establish the changes in tissue which morphologically are apparent but undoubtedly they exist and cause functional disturbances. We can judge these only by studying the subsequent course of the wound process, the general reaction of the organism and also on the basis of complications fairly often after gunshot wounds. This entire complex of local and general manifestations should be considered on the whole as damaging not only a certain area but the entire organism.

It is not surprising that in the fifteenth century on the eve of surgical observations of the course of gunshot wounds, certain scientists erroneously considered as wounds as poisoning and the poisoning effect of the powder is described.

Gunshot wounds and their environs actually are damaged not from the "poison" of the powder but as a result of sharp and rapid changes in pressure; these changes occur when the wounding projectile passes through the tissue as the result of its high speed whose source is an explosive substance.

Thus, in the modern concept, the genesis of gunshot wounds is due primarily to the "explosive" sharp changes in pressure in tissue and the foreign body plays primarily the role of a carrier of kinetic energy; its speed causes an "intratissue explosion." It is indisputable that the presence of a foreign body in tissue is reflected much later in the wound; however, in World War II there were a fair number of cases where the wound occurred as the result only of an explosive wave. While one encounters small particles of metal in such wounds, tearing of clothing, fragments of moss, earth or peat they are only random foreign bodies carried into the wound by the force of the explosion. Such wounds are caused, for example, by antipersonnel mines; as is well-known, the latter can not have a metallic housing: the explosive substance is enclosed in wood or even paper sheathing.

Damage to tissue which occurs from the blast wave sometimes reached significant dimensions (Figs. 2 and 3). Such a type of wound could be observed after an explosion of a grenade capsule in the hand. The wounds were impregnated with a mass of small metal fragments due to the explosion of such fragments and the force of the blast wave.

Fig. 2. Laceration wound of the right hand with the thumb blown off. Wound caused by explosion of a hand grenade. Specimen VMM No. 2921/66. (Artist S. A. Moiseyeva)

The character of change depends on the force of impact caused in particular by the distance which separates the soldier from the weapon including the direction and position of the explosion of the artillery projectile or aviation bomb.

As was already indicated one must assume in the calculation, changes occurring in the organism which do not have a morphological expression. Some of these appear later in the course of the wound process and some can be detected by a comparison with the course of non-gunshot wounds. Finally, this involves further complications that the different tissue of the human body react to impact or "explosion" variously. This is especially true for wounds which damage tissue of different structure and different density, in

Fig. 3. Crushed foot. Wound from antipersonnel mine.
Specimen VMM No. 6945/68. (Artist M. N. Akulyari).

particular bone. The conditions for propagation of a blast wave in the tissue of different structures shows the varying character of the damage. For instance, when a projectile passes through the brain, including the dense structure of the skull, a breakdown in tissue occurs of a very different character than when the projectile passes through pulmonary tissue containing air; different conditions exist when the projectile passes through massive muscle tissue surrounding bone, etc. In view of this, even N. I. Pirogov concluded that the "effect on organic tissue causes an infinity of differences." It is understood that the most important special feature of a gunshot wound is the intratissue "explosion" and involves variations in it; this cannot be true with wounds from cold weapons. Therefore, damage with these wounds has much more localized character: with a cutting wound, the damage is almost completely limited to the wound itself; with contusion, laceration and crushing wounds - to one oı another degree, the wounding edges are involved but on a much smaller scale than from wounds from firearms.

General Characteristics of Gunshot Wounds

Damage from gunshot wounds in World War II reached the highest degree in comparison with all preceding wars. If one takes all of the wounds from cold weapons out of the total number, then 99.98% of the wounds are from firearms including damage from secondary projectiles.

Gunshot wounds can be divided into bullet and fragment wounds. Such a division in most cases is fairly well verified. As to fragmentation wounds of different origin, here the documental data can be only approximate because some of the records are based only on the words of the wounded.

With perforated wounds one can judge the shell inflicting the damage only on the basis of the character of the wound. It is not always possible to successfully establish the character of the wound and after surgical treatment, often it becomes impossible.

With nonperforated wounds it is not difficult to determine the bullet wound by X-ray but with fragmentation wounds it is often impossible to conclude with accuracy as to which were the causes: fragments of an artillery shell, mines of avaiation bombs, if one does not know the conditions of battle in which the wound occurred.

This question was not always solved correctly even when the fragment was removed because the shape, exterior appearance and composition of the fragments are extremely varied and an evaluation would be given by physicians who were little acquainted with the shells inflicting the damage.

In this way, a precise differentiation of fragmentation wounds en masse is not always possible. A precise conclusion as to the origin of the fragment and also the damaging character of the bullet can be made only after thorough and multifaceted study.

The ratio of fragment and bullet wounds for the entire war was expressed at 57:43 (56.8:43.2). This ratio corresponds to that observed in each of the preceding wars with an increase in frequency of fragmentation wounds in comparison with bullet wounds as the result of an increase in the role of artillery, an increase in caliber of weapons, the broad use of mortars and aviation. However, this predominance of fragmentation wounds was equalized by the very broad use in the German army of automatic weapons and machineguns.

The predominance of wounds from artillery shells in the first World War was high; this is obvious in the American army who entered the war in the period of the greatest development of such means of destruction. For instance, 72.0% of wounds were clearly from artillery shells and only 28.0% were from bullets.

However, one must take into consideration that the number of artillery wounds include shrapnel as well. In the Soviet Army in World War II, shrapnel wounds were almost nonexistent.

The comparative frequency of bullet and fragmentation wounds according to the year of the war is presented in the following diagram (Fig. 4).

As we see from this diagram, bullet wounds occurred most frequently in the first year of the war. In the second year of the war, an increase in frequency of fragmentation wounds was noted and correspondingly, a drop in bullet wounds. The third year of the war showed an increase in frequency of fragmentation wounds and consequently, the same drop in frequency of bullet wounds as in the second year. In the fourth year, the frequency of fragmentation wounds had increased even more, somewhat more in comparison with the preceding year. In this way, frequency of fragmentation wounds

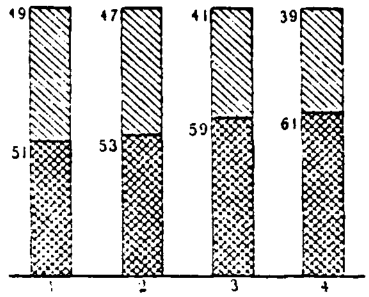

Fig. 4. Comparative frequency of bullet and fragmentation wounds according to the year of the war. Key: (a) Years of the war; (b) Bullet; (c) Fragmentation

with each year of the war was increased and the severity of wounds, the tendency of them for complications began and grew.

Variations in frequency of fragmentation and bullet wounds during certain combat operations were very significant depending on battle circumstances. Attention should be given to the huge predominance of bullet wounds with branching out and destroying the surrounding groups of enemy when the number of bullet wounds exceeded sometimes 80.0% at a given front which was conducting this operation.

Here it is necessary to note also the very high percentage of multiple wounds. For instance, multiple bullet wounds occurred in 1/3 of the cases while this relationship was maintained during all four years of the war, only 2/3 of the bullets wounds were single. The ratio of single and multiple fragmentation wounds was just as stable and the number of these wounds per year and for the entire war was almost identical with a small predominance (1.0-2.0%) of multiple wounds.

Thus, all of the wounds as a whole also retained a constant relationship according to the year of the war, namely, almost 3/5 of all wounds were single and somewhat more than 2/5 of the wounds were multiple. This high percentage of multiple wounds had not been observed in past wars.

Localization of combat damage, as is known, depends on the comparative dimensions of different parts of the body and the position which it occupies at the moment of being wounded. Even in preceding wars, certain principles of damage to certain parts of the body were established.

However, in certain combat operations, one encounters fairly significant variations. Therefore, when evaluating the data, more significance is given to the dimensions of these variations than the average figures. The latter were used only in order to indicate the dynamics of frequency of wounds of a given localization according to the year of the war.

If we throw out the extreme cases caused by special conditions, then the boundaries of variation with different locations of the wounds are expressed with the following numbers: wounds to the head - 7.0-13.0%; to the neck - 0.5-1.5%; chest - 7.0-12.0%; stomach - 1.9-5.0%; pelvis, lumbar and buttocks - 5.0-7.0%; spine - 0.3-1.5%; upper extremities - 29.0-45.0%; lower extremities - 30.0-40.0%.

The numbers presented relate to different fronts, large combat operations, and also sections of the front with relative quiet between large combat operations. From these numbers it is apparent that the basic principle of localization of wounds is always maintained, that is, that the largest number of wounds occur in the extremities. However, tendencies of practical importance in relation to frequency of localization of wounds during World War II can be defined if one takes into consideration data according to the year of the war. For this purpose, the curves presented below were drawn, where the frequency of wounds of a given localization for the first year are taken as the initial data and frequency of these same wounds three years later are placed on a curve correspondingly higher or lower; the scales of the curves are made different for a more graphic representation of the frequency of a given localization.

A special mark (O) indicates the average frequency of wounds of each localization for the entire war; then also it is easy to judge which period of the war corresponds to the average frequency of wounds.

The curves of wounds to the head (Fig. 5) indicate uniform increase of frequency of these wounds for the second and third years of the war and even more significant increase in the fourth.

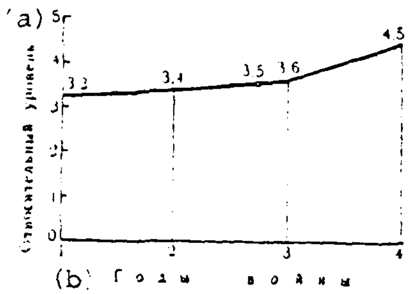

Fig. 5. Comparative frequency of wounds to the head according to the year of the war.
Key: (a) Relative level; (b) Years of the war.

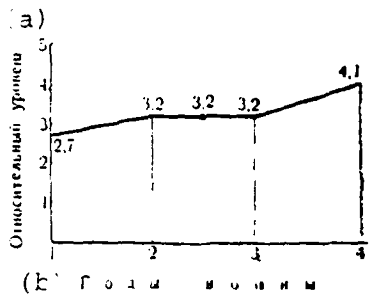

Fig. 6. Comparative quency of wounds to the head according to the year of tne war.
Key: (a) Relative level; (b) Years of the war.

The curve of frequency of damage to the neck (Fig. 6) shows a tendency toward an increase but it is insignificant and essentially the frequency of wounds to the neck during the entire war was stable. It is understood that here the average number of wounds is located at the center of the curve.

Another picture shows the curve of wounds to the chest according to the year of the war (Fig. 7). The frequency of damage in the second and third years of the war remains at a single level which corresponds also to the average level for the entire war; as to the first and fourth years, they are mutually leveled out: the first - toward a decrease from the average level and the last, toward an increase.

The frequency in wounds in the area of the stomach increases

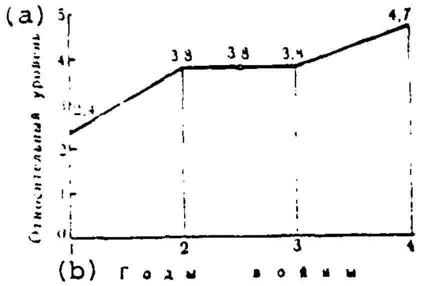

Fig. 7. Comparative frequency of wounds to the chest according to year of the war.
Key: (a) Relative level; (b) Years of the war.

very uniformly (Fig. 8); the average number of wounds lies between the second and third years of the war.

The frequency of wounds to the spine (Fig. 9) as is obvious, remains constant during the entire war. The tendency toward an increase in frequency of these wounds is very slight.

The first curves are arc shaped with wounds to the pelvis, lumbar and buttocks region (Fig. 10). A certain increase in frequency of these wounds is observed in the second year of the war, a somewhat smaller increase in the third and an obvious drop in the fourth; however, the frequency of wounds of these areas in the fourth year is even higher than in the first. The average number of wounds is lower than in the second year of the war.

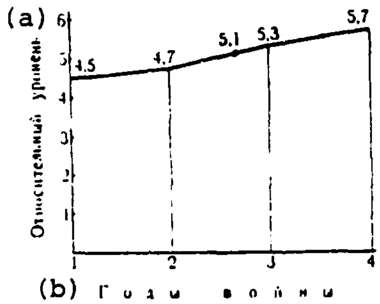

Fig. 8. Comparative frequency of wounds to the stomach according to the year of the war.
Key: (a) Relative level; (b) Years of the war.

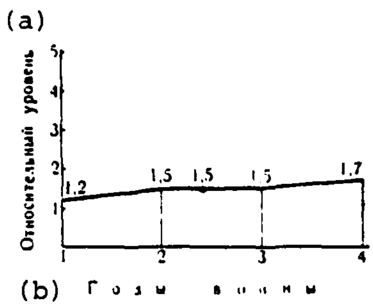

Fig. 9. Comparative frequency of wounds to the spine according to the year of the war.
Key: (a) Relative level; (b) Years of the war.

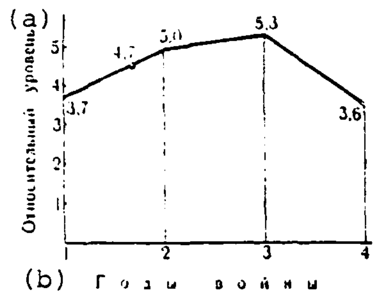

Fig. 10. Comparative frequency of wounds to the pelvis, lumbar and buttocks region according to the year of the war.
Key: (a) Relative level;
(b) Years of the war.

The curve of frequency of wounds to the lower extremities (Fig 11) rises with each year of the war. The average figure for frequency of these is approximately at the level of the second year, exceeding it somewhat.

The curve of frequency of wounds of the upper extremities (Fig. 12) in distinction from the curves previously obtained, shows a sharp decrease in the second year of the war and a significant drop with each subsequent year. At the center of the curve are figures of average frequency of these wounds for the entire war.

Thus, the frequency of wounds to the head, chest, stomach and lower extremities increased significantly from year to year; curves of wounds to the neck and spine were almost unchanged; the curve of wounds to the pelvis, lumbar region and buttocks decreased in the fourth year of the war; the curve of wounds of the upper extremities decreased unfailingly and significantly.

To discover the causes for this phenomenon it is necessary to define the character of the wounds, that is, take into consideration the weapon inflicting the wound, to divide the wounds into bullet and fragmentation wounds. It was pointed out above (Fig. 4) that the frequency of fragmentation wounds increased from year to year and that of bullet wounds dropped. Below we will present diagrams

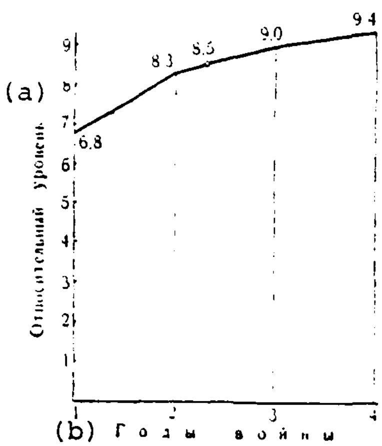

Fig. 11. Comparative frequency of wounds of the lower extremities according to the years of the war. Key: (a) Relative level; (b) Years of the war.

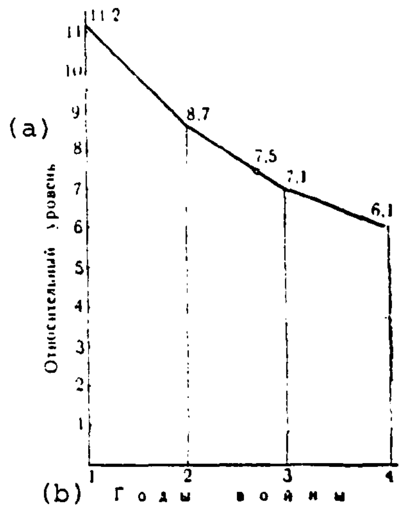

Fig. 12. Comparative frequency of wounds of the lower extremities according to the years of the war. Key: (a) Relative level; (b) Years of the war.

which cnaracterize tne frequency of fragmentation and bullet wounds according to localization.

Wounds to the head by fragments (Fig. 13) were observed much more often than bullet wounds and the frequency of fragmentation wounds from year to year increased but the frequency of bullet wounds dropped.

This same character of the columns existed for damage to the neck (Fig. 14); however, the total number of bullet wounds is closer to the total number of fragmentation wounds.

The columns which represent wounds to the chest (Fig. 15) indicate an increase in frequency of fragmentation wounds for the entire first three years of the war; for the fourth year of the war, the frequency of fragmentation wounds dropped somewhat in comparison with the third year of the war and the frequency of bullet wounds increased.

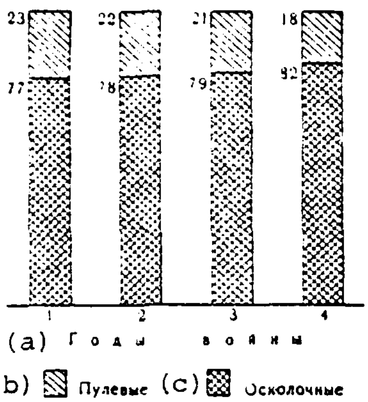

Fig. 13. The ratio between bullet and fragmentation wounds to the head according to the year of the war.
Key: (a) Years of the war; (b) Bullet; (c) Fragmentation.

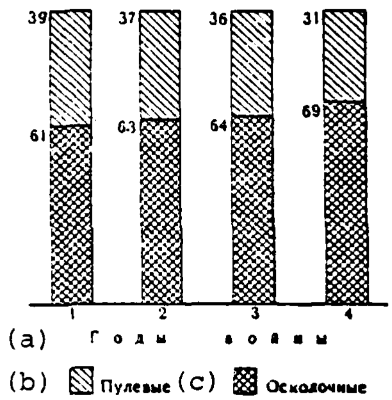

Fig. 14. The ratio between bullet and fragmentation wounds to the neck according to the year of the war.
Key: (a) Years of the war; (b) Bullet; (c) Fragmentation.

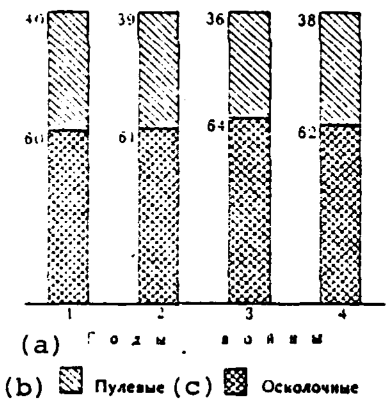

Fig. 15. The ratio between-bullet and fragmentation wounds to the chest according to the year of the war.
Key: (a) Years of the war;
(b) Bullet; (c) Fragmentation.

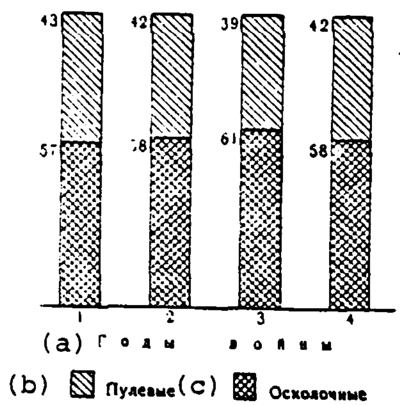

Fig. 16. The ratio between bul- and fragmentation wounds to the stomach according to the year of the war.
Key: (a) Years of the war:
(b) Bullet; (c) Fragmentation.

In the second year of the war the number of fragmentation wounds to the stomach (Fig. 16) increased somewhat in comparison with the first year; by the third year it had increased again. In the fourth year of the war one notes a certain decrease.

The frequency of wounds of the spine (Fig. 17) as usual is distinguished by a constancy and is subjected to insignificant variations. However, fragmentation wounds to the spine predominate.

Frequency of fragmentation wounds of the lower extremities (Fig. 18) increased steadily; frequency of bullet wounds steadily declined from year to year.

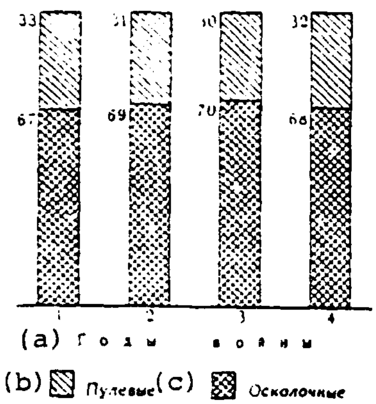

Fig. 17. The ratio between bullet and fragmentation wounds to the spine according to the year of the war.
Key: (a) Years of the war; (b) Bullet; (c) Fragmentation.

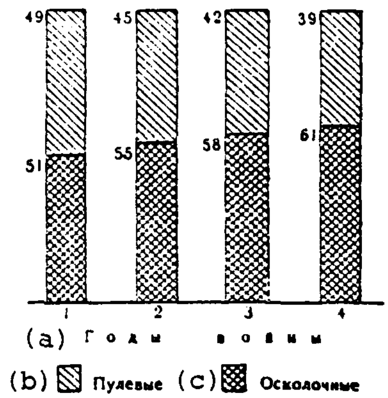

Fig. 18. The ratio between bullet and fragmentation wounds of the lower extremities according to the year of the war.
Key: (a) Years of the war; (b) Bullet; (c) Fragmentation.

Diagrams of wounds of the upper extremities show a completely different picture (Fig. 19). First of all during the first three years of the war, one notes a predominance of bullet wounds and not fragmentation as with other localization. However, frequency of fragmentation wounds with each year of the war increased and frequency of bullet wounds dropped; by the fourth year fragmentation wounds of this localization predominate.

If one draws a diagram of damage to the upper and lower extremities, that is, the overwhelming majority of all military wounds, then one can see that the frequency of bullet wounds decreases with each year and fragmentation wounds increase slightly; by the second year of the war, the frequency of bullet and fragmentation wounds has become the same (1:1) (Fig. 20).

For a correct evaluation of the ratio of wounds by location of the injury, it is necessary to pay attention to the two most significant circumstances. First of all one must take into consideration the character of combat in the first and part of the second years of the war where, for our troops, it was not possible to remove some of those severely wounded in the lower extremities from the field of battle, particularly in forest and marshy localities; at the same time, those wounded in the upper extremities could walk out from the field of battle themselves and even from the surroundings. Beginning with the second half of the second year of the war when the battlefield was controlled by our troops, removal of the wounded could be done completely and it was only necessary to overcome the difficulties involved in the character of the terrain (see page 207). As a result, the ratio of wounds of the upper and lower extremities leveled out.

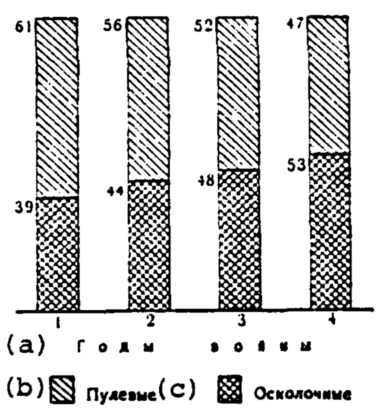

Fig. 19. The ratio between bullet and fragmentation wounds of the upper extremities according to the year of the war.
Key: (a) Years of the war; (b) Bullet; (c) Fragmentation.

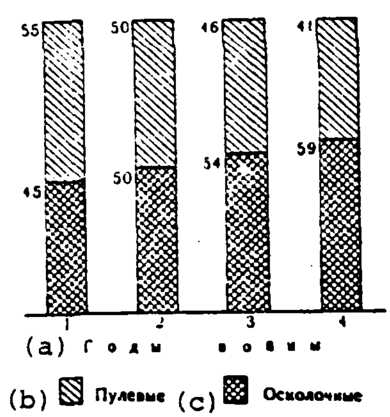

Fig. 20. The ratio between bullet and fragmentation wounds of the upper and lower extremities according to the years of the war.
Key: (a) Years of the war; (b) Bullet; (c) Fragmentation.

However, one of these circumstances cannot be the complete explanation because the frequency of wounds of the upper extremities continued to drop from year to year until the end of the war. It is necessary to pay attention to the fact that training of the troops improved constantly; soldiers and officers more skillfully used all possible cover and camouflage and mastery of their combat weapons was perfected. Nevertheless, a better protected enemy required going into closer and more severe combat with him, particularly when breaking through his defense lines. Due to this, the wounds from year to year became more severe and because of these serious wounds, the number of light wounds dropped.

From the data presented one can conclude that there was a constant increase in severity of the wounds. This conclusion will be confirmed later on.

One localization of wounds, although taking into consideration the shell inflicting the wound, is inadequate for a general characterization of the wounds.

One of the existing indices for the character of wounds is:

1) ratio of wounds only of soft tissue and soft tissue and bones; at the same time, one must take into consideration wounds with the presence of a foreign body and without;

2) penetrating or nonpenetrating character of wounds in the cavity of the skull, chest and stomach.

When studying wounds with damage and without damage to the bones, we are talking primarily about the extremities; with an analysis of the cavity wounds - exclusively wounds to the head and trunk.

As is known, in the war the first group of wounds is quantitatively predominant. It is understood that we are not limited to single extremities or with wounds to the head, very significant is damage to the bone of the skull because with wounds to the chest, damage to the skeleton is not excluded. Fig. 21 shows all types of

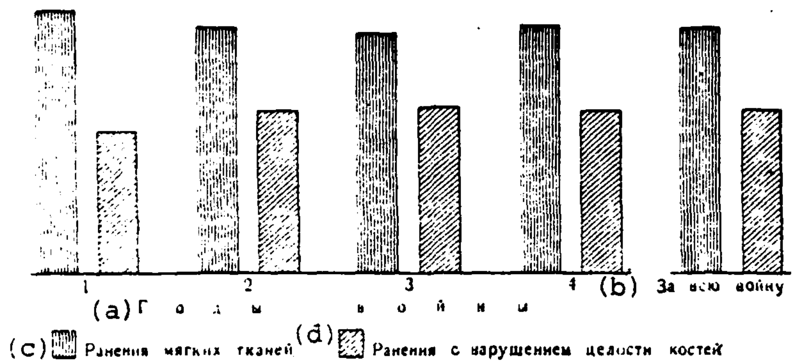

Fig. 21. Distribution of wounds according to the year of the war.
Key: (a) Years of the war; (b) For the entire war; (c) Wounds to soft tissue; (d) Wounds with destruction of bone.

wounds: the first four columns by the year of the war and the fifth for the entire war.

The diagram indicates a predominance of wounds without damage to the bone both for each year of the war and for the entire course of the war. In the first year of the war this predominance was more strongly expressed; one has to think that it is due to conditions of battle, general tactical circumstances and training of the troops. During the last three years of the war, one sees a slight increase in wounds only of soft tissue with a corresponding drop in relative frequency of damage to the bones.

The diagrams presented below indicate the same relationship for separate localizations.

For the entire war, one notes a certain predominance of wounds only of soft tissue of the head (Fig. 22) over wounds of soft tissue and bones. These ratios remain stable according to the year of the war except for the first year when predominance of wounds only of soft tissue is fairly rare. It is very probable that a drop in frequency of wounds of soft tissue in the head occurs due to a broader use of helmets and better training of the troops. A whole series of drops of weaker or smaller fragments occurs thanks to the protective

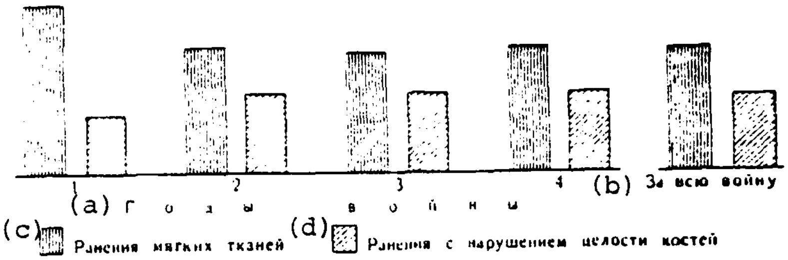

Fig. 22. Distribution of wounds to the head according to the year of the war.
Key: (a) Years of the war; (b) For the entire war; (c) Wounds to soft tissue; (d) Wounds with damage to the bone.

helmets which generally prevent wounds.

The variation in frequency of damage to soft tissue and soft tissue and bone in the chest (Fig. 23) according to the year of the war, is not great. However, predominance of wounds only of soft tissue with this localization does not give evidence of lightness of the wounds.

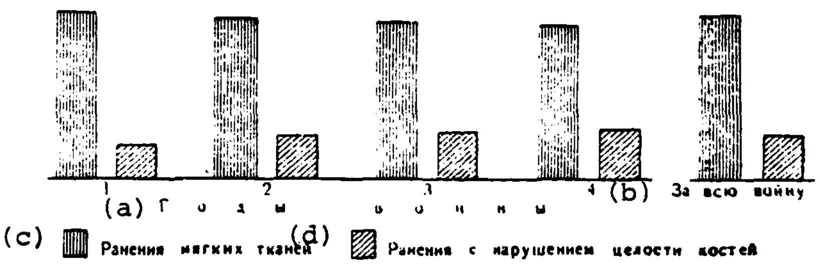

Fig. 23. Distribution of wounds to the chest according to the year of the war.
Key: (a) Years of the war; (b) For the entire war; (c) Wounds to soft tissue; (d) Wounds with damage to the bone.

In addition to the diagram it is necessary to point out that with perforated wounds to the chest with damage to the internal organs, there was no mention of breaking ribs in a number of case histories although according to the description of the wounds, this would have been assumed; therefore, one has to think that the number of wounds with damage to the bone is decreased. For instance, this circumstance does not have particular meaning because the severity of the wounds to the chest is determined mainly by damage to the internal organs.

With damage to the lower extremities (Fig. 24), one notes a significant predominance of wounds only to soft tissue. In the first three years of the war, the frequency of damage to the bone increases; in the fourth year one notes an insignificant decrease. In comparison with lower extremities, the ratio of wounds to the upper extremities (Fig. 25) with damage and without damage to the bone was reversed, that is, the bones of the upper extremities were damaged more often than the soft tissue. This is easily explained by the anatomical peculiarities of the upper extremities. Variations in wounds according to the year of the war are insignificant.

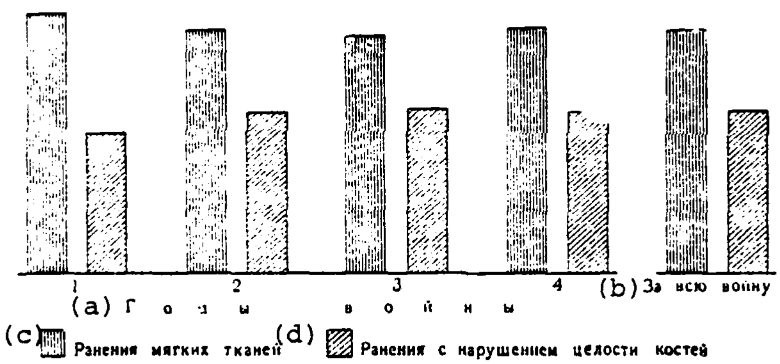

Fig. 24. Distribution of wounds of the lower extremities according to the year of the war.
Key: (a) Years of the war; (b) For the entire war; (c) Wounds to the soft tissue; (d) Wounds with damage to the bone.

When studying damage to both extremities (Fig. 26), the difference noted above is leveled out and the number of wounds to soft tissue without damage to the bone only slightly exceeds the number of those involving damage to the bone. The ratio of these amounts to almost 1:1 both for the entire war and separately by year of the war. Significant variations according to the year of the war are not noted.

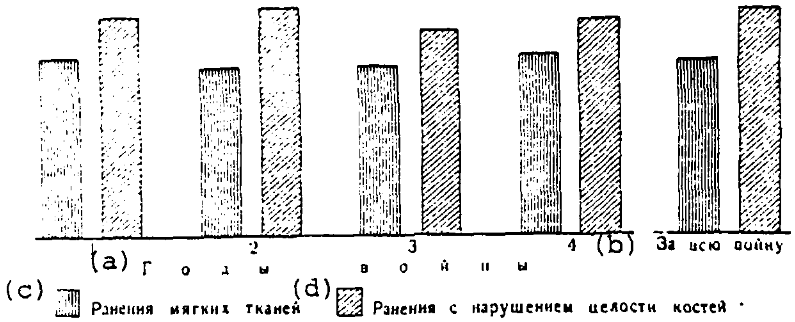

Fig. 25. Distribution of wounds of the upper extremities according to the year of the war. Key: (a) Years of the war; (b) For the entire war; (c) Wounds to the soft tissue; (d) Wounds with damage to the bone.

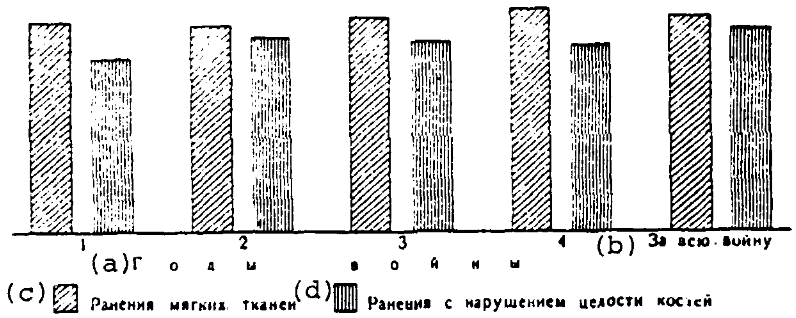

Fig. 26. Distribution of wounds of the upper and lower extremities according to the year of the war. Key: (a) Years of the war; (b) For the entire war; (c) Wounds to the soft tissue; (d) Wounds with damage to the bone.

The principle difference in ratio of damage from bullets and fragments both as a whole and separately are nonexistent but one has to note that with fragmentation wounds, often only soft tissue is damaged.

When analyzing the ratio of bullet and fragmentation wounds, it is necessary to take into consideration that rifle and machinegun fire usually are laid at close distances. Fire from automatic weapons also is laid in close combat in distinction from preceding wars where they tried to use the entire distance for flight of the rifle bullets.

At the same time the fragments from different shells, in particular, of mines and hand grenades often do not have adequate power for deep penetration and damage to the bone.

The ratio of nonpenetrating and penetrating wounds is presented in detail both in the chapter entitled "Foreign Bodies" and in sections 2-15 of the part entitled "Surgery." In the diagram presented below (Fig. 27), the ratio of nonpenetrating and penetrating wounds is presented for certain segments of the extremities. It is easy to confirm that the character of wounds is clearly related to the massive character of tissue of the region damaged; for instance, the maximum number of nonpenetrating wounds is in the femur, second place is in the crus; third place is the shoulder and last is the forearm. With penetrating wounds, these localizations should be in the reverse order.

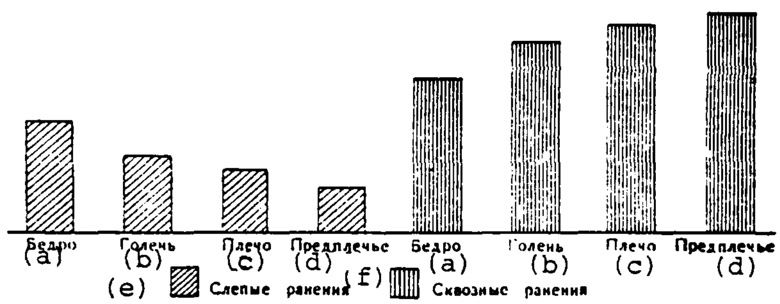

Fig. 27. Ratio between nonpenetrating and penetrating wounds of different sections of the extremities.
Key: (a) Femur; (b) crus; (c) Shoulder; (d) Forearm; (e) Nonpenetrating wounds; (f) Penetrating wounds.

The question of frequency of damage to the right and left sides of the body by firearms projectiles deserves particular attention. The easiest object for this study are wounds to the extremities because, with damage to the head and trunk, this relationship is distorted due to the fact that the severity of the wound and consequently the mortality rate to a definite degree depends on the side damaged whereas with wounds to the extremities, the side of the damage

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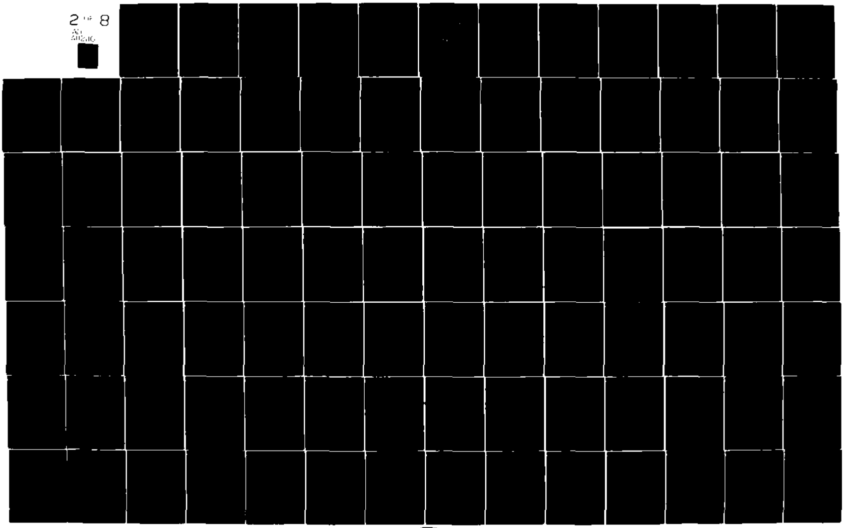

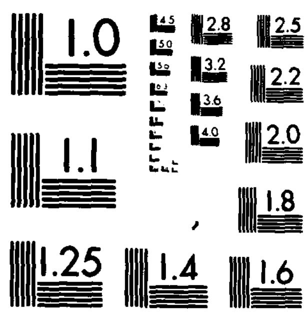

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does not determine its severity.

Primary damage of the left side in different wars is a generally known fact. This question has arisen a number of times during wars and has been considered from different points of view. Larrey, as is known, studied this question on request from Napoleon and pointed out that the left side is damaged much more often. In the Soviet Army in World War II, this principle was also apparent. The fact of higher frequency of wounds to the left half of the body was established in a report by Ye. I. Smirnov back in 1942. Confirmation reports of this principle are also presented by Ye. I. Smirnov for the relation of wounds to the left and right sides in battles for Lake Khasan which, as is known, continued for several days and began suddenly. The ratio of damage of the right and left upper extremities was expressed as 1:1.5, the lower right and left as 1:1.15; the hands and fingers, as 1:2.64. The reasons causing such nonuniformity are a certain feature in the position of the soldier at the moment of opening fire, firing from rifles and automatic weapons; when moving forward the trunk of the soldier is turned with the left side forward so that the right side is hidden from the enemy by the soldier's body.

Table 2 shows data on localization of wounds for the two sides (in percentages).

Table 2. Distribution of wounds of the right and left side.

	(a) Правая сторона	(b) Левая сторона	(c) Обе стороны	(d) Всего
(e) Верхняя конечность	31,9	63,3	4,8	100,0
(f) Нижняя »	34,6	56,5	8,9	100,0
(g) Обе конечности . . .	33,4	59,8	6,8	100,0

Key: (a) Right side; (b) Left side; (c) Both sides; (d) Total; (e) Upper extremity; (f) Lower extremity; (g) Both extremities.

These data show a clear predominance of damage to the left side. Wounds to the left upper extremity are observed twice as often as to the right; on the lower extremities this ratio equals 1.5:1. With simultaneous wounding to the hands and feet, predominance of the left side is of the same degree and the portion of crossover wounds of hands and feet is a total of 6.8% of the number of simultaneous wounds to feet and hands.

The cavity wounds, as was indicated already, must be considered separately for their most important characteristics - damage to internal organs located in the skull, chest and abdomen. Wounds to the abdominal cavity can be considered as wounds to the organs of the abdominal cavity itself and to organs located in the pelvis. Such a division does not correspond to the anatomical and physiological division according to the system of organs or their relationship to the abdomen and is caused by purely topographic conditions. The random nature of the course of bullets is well known: an entry hole in the femur or neck with subsequent damage by the same fragment or bullet to the gastrointestinal tract has been noted, etc. but all the overwhelming majority of cavity wounds occur with penetration of the wounding projectile through the wall directly covering a given cavity. Here wounds to the abdomen are considered as wounds where the projectile has damaged soft tissue from the front and sides without damage to the bone, and pelvic wounds are considered those where the bullet course is through the pelvic bone or there has been injury to the internal organs from the side space. In this way, cavity wounds are separated into four groups: the first consists of wounds to the head, the second wounds to the chest, the third wounds to the abdomen and the fourth to the pelvis. Each of these groups is subdivided for penetrating and nonpenetrating wounds. A detailed analysis of each of these groups will be presented in special sections where these wounds will be considered from all aspects; the diagrams presented below are to give a general survey characterizing wounds mainly in relation to their severity (Figs. 28, 29, 30 and 31).

During a comparison of data of the four diagrams presented, it is apparent that with wounds to the head, chest and pelvis nonpenetrating wounds predominate and with wounds to the abdomen - penetrating. Nonpenetrating wounds occur most often with damage to the

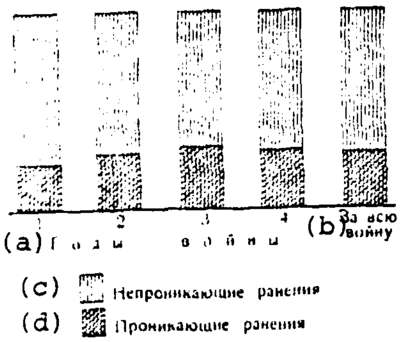

Fig. 28. Ratio between penetrating and nonpenetrating wounds to the skull according to the year of the war. Key: (a) Years of the war; (b) For the entire war; (c) Nonpenetrating wounds; (d) Penetrating wounds.

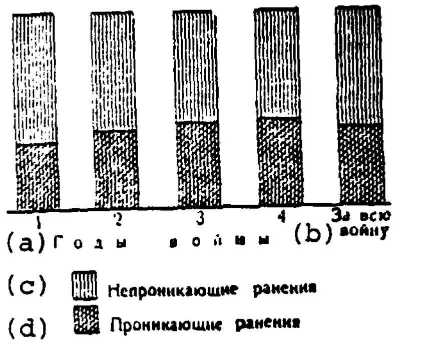

Fig. 29. Ratio between penetrating and nonpenetrating wounds to the chest according to the year of the war. Key: (a) Years of the war; (b) For the entire war; (c) Nonpenetrating wounds; (d) Penetrating wounds.

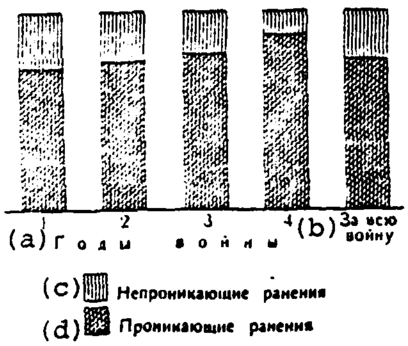

Fig. 30. Ratio between penetrating and nonpenetrating wounds to the abdomen according to the year of the war. Key: (a) Years of the war; (b) For the entire war; (c) Nonpenetrating wounds; (d) Penetrating wounds.

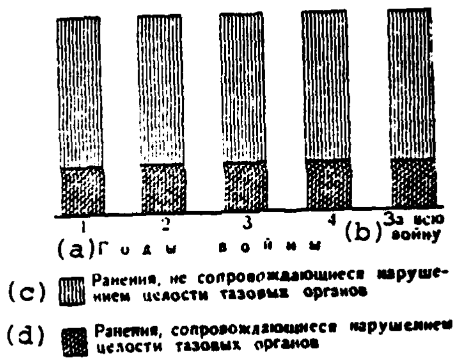

Fig. 31. Ratio between wounds accompanied by damage to the pelvic organs and wounds without damage to the pelvic organs. Key: (a) Years of the war; (b) For the entire war; (c) Wounds not accompanied by damage to the pelvic organs; (d) Wounds accompanied by damage to the pelvic organs.

pelvis; second place goes to the head and third to the chest. Penetrating wounds have, understandably, the opposite picture.

To explain this fact with a high degree of probability one can use the anatomical and topographic peculiarities of each of these fields. The pelvic organs are protected by a powerful layer of muscle tissue and pelvic bone and therefore the walls of this region most often are capable of withstanding the wound-inflicting projectile. On the head the soft tissue is thin but then it has a closed bony cover whose destruction requires significant force; the wearing of steel helmets also has a definite effect. The chest walls in certain sections have a bone formation; the abdomen does not have a wall but consists only of soft tissue.

Attention should be given to the fact that variation in wounds according to the year of the war is not great and the ratio of penetrating and nonpenetrating wounds for each localization remains stable. In particular, variation and frequency of wounds in the field of the pelvis hardly exists by year of the war; except for the first year of the war (which we talked about above) and in relation to wounds to the head, there is a difference. Frequency of penetrating wounds to the chest and abdomen increased from year to year.

Thus, from the data presented, with full verification one can point out that the severity of wounds increased with each year. If one takes into consideration the data presented above, that frequency of wounds of all localization was increased due to a drop in the number of wounds in the upper extremitities and that the number of fragmentation wounds also increased each year, then one can draw the first and basic conclusion: severity of wounds in World War II not only was very high in comparison with all preceding wars but all of them increased from year to year.

A detailed study of wounds with all localizations according to section fully confirms this position.

Structure of Gunshot Wounds

Gunshot wounds can be divided according to the entry aperture, the wound channel or the cavity of the wound (Fig. 32) (depending on the configuration of the latter), and with perforating wounds the exit aperture. This system confirms significant perforating wounds depending on localization of the wound, the character and dimensions of damage and the external appearance of the gunshot wound.

The entry aperture can be a point, slight depression, but can be a defect in the skin circular, starshaped or of an irregular shape (Figs. 33, 34, 35 and 36). The openings in the skin in such cases usually hardly exist because after the wound, they close up with coagulation of the blood. In those cases where the wound is from a large fragment, the entry aperature may be different from the defect on the surface and the underlying tissue will be visible through it, sometimes the inside of a bone or joint surface. Finally, when sections of the extremities are blown up, a solid wound surface is formed consisting of damaged and bleeding tissue which is hard to differentiate.

Usually with penetrating bullet wounds or small fragments, the exit aperture is larger than the entry. The edge of the exit aperture is shattered and hemorrhaging and in the subcutaneous cellular tissue extends over a larger area than near the entry aperture. The external appearance of the entrance aperture is found in accordance with the shape, dimensions, kinetic energy and angle of incidence of the wound-inflicting shell. The shape and dimensions of the entrance aperture depend on these factors: on the point, filled with coagulated blood, irregular shape of a large defect in the skin, fully observed for all wound cavities. The exit aperture often is increased due to secondary damage to tissue subjected to bone fragments from inside. However, wounds with narrow point apertures both at the entry and the exit are not so rare. At the same time the entire internal area is damaged; its wound channel forms an extremely large cavity with tremendous damage (crushing) of soft tissue and bone filled with coagulated blood. On the extremities, the wound cavity is like a sack filled with a mixture of damaged tissue and blood. Taking all of this together one can truthfully say

Fig. 32. Section through the wound channel in the forearm. 1 - Central section of the wound channel, 2 - Peripheral section of the wound channel. Specimen VMM No. 1457/3211. (Artist: S. A. Moiseyeva)

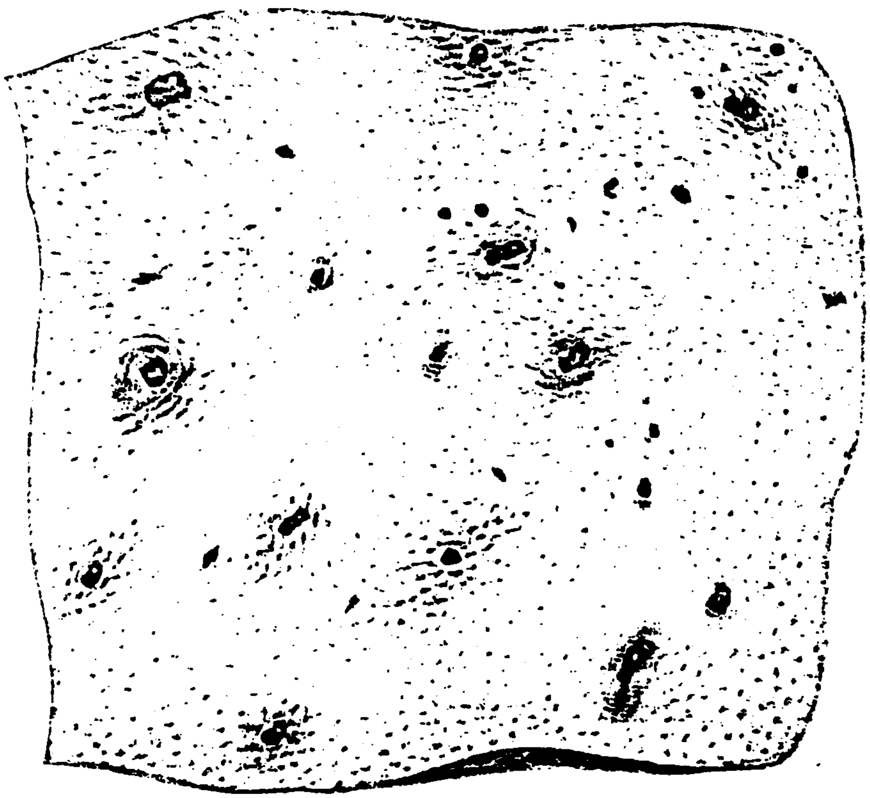

Fig. 33. Multiple fragmentation wound. Section of skin with damage by small fragments. Specimen VMM No. 3073/1593. (Artist: S. A. Moiseyeva).

that gunshot wounds must be evaluated as a whole and not only in view of the entry and exit apertures.

Of course, when studying wounds the wound apertures are more available for inspection but all wounds as a whole have been subjected to study. Such research is valuable and only using it can one develop a topical diagnostic for wounds and consequently treatment measures.

One should note individually the tangential wounds received at low angles formed by the line of flight of the projectile and the surface of the section damaged. As a result of these wound-inflicting projectiles with surface damage, the skin can be broken

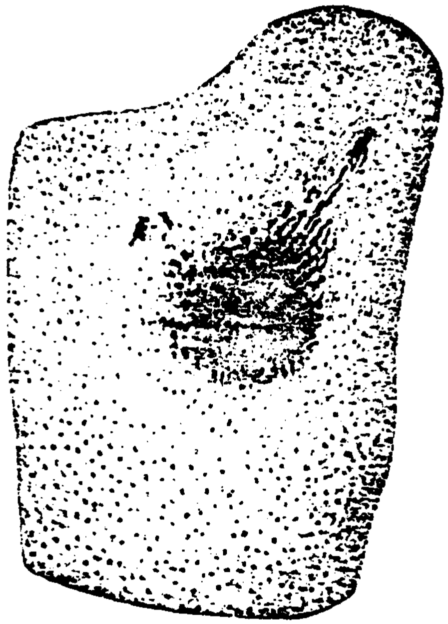

Fig. 34. Powder blackened skin with wound at a short distance. Specimen VMM No. 5044/1699. (Artist: S. A. Moiseyeva).

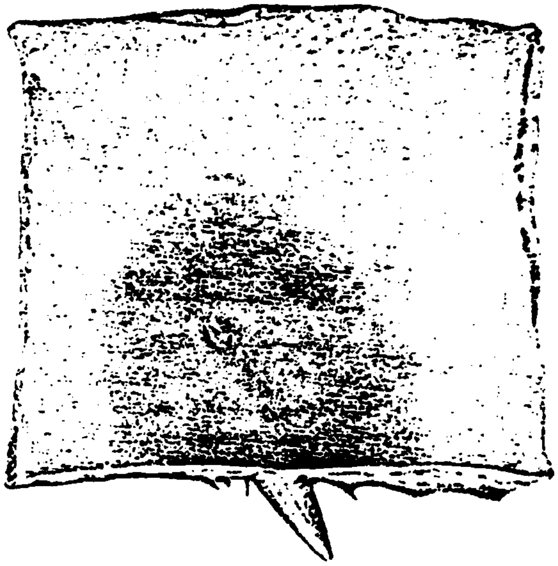

Fig. 35. Nonpenetrating bullet wound. Bullet caught under the skin. Specimen VMM No. 2009/2791. (Artist: S. A. Moiseyeva).

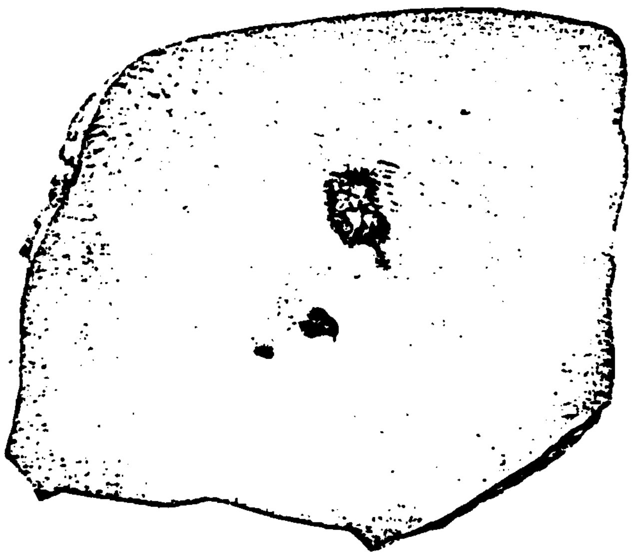

Fig. 36. Section of skin with multiple fragmentation wounds. Specimen VMM No. 3191/2818. (Artist: S. A. Moiseyeva).

for the entire length. Such a wound has a trough-like or flattened shape, the wound channel is open along its entire length and its depth depends on the shape and dimensions of the wounding body. Sometimes also the "trough" can be covered but not completely break down the skin, forming the so-called surface tunnel.

Wounds which occur only from a blast wave without the introduction of foreign bodies do not have a wound channel. In such cases one observes only a defect in the skin and underlying tissue with more or less pronounced wound cavity or a breakdown in part of the extremity. These wounds have all of the intrinsic peculiarities of gunshot wounds (Figs. 2 and 3).

But what would be the shape of a gunshot wound if the following characteristic traits were present:

1) a defect in tissue as the result of a breakdown of them by a foreign body and by a blast wave;

2) disorders in the vital capability of tissue in the surrounding area of the wound channel (or cavity) to various degrees;

3) microbe contamination, particularly accompanying a wound.

These special characteristics of gunshot wounds approximate all of their individual characteristics and make it possible to look at the essence of a wound injury on an example of a perforated gunshot wound.

The great variation in gunshot wounds depends on quantitative and qualitative variations in each of the factors presented above and a combination of them caused by the symptomatology, course and outcome of the wound, taking into consideration functional disorders.

Functional disorders are closely connected to localization of wounds. Obviously the picture of these disorders to a large degree depends upon whether or not the wound channel pases through subcutaneous cellular tissue or brain tissue, whether it hits large main arteries or nerve trunks. All of this so complicates the clinical picture that one must consider gunshot wounds according to their anatomical and physiological peculiarities. This question will be discussed in all of the subsequent sections in the surgical part of this work.

However, when studying the gunshot wound, it is adequate to take a system of a noncavity wound, for example in the extremities, or a basic clinical picture of a wound not complicated in this case with a drop in function or damage to the vitally important internal organs, vision, hearing, etc.

As such an example we will use a wound in the forearm; the section on the wound channel is shown in Fig. 37 and a diagram of this channel in Fig. 38. The specimen was obtained from a person who had died on the battlefield, wounded simultaneously in the shoulder and the head; it gives the picture of a fresh wound directly after injury.

A longitudinal section of the wound channel shows that the foreign body came in on the left, going through soft tissue, broke both bones and passed through the exit aperture taking with it part of the bone fragments and also, probably, bits of soft tissue. The laceration-contusion character of the damage is determined along the entire channel. One should pay attention to the fact that the channel here is not in a straight line between the entrance and the exit apertures. If the bullet and fragments are in flight where they have a weak penetrating force, then a nonperforation wound will result with the course of the wound-inflicting shell inside the tissue; it can be deflected due to the resistance of solid tissue, for example, of the bone. In these conditions, the wound channel even at the moment of its formation does not coincide with a straight line. In those cases where the wound-inflicting projectile retains high penetrating force, it goes into the tissue as experiments showed, in

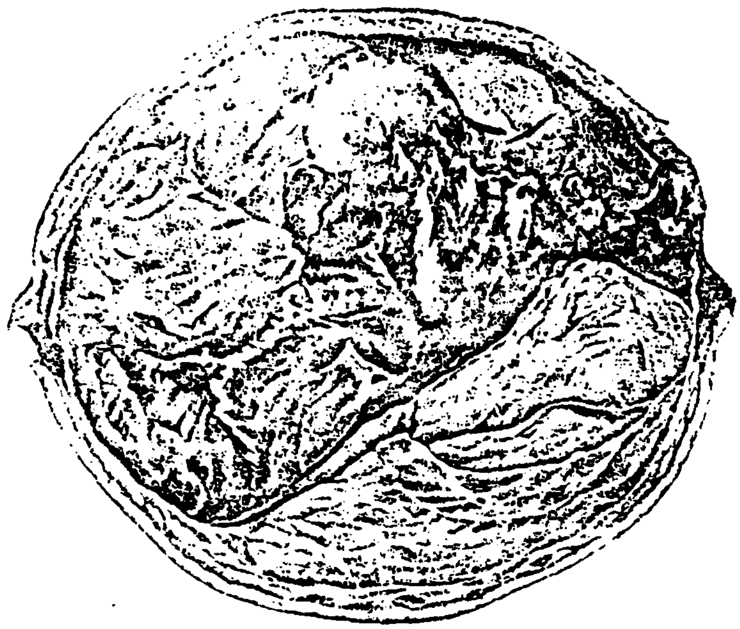

Fig. 37. Section through the wound channel of the forearm. Specimen VMM No. 2952/233. (Artist: S. A. Moiseyeva).

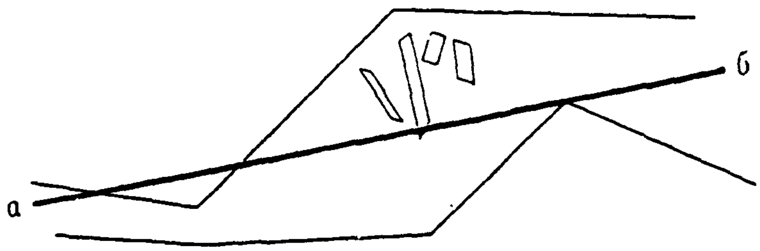

Fig. 38. Diagram of the wound channel (for Fig. 37).

the smallest portion of a second; then the wound channel at the moment of formation is in a straight line from the center of the entrance to the center of the exit aperture just as indicated by the red line in the diagram (Fig. 38). Deformation of the wound channel occurs in these cases but it is secondary and occurs after flight of the wound-inflicting body outside as a result of damage to tissue of various structure. At the input aperture the subcutaneous cellular tissue is saturated with blood and as a result of bleeding existing in this, sometimes damage is increased; the damaged bundle of muscle fibers clearly is incapable of contraction; part of the fascia and periosteum is torn and these tissues are not capable of vital activity. Both of the bone cracks of the radius are misaligned toward the exit aperture and their ends have the periosteum removed; part of the small fragments are in the environs of the wound and part are outside. The size of the wound channel at the exit aperture in its broadest part is 5-6 times larger than the narrowest. According to other observations, this difference was even more significant, reaching 10-15 times more.

Damage to the bone is demonstrably greater: muscles located on the path of the channel to the bone are the least damaged, less so than the muscle tissue lying on the other side of the damaged bone. The entire channel is filled with paste-like material consisting of damaged tissue mixed with blood.

Impregnation with blood depends on position in relation to the wound channel of the nonwounded fascia sheets: where they are damaged the bleeding occurs further in the intermuscular cellular tissue, the undamaged fascia prevents its spread.

The skin at the exit aperture for a considerable distance is separated from the fascia by the force of the impact from within and the blood not only saturates the subcutaneous cellular tissue but also accumulates between the surface fascia and the separated skin. In this way the environs of the exit aperture differ considerably from the entrance.

Such microscopic morphological changes occur in the location of the direct effect of injury from gunshot wounds. However, this certainly is not limited to all changes in the wound. A. V. Smol'yannikov in the work mentioned above described the small particles of bone exploded in the bone marrow of the damaged femur bone; obviously this is possible in any other bone. Besides the bone "spray" one detects small hemorrhages in the bone marrow. The latter are due not only to damage of the vessels by the bone particles but also by breakdown of the small vessels with total deformation of tissue from the blast wave.

Experiments showed how far the explosive wave propagates from the wound channel. The apparatus located in the stomach of an experimental animal hardly records the explosive wave when the animal's femur is shot. If one compares data of the experiment and clinical experience, then one can see that the direct morphological changes caused by injury during gunshot wounds are limited to the extremities of the two adjacent large joints, in the torso - the chest and abdominal cavities, in the head - the cavity of the skull. Of course the degree and extent of propagation of changes in each case of wounds differs greatly and depends on the force of the blast wave and other factors listed above.

All that has been said, however, concerns only the basic changes caused by injury to the tissue at the moment of the wound. The process of healing of the wound which develops then and the possible complications depend on these changes. Moreover, one must take into consideration the functional significance of the breakdown in tissue and the total effect of trauma on the entire organism of the wounded person as a whole.

The structure of the gunshot wound, the character of change of damaged tissue and the processes which develop in them later on are presented in detail in the section entitled "The Pathology of Gunshot Wounds and Injuries." However, some of the processes have an exceptional great significance when one is conducting therapeutic measures and it is necessary to pause to discuss them here.

In the area of the wound, a well-known quantity of different tissue is destroyed at once: part of it can be from the projectile or the explosive wave from outside but part remains in the area of the wound. This also includes the blood which has hemorrhaged into the tissue. Besides these tissues which are incapable of life, in the wound there is a significant quantity of tissue whose death is unavoidable in the time immediately after the wound occurs. The cause for this is damage to the vascular system in the form of contusions, complete destruction and thromboses of the vessels. Even at the end of the first days when treating the wound, one can constantly observe thrombosed vessels. Simultaneous damage to peripheral nerves undoubtedly also decreases the vital capability of the tissue. In this way, in the gunshot wound, one must differentiate the primary necrosis of the tissue and subsequent necrosis. It is preferable to call this necrosis subsequent and not secondary because this term denotes a lack of simultaneousness in its onset and particularly the fact that different tissues are capable of "surviving" the unfavorable conditions of exchange and supply variable in duration.

Do the cells and tissues die directly from those vibrations which cause the blast wave? It is impossible to give a precise answer to this question but in any case, these vibrations undoubtedly do not cause more or less expanded necrosis. But necrosis is an extreme stage of damaged tissue which occurs as the result of the wound. Certain tissue retaining its vital capability, loses normal reactivity and being incomplete, participates inadequately in subsequent reparation processes in the wound; in the case of further development of unfavorable conditions, for example, infection, these tissues die primarily. It is possible that under favorable conditions reactivity existing in a given type of tissue is reestablished. Vibration of the tissue from the blast wave belongs to the factors which suppress the vital capability of the tissue primarily.

Consequently, besides the necrotic tissue which has died, in the wound there is tissue which is not killed immediately but later on, a few hours after the wound occurs.

Necrotic sections of tissues themselves are factors causing a reaction of the surrounding vitally capable tissues. In this way, all of the subsequent process of healing of the wound which is a very complex set of biological phenomena occurs with the presence in the wound of an increased quantity of necrotic tissue and with a decrease in the vital capability of the tissue in the area damaged by the trauma.

The process of healing of the wound has attracted the attention of scientists for a long time, however, it has been hoped for many centuries that one could understand the essence of changes which occur in the wound.

The first work on the question of gunshot wounds was a book by Hunter entitled Ucheniye o krovi, vospalenii v ognestrel'nykh ranakh.[1] The basis for Hunter's study was not only observation of the sick but also the first experimental studies on animals using a microscope.

Hunter developed a classification of the process of healing of wounds, put healing with scabs into a special form; this indicates the significance of blood clotting and granulated tissue; he considered gangrene unavoidable if the edge of the wound remained unjoined for some time. He established that the new skin "grows" from the old, surrounding the wound.

Later on, after almost three-fourths of a century, the significant obstacle for developing and understanding of wounds was the impossibility of separating the healing process for the wound from the process of infectious complications although even Larrey[2] who observed during the Napoleonic Wars different forms of gangrene in gunshot wounds, did not consider it an obligatory stage in the healing of wounds. The positions and views of N. I. Pirogov, the founder of modern military field surgery, are classical in form and content.

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[1]Hunter's treatise on the blood inflammation gunshot wounds, London, 1794.

[2]Larrey, Mémoires de chirugie militaire, 1812. [Memoirs of a Military Surgeon, 1812].

They separate the wound complications as special nosologic forms; he talks about the "miasmas" in contamination, about the importance of hygienic conditions for the course of the wound process. N. I. Pirogov approached a complete discovery of the pathogens for infectious diseases.

In a number of subsequent works by Russian and foreign authors at the end of the last century, there remains undeservedly in the shadows the name of one of the greatest Russian scientists - M. S. Subbotin who studied the inflammatory traumatic process independent of infectious complications. Later on, A. A. Maksimov gave the basic positions on genesis of tissue joining elements which play an important role in healing of wounds.

It is necessary to remember the importance which N. I. Pirogov gave to blood clotting in tissue of healing wounds as "simulators" for healing which are contained in the discharged blood.

As was mentioned above, the Russo-Japanese War of 1904-1905 disproved the notorious "humanity" of the small caliber cartridge. Generalizing the experience of this war, R. R. Vreden confirmed the severity of gunshot wounds in comparison with all other types of wounds.

During the first World War of 1914-1918, attention of the surgeons was again turned to the unusual number and severity of wound complications; their basic efforts were expended in combating them. The process of healing the wound itself became the object of study even after the war on the basis of the data of morphology, biochemistry and colloidal chemistry which had been developed considerably.

The materials published at this time indicate broad experience in treating gunshot wounds at different locations. However, the object of study of experimental research was not the complex gunshot wound received in military conditions but the simplest operational wound. Nevertheless, in the study of the process of healing of wounds in the period from 1920 to 1930, a good deal was achieved.

First of all, it was established that the reaction of inflamed tissue changes sharply and the initial point for formation of new chemical bodies is tissue damaged during trauma. The general reaction of the medium, according to the data of Schade and his coworkers, during supperative inflammation is acidic. In 1924, S. S. Girgolav successfully indicated the same thing in relation to non-gunshot, aseptically healing wounds. A number of studies by Soviet and foreign authors established the significance of wound hormones and other substances of an enzyme character which have a stimulating significance for the reparation processes. This category of studies includes works on the effect of cellular decay during the wound process (S. S. Girgolav, Yu. Yu. Dzhanelidze, A. M. Zholondz', Ye. A. Sel'kov, A. A. Vasil'ev et al.). All of this resulted later in the practical use of products of dead cells for stimulating regenerative processes of man. For instance, V. P. Filatov began to use a precipitant preserved in the cold tissue for this purpose; V. V. Koval'skiy, L. I. Palladin et al. - an aqueous extract of dead skin of rabbits; N. I. Krauze - the precipitant of preserved human fetal membranes; G. F. Skosogorenko - dead autotransplants. Standing somewhat by themselves, undoubtedly, are the stimulating regenerative embryonic extracts (D. I. Gol'dberg, G. Ye. Vladimirov, A. I. Govorov, I. A. Pelishchenko and A. A. Rayko et al.). Further, the trephone from leukocytes were subjected to study; these are necessary for proliferative process (G. K. Khushchov.). R. I. Belkin proposed reinforcing the trephone formation by using small doses of thyreoidine. For stimulation of healing the wounds, A. A. Bogomol'et's antireticular cytotoxic serum was used (ACS). All of these experiments were made even before World War II.

On the basis of the pathologoanatomical material obtained during World War II, the morphology of the process of healing wounds was considered. A very important work on this aspect was done by I. V. Davidovskiy, A. V. Smol'yannikov, A. P. Avtsin, V. G. Garshin, A. G. Smirnov, G. P. Sacharov et al. We will discuss these works in the appropriate section entitled "Pathology of Gunshot Wounds and Injuries."

Systematizing the process of healing wounds. S. S. Girgolav divided it into three periods directing both the morphology and biochemistry (physiology) of the wound process. I. G. Rufanov again simplified this system, by combining the first and second periods of healing and by having established in this way the two-phase aspect of the processes. He considers the characteristic feature of the first phase as hydration of tissue, its enrichment with water and an acid reaction; the special feature of the second phase is dehydration, that is, the release by the tissue of water and the return to a normal, slightly alkaline reaction of the medium. Later a number of other systems were proposed, for example, the systems of A. A. Vasil'ev, M. P. Sokolovskiy, V. I. Sazontov et al., essentially various types of systems presented in one way or another above which they attempted to make more precise.

The principle and sequence of the process of healing is found to be closely related to conditions which are created in the wound and these conditions can differ greatly even in the same wound. Even a permanently protected operation wound heals uniformly for its entire extent but the presence of a foreign body in the form of a suture or a significant blood clot even, changes the process and form of healing.

The more detailed is the study of the process of healing wounds, the clearer the dynamic state of its conditions becomes; biological processes resulting in the final outcome of a healed wound have a continuous chain. Each link in this chain occurs one after the other and changes the general course of healing of a given wound for a given section appropriate to the conditions created here and also the factor depending on the state of the entire organism and on the external effects, in particular, treatment of the wound.

For the clinician, one or another type of healing very significantly differs in its final outcome: in one case the wound after 7-10 days is closed to a narrow scar covered with epithelium and the wounded person can be considered as healed; in another case the wound will form granulation for a much longer time, the scar will be more massive, and sometimes there will be tendency toward bleeding which can require additional surgical intervention.

The special features presented above of a gunshot wound significantly complicate the process of its healing and force the surgeon, by active intervention, to change conditions in the healed wound for the better.

All gunshot wounds have a laceration-contusion character. The result of this is the constant presence in the wound of a large quantity of dead tissue. But, as was pointed out above, besides the dead tissue, more truthfully there is also tissue in the gunshot wound which is not capable of living, that is to say, "tissue that is 'sentenced to death' and which becomes necrotic later on." The first applies to tissue with blood which has hemorrhaged in it, crushed sections of tissue and organs devoid of circulation and often the connection with the organism or which depend on a nonviable support such as shreds. As to the nonviability of these tissues, the surgeon can judge by eye and their identification in the wound does not cause difficulty.

The life capability of tissues surrounding the wound channel is decreased to one or another degree with areas that are so significant that part of the tissue is found on the edge of necrosis which sets in a few hours after the wound occurs. During primary processing of such tissue, in its external appearance, it is little or entirely unchanged. It is just in these tissues that the subsequent necrosis mentioned above develops. The evaluation of them for viability by eye during treatment of the wound often involves great difficulty. Subsequent necrosis sometimes is so expanded that it can involve fatal consequences. For example, with wounds of the extremities with damage to the basic nutritive vessel, subsequent necrosis can involve part or even the entire extremity; with injuries to one of the branches of the hepatic artery, a significant part of the liver sometimes become gangrenous, etc. One should also take into consideration that a gunshot wound in combat is contaminated with microorganisms and subsequent necrosis is their focus from which the infectious process often spreads.

It should be noted that in practice, most often one encounters breaks in the relatively small vessels or their thrombosis which nevertheless involves necrosis of tissue, primarily that which is not changed at all or is damaged very little. This subsequent necrosis is complicated and increases as a result of the frequent presence in gunshot wounds of foreign bodies. Without even talking about significant pieces of metal which themselves are capable of causing pressure on and a change in neighboring tissues, without differentiation one can point out the smallest fragment. The reaction of tissue to the presence of any type of foreign body itself complicates the course of the wound process (see the section entitled "Foreign Bodies").

Thus, in a gunshot wound there is always a significant quantity of necrotic tissue of varying structure remaining even with a very thorough surgical treatment; some of these occur in the wound as a result of processing. These same necrotic tissues exist in each operational wound in spite of all precautions taken with the tissue during surgery.

This nowhere nearly exhaust the significance of necrosis in gunshot wounds. The question of development of necrosis in the wound channel and its importance are discussed in a number of I. V. Davydovskiy's studies.

The study of the wound process indicates the presence of necrotic tissue is a necessary condition for healing of the wound. For development of reparation processes, the presence in the wound of a very insignificant quantity of necrotic tissue is sufficient; new chemical compounds and substances which occur from a breakdown in tissue have the properties of catalytic agents, enzymes and hormones and are effective even in very small quantities. Local acidosis begins to develop in the tissues whose degree is found in connection with the character of decay; with the presence of suppurative it reaches the highest degree. Decomposition of the protein particles in an acid medium occurs differently than in an alkaline medium and therefore the cellular and intercellular exchange is changed, swelling occurs, hydration of tissue and edema. Within the limits of the zones with necrosis, an exudate begins to form, ejection of mobile elements which often also die but partially go into the building of new tissue.

In actual practice it is very important that the wound surface is bounded by the exterior environment and primarily its bactericidal functions. Morphologically at the very beginning of the healing process, the tissue is covered with a layer of fibrin and thrombosis of the lymphatic vessels occurs. However, this barrier is still very weak and the wound surface is inadequately protecting the deep tissue from the effect of external factors.

Later on in the zone bounding the necrosis, very rapidly there occurs an expansion of the vessels connecting the fibers and an accumulation of mobile connecting elements. All of this taken together forms the so-called granulation tissue. The details of this construction and course of subsequent development are presented in the section entitled "Pathology of Gunshot Wounds and Injury."

Granulation is a simple barrier tissue which separates necrotic sections from those capable of life. The absence of lymphatic vessels and granulation interferes with absorption and in a way, isolates the organism from foci of necrosis; the covering defect of the tissue of the granulated surface in this way should be looked at as the provisional skin in that it protects the underlying tissue, for example, from infection. However, granulation tissue is active tissue which is found in a state of growth and changes its structure; chemically it obviously is very active, at least the foci of necrosis are fused and absorbed. An acid reaction of the medium facilitates this considerably. Granulation tissue is slightly cut and a breakdown in its wholeness results in a well-known dysfunction of its barrier functions.

The formation of granulation tissue begins very early: it corresponds to the appearance of fibroblast and the first branches of the vessels. The entire process is developed more rapidly than the viable tissue in the environs of the wound. Primary granulation appears 3-4 days after the wound. With a breakdown in viability of the tissue, the entirety of the vessels and inadequacy of blood supply, in the presence of virulent infection and the formation of active toxins, development of granulation is slowed down sometimes until it stops completely. Also there can occur excess blood loss, avitaminosis, alimentary dystrophy, etc.

But in the first place the presence in the wounds of a significant quantity of necrotic tissue which is characteristic for wounds of gunshot origin, primarily prevents their healing. Therefore, a consideration of the necrotic sections is very important: they can be subjected to complete or partial resorption with replacement by the scar tissue, encapsulation or rejection outside of part in a fused form, part in the form of dense necrotic mass - sequesters. The first two possibilities take place primarily in aseptic wounds. Rejection of the necrotic masses occurs during suppurative inflammation almost always due to microorganisms.

The first possibility, that is full resorption of necrotic sections, is usually observed in the operation wound healing by first intention; this also occurs in gunshot wounds surgically belonging to the type of gunshot wound which does not require surgical intervention and heals with conservative treatment. Inasmuch as this category of gunshot wounds amounts to about one-third of all wounds, the practical value of resorption of necrotic sections is very high.

The second possibility is the so-called fusion of a nonviable section of tissue with full restructuring of it. In accordance with this, sometimes one observes fusion of bony primarily fully separated sections of tissue. This same possibility is used in surgery with autotransplantation. Such a section of tissue (and as well the transplant) is subjected to intergrowth of the vessels reorganization and even healing in this form. This process is possible with gunshot wounds; it is very clearly shown with healing of bone fragments (see "Osteomyelitis"). Healing of certain tissues of connective origin covered with epithelium, etc. is possible. The sections of muscle and gland tissue from parenchymatous organs of the central nervous system, which are isolated, die and are replaced by scar tissue.

If infection is involved in the process of absorption or healing of isolated tissues, a general suppuration of the wound occurs and rejection of the necrotic part toward the outside. Experience in the last years of the war and particularly in postwar years showed that the number of wounds healing without suppuration undoubtedly is increased with simultaneous prophylactic use of antibiotics, in particular, penicillin. Therefore the possibility of healing and resorption of necrotic tissues is increased and is observed more often.

The most frequent form of removing necrotic tissue from gunshot wounds is its separation and removal along with the pus. This process will be discussed in more detail in the section entitled "Pathology of Gunshot Wounds and Injuries."

Finally, it is also possible to have encapsulation of necrotic sections like a type of encapsulation of foreign bodies.

At the same time with resorption, healing or encapsulation and rejection of the dead tissue, there occurs filling of the wound channel or cavity of the wound with granulation which, fusing, as a whole replaces all of the dead tissue and thus eliminates defects. This completes a very important stage in healing of the wound. But granulation tissue gradually loses its further conversion and primarily in the sections which were formed earliest, that is, those located immediately in the remaining viable tissue of the wound surface and then a change spreads to granulation developing later. Thanks to maturation of granulation, the final stage of healing of the wound begins. Connective tissue scars are formed. All of the tissue is wrinkled, some of the vessels are wasted, the number of movable elements decreases sharply. All of this results in a decrease in the dimensions of the wound as a whole.

It was mentioned above that in wounds this process occurs non-uniformly. At the same time that the cavity of the wound is still filled with fresh granulation, old granulation along the edge of the wound already loses its wrinkles and decreases the dimensions of the wounds including the cavity, thus accelerating the time period for healing.

As the cavity of the wound fills with granulation, along with maturation, in the areas of contact with the skin, epithelialization occurs; the epithelium grows by plates made up of cutaneous epithelia surrounding the wound. The epithelium located on the surface keratinizes and then in exterior appearance the wound is healed. However, the process of transformation of this new tissue at the moment of replacing the defect is not completed. It continues very slowly and is ended only when all of the tissue formed in the area of the defect acquires a correct structure. If such tissue as bony tissue is involved in the wound, then weeks or months are required so that the new bone tissue will be complete both morphologically and functionally.

In any tissues and organs where a defect has formed or even when a simple breakdown in its entirety such as a wound has occurred, this prevents the process of the healing of the wound and ends with the formation of a scar. Regenerative capabilities of tissue in the human organism are limited. Full recovery is possible only for the most superficial wounds or surface damage to the skin caused by high temperature of the effect of cold (burns and second degree frostbite) although over a significant time period. With deeper damage, scars form. The development of scar tissue in the wound area in a number of cases is the cause of incomplete recovery of functions and sometimes complete separation of it.

In the damaged section after healing of the wound, besides the scar tissue, there are new formations of vessels, nerve fiber and their endings and also covered partly glandular epithelium. The possibility of metaplasia of fibrous connective tissue in the bone and cartilage is very important. The tissue of the parenchymatous organs, the muscle tissue, is not devoid of regenerative capability but in humans regeneration of these tissue does not have practical importance. The tissue of the central nervous system in general does not regenerate.

In summary, in spite of the fact that as the result of regeneration of connective tissue, the wound defect is filled and forms only tissue important for the bone and cartilage support, the function of the damaged section after healing of the wound breaks down to various degrees. For certain locations in many parts of the body with compatively small scars, work capability and combat capability are not disrupted. It is known that the scars in the lung and liver and even in the heart and other organs cannot noticeably be reflected in their functions.

Thus the outcome of healing gunshot wounds results in a high percentage of return of the wounded to combat. However, the presence of scars in locations of highly organized and functionally important tissue in certain cases causes invalidism: such scars as in the brain tissue, the optical nerve, etc.

Often in scars of healed wounds are different foreign bodies such as parts of clothing, etc. which are encapsulated. Often in the wounds, microorganisms and their spores are retained. Thus, the scars can be the foci of latent infection during very long time periods. But independently of the presence of foreign bodies in scars, pathogenic microorganisms are often observed.

The details of the wound process are presented in the section entitled "Pathology of Gunshot Wounds and Injuries." A significant role is played by localization of wounds and their intrinsic characteristics.

One should emphasize the importance for healing of wounds of the aftereffects of excess bleeding, breakdown in general nutrition, etc. When studying the clinical aspects of gunshot wounds, their connection with the entire organism becomes even more obvious. However, it is necessary to take into consideration one more factor noted above which, due to its special importance, must be considered separately - microbe contamination of gunshot wounds in combat.

Flora of Wounds

The flora of gunshot wounds was subjected to a thorough study during the first World War. A significant number of fragmentation artillery wounds even then caused a large number of severe infectious complications. Prevention and treatment of these complications had little effect as a result of which a detailed study was made of these complications and in passing the flora of gunshot wounds. Wound complications which have developed as the result of anaerobic infection were accompanied by high mortality rates and therefore they were subjected primarily to bacteriological study.

In the period from the first World War to World War II, both microbiology and immunology noticeably progressed. The effect on the development of the military field surgery also showed that the study of wound infections had occurred on traumatized material in the interwar period. The military conflict at Khalkhin-Gol especially during the war with the Byelofinns in 1939-1940 forced us to sharply differentiate between wounds in peacetime and gunshot military wounds. A large amount of scientific research work conducted during World War II led to the modern understanding of the importance of flora in wounds and the infection in wounds in wartime.

Before the Russo-Japanese War of 1904-1905, mainly on the basis of Bergman's judgment, bullet wounds were considered practically uninfected. However, even in the Russo-Japanese War, studies of wounds showed their bacterial contamination. This was finally confirmed in material from World War I. A. A. Opokin wrote that some of the authors who had studied the flora of wounds had taken on the burdensome problem of studying the numerous microbe flora which they encountered.

Finally, it was pointed out that the presence of microbe flora in wounds which have just occurred is technically much more difficult than in wounds which have occurred a few hours or particularly a few days ago: in the first case it is necessary to determine the primary microbe contamination and in the second to discover microbes which have already multiplied.

A. D. Pavlovskiy and N. I. Kochetov in World War I conducted systematic observations of the flora of wounds in different periods of their healing and determined essentially all types of suppurative microbes, a number of putrid microbes and anaerobes and also a large number of saprophytes. Then, in the West it was established that wounds, in spite of the presence of pathogenic microbe flora in them can heal without clinical signs of infection, even in cases where Cl. perfrigens or tetanus bacilli are found.

Particular attention was attracted during the war to anaerobic infection which was almost forgotten in peacetime; this produced a high mortality rate. Microbiology of this wound complication was mainly studied by Seguin and M. V. Veynberg, our compatriots, who worked along with I. I. Mechnikov in the Pasteur Institute in Paris. All four classical anaerobic infection pathogens were isolated; their microbiology was studied and a specific antitoxin serum was developed; although the leading role in the development of this infection was due to Cl. perfrigens, however, the great significance of polymicrobe association was established, in particular, the role of putrefactive microbes which increased the severity of infection with their development in the wound.

The sources of contamination of wounds were considered both for gunshot shells and for the underclothing and equipment of its soldiers. N. K. Rozenberg isolated pathogens of anaerobic infection from lubricant materials used for firearms and also their projectiles. Moreover, a possibility of infection getting into the wound from the areas of skin surrounding it was proven.

After the first World War, a view was established that gunshot wounds are not only bacterially contaminated but also infected. Essentially most authors did not look at the difference between these two concepts. Conditions created by trauma in wounds were little considered, if you please, only in relation to anaerobic infection (see Anaerobic Infection").

In the postwar years a large number of studies were made by bacteriologists and surgeons on the questions of the flora of wounds and its significance. The plague of the first World War was anaerobic infection, naturally, bringing it to the center of attention. Soon it was established that pathogens of gaseous anaerobic infection are often detected in the wounds in peacetime. The microbes get onto the skin of humans from the soil and particularly, Cl. perfrigens is detected. V. A. Krestovnikov and a number of other authors devoted their research to anaerobic infection, its prophylaxis and serum therapy. The presence of anaerobes in a fresh wound without indication of infection and also their remaining in a latent state over a long period of time are confirmed by a number of clinical observations (V. A. Oppel', S. S. Girgolav, and I. I. Grekov).

The significance of the character of the wound for development of infection caused by flora which contaminate the wound was the primary subject during anaerobic infection. Observations indicated that wounds of the lower extremity are affected most often with this type of infection, particularly wounds with a multiplicity of large masses of muscle tissue.

The study of polymicrobe contamination of a wound led to the study of the effect of microbe associations on the development of infections (the works of N. K. Glotova, A. M. Ostrovskaya and T. T. Pozyva, A. I. El'yashev and A. A. Sinitskiy).

In the microbiological laboratory of the Central State Traumatology Institute of T. A. Kolpakova systematic studies were made of microflora of all random fresh wounds in wounded persons delivered by emergency first aid transport. In almost all of the wounds one detected microflora including pathogens often found and Cl. perfringens. Surgical treatment of wounds resulted in a decrease in the microflora but later on the wound was not often free of them.

As a result of the work done it was established that in 203 wounds contaminated with a pathogenic microflora, suppurative after treatment occurred in 11 wounds (5.0%). The protected wounds in almost 90.0% of the cases healed without any infectious complications.

Similar data were presented in foreign literature. The development of the study of microbe contamination of wounds resulted in the fact that surgeons in all countries had to take microflora in the primary wound into consideration for any sugical treatment. Beler, one of the outstanding western European traumatologists stated in the press that it was even possible that surgical treatment of a wound makes the injection of antitetanus serum unnecessary.

At this time military encounters on Lake Khasan, on the Khalkhin-Gol river and war with the Byelofinns took place.

Military actions on Lake Khasan continued for several days and were confined to a relatively small region; therefore, as a result of surgical experience in these battles, one could judge only the character of gunshot wounds; the effect of the same military circumstances on conditions of surgical operation remain far from clear. Events at Khalkin-Gole made it possible to draw two main conclusions:

1) gunshot wounds in their structural properties differ sharply from peacetime wounds;

2) surgical treatment in this form and volume which was used for wounds in peacetime is unsuitable for gunshot wounds both as a result of their special features and due to combat conditions. From here it follows that the flora in wounds themselves do not cause infection but are only a component of it.

Both these hypotheses not only were confirmed during battle with the Byelofinns in 1939-1940 but also were developed further. Time does not make it possible to use completely all of the material of this war. The time periods established by Fridrikh for expansion and development of infection, that is, 6-12 hours, were limited by the actions of the surgeons. The study of flora in wounds was affected by the opinions at the end of the first World War.

From the beginning of World War II, the study of flora in wounds, particularly in connection with the development of infection, continued very intensively; however, the conditions for this were extremely unfavorable. For research work by microbiologists, laboratory conditions were necessary and for surgeons, prolonged clinical observations. Both of these were involved in the first months of the war with many complications. It was just at this time when the front was stabilized that these works became adequately broad and lasted until the end of the war and then into the postwar period. Therefore, it is natural that at the beginning, the very intense research work on the question of flora in wounds was carried out in Leningrad where from September 1941 for a period of 1900 days, the wounded both in the early time period and to a much greater degree in the later time period, after being wounded were concentrated.

Conditions similar to those in Leningrad were created in Moscow in October 1941 and lasted for about three months. However, a significant part of the special institutions was cut back and at the beginning of the recovery of their activity, the front had shifted far to the west; evacuation of wounded from Moscow in the period from October 1941 to January 1942 was uninterrupted. This explains the fact that basically observations made in Leningrad on characteristics of microflora in wounds are used.

T. A. Kolpakova, on the basis of these works, concluded that: flora in gunshot wounds is polymicrobic and very changeable; the results of research depend on the time periods of the study, how long ago the wound occurred, the type of tissue damaged, location of the wound and on the general state of the organism.

A large number of works on the effect of flora on the clinical course and on treatment measures was devoted to the study of flora in infectious wounds (Ya. M. Krinitskiy, N. N. Vorob'eva, R. M. Shapiro, T. L. Simakova, V. I, Kolesov et al.) at different stages of the evacuation. All of the scientists confirm the polymicrobe character and changeability of the flora. Among these studies it is necessary to note the works of N. I. Grashchenkova and G. P. Sakharova and their coworkers, based on the study of fresh wounds and on observations of wounded persons evacuated to Moscow. These authors established the polymicrobe contamination of wounds of the brain, separated the pathogens of anaerobic infection from them and, moreover, the varying course of this infection in the brain; they noted the "symptomless course with favorable outcome," that is, essentially no infectious complications of wounds and its microbe contamination. The authors call the latter the latent form of wound infection. One must assume that the "latency" is equivalent to an absence of suitable conditions for the development of microbes. From this same point of view the work of T. L. Simakova is extremely interesting; it involves the study of microflora gunshot wounds in different joints and established the predominance of aerobic groups in them; it is particularly interesting that each joint has a characteristic association of aerobic microbes. It is difficult to present perfect evidence of the fact that microbe contamination is due to infection only in the presence of suitable conditions which include the importance of the structure of the tissue contaminated even if temporarily (and finally, incorrectly) the opinion is put forward that these tissues are damaged moreover differently in different cases.

S. S. **Rechmenskiy** considered that two types of contamination of wounds with microbes exist: the primary at the moment of the wound and subsequent during the patient's stay in a treatment institution. This leads us to the Nikol' system which considers that microflora in wounds consists of three groups:

1) saprophyte (from the soil);

2) conventionally pathogenic microbes of the skin and mucous

membranes of the wounded person and

3) extremely virulent suppurative microbes of the hemolytic streptococci group. In 95.0% of fresh wounds one can find microbes of the first group and in 65.0% microbes of the second group; only in 13.4% can one find microbes of the third group. During hospital studies the third group is predominant.

Thus, if one agrees with the conclusions of these authors, both our own Soviet authors and foreign authors, then we are not far from the pyrogenic times where hospitals are considered the location where contamination of wounds occurs. Undoubtedly this is untrue. We know that multiple studies in hospitals and clinics actually indicate a high microcontamination of incoming objects and other objects of customary hospital use which are not suitable however in contact with surface wounds; the fact of this contamination is generally known and with correct organization of the work, a number of measures are taken which paralyze its effect. Intrahospital contamination of wounds, of course, is possible but the course of the wounds in the treament institutions both in peacetime and in wartime, does not give us the basis for considering it to be widely distributed. This can be explained simply. To conduct a single microbiological study of a wound, that is, to obtain the appropriate wound material, is technically simple and largely falls to the microbiologist. Another job is to subject the wound to a systematic bacteriological study. Once again from the wounds with a favorable course, it is impossibe to get adequate material for the study, not even mentioning the fact that pieces of tissue from this wound cannot be taken and in a smear, there is not adequate flora from the wound, etc.

During studies of infected wounds themselves, one obtains material easily and therefore these wounds are taken by most microbiologists as the research object. In any case, for the conclusions drawn above as to the importance of intrahospital infection, it is necessary to have more proof.

More correct information on the development of bacterial flora can be obtained by systematic study of the effect of the condition of the wounds on the microflora.

In relation to this, there is definite interest in the work of T. L. Simakova who, using a microbiological laboratory of the Institute of Experimental Medicine, conducted a systematic study of the flora in wounds in one of the evacuation hospitals in Leningrad. For the entire war, observations were made of 11,826 patients and the number of studies reached 13,457.

The data presented have a fairly relative significance. The work was done basically in wounds in the extremities where primarily the large joints were the damaged objects. There were no minor wounds among them because, as is known, they were concentrated in hospitals for those with minor wounds.

During observations of 262 patients wounded in the lower extremities, 123 times Cl. perfrigens was observed; clinically infection developed in 33 persons. In 77 Cl. perfrigens was detected along with pathogenic anaerobes and in 43 persons a clinical picture of infection occurred. Finally, in 62 wounded patients simultaneously with Cl. perfrigens, also Cl. oedematiens was apparent; of the number of those wounded, 59 were ill and only 3 showed clinically established complications. In all, thus, in 262 wounded with severe fragmentation wounds of the lower extremities, mainly of the femur and crus, the clinical picture of gaseous infection developed in 135. Here, purposely these numbers are not presented in percentages because thev cannot be used for comparison due to the fact that these comprised basically severe wounds with a view toward anaerobic infection. These numbers are evidence only of a single relationship: when there is anaerobic flora innoculation of severe fragmentation wounds of the lower extremities, only in half of the wounds did a clinical picture of anaerobic infection develop.

We see this relationship in the material by this same author: in 91 wounds, anaerobic flora was detected in the first week after the wound occurred; clinically illness was apparent in 66; out of 45 patients in which these microorganisms were detected, only in the second week after the wound occurred, 15 were sick, that is, illness was observed 2 times less frequently. This corresponds fully with the fact that of the old wounds, particularly with damage to the bone, very often anaerobes were inoculated with the complete absence of clinical signs of anaerobic infection.

Anaerobic flora were detected by T. L. Simakova primarily in wounds of the lower extremities and in wounds with damage to the bone (Fig. 39).

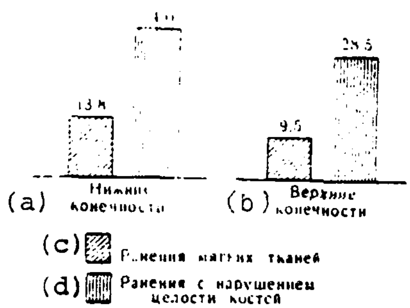


Fig. 39. Frequency of density of anaerobic flora in wounds. Key: (a) Lower extremities; (b) Upper extremities; (c) Wounds of soft tissue; (d) Wounds with breakdown of the entirety of the bone.

It is interesting that in all of T. L. Simakova's great quantity of material, Cl. histolyticus was detected only 4 times.

The very significant difference in quantitative relationship of the anaerobic flora is obtained when comparing fragmentation and bullet wounds (Fig. 40).

Thus, when studying material from the same hospital, fragmentation wounds were much more often contaminated with anaerobes than were bullet wounds. As one should expect, most often anaerobic

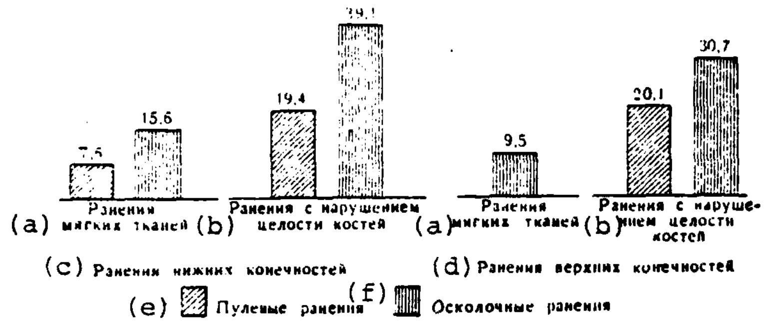


Fig. 40. Frequency of the density of anaerobic flora in wounds depending on the type and character of the wound.
Key: (a) Wounds of the soft tissues; (b) Wounds with a breakdown in entirety of the bone; (c) Wounds of the lower extremities; (d) Wounds of the upper extremities; (e) Bullet wounds; (f) Fragmentation wounds.

flora were detected during framentation wounds of the lower extremities with damage to the bone.

Anaerobic flora with complications of the wounds is particularly important but this does not decrease the significance of other types of microorganisms. In particular, in a gunshot wound with an excess of necrotic masses of putrid flora in them, there is another pathogenic microbe involved which causes a decay of necrotic masses and, undoubtedly, affects the course of healing of the wound. It is very difficult to clinically determine the putrid infection in combat conditions; usually in the history of disease one finds indications as to the character of infection only during microbiological studies which, of course, could not be established on a mass scale. Besides the sporogenic and asporogenic microorganisms, this type of microbe includes B. coli because the capability of proteolysis is inherent to it. Unfortunately, to find comparative data as to putrid microbes and B. coli cannot be successfully done. In the work of T. L. Simakova, such data also are not indicated but then in her doctoral dissertation (1948), she presents the following comparisons (Fig. 41).

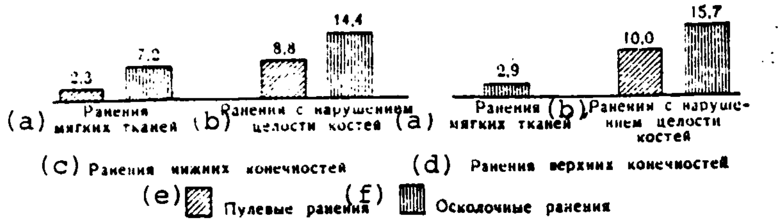


Fig. 41. Frequency of density in wounds with pathogenic flora depending on the type and character of the wound.
Key: (a) Wounds of the soft tissue; (b) Wounds with destruction of the entirety of the bone; (c) Wounds of the lower extremities; (d) Wounds of the upper extremities; (e) Bullet wounds; (f) Fragmentation wounds.

Comparing Figs. 40 and 41, one can prove that the principle characteristic for pathogenic anaerobes remains in force and for apathogenic, that is, the microflora finds the best conditions for its development in fragmentation wounds.

From Fig. 42 it is apparent that independent of localization of wounds and the type of the wounding weapon, the primary position in the bacterial landscape is occupied by putrid spore bacteria followed by pathogenic anaerobes and finally by apathogenic anaerobes.

As Fig. 43 shows, the density of putrid spore bacteria in wounds is extremely high; moreover, here one can truthfully say that for all four groups of microorganisms presented, there is a common principle: the character of damage to the tissue, the presence of necrosis in the wound are the basic conditions which determine the population density in the wound.

A strict parallelism exists between the magnitude of tissue destroyed and the degree of the population density of pathogenic and apathogenic microorganisms.

In order to obtain a full understanding of the wound flora, it is necessary to analyze the suppurative flora.

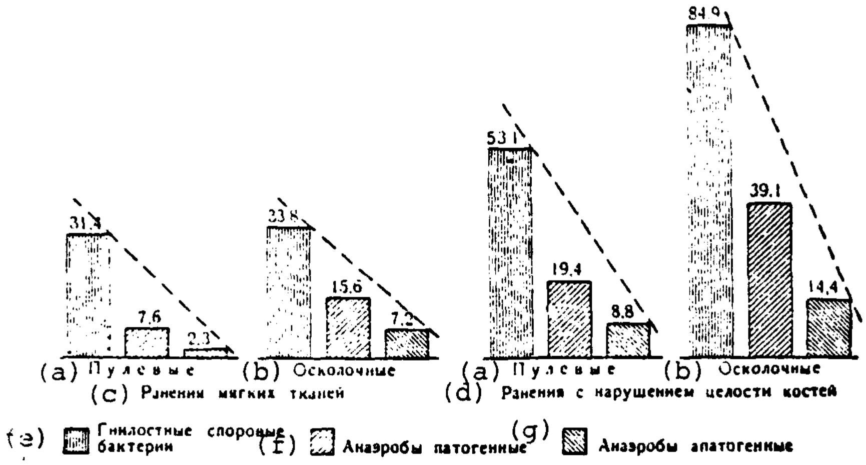


Fig. 42. Frequency of density of wounds of the lower extremities of different groups of microorganisms.
Key: (a) Bullet; (b) Fragmentation; (c) Wounds of the soft tissue; (d) Wounds with a breakdown in entirety of the bone; (e) Putrid spore bacteria; (f) pathogenic anaerobes; (g) Apathogenic anaerobes.

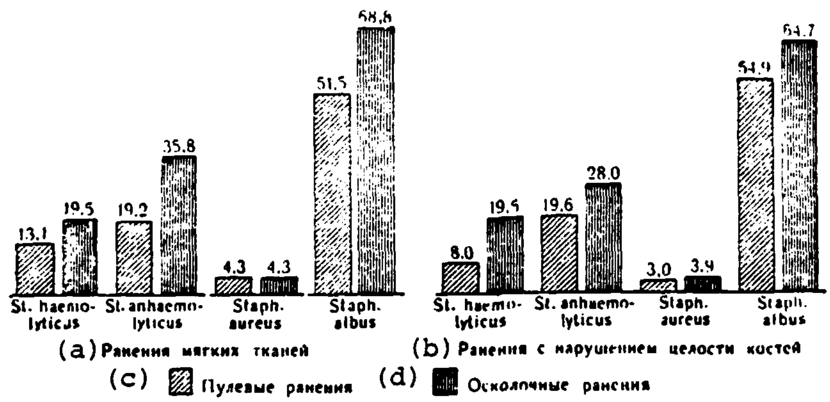


Fig. 43. Contamination of wounds of the lower extremities with suppurative flora.
Key: (a) Wounds of soft tissue; (b) Wounds with breakdown in the entirety of the bone; (c) Bullet wounds; (d) Fragmentation wounds.

Figs. 43 and 44 confirm the basic position: flora of fragmentation wounds is more abundant than that of bullet wounds. This difference is less clear for suppurative microbes.

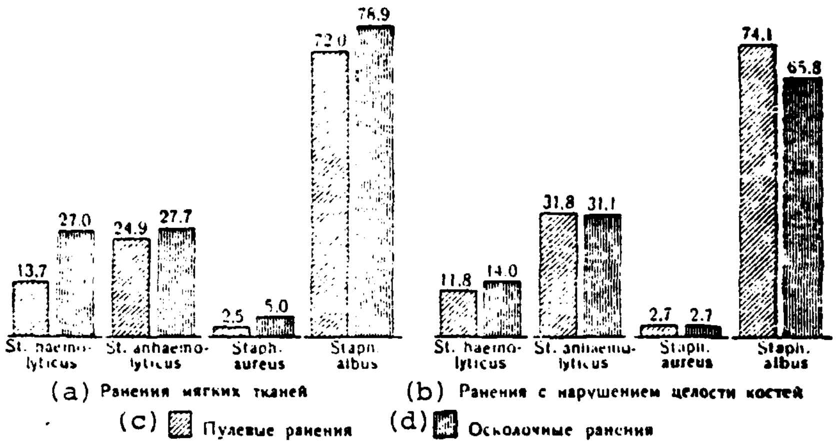


Fig. 44. Contamination of wounds of the upper extremities with suppurative flora.
Key: (a) Wounds of the soft tissue; (b) Wounds with breakdown in entirety of the bone; (c) Bullet wounds; (d) Fragmentation wounds.

A predominance of white staphylococcus is observed. If one compares all types of flora for fragmentation or bullet wounds, then it is possible to note a certain principle in relation to aerobic and anaerobic flora.

As is apparent, the suppurative microbes and anaerobes have a sort of inverse relationship, that is, certain wounds contain a predominance of anaerobes and others of aerobes; consequently, the conditions existing in the wound affect the type of microbes (Fig. 45).

The data of T. L. Simakova on contamination of wounds with microbes during a year give a definite principle taking into consideration the conditions of Leningrad. Similar data applying to the swamps of Byelorussia, the steppes of the Volga region of Pomerania can be sharply differentiated from the Leningrad, and from each other.

In parallel to this data one can present curves with are the result of processing the charts of deep characteristics: if one assumes a number of bullet wounds healing without complications as 100, then the number of fragmentation wounds is 92.8. If the number of complications of bullet wounds with suppurative infection

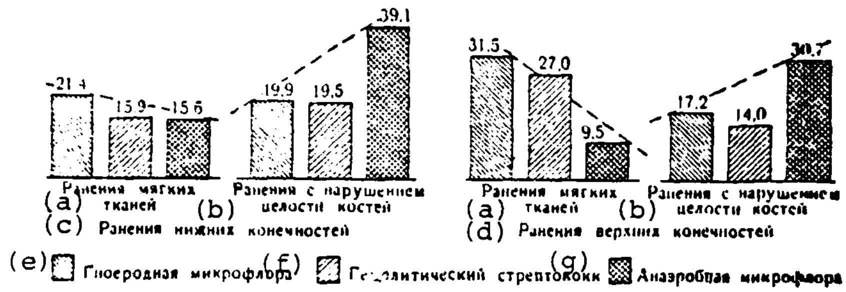


Fig. 45. Relationship between the contamination with aerobic and anaerobic microorganisms.
Key: (a) Wounds of the soft tissue; (b) Wounds with a breakdown in entirety of the bone; (c) Wounds of the lower extremities; (d) Wounds of the upper extremities; (e) Suppurative microflora; (f) Hemolytic streptococci; (g) Anaerobic microflora.

which required additional operative intervention is taken as one, then the number of complications during fragmentation wounds would be designated as 1.5. The ratio of bullet wounds complicated by anaerobic infection including complications during fragmentation wounds, equals 1:1.6; the number of complications of total infection (sepsis) with fragmentation wounds is 0.2% greater than with bullet wounds.

All these data and also the study of a large number of histories of patients makes it possible to formulate basic opinions confirmed or established from the factual material of World War II.

Contamination with microflora occurs primarily in the direct neighborhood of the wound both at the moment the wound occurs and at any subsequent moment in the future up to the primary surgical treatment or up to correctly completed cleansing of the wound. It is very difficult to differentiate contamination of wounds which occurs at the moment of the wounding from the application of microflora along with the shell and particles of underclothing and outer wear of the person wounded, contaminated from the soil or wounds which, after the event, have been contaminated by the earth and wounded surfaces which come in contact with the soil.

Even correct application of bandages during first aid does not guarantee protection from contamination by flora from the skin surrounding the wound. Bandaging prevents deep contamination and considerably decreases it but in spite of its great advantage, there is no complete guarantee that microbes will not be able to penetrate. In combat conditions there are too many possibilities for subsequent contamination of wounds in the first minutes and hours after the wound occurs. Here primary inoculation of the wound occurs independently of whether or not microbes get into the wound at the time or a few minutes later. Finally, after the wound occurs, the microbes often get into it from the surface sections of the wound. Microbiological studies of different sections of fresh wound indicated that the most contaminated area is the edge of the wound bounded bv the skin. It is understood that with all other conditions being equal, the larger the area of the wound surface, the more easily it becomes contaminated. Contamination always is polymicrobic - that is, pathogenic microbes and saprophytes exist in it. Thus, the polymicrobe microflora of the surface have the greatest importance in contamination of the wound. Under these conditions it is natural that localization of the wound requires considerable importance: when the wound is in the mouth or upper respiratory tracts, their flora are a primary source of contamination; with wounds in the vicinity of the posterior passages, there are the appropriate flora; the same is true for all other locations. It goes without saying that ordinary everday cleanliness of the body and clothing plays a very definite role although it does not coincide with bacteriological cleaniness; for example, the hands of metal workers can appear dirty but according to peacetime data, the pathogenic flora on them are lower, for example, than on the hands of a person working in wood finishing industries. Such differences are observed in soldiers of different ranks.

Contamination of any gunshot wound with microbes is a permanent phenomenon and is true of peacetime wounds including even operational wounds.

Besides mircroflora on the surface of the wound, a primary source of infection for the wound is also the soil. Multiple studies of soil indicate the presence of pathogenic flora both in plowed fields and in the dust of streets. The soil around dwellings where a great many people live can become contaminated easily just as occurs during battle conditions.

The danger of microbes settling in wounds is not excluded by the primary surgical treatment or by cleansing of the wound. It is only when a wound barrier is formed along the entire extent of the wound surface that microbe contamination becomes negligible but it is possible when there is any breakdown in this barrier.

All of the secondary studies of flora of wounds indicate that the types of microbes in them change with the "age" of the wound. However here by "age" it is not as much the change in conditions in the wound but more the development of various microbes passing through it. Some of these conditions at the present time are completely clear; some have been established as the result of experience in World War II and some others need clarification.

It is easier to establish the significance of conditions for development of such groups of microbes for whose growth one needs the opposite conditions of the medium: such as anaerobes and aerobes.

The curves presented above obviously indicate that if conditions in the wound favor the development of anaerobes then, at the same time, the development of aerobes is prevented and the reverse. Pathogenic and apathogenic aerobes develop in parallel; putrid aerobes develop only in the presence of excess necrotic sections.

During World War II, many studies were made by I. V. Davidovskiy and his coworkers. These studies indicate a very important sometimes decisive value for the medium of the wound in the development of infectious complications.

Time has passed when it was thought that microbes getting into the wound had to lead to the development of the corresponding infections. Where even in artificially created laboratory conditions it is necessary to select the most favorable medium for cultivation of the desired form of microbes, the more appropriate attempts must be made in the area of the wound, particularly with conditions continuously changing in it.

A whole chain of reactions which occur as the result of interaction of the microorganisms and the tissue of the human organism limit their harmful effect and in the final analysis can result in immunity. As is known, this immunity occurs due to the effect both of substances ordinarily contained in the organism and specific antibodies which occur in the organism in the form of a response action to specific antigens.

It was indicated above that the contamination of a wound very often is polymicrobic and later on in the wound a definite microbe association develops in which one of the microorganisms plays the decisive role. Then if a transition occurs to a monoinfection, then with prolonged healing the microorganism can shift or form associations again. The character of the wound, operative intervention and a number of other treatment factors have a clear effect on the microbe population of the wound, for instance: rest of the wounded person, hyperemia, general and local effect of antiseptics and antibiotics, physical factors, heat, cold, light, etc.

While the concept of Lister antiseptics included killing microbes in the wound, the principle of aseptics is such that the microbe does not reach the wound and further, the problem of surgery could be solved only by creating a course of reactive processes in the wound which would be maximally favorable for regenerative processes and maximally unfavorable for the development of microorganisms. This position became generally adopted in surgery after the first World War; it was confirmed by the material of the "small wars," but it was only World War II that made this position fully clear. The key to the solved problem of prevention and treatment of wound infections lies in the effect of the wound on the person wounded and not only on the microorganisms. In any case, action only on microorganisms is less effective and makes solution of the general problem easier without solving it completely.

For instance, the importance of conditions which are unavoidable on the battlefield of excessive and varying populations of microbes in wounds were studied from three aspects:

1) the course of healing of the wounds was studied;

2) development and vital activity of microorganisms and their associations both in the wound and outside it were studied;

3) the effectiveness of physician and surgical measures during treatment of infectious wounds was studied.

The most important condition for development of microbes is the presence of necrotic tissue in the wound. A gunshot wound again is distinguished by an excess of tissue subject both to the primary and to subsequent necrosis. Development of subsequent necrosis increases the possibility of multiplication of the microbes even where the primary necrosis was eliminated by an operative approach. As to the importance of necrosis, the gunshot wound is similar to a laceration contusion. However, no one type of wound has the characteristic to so strongly maintain normal biological processes in the viable tissues as does the gunshot wound due to the results of intratissue "explosion," which we talked about earlier. The blast wave as we have seen is propagated far beyond the limits of the wound channel; it is perceived by all elements of the tissue including the nervous system; this condition which was defined earlier by N. I. Pirogov as "local shock" stupor is related to it. How long it lasts and which elements of the tissue are released from its effect earlier and which later are all matters for future studies but in any case the reactivity of the tissue is maintained for a time period adequate for multiplication of the microbes. During the first hours after the wound occurs, even in a wound covered with bandages if one excludes action taken by physicians (for example, the injection of penicillin), the number of microorganisms increases constantly. The more favorable are conditions for development of microorganisms in the wound, the more rapidly they multiply. It is very important however that not only the quantity but also the quality, in other words the type of the most numerous microbes corresponds to the conditions in the wound. This was clearly shown in data obtained on the war by T. L. Simakova, T. A. Kolpakova et al., and also in the postwar experiments by N. N. Anichkova. In the final analysis, the etiological value of microorganisms in the development of infections in wounds must be formulated thusly: the conditions which exist at each given moment in the wound make multiplication of a certain type of microbe or their associations easier and transition of the microbe invasion to infection easier as well; changing conditions in the wound involves a change in flora both quantitatively and qualitatively. The entrance of microbes into the wound is unavoidable in wartime but there multiplication and the special features of transition of invasion to infection are mainly due to the presence of conditions favorable for this in the wound. As a result of this, our views on methods of combatting microbes and on infection of wounds unavoidably change back and forth.

The microflora of infected gunshot wounds is developed from microbe contamination of a fresh wound and depends mainly on the conditions which are created in the wound and which facilitate the development of various associations of microbes or their separate species.

The numbers presented in Table 3, borrowed from the research by T. A. Kolpakova, give us a concept of the frequency in location of different types of microbes taken from wounds at different time periods.

Table 3. The relationship of different species of bacteria in gunshot wounds for different inoculation times (in precentages in relation to each group).

(a) Срок посева	(b) 1 вид	(c) 2 вида	(d) 3 вида	(e) 4 вида	(f) 5 видов
(g) 1—5 дней	8	35	40	14	3
6—10 »	14	25	35	25	1
11—15 »	4	30	50	9	7
16—20 »	19	38	37	6	—
21—30 »	8	57	19	14	—
(h) 1—2 месяца	11	45	30	14	—
3—4 »	35	54	6	5	—
4—6 »	34	48	15	3	—
(h) 6—12 месяцев	35	45	14	6	—

Key: (a) Time of inoculation; (b) Species 1; (c) Species 2; (d) Species 3; (f) Species 5; (g) Days; (h) Months.

From Table 3 it is apparent that in the first five days one removes species 3 and 2 microbes; species 4 is 2-3 times less frequent and species 1 and 5 are removed in the smallest percentage. Later on after prolonged periods in the wounds, this number is changed; only two rows of numbers have a marked tendency toward an increase - these have the numbers which indicate the percent of inoculation of species 2 and species 1 of the microbes. At the end of the first month, primarily there are two types of microbes which are retained later on. With observation and osteomyelitis this phenomenon becomes almost typical. Monoinfection during the first month occupies a very modest position but then jumps sharply upward and at the end of a year, occupies second place while all other variations either are reduced or are close to attentuation.

These data from the same author are shown in Table 4 where comparative data are presented on the microbiology of fresh infected wounds, wounds which have granulated, ulcerated scars, osteomyelitic foci, healed scars, but those containing more or less varied types of microbes. Moreover, data on flora obtained during inoculation with metal fragments are presented in a table (Table 5). All of the tables are compiled on the basis of studying the flora of infected wounds in the extremities; the percentages are calculated for

Table 4. Microflora with different conditions of the wound process on the extremities.[1]

(a) Название возбудителя	(b) Свежие раны	(c) Вяло гранулирующие раны	(d) Рубцы	(3) Изъязвившиеся рубцы	(f) Остеомиэлиты	(g) Наличие металлических осколков
Cl. perfringens	78,1	2,4	8,0	—	12,5	55,0
Cl. oedematiens	43,1	—	—	—	0,5	4,0
Cl. septicum	9,4	—	—	—	—	—
Cl. sporogenes	7,2	15,5	2,1	5,7	8,0	6,0
Cl. putrificum	17,3	3,6	1,0	0,9	12,3	14,0
Cl. tertium	3,0	14,5	4,0	2,0	3,5	21,0
Streptococcus anaerobicus	29,0	50,6	23,0	55,0	71,0	52,0
» putridus	13,9	9,8	8,0	15,7	23,0	—
» parvulus	0,6	—	10,6	—	2,0	—
Staphylococcus pyogenes	4,3	2,4	—	1,9	3,0	—
» anaerobicus	—	—	—	0,9	—	—
» aureus	9,0	30,0	5,0	37,0	11,0	—
» aureus pyogenes	4,0	—	—	2,8	5,0	—
Staphylococcus albus	—	—	—	3,4	—	—
Proteus vulgaris	48,7	18,0	2,8	8,5	26,0	—
Aerobacter aërogenes	0,3	—	1,0	5,1	2,0	—
Споровые аэробы	0,5	3,0	—	0,9	3,0	—
Pseudomonas aeruginosum	13,1	3,6	15,0	15,5	2,0	—
Corynebacter pyogenes	1,8	29,8	2,1	26,2	7,0	—

[1] Percentages all were calculated for the total quantity of wounds of a given group.

Key: (a) Name of the pathogen; (b) Fresh wound; (c) Wounds which have granulated; (d) Scars; (e) Ulcerated scars; (f) Osteomyelitis; (g) The presence of metal fragments.

Table 5. Ratio of different microflora of infected wounds.

	(a) Количество определений	
	(b) абс. число	процент (c)
(d) Один вид анаэробов	79	47,3
(e) Анаэробы в ассоциации с другими микробами	35	
(f) Один вид аэробов	54	50,4
(g) Аэробы в ассоциации с другими микробами	67	
(h) Посевы не дали роста	6	2,3
(i) Всего	241	100,0

Key: (a) Number of determinations; (b) Absolute number; (c) Percentage; (d) One species of anaerobes; (e) Anaerobes in association with other microbes; (f) One species of aerobes; (g) Aerobes in association with other microbes; (h) Inoculations do not result in growth; (i) Total.

the total number of wounds studied.

Attention should be devoted to the large specific weight of suppurative microbes and also to anaerobes. The latter do not correspond to the quantity of complications of anaerobic infections. The appropriate data are presented above (page 46). In the flora of fresh wounds before treatment and after, there are many anaerobes. The same thing is observed in fresh wounds with a suppurative section; however, without clinical symptoms of the spread of the infection beyond the limits of the wound. This fact explains the special feature of gunshot wounds which contain a large quantity of necrotic sections remaining after surgical treatment and which are the foci for multiplication of anaerobes and suppurative microorganisms. In complete accordance with this one finds data relative to the flora of osteomyolitic foci; from here microorganisms are inoculated which do not cause an inflammatory process but only settled bone necrotic foci. The flora inoculated from the surface of foreign bodies consists almost exclusively of anaerobic and suppurative microbes.

In the granulated tissue of wounds lasting for a long time, basically putrefactive flora predominate. Ulcerated scars differ in that there is pyogenic flora clearly apparent from the ulceration.

In actual practice it is very important that there are microbe flora which last for a fairly long time in scars. Consequently, one has to look for an explanation of this fact that a number of plastic surgery interventions made for different purposes on fresh scar tissue have infectious complications. This forces one either to attempt preliminary provoked measures for activity of the infectious origin or to excise the scars and replace them with new skin tissue. In earlier times, in particular after the war of 1914-1918, a long time (six months to one year) was recommended before restorative operations were undertaken.

R. B. Kruk gives us less detailed data on the microbiology of infected wounds. His data are of interest in that they were obtained by a single author but at different stages of evacuation. For instance, on the basis of studies in the army region of the Western Front (1942), the following was established: [see Table 5].

Growth did not show inoculations with well granulated and epithelialized wounds. Inoculations were taken from wounds with clinically marked infectious complications which is explained by the fact that in many cases a single species of microbe predominated.

Table 6 presents data from the front region of the Western Front and the deep rear.

Table 6. Relationship of different microflora of infected wounds (front region and deep rear).

	(a) Количество определений	
	(b) абс. число	процент (c)
(d) Фронтовой район		
(e) Один вид анаэроба	145	47,8
(f) Анаэробная ассоциация	484	
(g) Один вид аэроба	445	52,2
(h) Аэробная ассоциация	241	
(i) Глубокий тыл		
(e) Один вид анаэроба	1	2,7
(f) Анаэробная ассоциация	5	
(g) Один вид аэроба	128	89,9
(h) Аэробная ассоциация	66	
(j) Посевы не дали роста (контроль)	16	7,4

Key: (a) Number of determinations; (b) Absolute number; (c) Percentage; (d) Front region; (e) Single type of anaerobe; (f) Anaerobic association; (g) Single type of aerobe; (h) Aerobic association; (i) Deep rear; (j) Inoculations do not produce growth (control).

The data presented fully correspond to a contingent of wounded studied by the author whereas in T. A. Kolpakova's tables one observed flora in wounds without symptoms of acute infection occurring. Be that as it may, R. B. Kruk in his conclusions notes that in 70.0% of gunshot wounds in the state of acute inflammation, the flora is mixed. If these data are presented in the form of a diagram, then it becomes clear that as the time increases which has passed from the moment of the wounding, the frequency of binding anaerobic flora drops sharply and the specific weight of putrefactive flora increases sharply. The aerobic putrefactive flora is very often inoculated right up to complete epithelialization of the wound. As is apparent from Fig. 46, even in the rear hospitals, specimens from the wounds remained sterile only in 7.4% of all wounded observed by the author and in 89.9%, aerobic flora was increased.

The data presented above involve wounds of the extremities; however the location of the wounds affects the flora developed in them. Fig. 47 illustrates this.

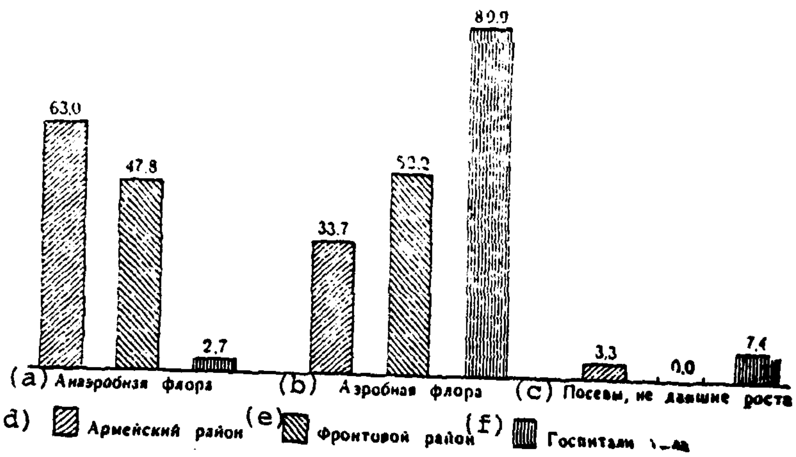


Fig. 46. Microbiological findings in infected wounds at different stages of evacuation (in percentages in relation to all wounds observed).
Key: (a) Anaerobic flora; (b) Aerobic flora; (c) Inoculations which did not produce growth; (d) Army region; (e) Front region; (f) Hospitals in the rear.

A detailed analysis of the special features of wounds according to area is presented in the appropriate sections; the circumstance that with cavity wounds, the purtrefactive forms of microorganisms are encountered very frequently is particularly important

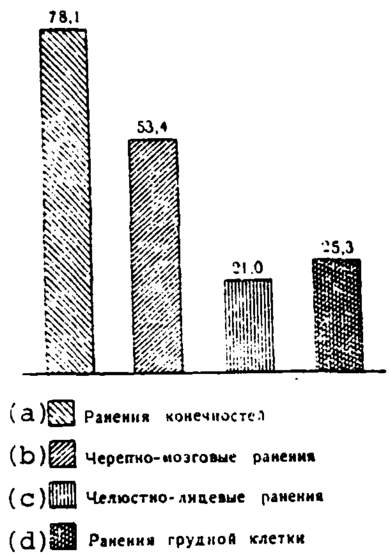


Fig. 47. The connection between the frequency of bacterial findings and location of the wounds (in percentages of all wounded in any group observed).
Key: (a) Wounds in the extremities; (b) Wounds in the skull and brain; (c) Neck and face wounds; (d) Wounds in the thoracic cage.

for us. Fig. 47 shows the dependence of the flora of the wound on the location of the wound. Here all of the extremities are combined together.

However the data of Table 7 indicate that the location is important even as to which segment of one or another extremity it occurs on. For the clinician this is not unexpected but in Table 4 it is confirmed from the point of view of the microbiology of the wound.

Although in the first World War microbiology of gunshot wounds was studied in fairly great detail, the greatest attention was attracted by the so-called gaseous infection. This type of wound infection did not lose its importance during the years of World War II. However, during this time, the view of infectious complications from gunshot wounds both by microbiologists and in special features by

Table 7. Frequency of the density of pyrogenic, putrefactive and anaerobic flora in the wounds.

(b) Сроки в днях / (a) Микробы	(c) Раны бедра			(d) Раны голени			(e) Раны стопы		
	1—3	4—7	8—14	1—3	4—7	8—14	1—3	4—7	8—14
(f) Гноеродные	19,8	23,0	39,4	39,0	29,7	41,3	0	16,0	11,4
(g) Гноеродные и гнилостные	21,6	33,0	49,3	34,0	31,3	45,2	56,0	61.0	80,0
(h) Гноеродные и анаэробы	16.2	6,0	3,1	1,7	14,7	2,5	21,3	14,8	1,1
(i) Гноеродные, гнилостные и анаэробы	42.4	38,0	8,2	25,3	24,3	11,0	12,2	8,2	7,5

Key: (a) Microbes; (b) Time period in days; (c) Wounds on the femur; (d) Wounds of the crus; (e) Wounds of the foot; (f) Putrefactive; (g) Putrefactive and pyogenic; (h) Putrefactive and anaerobic; (i) Putrefactive, pyogenic and anaerobe.

surgeons changed considerably. The evolution of the views on wound infection was formulated, in particular, at a conference on wound infections set up in Moscow.

It must be emphasized that the importance of putrefactive microorganisms was studied so little by clinicians that the clinical characteristics of putrefactive complications of the wound process were not expressed in the broad surgical practice.

At the conference mentioned above with the main reports entitled "The Morphology of the Wound Process and Basic Principles for Its Development" and "Wound Infection, Wound Intoxication and Wound Depletion" were presented by I. V. Davidovskiy. These studies were the basis for the opinions by the author and are presented in detail in the section entitled "Pathology of Gunshot Trauma."

N. I. Grashenkov and P. P. Sakharov differentiate pathogens of wound infection and those not forming toxins of flora in whose make-up putrefactive microorganisms play an important role. The virulence of the pathogens of wound infection increases with association of microbes, in particular, with putrefactive microbes. The authors consider that introduction of infection which can be important in the first period of the wound process when a strict dependence of the severity of the patient on the virulence of microbes in the wound is established.

Active immunologic reactions occur in the organism; in usual time periods for immunization, antibodies form which enter into the wound and can be observed. Protective reactions are indices of the activity of the organism of the wounded person in accordance with the clinical course of the infection.

General material selected as a result of the large quantity of studies of the flora of wounds personally made make it possible for T. L. Simakova to compile a concept as to the dynamics of microbe association in wounds contained from the very beginning of suppurative flora. A comparative table of data on anaerobic flora in wounds of the femur, crus and foot are presented as the index as usual (Table 7).

It is impossible not to turn attention to a multiplicity and abundance of bacterial flora. In its character however it is uniform because the general character of these wounds is not so similar. It is very obvious that this occurred because conditions in these wounds are the most favorable particularly for this type of flora. However, the wounds were gunshot wounds and therefore the presence of necrotic sections of tissue in them and also tissues with decreased viability and reactivity is unavoidable. In this way, even in spite of surgical treatment of wounds, these sections are foci of putrid flora. It is characteristic that the quantity of anaerobic flora dropped sharply with time which is an index of the relationship of flora to conditions created in the wound. The frequency of finding suppurative flora in wounds of the femur and crus up to the fourteenth day continues to increase. With wounds of the foot a pure suppurative flora in the first three days is generally never observed. Suppurative microbes appear in the second half of the first week and in the second week their quantity decreases. Suppurative microbes in combination with anaerobes are apparent in the initial period in a very small group; later on at the end of the second week they have almost disappeared and only in wounds of the crus at the end of the first week does one note a certain increase in their quantity which then again is decreased in accordance with other locations on the lower extremities. Associations with suppurative microbes are particularly important and the number of groups in which there are anaerobes always drops with time. Therefore the greatest importance is acquired by the flora consisting of suppurative microbes in combination with putrid microbes. This flora obviously corresponds more to the entire process of healing of the wound in the period of its "purification" (I. V. Davydovskiy), that is, sloughing off of the necrotic tissue. On the foot one observes wounds most inoculated with suppurative microbes and possibly this is because, with this location of the wound, one encounters greater difficulties during surgical processing of the wound due to anatomical conditions of this area.

CHAPTER II

CLINICAL TREATMENT OF WOUNDS

Injury from a firearm involves the sudden destruction of tissue in the human body in a certain section of it. Soviet medicine considers the wound and the wounding as a complex breakdown in viable functions of the entire human organism in relation to the character of the injury obtained from the appearance of functions of damaged tissues and organs and from general disorders in vital activity of the organism caused by the wound as a whole.

All of this involves the greater or lesser duration of different severity of the illness with participation in the recovery processes of the organism as a whole and its nervous system as the regulator of these processes. In this way, the clinical treatment of wounds is setup from sequentially developing symptoms made up of general phenomena present in each wound and special symptoms characteristic for damage of different areas of the human body.

General symptomatology. The clinical treatment of wounds is compiled from symptoms immediately following the wounding and symptoms which develop later on in its course.

The direct results of the wounding are:

1) opening of the skin,

2) bleeding,

3) pain,

4) a drop or breakdown in functions of the damaged tissues or organs.

Opening of the skin covering. With a gunshot wound we are talking essentially not only about opening of the skin (the skin or the mucous membrane) as a result of separation of the wound edges but also about defects in the coverings. The laceration bruising character of the damage is due to a breakdown in the elasticity of the covering because they are less contracted than, for example, with a wound incision; however under the effect of a foreign body or a blast wave, part of the covering dies and therefore a flaw is formed; the latter, it is understood, can include not only the skin but also the tissue lying deep underneath. A characteristic property of the wound precisely separating it from hidden damage is just this breakdown in the entirety of the skin. The flaw in the skin can vary considerably in its dimensions: from a spot to continuous separation for an indeterminately large extent.

One must keep in mind that when the wound aperture is in the fold of the skin, for example, in the navel or near the anus, it appears negligible particularly with multiple wounds."

The absence of covering revealing underlying deep tissue results in the fact that it begins to be subjected to external factors; this breaks down the normal course of the vital processes. The most significant aftereffects of this defect is drying and contamination of the tissue. Even short term drying has a disastrous effect on the tissues. The peritoneum, the pleura, sinews and synovial membranes of the joints, etc. are particularly sensitive to drying.

Contamination of the wound surface is possible by solid and liquid bodies and at the same time by microorganisms.

It is necessary to indicate that the skin of a human here is not a purely mechanical protection for the deep tissue, it has active barrier functions, in particular bactericidal properties. The bactericidal effect is due to an acid reaction of its secretion. These properties of the skin however, do not prevent surface growing of a certain quantity of those types of microorganisms which are adapted to existing conditions and the flora characteristic for different sections of the body.

Contamination of the wound by solid bodies often occurs. In the wound dirt, particles of metal, wood, stone, bits of clothing, weapons and equipment can get in. Even N. I. Pirogov wrote: "An entire museum could be furnished with the foreign bodies put into a wound from a firearm projectile."

The wound can be contaminated also with liquids and semiliquid emissions from the person: mucous, urine, the contents of the stomach and intestine, etc.

One of the most important and unavoidable results of wounding is bleeding. Bleeding and its control are considered in a separate chapter. Here we will look mainly at bleeding which occurs in the cavity of the wounds and spreads from there along the intertissue rima.

With cavity wounds, for example, of the skull, chest, abdomen, blood is accumulated in the cavities and has a significant effect on the clinical course of the injury. With each of these wounds the bleeding can have a fatal outcome coming, in truth, from different causes (see the appropriate chapters). During intratissue bleeding an accumulation of liquid blood occurs in any section (with wounds of the large vessels) or it penetrates loose tissue accumulating in pockets of the wound, its cavity or the wound channel and spreading along the intertissue rima. As we have already mentioned, a small amount of bleeding is observed far from the wound channel.

The blood which is excess in the tissue such as a necrotic section is subjected to further absorption, emission outside or in rare cases, encapsulation (encapsulated hematoma). It acts as a favorable medium for the devlopment of microbes and, consequently, increases the danger of infection. However, coagulation of blood at the same time is a favorable medium for the growth of the cellular elements during healing of the wounds and for emigration of mobile cells lying close by; this facilitates the process of regeneration.

One should take into consideration that the first aid measures for stopping the blood flow are important for the course of the wound. During World War II, always there was a fight against unfounded application of tourniquets on the extremities to stop the bleeding because stopping the bleeding in the final analysis sharply reduces the reactivity of the tissue and makes the wounded area more susceptible to the development of infection. Tightly packed wounds to stop the flow of blood also have just as harmful an effect. Fig. 48 shows the comparative data which characterize the frequency of complications of suppurative, anaerobic infections and general suppurative infections (sepsis) for wounds accompanied by insignificant (the hatched columns) and significant (the non-hatched columns) blood loss (according to the data of the chart for fundamental characteristics)

As is apparent from the drawing, the complications mentioned most often are encountered with the appearance of anemia and more severe forms of complications - anaerobic infection and sepsis, and develop much more often in wounds accompanied by significant blood loss.

From the data for developing the chart for fundamental characteristics one sees that with wounds with an excess of blood flow the complications are encountered 22.3% more often; these wounds 6.6% more often are complicated by anaerobic infection than bullet wounds and by 5.6% more often than fragmentation wounds. Sepsis developed 3 times more often than in wounds with an excess blood

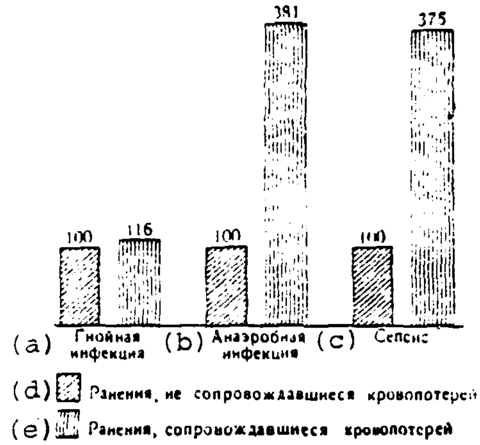


Fig. 48. Frequency of complications with wounds accompanied by loss of blood (the average frequency of a given complication in all wounds is taken as 100). Key: (a) Suppurative infection; (b) Anaerobic infection; (c) Sepsis; (d) Wounds not accompanied by loss of blood; (e) Wounds accompanied by loss of blood.

loss. The mortality rate in them is 4 times greater than the general mortality rate for wounds.

Pain. Due to the characteristics of gunshot wounds and the conditions for its occurrence, stimulation of sensitive nerves is distinguished by large force and an extremely short time effect. It is understood that the anatomical and physiological characteristics of the area of the wound also play an important role in the occurrence of pain. However, a number of wounds which are usual for bullet or small fragmentation wounds are not noted generally at the moment of the wounding. Often the flow of blood in the wound or around the wound is given attention and only after this does one recognize the fact of wounding and the position of the wound. It is necessary to believe that the force of the impact and the intratissue explosion, at a certain time, paralyzes the capability to perceive stimuli and only when the conductivity of the nerves is returned does one perceive and recognize pain perception. One should add that the pain perception during a wound is absent not only in soldiers who are actively participating in combat and who are in a state of nervous excitation, but also in soldiers who are in shelters and who are not directly occupied with carrying out military missions. The perception of the wounded often is characterized at the moment of the wounding as an "impact," causing one to fall to the ground. The impact is perceived as the effect of a solid massive body and less often the wounds are characterized as impact from a whip. The pain perceptions in the region of the wound usually appear a few minutes after the wounding. Later on the pain completely depends on the location of the wound, the character of the injury, the first aid given, etc. A complete absence of pain perception is possible only with wounds to the nervous system with a breakdown in their continuous path which conducts the perception of pain.

With the timely and efficient rendering of first aid, pain as a rule is lessened and usually 10-12 hours later is replaced by feelings of discomfort which occur when changing position, sometimes when coughing, sneezing, etc. and depending on the location of the wound. Pain from wounds in the extremities depends significantly on the degree of immobilization. Each person who transports the wounded knows that their complaints of pain in the wound either are caused by incomplete immobilization or are a sign of infectious complications beginning in the wound.

In fresh wounds pain occurs with pulsing hematomas and the formation of traumatic aneurisms. These pain perceptions sometimes are distinguished by great persistence and the patient cannot rest night or day but requires operative intervention (these types of pain and combatting it are discussed in section XV).

Pain perceptions which occur in the wounds with damage to the nerves, the so-called causalgia, and also pain in the stumps which appear to occur in the removed sections of the extremity are called phantom pains.

Speaking of the damage to peripheral nerves, it is impossible not to involve the state of the central nervous system in wounds and, particularly, their psychological aspects.

The most functional disorders were observed soon after the wounding. The primary absence of wound perceptions, high consciousness of military duty, a persistent desire to fulfill the combat assignment in a large number of cases explained what appeared to be improbable actions which were fulfilled by many wounded persons immediately after the wounding.

An analysis of functional disturbances is the most precise method for diagnostics of wounds. In perforated wounds of interrelated entry and exit apertures, there is a basis for drawing conclusions as to the damage of various anatomical formations. Determination of the breakdown in functions then is closely related to determining the clinical state and diagnostics of the wound.

Diagnostics and Classification

Diagnostics of the wound include as precise as possible a determination of those disturbances which caused the injury to the organism. In combat conditions this determines where the wounded person is sent at the appropriate stage of evacuation, depending on the scope of assistance which the wounded person needs and which can be given under the given combat circumstances. Therefore, it is understood that the primary diagnostics are closely related to classification and are made rapidly in order to separate wounded into groups rather than for individual diagnosis. The latter is possible only taking into consideration the location of the wound and therefore is discussed in detail in the appropriate sections of the surgical part. We mention this because in almost 25.0% of the cases of cavity wounds the wound itself plays a secondary role because the clinical picture of the wound is determined by damage to the brain, lungs, heart, intestines, etc.

A drop in functions of the central nervous system gives us the basis for a fairly precise diagnosis for damage of the brain and spinal column.

However, very often a correct diagnosis can be posed only after a certain time and therefore conclusions on these wounds in a military region are of an approximate value. It is important only to discover indications for urgent intervention for conditions of pressure on the brain which are life threatening An approximate diagnosis in all other cases based on the presence of neurological symptoms was necessary in order to conduct special treatment with evacuation as needed.

For wounds in the chest and abdomen, the first examination was to determine whether or not they were penetrating or nonpenetrating wounds; with damage to the stomach the question of intervention was decided. With wounds to the chest one needed to recognize the presence of pneumothorax and other disorders and also their character.

The main problem of surgical intervention is treatment of damaged organisms; the wound itself is either treated incidentally or sometimes requires no treatment. One must take into consideration that insignificant damage to important parts of the brain, heart or large vessels results in a number of cases in death in spite of the favorable condition of the wound itself, as such.

Thus, studying material on these wounds for clinical treatment of gunshot wounds is not advantageous. For this purpose it is more correct to analyze wounds of the extremity whose clinical course to a great degree reflects changes which occur in the wound itself.

With the initial examination of the wound, the surgeon must decide immediately questions of treatment and organization. He must discover the character and severity of the wound and also determine the stage where the wounded person is to be sent. When solving these questions both for wounds in the extremities and wounds with damage to internal organs, he has to take into consideration the combat conditions. The indicated characterisitics differentiate the combat field surgery from peacetime surgery.

Depending on combat conditions, for similar wounds different solutions can be taken in strict accordance however with the basic principles of the medical service of the Soviet Army.

The diagnostics of wounds begins with an individual evaluation of the state of the wounded and proceeds with means allowable for a given stage.

Significant shattering of bone is easily recognized without X-ray examination but breaks which are not accompanied by deformation present more difficulty for diagnosis particularly in MSB (Battalion Medical Service) conditions. Errors in this are rapidly eliminated by army surgeons who have devoted, particularly in combat, particular attention to the military region. Perforated and incomplete breaks are recognized usually in the army region using X-ray examination. Cases were observed when unrecognized incomplete fractures during careless transport of the wounded and incomplete immobilization became full fractures. In general the conduct of correct immobilization required a great deal of attention and effort on the part of the surgeons in charge. One should note that in contrast to the war of 1914-1918, in World War II, the demand for splints was fully satisfied and makeshift splints were not necessary. Attempts at "improvization" which occurred here were only to improve the standard models. Diagnosis of wounded persons is closely connected to classification of the wounds. Whereas N. I. Pirogov defined classification as separating the wounded into groups in accordance with the proposed surgical actions at a given stage for a given combat circumstance, in World War II the word "classification" had a much broader meaning according to the scale and character of diagnostic methods of the physicians.

Without correct distribution of the wounded into groups, depending on diagnosis, the entire system of specialized treatment with evacuation basically would be nonexistent.

Classification of the wounded is accomplished even before intervention by a physician beginning from the moment first aid is given to the wounded. Of course it is primitive and only the question of whether or not a given wounded person should be given outside aid before leaving the field of battle or not was decided. In view of the importance of providing surgical assistance as soon as possible, the wounded are carried out during battle but of course this depends on combat conditions, the conditions of the terrain, etc.

The first physician assistance, as is well known, is given at the PMP (Regimental Medical Station) and here the first medical classification is made. The volume of medical assistance of the PMP and, consequently, the character and classification of the wounded at this stage, were determined depending on combat conditions. The volume of medical assistance even during the most favorable conditions is not large but all of it requires intrastation and evacuation classification. A group of lightly wounded is separated, who remain at the PMP, wounded who require bandaging and temporary rest and also wounded who do not need transportation and evacuation immediately. Appropriate to this, at the PMP there are a receiving classification section, a bandaging and evacuation section; the first of these podrazdeleniye is designated as a classification post. More complicated classification is done at the DMP (Division Medical Station). Combat circumstances which have a decisive influence on the volume of aid given at the DMP understandably affect the classification. In this connection, during a war one notes significant variations both in the planned treatment and evacuation plan and that used depending on the conditions which have been created. Moreover, as one improves the specialized treatment, medical indications are changed for operative intervention which affected the intrastation and interstage classification. Classification began immediately upon receiving wounded at the DMP. All of those who arrived were divided into three groups (after 1942):

1) the lightly wounded, that is, those who could be treated at a GLR (hospital for light casualties),

2) the remaining wounded and

3) those who are sick. Division of a group of the sick was done, besides for treatment purposes, for full separation of them at this stage from the wounded. Each group was sent to separate receiving-classification tents where a more detailed medical classification was made with an appropriate diagnosis. The lightly wounded were sent for bandaging where the diagnosis could be made more precise and where they could again be redivided into groups. Some of the wounded requiring the shortest time period for treatment remained at the DMP; another part was sent to the AGLR (army field hospital for minor casualties) or the FGLR (field hospital for lightly wounded) depending on the time period for the treatment. These time periods as different periods of the war and under different combat operations varied. At the MSB (medical battalion) the wounded often stayed for 10 days; in the army region they stayed for 3-4 weeks; and at the front they remained for from 1 to 2 months.

In the receiving-classification tent where the "other" wounded were concentrated including those who were severely wounded, a good deal of experience was required for classification and often for making the diagnosis more precise, the necessity arose to send the wounded to be bandaged. For convenience a classification marking was used for directing these wounded. The classifications markings usually were distinguished by color: the red marking with the number 1 meant send for operation first, with the number 2 - second, a blue notice meant sent for bandaging in turn; blue with the letter O meant remain at this post and yellow - isolation is necessary. The wounded who were sent for further evacuation received white tags with the symbols E-1 and E-2 indicating priority. The supply of classification tags was centralized. In addition at the institutions in the combat region tags were used indicating the necessity for sending the patient to the shock tent.

In those cases where besides the DMP in the combat region a KhPPG (Mobile surgical field hospital) of the first line had been set up, in certain cases the general classification post was set up here for distribution of patients according to an earlier plan.

In the combat region, as a rule, wounded were operated on who needed primary treatment of the wounds, wounds in the stomach requiring stopping the bleeding, certain wounds in the chest, patients who could not be transported, wounded with complicated anaerobic infections and the lightly wounded who required a short term treatment. As has already been indicated, distribution of wounded to a significant degree depended on combat circumstances. For instance, before large attack operations, sometimes in the first periods of the battle, the wounded were sent directly to evacuation hospitals set up right next to the combat region at the same time that the treatment institutions of the army and particularly the combat region remained available expecting casualties first from the attacking armies. During the Leningrad blockade, MSB and front evacuation hospitals were placed often in direct proximity to each other on the city streets. In the organization of the medical service, one could take into consideration the special features; however in most combat operations, the DMP particularly and the KhPPG attached to the first line are the basic stage for giving surgical aid and the location for basic classification of the wounded with evacuation intended for specialized treatment.

In the army region with improvement in specialized treatment, that is, since 1942, classification was done in a special evacuation receiving station and sometimes assigning a hospital to it which thus was a classification evacuation SEG (clearing and evacuating hospital). From here all transport was sent from the combat region and interhospital classification was made, that is, distribution of the wounded for specialized treatment. This sorting also depended on combat circumstances, on the character of the combat operation and on dislocation of medical institutions of GBA (army base hospital).

However, in all circumstances the lightly wounded were especially separated and concentrated in the GLR.

In the group of lightly wounded there were wounded requiring an ambulatory treatment. One of the causes for setting up hospitals for lightly wounded was to avoid transporting excessive contingents to the rear and combining treatment of the wounded with an increase in professional knowledge and habits of soldiers.

It was characteristic for GLR, for example, that for all systems of specialized treatment a complex of treatment was set up, that is, the use simultaneously with surgical treatment of the wound of physical therapy methods, therapeutic physical exercise and work therapy. Incidentally with the wounded combined into groups according to their state of health, exercises in combat and political training were given. Only in the first section of the hospital were the wounded actually hospitalized. In the second and third sections they were located in camps and were in uniform. The orders for the day were set up in the same way as in combat chast'.

The GLR were equipped with the appropriate apparatuses for treatment and training exercises. Instruments for therapeutic physical exercise were continuously improved in the hospital shops and at the same time were demonstrated at exhibits during army and front conferences.

If one considers not only the scale of the war but also the movement of the armies for hundreds of thousands of kilometers, the importance of hospitals for the lightly wounded cannot be overevaluated. Only on the basis of experience in operating GLR did it become clear that to fully reestablish the functioning of the damaged extremity in the lightly wounded was not so easy in general. This requires sometimes a great deal of knowledge and skill, more so than treating wounds with broader and more complex damage.

One of the first specialized hospitals (besides the GLR) was organized by assigning groups of forces from ORMU (separate medical reinforcement company) and KhPPG hospitals for treatment of neurosurgical wounds, in particular the GBA (army base hospital) were the basic stage for surgical treatment of wounds of the skull. In these hospitals, besides wounds in the skull, sometimes there were wounded with wounds in the neck, eyes, ears and nose. Moreover, classification in the evacuation reception and SEG (clearing and evacuation hospital) GBA included hospitals for treatment of patients with wounds of the long tubular bones (primarily the femur) and large joints, then for wounds in the chest, and the urogenital organs. The wounded with anaerobic infections and tetanus, if these were undetected in the general classification, usually were sent to special SEG sections. In this way, the so-called general surgical hospitals in time essentially no contingents remained.

The time periods for the wounded staying in the GBA, classifying them and further evacuation depended on combat assignments of the army in combat circumstances. Often planning a new attack combat operation urgently required release of bed patients at the army base and evacuation of wounded to the FEP hospitals.

Thus, the task of the GBA included conducting specialized treatment of wounded evacuated from the combat region and keeping in the GBA hospitals those who should complete treatment within 30-45 days. Moreover, the GBA task also included preparation of all other wounded to evacuation to GBF (base hospital at the front) for further treatment and evacuation to the rear. One must note that the number of beds in the GBA hospitals was increased throughout the war; for instance, in the later period, a very wide contingent of wounded were treated in conditions as close as possible to the combat operations area.

GBF (base hospital of the front) were deployed in the front rear and connected to the GBA by railway and water routes. Classification of the remaining wounded was accomplished in railway receiving areas and in more detail at SEG which were distinguished by their high capacity. Here at the same time intrahospital and interhospital classification was made. In accordance with this the wounded were distributed to specialized evacuation hospitals.

The problems of the GBF hospitals were treatment of wounded until combat capability was restored, and in a time period which would not exceed 2-3 months. Moreover, in the GBF hospitals there remained the possibility of transporting wounded who would have to continue treatment in rear treatment institutions. Classification and delivery of wounded to hospitals of GBF in no way excluded the intrahospital classification. On the contrary, here classification occurred both at the moment of receiving the wounded and when the diagnosis and course of treatment was made more precise. Depending on this, the question was finally solved as to further evacuation of the wounded to rear institutions.

The front base of the hospitals, due to their scope, were located as a rule in several populated areas, usually in cities. Evacuation classification at GBF must be done particularly carefully taking into consideration the tremendous distances in our country and the necessity involved with this of prolonged transport during evacuation to hospitals in the deep rear. Observation of classification and monitoring was accomplished by the clearing and evacuation hospitals (KEG) which existed only with very large front hospital bases.

Classification of wounded being a necessary prerequisite for specialized treatment was also done upon arrival of military-medical trains at the evacuation post in the rear of the country. The wounded who had arrived at the rear were in the final stage of evacuation where their treatment must be completed. Classification of the wounded who had arrived on military-medical trains occurred in the receiving area near the railway station and at the SEG and final classification was done at the designated hospital.

As one went deeper into the rear, specialized treatment changed greatly depending on the contingent of wounded. According to the system of classification and distribution of wounded which was used, in the rear hospitals there were concentrated particularly the wounded who required long periods of treatment and also those who would be discharged upon completion of treatment. Here wounded were evacuated with amputated extremities, with osteomyelitis, those with incorrectly healed fractures, with twisted extremities and deformations of them, with badly healed joints, ankylosis, contractures, unhealed ulcers, etc. However, in some of these wounded after various operations, not only was their work capability restored but also their combat capability.

On the whole, the entire system of specialized treatment was completely developed during World War II and could be very correctly considered as a tremendous achievement for Soviet medicine. It provided conditions for qualified care of patients, facilitated the broad use of medical equipment, made treatment means available as much as possible. This system was the further development of the Pirogov classification of wounded. Based on stage treatment with evacuation according to need, it was a prerequisite for successful surgical treatment during wartime. Only evacuation according to need with reclassification of wounded at each stage by group which combined uniform treatment measures, provided a stage treatment by speciality.

N. I. Pirogov evaluated the significance of the total preliminary examination of patients and distribution of them into groups. During classification of wounded he pointed out that a definite order in giving aid had been achieved in accordance with instructions and possibilities of effective surgical treatment at each stage. In the final analysis this "classification" led to specialized treatment. The path from intrastage classification to specialized treatment and evacuation according to need, duties and work was completed during World War II. Who among the senior physicians does not understand how during the first World War in military hospitals at the front in rows of bunks side by side there lay malaria patients, those with chest wounds, patients after operations as a result of appendectomy, those wounded in the large intestine, those with amputations of the fingers, persons wounded with amputation of the femur, etc.? There are even some advantages in this positioning of wounded and sick keeping in mind that those who are recovering or the lightly wounded can help the severely wounded, feed them and participate in changing bedding and doing other housework.

Attempts to group patients with uniform wounds, for example, face and neck, separately from penetrating wounds of the skull was done even in the first World War. Such attempts were made in foreign armies. But nowhere was it systematized. During combat actions at Lake Khasan and the Khalkin-Gol river, these attempts were begun more persistently; however, a real system was still far off.

Before World War II the most highly developed specialized treatment was achieved in Leningrad during the war with the Byelo-finns in 1939-1940. It is explained that the entire front was served by such a tremendous city as Leningrad and with its numerous clinics, institutes, exemplary hospitals directed by highly qualified specialists. But here it is impossible not to talk about a system because the existing treatment institutions were already in use. It was completely natural to send the wounded with injuries to the central and peripheral nerves to the neurosurgical institute and the wounded with gunshot fractures of the femur to the traumatology institute.

Even in World War II a system of specialized treatment was completely developed beginning with the combat region and going to the deep rear.

However, organization of the system of specialized treatment of wounds was not a purely medical measure. Although it was dictated by the state of modern surgical science, it was also closely connected to the successes of surgical treatment at evacuation stages and at the same time depended on combat and sanitation-tactical circumstances.

In the conditions of modern war, certainly not always can one require fulfillment at each stage of all of the surgical measures. The requirements of this must be limited to fulfilling the most expedient measures in given conditions for a given wound and at this stage in which they are found, then, it is necessary to take into consideration everything that was done at the preceding stage and to discover the problems of the succeeding stage. This means that no abstract surgical science could dictate the volume of aid at a given stage but that the combat conditions which determine the treatment and evacuation plan developed for a given combat operation and which change over the entire duration of the whole system of treatment at evacuation institutions of combat, army and front regions, are significant.

Documentation

From the moment of examination of the wounded patient at the MSB (or the KhPPG of the first line), it was possible to pronounce a precise diagnosis and draw up documentation in the form of a history of the patient if the wounded person did not come from the army region without delay in the combat region. Speaking of the course of the wound, it is impossible to establish in the documentation clinical observations. The stage treatment of the wound without recording in the documentation is impossible and therefore must be given primary significance in the combat field surgery. Where in peacetime conditions with treatment of the patient by various physicians and upon arrival, by one or another average medical worker, the documentation plays a very important role; during transportation of the wounded person from one medical institution to another, discovering the clinical course of the wound would be unthinkable without the accompanying documentation. Equally, generalization of the outcome of the treatment is unthinkable.

In this chapter we will consider only the documents which are basically studied in clinical practice and for treatment of the wound.

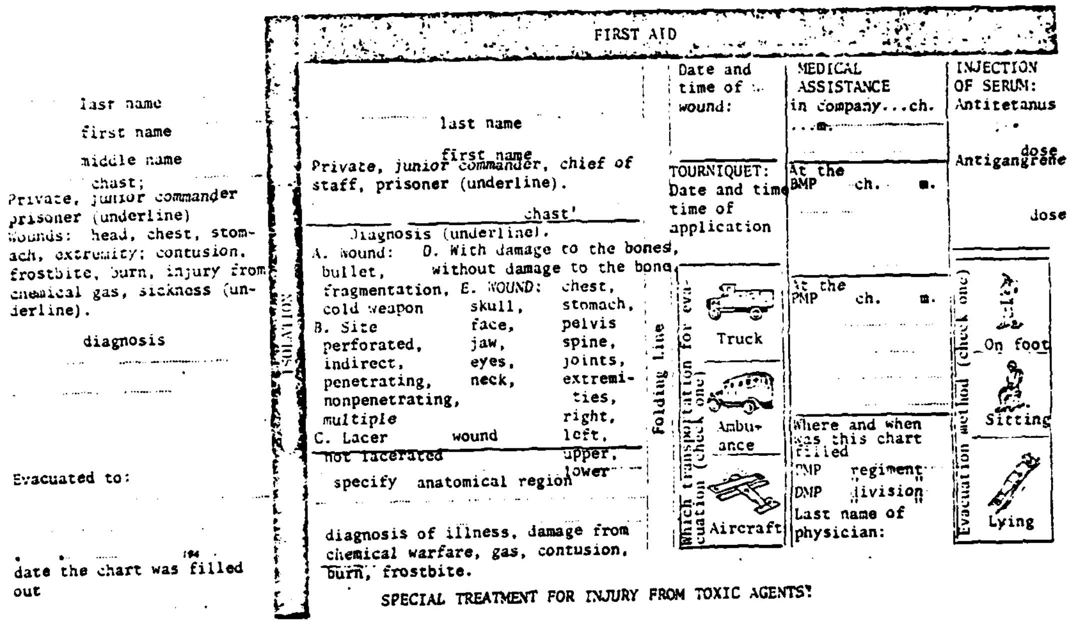
1. The medical chart from the front region (Figs. 49 and 50) is filled out when the patient receives first aid from the physician. It is essentially a brief history of the disease. It is a very important document making it possible to judge the time of the wound, the time and character of the technician and physician primary assistance, the severity of the wound and the effectiveness of the measures taken. An evaluation of the initial period of the wound is based on this document which accompanies the wounded patient during his treatment.

2. History of the illness. The history of the illness is the basic document. It accompanies him everywhere when he is evacuated and to any treatment institutions where he may stay. The history of the illness is compiled for a single injury. It reflects the course of the wound process from the moment of its occurrence to its final outcome. During wartime in each hospital where the patient is sent, a new sheet is added to the history of the illness without making any changes: this is a new insert which adds to the history of the illness and which stays with the patient.

3. Additional documentation are X-rays, reports of laboratory studies, etc. and these make up part of the history of the illness. The envelope evacuation card (Fig. 51) is used not only for packing the sheets but includes a transport notation for the patient.

4. Operation log. It includes not only a detailed description of operative intervention listing its sections but also gives information on the most recent results at any treatment institution.

5. A book with records of surgery. In it the special features of the wound, the operative interventions and a brief analysis of the wound and its latest treatment are recorded. Moreover, every day a list of information is recorded in the book with a compilation of monthly reports.



last name
first name
middle name
chast;
Private, junior commander
prisoner (underline)
Wounds: head, chest, stomach, extremity; contusion, frostbite, burn, injury from chemical gas, sickness (underline).
diagnosis

Evacuated to:

194
date the chart was filled out

FIRST AID

last name
first name
Private, junior commander, chief of staff, prisoner (underline).
chast'

Diagnosis (underline).
A. Wound: bullet, fragmentation, cold weapon
B. Site perforated, indirect, penetrating, nonpenetrating, multiple
C. Lacer wound ~~not lacerated~~
D. With damage to the bones, without damage to the bone
E. WOUND: skull, face, jaw, eyes, neck,
chest, stomach, pelvis spine, joints, extremities, right, left, upper, lower
specify anatomical region

diagnosis of illness, damage from chemical warfare, gas, contusion, burn, frostbite.

Folding Line

Date and time of wound:

TOURNIQUET: Date and time time of application

Which transportation for evacuation (check one)
Truck
Ambulance
Aircraft

MEDICAL ASSISTANCE
in company...ch. ...m.
At the BMP ch. m.
At the PMP ch. m.
Where and when was this chart filled
PMP regiment
DMP division
Last name of physician:

INJECTION OF SERUM:
Antitetanus
dose
Antigangrene
dose

Evacuation method (check one)
On foot
Sitting
Lying

SPECIAL TREATMENT FOR INJURY FROM TOXIC AGENTS!

Fig. 49. Front region chart.

Recording of the Following Stages of Evacuation

Date and time of arrival	Stage	Date and time of departure		Date and time of arrival	Stage	Date and time of departure

Aid given (type of operation)

Sent to
Last name of
the physician:

FOLDING LINE

Aid given (type of operation)

Sent to
Last name of
the physician:

name of the treatment institution
where the outcome is entered
Outcome:
Return to chast' for combat, noncombat, sent to battalion recovered, released on leave, discharged (check one).

Died 194
From
Buried
Last name of
physician:

SPECIAL COMMENTS
BY THE PHYSICIAN

Fig. 50. Reverse side of the front region chart.

6. Chart of the sections. This document is filled out upon death at any stage and is very important for evaluating the character of the wound and the treatment measures.

Besides these documents, for studying the wound sometimes one encounters the necessity for using a number of other chiefly monitoring and comparing evaluations of data - a book of records of the wounds, a dictionary of wounds, a manual on dressings, a manual on blood transfusion, orders for evacuation, etc. Also the classification notices mentioned above are attached to the document.

A very important document is the record of the surgeons. In the first years of the war these reports were compiled according to calendar date and only in the second half of the war was it deemed necessary not only to separate the calendar periods of certain military operations but also to compare them appropos of a given combat operation. One should note that the records not only of the front and the army surgeons but also of the chief surgeons of division hospital bases and hospitals are of particular interest and require serious study.

The report data in most cases was not purely statistical; it contained an analysis of the materials obtained and was the basis for reports at conferences of the army, the fronts or the rear bases. These reports were also of great assistance in studying the surgical experience of World War II.

These reports were used when compiling most of the work published in surgical journals and manuals during the war.

During the war also a large amount of illustration material was accumulated: photographs, drawings, preparations and documentary films.

Difficulties in collecting these documents in a military region are sometimes extremely great but they were sent so that the accumulated material could reflect as objectively as possible the experience of World War II. What has been said gives us an understanding

ENVELOPE-EVACUATION CHART

Form No. 6

1. Last name ____________ First name ____________

   Patronymic ____________ Military title ____________

2. Diagnosis ____________________________
   (write in Russian)

3. Sent to ____________________________
   (name of hospital and department)

4. How and by what transport means ____________ is the person evacuated ____________

5. Special instructions ____________________________

____

(name of the hospital) ____________

____ ________________ 194

Signature ________________
(write the last name of the physician clearly)

Reverse side

Name of the institution	Date		Name of the treatment institution to which the person is evacuated
	Admission	Discharge	

Fig. 51. Envelope-evacuation chart

of the requirements which face the military and medical service of the Armed Forces for fulfilling these documents: not doing this would have been the same as not giving aid to the wounded.

Changes in the General State of the Wounded

The general condition and feeling of well being of the wounded patient changes sharply in the first hours and days after the wound occurs with an excessive blood loss, shock, asphyxia (open pneumothorax), irritation of the peritoneum, infrequent, rapidly occuring forms of anaerobic infection and in general, with severe wounds.

In the absence of these phenomena, the overwhelming majority of wounded in the first days after their occurrence and surgical assistance, slept for a large part of the time. This tendency to sleep, undoubtedly, is a reaction of the organism to the transfer from a stress state which it has undergone during combat assignments to a state of relative calm in conditions of the treatment institutions.

Soon after the wound occurs, the wounded persons suffer from thirst which is easily satisfied if the blood loss is not great. An increased appetite with the favorable course of the wound process is apparent by the third to fourth day after the wound occurs.

Only those who are very lightly wounded undergo no temperature reaction or appropriate changes in cardiac activity and state of the blood. As a rule with all wounds with damage to the skin and deeper damage, temperature rises after a few hours. With noncavity wounds the first rise in temperature is noted only on the day the wound occurs or on the following day. Further, in the following 3-4 days, the temperature continues to rise giving a typical curve with morning drop and evening rise. However, in the absence of severe infeccious complications the temperature does not exceed the usual 38.5°. Beginning on the fourth to fifth day, the temperature curve shows a tendency toward a decrease; at the end of the first week, rarely later than 10-12 days, the temperature reaches a normal level and in the absence of new complications does not rise further. Evacuation of wounded with elevated temperatures often prolongs the indicated time periods even with satisfactory immobilization and transport with good shock absorption.

The question of causes of fever in wounded persons, includir postoperative patients, arose after the introduction of methods of antiseptics and aseptics because up until then, the postwound fever was considered an unavoidable result of the wound. It was noted that when the wound healed even without clinically noted local inflammatory reactions, the temperature can be elevated for several days. In a number of studies it has been established that absorption of the products or protein decomposition, autolysis in particular, absorption of hemotomas in blood which impregnate the tissue involve an increase in temperature in the wounded persons and in postoperative patients. However, with the passage of time, it was discovered that sterile wounds are almost nonexistent and the majority of studies have concluded that the microorganisms in the wounds and their vital activity, causing an increase in breakdown in tissue and themselves forming "pyrogenic" products, are an etiologic factor causing resorption fever during the clinically smooth course of the healing process.

Observations showed that a fever-less course of a postoperative period after small aseptic operations is very rarely encountered; gunshot wounds themselves rarely occur without temperature. It is completely obvious that injury to the tissue during operations cannot be compared with trauma from a gunshot wound. In the latter case, due to the use of penicillin, the postoperative period in patients has begun to occur without fever or with insignificant or short-term elevations in temperature. Penicillin does not cause resorption of the decay products but clearly inhibits the life activity of microbes; it is again confirmed that the wound microflora are part of a factor playing an important role in the elevation of temperature in the wounded.

If one excludes the excessive blood loss and appearance of shock, then one does not observe in gunshot wounds a disturbance in functions of the cardiovascular system: pulse rate usually corresponds to temperature. Mass measurement of blood pressure done during the war in a number of DMP in order to discover signs of shock, indicated that uncomplicated wounds do not cause a drop in blood pressure or in general it corresponds to blood loss and is rapidly equalized. The wound does not occur without change for the organism and undoubtedly is reflected in the functions of the internal organs of the wounded person. For the first time in the history of wars, these changes were studied in such detail that at the present time, they are the basis for developing a general regime for the wounded which up until now has been done only empirically. However, it should be noted that N. I. Pirogov even in the Sevastopol' campaign treated the wounded both as an attentive and responsive physician and as a scientist who was taking into consideration all of the functions of the organism. He indicated a very basic line of behavior and relation of wounded and workers in the military and medical service.

Information on reactions of the blood, exchange of substances, etc., are presented in special sections.

The clinical course of a wound which is not complicated with severe infection depends on the degree of damage which occurred with the injury and its location and character. The character and type of surgical intervention when rendering first aid plays a very important role in the progress of the wounded person. The surgical treatment in turn depends on the diagnostics of the wounded and classification of the wound.

Groups of Wounded

The wounded are divided into groups according to the location of the wound and also in accordance with special characteristics.

Among those wounded in battle is a group of wounded with contusions, that is, those whose skin covering has not been damaged.

Wounded, that is, those with damage to the skin, are divided into those who have received simple and those who have received multiple wounds. In the latter case one or several regions of the body may be damaged by two or more bullets, by two or more fragments.

Combined or associated wounds are those where the same bullet or the same fragment damages two different areas of the body, for example, the chest and stomach, femur and stomach, hand and chest, etc.

The type of wound is specified by the weapon causing the wound and these are divided into cold weapons, wounds from bullets, fragments, mines, etc.

Further, the wounds are divided into wounds of soft tissue without damage to the bone, and those with damage to the bone penetrating into a cavity and those which do not penetrate.

The severity of the wound is very important for further direction of the wounded in combat field circumstances. The wounded, according to the severity of the wound received by them, are divided into serious, average severity and light. We have already talked about the latter group above. For this group of wounds the possibility of self care is characteristic, there is an absence of danger to life, there is a favorable prognosis and possibility of evacuation sitting up by any means of transportation including returning empty cars.

The severely wounded are those who have received cavity wounds with damage to the internal organs, gunshot fractures of the femur, wounds to the coxofemoral joint, most of the wounds to the knee, wounds to open extremities, damage to large blood vessels, those found unconscious, in a state of shock, etc.

All of the other wounded belong to the group labeled average severity. This group includes those who have received gunshot fractures of the shoulder, forearm, crus, wounds to the face with damage to the bone, part of the wounds with multiple injury, with significant damage to soft tissue. The indications for surgical intervention are of decisive importance for the further course of the wound. Even in the first examination of the damaged area and the wound, one should solve the basic question: whether or not it is necessary with any given wound to use operative intervention or primarily should conservative treatment be followed.

Gunshot wounds, according to the practice of World War II, are divided into two groups: those subjected to operative intervention even in surgical first aid and those not subjected to such treatment.

At the beginning of World War II in the medical reports, operative intervention was divided into operations conducted in order to eliminate damage to internal organs and primary surgical treatment. However, such a division was not only unnecessary but also was not used in practice because these interventions could not always be differentiated. For instance, for example operative intervention with an open pneumothorax is essentially identical to surgical treatment of the wound of the chest wall, the pleura and lungs; first amputation with removal of part of the extremity has just the same purpose and in principle, the techniques coincide with primary treatment of the wounds, etc.

Due to this, the primary surgical treatment was included in the understanding of operative intervention, and classification of gunshot wounds took on a complete form, that is, they were divided into gunshot wounds which did not need operative intervention and gunshot wounds which did need operative intervention.

Inasmuch as this division was practically accomplished during mass operations, the following data can be given.

The first category of wounds (those requiring operative intervention) include all wounds which as a result of intratissue "explosion" and damage with lacerations and bruises were apparent even in the very first examination according to the following clinical signs: swelling, edema, stress on the tissue, deformation, etc. It is understood that with penetrating wounds of the skull, chest and abdomen, operative intervention was indicated. This division was retained throughout the war.

The second category of wounds (those which do not require operative intervention) include perforated bullet wounds with narrow entry and exit apertures, without noticeable swelling of the extremity, that is, without hemotomas along the wound channel, without deformation of the extremity, depending on damage to the bone. Further this category includes small wounds received from fragments of mines or hand grenades if they were on the surface and small fragments which did not penetrate deeply into the skin. Finally, here we should list certain nonperforation bullet (except for fragmentation) wounds with small entry aperture and narrow bullet course without hemotoma.

On the basis of the chart of fundamental characteristics which has been developed, one can present the following figures which characterize the practical use of this classification of gunshot wounds in World War II 1941-1945.

Of all of the wounds which are not subjected to primary surgical treatment in whatever form, one can say that 85.7% healed without complications, that is, in all those cases the diagnosis of wounds which need consersative treatment of them was correct. In 5.3%, suppuration of the wound occurred which required special intervention and in 1.4% anaerobic infection developed; in 0.2% sepsis occurred and in 7.4% other complications set in. The last category of complications in the majority of cases did not depend on the method of treatment or was related to cases in which operative intervention was not done for one reason or another. Considering the circumstances, one can state that the percent of correct identification or even just the percent of cases in which conservative treatment was correct reached 90.0%.

Let us assume that in all wounds where operative treatment was not done, 10.0% were erroneously included in this first category. If one remembers that identification of wounds at DMP was done in combat circumstances, often under fire, with a large overload and high fatigue of the medical personnel, with inadequate illumination, with frequent changes of location of the MSB, etc., then one can recognize that the number of errors was not high and consequently the classification was adequately simple and suitable for mass use.

The total quantity of wounded in the first group varied within significant limits, namely in large free material from 15.0-20.0 to 47.3%; it increased in parallel with the number of bullet wounds because a significant part of these wounds did not need treatment.

In the character of the clinical course, the wounds of the first group are similar to closed injury: a breakdown in the general condition, temperature reaction and reaction of the cardiovascular nervous systems in them to various degree.

Essentially we are saying that these wounds can be fully healed with only a primary application of bandaging. However, complex treatment (see "Treatment") required close observation of the wound and therefore these wounds must be rebandaged.

If there was no pain, wetting of the bandaging and unusual temperature reaction, then rebandaging was done very rarely. On the third to fourth day of the wound, edema and absorption of the liquid part of the blood (with unavoidable bleeding in the wound in its environs), some small tension of the tissue was apparent in the region of the wound path if it could be palpated. The entry and outgoing apertures were covered with semidried crusts; the low functional stress of the muscle became possible and there was little sickness. The skin covering on the wound apertures either remained unchanged or became red and slightly sensitive. At the end of the first week, the wound apertures were covered with dry, tightly attached scabs, the slight swelling caused by edema had decreased and by day 10-15, the scabs had fallen off; later, in the area where the wound aperture had been, one observed a reddish tender epithelial covering. The further course of the wound entirely depended on the existing damage and on the complex treatment used.

With surgically treated wounds it is easier to follow the course of the healing. In the absence of complications of severe infection which we will talk about in the appropriate chapters, the essence of the process was reflected in the sloughing off of necrotic tissue and in the development of granulation tissue.

In the absence of bleeding, primarily the secretion of the wound is not great. The tissue under the bandaging, in spite of its absorption properties, remains moist. The bottom of the wound may be covered with layers of gauze which adhere tightly to the tissue in the first days. The skin edges of the wound have a normal coloration. The favorable course of the wound can be judged by the insignificant quantity of secretion and its character, by the absence of pain and morbidity in the environs of the wound and also by the general state of the wounded person in the first days after treatment. In the presence of indications for changing the bandage, it is necessary for the wound to be at rest so that only its surface layers will be disturbed and the deeper layers of bandaging intimately connected to the tissue are not moved. In order to protect the tissue from damage when changing the bandaging, liquid lubrications were used. 4-5 days later the secretion of the wound took on a suppurative character. When necrotic sections are being sloughed off it would be difficult to expect a sterile, that is, a bacteria free wound; however, as the granulation forms, the importance of the microorganisms as a pathogen for infection becomes secondary. The absence of morbidity and gradual drop in temperature to normal, a normal picture of the blood, force one to assume that microorganisms in the wound are alive only on the surface. Therefore, the development of "healthy" granulation along the entire surface of the wound was the main stage in its healing. It is necessary to note that in severe wounds and in wounds of average severity, as a rule, one observes a drop in the percent of hemoglobin which was returned to normal at the end of the first month after the wound occurred.

CHAPTER III

TREATMENT OF GUNSHOT WOUNDS

Historical Review

One cannot help but note that the main view of Hippocrates are close to the modern beliefs. Hippocrates sharply separated healing of wounds without suppuration and with suppuration; he considered the difference in the course of healing depending on the character of the wound, and required observation of cleanliness when treating wounds.

He required that the bandaging material be clean and used wine for irrigation of the wound. Hippocrates was distinguished by his great observation capability: he directed attention to the fact that a wound does not form pus if it does not come into contact with the fingers. Of course, all these proposals which are so similar to modern aseptics but separated from it by many centuries were based only on observations and were not scientifically founded but they could be developed further. Five hundred years after Hippocrates, these positions were defended by Cornelia Tsel'z. However, new active methods of surgical intervention or treatment of wounds were added to them: establishing blood pressure and applications of ligatures even double ones with intersection of the vessel between the ligature, application of sutures in order to decrease the dimensions of the wounds. 150 years later, Klavdiy Galen was already on the path of active intervention in the process of healing wounds - he attempted to directly close the edge of the wound and identified the development of a bony callous. In order to stop bleeding, Galen used torsion of the vessels, pressure of the bandages, incandescent iron and ligatures.

A later representative of the classical Greek-Roman school was the Byzantine Pavel Eginskiy who is well known as the first physician who described removal of a bullet from a wound and ligature of the vessels preventing bleeding. In general surgery of the vessels was developed by Pavel Eginskiy for a modern level of knowledge in great detail.

It is important to note that all the representatives of the Greek-Roman classical school for treatment of wounds did not forget the therapeutic measures of a general character and judging from their reports, they were proponents of it to stimulate the appearance of vis medicatix naturae.

From the beginning of the Middle Ages, in medicine including in surgery, superstitions characteristic for the Middle Ages came in involving religious superstition and belief in the force of the "devil." In ancient times treatment of wounds and the wounded, particularly the latter, were based on thought and observation and not on theoretical conclusions. The Greeks and the Romans used ways and means which they had observed useful and the doctors of the Middle Ages used those, which in their opinion, had to be used due to mystical superstition. The absence of effect was due to mystical causes which are absurd from the point of view of modern knowledge.

The accumulation of facts and observations in the Middle Ages was extremely slow. As is known, there was a time when the leading role was played at this time by an Arab scientist (Abul'kas). Later on, in the works of Theodorikh and in particular, the works of Mondevillya, a partial return to the principle of treatment of wounds presented by Hippocrates was noted. However, new observations were added to his and essentially ligature of blood vessels was introduced which had been forgotten at this time (Ambrose Pare) and attempts were made to treat wounds with diet. Gunshot wounds which appeared in the fifteenth century required particular study. However, the entire history of treatment of wounds right up to the eighteenth century contains more attempts to treat wounds in military conditions than just treatment because for treating wounds it is necessary to have anatomical and physiological information and also an acquaintance with the basics of pathology. However, life did not lead one to expect continuous wars which required treatment of wounds. The development of a military field surgery depended not only on the development of surgery but also on the development of military medicine and therefore as military medicine was formed, military and field surgery developed. Physicians and surgeons always participated in war.

Knowledge of military surgery in war was highly evaluated even by Homer in the Iliad, talking about Makhaon. The army needs a medical service not only in wartime but also on a day to day basis for constant maintenance of its combat capability at the required level. A number of systematically conducted measures can be used to solve this problem; these measures are vital only in cases where they exist, taking into consideration all aspects and peculiarities of combat activity when they were organized involving fulfillment of combat assignments, that is, when not the work of separate physicians is involved, but of the entire military and medical service carrying out medical measures on the basis of medical medicine one of whose sections is military and field surgery.

The pioneers in military field surgery as a set of special devices for combat conditions for surgical measures are the surgeons and organizers who participated in wars at the end of the 18th and the beginning of the 19th centuries, who considered the basic problem of organization and sugical assistance for the wounded. The creator of the military-field surgery as a science and the branches of surgery is N. I. Pirogov who must in all truth be called the founder of modern military-field surgery. He was the first to point out how one must treat the wound and the wounded in wartime. It is characteristic that even having the experience of the Caucasus expedition and then that of the Sevastopol' campaign, it was only after 10 years that he wrote and published his work entitled Nachala obshchey voyenno-polevoy khirurgii [Beginning of General Field-Military Surgery] and then added to his hypotheses, starting with experience in more recent wars in which he was only an observer. Other works are entitled Otchet o poseshchenii voyenno-sanitarnykh uchrezhdeniy v Germanii, Lotaringii i El'zase 1871 g. [Report on Visiting Military-Sanitation Institutions in Germany, Lotharingia and Alsace, 1871] and Voyenno-vrachebnoye delo i chastnaya pomoshch' 1878-1879 gg. [Military-Physician Activity and First Aid 1878-1879]. The latter work by N. I. Pirogov is particularly important. In this work, N. I. Pirogov notes that the basic beginnings of field surgery laid out by him on the basis of experience in the first two wars in which he participated were confirmed in the next six wars. N. I. Pirogov counted 12 basic premises. We will consider some of these below.

The basic position of N. I. Pirogov that war unavoidably is accompanied by a "traumatic epidemic" indicates that he considered the problem of combating this epidemic as an organizer because it is impossible to combat a single epidemic if the role of the physician is limited only to treating patients.

In his second position, N. I. Pirogov pays a great deal of attention to the special features of wounds and their relationship to different types of firearms. This position deserves particular attention because the character of the wounded changed with time. Wounds with a cold weapon which a hundred years ago were significant, with each succeeding war have decreased more and more and the role of artillery has increased. But artillery fire is changing: the number of shrapnel wounds in the Russo-Japanese war of 1904-1905 was very significant; there were few of them in World War I and in World War II these wounds had almost disappeared and they have been replaced by fragmentation wounds. Injury from fragments of aviation bombs and mines increased sharply in comparison with World War I.

The third hypothesis of N. I. Pirogov: "Without orderliness and a correct administration, there is no utilization of a large number of physicians and if there are not enough physicians, then a large number of the wounded will remain without help." "I believe," writes N. I. Pirogov, "in the experience that in achieving favorable results in military-field hospitals, it is necessary not so much to have scientific surgery and physician proficiency inasmuch as it is necessary to have good institution administration." Modern military-field surgery is based on scientific surgery and physician organization. In its essence, as a result of this, it occupies an independent position among the other medical disciplines. For surgical work in peacetime, the organization of treatment is also important but being established once it remains unchanged. In the military-field conditions, organization of treatment depends primarily on combat circumstances which cannot always be predicted; decisions on treatment in combat-field conditions often have to made rapidly.

The fourth position of N. I. Pirogov at the present time is of particular significance. Looking over the "economical treatment," N. I. Pirogov anticipated the main problem of modern surgery - prudence in relation to tissue and organs and limitation of crippling operations. N. I. Pirogov applied this principle of surgical treatment to military-field surgery. N. I. Pirogov gives operative intervention a basic position in the total complex of all treatment measures taken for establishing the health of the wounded.

The fifth, sixth and seventh positions of N. I. Pirogov discuss the concentration and distribution of wounded. As a result of further development of surgical science, in particular, the introduction of aseptics and antiseptics, the method and means of combating complications of the wounds changed considerably and therefore significant changes have occurred in the measures for combating these complications. Moreover, in view of the development of a stage treatment with evacuation according to the express purpose on which the measures put forward by N. I. Pirogov were based, they have lost their importance.

The eighth position of N. I. Pirogov, classification of the wounded, was put into practice at each combat medical institution of the Soviet Army. We discussed this earlier and indicated the forms which have come from the Pirogov position.

N. I. Pirogov's ninth through eighteenth positions relate to treatment of the wounded: in them, N. I. Pirogov considers that treatment of the wounded should use all of the achievements of surgery of its own time.

In his nineteenth position, N. I. Pirogov discusses the statistics and the mortality rate of wounded; the twentieth position (first aid to the wounded in combat) we have completely dropped.

The positions of N. I. Pirogov were further developed in World War II and underwent a number of changes but in principle, they are the basis of Soviet military-field surgery. These principles were established almost a hundred years ago and became widely known 80 years ago. They were developed on the basis of experience in the last wars but carrying them out fully in conditions of mobility and land owners in Tsarist Russia was impossible to the general political conditions. In particular, the correct positions on physicians in the army could not be taken; organization and evacuation were taken out of the hands of the physicians and there was no unified organization for caring for the wounded.

The name N. I. Pirogov, creator of modern military-field surgery, has become honored by our people; it is one of the names which will never be forgotten. N. I. Pirogov lived and worked on the eve of the introduction of antiseptics and aseptics into surgery; his relationship to wounds reflects the achievements of medical science in the preantiseptic period.

Surgical activity when treating gunshot wounds in the nineteenth century was very high. For instance, Larrey during the Borodin battle had performed 200 amputations in a single day. All operative interventions during the wars with Napoleon were done without anesthetic. N. I. Pirogov during the wars in which he participated, introduced narcotics which broadened the scope of action for surgeons much more. However, the concept of the so-called "economical" treatment which was envisaged by N. I. Pirogov ended in forbidding amputation in all cases where another noncrippling operation could be used to save the extremity. The "economical" treatment of N. I. Pirogov was opposed to treatment by amputation which was extremely widespread before N. I. Pirogov. When the question of amputation came up, N. I. Pirogov transferred the center of severity of treatment from "operations sucessfully made to the correct organization of economical treatment for the wounded ... ." One can understand N. I. Pirogov, the great surgeon and technician, authority on anatomy, if one pays attention to the results which were "the rule" at this time. One can understand the tragedy of N. I. Pirogov as a surgeon who knew that although the operation was technically brilliant, anatomically correct, its results in mass use would produce a high, terrifyingly high, fatality rate. The cause for this complication in the time of N. I. Pirogov was the serious clinical course of wounds in the postoperative period, nullifying all the achievements of surgical technology. Methods of combating infectious complications "miasmas," that is, methods of aseptics and antiseptics were still unknown. Amputation of the femur resulted in a fatality rate of 50.0 to 80.0%; primary exarticulation of the femur had a fatality of 98.0%; secondary - 83.0%; exarticulation of the shoulder - 72.0%. This lead to despair!

Along with surgery, combat equipment developed which reflected the character of the gunshot wounds. At the end of the past century rapid fire weapons and small caliber armored bullets appeared. Antiseptic and aseptic surgery for wounds with these bullets gave the best end results in treatment and therefore the new bullets were ascribed "human" properties.

The "humanity" of the bullet wounds was at its height during the Russo-Japanese war of 1904-1905. Confirmation data were introduced not only in the surgery departments based on their experience but the chief surgeon of the Manchurian army, Professor R. R. Vreden sent the appropriate reports to the press and also to the Surgical Society of N. I. Pirogov.

Nevertheless, the relationship of surgeons to firearm bullets continued very early to be conservative: operative intervention was done only for vital indications in order to stop hemorrhaging, mainly due to complications.

The Russo-Japanese war showed the unsatisfactory nature of organization to assist the wounded in war and again questions arose in medical medicine which N. I. Pirogov has posed 50 years earlier and whose solution under the Tsarist regime was impossible. The necessity arose for general organization standards for the medical service. Every attention was given to P. I. Potiralovskiy's dissertation entitled "Tyurenchen-Vafangou-Lyaoyan on Sanitation and Tactics," and a number of journal articles. A government commission was assigned under the chairmanship of Lieutenant General Trepov whose proposals, as modest as they were, did not meet cooperation from the government, particularly with the revolutionary rise of 1905 and subsequent reactions. Military physicians remained outside of this "administration," which in Pirogov's opinion, is decisive in giving assistance to wounded in battle.

As a result of the experience of the Russo-Japanese war, transportation was improved for wounded and also transportation tires; X-rays were used for diagnosis of wounds for the first time, moreover, the volume of material on injury to the vessels (false aneuisms) and peripheral nerves were collected and processed much more than in past wars. The question of prosthetic devices made some progress, however, the general results reached during this war in the military-medical field were not great.

When looking at the surgical treatment of gunshot wounds in World War I 1914-1918, it is necessary to take into consideration the general level of surgery in all of the fighting countries immediately before the war.

Aseptics and antiseptics opened up new fields and new horizons for surgical treatment. The abdominal cavity where only at times the most daring considered intervention became the arena for everyday operations achieved by any surgeon. General intervention because of tumors in organs in the abdominal cavity became possible. The mortality rate with operative intervention decreased with each year. The number of inflammatory complications in wounds operated on was not great. Suppuration, if it occurred, only delayed healing, and did not significantly change, as a rule, the mutual relationship of tissue which was achieved on the operating table. Besides the development of gastrointestinal surgery, surgery on the biotracts and the parenchymatous organs came into general surgical practice. New branches of surgery appeared: neurosurgery, operative urology, oncology, which became the contours for separate specialities. All operative surgery required reconsideration. Trauma to the extremities which previously had been a focus for the attention of surgeons, was reconsidered in the light of cavity surgery according to the newest plans; from operations on the extremities, the attention of the surgeons was attracted to operations of a restoration type, transplants, etc. Providing aseptics for operations made the use of antiseptic substances almost excessive.

Endoscopy, roentgenoscopy, roentgenography and laboratory methods of research were developed to assist surgery.

And it was just at this period of significant successes in surgery that the first world war broke out - a war on a completely unexpected scale. From the very first days of the war, the surgeons in all of the combatant nations were deeply disappointed. It rose again but more with a sense of tragedy described by N. I. Pirogov at Sevastopol'. Wound infection spread tremendously; no one knew anything about the bacteriology of wounds; surgeons were helpless in fighting massive complications. Suppurative complications accompanied all severe wounds. Wounds of the femur, large vessels, even the shins began to have exceptionally high fatality rates. But it was even more discouraging that infection in many cases complicated wounds much earlier than the wounds which were operated on in surgery. Moreover, as always in war, damage to the extremities was predominant and this was a field once more where surgeons, when most of the surgeons were young, generally had no experience. The congresses and conferences held during the war for surgeons showed the extremely unfavorable prospects for treatment of wounds.

It became clear that it was necessary:

1) to change organization of first aid for wounds and more surgical intervention closer to the location where the wounds were occurring;

2) to study the conditions for the occurrence and development of infection in gunshot wounds and to establish its pathogens;

3) to find new treatment ways and means for prevention of infection as well as its treatment.

In the West, the conditions for waging war made solution of the first question considerably easier. A dense network of highways and railways, an abundance of rolling stock and an adequate quantity of vehicle transport facilitated this. Aviation at this time interfered very little with the movement of troops and was rarely used. It is not surprising here that there was less difficulty in organizing timely delivery of the wounded to the treatment institutions. Here it is significant that the administration-medical assistance was combined and put into the hands of the physicians.

Operation in the Tsarist army was completely different. There were few railways and highways; the dirt roads were poor; vehicles for evacuation of wounded were inadequate. But this was not all. With good organization it would have been possible to overcome these difficulties, the most important of which involved inadequate organization of the medical service in the Tsarist army. A unified medical service did not exist Besides the military-medical service in the army, there were a number of other independent organization including: the medical service of the Red Cross, the Zemstvo union, the city unions. These organizations were independent not only of the medical service of the army but also of each other. Basically the separate teams and hospitals also suffered from a lack of competent personnel.

Therefore, the maneuverability of medical institutions was difficult, the "teams" and hospitals were either overloaded or without work. In all organizations including the military-medical service of the army, the physicians were eliminated from the administration and organization of work. The head of a team, a railway, hospital, station, was always either an officer unsuitable for combat action or discharged from it or in all of the relationships mentioned, was only "authorized" by the appropriate organization.

A number of outstanding Russian surgeons, most often on their own request, participated in the war but only in treatment work. Some of them were used as consultants. For instance, Professor S. P. Fyedorov was on the staff of the Supreme High Command. N. A. Vel'yaminkov could not find any kind of definite assignment. V. A. Oppel' moved from front to front, using his authority in order to do something; sometimes he was successful and sometimes, as on the Caucasus front, all of his efforts were useless. N. N. Burdenko, S. R. Mirotvortsev, N. N. Petrov, A. P. Krymov, K. M. Sapezhko, V. N. Shevkunenko (in the Red Cross), V. I. Tomashevskiy, A. L. Pavlovskiy and others worked separately in different institutions at the fronts.

Each of them could have and did have results which were not bad in their own work but this was a mere "drop in the bucket." A majority of experienced surgeons worked in the front rear. In the forward institutions there was no one to direct the surgical service.

Russians surgeons and Russian physicians at this time had high qualifications and knowledge of their work but they could not produce the desired results. Even N. I. Pirogov recognized that with the general orders reigning in Sevastopol', he could not produce what he was capable of. The ranks in the army at the time of the First World War in Russia changed little. The only outstanding success were the "consultants" who were mentioned above who made efforts which were sometimes successful in directing the surgical work. The activity of V. A. Oppel' and N. A. Vel'yaminov deserve particular recognition; their names have gone down in the history of military-field surgery - the first as the discoverer of stage treatment and the second as the surgeon organizer who clearly recognized the necessity for carrying out the principles of N. I. Pirogov.

One should take into consideration that maneuvering medical means in war had never been practiced. Any type of movement of medical institutions was outside the power or competency of the physicians. If this occurred it was only as a result of being forced by complex combat circumstances. During an army attack, the medical institutions followed them; with any movement their concentration at earlier marked positions was not nonexistent and also no one established the volume of surgical work for different stages depending on battle circumstances. The directing surgeon-consultant visited these sections, giving instructions on operations for the wounded who had been admitted and gave advice and judged the treatment for severe wounds, operated and treated the "high commanders," etc. The main problem of medical organizers was evacuation, that is, sending the wounded to rear institutions.

In the treatment of jaw and face wounds, there was a certain hint of future specialized treatment. With serious damage to the mouth and jaw, the wounded person became completely helpless; at this stage he could neither talk nor eat; moreover, their faces became permanently mutilated if special types of treatment were not used. At this time, with the number of special methods for surgical treatment, the specialist could successfully improve the state of the wounded and eliminate the disfigurement of his face. Unfortunately, many surgeons did not know how to treat such wounds and continued to treat them conservatively. The results of such

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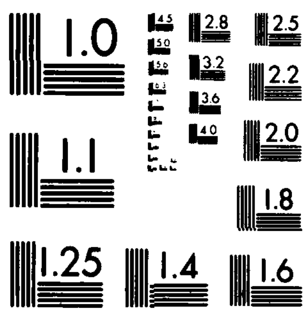

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treatment were clearly unsatisfactory. As a result of this at the rear there arose specialized hospitals for jaw and face wounds. Some of the general surgeons acquired the technique for helping these wounded, for example, N. N. Petrov et al.

As always, during this time the methods of treatment of the jaw and face wounds were improved and perfected. Some of the modern schools of jaw and face surgeons arose from this work.

By 1916, the position of the wounded and their treatment had become so intolerable that at the XVI Congress of Surgeons in Moscow, Professor N. A. Vel'yaminov presented a report in which he outlined the dismal picture of evacuation and treatment of wounded in the country and demanded that the work be put into the hands of physicians and also that all organizations which participate, be combined. However, no reforms in medical work were made right up to the Great October Socialist Revolution when the very basis of our country was changed. The Red Army was developed soon with its medical service.

In accordance with the general structure of the Red Army as a national army, first aid and treatment of wounded was developed during the war.

The basic feature of the new medical service was unification within its framework of all medical assistance of the army and their direction and responsibility was put in the hands of the physicians. Our problem was to develop first aid and treatment of wounded in wartime on the basis of new organization methods based on effectiveness of surgical measures. Essentially the work was creating a modern military-field surgery and military-medical work.

The total work in the field of treatment of wounds during the First World War was formulated in the following manner:

1) gunshot wounds are infected (the authors at this time did not differentiate between microbe contamination and infection) and therefore surgical intervention is necessary in the first 6-12 hours;

infection of wounds in wartime required special new measures for prevention and treatment;

2) the overwhelming majority of wounds in war are wounds of the extremities in which, besides operative intervention, immobilization is very important;

3) wounds of the abdominal cavity require immediate operations;

4) wounds of the chest are treated conservatively;

5) those who have received jaw and face wounds and damage to the brain need special attention.

The former conservative approach to gunshot wounds was unthinkable. This is particularly dangerous as far as the development of serious infections is concerned from fragmentation wounds with damage to the skin. Intervention because of infection which has developed, sometimes even amputations, clearly were delayed. It was clearly necessary to prophylactically open the wound adequately and drain it. But experience showed that this did littl^ good, that infection set in in very serious, often fatal, forms. They turned to antiseptics, however, all of the antiseptic means known to surgeons then were inadequate and little used. As a result of numerous studies and experiments, the following three basic methods of combating infection occurred.

The first method involved combining the draining of wounds with the effect of antiseptics on the wound surface. This method was called a method of continuous irrigation and was developed by Carrel, and the antiseptic fluid was made up by Dakin. The method was called the Carrel-Dakin method. However, even N. I. Pirogov had used bleaching powder and constant irrigation.

Incisions were made in the wounds, pockets were opened up, they were drained and when desirable, countermeasures were used which the French called débridement (removal of foreign material and contaminated tissue); here it was used to eliminate any obstacles to the free outflow of the wound secretions. This term was adopted in English literature; it has been used by some of our authors for some time.

After this preparation, thin rubber drains were put into the wound with lateral apertures connected to a glass main tube. In order for this system to be effective, a large container with a solution was placed on a bracket by the patient's bed; from it a solution was fed into the main tubing and through the small tubes, irrigating the entire surface of the wound. The rate of flow of the fluid was 20 drops per minute. The wound was loosely filled with gauze, and continually moistened with liquid; the edge of the wound was protected from the irritating effect of the fluid, lubricating it with a thick layer of vaseline. The wound was either constantly under the effect of the fluid or periodically (every half hour, hour) it was irrigated through the same system of tubing from a syringe. Periodic irrigation was used when for some reason one could not use constant irrigation.

As a result of this treatment, in the wound, in the opinion of the authors, sloughing off of the dead tissue occurs and a good granulation covering develops; bacterioscopic samples when studying a draining wound (wound impressions), indicate that the quantity of free microbes is decreasing and that of the phagocyte is increasing. When microbes in the wound become insignificant, that if in the field of vision there are only isolated microorganisms, then one can bring together the wound edges or apply a secondary suture.

When putting this method into practice, the results of treating the wound, in the opinion of many physicians, has greatly improved. This method found proponents on our front. Later on, instead of the Dakin fluid, we successfully began to use more stable solutions of chloramine, pantosept and other antiseptics. K. M. Sapezhko introduced a "washing," that is a periodic irrigation with 0.25-0.5% solution of iodine in 30° alcohol with a 1% potassium iodide. As a result of a number of proposals in the West, we changed and improved both the method of irrigation and the antiseptic solutions.

A second method differing basically from the first was proposed by the Englishman Wright. This author studied in detail the process of transfer of microorganisms from the wound to the tissue and concluded that with a high concentration of irrigation solution, due to the difference in osmotic pressure, an excess generation of lymphatic fluid occurs in the wound and a sort of washing of the lymphatic system of the tissue; then not only is absorption of microbes and products of their life activity made difficult, but also they are even given off from the tissue. Wright proposed introducing tampons moistened in a 10% solution of sodium chloride into the wound. The Russian authors who used this method were V. A. Oppel', A. P. Gubarev, V. M. Nazarov, N. N. Samarin, A. A. Opokin, et al.

The use of a hypertonic solution undoubtedly gives favorable results. The method was widely used but it never acquired universality.

A third method, putting it briefly, attempted to solve the problem of treatment of infected wounds and included search for new antiseptic means which would have bactericidal properties but which would not damage the tissue of the wounds. Then the possibility was proposed not only for affecting the surface of the wound but also impregnating the tissue with a solution in order to decrease those microorganisms which had sucessfully penetrated into the tissue. In this way work was done on the so-called deep antiseptic. An example of such preparations was quinine which killed malarial plasmodia without damaging or at least damaging only slightly the blood cells. The first preparations used for deep antiseptics were optochine, vuzine, etc. Later acridine compounds were used (aneline dyes). The most widely known of these is Rivanol; it is even used at the present time as an antiseptic means. However, all of these substances did not solve the problem of deep antiseptics because their effect on the tissue was far from indifferent.

The quantity of different substances proposed and used for treating wounds is tremendous. Most of these did not have basic importance and while their use was accompanied by a certain success in the hands of their authors, this was explained not only by the effect of the means being tested as much as it was the thoroughness of care of the region during observation of the effect of the test preparation.

One should remember that the use of balsam and oily substances including liquid vaseline became very widespread during the first World War. Besides this, one can add other antiseptic substances and they themselves covered the delicate granulations and protected them from harm, made bandaging easier and gave the tissue a rest. Finally, during the first World War, combination use of surgical treatment and physical therapy procedures were begun; in World War II this was developed into a system of complex treatment of wounded.

At the end of World War I, experimental studies by Friedrich had been remembered; these studies were made in 1898. On their basis one could propose that the affected contaminated base of the wound being removed like a malignent tumor during the first six hours after contamination when infection had not yet successfully spread outside the wound, could even be permanent protection. A deep suture is not an obligatory final act for an incision; if there is any doubt as to the sterility of the wound, it must be protected partially or even left open. Of course with deep suturing of the wound, it will heal in the shortest time possible and this is very important.

The method described for excision was rarely used during the first World War.

After the war, the method of excision became generally recognized when treating production, household and street wounds; the method of excision was mastered by many surgeons. The successful results obtained when studying wounds in peacetime caused the use of this method in combat conditions for combat encounters on the Khalkin-Gole river in 1939. Here it was found to be a failure.

First of all, one very rarely encountered wounds which technically could be excised. Where attempts were made to do this, the operations took so much time that most of the wounded remained without any assistance at all. The excision in the suitable cases was so incomplete that there was not even any talk about suturing the wounds.

However, the practice in peacetime had become such a habit for the surgeons that they continued to use it in combat conditions and in a number of cases, very incomplete "excision" of the wounds with subsequent suturing of them led to severe infectious complicatons and made it necessary to forbid excision of wounds with subsequent suturing of them except in specific cases (for example, suturing after laparotomy, suturing of the open pneumothorax, etc.).

With these data, the Soviet physicians came to a period where military conflict in different parts of the world had begun to break out and expand into a war involving almost all of mankind.

The Italian Abyssian War of 1937, the aggression of the Japanese in China had not produced any new medical contributions.

More promising in this aspect was the Civil War in Spain in 1936-1938. The most impressive result was long-term deep gypsum bandaging applied without a base on the wound on extremities on damaged bone. Application of deep gypsum bandaging was adopted as an "innovation," and its proponent and propagandist Trueta recognized N. I. Pirogov as its founder; nevertheless he described it as a new method. In this connection one could cite the well-known work of N. I. Pirogov Voyenno-vrachebnoye delo i chastnaya pomoshch' na teatre voyny v Bolgarii i v tylu deystvushchey armii v 1877-1878 gg. [Military-Civilian Work and First Aid in the War Theater in Bulgaria and at the Rear of the Active Army in 1877-1878], St. Petersburg, 1879:

"I also note that the application of my (emphasis by the chapter author) gypsum bandaging has become a general requirement in Germany so recently, in the Franco-Prussian War, that its own recentness as I propose, has not yet proved itself here. It is known that the deceased and esteemed Shtromeyer who also participated in the war in '70-'71 was a strong proponent of the gypsum bandagings; as to the French and English, they don't like anything foreign; the Italian physicians also did not require gypsum in the war of '59. Also there is talk in favor of the Lister bandaging which cannot be compared with the gypsum bandaging, but is still 'vidibimus'" (let us see) (page 194).

It is completely clear from these words that gypsum bandaging was proposed by N. I. Pirogov and that the application of gypsum bandaging for gunshot wounds in wartime was first used by him.

The combat on Lake Khazan and even more on the Khalkhin-Gol river and other special features of the war with the Byelofinns 1939-1940 were of particular importance in preparing for treatment of gunshot wounds in wartime. First of all, here the organization of our military-medical service was tested in which a number of improvements were made making it easier for the medical directors of the army and the fronts to maneuver the medical means and to put in reinforcement means for it.

The first attempts to formulate principles of stage treatment with evacuation according to use were made in 1939.

The following positions were put forward to accomplish this organization in practice:

1. It is necessary to clearly formulate a unified Soviet military-medical doctrine for all medical institutions of the combat, army and front regions of the active armies and in turn to assist in treatment of the wounded.

2. It is necessary to have a quantitative and qualitative supply to active troops of mobile medical institutions where all surgical work can be done with an obligatory hospitalization of those wounded and patients who urgently need it.

3. It is necessary to organizationally provide hospitalization, emergency aid to the wounded at the stage where they were operated on.

4. It is necessary to organizationally provide for maneuvering of field medical institutions and transportation for medical directors of the army and the front.

5. It is necessary to have specialization of the bed setup beginning with the PPG right up to the evacuation hospitals of the rear in accordance with distribution of the wounded according to the region of the body and taking into consideration the presence of physican specialists and local means.

6. The supply of beds at the rear stages in sanitary evacuation including the necessity for meeting the requirements of each stage according to medical and operative indications is required.

As we see, the requirements for organization of the medical service are precise and clear; however, carrrying them out in practice involves certain obstacles. On the one hand, organization must be distinguished by great flexibility and adaptability to circumstances but on the other hand, it must be based on solidly founded principles without which any success in treatment would be impossible, but even at the same stages, conducting it will depend on the views of the physicians, their schools, experience, etc.

Thus, one of the first and basic conditions is a unified system of medical measures correspondingly conducted at all stages. The following proposals were adopted as the basis for the Soviet military-medical doctrine:

1. A unified understanding of the origin and development of sickness, a single concept as to the principles of surgical and theoretical operation in the field of medical service.

2. Succession of treatment of sick and wounded at stages of evacuation based on a unified concept.

3. The necessity for precise medical documentation which provides a unified system and a succession of treatment.

4. The presence of a single school and single view on methods of prophylaxis and treatment of patients and wounded in the evacuation system.

5. The use of forces and means of the medical service depending on the actual conditions of combat and medical circumstances.

It is understood that the principles and methods of prophylaxis and treatment here do not remain immobile; they change and change even during a single war; however, always with a well thought out plan, with constant effort to accomplish for bed patients the most effective methods of treatment, with preliminarily tested and worked out specially selected medical institutions for this purpose. The method developed is considered before it is recommended for mass use.

A single Soviet military-medical doctrine in the field of the military-field surgery was based on the following proposals:

1. All gunshot wounds are primarily contaminated with bacteria.

2. A single reliable method for preventing the development of infection is as early as possible surgical treatment.

3. A large number of the wounded must be included in the early surgical treatment.

4. Prediction of the course and outcome of the wound is the best if early surgical treatment is conducted.

5. The volume of medical aid, selection of treatment measures and order of evacuation depend not only on purely surgical indications but mainly on combat and medical circumstances. The significance of combat circumstances is fully understood and by medical

circumstances we mean the number of wounded coming in at a given stage and their condition, the number of surgeons, the amount of transport equipment and type, medical equipment, etc.

In accordance with these hypotheses a number of frequent problems in the medical service are specified, namely: carrying the wounded from the battlefied is necessary during combat without considering enemy fire and first aid should be given to the wounded as early as possible both from the general physical and special surgical point of view; consequently the persons giving aid should be as close as possible to the front line. Specialized treatment must be begun at the army KhPPG which uses reinforcement means (ORMU [separate medical reinforcement company] groups). It is necessary to observe the succession of surgical measures at stages of evacuation which is impossible without brief but precise documentation. Finally, the medical supply of stages of evacuation must be impenetrable and correspond qualitatively and quantitatively to the demands of a given medical institution.

As we see from what has been presented above, accomplishing specialized treatment with evacuation according to need and having surgical assistance as close as possible to the combat line can only be done with adequate bed systems. For successful treatment of wounds the Chief Military-Medical Administration of the Armed Forces for the entire length of the war took all of the measures so that the bed network in the army and at the fronts would actually provide successful treatment of the wounded in order to evacuate to the rear of the country only those wounded who require it. This essentially ordered the evacuation and resulted in full accordance between contingents of wounded treated in the army and front regions and contingents treated in the deep rear.

The significance of these measures cannot be overestimated in all aspects and the numerical indices are evidence of the significant changes the bed system has undergone during the war.

In his report at the fourth plenary Hospital Council, Ye. I.

Smirnov presented the following data: if we take the entire bed system at 100, then on 8/1/1941 in the army region there was 9.1%, at the front 22.8%, that is, a total of 31.9% of the bed system was located in the army and front regions and 68.1% was concentrated in the deep rear, that is, more than 2/3 of all wounded.

On 1/1/1942 with the armies there was 7.4% of the bed system, in the front region 28.4% more and in both regions a total of 35.8%; in the deep rear, there was 64.2%.

By 1/1/1943, the number of beds in the army region had increased sharply - to 27.6%; at the front it equaled 27.5% and in all, 55.1% whereas in the deep rear, only 44.9% remained. Thus, there was more than half of the bed system located with the active army.

By 1/1/1944, the bed system of the army region had reached 30.1% and at the front 35.1%, that is, the total for both regions was 65.2% and in the deep rear, it was 34.8%. Thus, the ratio of the forward and rear bed system which had existed in 1941 was reversed.

For the rest of the war this relationship remained unchanged. It is natural that the period for treatment of wounds in the regions of the army and fronts increased and in certain periods, only those patients who were to be discharged upon completion of treatment were sent to the deep rear.

In this way the problem of medical service for treating wounded in large quantities was solved. Unification of surgical measures and the succession of treatment required continuous administration and observation of the quality of surgical assistance. This required a standard formulation of the surgical service; the problem of training surgical work and monitoring of it in the evacuation stages was involved here. The surgical service at the beginning of World War II was supervised by the chief surgeon of the Red Army; at fronts, by the chief surgeons of the front; later on, surgeons of the army and surgeons of large combined hospitals (FEP, MEP [clearing station of a front, local evacuation station], etc.) came in. As is apparent this organization could be improved more with "downstream" administrators in separate hospitals inclusively which was done even during the war.

Finally, with the director of the Main military-medical institution, an improved organization was set up - the Scientific Medical Council, whose surgical section participated in considering the measures of practical necessity.

War with the Byelofinns in 1939-1940 graphically showed the advantages of a unified surgical administration which had been completed by the beginning of World War II. When it started in 1941, the "Instructions on Military-Field Surgery" was published. Thus, even at the very beginning of the war a service was organized which had as its mission improvment in the quality of surgical work.

At the beginning of World War II, due to the lack of time since the end of the war with the Byelofinns, experience in the latter war had not yet been fully assimilated. The chief surgeon of the Leningrad front, Professor P. A. Kupryanov wrote a number of articles based on experience in the war with the Byelofinns. The importance of this experience was expressed in the manual on military-field surgery compiled jointly with Professor S. I. Banaytis. The report on the war with the Byelofinns had been begun but not written. The large scale of the first World War forced one to consider hypotheses put forward in this war that experience in treating wounds in peacetime does not always give a correct approach. Therefore, with further presentations one should return to the prewar view but digress into history, as recently as possible.

There is no doubt that such historical digressions facilitate a better understanding of the experience of Soviet surgery so enriched in World War II 1941-1945.

First Aid and Treatment of the Wounded

Treatment of the wounded begins from the moment that first aid is given no matter who gives it. There is no possibility of organizing things so that first aid is given by a physician. There is no necessity for it because on the battlefied, aid can be rendered only in a very limited way so that any person even with a very slight medical knowledge can do so.

In the Red Army it is planned that there be a battalion physician who must be at the BMP (battalion medical station) during combat. However, the military collisions in the Far East even in 1938 and 1939 showed that at the BMP the possibility of giving aid is such that it can be done completely by paramedics; having a physician there is not only not useful but, at the same time, decreases the number of physicians available at subsequent stages where each physician is extremely necessary.

After this experience was acquired, the duties of the physician at the BMP were corrected. In this way, the wounded person first was given physician aid as a rule at the PMP (regimental medical station). The amount of treatment given at the PMP is such that it can be done only by a physician. However, prephysician assistance is under the supervision of a physician and the direction of the medical service of the regiment; timely and correct care of the wounded depends greatly on this. At this time a position has been put forward that "the fate of the wounded depends on the first bandage." Of course, one cannot agree with this. Fate of the wounded depends on the entire set and timeliness of the treatment measures and therefore each measure making up the system must be completed without reproach. The carrying of the wounded from the battlefield plays an important role. The significance of these isolated measures depends on the character and location of the wound: for a wound with damage to the main vessels of the extremities and a disturbance in blood flow, it is decisive that a tourniquet be applied; for a wound in the stomach, an early operation is necessary, etc.

Carrying the wounded deserves special attention: special training and instruction is given to the stretcher bearers. An order from the Supreme Commander Comrade Stalin on presenting awards for carrying wounded from the battlefield played an important role in improving this important work.

However, both for improving organization of carrying the wounded from the battlefield and for perfecting other elements of the system of treatment of the wounded, a certain time was necessary. The medical commanders and the chief surgeons of the front correctly evaluated the necessity for a complete, timely and constant inquiry into progress in carrying wounded on the battlefield. The formations arriving at the front every 24 hours must be presented with these data for the entire battle operation. Then any deficiencies can be quickly corrected.

The character of the combat action mainly determined work of the medical institutions, in particular, the location for getting the first surgical aid and its volume. Rendering of this assistance on the battlefield was particularly involved.

The extremely varied conditions in which combat activity of our troops occurred were: maneuvering and on-position defense, retreat, attack, moving at an increased speed, sharp variations in climate on a huge front from the Bering to the Black Seas, varying terrain - these all affected the time period and character for getting first aid.

The extreme saturation of the fighting armies with firearms created great difficulties in the first stage of giving first aid.

Only the persistent efforts by the paramedics and paramedic instructors of the company resulted in 2/3 of the wounded being given first aid within 30 minutes after being wounded.

The average figure, of course, does not characterize the aid given in different conditions of battle with different combat operations but it makes it possible to conclude that the organization of first aid in the Soviet army was set up on the correct principles and fully withstood the test of battle.

The rendering of first aid on the battlefield was given particular attention. It was accomplished by a special staff of paramedics in the company headed by the paramedic instructor. The basic problem of the paramedic in the battalion was organization of this assistance and timely removal of the wounded. In the overwhelming majority of cases, aid was given to the wounded as soon as it was detected regardless of the phase of the battle and the time of day. If the access to a particular wounded person was under enemy fire, the paramedic instructor or the paramedic would request fire cover from our troops from the commander.

The volume of medical measures at the company level is not great. It is limited to the first bandaging and the individual's packet is used.

The role of the first bandaging applied on the wound is done to stop bleeding, prevent the wound from subsequent bacterial infection and to protect it from trauma.

The reports of the senior physicians of the regiments on different types of combat activity of the troops makes it possible to establish the special features of organization of first aid on the battlefield.

One does not need proof of the fact that in conditions of maneuvering a defense, giving first aid on the battlefield is extremely difficult. Here the solution to the problem lies in rapid removal of the severely wounded. Bandages are applied only when the wounded are at an adequate distance from the front line and the danger of falling into enemy hands is at a minimum. Therefore, with a maneuvering defense, the time period for applying the first bandage is increased.

This problem is solved differently in offensive combat when breaking through a fortified enemy line; here there are significant concentrations of fire and losses are particularly high; here first aid is preceded by finding shelter for the wounded (sometimes entrenchment). Only after they are sheltered can bandages be applied.

When the troops are attempting to move forward, when the enemy is on the run, losses among personnel are not high but the wounded often become separated from company orderlies and medical instructors. In such cases first aid to the wounded is given by medical personnel of regiment and division institutions because the medical staff of the company battalion does not have the capability of remaining separated from their podrazdeleniye. In these conditions, the highest percentage of first aid is given by mutual assistance and self help.

Rendering first aid to the wounded with a fixed position defense is accomplished, as a rule, by orderlies and orderly instructors.

In solving questions of giving first aid, first of all one has to establish where, when and to whom it is given.

The initial material for judging this can be taken from the following average numbers.

	(a) Срок оказания первой помощи	(b) Процент раненых
(c)	Немедленно	32,8
(d)	В течение первых 30 минут	32,6
(e)	От 30 минут до 3 часов	27,4
(f)	От 3 до 6 часов	4,1
(g)	После 6 часов	3,1

Key: (a) Time period for giving first aid; (b) Percent of wounded; (c) Quickly; (d) During the first 30 minutes; (e) From 30 minutes to 3 hours; (f) From 3 to 6 hours; (g) After 6 hours.

Perhaps for analysis the variation in these figures in different combat operations is important but in this case the average numbers give an adequate understanding of first aid for the wounded.

Thus, 1/3 of all wounded persons would be given first aid almost immediately and almost 2/3 before a half hour had elapsed. When studying the data presented in the responses, it seemed that this number varies within limits of no more than 10.0-15.0% and on the other hand, depending on conditions of combat activity of the troops.

For instance, according to the data from December 1941 (the N division) during a combat operation, the first bandage was applied to most wounded only a few minutes after the wound occurred.

In response to the Public Health Administration of one of the fronts, data of a special study was presented which was taken during an attack by our troops. According to this data, first aid was given almost immediately to 40.6% of the wounded and during the first 30 minutes after the injuries had occurred, to 53.5%. According to the data of the report of the medical service of the N rifle division, 85.5% of the wounded were given first aid in the first 30 minutes after the wound occurred.

There is considerable interest in the question of who gives the first aid. We can judge this according to the following data:

	(a) Кем оказана первая помощь	(b) Процент раненых
(c)	Самопомощь	5,9
(d)	Взаимопомощь	32,3
(e)	Санитар и санитарный инструктор роты	53,0
(f)	Фельдшер батальона	2,6
(g)	Врач части	6,2

Key: (a) Who gives first aid; (b) Percent of wounded; (c) Self help; (d) Mutual assistance; (e) Orderly and orderly instructor of the company; (f) Battalion medic; (g) Chast' physician.

In this way, the orderlies and orderly instructors of the company gave first aid to more than half of all the wounded.

The fact that the medics gave first aid to a total of 2.6% of the wounded and the physicians, to 6.2% is of interest.

Data on the location for giving first aid is presented below:

(a) Место оказания первой помощи	(b) Процент раненых
(c) На поле боя	84,4
(d) БМП	4,0
(e) ПМП	8,2
(f) ДМП	2,8
(g) Другие лечебные учреждения	0,6

Key: (a) Location where first aid was given; (b) Percent of wounded; (c) On the battlefield; (d) Battalion medical aid station; (e) Regimental medical station; (f) Division medical station; (g) Other treatment institutions.

Consequently, on the battlefield 84.4% of all wounded received first aid; the remaining 15.6%, that is, almost 1/6 of all the wounded received aid in institutions at greater or lesser distances from the front line.

One should note that there is a relationship between the time first aid is given and the person who gives it.

Usually first aid is rendered immediately after the wound occurs in cases where it is done by the person himself (bandages are applied by the wounded person); the number of persons in this group exceeds 90.0%. The group of wounded who use mutual assistance on the battlefield amounts to 42.6%.

First aid rendered by orderlies and orderly instructors was accomplished in almost the same time periods as the mutual assistance.

Taking into consideration the fact that mutual assistance, as a rule, is given by soldiers who are in direct proximity to the wounded where the orderly or the orderly instructor for this purpose would have to cover a certain distance often under enemy fire, one can conclude that the orderlies and the orderly instructors have managed their duties very successfully.

The physician gave first aid in most cases at the regimental medical station or at other medical institutions located close to the rear. More than 60.0% of the wounded who received first aid and bandaging from a physician were bandaged within an hour from the time they were wounded.

Discussing the time period when the first bandage is applied in correspondence with the location first aid is given, one should note a general principle: when applying the first bandage on the battlefield, at the battalion aid station and the regimental medical station, the number of persons with bandages applied early at each succeeding stage is 10.0-15.0% less than at the preceding.

One should note that first aid given at the regimental medical station, the division medical station and at other institutions removed usually from the front rear by more than 4 km, in a number of cases occurred within 30 minutes of the time the wound occurred. This is possible only in cases where the wounding was not on the front line but in the rear in the territory of the regimental medical station and the medical battalion or close to them.

It appears that less than 2.0% of all wounded (1.96%) are wounded on the front line. This forces us to draw two organizational conclusions:

1) the individual packets must be part of the equipment for all personnel of the chast' (including workers in medical and sanitary institutions);

2) all medical institutions of the troop and army rear have the duty to report to all of the nearest podrazdeleniye the area

of their changes and to stake them out not only in the direction of the front.

If one recalls the frequency of artillery fire and aviation shells in the so-called "rear," including treatment institutions, the efficiency of these measures becomes obvious.

Above we were talking about the effect which the first bandage has on the progress of the wound. This effect is illustrated by the numbers obtained when developing the chart for fundamental characteristics.

Fig. 52 graphically shows that although the frequency of complications during the wound process is distinguished by a tendency toward an increase, depending on the time period for applying the first bandage, all of these time periods do not have the decisive value which is ascribed to them.

A study of data obtained when developing the chart for fundamental characteristics showed a definite relationship between the quality of first aid given and the course of the wound. For instance, comparing the frequency of complications in wounded who received first aid immediately in various conditions can confirm that the best results were observed when first aid was given in medical institutions; this group includes the wounded who received their wounds in the area of the medical institution or close to it (Fig. 53).

A sharp decrease in the number of complications depending on where first aid was given is completely understandable if one takes into consideration the quality of the bandage applied. At the regimental station and the division medical station, first aid is always given by the most qualified personnel and is accompanied by cleaning up the area around the wound and using bandaging material appropriate to the dimensions of the wound. Of course one should take into consideration the fact that this group of wounded

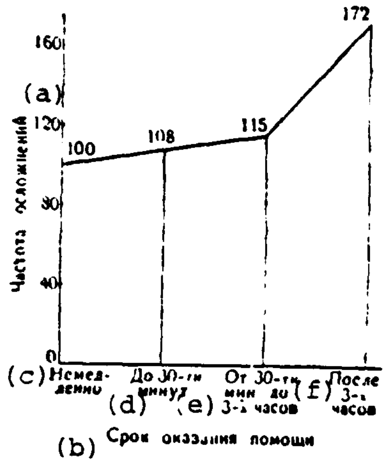

Fig. 52. The relationship between the time first aid is given and the frequency of complications.
Key: (a) Frequency of complications; (b) Period for giving first aid; (c) Immediately; (d) Before 30 minutes have elapsed; (e) 30 minutes to 3 hours; (f) After 3 hours.

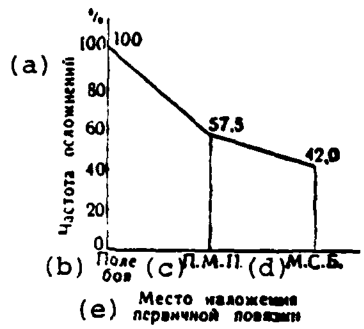

Fig. 53. Frequency of complications in connection with the location where the first bandage was applied (in cases bandaging was applied almost immediately.
Key: (a) Frequency of complications; (b) Battlefield; (c) Regimental medical station; (d) Medical battalion; (e) location where the first bandage was applied.

undoubtedly will undergo primary surgical treatment very early.

When giving first aid one usually uses the so-called rebandaging packet for first aid (Figs. 54 and 55).

Without precise information on the number of cases where the first bandage was applied using the individual packet because no type of precision during military operations can be considered for these data, it is still possible however to assume that this number is at least 75.0%. In any case with the application of bandages immediately after the wound occurs, almost always the individual packet was used.

In the first years of World War II, in the equipment of our army besides the aseptic individual packets there were also sometimes antiseptic individual packets; beginning in 1943, more and

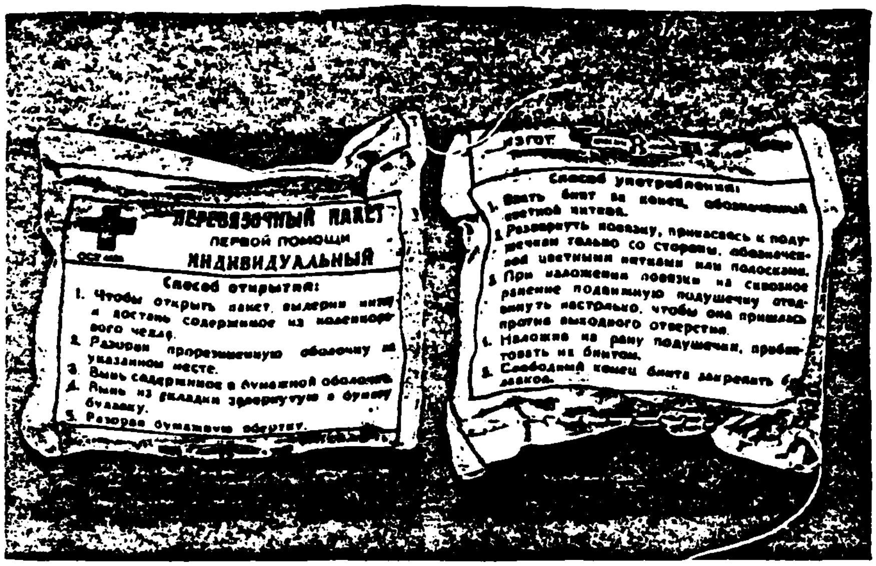

Fig. 54. Rebandaging packet for first aid.
Left:

FIRST AID
INDIVIDUAL

1. To open the packet, pull the string and take the contents from the calico bag.
2. Tear the bag along the indicated line.
3. Extract the contents in the paper cover.
4. Extract what is wrapped in the paper roll.
5. Tear the paper wrapping.

Right:
METHOD OF USING

1. Take the bandage at the end marked with the colored thread.
2. Wrap the bandaging touching only the side marked with the colored thread or bands.
3. When bandaging a perforated wound the movable padding is unwound in such a way that it will cover the exit wound.
4. Having put the padding on the wound, wrap with bandages.
5. Fasten the free end with the pin.

the aseptic packets were used.

Experience in World War II showed that in many cases of wounds including multiple wounds, the packets were inadequate in size so that often a wound needed to be bandaged with not one but with two packets. The supply of individual packets in the kits for the orderlies and the orderly instructors made it possible to use several individual packets for rebandaging a single wound.

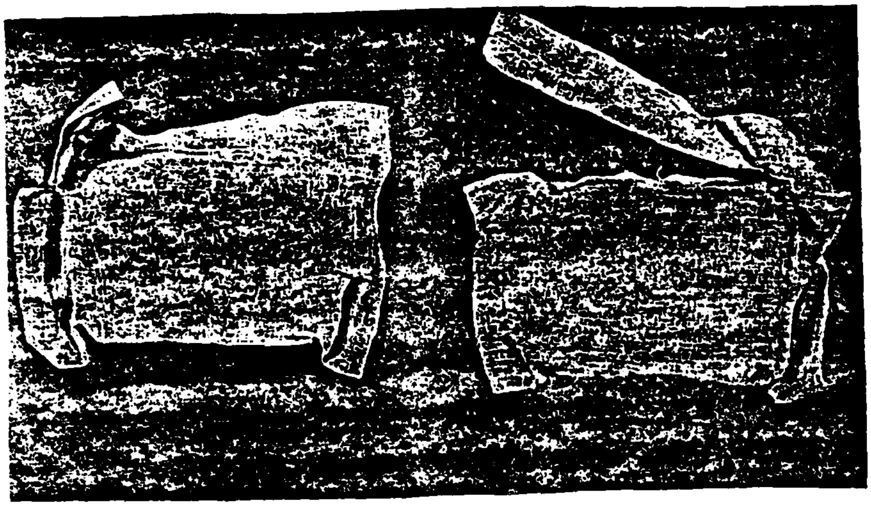

Fig. 55. Rebandaging packet for first aid without without the outside wrapper.

In view of the fact that bleeding is a symptom of wounds which attracts the most attention, the primary bandaging with multiple wounds, as a rule, is placed on the wound which is bleeding the most. If the bandaging was large enough to be successfully applied, it was completely useful.

The correct application of bandages provided mechanical protection of the wounds from the friction of the clothing. In the first months of the war sometimes one encountered incomplete covering with the primary bandaging. However, by 1942 the frequency of deficiencies in giving first aid had been reduced sharply.

The first bandaging is of great importance for morale. More than once one can observe how the wounded quiet down immediately after it is applied.

Characteristics of the Stages of Evacuation and Their Treatment Functions

A large part of the wounded after application of the first bandage, and often before it go to the battalion medical station.

Data on the reports indicate that the organization activity of the battalion medical station varied in accordance with combat conditions. But as to their wounds, they reported only that bandages were applied.

It is necessary to note that primary bandaging at the battalion medical station is applied even less often than at the regimental medical station. The medics who are directed by the battalion medical station are much more often involved in evacuation and correcting bandaging. Changing bandages at the battalion medical station is done fairly rarely. Even in cases where, due to battle conditions the wounded are kept at the battalion medical station (most often at night), the amount of assistance amounts to improving the splints and rewinding bandages which have been put on in the battlefield.

The battalion medical stations were very mobile. During attacks by our troops, sometimes in cross country conditions, the battalion medical station never lagged behind its battalions but often they were deployed in two-wheeled carts, carts and trucks.

One should note that in conditions with fixed positions for defense at the battalion medical station protected by blinds 800-900 m from the front line, the area surrounding wounds was carefully treated before applying bandages in cases where the wounded were brought to the battalion medical station with unbandaged wounds. The number of wounded who passed through the battalion medical station and the regimental medical station increased during activation of combat activities when some of the lightly wounded were transported to the division medical station and the mobile field hospitals, skipping the preceding stages. All of this can mean that from the moment of staying at the battalion medical station, the wounded go into a zone where planned medical assistance is given inasmuch as combat conditions permit, of course. From here the time period for delivering the wounded to the battalion medical station becomes very important.

However, actual examples rather than abstract averages are of graphic importance. If one compares these time periods in different combat operations, then one finds the following data.

1. The Stalingrad operation for breaking up and destroying the enemy. The Don front. From 1/10 to 11/8, 1943.

(a) Сроки прибытия раненых на БМП после ранения	(b) Процент раненых
(c) До 2 часов	80,0
(d) 2—4 часа	9,0
(e) 4—6 часов	1,0
(f) 6—8 »	5,0
(g) Свыше 8 часов	5,0

Key: (a) Time period that wounded remained at battalion medical stations after being wounded. (b) Percent of wounded; (c) Less than 2 hours; (d) 2-4 hours; (e) 4-6 hours; (f) 6-8 hours; (g) More than 8 hours.

The steppe, the open terrain and snow covered fields made it much easier to look for the wounded.

2. The Orlov-Kursk operation. July 1943.

(a) Сроки прибытия раненых на БМП после ранения	(b) Процент раненых
(c) До 2 часов	43,0
(d) 2—4 часа	26,9
(e) 4—6 часов	15,3
(f) 6—8 »	9,4
(g) Свыше 8 часов	5,4

Key: (a) Time period for wounded remaining at the battalion medical stations after being wounded. (b) Percent of wounded; (c) Less than 2 hours; (d) 2-4 hours; (e) 4-6 hours; (f) 6-8 hours; (g) More than 8 hours.

The battles took place on fields covered with high ripe grasses which made it difficult to look for the wounded. As a result, in the period 2 hours after being wounded, apparently a large number had arrived at the battalion medical station independently and only about half the number of wounded as were there in the Stalingrad operation.

3. The Byelorussian operation.[1] January-February 1944.

(a) Сроки прибытия раненых на БМП после ранения	(b) Процент раненых
(c) До 2 часов	58,3
(d) 2—4 часа	25,1
(e) 4—6 часов	7,5
(f) 6—8 »	2,3
(g) Свыше 8 часов	6,8

Key: (a) Time period for wounded remaining at the battalion medical stations after being wounded; (b) Percent of wounded; (c) Less than 2 hours; (d) 2-4 hours; (e) 4-6 hours; (f) 6-8 hours; (g) More than 8 hours.

The combat operation occurred in the forest-marshy terrain. Search for the wounded was made very difficult due to poor visibility, difficulty in moving forward and the impossibility of using dog sleds. The position reminded one of the Orlov-Kursk operation. The reasons were different although they mainly depended on the character of the terrain.

4. Operations on the Visla-Oder.[2] Winter and early spring, 1945.

(a) Сроки прибытия раненых на БМП после ранения	(b) Процент раненых
(c) До 2 часов	77,5
(d) 2—4 часа	13,1
(e) 4—6 часов	4,2
(f) 6—8 »	1,6
(g) Свыше 8 часов	3,6

Key: (a) Time period for wounded remaining at the battalion medical stations after being wounded; (b) Percent of wounded; (c) Less than 2 hours; (d) 2-4 hours; (e) 4-6 hours; (f) 6-8 hours; (g) More than 8 hours.

[1] Data at the N front.
[2] Data at the N front.

The operation was distinguished by a fierce attack and pursuit of the resisting enemy with high activity of their airforce.

If one adds up the number of wounded delivered to the battalion medical station in the first four hours after being wounded then one finds that 90.6% of the wounded were received from the battlefield. This exceeds the data for the Stalingrad operation where the percent taken from the battlefield equaled 89.0.

5. Berlin operation.[1] April-beginning of May 1945.

(a) Сроки прибытия раненых на БМП после ранения	(b) Процент раненых
(c) До 2 часов	61,7
(d) 2—4 часа	29,3
(e) 4—6 часов	6,4
(f) 6—8 »	1,2
(g) Свыше 8 часов	1,4

Key: (a) Time period for wounded remaining at the battalion medical stations after being wounded; (b) Percent of wounded; (c) Less than 2 hours; (d) 2-4 hours; (e) 4-6 hours; (f) 6-8 hours; (g) More than 8 hours.

The operation was conducted in the largest settled point with very strong enemy resistance; there was close hand combat but also independent removal of the wounded from the battlefield due to the intense enemy fire. However, in the time less than 4 hours after being wounded, the battalion medical stations had received the highest number of wounded 91.0% and after 8 hours - the least for the entire operation, namely 1.4%.

It is very clear that for effectiveness in removing the wounded from the battlefield in different conditions, one must plan and carry out a type of organization which can be used in the combat conditions which arise.

Assistance to the wounded at battalion medical stations was only

[1]Data of the N front.

a forerunner of treatment by physicians which was done at the PMP (regimental medical station). The volume of this assistance to a large degree depended on combat circumstances but only very rarely was it reduced to a minimum.

The minimum volume of primary physician assistance to the troops included stopping bleeding, temporarily or permanently, application of bandages to the wound with transport temporary immobilization (where indicated), the injection of preventive serums and the filling out of documents.

The main mass of the wounded with a position type defense were almost all sent to the regimental medical station. Here they were registered and sent through the clearing procedures, and consequently, the first diagnosis of the wounds was recorded.

At the regimental station the wounded received emergency care from a physician. The regimental station is the first stage where bandaging of wounds can be done according to all the requirements of surgery. This is one of the reasons why the time period for bringing the wounded to the regimental medical station took on such importance during World War II.

The necessity to subordinate organization of assistance to the wounded with the demands of actual combat circumstances was a decisive condition when organizing operation at the regimental medical station.

The time periods for delivery to the regimental medical station did not determine the time periods for giving surgical treatment to the wounded if there was no precision in the operation of the regimental medical station itself. This forced the medical leaders to strictly calculate the time the wounded were to stay at a given stage. In those cases where this calculation was operative, one noted a decrease in the time period the wounded remained at the next stages and the time period for giving them qualified assistance.

Battles which preceded World War II, chiefly the war with the Byelofinns, to a significant degree, determined the functions of the regimental medical station which was limited in the measures to be taken there.

At the beginning of World War II, the structure and volume of work at the regimental medical station was fairly precisely rotated; changes which occurred during the war only affected certain technical means with different locations of the wounds.

Characterizing the volume of aid given at the regimental medical station, N. N. Yelanskiy writes: "All of the wounded must primarily be looked at without removing the bandaging and all of the wounded must be given tetanus shots. During this examination, the required rebandaging is done. With extensive and contaminated wounds, antigangrene serum is injected subcutaneously and powdered white strepticin is applied as deeply as possible into the wound in a quantity of 10-12 g." However, on the next page, N. N. Yelanskiy indicates that the "reduction of the volume of aid at the regimental medical station is possible with a mass admission of wounded and the necessity of constantly moving the regimental medical station along with the regiment."

M. N. Akhutin recommends the prophylaxis of subsequent infection "application of bandaging after shaving the area surrounding the wound (except for the head), painting of the skin with tincture of iodine, and of course, the injection of antitoxin serum and when necessary, antigangrenous serum."

Monitoring the use of tourniquets is important for prevention of infectious complications of wounds, particularly anaerobic infection. P. A. Kupriyanov points out that "a significant number of tourniquets to stop bleeding applied without adequate instructions were used in past wars; to a certain degree this extremely unfavorable phenomenon remains an obstacle at the present time."

The instructions cited above in connection with the volume of surgical measures aimed at prophylaxis of suppurative and anaerobic complications of the wound process, are the basis for surgical activity at the regimental medical stations.

During World War II, the regimental medical stations as a rule were located in tents, less often in homes or earthen huts. The distance from the regimental medical station to the front defense line varied depending on the conditions of the terrain and the character of combat action from 1.5 to 4 km. The separation of the regimental medical post from its regiments even with vigorous forward movement of the troops was a very rare phenomenon although in the reports, there are indications of relocation of the regimental medical stations 6 times in 24 hours (the Umansk operation, 1944).

The character of the terrain where the combat actions took place affected the time period for delivering the wounded very sharply, even more than the character of the combat action.

In the spring of 1944 when moving to the so-called "panzer line" (the Velikaya river-Pskov-Ostrov), the regimental medical stations were located 3-4 km from the front line but in between was solid swamp which could only be overcome with great difficulties. 6-8 hours had passed and the wounded were successfully brought into the regimental medical station on stretchers.

The time period for delivering the wounded to the regimental medical stations in different combat operations are presented in Table 8.

According to the data showing the average numbers for the entire war, during the first two hours after being wounded, 50.0% of all wounded reached the regimental medical stations and after 4 hours, this number reached 85.0%. It is necessary to take into consideration that depending on the conditions of combat action, some of the wounded could be successfuly brought in only under cover of darkness.

Table 8. Time periods for delivering wounded to regimental medical stations in various combat operations

(a) Срок доставки раненых на ПМП после ранения	(b) Орловско-Курская операция (Центральный фронт)	(c) Белорусская операция (1-й Белорусский фронт)	(d) Операция на Висле—Одере	(e) Берлинская операция
	(f) процент раненых			
(g) До 4 часов	42.6	28.5	66.4	64.8
(h) 4—8 »	41.8	55,6	25.0	26.3
(i) 8—24 часа	15,6	15,9	8,6	8,9

Key: (a) Time period for delivering wounded to regimental medical stations after wounding occurs; (b) Orlov-Kursk operation (central front); (c) Belorussian operation (first Belorussian front); (d) Operations on the Visla-Oder; (e) Berlin operation; (f) Percent of wounded; (g) Less than 4 hours; (h) 4-8 hours; (i) 8-24 hours.

However, the total numbers which characterize the time period for bringing the wounded to the regimental medical station do not reflect the quality of organization of medical service of the regiment because a large number of the wounded were delivered by transportation passing by or came on foot.

The data on time periods for delivering the severely wounded who could not be moved independently were much more significant.

In 1943, a thorough analysis was made of the time periods for bringing the wounded to the regimental medical station during the combat operation accomplished by troops of the N army of the Leningrad front. It appeared that of all the wounded who stayed at the regimental medical station, 26.6% had come on foot, 11.7% had been accompanied by comrades, ambulances had delivered 61.7%. The number of wounded who were at the regimental medical station in the first 3 hours amounted, respectively, to 37.2, 12.9, 49.9.

In the report of the N army of another front for January 1944, the time periods for bringing wounded to the regimental stations was analyzed depending on the location of the wound. Comparing the time periods for persons wounded in the upper and lower extemities, one can note the much later time periods for those in the latter group.

Later admission to the regimental medical station of stretcher patients is basic and with an increase in the flow of wounded, this principle becomes even more noticeable.

S. I. Banaytis presents figures for admission of wounded to regimental medical stations later than 4 hours after the wound has occurred according to six soyedineniye at the front during the East-Prussian offensive operation. These data, according to different soyedineniye, varied from 3.3 to 21.4%. The author emphasizes the real possibility of delivering the main mass of wounded to regimental medical stations in the period 4 hours after the wound occurs. If one pays attention to all of the difficulties which are encountered on that part of the route from the front line to the regimental medical station, then it is necessary to recognize that the time period for delivering the wounded is completely satisfactory and considered that the existence of circumstances which are controlled when selecting terrain for deploying the regimental medical stations during wartime justify themselves.

In relation to the volume of assistance given at the regimental medical stations, as was indicated above, they exist in a fairly strictly ordered framework.

The volume of medical assistance given at the regimental medical stations changed very significantly depending on combat circumstances; however, this assistance included actions by physicians. Expanding the volume of assistance was done by more complete preparation of the wounded for surgical aid at the next stage. Any type of attempt to increase the volume of assistance and replace work of the division medical station is not justified and therefore is not encouraged. Expansion of work at the regimental stations over a period of time has been done in the following directions: improvement of transport immobilization and the use of antishock measures for gunshot fractures of the femur, that is, the production of container anesthesia in the location of the wound and general measures (morphine, antishock fluids, blood transfusions), application of completely occlusive bandaging with open pneumothoraxes and also antishock measures including introduction of a vago-sympathetic blockage according to A. V. Vishnevskiy's method. A very important function of the PMP (regimental medical station) was testing the tourniquets which had been applied to stop bleeding. In most cases, the tourniquet was removed and bleeding was stopped by bandaging the damaged vessel or a blood stopping clamp was used, leaving it in the wound or packing it. Only in extreme cases was the tourniquet applied again and the wounded person was quickly evacuated.

Further, an important part of the work at the PMP was antishock measures in general.

Surgical intervention at the PMP was done only in a case where life was directly threatened, for example, tracheotomies, suturing and fixing of the tongue during retraction; catheterization of puncture of the bladder when urine is retained.

Changing bandages is done only when they are completely useless. Prophylactic injection of serum was obligatory. At the PMP, the front region chart was filled out.

The minimum volume of assistance at the PMP amounted to stopping bleeding and injection of serum and documentation.

Thus, all of the wounded at the PMP were prepared for evacuation and were evacuated except those who were in extreme agony and wounded with very slight injuries who could be returned to duty in 2-3 days.

Deployment of functional podrazdeleniye of the PMP and internal organization of them was accomplished taking into consideration fulfillment of the basic problems noted above. At the beginning of World War II, the PMP organization was adequately laid out and changes introduced in certain locations, as was already noted above, did not have a basic character but were mainly a series of minor details (positioning of separate areas in relation to each other, location of boxes and storage inside the rooms) (Fig. 56).

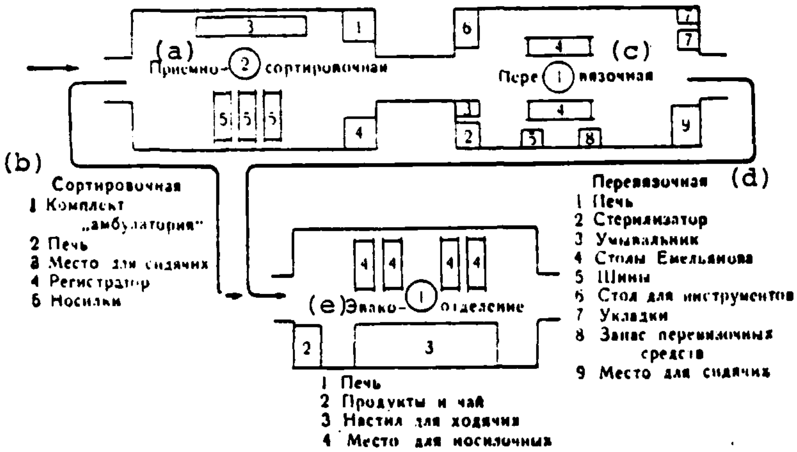

Fig. 56. Diagram of a PMP.
Key: (a) Receiving-clearing; (b) Clearing; 1. Ambulatory set, 2. Furnace, 3. Area for sitting, 5. Stretchers; (c) Bandaging; (d) Bandaging, 1. Furnace, 2. Sterilizer, 3. Washer, 4. tables, 5. Splints, 6. Table for instruments, 7. Packing, 8. Reserve of bandage supplies, 9. Location for sitting; (e) Evac-section, 1. Furnace, 2. Products and tea, 3. Benches for the walking, 4. Location for stretcher patients.

The PMP had three basic rooms: the sorting section, bandaging section and the evacuation section. Equipping the PMP made it possible to conduct all surgical measures aseptically even under very stressful work.

Sterile packets were used for applying bandages. Syringes and surgical instruments were sterilized with boiling water.

In connection with the lack of primus stoves, the syringes and instruments were boiled in the wintertime on iron stoves in tents and in the summertime, specially set up centers and this method took less time than the use of primus stoves. The PMP did not have its own autoclave; for sterilizing linen it was put into sacks or into two pillow cases, one inside the other, and sent to the DMP (division medical station) where it was sterilized in an autoclave.

The standard equipment for the PMP included a wash basin of the ordinary suspension type and basins for washing the hands according to the Spasokukotskiy-Kochergin method. Rebandaging work at the PMP was done in gloves. Sterilization of the gloves was done, as a rule, with a "cold method," and often a solution of mercuric chloride, 1:1000 was used.

The gloves were not changed between rebandagings but were washed with a solution of ammonium hyroxide which was used for the hands (0.25%); then the gloves were scrubbed with cotton moistened with 5% formalin alcohol. It is recommended that the Spasokukotskiy-Kochergin method be used for treating the hands.

The standard wash basin was used only for preliminary washing of the hands.

The medicinal substances used at the PMP were received in sterile form in closed ampoules (blood substitutes, glucose, novocain) or were sterilized in boiling water (hypertonic solution). Monitoring of the aseptic state of surgical work at the PMP is the responsibility of the administrative surgeon of the division medical station.

Classification at the regimental medical station does not have a complex character and often is done without classification tickets; the intrapost classification overlaps closely with the evacuation classification. First of all, a group of wounded is separated who are to be sent further on without rebandaging; an order is established for the wounded who are to be sent for bandaging. The indications for examination primarily were the severity of the condition and the need for splints. Clearing classification included only determining the order of evacuation; the direction was almost always the same - the division medical station. Much less often the PMP received instructions for evacuation of certain categories of wounded to the mobile surgical field hospital at the front line.

At the same time that the volume of assistance at the PMP was low and did not require complex equipment, at the division medical station and at the mobile surgical field hospital of the first line, a great deal of surgical work was done; the appropriate conditions which meet all the rules of aseptics and the appropriate medical equipment were needed here.

Both at the division medical station and at the mobile surgical field hospital at the front line, the work was done in dwellings which were outfitted for this purpose or in other structures, in tents and less often in mud huts. The volume of surgical activity made it necessary to deploy a whole series of functional podrazdeleniye equipped with a large quantity of aseptic materials and medications. Among the equipment at the medical battalion level were the standard packaging and a large quantity of stores, often even nonstandard, usually packed in boxes or pillowcases.

The set of stores is intended to provide the possibility for dividing the medical battalion station into two echelons which can operate independently in full volume. Wartime conditions sometimes force one to divide the medical battalion station into three echelons or more. It is well known that fractionation of the medical battalion decreases the capability for completely valuable work.

The basic types of bandaging material which should come in contact with the surface of wounds are, in modern conditions, gauze, cotton batting and lignin. Different substitutes proposed during World War II were not widely used. The batting, gauze and lignin were supplied to the institutions in the combat region in two forms: sterile and nonsterile.

In the first case these were prepared packets with the batting or gauze napkins in 3 sizes. The bandaging differed from that in the individual packets only in its size (large, average and small bandages).

In the Russian Army, the prepared bandaging was first used by the Navy in the Russo-Japanese war of 1904-1905. The absorption capabilities of the materials from which they were made, gauze and batting, were the basis for all bandages.

One should note that the packaged articles were supplied to medical institutions in sterile and unsterile fashion. At the beginning of the war, supply of these objects by the piece was introduced (Fig. 57).

Fig. 57. Sterile bandaging.
Key: (a) Sterile bandaging; (b) Large; (c) Manufactured 1945; (d) GOST (number illegible); (e) Factory No. 1; (f) USSR.

It is difficult to overestimate the role which sterile material manufactured in factories played in the war. For the battalion medical aid station this was the only form of sterile bandaging material. One has to mention that the pacl ıng method was satisfactory from all points of view. The sterility of the material was maintained indefinitely (as long as the packing was not broken; it consisted of 2 layers of waterproof paper with the ends covered with paraffin). Sterility was not lost when removing the bandaging material from the wrapper: the orderly with unsterile hands could break the paper wrapper, pulling the string with one hand and with the other, holding the entire end of the packet (Fig. 58). Having torn the wrapper, the orderly could throw away the string, freeing his hand to remove half of the wrapper, holding it at the second end and giving the nurse half of the packet taken from the wrapper. The contents of the packet were removed with sterile hands in such a way that the second part of the wrapper would remain in the hands of the orderly (Fig. 59). Even if the material was removed from the packet with unsterile hands, one could place the bandaging aseptically without moving the batting and gauze pad protected by bandaging at its ends.

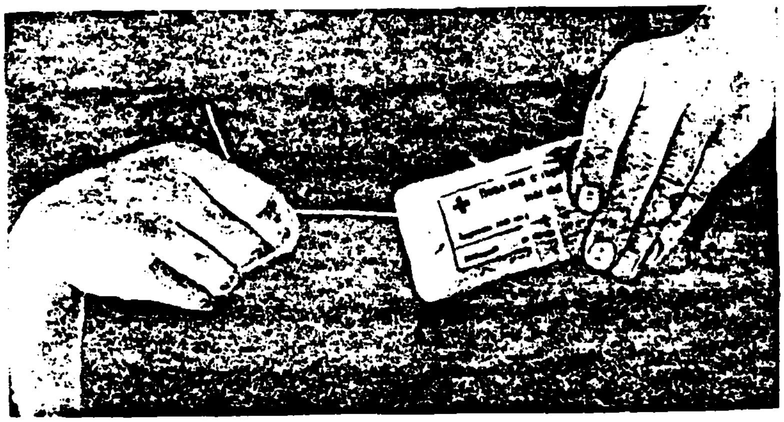

Fig. 58. Opening the packet. The first action.

Fig. 59. Opening the packet.
Second action.

A basically new measure taken, beginning at the medical battalion station, is sterilization of bandaging material and linen in an autoclave. Besides the use of sterile material from factory manufacture, in the operating conditions of the division medical station, one needs a large quantity of sterile linen and bandaging material of all shapes which are not in the standard sets. This made it necessary to outfit a special room with sterilization material.

At the mobile surgical field hospitals, as a rule, there are the same podrazdeleniye as at the division medical stations, but sometimes there is also an X-ray unit and laboratory.

The best possibilities for setting up extra rooms en route were in conditions where the division medical station and the mobile surgical field hospital were set up in tents. Then the most convenient positioning was possible for separate functional podrazdeleniye on the area and convenient positioning for travel was provided. This resulted in the fact that when the medical battalion set up in houses or earthen huts, as much as possible they kept to the usual relationship in positioning the functioning podrazdeleniye (Fig. 60).

Without going into positioning en route of all functional podrazdeleniye, one should pay attention only to positioning and setting up rooms in relation to care of patients.

Remaining at the division medical station, a patient always goes into an admission classification department. According to the possibilities, he is put into one of two tents: one of these is set up for bed patients and the other for ambulatory patients. The surgical block is set up at a distance of 15-20 m from the tents. There is no better way for distribution of the rooms.

It would be incorrect to set up one surgical area in an isolated tent. Even the experience in the first combat encounters (Khalkhin-Gol) showed the necessity for setting up the two areas in a row: the preoperative and the operational chambers because an entire series of measures involving surgery cannot be done in the operating room

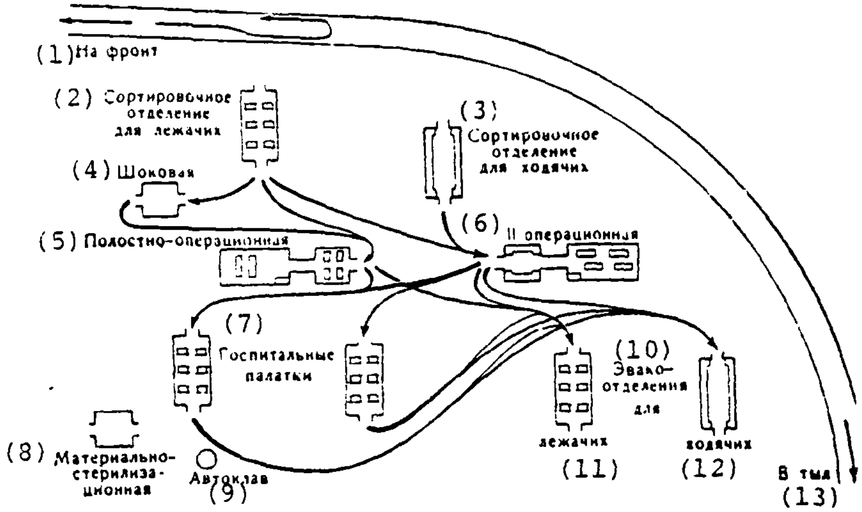

Fig. 60. Diagram of the division medical station surgical block.
Key: (1) To the front; (2) Classification section for stretcher cases; (3) Classification section for ambulatory patients; (4) Shock; (5) Surgical housing; (6) Surgical II; (7) Hospital tents; (8) Material sterilization; (9) Autoclaves; (10) Evacuation department for; (11) Stretcher cases; (12) Ambulatory; (13) To the rear.

itself. This would force one to divide the tent, setting up covered doors between them.

The simplest system for setting up the operation block occurred in this way.

For a long time there have been arguments about the expediency of connecting the three tents, for having the sterilized material tent close to the operating tent. The only argument against this was the danger of fire; however, the wartime experience showed that this was a very rare thing. Careful observation of all the workers in the tent around heaters, primus stoves and lights can almost completely guarantee safety. Dividing and connecting tents was used in all sections of the front in all periods of combat action. During World II, the operating block of the division medical station and the mobile surgical field hospital were broken up according to the following system (Fig. 61).

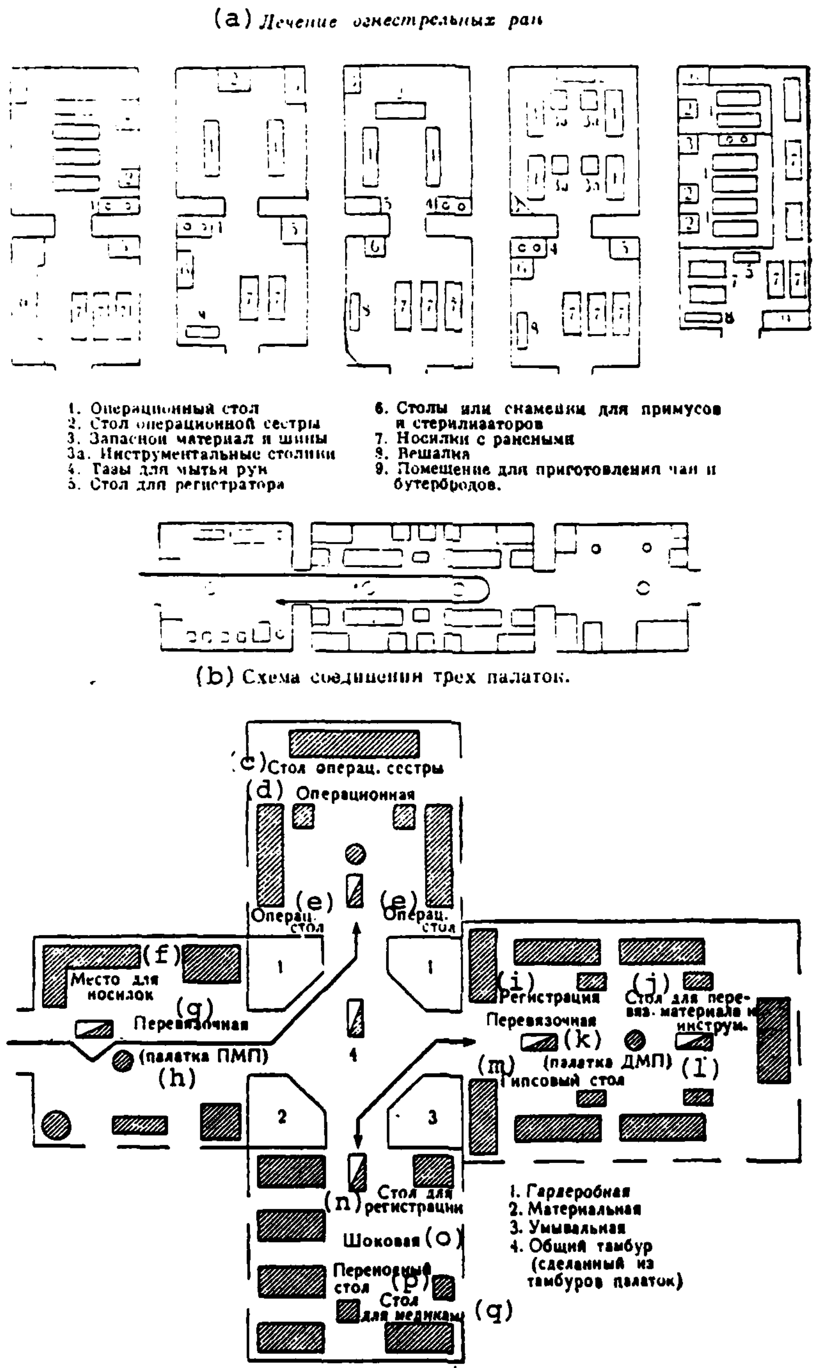

Fig. Diagram of the Operation blocks.
Key: (a) Treatment of gunshot wounds. 1. Operating table, 2. Table for the surgical nurse, 3. Spare materials and splints, 3a. Instrument tables, 4. basins for hand washing, 5. Table for records,

6. Tables or stands for primuses and sterilizers, 7. Stretchers with the wounded, 8. Racks, 9. Room for preparing tea and sandwiches; (b) Diagram for connecting the 3 tents; (c) Nurses operating table; (d) Operation; (e) Operating table; (f) Location for stretchers; (g) Bandages; (h) (Regimental medical station tent); (i) Records; (j) Table for bandaging material and instruments; (k) Bandaging; (l) Division medical station tent; (m) Gypsum table; (n) Table for records; (o) Shock; (p) Movable table; (q) Table for medications. 1. Coat closet, 2. Material, 3. Lavatory, 4. General door (made out of tent flaps).

The first four systems were very widely used. The system called the "Volkhovskiy Cross" was widely used on the Vokovskiy front.

Each of the systems presented has its advantages and disadvantages. But they all satisfactorily meet the requirements.

Experience showed that setting up chest operations can be done in a regimental medical station tent; the placement of the tables will fully meet the requirements of a mobile surgical field hospital and a division medical station. As to the second operation, here every extra table will speed up the work.

The most convenient system is setting up tents without support stakes (when the tents are "suspended" on outside crosspieces which have the shape of the letter П). The heater can be put not in the center of the tent but at a corner (placing it of course, at a fair distance from the netting in order to avoid fire).

During the war, the personnel of medical battalion stations and mobile surgical field hospitals became very expert in setting up an operation block. Separate technical components of the internal setup also were improved all the time. More successful technical innovations were reported in manuals periodically published at the front and in the army.

Often when division medical stations and mobile surgical field hospitals were set up in homes, tents were added as well.

When the front was stable for a fairly long time, part of the podrazdeleniye and sometimes all of it were deployed in specially set up earthen huts and then principles of placement were observed in the same way as when deploying the division medical station or mobile surgical field hospital in tents.

It is important to note that when tracing the functional podrazdeleniye and the placement of furniture and maintenance in tents, always one must take into consideration the necessity for observing aseptic conditions of work.

A separate "material-sterilization" room was set up for sterilization of materials. The demand for a large quantity of sterile material and linen caused high stress operation of the material-sterilization unit. The material was prepared by the nurses. Sterilization was done either by the senior nurse or one of the surgical nurses especially assigned for this purpose. Often the autoclave was not set up in the same tent but outside it - in a hut, boiler room or earthen hut. A three burner primus was used for the standard stores and usually did not satisfy the needs; in most cases the autoclave was cemented into the heater. Firewood was used for heating because it was economical and fast. The bandaging material was made of gauze obtained from the field pharmaceutical warehouse.

Monitoring operation of the autoclave was done by the ordinary methods; moreover, the SEL (epidemiological laboratory) workers periodically took bacteriological samples. The ligature material, as a rule, was obtained in ampoules in sterile form; before the ampoules were put on the table, they were often boiled. The suturing material widely used during wartime was sterilized in the autoclave or by one of the ordinarily accepted methods. Gloves for cavity operations were usually sterilized in the autoclave, less often they were boiled.

During cavity operations in most division medical stations and mobile surgical field hospitals, gloves were changed after each operation; in the second operation where one surgeon during his shift performed a large number of operations, the gloves between the operations were sterilized by one of the "cold methods." The instruments were sterilized by boiling. The scalpels and amputation knives were treated with alcohol. The sterilization of solutions (novocaine, hypertonic, physiological) was done in the pharmacy. The streptocides sprinkled into the wounds were not sterilized. During the war, bacterial contamination of bandaging and division medical station and mobile surgical field hospital operating rooms were checked. Double checking of three division medical stations and two mobile surgical field hospitals showed that the sterility of the instruments, medications and hands, done by the Spasokukotskiy-Kobhergin method, was fully satisfactory. Medical institutions located in adapted peasant's huts were inspected.

A large population of anaerobic bacilli of the type B. perfingens was established in the equipment for special bandaging for wounded with anaerobic infections. It was concluded from this that it was necessary to separate bandaging for each group of patients. Ordinary cleaning of rooms where the patients with anaerobic infections were housed was inadequate; it was necessary to use a bactericide in these cases.

Repeated bandaging of wounds at division medical stations for the most part was done in a special separate corner of the tent where these wounded were hospitalized. If for any reason this could not be done, which was rare, the division medical station kept the wounded then carried out separate suppurative bandaging. Because the number of containers for sterilization of bandaging material and linen was always inadequate and a large part of it was sterilized in double pillowcases, it was preferable that the material in the containers be bandaging material. In operations where much more material was used than in bandaging, the cases were filled and sent again for sterilization.

In World War II, the head surgeons had the categorical demand for operating in masks and to eliminate the possibility of dust getting into the operation and bandaging areas. This second condition depends on the fluorine in the rooms where the work is being done. A canvas floor was cleaned two to three times more than the tent itself. The best floor in the tent is considered to be that made of wooden planks. Unfortunately, it is difficult to move and making a new one each time is impossible due to lack of materials and time. When possible, the floors is made of old boards, bricks, etc.

For setting up division medical stations or mobile surgical field hospitals in houses or mud huts, the space under the operating tables and under the tables with the sterile instruments is covered with sheets in order to avoid bits of plaster or paint getting into the wound.

At the division medical station or mobile surgical field hospital at the front line, an order existed according to which the wounded person was delivered to the operating table dressed in clean pants and shirt. At the second operation (bandaging), the patient was sent with the wound uncovered: when the wounds were in the upper half of the chest, the undershirt and shirt were taken off (in the wintertime there were usually several) and with wounds of the lower half of the trunk and legs, the britches and pants were taken off.

Experience in the war showed that in field conditions even with very large numbers of wounded, if the personnel of the medical institution were adequately qualified and it was requested, the surgical work could be done observing all of the rules of aseptics.

If primary physician aid was given at the regimental medical station, then the division medical station was the area where the first surgical treatment was given. Throughout the entire war, the division medical station was the "combat region operating center," where, except for wounds of the skull and sometimes of the large vessels, all of the wounds were divided into two groups according to a clinical principle: those needing surgery or those requiring conservative treatment.

Experience in the war with the Byelofinns indicated that 75.0-80.0% of the wounded when given first aid, needed surgery. It is obvious that this percent cannot be stable because the character of the wounds changes, depending on the conditions of the locality and the phase of combat (more precisely it is because there is no stable ratio of bullet and fragmentation wounds).

Even with a superficial acquaintance with the question of frequency of primary treatment of wounds, one had to encounter a significant variation of data in different periods of the war with different combat operations and even at different division medical stations, but the same army and in the same time period. From the reports, it is not possible to state precisely what percent of cases needed surgery among those receiving first aid at the same stage. Basically, the primary treatment was done at two evacuation stages - at the division medical station and the mobile surgical field hospital and the percent of those operated on at the mobile surgical field hospital at the first line was made up of two categories of patients: those who for any reason could not be operated on at the division medical post but required primary treatment, and those who had been sent to the mobile surgical field hospital, skipping the division medical station.

Inasmuch as the mobile surgical field hospital of the front line was in a line with the division medical station on all fronts during the entire war, often identical functions to the division medical station were carried out and there were patients at the division medical station, particularly during large offensives, who could not be found in the documentation where compiling reports could not always be done for differentiation of both groups of wounded. For comparison, both reports must be used. Also it is necessary to remember that the total percent of wounded subjected to primary treatment, as one clearly sees from the reports presented above, is always lower than the total percent of those treated at the division medical station and the mobile surgical field hospital.

In order to illustrate the significant variations in frequency of primary treatment, below we will present comparative data for armies of different fronts and for different years of the war.

For instance, during the destruction of the Germans near Moscow, the number of primary treatments at the division medical station for different armies (February 1942) varied widely, sometimes reaching 98.2% of the total number of wounded. According to A. Ya. Barakanov's data, the operating rate at the division medical station during combat operations is reflected in the following numbers: when destroying the Germans surrounding Stalingrad - 42.8%; during the Orlov-Kursk operation - 48.7%; the Byelorussian operation - 62.1%; the operation on the Visla-Oder - 45.55%. On the basis of studying the chart of fundamental characteristics, it was established that primary treatment was given to 52.7% of all wounded patients. Primary treatment was not given, primarily, to wounded who had received undoubtedly fatal wounds. Some of the wounds were not treated due to the presence of very large numbers of small wounds. In most cases, the primary treatment was not done due to the fact that surgeons considered it inadvisable (the wounds were not suitable for treatment). A small number of the wounded (approximate count no more than 2.0% of the wounded in a selected group) did not receive primary treatment due to complex tactical conditions. These wounded undoubtedly were operated on somewhat later as soon as possible.

It was also undoubtedly true that an insignificant number of wounded later underwent certain elements of primary surgical treatment. These small operations were done by stages during the bandaged period. Usually they were only insignificant but they are not adequately shown in the case histories. Most often these small operations were to remove surface foreign bodies from the wounds, remove sections of dead muscle or cells.

Classification of wounds was done so correctly among the troops that one can be sure that of all the wounded who did not receive surgery during primary treatment, 85.7% of them showed no complications later on which required operative treatment.

The results of treatment of this group of wounded must be recognized as very satisfactory; 83.0% of those wounded were completely healed and released from the treatment institutions.

It seems the activity of the surgeons was in direct relationship to the character of the wounds themselves which in turn, depended on the predominant type of fire from the enemy.

Although bullet wounds were encountered less often than fragmentation wounds (43.2% bullet and 56.8% fragmentation), among the nonoperated wounds one observed the opposite relationship (51.3% bullet and 48.7% fragmentation) (Table 9).

Table 9. Relationship between bullet and fragmentation wounds among nonoperated wound cases.

(a) Ранения	(b) Процент по всем ранениям	(c) Процент среди неоперированных
(d) Пулевые	43,2	51,3
(e) Осколочные	56,8	48,7
(f) Всего . . .	100,0	100,0

Key: (a) Wounds; (b) Percent of all wounded; (c) Percent among those not operated on; (d) Bullet; (e) Fragmentation; (f) Total.

In order to make the question of the role of bullet and fragmentation wounds more precise, let us introduce data on wounds which were not operated on which occurred in the extremities (Table 10).

Table 10. Distribution of wounds not operated on depending on the character of the wound in the extremity.

(a) Ранения	(b) Сквозные	(c) Слепые	(d) Итого
	(e) процент ранных		
(f) Пулевые	93,3	6,7	100,0
(g) Осколочные	44,9	55,1	100,0
(h) Всего . . .	71,4	28,6	100,0

Key: (a) Wound; (b) Perforated; (c) Not perforated; (d) Other; (e) Percent of wounds; (f) Bullet; (g) Fragmentation; (h) Total.

It is clear from Table 10 that among the wounds not operated on, patients with perforated wounds clearly predominate; those which are not perforated were observed only in 28.6%. Wounds of the extremities were taken because it is just that with these wounds that the presence of fragments or bullets in the tissue can solve the question in a number of cases of active or conservative treatment. When the question was of wounds in cavities, the character of primary treatment was determined on the basis of appropriate indications and the presence of a foreign body was not of particular significance.

Table 11 shows data on the frequency of the uncomplicated course of wounds.

Table 11. Frequency of complications in wounds not operated on.

(a) Ранения	(b) Процент случаев, не потребовавших дополнительных мер, по всем ранениям данным оружием
(c) Пулевые	50,1
(d) Осколочные	32,6
(e) Всего	40,3

Key: (a) Wounds; (b) Percent of cases not subjected to additional measures but all wounds of a given weapon; (c) Bullet; (d) Fragmentation; (e) Total

It seems that 40.3% of the wounded were not subjected to surgery during the treatment period and recovered. This 40.3% of the wounded in most cases also were subjected to active surgical action, however, the open wound in which the conditions were created which did not prevent the process of repair, made it possible in these cases to conduct the whole period of treatment without surgical intervention, taking all of the necessary actions during the bandaging period. In truth, as was mentioned above, primary treatment done with subsequent bandaging is not clearly reflected in the case histories. Undoubtedly one should take this into consideration when interpreting the data obtained.

It is completely clear that operative treatment is not used for the lightly wounded (except for small groups of the more severely wounded) and therefore the number of complications with suppuration and anaerobic infection in this group was lower than in those operated on (Table 12).

Table 12. Frequency of complications in wounds not operated on depending on the type of weapon causing the wound.

	(a) Ранящее оружие	(b) Без осложнений	(c) Гнойная инфекция	(d) Анаэробная инфекция	(e) Сепсис	(f) Прочие осложнения
(g)	Пуля	87,7	3,9	0,9	0,2	7,3
(h)	Осколки	82,9	6,8	1,9	0,2	7,2
	(i) Всего ...	85,8	5,3	1,4	0,2	7,3

Key: (a) Weapon; (b) Without complications; (c) suppurative infection; (d) Anaerobic infection; (e) Sepsis; (f) Other complications; (g) Bullets; (h) Fragments; (i) Total.

In the group of patients not operated on, the suppurative and anaerobic infections (we are talking only about complications which require surgery) were encountered with fragmentation wounds twice as often as with bullet wounds (Table 12). Later complications, sepsis and osteomyelitis, were observed just as often both among the bullet and the fragmentation wounds. This relationship exists for bullet and fragmentation wounds with other operative interventions carried out when treating the wounds. For complications which developed early, common pus and anaerobic infection, the role of the weapon causing the wound is very great. An excess of destroyed necrotic tissue plays the basic role. When complications developed later on, this factor loses its overwhelming significance.

Operative treatment of wounds in all localities is done, obviously, and those which are done are in a group where the suppurative and anaerobic complications occur less often.

For instance, with wounds, for example, of the head, conservative tactics are used by surgeons twice as often as with wounds of the pelvis: according to the data in the chart for fundamental treatment, in 66.7% with head wounds and 33.2% with pelvic wounds; with wounds of the upper extremities, in 56.1%, with wounds of the lower extremities in 38.1% of all wounds in this region.

We pointed out above that when determining indications for the treatment to be taken, the time which is passed from the time the wound occurred is not a decisive factor, although it plays a certain role in the further course of the wound. Moreover, the time the primary treatment was made characterized the quantity organization of the whole health service of a given division and always was strictly considered.

Primary treatment of wounds was done in the following time periods after the wound occurred (Table 13):

Table 13. Distribution of time periods for primary treatment of the wounded.

	(a) Срок первичной обработки	(b) Процент раненых
(c)	До 6 часов	21,9
(d)	7—12 »	24,2
(e)	13—24 часа	24,3
(f)	После 24 часов	29,6

Key: (a) Time period for primary treatment; (b) Percent of wounds; (c) Less than 6 hours; (d) 7-12 hours; (e) 13-24 hours; (f) More than 24 hours.

During the first 12 hours after a wound occurs, primary treatment was conducted in almost half of all cases; treatment of 2/3 of the wounded was carried out in the first day.

A considerable number (1/3) of the wounded operated on later than 24 hours, is explained by the fact that beginning in 1942, many of the wounded were subjected to treatment in specialized hospitals (wounds of the skull, joints). It is just these groups where the main mass of operations are done at later periods. Almost always primary treatment was done within the limits of the army. For instance, at the regimental medical station[1] 0.5% of the wounded were

[1]Surgical treatment of wounds at the regimental medical station must occur only in special conditions (necessity for evacuation to the rear). Cases where it was done without significant indications were rarely found.

operated on; at the division medical station - 72.6%; at the mobile surgical field hospital - 18.8%; at the army base hospital - 7.0%; at the base hospital at the front - 0.9%; at other institutions - 0.2% of the wounded. Thus, the overwhelming majority of the wounded were operated on at the division medical stations.

When comparing the time periods and location where primary treatment was carried out, one sees that at the division medical station during the first days after wounds occurred, 83.6% of all wounded were treated, and operated on at this stage. In much later periods, treatment of wounded at the mobile surgical field hospitals is explained by the fact that in this group, the mobile surgical field hospitals from the first and second lines were combined (Table 14).

Table 14. Relationship of time periods, stages and quantity of primary treatment.

(a) Срок обработки после ранения	(b) ПМП	(c) ДМП	(d) ХППГ	(e) ГБА	(f) ГБФ
	(g) процент раненых				
(h) До 24 часов	85,7	83,6	37,2	25,7	22,4
(i) После 24 часов	14,3	16,4	62,8	74,3	77,6

Key: (a) Time period for treatment after being wounded; (b) Regimental medical station; (c) Division medical station; (d) Mobile surgical field hospital; (e) Army base hospital; (f) Base hospital of the front (g) Percent of wounded; (h) Less than 24 hours; (i) More than 24 hours.

This is completely understandable because, according to the documents, it is necessary to establish whether or not a given mobile surgical field hospital at the time they were treating a particular wound, was functioning as the mobile surgical field hospital for the first or the second line.

Moreover, one should note that although the mobile surgical field hospital was often located on the medical battalion line, the wounded were sent here not strictly in turn but on the basis of a certain selection. Most often the mobile surgical field hospital accepted the most severely wounded (wounds in the chest, abdomen, head, femur, joints) because these wounds require longer periods of hospitalization after surgery.

Table 14 shows how the division medical station deserved their title of "operation unit of the combat region." In the time periods for the treatment, in the number of wounds treated, they deserve a great honor for their jobs.

The number of operations is closely related to the number of wounded admitted. If the daily admissions of wounded to the medical battalion station, not counting the separate medical reinforcement company, exceeded 150 persons, the number of operations would be decreased and the time periods for waiting in the clearing section would be increased. At this time, skillful timely maneuvers of hospitals and surgical groups for reinforcement resulted in rapid elimination of the "bottle neck" and a significant increase in the percent of operations. As an example of this maneuvering, one can present data on the work of the medical battalion stations and the mobile surgical field hospitals for the N army where, of all of the patients going through the medical battalion stations, only 50.1% were passed through and the others were sent from chast' and the regimental medical stations directly to the mobile surgical field hospitals of the first line.

It has already been pointed out that about 1/2 of the bullet and 1/3 of the fragmentation wounds were treated surgically. Of all the wounded subjected to operative treatment, the bullet wounds amounted to 36.3% and the fragmentation to 63.7%. With wounds in the chest, the decisive role was played by the question of whether or not the wound penetrated into the cavity. When establishing indications for primary treatment of wounds of the extremities, much depended on whether the wound was a perforation wound or not. For instance, with perforation wounds of the extremity, primary treatment was done in 58.0% of the cases and with nonperforation - in 70.1%. It is necessary to note that the ratio of surgeons when treating wounds of the extremities was more active than when treating nonpenetrating wounds of the chest. This meant the threat of anaerobic infection whose occurrence in any case in the first years of the war in most surgeons, was associated with injury to the extremities, particularly to the lower extremities.

Primary treatment with nonpenetrating wounds of the chest was done in 48.6% of the cases; with nonpenetrating wounds of the abdomen - in 52.0% and with wounds of the soft tissue of the extremities - in 57.7%.

There is well known interest in the relationship between the type of fragment and frequency of surgical treatment of the wounds. For instance, with wounds from hand grenade fragments, primary treatment was used in 59.4% of the cases, from artillery shells - in 61.5%, mines - in 61.7% and in aviation bombs - in 54.3%.

The highest percentage of surgical intervention was for cases of fragments of artillery shells and land mines and the lowest for wounds with fragments of grenades and bombs. When grenades explode, they form a large number of very small fragments which are imbedded usually in soft tissue. To conduct an operation to remove such fragments is not expedient because most of them are forced in and some are discharged with pus when they are opened and surrounded by abscesses.

Wounds with fragments from bombs were usually very severe. Wounds in these cases were large, destroyed tissue, were subjected to necrosis and were very numerous. In spite of the fact that the wounds undoubtedly required treatment, the severity of the condition of the wounded persons often made it impossible to operate in any way.

The further course of the wounds which were treated surgically is evidence of the fact that the amount of intervention as a whole was correctly determined in spite of the fact that it is very difficult immedia' 'ly to determine the boundaries of necrosis. The uncomplicated course of this type of wound was observed in 76.4%, that is, more than 3/4 of the wounds were subjected only to primary treatment.

In the first month of World War II, attempts were also encountered to excise gunshot wounds with subsequent application of closing sutures, but they were rapidly stopped. In certain cases, the surgeons dissecting the skin and part of the soft tissue of the wound opening were convinced of the complete impossibility of "dissecting the wound."

Obviously, such treatment was completely unacceptable. A great deal of work was still necessary for complete mastery by all surgeons both of the principles of treating wounds and the techniques of doing it.

The basic arrangements affecting methods of treating wounds were given by the Main Military-Medical Administration of the Red Army. At the same time, terminology was also reconsidered. By the term "surgical treatment of wounds" only intervention was meant which was carried out using cutting instruments and involved the use of an anesthetic. In the accounting forms, surgical treatment of wounds first was recorded in the main graph separately from other surgical operations in connection with wounds. In practice this causes difficulties because, on the one hand, it was not permissible to apply all manipulations to surgical treatment which did not have the characteristics of surgical intervention (toilet of a wound) and on the other hand, it was necessary to determine operative intervention which had typical characteristics of surgical treatment of wounds and operations in connection with a wound cavity (with an open pneumothorax, with certain wounds of the joints, skull, etc.). All this made it necessary to develop new forms of accounting where all surgical intervention could be put on a single graph. The new forms which simplified the record keeping, showed the correct concept of surgical treatment of wounds as surgical intervention. They were rapidly mastered by surgeons in all medical institutions.

In accordance with the clinical subdivision of wounds used in the Soviet Army as wounds of the first group which do not need surgical operative intervention, they were put into a general set of wounds and given the name toilet of the wounds. They were very simple and the damaged area could be examined fully. The wounded person was put onto a table and the wounded area was disclosed; by ordinary surgical investigation, it was established that the primary surgical treatment was not necessary. It is stated that the wound is not bleeding, that there are no changes in the coloration of the skin either at the edges of the wound or on its extent; the area of the wound is not swollen, there is no accumulation of blood in its depth, no edema, at the periphery in the locale of the wound, one can feel pulsation of the artery corresponding to the healthy side, and also there are no particular deformations observed, the pain is confined to the area damaged. If the wound is on the head, chest or abdomen, then hair is shaved off from the area surrounding the wound aperture, the skin is washed with gasoline or ether, wiped with alcohol and a 5% solution of tincture of iodine or aniline dyes are applied. With wounds in the region of the inguinal fold, and the scrotum, in the region of the anterior passage, application of iodine can be considered as excessive in order to avoid stimulation of the skin of these regions. The wound apertures themselves, or more correctly, defects in the skin in the area of the wound when they have a point character, also can be painted with iodine or powdered with a sulfanilamide preparation (white streptocide). On top of the wound an ordinary bandage is applied; the extremity, if necessary, is splinted in a physiologically acceptable position. Slight surface wounds do not require wrapping with bandages; the bandaging material can be successfully attached with sticking plaster or kleole.

The technique of surgical treatment of a wound is basically different from its toilet. The operation begins with preparation of the operational field, and its elements are those measures which are used for toilet of the wound. The dimension of the prepared section of skin corresponded to the dimensions of the proposed operation. The wound itself during preparation was covered with gauze. The skin was cleaned with gasoline, treated with alcohol and most often painted with iodine, less often with dyes. When necessary, first of all the hair was shaved off according to the usual rules. This part of the preparation caused difficulty only in the hairy parts of the head. Anesthetic was given at the same time as the preparation (narcosis); local anesthesia was used for the final preparation of the operational field. The wound surface was subjected to additional inspection for making diagnosis of the damage more precise; all foreign elements were removed from the surface of the wound (dirt, bits of clothing, etc.). Further, removal of jagged edges of the wound should be done and an examination of this. All bits of tissue forming pockets and semiclosed depressions were cut away. In a large number of cases, one had to begin treatment with excision of the skin and aponeurosis in order to increase the length of the wound and thus make inspection of its deep parts more available. One should consider it an error to cut a circular shape for defects on the skin which makes it difficult later on for the wound to heal. Fig. 62 shows incorrect (a) and correct (b) dissection of the wound. Dissection must be such that the wound surface is open for inspection by eye.

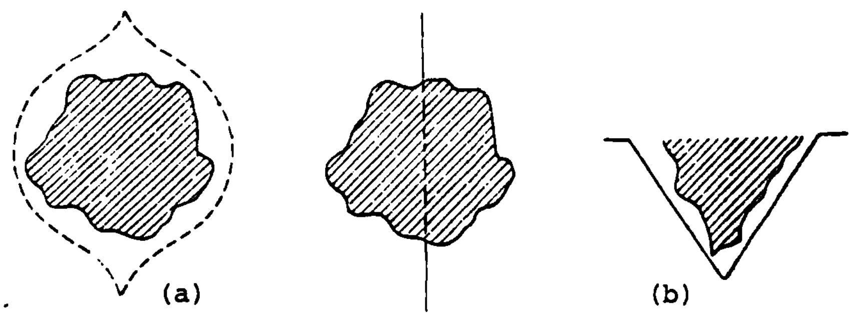

Fig. 62. Incorrect (a) and correct (b) treatment of the wound.

Clots of blood and fluid blood should be removed from the wound as well as foreign bodies; the free sections of tissue should be removed completely and also bits of tissue suspended on the limbs which are not viable should also be removed. Crushed and smashed muscles should be dissected particularly carefully; the presence of fibular contractions during contact with muscle fiber is a sign of their viability. Treatment of the wound was done systematically and in sequence beginning with the surface sections down to its bottom. Dissection of aponeurosis is particularly important because sometimes under it one observed large sections of damaged muscle. Moreover, dissection of strong aponeuroses makes hemorraghing easy later on in the underlying tissue in the stage of inflammatory edema. With a whole aponeurosis, deep tissue is compressed, circulation is worsened and favorable conditions are created for developing infectious processes. With subsequent dissection and excision, the wounds become available for inspection and the entire wound surface is made up of tissue which is most cases is viable.

The bony tissue was removed in cases where separate fragments had lost their connection with the soft tissue. An evaluation of the viability of different tissues required a good deal of experience and attention. Under all conditions, the operation was completed with careful drainage of the wound.

In a number of cases the surgical treatment of the wounds was a very complex operation technically which repeatedly was stressed by experienced surgeons with brilliant techniques. Who among surgeons, even those with a great deal of experience in treating wounds, has not been severely disappointed when during operations, it appeared that all the nonviable tissue had been removed from the wound and during revision on the third to fourth day, was convinced that significant foci of gangrene had developed in the wound.

It was pointed out above that part of the tissue in the wound does not die immediately but after a certain length of time. At the moment of treating them, their nutrition was still adequate but then thrombosis of one vessel or subsequent edema can so decrease the blood supply that the section becomes necrotic.

For instance, if the wound is treated very early, for example, a few minutes after the wound occurs, then almost all of the tissue except that directly crushed and sheared as a result of the injury appears to be viable and can erroneously be left in the wound; they become necrotic after a few hours and require additional intervention.

Surgical treatment of wounds cannot completely sterilize them or remove from the wound an infection begun by excision of tissue contaminated by microbes. Neither dissection of the tissue nor excision of it in the form described can possibly achieve this purpose. This task does not face the military field surgeon in the combat region.

By subsequent dissection and excision, the most favorable conditions are created for subsequent regeneration. A minimum amount of tissue is removed and when inflammation develops, the isolated wound will drain outward into the bandages.

Also gunshot wounds are encountered which require for successful healing only dissection of the tissue and excision is not generally necessary because there are no underlying sections with accumulation of blood. Naturally if there is nothing to excise, then excision is not done. There are also wounds whose entire cavity is fully available for examination and there are no closed or semiclosed spaces or pockets and therefore it is not necessary to have dissection but only excision. In these examples it is clear that neither dissection nor excision are different, hardly opposite methods but are only technical means for the same method for the same purpose.

Thus, in the Soviet Army during the war, a single method of surgical treatment was finally developed.

In conclusion we should pause to discuss the question of the time periods for primary treatment of wounds.

According to Fridrikh, when treating wounds with a method of excision, the time period is of decisive significance. By experimental studies it was established that primary treatment of wounds must be conducted within six hours after the wound occurs. In peacetime practice, in certain cases, this time period reached 24 hours but the majority of authors considered that it should not exceed 12 hours.

In combat circumstances it is impossible to guarantee that surgical assistance can be given to each wounded person requiring it within the obligatory 12 hours, even during the time period for evacuation to the division medical station because, primarily, the wounded with indications of emergency operations will be operated on. Experience showed that the time periods which limit the use of surgical treatment of wounds do not exist and all of those requiring operative assistance can and must be given at any time. It is understood that with later treatment, that is, when signs of infection are already there, the character of the operation can be changed but not because of the time period but due to the presence of various complications in the wound. The principle of treatment of wounds remains unchanged and always leads to the measures described above where the character of a given wound and the person as a whole are taken into consideration.

Additional Measures for Surgical Treatment of Wounds

During the first World War in 1914-1918, when treating gunshot wounds, it was obligatory to use antispetic means. After this war, new antiseptic means appeared. The most widespread of these were Rivanol, chloramine and hypertonic solutions. During combat on the Khalkhin-Gol river during the war with the Byelofinns in 1939-1940, Vishnevskiy's ointment was widely used although basically it was to combat infection and not prevent it. During World War II, a butyro-balsamic bandaging was widely used. Preparations from the sulfanilamide group were also widely used, primarily white streptocide and then sulfidine and sufazol. The importance of these preparations both for prevention of wound infection and for combatting it was established at the very beginning of World War II with the attack of Germany on Poland and then in the war theaters in Norway, Holland and France. The first attempts to use sulfanilamides in the Soviet Army in combat field conditions were confirmed during the war with the Byelofinns. At the beginning of World War II, the introduction into practice of sulfanilamides was speeded up which, to a significant degree, was facilitated by broad propaganda in its use including propaganda in the general press (N. N. Burdenko). Even in the first publication of "instructions on military-field surgery", sulfanilamides were recommended and our industry, for a short time, guaranteed output of an adequate quantity of these preparations both for surgical and for other needs.

At first it was proposed that using the bacteriostatic effect of sulfanilamides, it is possible with their use on a fresh untreated wound to cut down on the surgical treatment time. For this purpose cylindrical tubes of streptocides were manufactured which were intended for injection in narrow wound channels. However, it was very soon established that sprinkling an untreated wound with streptocide powder not only was not useful but was even harmful because the crust which formed from the powder mixture on the surface of the wound with the blood, covered the inflammatory process which occurred and it expanded without limit. Equally, the streptocide applied to dead tissue was not absorbed and did not have any effect.

In this way, the use of sulfanilamides from the very beginning of their use at the front took on the character of auxiliary treatment of the wounded surface most often with streptocide powder. This measure was the last one and was used only after completion of surgical treatment, stopping bleeding and thorough revision of the wcund. The sulfanilamides were applied to the wound surface either with an applicator or using an insufflator. The quantity of streptocide required depended on the size of the wound surface, sometimes one observed clearly excess use of sulfanilamides. As subsequent experience showed, on the average no more than 5-10 g of streptocide is needed for a wound.

The wound surface or cavity is loosely covered with gauze and then the bandaging required for a given wound is applied.

Of the antiseptic means, the most widespread was chloramine which was discovered during the war with the Byelofinns and which had many proponents also in World War II. Already treated wounds were moistened with the chloramine solution and then loosely covered with moist gauze pads. It is natural that sulfanilamides and chloramine were used primarily for the most severe wounds and were not used uniformly on different fronts.

The type of use of sulfanilamides first carried out on the Western Front deserves particular attention (Chief Surgeon S. I. Banaytis). B. M. Solov'yev, using ultrasonic oscillations prepared a particularly thin 5% emulsion of streptocide where the dispersion medium is fish oil and water. Such a "reversible" emulsion is very stable; it is used both for impregnation of the gauze put into the wound and directly on a surgically treated wound surface. The streptocide emulsion is just as effective as the powder but it is more economical and does not cause the formation of a scab; the gauze can easily be removed from the wound.

On certain fronts, after primary treatment, washing of the wound was done. During the Civil War in Spain, Truetta was a great proponent of washing the wound surface and cavity and also the surface surrounding the wound with a soapy solution. In his work on military surgery, he presents a number of studies showing the antiseptic value of the soapy solution. However, these properties of the soapy solution had such a short term effect on microbes that obviously they play a very secondary role. Truetta himself recognizes that the use of soap is important for the removal of dirt. This effect of the soap solution depends on its absorptive properties in relation to particles of dirt. Attention was directed to the fact that if, after thorough treatment of the wound and thorough cleansing of it with moist gauze tampons, one washes the cavity of the wound with a soapy solution, then it would seem from the completely clean wound most of the small fragments, clots, etc. would be removed. Thus, the expediency of washing wounds with a soapy solution obviously is indisputable. This method was broadly used even at the end of the last century by Professor M. S. Subbotin and was then replaced with other methods due to its unwieldy nature. In the institutions in the combat and army regions with a large influx of wounded, when the personnel could harly cope with the work, each extra minute required for treatment lengthened the wait for the next wounded person and these minutes can add up into hours. Moreover, with this method, unavoidably a great deal of water has to be used which often is not available in field conditions. It is natural that the method of washing the wounds should be used only by special teams.

The next stage closely related to surgical treatment of the wounds is providing rest of the wounded region. The more severe the wound, the more important this rest is. Even from descriptions of changes which occurred in gunshot wounds, it follows that after removing the nonviable tissue in the wound, there still remains sections with a breakdown in nutrition and blood supply. Each functional load in these cases involves inadequacy of exchange and threatens the viability of the tissue. For "reviving" such tissues, rest is completely necessary. Further, a number of biological reactions occur in the tissues, in particular the "protective" character in relation to the toxic product formed in the wound as a result of breakdown of tissue and vital activity of the remaining microbes. Finally, an "explosion" which occurred at the moment of the wound undoubtedly leaves a number of harmful aftereffects. The clinician is well acquainted with the picture of initial infection in wounds which is slowed down after immobilization is carried out and further complications may not even arise. Thus, rest and immobilization facilitate prevention of wound complications. With damaged bone and joints, the importance of immobilization is generally accepted and we are talking only about the form of its use. Almost all wounds except the very light wounds, during prephysician first aid or first aid by a physician, are sprinkled with 1% morphine per 1-2 cm^3. Moreover, each wounded person must receive a prophylactic dose of antitetanus serum and with wounds of the lower extremities, the pelvis, the perineum and regions with broad musculature when there is crushing must also receive antigangrene serum.

Surgical aid is generally given first at the division medical station. At this stage, classification and documentation is done.

Here the wounded receive hot, sweet tea and food (except in cases where this is contraindicated due to the character of the wound). In the wintertime, all of the wounded receive 100 g of vodka. Beginning with the army region, all of the wounded received at hospitals are given hygienic treatment.

CHAPTER IV

COMPLICATIONS IN THE COURSE OF WOUNDING

The tendency of gunshot wounds to complications has always attracted the particular attention of surgeons. The overwhelming majority of wound complications observed during World War II can be divided into the following four groups.

1. Complications dependent on the severity of the trauma, its localization and nature. Profuse hemorrhages, shock, disorders associated with a reduction in function of different systems or individual organs, for example, respiratory disorders in lesions of the respiratory passages, urination in lesions of the urinary tract, paralysis in lesions of the nervous system, etc., are such. The presence of a foreign body in tissues also can be the cause of complications.

2. Complications caused by the effect of various factors on the wounded: cold, fatigue, etc. (see Frostbite).

3. Complications which occur with alimentary dystrophy and avitaminosis.

4. Complication of a wound by infection.

Wound infection is of exceptionally great importance. Essentially only with some reservation can complications of the first group be considered complications, because they are closely associated with the nature of the wound and its localization. Some of them are discussed in separate chapters (Hemorrhage, Shock, Foreign Bodies). The majority of them have been described in special sections according to wound localization.

The basic position of the military field surgeon is that any gunshot wound is considered infected. This position should be understood in this way: a gunshot wound received under combat conditions always contains a source of infection in the form of a mixed microbe flora, as well as necrotic foci which are favorable grounds for the development of an infectious process. Numerous studies of the flora of recent gunshot wounds of varied localization and different natures, both before and during World War II, have found the invariable presence of pathogenic microbe flora and necrotic tissue sections in wounds. Part of the tissue dies at the time of the wound and part after some time. Moreover, the reactivity of viable tissue is reduced to some extent because of the characteristics of gunshot trauma. Thus, there are the conditions for the development of infection in each gunshot wound.

Any healing of a wound is accompanied by an inflammatory process. However, experience shows that the clinical course of a quite substantial portion of gunshot wounds is favorable. In these cases, the inflammatory process is not accompanied by explicit symptoms of complications, but it appears to combine with the wound healing process. An infectious complication of a gunshot wound has been recorded in case records in the following cases: 1. if acute inflammatory processes and the corresponding general reactions developed in a wound which requite surgical intervention as a rule did not undergo surgical treatment or protection for some reason; 2. if a wound left open after treatment produced an abundant purulent discharge containing viable pathogenic microbes, as well as if the infectious process spread beyond the wound and required additional surgical interventions.

In the remaining cases, if a wound heals without the complications indicated, despite the presence of a source of infection in the wound, healing occurs.

A gunshot wound suffers infection due to the flora which find the most favorable conditions for its development in the wound. Infection appears in monomicrobe or polymicrobe form. The clinical pattern of such an infection with different microorganisms or associations of them present is almost identical, and it reveals characteristic features only with respect to a specific species of microbe. Corresponding to this, wound infections can be subdivided into the following forms:

1. purulent infection due to a group of aerobic pyogenic microorganisms;

2. putrefactive infection due to putrefactive microorganisms (frequently nonpathogenic) usually accompanied by aerobic or anaerobic infections;

3. anaerobic infection due either to individual microbes of this group or associations of them;

4. tetanus as a special form of anaerobic toxic infection;

5. rarer types of infection (wound scarlatina, diphtheria, etc.).

Each of the types of infection presented above should be considered separately, since each gives a characteristic clinical pattern. A purulent aerobic infection, because of its frequency and various forms of clinical patterns depending on localization and extent is discussed according to its varieties.

Purulent aerobic infection is found in the following forms:

1. focal infection of a wound, although it sometimes spreads to neighboring sound sections, most often by lymphatic path-

ways and blood vessels, usually through veins;

2. general infection of the entire body by a serious general infection, in which the wound is only the initial gateway for it and stops playing the role of the only principal focus.

The clinical pattern of a focal purulent aerobic infection differs, depending on the infection site, in the following manner.

1. An infectious process accompanies each open gunshot wound and, consequently, it accompanies the majority of gunshot wounds in combat. It is either eliminated as a result of conventional treatment, or it produces complications of a so called local nature of the congestive, abscess, phlegmonous inflammation of nearby tissue, lymphangitis and lymphadenitis and thrombophlebitis types. Additional surgical interventions may be needed in these complications.

2. In gunshot wounds associated with bone damage, a purulent infection can develop in the bone tissue, and it then causes the particular clinical pattern of gunshot osteomyelitis.

3. In complications of cavity penetrating wounds, purulent infection involves the serous membranes of the cavities and internal organs, producing the clinical pattern of peritonitis, purulent pleuritis, meninginitis, encephalitis, etc.

The focal form of aerobic purulent infection is so integrally associated with the occurrence of gunshot wounds in combat that it should be discussed in inseparable association with the pathology and therapy of gunshot wounds in general. The remaining forms of aerobic purulent infection are discussed in connection with wound localization.

The abovementioned classification of infections which complicate a gunshot wound is dictated by both the difference in clinical pattern of the wound process as a function of the type of infection and localization, and the characteristics of military field surgery. The fact is that all suppurative lesions of the soft tissues normally develop soon after wounding, and they are treated mainly in the army area. Wounded with bone lesions are subject to evacuation to the rear at the end of the acute period of suppuration. A large number of these complications become chronic and are the cause of invalidization of a considerable portion of wounded in the postwar period. Those wounded in whom a general purulent infection is diagnosed (except acute cases) are sent to FEP [frontline evacuation station] hospitals and rear hospitals. Wounded with infectious complications of chest and abdominal wounds are concentrated in the corresponding hospitals or units (the so called "thoracoabdominal") and those with meningitides in neurosurgical units. The treatment of tetanus and anaerobic infections in the stage in which they are detected is carried out in complete isolation. Thus, under combat conditions, infectious wound complications are distributed according to their subdivision into groups, and they are treated at different stages and in different units of the specialized surgical assistance system.

In subsequent presentations in this chapter, only that form of purulent infection which complicates a nonpenetrating wound of the soft tissues regardless of its localization is intended.

However, as was pointed out earlier, the sources of infection in gunshot wounds are extremely diverse. This diversity was partly presented in the tables of wound flora in accounts of the course of the wound process. How high the probability of infection is was evident then, but study of the conditions of development of infection and experience have shown that, both in peacetime surgical wounds and accidental wounds and in gunshot wounds in war, infection is successfully prevented or its development is restricted to the limits of the wound cavity in an extremely large number of cases, to such an extent that repeated surgical intervention is not required subsequently. Thus, control of wound infections is naturally broken down into two kinds of measures: prophylactic and therapeutic. Both the former and the latter can have the purpose of control of either wound infections in general or a special form of it, for example, tetanus. Because of the composite nature of wound flora, initial prophylactic measures are of a general purpose nature. These are primarily surgical treatment of the wound, protective bandage, immobilization and a number of general measures. Prophylactic measures against both possible anaerobic gangrenous and tetanus infections are carried out at the same time.

The danger of wound complications, infectious complications in particular, depends on many conditions. Some of them have already been discussed. The remainder will be discussed subsequently. But there is one source of wound infection which is subject to elimination first. This is those factors which arise during therapeutic manipulations on the wound. Thus, conditions must be created in the first phase which ensure an aseptic situation for surgical work. This involves considerable difficulty under military field conditions, both in the organization of surgical work and in conducting it, particularly in the mass admission of wounded.

The frequency of wound complications totally reflects the frequency of wound infections. The difficulty of conduct of prophylactic measures increases with the mass admission and treatment of wounded. It is common knowledge that the number of wound complications in all frontline medical institutions decreased sharply in the intervals between actions, increased in a period of vigorous attacks and again decreased during pursuit of a defeated lightly resisting enemy. Therefore, skillful and timely maneuvering of medical means and facilities, as well as medical reinforcements in order to prevent overload of individual facilities and properly distribute the work of aiding wounded are an effective measure for control of wound complications.

Thus, it must be recognized that all prophylactic measures with respect to wound complications, of which the most important is wound infection, depends first and foremost on the organization of assistance to the wounded and their treatment. Timely and reliable assistance to all combat casualties was only possible through the conduct of organization measures. This principle of the combination of therapeutic-prophylactic measures with organization measures, proposed by N.I. Pirogov, is the foundation of military field surgery.

Purulent Infection of Wounds

In discussion of the previously cited work of N.I. Grashchenkov and P.P. Sakharov, attention was drawn to the fact that wound flora completely correspond to the clinical manifestations of infectious complications. The clinical pattern is decisive for diagnosis of infections, and the bacteriological findings only confirm or refine it to some extent. Tetanus, an anaerobic infection, gives a quite clear clinical picture. It is more difficult to identify chronic infections. The bacteriological data are sometimes decisive in them. A putrefactive infection usually is combined with other kinds of infection, and it acquires the leading part under conditions which are particularly favorable for it (see the chapter Putrefactive Infection). Consideration of purulent infection and its combinations with putrefactive infections has to be guided here by subsequently presented conditional considerations. Namely, complication of a wound by purulent infection, based on the case record, must be understood to be those forms of infection which required special surgical intervention for treatment.

Shrapnel wounds were complicated by purulent infection of the soft tissues in 4.9% and fragment wounds in 7.3% of the cases. This complication occurred in 5.3% of wounded not treated surgically and in 7.1% of those treated.

A portion of the wound complications in this category were observed in cases when treatment was not carried out or because of an improper surgical tactic or due to the combat situation. Only 7.1% of the surgically treated wounded required secondary intervention for purulent infection.

The lower percent of complications among the unoperated wounded, as was pointed out above, depended on the fact that lighter wounds predominated among this group.

A primary suture was applied to a relatively small number of wounded, partly on sufficient grounds and partly in error. Purulent infection developed in 7.8% of these wounded.

The advantage of additional treatment of wounds with sulfanilamides over other antiseptics shows up quite clearly, in that purulent infection complications in the use of sulfanilamides was observed in 6.1% but, in the use of the remaining antiseptics, in 8.8% of the cases. It should also be taken into account that sulfanilamides were used in more severe cases.

The largest number of purulent infection complications were observed in those cases when a plaster bandage was applied immediately after primary treatment (12.0%). Of course these were wounded with severe gunshot fractures, and the high percent of purulent complications by no means discredits immobilization with plaster. This is proved best of all by the fact that anaerobic infection developed in only 1% of such wounded. The development of a given form of pyogenic infection was an indication for a new surgical intervention.

As to wound complications of the exsanguinated wounded, together with a high percent of complications of these wounds with gas infections and sepsis, as well as other complications, the frequency of pyogenic focal infection does not at all exceed the number of complications observed in those wounded by shell fragments. Thus, exsanguination reflects mainly on the general resistance of the body, and focal forms, although they increase in number, do not increase to such a substantial degree.

The severity of clinical manifestation of pyogenic infection in wounds which do not penetrate a cavity depends on retention of the wound discharge, on the development of congestion, abscesses and on the development of phlegmonous tissue inflammation involving the lymphatic and blood vessels, mainly the veins.

The development of a pyogenic infection in the initial period of wound healing can be extremely violent. The lack of a granulation barrier with highly virulent microbes produces extremely favorable conditions for their spread beyond the wound, and the disease then proceeds as a general purulent infection (sepsis). The frequent development of sepsis in dystrophy when, as is known, the production of wound barriers slows down abruptly, can be an example. According to the data of P.A. Kupriyanov for the period of the siege of Leningrad in the first half of 1942, the cause of death of wounded was septic complications in 1/3 of the cases. Before the development of granulation, the fibrinous inflammatory exudate and inflammatory edema of the tissues, which develop extremely rapidly after trauma, carries the barrier function to a certain extent. However, the barrier function of the exudate and inflammatory edema is extremely limited, since absorption from the wound cavity occurs simultaneously, which contributes to the spread of bacteria and their toxins beyond the wound. In accordance with changing conditions, the interaction of the intertissue fluid on the one hand and the blood and lymph on the other also changes. Together with the appearance of a fluid exudate, migrating leukocytes appear extremely rapidly (as was seen in the description of wound healing). Partly because of phagocytic capacity and partly because of the excretion of specific antibodies, they paralyze the spread and toxic action of the microbes. However, an increase in osmotic pressure in the inflammatory exudate produces conditions for the absorption of its products into the blood and lymph. The observations of a number of authors who studied the inflammatory process in general in the past (I.V. Davydovskiy et al), as well as the latest observations, in particular of S.S. Girgolav on the state of the peripheral nervous system, have shown that the lymphatic fissures and vessels are enlarged and overfilled with exudate in a purulent inflammation. As a result of such symptoms, part of the source of infection is fixed in place, but a considerable portion enters through the capillaries and mainly through the lymph system into the body and causes a general response. As early as 1909, A.Ya. Pavlovskiy showed that, with an increase in local inflammation due to an accessory chemical stimulus, the absorption of microbes from the inflammatory focus into the blood is successfully delayed. But however that may have been, it must be recognized that the barrier function in a wound increases with development of the granulation cover. It should also be taken into account that the ability of various microbes to penetrate the lymph and blood circulation differs. It depends on the species of microbe, its virulence and on the conditions in the wound. The absorption of wound traumatizing toxins is particularly favored. Therefore, the importance of immobilization of the damaged region under combat conditions, when the transportation of wounded is almost unavoidable, is so great.

The importance of immobilization, i.e., rest, does not restrict the effect on adsorption from the wound at all. The importance of immobilization increases when the inflammatory infectious process moves beyond the wound and when microbes spread through the lymph and blood circulations, when rest of the wound is a necessary condition of successful treatment.

Upon development of an infectious complication in the wound, microbes appear extremely rapidly in the lymph vessels and regional lymph nodes. They are retained there in considerable numbers because of the phagocytic capacity of the reticular cells and endothelial elements, as well as the high antibody content of the lymph. If new microbes do not enter from the wound, microorganisms which reach the lymph nodes die and the infection does not spread further. The inflammatory process frequently spreads to adjacent sections through thrombosed veins. In those cases when more and more microbes enter from the wound, the regional lymph node barrier is broken, and microbes and their toxins spread further, which can result in generalization of the infection.

All of the abovementioned shows that the wound remains the main focus of infection for a long time. Therefore, of course, the wound cavity must be acted on first and foremost to liquidate a developed infection.

It follows from Fig. 47 that there is a connection between localization of a wound and its flora. Wound localization also is extremely significant in the development of a purulent inflammation. A number of studies, the recent work of M.V. Strukov in particular, showed that the resistance of different tissues to purulent infection differs. Tissue has the least resistance. Therefore, a purulent inflammatory process develops most often just in it. The resistance of damaged tissue obviously is weaker than that of undamaged tissue.

The infection of bone tissue is of extremely great importance to the occurrence of pyogenic infection. While a necrotic section which is a focus of infection in damaged soft tissues is comparatively easily detected by eye and is removed by treatment or is eliminated independently partly in liquid form, it becomes more complicated with necrotic foci in bone. It is extremely difficult to detect their boundaries in recent wounds by eye and, consequently, their removal also involves difficulties. As to independent rejection or resorption of necrotic bone, these processes take longer, because of which bone foci become sources of chronic wound complications (see chapter Osteomyelitis).

Finally, the substantial resistance of peripheral nerves to purulent infection must be noted again. It has been determined that both nerve trunks and individual nerve fibers and their endings do not change morphologically, even when the tissue surrounding them dies and undergoes purulent liquefaction. A consequence of this is both preservation of sensitivity to pain in the inflamed region and painful sensations during inflammations, which depend on stimulation of the peripheral nerve fibers and their endings by the products of cell breakdown and bacterial toxins. Therefore, it is clear that pain is one of the basic indications of inflammation.

As a rule, a purulent infection develops in a wound before granulation, i.e., in the first days after wounding. A wound by no means always entirely and immediately undergoes purulent inflammation. In wounds of large dimensions or with long wound channels present, purulent complications in the form of retention of pus, congestion and abscesses can be observed only in some parts of the wound located deep and are clinically difficult to detect.

In an inflamed wound which is not surgically treated and which has either a single entry or an entrance and exit, typical signs of inflammation have been observed. The region of the wound is swollen, it becomes painful, and the skin around the wound opening is edematous and reddened; upon palpation, infiltrate is det... ed, and a cloudy fluid and sometimes pus is discharged from wound openings upon pressing.

With an open wound cavity and after surgical treatment, wound tissue also has appeared edematous and red; the amount of discharge increased, and it was bloody and cloudy in the initial period of inflammation of a recent wound. The tissues were edematous; upon probing wounds with retractors, retention of the discharge in pockets was discovered; if a wound was rigidly tamponed, upon removal of the tampon, considerable amounts of pus were discharged. Upon palpating the region of the wound, particularly painful sections could sometimes be detected, upon pressing on which pus appeared from deep in the wound. If a wound was already granulated, the granulation was covered by thin coatings, and some parts or everywhere became edematous and easy bleeding. Despite the surgical treatment, no foci of necrosis could be detected.

Purulent infection also has appeared in the direct vicinity of wound edges. Indurated inflammatory infiltrates, sometimes with softening foci, were detected deep in the tissues; if they were on the surface, the skin above them was red and became edematous. In a number of cases, the purulent infection displayed a typical lymphangitis pattern, and it sometimes took on a reticular pattern. However, in the absence of lymphangitis, the regional lymph nodes enlarged and partly palpated like individual indurations and were partly fused into tuberous conglomerates in periadenitis. Subsequent purulent liquefaction of such conglomerates sometimes occurred.

Infection of the regional lymph nodes without subsequent purulent liquefaction undoubtedly was observed very much more often than was noted in the case records. These forms of purulent infection very frequently developed with inadequate immobilization during transportation and were then eliminated after normal treatment of the wound.

Wound complications typically occurring with erysipelateous inflammation were found very rarely during World War II, in distinction from what was observed during previous wars.

A typical course of erysipelateous inflammation (erysipelas erythematosum, bullosum, phlegmonosum) frequently became atypical and sometimes was accompanied by congestion, which had to be taken into account in treatment. The development of erysipelateous inflammation under a closed plaster bandage was noted extremely rarely.

A general reaction was observed corresponding to the local manifestations of purulent infection. The increase in body temperature remained stable or progressed and became remittent. Pains developed in the wound and the appetite and sleep were disturbed. A change in differential blood count and an increase in leukocytosis were noted. The wound discharge together with the dead and decomposing white blood cells contained a large amount of flora, from which pyopoetic microbes were easily inoculated. The number of phagocytosed microbes was small or they were completely absent. With increase in temperature, the pulse usually corresponded to it but, with a decrease, it proved to be more rapid and poorly filling. Respiration quickened to the same extent. Intoxication frequently was manifested by insomnia. Delirium and loss of consciousness were noted in far advanced cases. The latter indicated generalization of the infection.

Purulent infection of a granulating wound can frequently arise upon damage to the granulated integument. One cause of damage to granulation is rough bandaging technique. The day of bandaging can sometimes be determined from the temperature curve (from the evening temperature rise). However, sometimes despite caution in bandaging, granulation damage cannot be avoided because of the nature of the wound, its shape and other features. The necessity then arises for the use of a permanent bandage (for example, closed plaster) or irrigation, etc.

Trauma to the walls of the wound frequently is due to transportation and incomplete immobilization. Further, granulation damage occurs by rigid tamponage or pus retention in the wound cavity as a result of toxic substances of microbial or tissue origin. Finally, the use of concentrated antiseptics can cause damage nd killing of granulation. Abscesses frequently form in recent wounds around a foreign body of a necrotized portion of bone or even in soft t s. Abscesses sometimes form in a granulating wound upon partial closing of the wound channel.

Both congestion and abscesses are accompanied by some increase in temperature and painfulness and, upon opening the abscess and elimination of the congestion, the general symptoms quickly fade away. With deep abscesses in cases of cavity wounds (for example, with brain abscesses), localization of the inflammatory focus was reflected in the clinical picture.

A phlegmonous inflammation spreading corresponding to the tissue location was a more serious complication. This complication developed in both recent wounds and in later stages in the presence of a granulation cover which was disrupted for some reason. This was manifested clinically by considerable congestion of the infected section, pains, an increase in discharge and sharp aggravation of the general symptoms. In tissue infections along a vascular bundle, exposure of the later was observed, and a real threat of "corrosion" of the vessel wall with subsequent abundant hemorrhage arose. This kind of complication sometimes developed during evacuation of the wounded.

A purulent inflammatory process localized in the immediate vicinity of large deep veins caused thrombophlebitis upon passing through the venous wall, which was characterized by a prolonged course and disturbance of blood circulation of an extensive region.

Wounds were substantially complicated when a purulent inflammatory process passed into bone. This complication was possible in undamaged bone only in the form of an exclusion. It was found often in a bone wound and, as is evident from the chapter Osteomyelitis, it is considered a complication of a bone wound.

Besides all the clinical signs listed which indicate healing of the wound, systematic study of the morphological composition of a wound discharge plays an important part. This method was developed by M.P. Pokrovskaya and M.S. Makarov, and it was quite widespread during the war. Among the cells of a wound exudate, polymorphonuclear neutrophilic leukocytes are of great importance. Their presence and even predominance in Romanovskiy-Giemsa stained prints of wound discharge with clearly expressed phagocytic capacity of these cells indicates their high activity, and it is an extremely favorable sign. Under such conditions, destruction of microorganisms inside macrophages and the gradual disappearance or substantial reduction in number of free microorganisms is frequently noted.

On the other hand, a decrease in phagocytic capacity in the presence of neutrophils forces the reason for this to be sought in deviations of the wound healing process from the normal course. Degenerative changes of the neutrophilic leukocytes, in the form of pycnosis of the nuclei, hyperchromatosis and even their direct destruction is a particularly unfavorable sign.

Mononuclear blood cells and histiocytes, elements of the reticuloendothelial system (the polyblasts of A.A. Maksimov) also are a sign of wound healing. These cell elements are extremely diverse in shape and staining capacity. Their presence indicates a favorable course of the repair processes. As is known, by transformation ("maturing"), these elements change into connective tissue elements, into fibroblasts in particular. The more of such mature elements, the more active the regeneration process (I.V. Davydovskiy). The cells of the reticuloendothelial system, which are known by different names ("ameboid cells at rest" of A.A. Maksimov, the histiocytes of Ashof, etc.), have the capacity to absorb colloidal matter from the blood and lymph. As is known, this capacity is used in experiments for vital staining. The presence of such cells in the wound exudate indicates a favorable active response to the absorption and destruction of toxic products of tissue breakdown and of microbial origin. These cells are large and filled with particles they have captured (phagocytosis). Besides this, they form substances which cause the development of immunity.

A number of other wound exudate cells (Unna cells, eosinophils, giant polynuclear cells) also permit a decision on the course of healing of the wound in association with the clinical picture.

It often proves no less difficult to determine the cause of delays in wound healing than to eliminate them but, in a very large number of cases, the wound healing process can be accelerated. The state in which both wound healing and complete recovery of the function of the wound area occur should be considered complete recovery. Of course, such a determination is purely clinical, since only scar tissue formation at the wound site always reduces the function of the traumatized skin, muscles and other tissues. However, such a reduction can be felt so little that full recovery can be spoken of clinically in these cases. A second outcome of wounding is persistent changes which cannot be eliminated by treatment. In a number of cases, the deformations produced can be eliminated by further treatment and function restored by subsequent treatment of both the trauma itself and a new pathological condition resulting from the trauma.

Wound Healing with Inadequate Nutrition

The question of the effect of disturbances of gèneral nutrition and avitaminosis on the course of a wound has been studied in wartime.

The effect of inadequate nutrition has been studied well in experiments at the Military Medical Academy in particular (V.V. Pashutin et al). The question of the effect of avitaminosis on wound healing has been studied experimentally in considerably more detail, but not inadequate nutrition alone plays a part in wartime.

While inadequate or inferior nutrition is reproduced experimentally, a whole series of additional conditions most often affects the wound process under combat conditions, and each of them in itself can sharply degrade the outcome. The body of a wounded person has to fight various harmful factors, which are both difficult to reproduce experimentally and sometimes difficult to take into account.

In the interaction of pathological changes in the body with a large number of factors with negative effects, the course of a wound takes on a series of unique characteristics, which sometimes require unusual therapeutic actions.

Therefore, in the treatment of this kind of wounded, exprimental data are of extremely relative value. Those observations carried out by physicians who have studied wound healing of these wounded are very much more important, since the entire aggregate of harmful factors are characteristic of just the combat situation. N.I. Pirogov has noted that the isolated effect of harmful factors on the course of a wound is rarely found during combat actions. Thus, in speaking of a wounded with scurvy, he describes it in the form in which it was observed in the 2nd land hospital in St. Petersburg, and he notes "transitional forms with various modifications were found most often in the Crimean gangrene sections."

During combat actions, normal supply of foodstuffs encounters a series of difficulties. These difficulties are sometimes aggravated by combat measures of the enemy (blockade). Therefore, particular disorders in connection with war have been described by the names "trench edemas," "siege disease," "alimentary dystrophy."

Descriptions of starvation in besieged cities have been preserved since ancient times. Subsequently, when the blockade of entire states became the goal of their enemies and the population was under reduced nutrition conditions for a long time, descriptions of the clinical manifestation of this pathological state appeared in the medical literature. Thus, for example, in 1917, Maas and Zondek described the mass diseases which developed from malnutrition in Austria and Germany during the first World War of 1914-1918 by the name "combat edema."

I.I. Grekov reported his observations on the course of postoperative wounds in 1918-1919 in Petrograd, when a food shortage was felt.

Yet the clinical pattern of the pathological process caused by inadequate nutrition was studied most comprehensively and in the greatest detail in Leningrad during the 1941-1943 blockade. The presence of a large number of scientific workers in all branches of medicine and biology permitted comprehensive study of the condition which was called alimentary dystrophy.

At the same time as this, the course of the wound process in citizens of Leningrad who were victims of the bombardments was subjected to detailed study in Leningrad.

The basis of the pathological changes which developed in the overwhelming majority of a selected group of wounded was a combination of a number of factors.

The primary factor was the quantitative and qualitative inadequacy of nutrition. This situation occurred in the winter months of 1941-1942. The inadequate calorie value of the food reached a maximum in December 1941.

It should be mentioned that a number of factors which were superimposed on and aggravated the effect of inadequate nutrition were of very great significance, a deficit and qualitative inferiority of protein, as well as the effect of cold. As is well known, the winter of 1941/42 was severe and only slightly less so than the winter of 1939/40. Beginning in the middle of December, the temperatures reached minus 30-35°. The very low temperature held on stubbornly until the first days of April. The constant artillery firing resulted in substantial deterioration of everyday living conditions in the buildings of Leningrad. The glass in the majority of the windows was broken and replaced by plywood or cardboard. Electric lighting and the water supply did not work, which disabled central heating, sewage and the X-ray and physical therapy offices of the majority of the hospitals.

The shortage of water, which had to be carried in buckets because of the shortage of fuel for motor transport, resulted in a sharp deterioration of the hygienic conditions in medical institutions.

The shortage of wood and the lack of furnaces in many medical institutions, which were built exclusively for central heating, led to the mass use of smoky "small stove" furnaces. The temperature difference in the wards and corridors sometimes was more than 30°.

Because of the low temperature in the dressing wards and its sharp fluctuations, only the damaged portions were exposed when applying dressings.

P.A. Kupriyanov says of this period: "The general nonhygienic conditions in some hospitals and the sometimes forced deviation from the rules of asepsis in the dressing wards of surgical units, as the wounded, protecting themselves from the cold, stayed in their own clothing and wrapped themselves up in everything possible above it by their own initiative was reflected in the considerable infection of wounds which was observed during these months."

Difficulties in evacuation led to considerable congestion. All this together could not help being reflected in the wound process.

Observations by V.M. Kogan-Yasnyy (cited by M.V. Chernorutskiy) are convincing indications of the undoubted effect of the psychogenic factor on the development of alimentary dystrophy. Fat people lost 10-20 kg in 2-3 weeks, frequently with food which could not in any case be called inadequate or inferior.

In his monograph, V.A. Sveshnikov frequently emphasizes the specific nature of the conditions produced in Leningrad for the pathogenesis of this dystrophy.

A number of features during the wound process in victims of alimentary dystrophy were found in the first moments after wounding. These wounded rarely complained of painful feelings in the area of the wound. "The damaging areactivity of the patient," of which P.A. Kupriyanov speaks, was expressed in the first hour after wounding. Some began to demand food. Wounding appeared to become secondary in their consciousness. A poorly applied dressing and an unsplinted fracture did not bother them. To the question of the physician about complaints, they most often pointed out hunger.

As early as December 1941, physicians paid attention to the fact that wounded began to be delivered in blood soaked bandages more often than usual. Increased hemorrhagic diathesis of wounds did not depend on reduced blood coagulability, which is rarely found in dystrophy. Atrophied muscles and frequently completely absent subcutaneous and intermuscular fatty tissue evidently did not contribute to the formation of intratissue blood accumulation. A wide open wound bled out into the bandage. Wounds had the appearance that they had just been inflicted, although more than a day had passed from the time of wounding. This unusually fresh appearance of these wounds lasted a long time.

The loss of the elastic properties of the skin caused the gaping of wounds (P.A. Kupriyanov). In patients with a nonedematous form of alimentary emaciation, the absence of traumatic edema with broken up skin ends gave a wound a unusual appearance. Under the wrinkled skin, frequently exfoliated around the wound, smashed muscles of a considerably darker color than in unemaciated people were seen for some distance. Because of the absence of fatty tissue in the intermuscle spaces, in the first hours after wounding, a wound gained the appearance of an anatomical preparation. The crushed portions of muscle bled moderately. Blood accumulated in the flat portions of the wound, reached the cutaneous margins and flowed from the wound. Only solitary clots could be noted inside the wound. Hematomas formed in the intermuscle spaces by the wounding of large vessels were distinctly seen and sharply outlined under the skin near the wound opening.

Irregularity of the general condition of such wounded was considerably more pronounced than in wounded who were not victims of alimentary emaciation. The result of this was that, in November and December 1941, there still was not sufficient experience in their treatment. Indications for surgical treatment of wounds were limited.

Beginning in December 1941, an increase in mortality among the wounded was noted. P.A. Kupriyanov noted in his paper that the increase in mortality was due to a whole series of causes and the development of anaerobic and purulent infections. However, death also began to be noted more often in proportion to the development of alimentary emaciation.

It should be noted that the lethality from wound complications decreased considerably by June.

The following characteristics in treatment of wounds of victims of alimentary dystrophy attracted attention: sleep in ethyl chloride intoxication or ether anesthesia began considerably more quickly and lasted 2-3 times longer than in unemaciated wounded with the delivery of the same amount of anesthetic (1 ampule of ethyl chloride was sufficient for a 15-20 minute sleep; 30-35 cm^3 of ether was enough to carry out a laparotomy in an hour).

An increase in frequency of purulent and anaerobic infections was established in the frontline evacuation station hospitals at this time. It was noted that, together with an increase in number of operations for recent wounds, the number of operations for complications increased.

Reoperations to control complications of the wound process became the basic kind of operation on wounded carried out in the Leningrad hospitals. The reoperation frequency increased particularly in February. It was 79.6% in March, and it rose to 101.6% in May of all the wounded treated.

It should be noted that a substantial portion of the wounded did not suffer alimentary dystrophy at the time of wounding. It developed after wounding.

Complications which required no further surgery also occurred in an extremely unusual manner. The necrosis of tissue in the wound progressed, the skin margin of the wound exfoliated from the fascia and frequently underwent dry necrosis. Tissues which usually remained viable in wounds despite disrupted nutrition inevitably necrotized in victims of alimentary dystrophy. The detachment of necrotized masses occurred extremely slowly. There was no autolysis. Granulations usually began to form only in the second week. The time of their appearance depended on the expression of alimentary dystrophy symptoms. The more pronounced the latter, the later granulation appeared.

P.A. Kupriyanov pointed out the absence of such unavoidable companions of inflammation as local stasis, hyperemia and exudative reaction in alimentary dystrophy. Despite the obvious infectivity, the wounds no longer suppurated. When dressing, the impression was created that the wound had just been treated. The sensitivity of both the damaged tissues and those around the wound was reduced.

If alimentary dystrophy developed sometime after the time of wounding, when the wounded person was in the hospital, the appearance of thenwound surface changed to a considerable extent. The previously succulent granulation became pale and flaccid, sometimes with a glassy surface. The liquid exudate disappeared. With increase in alimentary dystrophy symptoms, granulation could necrotize and detach.

P.A. Kupriyanov describes cases in which formed scars completely separated, and a dirty gray wound filled with tissue decay remained in place of them. After removal of this decay, fissures formed on the walls of the wound cavity with the appearance of brain convolutions.

Such long unhealed wounds took on the nature of trophic ulcers.

With improvement of the general condition of the wounded, a liquid exudate appeared, and the wound acquired a normal appearance.

In some cases, the appearance of the liquid exudate led to recurrence of the alimentary dystrophy symptoms, since a considerable amount of protein was discharged together with the pus. If the alimentary dystrophy symptoms progressed, death occurred.

The highest mortality from alimentary dystrophy was reached in March 1942, and it then decreased abruptly. Thus, if the maximum mortality (March 1942) is taken as 100, the corresponding figure in April was 33, and it was 23 in May.

In March 1942, alimentary emaciation was recorded as the cause of death of 31.8% of all who died, 10.3% in April and 7.3% in May.

It was pointed out above that wound complications increased considerably in the period of the maximum spread of alimentary dystrophy.

The atypical symptomatology and reduction in diagnostic capabilities (cessation of the work of many X-ray rooms, clinical laboratories, etc.) played an indisputable part in the increase in percent mortality, which reached a maximum in March 1942, i.e., in the period when the calorie value of the food had increased considerably.

The course of purulent infection of wounds in this period was extremely unusual. Intermuscular phlegmons and congestion increased sharply. Their clinical appearance was similar to that of "cold" abscesses. There very often was no pain or temperature reaction, and skin changes in the form of hyperemia were observed rarely. More often, there was no vascular reaction, or it was in the form of formation of cyanotic spots above a site of pus accumulation.

The general condition of the wounded changed little. If the intoxication of the body increased, slight euphoria developed, which frequently was wrongly interpreted against the background of the absence of local symptoms as improvement in the condition of the wounded, and only death and the autopsy data shed light on the real cause of this "improvement."

Simultaneously with improvement in nutrition, the number of septic complications increased. It increased in April and May 1942. This forced physicians to take radical measures in the treatment of purulent complications. The number of secondary amputations in the first half of 1942 was three times that in the second half of 1941.

If it is taken into consideration that the number of primary amputations also increased somewhat, the severity of complications of limb wounds becomes clear.

The spread of indications for amputation in the treatment of purulent complications of limb wounds was justified by the complete lack of any limitation on the purulent process at all. Despite the wide incisions made upon detecting congestion, the pus continued to spread and separate muscles or slough off skin on its way. It was clear that only timely amputation within healthy tissue could prevent a lethal outcome.

Together with the considerable increase in frequency of purulent complications, a change in their course should be noted. Abrupt slowing down of all vital processes in alimentary dystrophy was reflected in this case by the development and course of the purulent process (this was particularly clearly manifested by the development of generalized purulent peritonitises), which was drawn out over extremely long periods of time.

It should be noted that the regression of symptoms of alimentary dystrophy in wounded in the period of improvement of nutrition was slower than in patients who suffered an uncomplicated form of alimentary dystrophy and were not wounded. The characteristic dystrophy symptoms of recovered people frequently reappeared upon rewounding, despite the fact that their nutrition did not deteriorate and their physical load was sharply reduced. The wound appeared to provoke the recurrence of alimentary dystrophy.

Manifestation of Scurvy in Wound

Qualitative inferiority of foodstuffs began to be noted as an inescapable companion of their quantitative insufficiency.

Vitamin C insufficiency and protein insufficiency were accompanied by manifestations of scurvy in wounds. The first cases of scurvy were diagnosed as early as November 1941. The maximum development of hypovitaminosis was observed in April 1942.

In December 1941, Leningrad physicians noticed an increased soaking of bandages with blood. The smallest vessels in wounds, which extremely rapidly thrombose under normal conditions, bled a long time. Because of this, wounds had an unusual appearance during treatment, which attracted the attention of surgeons.

Manifestations of scurvy in wounds increased in frequency in January and February. At this time, the physicians were informed of the appearance of cases of this hypovitaminosis and, therefore, they began to study attentively and document in sufficient detail the symptoms associated with it.

At early times after wounding, scurvy in wounds was manifested in the form of increased bleeding, and the diagnosis was made mainly in the presence of the widely known symptoms of scurvy (bleeding of the gums, growth of their papillae, etc.). Scurvy was expressed by a whole series of symptoms at later times.

The observations of a large group of physicians were correlated by P.A. Kupriyanov.

Scurvy was manifested primarily by changes in external appearance of wounds. The discharge from wounds most often became sanious or sanious-purulent with the development of scurvy symptoms. According to the data of P.A. Kupriyanov, 1/6-1/4 of all wounded suffering from scurvy had dry wounds (absence of discharge). The more severe the disease, the more rarely dry wounds were observed.

The development of granulation slowed down drastically. Muscles at the bottom of a wound frequently took on a cyanotic color. The frequently observed hemorrhages of scurvy patients sometimes occurred in the wound.

It should be noted that hemorrhages in wounds, so brilliantly described by M.I. Pirogov, usually were observed in the most severe cases, the number of which was small.

Developed granulations were flaccid, cyanotic and bleeding. The edges of wounds appear eroded, and they sometimes had a cyanotic, rarely orange color. Purulent complications were observed extremely often in this group of wounded.

Efficient treatment produced a rapid effect in nearly all cases.

The best method of treatment, which most rapidly resulted in complete elimination of scurvy symptoms in a wound, proved to be intravenous administration of ascorbic acid.

Attempts at local application of vitamin C (dressings with ascorbic acid, coniferous needle infusions, dog rose) did not produce a marked therapeutic effect.

CHAPTER V

TREATMENT OF COMPLICATIONS OF INFECTED WOUNDS

General

Because all surgically treated wounds remained open, they healed in the presence of a more or less copious purulent discha ge. Thus, they could be considered formally as complicated by purulent infections. In medical institutions in peacetime such wounds are classified as purulent. This course of a gunshot wound is so much combined with the healing process that arbitrary classification as wounds complicated by purulent infection of only those which required surgery for control of the purulent infection when it spread beyond the wound is required.

Such surgery includes primary late surgical treatment of a wound, partly secondary treatment and operations to eliminate congestion, abscesses, phlegmon, lymphangitises, acute osteomyelitis, secondary amputation and a number of surgical procedures, the characteristics of which depend on wound location. The last category of surgery, as well as surgical treatment of osteomyelitis, are reported in special sections and chapters.

1. Primary late surgical treatment is the name of surgery in the

presence of clinical signs of infection in a previously untreated wound. The purpose of the treatment is to prevent the spread of infection beyond the wound, and it consists of dissection of the wound channel, removal (excision) of necrotized foci and provison of the most complete drainage of the discharge.

In descriptions of recent primary surgical treatment of the wound, it was pointed out that the time since wounding is not a contraindication to operations. The condition of the wound plays a part here. Therefore, the treatment of a wound is not called "late" because it is carried out too late in the sense of time. Sometimes, in the development of infection, treatment becomes late because of the corresponding clinical picture after 6 hours but, for example, in vessel damage, it still is not late after 24 hours in the majority of cases.

The technique of late surgical treatment differs fundamentally in no way from conventional primary surgical treatment of a wound. Practically the only difference may be the excision of necrotized tissue which is not entirely within healthy tissues, but with consideration of the demarcations formed, if there are the latter in a given wound. Moreover, the type of infection and the degree and form of its development affect the extent of surgery. Thus, if a purulent focus formed in a wound in the form of an abscess or a phlegmon, its exposure is not dictated by the extent and nature of the decay due to the trauma, but by the location and size of the purulent focus. Finally, all measures supplementary to the surgery lose their prophylactic nature and become therapeutic.

2. Secondary surgical treatment of a wound is the name of repeated surgical treatment carried out as a result of insufficiency of the primary treatment. The necessity for secondary treatment is partly determined by examination of the wound, independently of the infectious complication, for example, with insufficient exposure of the wound cavity, in refinement of diagnosis of the wound by X-ray examination, in the development of subsequent necrosis, etc. Secondary treatment of a wound is partly caused by the development of a purulent

infection and its spread beyond the wound.

The tasks of secondary treatment are the same as those of primary treatment. The technique also does not differ fundamentally, and it is dictated practically by the condition of the wound. As in primary treatment, the operation is accompanied by the application of sulfamides or antibiotics, as well as antiseptics as a supplementary measure.

3. A number of complications of aerobic purulent infections not only do not require surgery but, as is known, they are treated conservatively by treatment of the wound and complete drainage. Lymphangitises, thrombophlebitis, lymphadenitis before the formation of abscesses and erysipelatous inflammation (except the phlegmonous form) are classified as such complications.

All these complications since the initial focus was the wound, required first and foremost careful examination and elimination of all obstacles to complete drainage of the discharge into the dressing. With all these conditions present, treatment was carried out by immobilization; the use of antiseptics and bacteriostatics and partly physical therapy.

If the wound was localized on the head, chest and abdomen, the required rest was ensured by bedrest and delay of evacuation at the stage when a given complication was discovered. In the case of wounds of the extremities, it could be satisfied with splint and spar bandages only with the skeleton intact. With bone and joint damage, strict immobilization was achieved by the use of circular plaster bandages. The so called dead end plaster bandage played an important part in World War II, and it was used in such a way that it has been specially mentioned. Its therapeutic role appeared most clearly in aerobic purulent infections. Experience in the 1939-1940 Finnish War showed the great importance of the dead end plaster bandage in treatment of wounds of the extremities with bone and joint damage, especially with wounds of the thigh and shanks and in the regions of the hip and knee joints. However, the dead end bandage had a beneficial effect only with irreproachable treatment of the wound. Otherwise, the closed dead end plaster bandage of an inadequately treated wound frequently gave rise to anaerobic infections, the initial signs of which sometimes escaped the attention of the physicians. Moreover, the dead end plaster bandage required irreproachable technique, primarily because an easily broken bandage did not achieve the purpose and became harmful during transportation. All this forced the medical service leadership to behave for the first time with great caution towards the extensive use of the dead end plaster bandage, especially in the division and army areas. It proved to be necessary to carry out preliminary measures for the extensive introduction of plaster technique to the division surgeon practice. Centers were organized on nearly all fronts where, with the assistance of the most experienced surgeons, orthopedists and traumatologists, training of a large number of physicians, as well as middle level medical personnel, mainly nurses, in the application of the gypsum bandage was conducted. The technique of application of the gypsum bandage was worked out in detail. The rules of application of typical plaster bandages with explanatory drawings were [illegible]ng in the plaster rooms of many hospitals. Beginning in the summer of 1942, dead end plaster bandages could be recommended insistently without fear. It should be recognized that the technique of application of plaster bandages did not reach the heights reached in World War II in any of the preceding wars. Plaster bandages applied under field combat conditions frequently were superior to the bandages of the best orthopedic clinics in their strength and outward appearance. The bandages applied for a long time produced the required rest for the wound, ensured blood supply and absorbed the discharge. The therapeutic importance of the plaster bandage consisted of these properties.

The increase in frequency of application of plaster bandages can be shown, with the example of one of the most mobile fronts in the most important combat operations during World War II (Table 15).

It is evident from the table that, up to the beginning of 1944, the number of immobilizations in MSB [medical battalions] increased, but the number of plaster bandages was negligible. As should have been expected, the majority of wounded with plaster bandages were concentrated in the front area.

Table 15. Increase in frequency of application of plaster bandage in major combat operations during World War II.

(a) Боевые операции	(b) Иммобилизация шинами			(c) Гипсовая повязка		
	(d) МСБ	(e) ПЭП	(f) ГБФ	(d) МСБ	(e) ПЭП	(f) ГБФ
(g) Сталинградская операция	17.8	22,6	20,0	0,6	6,8	10,8
(h) Орловско - Курская операция	21,4	26,7	25,7	0,1	9,7	22,8
(i) Белорусская операция	27,3	37,3	36.6	0,1	18,6	31,8
(j) Висла-Одерская операция	25,9	39.4	34,0	0,2	13,7	28,6
(k) Берлинская »	21,2	34,3	33,0	1,1	16,3	32,6

Key: (a) Combat operation; (b) Splint immobilization; (c) Plaster bandage; (d) MSB [medical battalion]; (e) PEP [clearing station]; (f) GBF [field hospital]; (g) Stalingrad operation; (h) Orel-Kursk operation; (i) Belorussian operation; (j) Wisla-Oder operation; (k) Berlin operation.

Secondary Wound Treatment

The spread of both secondary and late primary treatment of wounds during World War II was due to two fundamental situations: 1. the conduct of surgical treatment of wounds regardless of time since wounding; 2. the spread of understanding of the so called wound barrier. Concerning the first situation, it requires no additional remarks beyond everything stated. The second situation requires a brief supplement.

Before World War II, it was considered that mechanical damage to granulation causes an unavoidable spread of infection through the lymphatic and blood circulation. The experience acquired in combat showed that the "wound barrier" concept cannot be reduced to a barrier of granulation alone. On condition of proper drainage of a wound, the spread of infection after destruction of granulation, which is accompanied by repeated surgery for infectious complications, is successfully avoided in the majority of cases. Thus, it proved to be possible to operate at any time after wounding by using surgical access through the granulation cover.

V.F. Voyno-Yasenetskiy considers that "the answer to the question of the permissibility of bold destruction of the granulation wall in infected and purulent wounds must be considered a major achievement of combat surgery in this war." This should be agreed with.

During World War II, many surgeons began to take extensive advantage of secondary wound treatment. Data on the frequency of application of secondary wound treatment during the war years is evidence of this.

Thus, the secondary treatment of wounds, from the data of fundamental characteristics charts, was expressed as the ratio to all wounded (1941 was assumed as 100) by the following figures:

1942	166
1943	240
1944	600
1945	620

These figures, as well as study of the practical use of secondary treatment (see Sections 2-15), shows that it is a firm part of surgical practice.

As follows from the definition of this concept, indications for secondary wound treatment occur when it is determined that the primary treatment was inadequate. The latter is possible in the following cases: 1. if there are direct indications of inferior primary treatment upon examination of the wound, for example, if unremoved dead tissue, foreign bodies or hematomas due to unarrested hemorrhage are seen in exploring the wound with or without retractors; 2. if indirect local and general signs of reactive inflammation (increasing edema and painfulness of the wound area, increasing pain, deterioration of gen-

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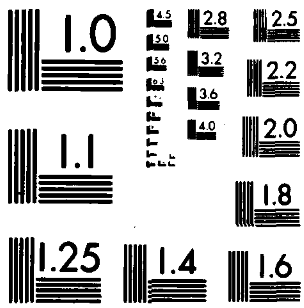

MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

eral condition, fever, etc.) point to inadequacy of the primary treatment. Such a condition frequently is designated as a purulent complication of the wound. All these indications are due to the presence of elements in the wound which prevent its healing; extremely frequently, this is the so called consequent necrosis.

In evaluation of operations conducted, it is difficult to distinguish secondary wound treatment from operations for purulent complication of the wound process.

The formation of abscesses and congestions is observed in a smaller and not a larger number of cases. Therefore, a sharp delimitation between secondary wound treatment and operations conducted for a purulent complication is possible in only a comparatively small number of cases. That is why, in conducting an operation 1-2 weeks after a gunshot wound of a knee joint complicated by infection and by removal of the necrotic fragments of damaged bone covered with pus, the surgeon can call such an operation and operations for purulent gonitis which developed as a result of a penetrating wound of the knee joint secondary wound treatment.

With a broad understanding of the question, all operations for wound complications after primary treatment can provisionally be called secondary treatment, since they all have the purpose of the most rapid healing of the wound and elimination of the complication. The nature of these operations is similar if not common, since they are directed toward the removal of elements from the wound which prevent normal healing in all cases. From this point of view, operations for acute and partly chronic osteomyelitis, for anaerobic infection and even purulent congestion can be combined and provisionally called secondary wound treatment. Yet the practice has separated from secdary treatment, first, operations for abscesses in the vicinity of the wound, second, operations for anaerobic infections and third, operations conducted a long time after wounding. Secondary wound treatment has to be defined as an operation conducted for inadequacy of primary treatment at early times after wounding.

Secondary wound treatment was applied subsequent to primary treatment (author's data of study of Military Medical Museum materials):

	Percent
Same day	9.0
Second day	13.0
Third day	15.9
Fourth day	12.4
Fifth day	7.9
Sixth day	9.6
Later than sixth day	32.2

Thus, 67.8% of all operations, i.e., the majority, were carried out in the first six days. As to the stages where secondary wound treatment was carried out, the frequency of its employment was as follows (in percent of all cases):

	Percent
Medical battalion	4.2
Mobile field hospital	52.8
Army field hospital	21.5
General field hospital	20.3
Other institutions	1.2

In 13.6% of all cases, secondary treatment was employed in the same institution as the primary treatment. Thus, half the operations were performed in combat region medical institutions and half in army and front institutions in the rear.

The fact that 9.0% of the secondary treatments (fundamental characteristics chart data) were carried out on the same day as the primary treatment and 13.6% in the same institution indicates the low relative significance of secondary treatment when there were direct indications for it in general, i.e., upon discovery of elements in the wound known to prevent its healing. In general, these indiations depend mainly on the nature of the wound and the time since wounding.

Under all conditions, the diagnosis is made with greater accuracy when only soft tissues are wounded and with less accuracy in the wounding of bones and damage to joints. Diagnostic capabilities increase with increase in time since wounding.

The diagnosis of tissue necrosis on the first day after wounding, as is known, involves considerable difficulties. Mainly clinical indications have to be employed for this purpose.

The smaller the amount of tissue destroyed, the later and more completely can primary treatment be carried out and, consequently, the less the need for secondary treatment. Great difficulties arise in the diagnosis of necrosis, i.e., tissues subject to removal, in cases when damage to bones, vessels, etc., occurs. X-ray study, which can assist in this case, is unavailable in the medical institutions where primary wound treatment is carried out (DMP [division aid station], first line KhPPG [mobile surgical hospital]). Finally, a number of wounds (brain, eye, ear, throat, jaw) require the presence of appropriate specialists and special equipment for full value treatment.

Due to the abovementioned, groups of wounds subject to secondary treatment consist mainly, not of soft tissue wounds, but more complicated groups of wounds.

Thus, from the data of the author's study of Military Medical Museum materials, among wounds subjected to secondary surgical treatment, bone damage was observed in 58.6% of the cases and they were absent in 42.4% of the cases. This relationship [illegible]ts the nature of the anesthesia, since the number of operations con[illegible]ted under anesthesia (41.6%) is relatively large. In 1/3 (30.6%) of all cases, secondary treatment was carried out for gunshot fractures, damaged joints, etc., which also confirms the abovementioned.

The proposal was made (P.G. Kornev) that, for certain groups of wounds, secondary surgical wound treatment frequently is unavoidable because of objective conditions. In other words, complicated wounds with bone fractures and joint damage cannot always have full value primary surgery treatment. If this hypothesis is valid, another question is natural: would it not be more logical to abandon primary treatment and evacuate such wounded to a stage where delayed but radical operations are possible? This question is dealt with in detail in the corresponding sections (in particular, in Sections 11 and 12). However, it is evident that the answer to this question is fundamentally impossible in such a categorical form, since unquestionably there are frequent cases when even the not completely radical wound dissection and drainage operation will permit the rapid development of threatening complications to be avoided and, thereby, make delayed radical operation possible.

Analysis of indications for secondary wound treatment produces the following data (data of author's study of Military Medical Museum materials):

	Percent
Presence of necrotic tissues in wound	31.8
Indications of purulent inflammation	26.7
Same indications, but determined by detailed analysis of complicated wound	30.6
Secondary hemorrhage	8.0
Other causes	0.6
Cause unknown	2.3

Thus, in approximately 1/3 of the cases, secondary treatment was carried out because of the presence of consequent necrosis, approximately 1/3 because of infection and approximately 1/3 when direct and indirect indications of necrosis and infection were due to the complexity of the wound.

The technique of secondary wound treatment does not differ fundamentlly from that of primary treatment. Individual details of secondary treatment, just like indications and contraindications for it, have some characteristics which are discussed in the appropriate place (pp. 154, 160).

World War II experience proved the adivsability of repeated surgery on gunshot wounds. The favorable effect of this surgery, because of which the number of amputations and deaths from progressive infections decreased sharply, is evident from analysis of materials on wounds by localization.

Secondary Sutures

General

As follows from the section on primary sutures of a gunshot wound, its abandonment was forced. Soviet surgeons everywhere refrained from the application of a primary suture in World War II, not because the purpose of the suture proved to be unjustified, but because a primary suture, as massive experience showed, cannot be applied to a gunshot wound subject to surgical treatment without serious danger to the life and health of the wounded. The idea of surgical wound treatment in order to simultaneously create the conditions for the briefest, i.e., primary, healing of a wound proved to be still impracticable.

One of the basic problems of the Soviet Army Medical Service was, as is known, to return the greatest possible number of wounded and ill to the army in the shortest time. Experience showed that both these problems are not solved at the same time. A combat area surgeon performing primary surgical treatment attempts first and foremost to prevent infection and produce favorable conditions for healing of the wound, where the time of treatment initially is of secondary importance. However, as soon as the first goal is achieved and the life of the wounded is safe, a second problem arises, the maximum reduction of treatment time.

It follows from this that joining the edges of a wound subject to surgical treatment, i.e., all types of so called secondary sutures, is not independent surgical intervention, but is the final act of primary surgical treatment, delayed to some time when joining the edges of the wound does not threaten complications.

In other words, complete surgical treatment of a wound is accomplished in not one, but two stages.

The abovementioned is a fundamental feature of the understanding of the nature of the secondary suture, which is characteristic of

Soviet field combat surgery.

To counterbalance this point of view, surgeons of foreign armies, French in particular, understanding the positive value of the secondary suture, considered primary surgical wound treatment and the secondary suture as independent operations from each other (Clavelin, Chevassu, Duval et al).

Soviet surgeons, who do not separate the secondary suture from primary surgical wound treatment and consider it an element of this operation, introduced this method with greater success than was done in foreign armies.

Secondary sutures of all types were applied almost exclusively in soft tissue wounds. Therefore, the number of cases of application of a secondary suture and its effectiveness are determined by the specific weight of soft tissue wounds in the total number of wounds. Available data on the frequency of soft tissue wounds are:

	Percent soft tissue wounds (of total number of wounds)
1st Baltic front (1944)	60.0
2nd Ukrainian front (1944)	60.0
Northwestern front (1944)	48.8
Deep rear hospitals (Kirov and region, 1944)	18.5
All deep rear hospitals at end of war (from data of S.I. Milovidov)	40.0
Fundamental characteristics chart data	from 42.4 to 54.2[1]

[1]Variations of percentage in different years of the war are given.

According to the data one army, in 1943, 67.2% of the wounded returned to duty upon recovery had soft tissue wounds.

According to the calculations of I.A. Krivorotov, the application of secondary sutures to 40.0% of all soft tissue wounds (i.e., 25.0% of all wounds) was shown. Approximately these same figures were obtained by N.N. Burdenko and N.N. Yelanskiy.

Thus, within the army and front rears, a secondary suture can be applied to approximately 1/4-1/5 of all wounds. As to wounded in the deep rear, the number of cases of application of a secondary suture there should also be extremely significant, if it is considered that indications for application of a secondary suture late after wounding become more extensive.

The data presented indicate the great importance of the secondary suture. It becomes still more evident, if it is considered that treatment time is shortened extremely significantly by the application of a secondary suture. Thus, the large scale use of the secondary suture and its high effectiveness make the problem of secondary sutures one of the major problems in modern war.

As was pointed out above, the primary value of secondary sutures is reduction of treatment time. However, this method also has a therapeutic value.

The studies of P.K. Povarnina showed that, as a rule, there are leukocyte infiltrates in scars excised in connection with a late secondary suture. N.N. Petrov considers the keloid scar which frequently develops in conservative treatment of gunshot wounds a real tumor, a fibroma. Microbes and foreign bodies can be encapsulated in scars.

The data of S.S. Vayla are undeniable and convincing. They indicate the following: 1. slow healing of sluggishly granulating wounds is observed in the distortion of the evolution of granulated tissue; 2. instead of the normal replacement of necrotized and destroyed tissue by granulations (initially by abundant cells and vessels and then gradually transformed into an epithelium covered scar) in long unhealed wounds, primary sclerosis of connective tissue can be observed; 3. connective tissue fibers adhere, their substance swells, sometimes undergoes necrosis and is immediately converted to fibrous dense tissue which is extremely poor in cells and vessels; this delays further healing of the wound, its epithelialization in particular; 4. both anatomical changes (arteriolosclerosis, arteriosclerosis, endarteritis) and circulatory disorders (persistent stasis) are observed in the vessels, which disrupts vascularization of the tissues and hinders regeneration; 5. primary sclerosis of the connective tissue combined with changes in the small vessels and peripheral nerves hinders regeneration and causes prolonged failure of the wound surface to heal.

Thus, the pathoanatomical data of S.S. Vayla indicate that discontinuing secondary closure of a treated wound both increases the treatment time of the wounded and, thereby, contributes to the development of complications in the wound process. Statistical data also indicate this. According to the materials of M.D. Artemov, there were three times more unfortunate outcomes in a group of wounded treated conservatively for ulcerated and ulceration prone scars than in a similar group of wounded treated by the secondary suture method. There were soft tissue wounds in both groups.

Thus, the therapeutic importance of the secondary suture is undoubted.

Beginning in 1942, the secondary suture problem was not lost sight of by the leadership of the Soviet Army medical service during the entire war and for sometime after it.

Terminology

The following terms are found in the literature: primary late or primary-secondary suture (M.M. Dieterichs). A suture applied 1-5 days after surgical treatment is intended by this.

The French call such a suture postponed or deferred. N.N. Petrov calls a suture applied in the concluding stage of surgical treatment but joined after several days primary deferred.

Lerish designates a suture applied to a recently treated wound after two smears taken at 1-2 day intervals with no more than 1 or 2 microbes detected in the field of view a late suture. In the German literature, such a suture is called early secondary. It is known that something different is intended by this name in the Soviet literature (see below). The terms late (N.Ye. Slupskiy) and postponed (Ya.B. Basina) sutures can be found in the Soviet literature, by which different concepts also are intended. Tertiary sutures are mentioned sometimes (A.V. Geyman).

Some authors avoid the terms "suture" or "sutures" for surgically drawing wound edges together, and they call it either drawing wound edges together or situation suture (N.O. Petrov) or even situation dressing (B.D. Dobychin).

The terminological differences sometimes depend on the nature of the action of the surgeon. Thus, F.R. Bogdonav does not consider a secondary suture an operation. P.A. Kupriyanov proposes to distinguish "actual" sutures, i.e., applied by means of needle and sutures, from connecting the wound edges with plaster, adhesive bandages, etc. V.V. Gorinevskaya classifies a secondary suture as secondary wound treatment.

N.N. Burdenko proposed the following terminology: 1. primary suture; 2. primary delayed suture; 3. primary suture with late primary treatment and late primary suture; 4. secondary suture, a. early, b. late (classical).

It is easy to recognize that the chronological principle on which secondary suture terminology is based became the cause of confusion in understanding and actions. Of course, the proposal of P.A. Kupriyanov to take into account the presence or absence of granulation in the wound met with general approval. By this criterion of wound condition, the development of granulation and not the time in days or weeks is considered.

The other P.A. Kupriyanov proposal, to distinguish "actual" sutures from the connection of wound edges with plaster, adhesive bandages, etc., was not applied. The basis of this classification is another secondary indication. The concept of the secondary suture is to make a wound with a microcavity from a wound with a large cavity by drawing its edges together. In other words, it is the substitution of secondary healing by primary healing, which reduces the healing time. The main purpose of secondary sutures is achieved by this. During World War II, drawing wound edges together by means of adhesive and similar bandages was widespread. Following the proposal of P.A. Kupriyanov would have complicated the terminology still more, by putting it into practice by the principle of the presence or absence of granulation and by the principle of suture technique. It is evident that this latter principle is of incomparably less importance than the former, because of which it cannot be used. For just this reason, N. N. Yelanskiy uses the term "secondary active intervention in primary treated wounds," in which he classifies the entire total or measures which contribute to the reduction and healing of gunshot wounds of soft tissues, i.e., adhesive or plaster bandages, all types of sutures and plastic surgery. There is no doubt that this expanded concept is fundamentally true, and only practical considerations force the exclusion of plastic or reconstructive surgery from the "secondary suture" group, as of complicated technique and essentially concerning restorative surgery.

After adopting the principles described above as the basis of characterization of surgical actions undertaken to reduce the size of gunshot wounds after primary surgical treatment, the 7th plenum of the Scientific Medical Council of the head of the GVMU [main military medical administration] adopted the following terminology, which then was included in Instructions on Combat Field Surgery.

A suture applied during the first (5-6) days after wounding to a previously treated wound before the appearance of granulation is called a primary delayed suture.

An early secondary suture is a suture applied to a granulating wound with mobile, unsecured edges without scars.

A suture appli to a anulating wound with scar tissue development after excision of the skin edges and bottom of the wound is called a late secondary suture.

The terms presented are used in subsequent reporting according to the definitions given above.

The aggregate of all sutures applied to a wound previously subjected to primary surgical treatment is intended by the collective term "secondary sutures."

Comparative Evaluation of Secondary Suture Method in Soviet and Foreign Armies

In the secondary suture literature, the opinion is repeatedly expressed that the mass use of this method is indebted to the work of Carrel. Now however, when several years have passed after the end of World War II and historical parallels with other wars have become possible, legitimate doubts of the validity of this hypothesis are appearing. Did the work of Carrel actually bring on the mass use of the secondary suture? Can the use of the secondary suture by French surgeons, true successors of Carrel, at the end of World War I be considered mass use of the method? Can the mass use of this method in the Soviet Army actually be considered "indebted to" the work of Carrel?

Familiarity with the World War II materials forces the question to be raised differently: was not the work of the Soviet surgeons developed regardless of the instructions of Carrel?

Just now, when the tremendous importance of secondary sutures has become obvious, the opinions on this question in the literature must be subjected to reexamination, from both the clinical and the military medical points of view.

There is no doubt that the work of Carrel was basic for French and Russian authors who wrote on the secondary suture during World War I (only French and Russian authors are discussed here, since the German, English and American surgeons of that time bypassed the question of the use of secondary sutures in nearly total silence). First, the basic importance of the work of Carrel is not so much the idea of joining wound edges with a secondary suture as the method he proposed for creating the conditions for this, by means of the Carrel-Dakin chemical antiseptic fluid. It is no wonder that the latter was mainly intended by the Carrel method in Russia. Second, as N.N. Yelanskiy notes, 30 years before World War I, Delorm wrote on secondary joining of the edges of a granulating wound in a manual on combat field surgery. Kocher mentioned secondary sutures in a textbook on operative surgery. However, not the formal priority, but the priority in the field of mass use of the secondary suture in war should be recognized as the most significant.

According to the data of V.N. Sheynis, obtained by study of materials of the French Army in the 1914-1918 war, French surgeons published only a small number of observations. Thus, Tuffier and Sachenier used the secondary suture 121 times and Leriche, 142 times.

In hospitals No. 5 and 25 and the hospital in Abbeville, the secondary suture was used in 127 cases. In the hospital center in Compiegne, when it came under Molmegean, the secondary suture was applied 231 times.

Tuffier points out that the method "became the most used" in 1918. There are no summary data on the entire French Army in the report of Mignon.

It is significant that nearly all French surgeons took advantage of the so called Carrel method, i.e., they applied the secondary suture after treating the wound with Dakin's fluid for 4-20 days and without fail after bacteriological monitoring. According to the evidence of Clavelin, microbe counting was carried out every 2-3 days, and the occurrence of streptococci was an unconditional contraindication for the suture. In addition to bacteriological monitoring, cytological monitoring according to Policar and the Delbet pyoculture method also were used. It can be assumed that, under these conditions, mainly the late secondary suture was used. Confirmation of this assumption is that there were persons with bone fractures among the patients of Carrel on whom the early secondary suture was not usable. It is known from experience in World War II that the early secondary suture is the most massive and effective.

Thus, the secondary suture method was used comparatively little in the French Army. The categorical requirement of Carrel for bacteriological monitoring partly hindered its spread.

The greatest number of cases of use of the secondary suture was in 1918, i.e., toward the end of the war when, according to the evidence of N. Bren, "close contact of the clinic and laboratory" was achieved in the French Army.

At the end of World War I, the method was forgotten, as was indicated by the appearance of Lenormant and Chevassu at a meeting of the French National Surgical Society in Paris in 1933.

This was the situation during World War I in the French Army. As is known, the French Army scarcely participated in World War II and, therefore, there are no significant data on the use of the secondary sutures in this period.

Little information on this question can be gotten on the US Army in World War I. According to summary data of I.M. Talman, "the question of the use of the secondary suture was decided as a function of the quantitative and qualitative evaluation of the bacterial flora from smears and bacterial inoculations" in the American army, and application of the suture was done strictly according to the Carrel-Dakin method (Poole). This evidently explains the limited use of the method compared with the armies of the European countries. The small number of wounded in the US Army in World War II also could not fail to be reflected in the use of the secondary suture method.

In the German Army, both in World War I and in the war with Poland in 1939, mass use of the secondary suture did not occur. This evidently is why the retrospective surveys of Franz and Payr for 1940 are so laconic (N.N. Burdenko).

The first Russian studies concern the 1914-1918 world war, when a number of Russian surgeons applied secondary sutures. The work of these surgeons was not published. N.N. Burdenko, with the cooperation of a bacteriologist, used secondary sutures in 305 cases in the second half of World War I. In Petrograd, N.N. Burdenko continued study of the secondary suture method in 32 wound cases.

A.E. Rauer took advantage of this method in the Civil War (Krasnoyarsk military hospital).

At the XVI Congress of Russian Surgeons in 1924, papers were read on contracting wounds with adhesive plaster and the conclusion of A.M. Zabludovskiy.

Further, works of 1930 and 1934 are known. In 1937, Z.A. Landers published a dissertation on secondary sutures. In 1939, during the armed conflicts at Khalkhin-Gole, B.A. Entin and L.M. Ballon during the war with the Finns (1940) used secondary sutures extensively in maxillofacial surgery. A.N. Bakulev, V.I. Sazontov, Ye.M. Schwarzberg and others applied secondary sutures in 1941.

In 1942, at a meeting of the Moscow Surgical Society, A.N. Bakulev reported that in the Moscow hospitals he ran, purulent wounds were sutured after appropriate treatment in 1941, and smooth healing occurred in the majority of cases.

V.V. Lebedenko followed the same procedure in skull wounds.

The secondary suture method was unusually widespread in World War II. N.N. Burdenko had available material on 9520 cases, B.D. Dobychin on 13,350 cases, I.A. Krivorotov in 12,163 cases and N.N. Yelanskiy in 22,000 cases.

According to data of the fundamental characteristics chart, the secondary suture was documented in at least 8.0% of all soft tissue wounds. This figure undoubtedly reflects only a small part of the sutures applied, since many of them were not recorded in the case records.

Thus, the question raised at the beginning of the chapter on the priority of mass use of the secondary suture is completely clear. This priority belongs completely and undividedly to the Soviet Army Medical Service.

It also is obvious that the work of Carrel did not bring on mass use of the secondary suture method in a single country, including France, of which the figures presented above on the French Army are evidence.

Finally, both requirements of Carrel, preparation of the wound by chemical antiseptic methods and obligatory bacteriological monitoring were repudiated by the World War II experience. This permitted the secondary suture method to be made actually a mass method.

Thus, it can be truly stated that the work of the Soviet surgeons was developed despite the requirements of Carrel.

However, this does not mean that the development and introduction of the secondary suture method did not involve difficulty.

The use of secondary sutures in a number of medical institutions of the army and rear of the country began during World War II: in 1941 in Moscow (A.N. Bakulev); in 1942 in Molotov (at the end of the year, F.A. Orlenko); on the Northwestern front (N.N. Yelanskiy); in one army of the 2nd Ukrainian front (at the end of October, army surgeon B.K. Babich); in a hospital of the 7th Independent Army (in September, L.G. Shalyt); in Kuybyshev (in July, L.A. Soldatchenkov); in Vologda (M.I. Kuslik); in the Volga Lands Military Region (N.T. Kansh); in the Ural Military Region (F.R. Bogdanov); on the Leningrad front (P.A. Kupriyanov); in Gor'kiy (Ye.L. Berezov); in Moscow (F.M. Plotkin).

But mass use did not occur everywhere at this time. Thus, F.R. Bogdanov reported only 193 cases in the Ural Military Region, Ye.L Berezov only 709 operations in Gor'kiy, and P.A. Kupriyanov pointed out that the secondary suture was used insufficiently on the Leningrad front.

Beginning in 1943, after the 7th plenum of the Scientific Medical Council of the chief of the Main Military Medical Administration, very extensive use of the secondary suture method began, and it was brought under special observation by the army and front surgeons.

A special Manual on the use of sutures on granulating wounds was published.

The reason for the known resistance of physicians to the mass use of the secondary suture undoubtedly was the requirement of Carrel for obligatory bacteriological monitoring of a wound before the application of secondary sutures. It was not even so much that surgeons initially refrained from the secondary suture upon finding streptococci in the wound, as that bacteriological monitoring was not carried out at all under the working conditions in combat, not only in the army and front regions, but in the deep rear.

Toward the middle of 1943, the Main Military Medical Administration had available the materials of N.N. Yelanskiy, I.A. Krivorotov and B.D. Dobychin which, on the whole, covered a large number of secondary suture cases, in which bacteriological monitoring was not carried out in the overwhelming majority of them.

Thus, it became obvious that success was achieved without bacteriological monitoring, without any complications which threatened the health or life of the wounded. In distinction from the use of the primary method, no cases of severe or anaerobic infection, amputations or death after application of a secondary suture were reported here.

After what has been said, it is not suprising that many ordinary and even army and front surgeons became convinced partisans of the secondary suture method, based on their own extensive experience in its use, when they were freed (in approximately 1943) from the influence of the Carrel procedure.

The mistake of Carrel and the surgeons who followed him was that they substantially raised the importance of the bacteriological method for diagnosis and prognosis of wound infections in the application of secondary sutures. Moreover, they consciously or unconsciously made an analogy between primary and secondary sutures. In other words, the surgeons did not see the difference in biological conditions in fresh and granulating wounds. They overlooked the fact that the development of an incomparably larger number of complications can be expected with a recent wound.

Finally, the secondary suture is applied almost exclusively to soft tissue wounds, i.e., the least dangerous ones in the sense of possible complications.

The following conclusion can be drawn on the basis of the present brief survey.

1. The priority of mass use of the secondary suture method belongs to the Soviet Army Medical Service.

2. The scientific substantiation of incomparable scale and depth of the Soviet Army refutes the requirement of Carrel of the mandatory nature of bacteriological monitoring for the application of secondary sutures. In these cases, the clinical criteria are thus sufficient for determination of indications for the suture.

3. World War II experience also is evidence that the hypothesis of Carrel and his followers, the French surgeons, had a negative effect on development of the secondary suture method and evidently was the main reason for the late, inadequate use of secondary sutures in the French Army in World War I. The conditions advanced by Carrel also were an indirect reason for insufficiently full use of the sec-

ondary suture method in the Soviet Army in the 1941-1945 World War II.

Groups of Wounded Undergoing Treatment by Secondary Suture Method

FINAL STAGE OF SURGICAL TREATMENT OF WOUNDS

(DIAGRAM)

PRIMARY DELAYED SUTURE	SECONDARY EARLY SUTURE	SECONDARY LATE SUTURE
It is applied to a wound without clinical signs of infectious inflammation before development of granulation.	It is applied to granulating wound without clinical signs of infectious inflammation. Granulations are not cut, wound edges are not mobilized.	It is applied to cicatrized wound without clinical signs of infectious inflammation. Granulation and scars are cut, wound edges are mobilized.
Normal application time day 5-7	Normal application time day 8-15	Normal application time day 20-30.

Fig. 63. Diagram of application of delayed primary suture and secondary sutures.

N.N. Burdenko considered that a secondary suture is basically indiated in wounded with soft tissue injuries. He distinguished the following in this group: 1. wounded who sometimes require prolonged (for a month) bed rest according to the extent of injuries; 2. slightly wounded who are many weeks in the hospital for the slightly wounded and 3. wounded with sluggishly progressing unclosed wounds. It is evident that only a secondary late suture is concerned here. Although N.N. Burdenko recognized the possibility of the employment of secondary sutures in wounded with bone fractures, he proceeded with observations of soft tissue wounds.

According to the author's data of study of Military Medical Museum materials, 80.0% of the secondary sutures were applied in soft tissue wounds and only 20.0% in gunshot bone fractures.

Analysis of the times of application of sutures from these data shows that only half of all the secondary sutures of soft tissues were applied at times of up to a month, and only 1/5 of this number in the group of wounded with bone fractures. It is evident from this that the calculations were based primarily on materials of late secondary sutures applied in field hospitals, where the scar and virtually the healing or nonhealing wound itself were cut. Calculations of the front and army surgeons were done mainly on analysis of sutures applied at early times (up to 1 month) i.e., on studies of primary delayed and early secondary sutures. Thus, according to the materials of N.N. Yelanskiy, 63.4% were in the first and 36.6% in the second echelons. Including plaster and adhesive bandages applied only early, they amounted to 84.6%.

General statistical data and the work of individual authors (N.N. Yelanskiy, I.A. Krivorotov, N.Ye. Slupskiy, Yu.M. Orlenko, M.D. Artem'yev, Ye.I. Dymnikova et al) also indicate that the primary group of wounded to whom secondary sutures were applied were wounded with soft tissue injuries.

It is impossible to account for and analyze the total number of sutures applied by Soviet surgeons during World War II, since the number of them is extremely high.

The materials presented give only an approximate idea of the prevalence of the secondary suture method in the Soviet Army in World War II. Nevertheless, there can be no comparison of them with the data of any army in the past, in particular, with the French Army data in World War I.

<u>Indications and Contraindications</u>

The general indications for a secondary suture are extremely broad. All soft tissue wounds (in the absence of contraindications) which do not heal in the average time because of considerable size or a sluggish wound healing process are subject to secondary closing.

The indication for a primary delayed suture is good condition of the wound and general condition of the wounded which permits its exclusion of a local or general purulent inflammation.

The indications for an early secondary suture are determined by the state of granulation (satisfactory or good), as well as the general condition of the wounded. Indications for a late secondary suture are a drawn out wound healing process, as well as ulcerated or keloid scars.

The indications for all types of secondary suture are established only after appropriate preparation of both the wound itself and the skin surrounding it. The first decision paragraph of the 7th plenum of the Scientific Medical Council of the chief of the Main Military Medical Administration on the question of the secondary suture reads: "Application of the sutures indicated (primary delayed, early and late secondary) is considered indicated in the absence of acute inflammatory changes in the wound, in the presence of a healthy granulated cover of its surface and in the absence of general contraindications on the part of the body of the wounded (decrease in nutrition, increase in temperature, etc.)."

The basic contraindication for all types of secondary sutures is clinical signs of acute purulent inflammation in the wound and serious general condition of the wounded. All the remaining cases of contraindications are classified as secondary and are of relative importance. They include:

1. the presence of foreign bodies (before their removal);

2. clinical and X-ray indications of osteomyelitis;

3. eczematous irritation of the skin around the wound (be-

fore its elimination);

4. impossibility of drawing the wound edges together without considerable stress;

5. impossibility of excision of scar tissue because of nearness of vascular and nerve trunks;

6. location of wound above bony prominences;

7. dystrophy, disseminated tuberculosis, marked forms of hypovitaminosis.

The presence of insignificant discharge does not prevent drawing the edges of the wound together. It can be done by a primary delayed and early secondary suture, initially in a pus free section and then in the entire wound.

Wound size is not a contraindication for application of a secondary suture. The data of a number of authors on this question are presented below.

Author	Wound size in cm
N.Ye. Slupskiy	6.6x34
Ye.I. Zakharov	2.5x20
A.K. Azizan	5.3x39
A.M. Dzhovadyan	3 x30
A.P. Vyrubov	5 x25
O.V. Neydorf	5 x10 (47.0%)
	2 x 5 (34.4%)
	10 x15 (13.6%)
	15 or more (5.0%)
	24 x 5 (largest size)
P.D. Feofilov	From 5 to 20 cm long and from 2 to 8 cm wide
F.K. Nazarov	5 x10
D.P. Fedorov	10 x22

As has been mentioned, World War II showed that the main contraindication for application of all types of secondary suture in combat, acute purulent inflammation both in the wound and beyond it, is established on the basis of clinical indications. The corresponding data were presented above but, since the question of the importance of bacteriological analysis played an extremely significant role in development of the secondary suture method, it should be dealt with in greater detail.

In the opinion of Carrel, all types of secondary suture can be used if: 1. repeated bacteriological monitoring by inoculation is possible; 2. if streptococci are not inoculated by bacterial monitoring; 3. if other microbes progressively decrease in number or are not detected for 2-3 days.

This opinion was preserved at the beginning of World War II. In 1940 Leriche wrote: "The method which Carrel taught us should be systematically resorted to, bacteriological counting in samples taken from the least clean corners of the wound."

According to the materials of N.N. Burdenko, based on analysis of 9520 secondary suture cases, bacteriological monitoring was carried out in no more than 14.5% of the cases. The greater part here was carried out by bacterioscopy of the wound discharge. Sterile wounds were not found once. The wound flora were characterized as follows:

Wound flora	Percent
Staphylococci	36.0
Streptococci	12.0
Escherichia coli	18.0
Undetermined flora	12.0
Other microbes	22.0

Thus, in at least 30.0% (streptococci and Escherichia coli), according to the initial opinions of the author himself, a secondary suture could not have been applied. Nevertheless, he achieved primary healing in 64.0% of the cases and partial healing in 18.0%. Yet it is most significant that N.N. Burdenko (like other domestic authors besides) does not report a single case of severe complication ending in amputation of a limb or death of the wounded. Not one case of anaerobic infection as a consequence of application of a secondary suture was recorded as well.

Data on bacteriological monitoring before application of secondary sutures on the fronts and in the rear during World War II follow below.

According to the materials of I.A. Krivorotov, in 13,526 cases of secondary suture application, bacteriological analysis was done 1320 times, i.e., in less than 10.0% of the cases, and no microflora were detected in only 7.0%. Streptococci were found in 16.3%, staphylococci in 44.0%, diplococci in 26.7% and saprophytes in 5.6%.

According to the data of P.Ya. Ivanchenko, bacteriological monitoring was carried out in 25.0% of the cases, M.P. Makarov in 13.0%, O.N. Neydorf in 20.0%, P.D. Feofilov in 50.0%. N.D. Garin, Ye.I. Kurzon and M.G. Skundina made no cultures at all.

As a rule, the authors who carried out bacteriological monitoring found varied microflora, including streptococci in considerable quantities. However, this was not reflected in the outcomes of operations and, the main thing, it did not cause complications. Thus, D.P. Feodorovich applied a secondary suture in 600 cases regardless of the results of bacteriological monitoring, in which 10.0% streptococci were found, and complete or partial healing occurred in 95.0% of the cases.

I.L. Mnatsakanov applied secondary sutures 109 times and obtained favorable results in 93 cases. Bacilli and cocci were detected 104 times and streptococci 5 times.

N.Ye. Slupskiy observed smooth healing in 88.0% of the cases where bacteriological monitoring was carried out and in 85.0% of the cases without the latter. There were no complications in either group.

In 420 cases of secondary suture, A.K. Azizan found streptococci in 12.0%, Escherichia coli in 10.0% and anaerobes in 5.0%. Complete or partial healing of the wound occurred in 70.0% of all cases.

N.V. Antelava, after thorough study of wound flora, had smooth wound healing in 71.0% of 115 cases, and Tovmasyan, who did not conduct bacteriological study of wounds, obtained smooth healing in 75.0% of 124 cases. Thus, in the cases presented, both with and without bacteriological monitoring, the results were generally the same.

It obviously follows from the abovementioned that, in solving the secondary suture problem in World War II, either the requirements of Carrel of mandatory bacteriological monitoring or the secondary suture had to be abandoned. By 1943, a contradiction was found between the practice of surgeons and their opinions, which were learned before the war. It is characteristic that, by the 7th plenum of the Scientific Medical Council of the chief of the Main Military Medical Administration, notes of doubt were heard in opinions on the advisability of the Carrel requirements. Thus, N.N. Burdenko in his paper, among other things, said: "No one requires general laboratory study in each case of a proposed suture, but keenness of clinical observation must be developed." N.N. Yelanskiy pointed out: "For application of a secondary suture, the absence of infection and inflammatory symptoms in the wound . . . is necessary. Bacteriological monitoring is desirable."

In the clinic of P.A. Kupriyanov, in the first part of the war, they refrained from application of secondary sutures upon detection of streptococci in a wound but, subsequently, wounds healed with even hemolytic streptococci present in cultures.

In 1944, S.S. Girgolav wrote: ". . . Cl. perfringens was repeatedly detected and identified bacteriologically in wounds after study; however the dead end suture was accompanied by smooth healing of the wound in these cases."

After resolute claims of the need for bacteriological monitoring in the spirit of the Carrel requirements, M.I. Kuslik reported: ". . . an insignificant purulent discharge was not an obstacle to a delayed suture. As a rule, bacteriological monitoring was not employed."

Thus, the practice completely repudiated the position of Carrel, and the following was recorded in the decisions of the 7th plenum of the Scientific Medical Council of the chief of the Main Military Medical Administration, which met in April 1943: "The impossibility of carrying out a bacteriological study (with the lack of a laboratory or in the case of great congestion with wounded) is not an obstacle to suture application." This decision played a tremendous part, by making it possible for surgeons to use the secondary suture method extensively.

All of the abovementioned in no way reduces the importance of microflora in wound pathology. However, the conclusion as to the nature and effect of microflora on the wound process is based in combat as yet mainly on clinical data.

There is no doubt that bacteriological study of the wound discharge and wound surface gives a complete idea of the wound flora. The importance of this factor for the course of a wound is obvious, but the resolution of another question is involved in this case, the possibilities of application of a secondary suture. A bacteriological study, conducted in simplified form besides, produces nothing more than clinical study for this purpose. The presence of an active infection usually is found clinically. If the clinical course gives no basis for assuming it, as a rule, to establish infection by means of a bacteriological study fails. The results of bacteriological study do not correspond to clinical data in only a very small percent of the cases. In such cases, secondary sutures do not achieve the purpose and may come apart. But this failure is paid for by many thousands of cases of successful application of secondary sutures based on clinical data alone.

Thus, World War II showed that clinical data are sufficient for resolution of the question of the application of secondary sutures.

Anatomical Localization of Wounds, Times and Stages of Application of Secondary Sutures

According to the fundamental characteristics chart data, the regions of the body to which secondary sutures were applied are distributed as follows: lower limb, 67.9%; upper limb, 28.4%; remaining regions, 3.4%. The corresponding data of N.I. Garber are as follows: lower limb (thigh and shank) 64.1%; upper limb (upper arm and forearm) 19.7%; back, chest 14.0%.

If the materials of N.N. Burdenko are put together in the same way, the following data are obtained: lower limb 43.8%; upper limb 27.0%; remaining regions 24.2%.

The course of soft tissue wounds of various regions differs somewhat from each other. Thus, for example, wounds of the distal sections of the lower limb heal more poorly in general than those in proximal sections; upper limb wounds heal better than lower limb wounds; wounds of the face and soft integument of the skull heal still more favorably.

Analysis of the times of application of secondary sutures reveals the following data (Table 16).

Table 16. Times of application of secondary suture

	Times of application of secondary suture (in percent)		
	up to 1 month	from 1 to 2 months	more than 2 months
Data of author's study	39.0	24.0	37.0
Data of N.N. Burdenko to April 1943 (in round figures)	45.0	24.0	31.0

In both groups, 63.0 and 69.0% were primary delayed sutures together with early secondary sutures, respectively.

The data of I.A. Krivorotov on the Kalinin front up to 1943 are demonstrative. On this front, 10.0% primary delayed sutures, 16.0% early secondary and 73.3% late secondary as well as plastic surgery were applied.

The corresponding data of the rear institutions are: according to N.D. Garin (Sverdlovsk, 1946) sutures were applied later than 3 months in 71.0% of the cases, later than 1 1/2-2 months in 73.0% according to A.I. Kurzan, and 58 of 125 operations were done later than 60 days according to Ye.I. Zakharov.

A.V. Geyman on the Western Front, by 1942 had applied secondary sutures up to 10 days later in 83.5% of the cases. In one PEP [clearing station] (Gor'kiy), M.P. Makarov recorded the application of secondary sutures at the following times: 678 times from 1 to 30 days, i.e., 41.1%; 430 times from 30 to 45 days, i.e., 26.2%; 532 times more than 45 days, i.e., 32.4%.

The material of N.I. Garber is distributed as follows: 48.8% up to 1 month; 14.9% from 1 to 2 months; 35.2% 2 months or later.

According to the fundamental study chart data, in at least 30.0% of the cases, a secondary suture was applied in later periods.

In the material of I.A. Krivorotov, more than 2/3 of the secondary sutures were applied very late. If it is assumed that soft tissue wounds are cleared of necrotic tissues by the end of the first month and can be protected in general and a certain number of cases with various contraindications are discarded, there still remains a large number of soft tissue wounds to which secondary sutures were applied too late.

These considerations appear all the more likely in that, according to the data of D.V. Geyman, the application of secondary sutures after 1 to 10 days is possible in 83.0% of all groups of wounded who underwent this operation. The data of M.P. Makarov and N.I. Garber indicate that the number of early secondary sutures can be incrased substantially in the immediate rear.

It is natural to assume that the effect of the requirement of mandatory bacteriological monitoring showed up here, according to which a suture is not feasible in the first 5-7 days, even with a favorable picture.

Data on the stages of evacuation where sutures were applied, reported by I.A. Krivorotov from his substantial material, confirmed the conclusions drawn. In army field hospitals, 11.2% of the secondary sutures were applied, 36.2% in evacuation hospital FEP [front clearing station] and 52.6% in evacuation hospital MEP [medical clearing station].

The materials presented thus indicate that primary delayed and early secondary sutures could have been used more often.

The following figures also indicate the predominant distribution of late secondary sutures (from data of a special study). The granulation was excized in 86.0% of secondary suture operations, it was curetted in 7.0% and was not excised in 7.0%. It is evident that there was a late secondary suture in the overwhelming majority of the cases and an early secondary or primary delayed suture in only 14.0%.

The same thing is indicated by N.N. Burdenko data collected up to 1943: total excision from the bottom of the wound was carried out in 39.0% of the cases, freshening of the edges of the wound and removal of granulation in 46.0%, plastic surgery in 2.0% and only freshening and only drawing together the edges of the wound in 13.0%.

Of course, the late secondary suture was applied primarily in the rear hospitals. However, the reports of some front surgeons and even rear surgeons indicate the extensive capability of application of early secondary sutures, if the corresponding chiefs and surgeons paid attention to this, and if practical activity was guided by combat experience and not obsolete concepts.

Thus, 14,064 secondary sutures were performed in the first echelon base hospital of the Northwestern front in March and 20 days of

April. Of them, 84.6% were sutures applied by means of plaster and adhesive bandages, 3.0% were early and only 5.6% were late secondary sutures. An adhesive bandage for stump traction was applied in 6.6% of the cases.

In the second echelon base hospital in 8452 operations, wound constricting bandages were used in 40.0%, late secondary suture in 40.0% and plastic surgery in 20.0%. Ye.I. Dymnikova in the rear applied 263 of 489 secondary sutures with adhesive bandages. P.Ya. Il'yachenko applied an early secondary suture to 69.0% and a late secondary suture to only 31.0%

The reports of other authors confirm the general tendency characterized above on the Western Front. By 1943, 50.0-80.0% early secondary sutures and 20.0-50.0% late secondary sutures were applied in army rear hospitals. There were 92.0% late secondary sutures, while there were only 8.0% early sutures in the front rear hospitals (S.I. Banaytis). According to the data of Ye.Ya. Vyrenkov (Kalinin Front), 56.2% late secondary sutures were applied.

Technique of Operation

The secondary suture operation technique is determined by the time since wounding. The less this time, the less complicated the technique and, vice versa, considerable time since wounding makes a secondary suture technically more complicated.

An idea of the relative significance of various types of secondary suture in World War II can be compiled from the following special study data: 88.0% of wound edges were drawn together by means of sutures, 7.0% by means of adhesive tape, adhesive bandages, etc. and 5.0% by other methods.

Preparation for Operation

With accumulation of experience, a completely obvious tendency toward expansion of the indications to a secondary suture began. It was permitted even with pus present in the wound, provided the pus was "not abundantly" secreted and was not "very thick" (N.N. Yelanskiy). This determination undoubtedly was dictated by combat experience. For partial constriction of the wound, complete removal of pus from it was not all mandatory. It is no wonder that staged and partial joining of the wound edges was widely applied in combat.

Extremely varied medicines and methods were proposed for preparation of the wound edges for secondary suture, from gastric juice (V.I. Sazontov and Ye.M. Schwarzberg) to clay (Ye.I. Zakharov). M.G. Taborisskiy proposed 11 methods of wound preparation for a secondary suture. Although the number of medicines proposed for wound preparation is very large, none of them had a specific effect. The necessary measures were determined by the general rules of surgery. Wound drainage, protection of its edges from maceration, removal from the wound of everything preventing normal regeneration and stimulation of the growth of healthy granulation as much as possible were ensured.

The type of medicine and the method of its application played a secondary role.

Without accurate numerical data available on the frequency of removal of granulation in application of secondary sutures during World War II, it can be stated that removal was often resorted to. In connection with this, N.N. Burdenko emphasized his negative attitude toward the removal of granulation in secondary sutures.

However, it must be taken into account that granulation in gunshot wounds very often contains metallic and nonmetallic foreign bodies, small sequestrae and leukocyte and lymphoid infiltrates. Therefore, they can be the cause of suppuration of a protected wound.

Fresh granulations, cicatrizing granulations and scars can be distinguished by time of development. An accurate subdivision of these three types is difficult even histologically, since they differ only in amount of vessels and elastic and collagen fibers.

It is completely evident that granulations which contain foreign bodies and other inclusions which can be the cause of suppuration should be removed in a secondary suture operation. In exactly the same way, extensive scars and masses of cicatrized granulation should be removed, since it is known from experience that sutures through scar tissue are inclined to cut through.

The practical requirement in application of a second suture follows from this: to remove pathological granulation and scars, which is a mandatory condition of success of the operation.

This does not at all mean that such a tactic should be adhered to with healthy and fresh granulations. Their removal not only reduces the likelihood of success of the operation, but primarily it lengthens the treatment period. This is why it is advisable to contract wound edges, even if not completely. Conditions are created thereby for the fastest healing in the section of the wound dissected in primary surgical treatment. It must be taken into account that extensive wound dissection in primary surgical treatment is dictated by considerations which are not found at the time of application of the secondary suture. Therefore, the attempt to close the wound incision is natural.

Criteria for evaluation of the condition of the granulation remain as before. They are clinical criteria. The possibility of error is determined here by the degree of accuracy of the clinical criteria in general and the experience of surgeons who employ the secondary suture method.

Some remarks on the technique of primary delayed and early secondary sutures.

The lack of fundamental differences in the method joining wound edges was mentioned above. Therefore, the simplest methods are preferable, i.e., the use of various types of adhesive bandages (Fig. 64). This type of primary delayed and secondary suture is most preferred, because it permits bringing the wound edges together by stages, does not require anesthetization, and it is easily and rapidly applied and removed. Thus, it is most adapted to combat conditions. N.N. Yelanskiy, after study of much material on the secondary suture method, fervently propagandized the use of adhesive bandages in combat. Their extensive introduction also was recommended by the 7th plenum of the Scientific Medical Council of the chief of the Main Military Medical Administration.

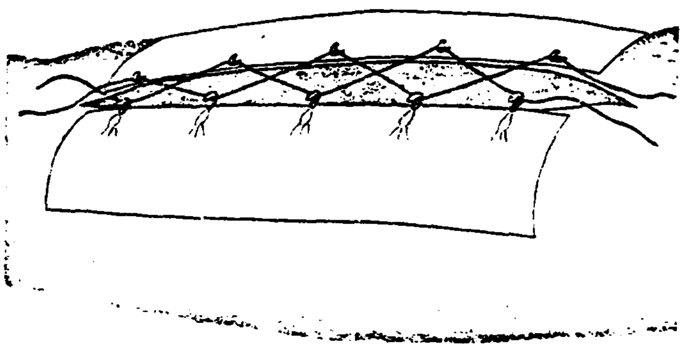

Fig. 64. Adhesive bandage.

Anesthetization

In the overwhelming majority of cases, the suture application operations were performed under local anesthesia. General anesthesia was used only as an exception. According to the data of a special study, 88.5% of secondary sutures were applied with the use of local anesthesia, and 11.5% were without anesthesia. The last figure evidently refers to sutures applied by means of adhesive bandages, and it demonstrates the possibility of a secondary suture without anesthesia on the one hand, and it again confirms the rarity of use of primary delayed and early secondary sutures on the other hand.

Complications

Neither the fundamental characteristics chart data nor the data of N.N. Burdenko on all fronts up to 1943 noted cases of death or amputation due to aggravation of infections or any severe complications at all after a secondary suture. This also corresponds to the observations of N.N. Yelanskiy, I.A. Krivorotov, B.D. Dobychin and others.

The following data were found in a special study of the literature on the question of complications after application of secondary sutures. In 204 operations, V.A. Landres found 1 case of congestion and 1 case of necrosis of the edges of a wound. A.V. Geyman observed 37.5-39° fever for 1-2 days in 5 cases in 265 operations. M.G. Skundina noted aggravation of infection and deterioration of general condition once in 714 operations. I.A. Soldatenkov observed complication of a wound by a gas phlegmon once in 162 operations. The patient recovered.

The overwhelming majority of authors who have published the results of their observations do not mention complications at all or they understand them as suture separation. Some directly indicate the lack of any serious complications in secondary sutures (Ye.K. Nazarov, M.G. Skundina).

The local importance of inflammatory processes in a wound, which frequently do not require even complete removal of the sutures, is confirmed by the work of A.Ye. Laz'ko, A.N. Vyrubov and N.O. Petrov. N.N. Burdenko reports exacerbation of infections in 18.0% of the cases. There is no doubt that cases with the insignificant complications indicated above are included in this group.

Finally, in Paragraph 22, Instructions on Use of Sutures on Granulating Wounds, the Main Military Medical Administration directly states that "the postoperative period in the majority of cases proceeds without complications. There sometimes are insignificant symptoms of inflammation, slight general symptoms in the sense of increase in temperature (subfebrile temperature) after an operation, but this does not affect the subsequent course of the postoperative period. Such a condition does not require removal of sutures."

A profound difference between primary and secondary sutures is evident from all the abovementioned. Although both have the goal of reducing the treatment time, experience has shown the danger and unacceptability of the former and, at the same time, the safety and possibility of mass use of the latter. The theoretical generalization of Soviet surgery that primary surgical treatment of a wound and the secondary suture are inseparable is based on this. The missing link of the surgical treatment of a wound, its suturing, resulting from the impossibility of a primary suture, is made up by the secondary suture.

Wound Healing Outcomes and Times After Secondary Suture Application

Analysis of the outcomes of treatment demonstrates a contradiction in the formulations. Thus, they speak of primary, complete and smooth healing, of separation and suppuration of sutures, complete and partial. With the abovementioned on complications after application of secondary sutures and the clinical picture which develops after this operation taken into account, it is most advisable subsequently to take advantage of the terms "primary healing," and "complete" and "incomplete" separation of sutures. Such designations are convenient for comparison and are justified by the clinical history. It must be noted that the primary healing which occurs after application of secondary sutures differs from the first intention of surgical incisions by a number of features. Of course, the point granulations and scabs which are so characteristic of even the best outcome are not an obstacle to establishment of primary healing in secondary sutures.

According to the data of a special study of all fronts, secondary sutures were responsible for the first intention in 54.0% of all cases, and the sutures were removed in 46.0% of the cases, because of partial or complete suppuration of the wound. In this case, only 19.0% of them were removed before day 7 and 74.0% were removed from days 10 to 15 (the times remain unknown in 7.0%). Thus, the sutures were removed because of complete separation of the wound edges in only approximately 1/5 of the total number of unsuccessful cases. To give a rough picture, the general outcomes of application of secondary sutures in World War II can be defined as follows: the sutures did not separate in 54.0% of the cases, partial suture separation was observed in 37.0% and complete separation of sutures in 9.0%.

Comparison of these data with data on the Northwestern (N.N. Yelanskiy), Kalinin (I.A. Krivorotov) and Western Fronts (S.I. Banaytis) for 1943, as well as with the data of N.N. Burdenko for all armies for the same time, brings out the following pattern (Table 17).

Table 17. Outcomes of secondary suture application during World War II on different fronts

Front	Sutures not separated	Partial suture separation	Complete suture separation
	In percent		
Northwestern Front	47.8	42.3	9.5
Kalinin Front	67.8	25.2	9.2
Western Front	71.3	14.8	14.0
All fronts (N.N. Burdenko)	64.0	18.0	18.0

If it is considered that information for April 1953, according to the data of N.N. Yelanskiy (Northwestern Front), changed, and there was 67.0% and not 48.0% primary healing, complete coincidence of data based on much statistical material on secondary suture application operations becomes evident. Primary healing was achieved in at least 64.0% of the cases, and the percent of total wound separation varied from 9.0 to 18.0%.

These are total data for the entire army and by front in 1943. They changed somewhat by the end of the war, but exclusively as to the frequency of primary wound healing (reduction from 64.0 to 54.0%). Total suture separation began to be observed less often (reduction from 9.0-18.0 to 9.0%).

The data of individual hospitals are evident from Table 18 (observations with at least 100 operations are presented).

If the extreme figures (90.0% or more on the one hand and 30.0-17.0% on the other hand) are discarded, it becomes evident that the results of individual hospitals are generally better than the average results of the fronts and armies as a whole. They vary most often between 70.0 and 85.0% primary healing. Substantial prevalence of the number of cases of partial wound separation over complete separation also is evident. Complete suture separation constituted no more than 10.0% of the cases, as a rule.

Table 18. Outcomes of secondary suture application during World War II from data of various authors

Author	Sutures not separated	Partial suture separation	Complete suture separation
	In percent		
	96.0	--	--
Ye.I. Zakharov[1]	95.0	4.0	1.0
B.D. Dobychin	92.6	5.0	1.9
Ye.M. Rubtsova	91.5	6.0	2.5
M.P. Makarov	89.0	11.0	
I.L. Mnatsakanov	88.8	7.0	4.2
P.Ye. Slupskiy[1]	86.0	9.0	5.0
N.D. Garin	85.0	10.0	5.0
D.P. Fedorovich	82.0	15.0	3.0
N.O. Petrov	80.8	19.2	--
P.D. Feofilov	80.0	20.0	--
A.M. Diavadyan			
N.N. Priorov (from M.G. Skundina)	80.0	20.0	--
M.I. Aspes	79.0	21.0	--
P.K. Povarnina	76.9	23.1	--
M.A. Soldatenkov	74.7	25.3	--
N.V. Antelava	73.0	22.0	5.0
Ye.L. Berezov	71.7	18.0	10.0
Ye.Ya. Vyrenkov	71.2	18.1	10.7
P. Il'yachenko[2]	71.0	5.0	9.0
A.K. Azizyan	70.0	30.0	
A.Ye. Laz'ko[3]	68.4	20.4	7.0
A.N. Vyrubov	67.7	22.7	9.6
M.G. Skundina	63.0	27.0	--
Ye.K. Nazarov	60.0	40.0	--
N.I. Garber	57.3	32.6	9.3
Ye.I. Kurzon	54.0	20.0	16.0
Yu.M. Orlenko	36.5	31.5	33.0
F.R. Bogdanov	31.6	44.0	24.4
A.V. Geyman	30.0	64.0	6.0
K.D. Artemov	17.5	57.5	24.3

[1] 4.0% not determined.
[2] 15.0% not determined.
[3] 4.2% not determined.

With the accumulation of experience, i.e., with proper and timely determination of indications for operations and the acquisition of technical skills, primary healing for individual surgeons reached 86.0% (data of Ye.L. Berezov), 87.0% (data of N.N. Yelanskiy), 88.0% (data of M.I. Kuslik) or more (Ye.I. Zakharov, B.D. Dobychin and others). The example presented by F.M. Plotkin is highly demonstrative in this respect: in the first 50 cases of secondary suture of one physician of the Moscow group of hospitals, unsuccessful outcomes were noted in 22.0%, but in only 10.0% in the next 50 cases.

There also is interest in the outcomes of different types of secondary suture. Data of I.A. Krivorotov are presented below (Table 19).

Table 19. Outcomes of use of different types of secondary suture

Suture type	Sutures not separated	Partial suture separation	Complete suture separation
	In percent		
Primary delayed	60.7	29.0	10.3
Early secondary	70.4	22.6	7.0
Late secondary	72.2	18.0	9.8

M.G. Taborisskiy presents the following data on the early and late secondary sutures (Table 20).

Table 20. Outcomes of use of early and late secondary sutures

Suture type	Sutures not separated	Partial suture separation	Complete suture separation
	In percent		
Early secondary	59.2	21.2	19.6
Late secondary	40.2	50.3	9.5

The outcomes of secondary sutures as a function of the time of their application, from the materials of N.I. Garber, are evident in Table 21.

Table 21. Outcomes of application of secondary sutures vs. their application times

Suture application time	Sutures not separated	Partial suture separation	Complete suture separation
	In percent		
Up to 1 month	49.2	45.9	4.9
From 1 to 2 months	47.6	49.2	3.2
3 months or more	52.6	30.2	17.2

Comparison of the tables indicates a lack of significant difference in both absolute and relative outcomes of all three types of secondary suture. Primary healing was observed in 49.0-60.0% of the cases.

Success of an operation evidently depends not so much on the time since wounding as on proper selection of indications and properly executed operating technique. It should be taken into account that the essence of the latter in all three types of secondary suture is generally the same. Its aim is to draw together the edges of the wound capable of healing. From this point of view, it makes no difference whether the edges of a wound covered with viable granulation or free of scars and cicatrizing granulations within normal tissue are joined. It is important to determine the viability of the connective tissues, i.e., to determine the proper indications and technique of the operation. It follows from this that the need for the earliest possible application of secondary sutures is not dictated by improvement of the immediate results of the operation, but by the time savings because of limitation of the period of conservative treatment of wounds by preparation for the secondary suture.

The importance of wound localization for the outcome of a secondary suture is illustrated by Table 22, taken from N.I. Garber.

Although there is no doubt that secondary sutures applied in regions where the skin cover has a smaller amount of underlying muscles and tissues give somewhat better results, the general results of treatment differ insignificantly. Thus, secondary sutures of soft tissue wounds basically produce a successful result in all regions of the body.

Table 22. Outcomes of use of secondary sutures vs. wound localization

Wound localization	First intention	Partial suture separation	Complete suture separation
	In percent		
Chest, back	62.8	27.9	9.3
Upper arm	62.1	35.1	2.8
Thigh	55.9	30.6	13.5
Shank	52.4	34.4	13.2
Forearm	43.7	43.7	12.6

Analysis of the outcomes of a secondary suture applied for wound treatment in World War II in the Soviet Army permits the statement that more than half the cases of operation were completely successful, i.e., they permitted reduction of the treatment time of soft tissue wounds to a minimum. Further, this analysis gives a basis for considering that, with proper organization, complete success can be achieved in at least 60.0-70.0% and, by individual surgeons, in 70.0-80.0% of the cases. It can also be considered that the success of a secondary suture is ensured in general, regardless of the time since wounding and, to a certain extent, its localization. It is difficult to overestimate the value of these conclusions, on consideration that they were applied to approximately 24.0-25.0% of all wounded.

The average healing time of soft tissue wounds with conservative treatment, according to the materials of N.N. Burdenko for 1943 were as follows: clearing station A, from 56.4 to 71.2 days; clearing station B, from 47.3 to 89.4 days; clearing station C, from 55 to 104.6 days.

The average time of conservative treatment of soft tissue wounds according to the data of I.A. Krivorotov was 2 months. With the summary data of N.N. Burdenko taken into account, this period should be considered the minimum.

What effect do secondary sutures have on reduction of the average treatment time of soft tissue wounds?

According to the materials of N.N. Burdenko for 1943, in primary healing, the average treatment times are 10-15-20 days, with partial suture separation, 20-28 days and with complete suture separation, 20-30-60 days.

The corresponding data of N.N. Yelanskiy follow:

Treatment time in days	Percent
10-15	38.2
15-20	17.5
20-30	24.4
30-40	11.2
40-60	8.4

N.N. Yelanskiy points out that, with early secondary and primary delayed sutures, 85.0% of the wounds heal in times of up to one month.

According to the observations of Ye.Ya. Vyrenkov, 70.0% of wounds heal in periods of from 15 to 20 days after wounding, 19.0% in from 20 to 30 days, 6.5% in from 30 to 45 days and 4.5% of the wounds in more than 45 days.

According to I.L. Mnatsakanov, treatment by the application of sutures is reduced by an average of from 17 to 30 days. According to B.D. Dobychin, healing occurs in approximately 4 weeks, in 21.7 days according to Ye.I. Dymnikova and in 28 days according to N.C. Petrov.

P.N. Il'yachenko considers that a secondary suture reduces the treatment time of soft tissue wounds from 45-60 to 20-30 days and K.D. Artemov, from 66 to 33 days, i.e., in half. A.Ye. Laz'ko also thinks that, with the application of secondary sutures, the average treatment time is cut in half.

Less reduction in healing time is reported by V.A. Landres (by

5-11 days), A.V. Geyman (13.7 days) and Ye.I. Zakharov (10 days).

A comparison of the data presented shows that the treatment time is successfully reduced in at least half of all secondary suture cases from 2 months to 1 month, i.e., by half.

Generally, a secondary suture can be used on at least 24.0% of all wounded, and at least half of them can be returned to duty in less than a month.

These are highly approximate, greatly understated figures. The average healing time of soft tissue wounds, 2 months, is the least in this case, as is evident from the calculations. Reduction of the treatment times in primary healing alone was used in the calculation, and the larger groups of wounded whose wounds healed with partial suture separation, but also in substantially reduced times, were not taken into account.

According to the data of N.N. Yelanskiy, based on an extremely large amount of material, healing of approximately 80.0% of all those operated on occurs in periods of up to one month. However, the understated indicators presented characterize the high effectiveness of the secondary suture method and its great importance.

Medicinal Therapy

Medicinal treatment during combat was used in some form in the treatment of all wounded, but its value was far from the same for different categories of them. Medicinal agents were used in giving aid before surgical treatment, during operations both for local and general effects, as well as in subsequent treatment.

Medicinal therapy was the main type of treatment of 37.4% of all wounded, from the time of wounding all the way to recovery.

Of all unoperated wounded, 85.7% were subsequently treatment exclusively conservatively, and more than 3/4 of all wounded given primary surgical treatment underwent conservative treatment subsequently. A number of pathological processes which arose in a wound were treated in just the same way with antiseptics or other medicinal agents. More than 350 works dealing exclusively with questions of medicinal treatment of wounds, and a very large number of works which touched on the question under discussion to some extent were published in our domestic literature on wartime. More than 100 preparations used for wound treatment had been proposed by the start of the war. The number of them increased substantially during the war, although it must be noted that the majority of them were not widely distributed and were used either only by the author advertising a given preparation or a small group of persons who worked jointly with the author (carbon gypsum, Talginsk water, Barents Sea water, toluidine blue and many others). No more than half of all wounded were treated with preparations proposed during the war. Preparations approved before the start of the war were used in the treatment of the remaining wounded.

Wartime experience confirmed the importance of antiseptics without fail with the appropriate indications for a supplement to surgical treatment of a wound. Development of new antibacterial agents and use of preparations which stimulated repair processes are brilliant achievements of modern surgery. With an efficient combination of surgical treatment and use of all these agents, success was achieved in considerably shortening wound treatment times and reducing mortality.

Efficient medicinal treatment of a wound should be based on rigorous consideration of processes occurring in the wound at the time of application of a given preparation. Further, its task is to eliminate features which hinder wound healing. In accordance with this, at different periods of healing of a wound, the indications for use of medicinal agents differ, and they should be directed toward factors which are of dominant importance at a given time.

Thus, immediately after wounding and before primary treatment, the main attention was given to prophylaxis of additional bacterial contamination of a wound, which was achieved by smearing the vicinity of the wound with a 5-10% alcoholic tincture of iodine.

The method of immobilizing microbes by smearing the vicinity of the wound with viscous substances (kleol, mastizol) did not become widespread in advanced stages although, in individual case records, there are indications that kleol was used in PMP [regimental aid stations] for additional securing of dressings.

In 1941, it was proposed to fill wounds with sulfanilamide (N.N. Burdenko) which, by hindering the growth of bacteria, should have delayed their reproduction in the wound and made its treatment more effective at later times. Streptocide "rods" were advertised for this purpose. However, they did not achieve popularity in 1941, and they were then abandoned as unjustified. Thus, the only antiseptic agent used for prophylaxis of infection of a wound during the entire war was iodine, which had been introduced into medical practice approximately one and a half centuries before. Besides,this, all wounded were injected with antitetanus serum for prophylactic purposes during the entire war.

Antiseptic agents were used subsequently only for completion of surgical treatment of a wound, and an antiseptic bandage was frequently applied in cases where surgical treatment was not indicated. The requirements placed on preparations used in the period preceding the development of granulation, when an infectious source in a wound still is not clinically manifested, are based on the presence of necrotic sections in a wound which contribute to the development of infection.

The preparations used in this period should, on the one hand, have antiseptic and necrolytic properties and, on the other hand, stimulate the development of granulation. Sulfanilamides and chloramines, which were widespread during the war, are such preparations.

Chlorine containing agents, as was pointed out above, were widely used before World War I for treatment of wounds, and they were first used in combat by N.I. Pirogov. Chloramine was introduced in medical practice in 1916 by Dakin, although dichloramines T and B were synthesized as early as 1896 and chloramines T and B in 1905.

The preparations we synthesized are superior to the foreign preparations in content of active chlorine, which is the active principle of the preparation.

A number of chlorine containing compounds were synthesized in the USSR which, although they were adequately tested before the war (pantosept, azochloramide, neopantocide, etc.), did not become widespread in treatment of wartime wounded.

The action of chlorine containing agents is based on three features:

1. displacement of hydrogen from its combinations in proteins and formation of hydrochloric acid by combining with it;

2. combination with the hydrogen of water, in which the liberation of nascent oxygen occurs;

3. formation of chloramine type compounds with the amino groups of proteins.

According to the data of a number of authors, besides their effect on bacteria, chlorine containing agents have the property of accelerating the separation of necrotized tissue and stimulating the development of granulation.

Chloramine, which is used as a 1-2% solution for wetting napkins and tampons inserted into a wound, does not damage the tissue in the wound. It was used extremely extensively in the war for treatment of wounded. Case records which have no indications of the use of chloramine at some period of treatment of the wounded are an exception.

Chloramine, as an antiseptic agent used in recently infected wounds, was subjected to no significant criticism in the pages of the press during the war. The use of other antiseptics together with it did not argue the negative properties of chloramine, but the more valuable properties of these compounds. Sulfanilamides, used as a powder in a wound, by contrast, encountered a number of significant objections. The basic negative property of the powdered addition was the formation of a scab of blood soaked powder (M.N. Akhutin) which, without adequate contact with the wound surface, did not display its antiseptic effect and, at the same time, contributed to the production of extremely favorable conditions for the development of bacteria in the exudate which accumulated under it.

Moreover, doubts arose as to whether a sufficient concentration of the preparation could be achieved in the wound by the local application of sulfanilamides (N.N. Burdenko, S.I. Banaytis, S.L. Libov and others). Local application of the preparation began to be combined with its internal administration in the first days of the war. In the first months of the war, it became necessary to control for adequate doses in the internal use of sulfanilamides. The doses were specified in special instructions on the use of preparations of the sulfanilamide series. Despite the fact that schemes for both prophylactic (1.0, 0.5 every hour and 0.5 each every 4 hours) and therapeutic (2.0, 1.0 every hour and 1.0 each every 4 hours night and day with the administration of up to 4 ℓ of water per day) doses were precisely specified, over a number of months prescription of sulfanilamides of 0.3 three times per day could still be found.

To avoid the unfavorable effects of powdered sulfanilamides, pastes and emulsions were proposed for local application. The most improved of them proved to be a reversible sonicated emulsion, proposed by B.M. Solov'yev and extensively used by S.I. Banaytis.

A number of works appeared in 1943 (V.N. Geynis, P.P. Sakharov, Ye.I. Gudkova, A.N. Leont'yeva), which recommended the use of powders, solutions and internal doses of sodium salicylate. This preparation, besides bactericidal activity, has pronounced necrolytic properties, and it accelerates granulation.

According to the data of S.N. Kolosovskiy, N.A. Sreseli et al, preparations of urea, metal peroxides (Ts.S. Kogan, A.B. Kolodner, A.V. Protasevich et al), hydroperite (P.Ya. Zil'ber) and a number of other compounds used by individual authors for treatment of fresh wounds in the period preceding granulation have the same properties.

The ointment of A.V. Vishnevskiy initially consisted of Picis liquidi, Xeroformii aa 3.0, Ol. Ricini 100.0; however, in 1942, A.V. Vishnevskiy recommended adding 20.0 sulfanilamide and 2.0 chloramine to this prescription.

The use of compounds which have antibacterial and bacteriostatic properties was dictated by the need to localize microbes in a wound in the period when mobilization of the protective properties of the body still had just begun, when the spread of infection in tissues still had not met an adequately developed barrier. World War II experience proved the advisability and justification of such a tactic (N.N. Burdenko, S.I. Banaytis et al).

A number of the most frequently found infection pathogens and recommended chemotherapeuticsagents are presented in Table 23, compiled by I.V. Lazarev.

Table 23 illustrates the possibility of specific action on those types of microorganisms which are the pathogens of the most serious infectious processes in a wound. It should be emphasized that all the compounds presented first became widespread during World War II.

Medicinal Therapy in Period of Acutely Developing Inflammation in a Wound

It is known that, in a number of cases, the development of an infectious process (anaerobic and sometimes aerobic) in a wound is extremely vigorous and sometimes lightning like.

Experience has shown that only active surgical intervention (amputations, extensive incisions with excision of infected tissues) are successful in these cases. However, medicinal treatment was extensively used together with surgical methods in the overwhelming majority of cases. Suffice it to point out that, after primary treatment or dressing of a wound, more than 4/5 of all wounded underwent medicinal therapy.

Table 23. Most frequently found wound infection pathogens and recommended chemotherapeutic agents

Pathogen	Chemotherapeutic agent
Hemolytic streptococci:	
Groups A, B, C	Sulfanilamide preparations, penicillin
Group D	Effective agents not found
Staphylococci:	
Aureus	Penicillin, sulfanilamide preparations less effective (sulfathiazole and, by some data, sulfacil strongest acting of them)
Albus	No exact data; penicillin ineffective; sulfanilamide preparations give good result in urinary infections
Bact. coli	Sulfanilamide preparations
Cl. Welchii	Penicillin, sulfanilamide preparations
Cl. septicum	Penicillin, sulfanilamide preparations
Cl. oedematiens	Penicillin, sulfanilamide preparations weak
Cl. histolyticus	Penicillin
Bac. pyocyaneus	Sulfanilamide preparations

At the time of appearance of the first signs of infection, medicinal treatment was carried out in two directions: in the form of general restorative measures (transfusion of glucose, giving vitamins and iron and calcium preparations, fish oil, etc.) and in the form of the use of antiseptic agents, both locally and by internal, subcutaneous, intravenous, intraarterial, etc., administration.

Chloramine, hypertonic saline, sulfanilamides, Vishnevskiy ointment and rivanol were most widely used in medical treatment at this stage of wounding.

The temperature curve, pulse and laboratory blood study data were the objective indications of the effectiveness of the preparations used.

The local course of the process was evaluated more subjectively, and the correct interpretation of the condition of the wound and the pathological processes in it depended on the experience of the treating physician to a considerable degree.

Beginning in the first days of the war, comprehensive study of a number of new medicinal agents was carried out.

Local irrigation, although it was not widespread nevertheless was used in a number of both frontline clearing station and army hospitals. The previously tested chloramine, sulfanilamide solution and preheated potassium permanganate were used as the irrigation solutions.

In some mobile field hospitals and evacuation hospitals, together with constant irrigation a simpler method proposed by N.I. Pirogov frequently was employed, periodic instillation through a system of tubing previously inserted into the wound or, more often, by periodic wetting of a napkin applied to the wound. In nearly all cases, the dressing was of the water-absorbent type.

A water-absorbent dressing with chloramine was used most often in the period of acute development of inflammatory symptoms (more than 60.0% of all wounded). The second most frequent was hypertonic solutions. Besides 8-10% saline solutions, hypertonic sugar solutions (Ya.I. Lipskiy), Barents Sea water (P.A. Kul'chinskiy) hypertonic solutions of 10-20% Magnesiae sulfurici and Magnesiae citricae, etc., were used. In cases where osmotherapy was used in quite wide open wounds, as in the years of World War I, it completely jusitifed itself.

Vishnevskiy ointment, which proved to be an extremely valuable agent, received considerable distribution.

Sulfanilamide therapy was almost universally acknowledged in this period. Besides local application (in the form of powder, irrigation, ointment and emulsions), internal administration, subcutaneous administration of 0.8% sulfanilamide solution and intravenous and intra-arterial infusion were recommended as early as the first days of the war (N.N. Burdenko, V.V. Kovanov, A.S. Chechulin, S.L. Libov).

Sulfanilamide and sulfidine profited from the greatest distribution among the sulfanilamide preparations (there are more than 200 preparation names). Sulfazole was extensively used in 1944-1945.

A substantial domestic literature was accumulated during the war, which dealt with the question of sulfanilamide therapy of wounds. More than 100 works appeared in the periodic press and in collections of individual institutions engaged in the treatment of wounded. Extremely pessimistic statements (M.N. Akhutin) were found together with enthusiastic testimonials. However, by the end of the war, the overwhelming majority of physicians considered sulfanilamides to be powerful antibacterial preparations.

One negative aspect of sulfanilamides is the necessity for continual maintenance of a high concentration of them in the blood, from 4 to 12 mg%. Such a concentration can only be maintained by their systematic application. More than that, in study of case records, cases of extremely irregular administration of sulfanilamides were found, which evidently contributed to the appearance of sulfanilamide resistant forms of microbes. In order to avoid this, on the fronts where surgical work was headed by S.I. Banaytis, the administration of sulfanilamides to patients and wounded was carried out at strictly determined hours of the day (for example, at 12 noon, 4 p.m., etc.), which considerably increased effectiveness. Combat experience showed that both sulfanilamides and other medicines, the effects of which depend to a considerable extent on the timely administration of subsequent doses, should be used according to a rigorously thought out system. Otherwise, these preparations not only do not yield a benefit, they sometimes become harmful.

Another unfavorable property of sulfanilamides and the resultant necessity of continuous laboratory monitoring of the condition of the hemopoietic organs and kidneys.

A.V. Rusakov notes an inhibiting effect of sulfanilamides on the healing of muscle tissue wounds. The experimental work of V.N. Mogil'nitskiy and A.V. Goryachev points out the retardation of proliferative and repair processes in cerebral tissues.

Besides, it should be taken into account that an adequate concentration of the preparation cannot be obtained at all in the blood of a number of persons. If it is added to this that many pathogenic microorganisms are sulfanilamide resistant, indication of the necessity for stopping administration of the preparation in the absence of an effect after 5-7 days of its use becomes completely justified.

The best results were obtained by a combination of local application of sulfanilamides with general application. V.M. Mysh, N.N. Burdenko, V.V. Kovanov, S.L. Libov, A.I. Chechulin and others point out the extremely promising results obtained by the intraarterial administration of these preparations.

In June 1948, at a meeting of the USSR Academy of Medical Sciences, sulfanilamides received a favorable evaluation by a number of those present (V.M. Karasik, S.I. Banaytis). S.I. Banaytis pointed out their positive prophylactic and therapeutic effects, and V.M. Karasik, the presence of antitoxic properties, together with bacteriostatic properties. Besides, the thought was expressed that there was a synergistic effect of sulfanilamides and penicillin (S.I. Banaytis).

A favorable result was obtained by use in the period of acutely inflammatory symptoms of bacteriophage. Bacteriophage was favorably evaluated before the Finnish War (M.P. Pokrovskaya and coauthors). During World War II, bacteriophage was successfully used in the form of dressings and injections around the wound by V.I. Kolesov in Leningrad. In 1941, 1942, 1943 and 1945, instructions on the use of bacteriophage were published, which were approved by the head of the Main Military Medical Administration. A number of reports (D.L. Tsulukidze, I.V. Yeroshchenko, Ya.S. Krinitskiy, M.Ye. Krol', A.V. Popova et al) confirm the favorable results obtained by the use of bacteriophage in hospitals and in experimental research.

However, it should be noted that phage therapy in the treatment of wounded did not become widespread during World War II. The reasons for this were the difficulty of obtaining effective preparations in sufficient quantity and difficulties in their storage.

As is known, substances extracted from bacteria, fungi and plants, which retard the development of microorganisms and were called antibiotics, practically began to be used during World War II. Based on the antagonistic action of microbes noted by Pasteur, I.I. Mechnikov and N.F. Gamaley, Fleming discovered a new agent which retarded the growth of staphylococci and then subjected them to lysis. A green mold contained this agent. The first observations of Fleming were in 1928. The existence of such an effect was noted as early as the last century by A.G. Polotebnov and V.M. Manassein, and it was even used for therapeutic purposes. However, much time was required before penicillin was obtained in sufficient quantity, studied and tested so much that it could be used under field combat conditions for control of infections of gunshot wounds. Its therapeutic action was shown in the work of Florey and Abraham.

The initial observations left a favorable impression, and testing was transferred to the front and to ships from the rear hospitals. Testing was carried out mainly on wounds of the extremities with bone damage.

Penicillin was applied locally, as well as in the form of intravenous and intramuscular injections. The calcium and sodium salts of penicillin were used for practical purposes in solution, in dry form and in the form of ointments. These initial studies and observations showed that the local application of penicillin is of less value, although it is easily absorbed through a fresh wound. It was determined that well purified penicillin is harmless, and that it does not act on all microbes, but mainly on straphylococci, streptococci, gonococci, pneumococci and slightly on the anaerobic group. However, primary surgical treatment of wounds remained mandatory, and only a relative effect of the use of penicillin was obtained in severe forms of general infection. An extremely favorable effect of penicillin was established in severe gunshot fractures. Thus, with penicillin treatment, 2/3 of fractures healed in two months and 4/5 in three months. Penicillin was administered every 3 hours for 5 days (or by the drop method with glucose). In wounds of the upper extremities, 500,000 units were administered during the entire course and from 700,000 to 1,000,000 units in 10 days in wounds of the thigh and shanks. In the Soviet Union, penicillin was initially obtained from abroad but, by October 1942, in the laboratory headed by Z.V. Yermol'yeva, the extraction of active strains of Penicillium began. The Penicillium crustosum strain proved to be the most active. The Soviet preparation penicillin-krustozin was obtained from it.

Soviet, English, Canadian and American penicillins were tested during the war. The initial observations were carried out in the clinics of N.N Burdenko, N.I. Grashchenkov, I.G. Rufanov and V.S. Levit and by S.O. Portugalov and I.M. Belousova under the direction of S.S. Girgolav, in the Main Military Medical Administration Scientific Research Hospital. The initial doses of intramuscularly administered penicillin were small, and the high doses now used arrived gradually. It was possible to test penicillin only on some fronts. Soviet Army Surgeon in Chief N.N. Burdenko personally headed the team for conducting the work on one of the Baltic fronts. This team was able to conduct the required studies under front conditions and compile instructions for combat surgeons. At the same time, N.N. Burdenko introduced intraarterial (in a. carotis) administration of penicillin solutions in purulent complications of brain wounds.

The conclusions of the team are reduced basically to the following:

1. penicillin does not replace surgical treatment of a wound, but it supplements it extremely significantly, contributing to the prevention of complications of purulent and anaerobic infections;

2. in the case of already developed purulent infections, penicillin undoubtedly is an effective agent, with simultaneous surgical intervention, however, if there were indications for it;

3. both local and general use of penicillin is recommended, but the combination of both methods is the most effective.

The testing of penicillin showed that it is a powerful agent for control of a wound infection but, primarily, that the use of antibiotics makes it possible to again raise the problem of control of infection of a gunshot wound, the most serious complication of combat trauma. Antibiotics should have an effect on a number of severe complications of wounds, by reducing their duration and increasing the percent recovery of complete fitness.

A large number of antibiotics are known at present but, during World War II, besides penicillin, only gramicidin was used on an extremely modest scale.

Its chemical structure is that of a crystalline polypeptide. In the Soviet Union, gramicidin was obtained in 1942 in the Central Institute of Malaria and Parasitology, by G.F. Gauze and M.G. Brazhnikova (gramicidin C). Its bactericidal strength exceeded that of the American preparation "thyrotrocitin."

Gramicidin is classified as a bactericidal preparation by its properties, and it is intended only for local action on a wound surface. Because of its hemolytic properties, gramicidin is unsuitable for intravenous and intramuscular administration. Because of the characteristics indicated, gramicidin was demonstrated as a therapeutic preparation in infected wounds, especially if staphylococci were predominant. According to the data of the clinic of I.G. Rufanov, the bactericidal properties of gramicidin exceed those of chloracid 32 times, chloramine 16 times and rivanol 4 times.

The properties of gramicidin now differ considerably from those of the initial preparation. With prolonged application to a wound, it inhibits the development of granulation tissue sooner (observations of the Main Military Medical Administration Scientific Research Hospital), which is not observed now. Gramicidin was applied locally to act on wound flora before secondary sutures, mainly on soft tissue flora.

Gramicidin did not become widespread during World War II. It was used mainly in rear therapeutic institutions.

As is evident from the brief survey presented, antibiotics failed to become widespread during the war but, after the war the use of antibiotics, of penicillin in particular, became extremely popular in surgical practice for both therapeutic and prophylactic purposes.

Medicinal Treatment After Abatement of Acute Symptoms

When acute inflammatory symptoms in a wound died down, temperature became normal and the wound was covered with granulation and only a small amount of pus usually was discharged, surgeons were faced with the task of achieving the most rapid epithelialization of it. This was achieved in two ways, by plastic closing of the wound or application of secondary sutures, and by stimulation of epithelialization. Healing of 1/7 of all wounded was achieved by means of the first method, and conservative treatment was carried out to complete wound healing of 6/7.

The question of the stimulation of healing of wounds arose in the first months of the war. It became of special importance for GLR [hospital for slightly wounded] and rear hospitals. The large number of works dealing with this question which appeared during the war actually came mainly from these institutions.

The basic cause of failure was inaccurate determination of the indications in cases of the use of stimulators. For example, in some cases, efforts were made to achieve cicatrization with sequestrae or foreign bodies subject to suppuration in the wound. Further, after acute symptoms passed, treatment was extremely often reduced to changing dressings with antiseptics (chloramine, rivanol or hypertonic solution). In these cases, epithelialization of a wound frequently was delayed and sometimes completely stopped. Based on this, a diagnosis of a long term nonhealing wound or ulcer was made, while it was necessary to change the medicinal agent used for treatment and carry out several redressings with careful dressing of the vicinity of the wound.

Each agent used for wound treatment was an irritant to some extent, which stimulated repair processes, but it lost this property upon extremely long term use and resulted in slowing down of epithelialization.

The efforts of biologists and physicians were directed for many years to finding methods which accelerate wound healing. As early as 1840, N.I. Pirogov pointed out the importance of outflowing blood for wound healing. In the opinion of N.I. Pirogov, blood forms adhesive substances which stimulate the plastic functions.

In the prewar years, a tissue treatment method was developed by V.P. Filatov (1935). He proposed the use of layer by layer partial scar homoplasty to clear up a necrotic transplant. Further studies led V.P. Filatov to the conclusion that the introduction of various cold preserved tissues or their derivatives (extracts, pastes) into the body stimulates its regenerative capacity. The author called the proposed method "tissue treatment."

V.P. Filatov proposed the following considerations as a working hypothesis:

1. substances enter the body of the recipient from cold preserved tissue, which stimulate regeneration and resorption processes which, with a pathological process present, can lead to its elimination;

2. these substances, which the author called "conservation factors," act on the catalyst principle;

3. part of the conservation factors are in the free state, and part are chemically or adsorptively bound to the transplant tissue;

4. the conservation factors are heat resistant;

5. conserved tissue introduced into the body mobilizes systems of sanitizing reactions which act as a broad range stimulus to the macroorganism;

6. a transplant subjected to low temperature does not die, but is in a state of "survival," and the low temperature protects it from breakdown and preserves its viability;

7. "difficult conditions force living tissue to change to other stimulators of its vital processes" (V.P. Filatov).

In 1936, A.A. Bogomolets proposed an antireticular cytotoxic serum (ATsS) as a substance capable of eliminating a number of pathological processes. Numerous observations of the action of this serum indicate that its administration is a strong impetus to the repair processes which occur in the body (A.G. Penshin and L.N. Chernysheva, A.A. Bogomolets, O.A. Bogomolets).

Thus, a sufficient quantity of domestic agents and methods for stimulation of wound healing was available to our surgeons by the beginning of World War II. Observation of the effect of these agents continued during the war.

N.I. Krauze (1943) changed the method of tissue treatment proposed by V.P. Filatov, by introducing their chemical treatment. During the war, various tissues preserved by the N.I.Krauze method were used for stimulation of wound healing with favorable results.

The ATsS of A.A. Bogomolets and the tissue supplement according to V.P. Filatov, as well as in the modification of N.I. Krauze, were used most often as stimulators. Moreover, a number of new substances were proposed which accelerate epithelialization. Thus, for example, D.I. Gol'dberg proposed an embryonic extract ointment. The observations of a number of authors (mainly the colleagues of D.I. Gol'dberg, N.F. Kochergin, V.A. Chepurin et al) confirmed the data of D.I. Gol'dberg. Toward the end of the war (1944), the D.I. Gol'dberg ointment was widely used in the hospitals of Tomsk (Ye.A. Gromova, V.P. Mirolyubov, P.M. Nagorskiy).

Together with ATsS, a granulotoxin proposed by I.M. Neyman, based on the same self stimulation principle, achieved some popularity. R.P. Belkin observed an epithelialization accelerating effect of small doses of thyroidine (1945).

The acceleration of wound healing was noted upon exposure to extract of coniferous needles (D.B. Bronshteyn), wild rose (R.K. Movshovich), Talginsk water (S.M. Nekrasov), extract of Diptera cocoons (N.V. Ryabinina), plantain leaves (R.K. Aliyev) and many other substances.

Physicians who proposed new agents tried to use preparations which were not in short supply in the locality where they worked. Therefore, the majority of the agents proposed were used mainly in the place where they were proposed.

It should be noted in summary that specific medicinal actions on a gunshot wound are characteristic of specific stages (Table 24).

Table 24. Purpose of medicinal treatment, preparations and methods of their use in various stages of evacuation

Stage	Medicinal treatment purpose	Preparations and methods of use
BMP [battalion aid station]	Prophylaxis of secondary infection	Smearing vicinity of wound with tincture of iodine
PMP [regimental aid station]	Prophylaxis of infection (anaerobic and aerobic)	Same and filling (in some cases) wound with sulfanilamide powders. Administration of antitetanus, antigangrene serums to wounded with muscle destruction
MSB and KhPPG [medical battalion and mobile surgical hospital]	Prophylaxis of infection	Locally extensive use of antiseptics
First line KhPPG and AGLR [army hospital for slightly wounded]	Control of developed infectious complications (mainly anaerobic infections)	General action: sulfanilamides, penicillin, sera, general restorative agents (blood transfusion, injections)
Hospitals, UGPEP [general advance field clearing station], PEP [clearing station], GLR [hospital for slightly wounded] and FEP [front line evacuation station]	Control of developed infections	Locally extensive use of antiseptics
	Attempt to localize infection within primary infected tissue	Use of tissue regeneration and wound epithelialization accelerators (stimulators). General action, sulfanilamides, antibiotics, ATsS, sera: antigangrene and antitetanus. General restorative preparations (vitamins, blood transfusion, etc.)
	Preparation of wound for secondary suture application and conduct of plastic wound closing procedures. Stimulation of wound healing	
Rear hospitals	Control of infections in wound, localization of infection within primary infected tissues Stimulation of wound healing	Same as in FEP hospitals, but methods of stimulation of wound healing and their preparation for secondary suture application of overwhelming importance

Table 24 Cont'd.

Preparation of wound for secondary suture application of plastic surgery	

World War II experience showed that the use of antiseptics is a highly advisable supplement in wound treatment.

Their use in treatment of suppurated wounds completely justified itself.

Medicinal treatment will be successful only in those cases where it is combined with timely surgical interventions when indicated (sequestrae, foreign bodies, etc.).

Efficiently performed medicinal treatment of a wound provides for strict individualization in selection of the appropriate preparations, rigorous follow up of the condition of the wound, the nature of the infectious process and steady attention to the general condition of the body (nature of the temperature curve, blood pattern, patient weight, etc.).

General and local application of antiseptics succeeds in localizing an infection to the primary infected tissue, preventing its generalization and reducing mortality in many cases. The strongest antibacterial preparations during the war was sulfanilamides and penicillin. The extensive use of penicillin gives no basis for constricting the indications for use of sulfanilamides. In many cases, the simultaneous effect of sulfanilamides and penicillin evidently produces the best effect.

The use of wound healing stimulators is efficient. However, there is no general purpose preparation at this time which could be used at all stages of wound healing.

Long term local application of the same substance in wound treatment results in a reduction in the therapeutic effect and slowing down and sometimes stopping of the regenerative and repair processes. A change of preparation is indicated in these cases. Table 25 presents preparations used during World War II in wound treatment, which were reported in the periodic press.

Table 25. Preparations used in wound treatment during World War II.

Agents proposed before 1914		
Name of substance	On fresh wound	On granulating wound
Alcohol	+	--
Iodine	+	--
Iodoform	+	--
Potassium permanganate	+	--
Mikulich ointment	--	+
Scarlet red	+	--

Agents tested during 1914-1918 war and interwar years		
Name of substance	On fresh wound	On granulating wound
Antitetanus serum	+	--
Antigangrene serum	+	--
Bacteriophages	+	--
Antiviruses	+	--
Chloramine	+	--
Hypertonic saline solution	+	--

Agents distributed after 1914-1918 war		
Name of substance	On fresh wound	On granulating wound
Rivanol	+	--
Vishnevskiy ointment	+	+
Neopantocide	+	--
Chloracide	+	--
Azochloramine	+	--
Bactericide	+	--
Ammagren	+	+
Aniline dyes	+	+
Chalk dressings	+	+
Hypertonic sugar solution	+	+
Hypertonic magnesium sulfate solution	+	+
Balsam fir	+	+
Naphthalane ointment	--	+

Vitamin C	--	+
Vitamin A	--	+
Vitamin D	--	+

Agents first used during World War II

Name of substance	On fresh wound	On granulating wound
Sulfanilamides	+	--
Antibiotics	+	--
Sodium salicylate	+	--
Zinc peroxide	+	--
Perborates	+	--
Urea	+	--
Carbon gypsum	+	+
Aqueous iodine solutions	+	--
Iodine vapor disinfection	+	--
Wood smoke fumigation	+	+
Hydrochloric acid solutions	+	--
Lye	+	+
Toluidine blue	+	--
Acidolphilus paste	+	+
Antiulcerin	+	+
Oxygen therapy	+	--
Juniper oil	+	--
Hemodressing	+	+
Tissue dressings	+	+
Chlorobutyrate dressing	+	+
ATsS	+	+
Gol'dberg ointment	--	+
Conserved tissues (Filatov)	+	+
Chemically treated tissues	+	+
Paraffin dressings	--	+
Talginsk water	--	+
Vegetable oils	+	+
Hormones	--	+
Animal fats	--	+
Used crankcase oil	+	+

In concluding discussion of the question of the medicinal therapy of wounds, it should be emphasized again that medicinal therapy is not an independent method. It achieves the purpose only in combination with timely surgical intervention, frequently as a supplement to it. The use of medicinal agents assumes the physician's knowledge of both the mechanism of action of a given substance and a profound knowledge of the processes occurring in a wound. Only on this condition can skillful selection of a medicinal agent channel the processes in the desired direction, and efficiently control those local and general complications which arise in a wound.

The abundant selection of medicinal agents available to our physicians during World War II presented all possibilities of efficient wound treatment. Wherever there was no standard, i.e., the physicians did not attempt to use a single medicinal form in diverse pathological processes occurring in wounds, elimination of the infectious process and healing of the wound succeeded in the overwhelming majority of cases.

It is true that far from all the medicinal agents listed above were widely distributed, but some of them (chloramine, sulfanilamides, Vishnevskiy ointment, hypertonic solution) were used everywhere. Some agents proposed as substitutes for those in short supply were used mainly at the place they were produced (for example, juniper oil). A portion of the agents proposed for wound treatment still have not gone beyond experimental testing, and their use also was limited to the author proposing them and his closest colleagues (carbon gypsum, fumigation, zinc peroxide, urea, lye, used crankcase oil (OKM), etc.).

Antiseptics were widely used at all stages of evacuation, while healing stimulators were used to a greater extent in the rear hospitals and hospitals for slightly wounded.

CHAPTER VI

OUTCOMES AND CONCLUSION

Outcomes

The outcome of a wound can be: 1. complete recovery, i.e., wound healing with a scar and complete restoration of function of the injured region; 2. wound healing with loss of capacity for work and combat readiness to some degree up to complete loss of them; 3. death of the wounded. Practically however, the state of health at the time when he leaves the last treatment institution must be considered the outcome of the wound. His discharge can occur when treatment of the wound or its immediate aftereffects still have not been completed. Subsequently, after discharge, the wounded loses contact with the hospitals. Therefore, such cases of wounds, the treatment of which is not essentially complete, but continues at a health resort, in a sanatorium or at home, as, for example, in chronic complications of the wound which do not, however, prevent the wounded from being outside a treatment institution or even performing work, are compelled to fall into "outcomes." Thus, incompletely healed wounds covered with a scab, fistulas remaining at the wound site and ulcers which developed at the wound site also must provisionally be considered outcomes.

Accounting is further severely complicated in that, with the passage of time, other illnesses and fatal outcomes from them are added to the primary suffering.

Two types of wound outcomes are distinguished in wartime surgery, expert and clinical.

Expert outcomes are determined by the functional state of health of a given wounded, with his combat readiness and fitness for continuation of military service taken into account first and foremost. With invalidism, the degree of loss of capacity for work is determined: temporary or permanent, according to which the wounded is included in a given group of invalids.

To a certain extent, expert outcomes are provisional, since they are determined at the time the wounded appeared before special expert commissions, which gave only a temporary decision, with reevaluation after specific periods in a number of cases.

Expert outcomes depend on the general statutes connected with the expiration of military service and on special temporary instructions. Depending on the severity of the war for a given state or a given time, evaluation of the health of army conscripts can change significantly. Thus for example near the end of the war in Germany, all the remaining male population was taken into service (total mobilization).

Returns to duty are of the greatest wartime importance of expert outcomes. The number of wounded returned to duty during World War II, according to official data, exceeded 70.0% of the total number of wounded.

The basic clinical outcome of a wound may be recovery and death. Besides cases of wound healing with a scar, ulcers, fistulas and incomplete cicatrization with a scab, i.e., all those conditions with which wounded were discharged from the last treatment institution, also should be included under the heading of outcomes. Scabs have to be evaluated differently. For part of the wounded discharged with a scab, especially if it occurs within the army and front areas, its presence frequently indicates the imminence of complete closure of the wound, and complete restoration of combat readiness occurs. Upon discharge from rear hospitals, a scab can indicate either an incompletely closed ulcer at the wound site or a temporarily or completely closed fistula. The presence of such epicrises in case records of a considerable number of wounded compels this condition to be considered an outcome. All clinical outcomes of wounds, in distinction from expert outcomes, poorly reflect the functional condition, and they sometimes do not coincide with the expert outcomes at all. Thus, for example, if a thigh is amputated as a result of the wound or complication of it and the wound heals with a scar, complete healing of the wound is noted as the clinical outcome but the expert outcome of such a wounded is classification in the category of war invalids unsuitable for military service. By considering a gunshot wound as a nosological unit and the wound as a disease, primarily the following outcomes were taken into account in study of case records: scar formation, presence of fistula, ulcer or scab upon discharge and death. In evaluating scar formation as a favorable outcome of a wound, it can be noted that, beginning in 1942, there was a steady increase in the percent of favorable outcomes during the war.

Table 26. Outcomes by year of war

Year	1941	1942	1943	1944	1945	All years
Wound healing with scar (in percent)	81.6	79.1	81.9	83.0	83.0	81.3

As is evident from Table 26, complete wound healing with a scar averaged 81.3%, and it increased from year to year (with the exception of 1942). This figure reached 83.0% in the last two years, i.e., it exceeded the average by nearly 2.0%. We recall that 82.5% (on the average) of bullet wounds and 80.3% of fragment wounds healed with a scar.

The percent mortality usually increases during a war. This was observed in the first 4 years of the war. However, 1945 produced a decrease.

The age of the wounded has an extremely great effect on the outcome of a wound. Thus, among persons born in 1905 and older ones, the smallest percent of healing with a scar and the greatest percent of fatal outcomes was observed. The difference is insignificant for the remaining outcomes. Healing with a scar of persons born from 1906 to 1915 occurred almost 1.5% more often, and mortality decreased by 1.0%. Among persons born in 1916, the highest percent of wound healing with a scar and the lowest mortality were noted. Mortality was 1.2% less than the average mortality of wounded. Outcome vs. age of wounded is presented below.

Wound healing with scar vs. age

Year of birth	Wound healing with scar
1905 and older	80.4
1906-1915	81.8
1916 and younger	82.2

Further, favorable outcomes vs. wound complications is presented. It is completely clear that healing with a scar, i.e., complete elimination of the wound process, was observed most often in wounds which had no complications. A large number of cases of discharge from a treatment institution with a scab also should be included in this group. It must be thought that wound healing with a scar could have occurred in many of these cases with later discharge.

With a purulent infection extending beyond the wound, the number of wounds healed with a scar dropped to 77.6%. The number of fistulas among the outcomes designated as "wound healing with a scab" increased sharply. With an anaerobic infection, complete wound healing with a scar was observed in a little more than half the cases. Mortality increased sharply in this group.

The severest wound complication is sepsis. With the development of sepsis, only 1/4 of the wounds heal with a scar, and mortality reaches very high figures. However, it must be noted that the diagnosis of sepsis, to decide from case records, was made sparingly, frequently only with a clear clinical picture.

The group of other complications cannot be considered without accounting for wound localization, since such complications as peritonitis, meningitis, etc., are included here. They can be taken into account by analysis of wounds according to their localization.

Wound healing with scar vs. complications

Nature of complication	Percent healing for each group
Without complications	84.5
Purulent infection	77.6
Anaerobic infection	50.6
Sepsis	25.1
Other complications	69.2

In conclusion, a diagram is considered which makes it possible to estimate the endurance of recovery upon return of the wounded to duty. It shows the extent to which wounded with healed scars coming to a treatment institution with recovery of function in wounds of varied localization proved to be capable of overcoming the difficulties connected with combat service in wartime.

There is no doubt that the commissions which returned wounded to duty were completely confident of complete restoration of combat readiness.

However, it was found that the scars sometimes proved to be unsound and that such wounded had to be rehospitalized because of ulceration of the scars, outbreaks of infection located in tissues, etc. The horizontal line on the diagram (Fig. 65) represents the average frequency of all cases of rehospitalization in connection with complications which developed after return to the unit, regardless of wound localization.

The individual columns of the diagram correspond to the percent of wounds of a given localization which were placed in treatment institutions for retreatment. Thus, wounds of each localization can be compared with the average level of all wounds requiring retreatment.

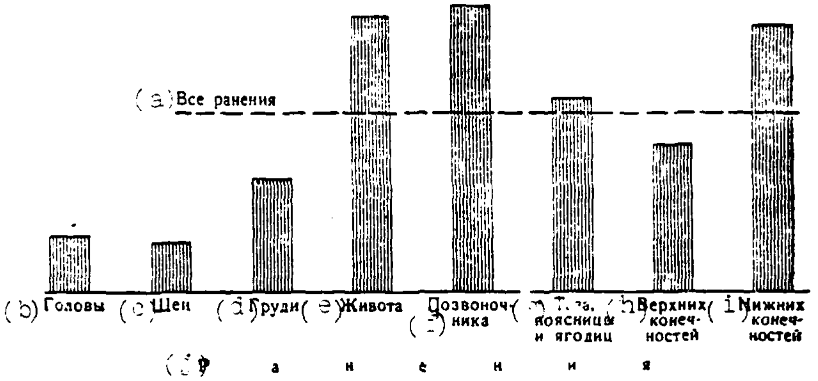

Fig. 65. Frequency of postwound illnesses requiring rehospitalization vs. wound localization.
Key: (a) All wounds; (b) Head; (c) Neck; (d) Chest; (e) Abdomen; (f) Spine; (g) Pelvis, loins and buttocks; (h) Upper limbs; (i) Lower limbs; (j) Wounds.

It is evident from the diagram first and foremost that the need for retreatment of those wounded in the head and neck returned to duty occurred in only a highly insignificant percent of cases, i.e., their fitness for combat service could be established extremely accurately. The percent of those wounded in the chest who required rehospitalization was somewhat higher. Fistulas were discovered and foreign bodies, etc., were removed from some of them but, in this localization, the percent who required rehospitalization was extremely low.

The pattern of those wounded in the abdomen and spine is completely different. It should be recalled that verification of the remote results after World War I in the west, which was carried out in 1935, found extremely low capacity for work of all wounded with penetrating infections of the abdomen and complaints of periodic disorders of the internal organs. Thus, those wounded in the abdomen and spine who were acknowledged combat ready at the end of treatment obviously actually poorly endure the combat situation, and a larger percent of them require rehospitalization. The percent of those wounded in the pelvis, loins and buttocks requiring hospitalization for additional treatment corresponded to the average percent for all wounded.

Extremely important data were obtained for the limbs. While the percent of rehospitalization of those with damaged arms is below the average, with damage to the lower limbs, the latter noticeably exceeds it. Evidently, the functional load on the lower limb under combat conditions is extremely high and can be compensated in no way by a greater load on the healthy limbs. A singularity of the functions of the arms also has an effect. One arm can replace the other arm very much more easily, with a somewhat reduced function.

Upon switching to analysis of mortality, it should be noted that there were bullet wounds in 31.8% and fragment wounds in 68.2% of those who died of wounds. These figures should be evaluated only according to the total number of bullet and fragment wounds. Nevertheless, they give a basis for concluding that fragment wounds proved to be more serious than bullet wounds. The number of single bullet wounds among the dead was more than double the number of multiple bullet wounds. Single fragment wounds also were observed more often among the dead than multiple wounds (Table 27). It must be thought that there is an inverse proportion among the dead.

Table 27. Frequency of bullet and fragment wounds among those dying from multiple and single wounds

Nature of wound	Wounded (in percent)	
	Multiple	Single
Bullet	33.2	66.8
Fragment	43.3	56.7
Total	40.1	59.9

The greatest number dying were in institutions which served a military region (58.1%), while the percent dying in army base hospitals was 14.0% of all who died. 17.6% of the total number of dead died in a front base hospital and 9.3% in rear hospitals. A fairly high percent who died during transport, 0.4% of all dead, attracts attention. The cause of death during transportation was subjected to thorough study during the war. Part of these fatal outcomes can be explained by forced evacuation, part was caused by the effect of long range enemy artillery or attacks of his aviation. But undoubtedly there were fatal outcomes because of incorrect diagnosis of wounds and underestimation of the degree of severity of them. The times of death are presented in Table 28, separately among the operated and unoperated, after bullet and fragment wounds.

Table 28. Time of death and frequency of fatal outcomes among operated and unoperated after bullet and fragment wounds (in percent)

Lifetime after wounding	Operated		Unoperated	
	Bullet wounds	Fragment wounds	Bullet wounds	Fragment wounds
Up to 1 hour	--	--	1.5	0.3
Up to 3 hours	0.2	2.4	0.5	0.1
Up to 6 hours	0.7	--	2.4	0.9
Up to 24 hours	13.3	24.4	28.7	17.5
Up to 3 days	15.9	17.1	22.0	17.4
Up to 5 days	4.8	6.1	3.4	5.7
Up to 10 days	20.5	19.5	13.2	17.3
Up to 30 days	24.3	17.1	12.5	20.8
Up to 3 months	13.3	8.5	9.8	13.6
More than 3 months	5.3	3.7	2.4	4.5
Undetermined	1.7	1.2	3.6	1.9
	100.0	100.0	100.0	100.0

Regardless of the nature of the wound and the type of assistance given, 27.8% of the deaths occurred up to 3 days from the time of wounding. These were deaths after fragment wounds in the overwhelming majority of cases. These obviously were the direct consequences of severe trauma here. The number dying dropped sharply after 3 months. Data on the causes of death are presented below.

It is evident from these data that the cause of death was the severity of the wound itself in nearly 11.0% of the cases and infections of the wound in more than 60.0%. Thus, control of wound infection still remains the basic task in modern combat and must continually be at the center of attention of the medical service.

Cause of death	Percent dead	
Wound severity	10.9	
Shock	14.5	
Hemorrhage	5.3	
Purulent infection	21.5	
Anaerobic infection	17.8	61.4
Sepsis	22.1	
Anesthesia	0.1	
Other causes	5.6	
Undetermined	2.2	
Total	100.0	

Conclusion

N.I. Pirogov, based on his personal experience, confirmed by six subsequent wars, established the basic "principles" of military field surgery. The second "principle" of N.I. Pirogov reads: "The property of wounds, mortality and success in treatment depend primarily on different characteristics of the weapons and particularly on the ammunition." This position cannot be adopted entirely at present, but the destructive force of a modern weapon must be taken into account.

The end of World War I is separated from the beginning of World War II by a total of two decades. Military technology developed considerably and the nature of the combat weapon changed sharply in these 20 plus years. The silent weapon retreated to the background, even in direct encounters.

Simultaneously with the increase in importance of firearms, the relative significance of artillery increased. A continually increasing frequency of fragment wounds attracts attention in the distribution of combat trauma by nature of the wounding weapon in the wars of the beginning of the 20th century.

The importance of artillery, mining and bombing increased still more in World War II.

Despite the introduction and extensive use of automatic weapons, fragment wounds exceeded the number of bullet wounds. Artillery wounds also became purely fragment wounds, since shrapnel was hardly used. All types of mines and aircraft bombing began to be used considerably more. The striking force of shells increased many times. In the 1939-1945 war, aviation participated in nearly all actions, raided cities and industrial centers, where the heaviest bombs were used, the weights of which were in tons, and huge structures were destroyed by direct attack. It is clear that the civilian population suffered in this case. In previous wars, the ratio of killed to wounded was 4:1, even 5:1 (the Prussian Army in 1870-1871). Almost the same ratio was preserved in the Russo-Japanese War. The number of killed began to increase in World War I and, in World War II, England lost 357,116 killed and 369,267 wounded from 3 April 1939 to 14 August 1945, i.e., the ratio was nearly 1:1. It is true that the number of killed included 60,058 peaceful inhabitants, of whom 7,736 were children. Therefore, in modern war, in calculating the killed to wounded ratio, the peaceful population can be excluded in no way (in England, the killed civilians were 1/6 of all killed). In his speech, V.M. Molotov, in giving the number of dead in World War II, did not distinguish between the army and the civilian population.

Based on these data, it can be established that the most destructive types of weapons were used in the 1941-1945 war, compared with all preceding wars.

One characteristic of this war whould also be indicated: toxic agents, which the Germans began to use for combat purposes in 1915 and which were then extensively used by all participants in World War I, were not used in World War II.

Finally, the severity of wounds in World War II was exacerbated by a large number of multiple wounds of both fragments and bullets.

Thus, gunshot wounds were the basic form of troop casualities.

Gunshot wounds differ sharply from all other wounds. N.I.

Pirogov pointed out that the molecular shocks which the region of the wound and the entire body of the wounded experience do not pass without a trace. These molecular shocks have now been studied in greater detail. It is known that they either are caused directly by the shock wave or they originate in the passage of the wounding shell, moving at great velocity, through tissue. The deformations caused by a shock wave in the wound region are extremely significant. There is no doubt that primary necrosis in a gunshot wound is a consequence of the shock wave to a considerable extent. The shock wave so strongly changes the conditions of vital activity of the tissue that reactivity of even the surviving cell elements is sharply reduced. All this leads to the formation of extensive sections of necrosis, which develop both immediately following the trauma and hours and days after it. The presence of necrosis has a significant effect on the subsequent course of the wound, by contributing to the development of the most threatening complication of a gunshot wound, infection.

Necrotic tissues are like a foreign body. Like a foreign body, they can become encapsulated in tissues, they can separate and escape outside and, finally, they also can be resorbed and replaced by new tissues. Therapeutic measures on these properties of necrotic tissues are based and carried out in relation to them. Their purpose is to facilitate either resorption, separation or encapsulation of them. Thus, in the conduct of therapeutic measures, each of these pathways is used in the direction which is most advisable for the circumstances given and for a given wound.

The experience acquired in World War II changed the opinion of surgeons on the nature of development of infectious complications in a wound. For the development of the microbes which contaminate a wound and, consequently, for the development of infection, specific conditions are necessary: primarily the presence of necrotic tissues and tissues with reduced reactivity in the wound.

Therapeutic measures have the purpose of achieving not so much sterilization of the wound, as the creation of conditions in it under which pathogenic microorganisms cannot find suitable conditions for their development. Of course, this does not exclude means of acting on microbes. This consists of prophylaxis of wound complications and their treatment. Of course, the time of intervention in a wound is of paramount importance. N.I. Pirogov pointed out the necessity for a combination of organizational and surgical measures. He considered this the most significant condition of provision of medical assistance during combat. During World War II, this opinion was not only confirmed, but it was expressed most fully compared with all preceding wars. The strictly defined times of action on a wound presented in various old studies were repudiated by the experience of World War II. There now is a sufficient number of means and surgical procedures to make it possible to guide the wound process in the desired direction at any time. Primary surgical treatment and its use combined with sulfanilamide group preparations and antibiotics played a large part in this case. The latter group of preparations, by acting on the entire body and locally on the wound, produce those conditions in them which hinder the further development of microbes and thereby the development of infection. It should be noted that they were extensively used in surgery only in the postwar period.

Ensuring rest of the wounded region proved to be a very important measure. The production of rest, the removal of any functional load from tissues with reduced reactivity, contributes to the development of repair processes in them. The importance of proper immobilization of damaged tissue is clear from this. It was achieved in part by means of plaster bandages. This explains the favorable results obtained in the treatment of limb wounds in dead end plaster bandages.

The mortality of the wounded was due mainly to the damage to the human body by the weapons used.

Modern surgery during World War II was convinced by the example of control of hemorrhage, frostbite, burns and electrical trauma that a condition previously considered irreversible and fatal can now be evaluated differently. Thus, those hemorrhages which previously were considered unquestionably fatal can be controlled, and those who appeared to be dead of a wound, cold or electrical trauma could be brought back to life. Nevertheless, there is damage which is fatal at present.

The mortality of the wounded depends on complications of a gunshot wound to a considerable extent. A substantial reduction in mortality was successfully achieved during World War II. The discoveries of subsequent years have demonstrated the possibility of an unlimited increase in the number of means used for control of wound complications. This gives the privilege of thinking that all wound complications could be prevented or cured in the immediate future. In just the same way, the progress in restorative surgery and prosthetic technology provide a broad promise of the recovery of combat and work fitness.

During World War II, surgery made considerable progress in both the field of theory and in practice and, if theory is directed towards the proper actions of surgeons, in turn, surgical practice would make easier an understanding of the pathological processes in gunshot wounds and would include the premises for further improvement in methods of treatment.

The practical achievements of military field surgery in different units differed, but understanding of the wound process and the principles of wound treatment remain unified, just like the ways of development of Soviet military field surgery.

Personnel losses of a fighting army are unavoidable, and the size of these losses is directly connected to the combat tasks performed. The outcome of wounds depends greatly on the improvement in organization of the medical service and the level of medical science at a given time in a given state.

PART II.

FROSTBITE

Introduction

Frostbite was long insufficiently studied, and this gap was only filled by Soviet surgeons in the 1930's. The concept of the nature of frostbite was preconceived, and its pathogenesis, clinical picture and semiotics were studied inadequately, since frostbite is observed rarely and in mild forms in peacetime. Of course, the treatment of frostbite was not scientifically sound.

In the present day treatment of frostbite, treatment of frostbite with skin changes as a result of cold is most significant and fundamentally new. This type of frostbite is not now treated conservatively as before, but by means of a radical operation after preliminary surgical treatment. Such treatment could not have been performed during wars of the preantiseptic period. It is highly likely that the subsequently so solidly rooted foundations of the conservative treatment of frostbite were laid just then. The mass frostbites during the Napoleonic campaigns, combined with the level of surgery of that time provided sufficient material for ultraconservative therapy. The Balkan wars and the 1914-1918 World War I when, as is well known, mass frostbites also were observed, occurred with a different level of surgical technique.

During these wars, especially in the 1914-1918 war, attempts were made to stimulate the treatment of severe frostbite with skin damage, the more so that the unfavorable long term results of especially conservative treatment had become evident. However, these attempts to stimulate treatment failed, since surgeons incorrectly evaluated the condition of the tissues above macroscopically detectable tissue necrosis, and they extensively practiced primary amputation. Only most recently, especially during the Finnish War, did the use of preliminary treatment of frostbitten limbs with subsequent early amputation and prosthetization begin. This became possible only as a result of experimental and clinical studies begun in the USSR in 1935. The most significant result of this study was analysis of the condition of the tissues of the entire frostbitten limb which, in turn, permitted the substantiation of early radical surgical treatment. It must be emphasized again that mainly frostbite with skin damage due to cold is concerned, since modern treatment is most effective in just this type of lesion.

Until most recently, frostbite was considered by many as the freezing of tissues. It was forgotten here that the mass wartime frostbite, "trench foot," occurred at just a temperature which excluded freezing. In accordance with this wrong opinion, frostbite was reproduced and studied experimentally exclusively as tissue freezing. One direct consequence of this was inadequate study of the pathological anatomy of frostbites, since this study was based on experiments which did not reproduce the majority of frostbites even to some degree. The widespread wrong opinion in the past, based on the concept of frostbite as freezing, has frequently been preserved to the present. For example, wrong opinions of the increased brittleness and hemolysis in freezing and thawing are concerned here. Frostbite was groundlessly classified by analogy with burns, and extremely diverse therapeutic measures were carried out without grounds, first aid measures in particular.

The following were characteristic of the treatment of frostbite in the past: 1. confusion of the forms, degrees and stages of frostbite, disregard or ignorance of the so called "latent" period in particular; 2. an ultraconservative direction in treatment; 3. attempts to somehow find and use general purpose and specific medicines; 4. fear of too rapidly warming a patient with frostbite or general chilling.

Since 1935, especially during and after the Finnish War, a large number of theoretical and clinical studies were conducted, the basic results of which should be considered: 1. analysis of the general state of the problem; 2. criticism of the old and the creation of new methods of experimental frostbite; 3. analysis of tissue condition in frostbite (tissue temperature, temperature at which a circulatory disorder and stasis are detected, X-ray study), which was the basis for the present understanding of the pathogenesis of frostbite; 4. detection of the so called "latent" period and its theoretical study; based on further study of the effect of cold (A.L. Izbinskiy, T.A. Achkasova, A.A. Kalyukhman et al), the term "latent" period, because of interpretation of some functional changes established in this period after the war (anoxia, disturbance of carbohydrate metabolism and the regulatory function of the central nervous system), should be replaced by a term which is more responsive to the state of affairs, the period of local and general hypothermia; the subsequently used term "latent" period thus is of a provisional nature; 5. reexamination of the principles of first aid in frostbite; 6. reexamination of the principle of ultraconservative treatment of frostbite; 7. critical study of attempts to find general purpose and specific means of treatment and prophylaxis of frostbite; 8. development of principles of surgical treatment of frostbite with skin damage due to cold.

Frostbite occupies a special place among combat losses (combat injuries).

Troop losses due to cold in a combat zone many times exceeds losses in the immediate rear, which is not subject to the direct action of enemy fire. Injuries caused by low temperature in peacetime occupy an extremely insignificant place among the other injuries and diseases.

Under normal conditions, low temperature can be the cause of frostbite only with additional, extremely diverse factors present.

Conditions for the development of frostbite can be created in the combat situation at the front. It does not appear possible to eliminate or reduce their harmful effect in the vast majority of cases.

Prophylactic measures to increase the general resistance of the body by reduction of heat transfer plays a large part in the prevention of mass frostbite, but they cannot have a decisive effect on the set of unfavorable factors which individual soldiers and small units have to face in a combat situation. These unfavorable factors depend on the specific combat situation in a given small section of the front, on the nature of the combat actions, enemy firepower, meteorological conditions, etc., and they do not yield to active regulation. Timely prophylactic measures, which prevent the development of frostbite under normal conditions, prove to be ineffective or insufficient for individual soldiers.

Frostbite depends on both the general combat situation and on the specific combat actions and enemy activity. Therefore, it should be considered a special form of combat injury.

Light frostbite (degrees I and II), in a substantial number of cases, were treated to completion at PMP [aid station] and in medical battalions, and the case records on them were not completed.

The present chapter is based on study of an adequate number of case records which include frostbite observed on all fronts during World War II. These case records were studied in detail, to obtain comparable statistical results.

It should be taken into account that the collections of the Military Medical Museum have predominantly material on frostbites observed in rear area stages. Thus, primarily severe frostbites were studied, which is taken into consideration in substantiation of the conclusions.

CHAPTER I

HISTORICAL DATA

Troop losses due to cold are noted over nearly the entire history of war. They sometimes reach extremely impressive figures, which should be regarded critically, for the reason that the losses from cold evidently include losses due basically to other causes. Thus, during the Napoleonic campaign of 1812, according to the evidence of Larrey, Idelson et al, there were infectious diseases (typhus) in a substantial portion of those retreating. N.I. Pirogov presented similar data for losses in the Balkans in 1877-1878.

The frostbite statistics of former wars suffer from inaccuracy. There are no summary data on a considerable majority of military campaigns. The most reliable data are presented in Table 29, but they cannot claim completeness, and they only refer to individual combat operations and not to the entire war.

The number of frostbites observed during combat actions in individual units and forces are distinguished by great nonuniformity. This nonuniformity depends on the specific combat situation in which combat actions had to be conducted. In particular, unfavorable climatic and meteorological conditions can considerably increase the losses due to

Table 29. Frostbite losses in various wars

War	Army	Number wounded	Number of frost-bites	Percent frost-bites of to-tal wounded	Source
Crimean War (1854-1855)	French	39,870[1]	5,215	13.0	Tolozan from Castallaneta
		39,870[1]	5,290	13.2	Sonnenburg and Tschmarke
Same	English	12,108[1]	2,398	19.7	Tolozan from Castallaneta
Franco-Prussian War (1870-1871)	French	16,000	2,632	16.4	N.I. Pirogov
Russo-Turkish War (1877-1878)	Russian, Danube	43,386[1]	5,403	12.4	N.I. Pirogov
Russo-Japanese War (1904-1905)	Russian, Manchurian	132,322[1]	1,490[2]	1.12	VSU [Military Medical Directorate] Rpt
	Jāpanese	173,425[1]	5,086[3]	2.9	F.G. Krotkov
World War I (1914-1918)	American Expeditionary	224,089[1]	2,064[4]	0.92	I.M. Talman
Same	English	2,161,134[1]	84,670	3.8	I.M. Green
Same	French	3,000,000[1]	150,000	5.0	Mignon from V.N. Sheynis
Same	German (1914-1915)	500,000	12,848	2.57	Schade
Same	Italian	947,000[1]	300,000	31.6	Bruni from Castallaneta
War in Spain (1936-1938)	Spanish Republican (December 1937)	--	500[5]	--	Ducuing and d'Harcourt
Finnish War (1939-1940)	Soviet	40,000	--	8.13[6]	P.A. Kupriyanov
Same	Finnish	66,000	8,000	12.0	Koronen
Italo-Greek War (1940-1941)	Italian	38,768	17,547	45.2	TASS report (*Pravda*, 2 June 1941)

[1]Number of wounded presented according to L.S. Kaminskiy and S.A. Novosel'skiy.

[2]Only hospitalized victims were taken into account.

[3]Data not accurate. According to other sources, the number of frostbites reached 15,000.

[4]Only trench foot without other forms of frostbite were taken into account.

[5]Frostbites constituted 0.42% of active troops.

[6]Percent frostbite of all medical losses, including 11.13% of the sick are presented.

cold. As an example, the data of N. Korsun for the Sarakamysh operation can be presented. In the period from 9 December 1914 to 5 January 1915, there was a total of only six frostbites of 20,000 killed and wounded in the Russian forces, with tremendous losses due to frostbite in the Turkish Army which participated in this operation. During the Erzerum combat operation in December 1915, in one battalion of the 17th Turkestan Regiment, the losses by wounds were 99 men and 45 from frostbite in 3 days of action. In the same battalion during actions in mountainous terrain from 28 December 1915 to 31 January 1916, of 100 wounded, there were only 15 men with frostbite (P. Abramov).

There is no doubt that the percent frostbites (of all combat losses) for the entire war was considerably lower than during individual operations or campaigns conducted in winter.

The total number of frostbite victims during a long war is extremely high. Thus, there were hundreds of thousands of frostbites during the 1914-1918 World War I. It is sufficient to point out that there were more than 300,000 frostbites in the Italian Army (Castallaneta), 150,00 in the French Army (Mignon, cited by V.N. Sheynis) and 84,000 in the English Army (Green).[1]

[1]Although the reliability of these data has not been completely established, they give a general idea of frostbites among the troops of these armies.

CHAPTER II

STATISTICAL DATA

Among the combat losses of Soviet Army personnel during World War II, the percent of frostbites was considerably less than in past wars.

As in past wars, the effect of the intensity of combat actions and climatic and meteorological characteristics on the rate of frostbite could be noted. However, it should be pointed out here that the effect of the meteorological factor was eliminated to a considerable extent by preventive measures, which were widespread from the first year of World War II.

The extensive use of preventive measures and better quartermaster supply of the Soviet Army had as a consequence that, beginning in the second year of the war, the basic factor which determined the frostbite rate was not meteorological conditions, but the nature of the combat actions. It can be noted that the acceleration of combat actions was accompanied each time by some increase in frostbite rate. This was reflected in both the reports of individual medical institutions and in the reports of the fronts.

The data of two different fronts are presented. Fig. 66 represents data for a front in which the combat actions were of a particularly violent nature in January-February 1943. As is evident from this figure, corresponding to this, the third year of the war is characterized by some increase in frequency of frostbite.

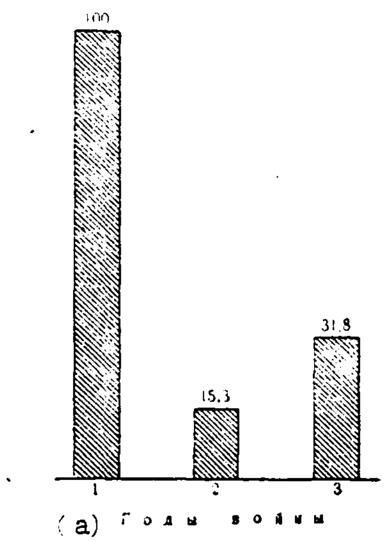

Fig. 66. Frostbite rate in different years of war from N-sk Front data.
Key: (a) Year of war.

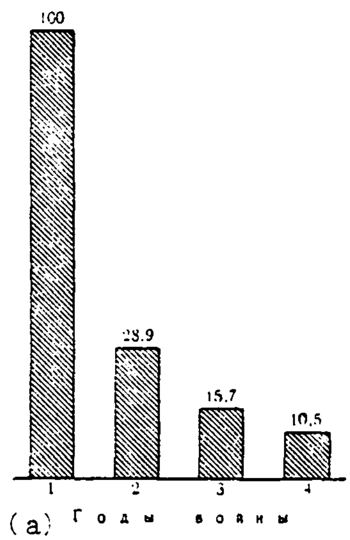

Fig. 67. Frostbite rate by year of war from N-sk Front medical battalion data.
Key: (a) Year of war.

The comparative frostbite rate is given in Fig. 67, from medical battalion data of the N-sk Front, which the intensity of combat actions in the winter months was approximately the same in all years of the war.

This distribution of frostbite is characteristic of the entire Soviet Army. It indicates that frostbite prophylaxis improved more and more from year to year, since the meteorological conditions of the second and third years of the war were approximately the same.

The meteorological factors which contribute the most to the development of frostbite were produced in the northermost sections of the front, where severe frosts frequently were combined with sharp winds, as well as on the southermost sections of the front, where frequent thaws and seasons of bad roads alternated with frosts, which also amounted to significant figures. This also was represented in the frequency distribution of frostbites on various sections of the front (Fig. 68).

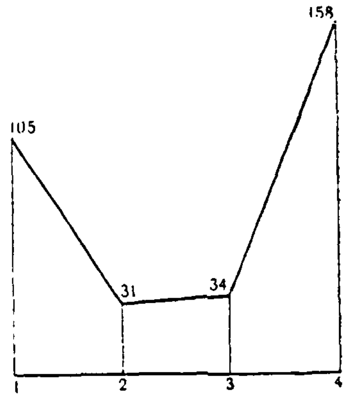

Fig. 68. Relationship of number of frostbites in different sections of front in coefficients of obviousness (second year of war): 1. northermost sections of front; 2. sections of front located in middle zone; 3. southermost sections of front.

Thus, it becomes clear that the basic, decisive factor which affected the frostbite rate was the combat activity of the troops.

The climatic and meteorological conditions were of secondary importance at the present state of preventive measures in the Soviet Army.

Frostbite Localization and Frequency

Different sections of the body can become frostbitten, but the peripheral parts of the body which are the most susceptible to cold are involved most often: limbs, nose, ears, etc. The blood supply conditions play a significant part here.

Statistical data indicate predominance of lesions of the lower limbs during various wars. According to Kirschner in wartime there are only two frostbitten upper limbs for 100 frostbitten lower limbs. K.N. Pikin (1941) observed 92.0% leg frostbites, P.N. Mazayev (1942) 90.0% and A.I. Kulikova 77.5%.

The cause of the relatively frequent involvement of the lower limbs becomes completely clear, if it is considered that the duration of exposure to cold plays a significant part in the pathogenesis of frostbite. In a combat situation, it is hard to dry or change soaked footwear and dry foot cloths, while it is considerably more practicable to take measures to warm the hands, even under conditions of forced immobility.

Besides, the lower limbs are continually in close contact with a cooling medium in the form of snow, ice and cold mud, while the remaining parts of the body are cooled primarily through the air.

Data on the different localizations of frostbite in peacetime are presented in Table 30.

Some authors do not take combined frostbite of the upper and lower into account (Brendi). It is difficult to suppose that there were no such cases among a considerable number of frostbites. The nonuniform method of distribution of frostbites by localization used by different authors evidently prevents exact determination of the ratio of upper and lower limb frostbites.

Table 30. Peacetime frostbite distribution by localization

Author	Number of cases	Frostbite localization in percent of number of observations				
		Lower limbs	Upper limbs	Upper and lower limbs	Face	Other localizations
Brendi	274	15.1	41.2	--	43.7	--
I.A. Bogoraz	77	53.2	42.9	--	--	1.3
I.A. Krivo-rotov	96	59.4	19.8	11.5	7.3	2.0
Fremmert	494	65.0	21.2	?	?	?
V. Zagoryan-skiy-Kisel'	531	65.2	25.8	4.5	3.4	0.1
Geracimenko	555	78.1	13.4	8.5	--	--

Table 31. Localization of frostbites recorded in a number of wars preceding World War II

Author	Number of observations	Frostbite localization in percent of number of observations			
		Lower limbs	Upper limbs	Upper and lower limbs	Face
Zuckerkandl	--	96.0	4.0	--	--
K.N. Pikin	100	92.0	8.0	--	--
A.I. Kulikova	273	77.5	22.5	--	--
Wittek	434	94.9	2.2	2.7	0.2
B.L. Kaz and A.F. Lukanov	--	82.6	16.8	--	0.6
P.S. Delevskiy	--	70.8	21.9	7.3	--
M.S. Ioffe	--	63.0	24.0	13.0	--

An attempt is made in Table 31 to compare some observations which take into account the method of distribution of frostbites by location used by the authors. The table includes data on the localization of frostbites recorded in a number of wars preceding World War II.

The first group includes data of authors who did not consider combined frostbite of the upper and lower limbs. Therefore, it can be considered that they made the distribution by localization on the basis accounting for the number of parts but not victims involved.

The second group includes data of authors who distributed frostbite by localization based on the number of patients.

A significant predominance of lower limb frostbites also was noted in the materials of individual authors for the World War II period.

P.N. Mazayev, after observing frostbite (1942), notes that 90.0% of the lesions occurred in the lower limbs, 4.75% in the upper and 5.25% combined frostbites.

In the army hospital of N-sk front, according to the data of S.A. Grubina (1941), 90.9% of the frostbites were observed in the lower limbs and 9.1% in the upper limbs. According to the data of V.I. Zharkova (1942), in the front hospital of the same front, 82.9% of the frostbites were of the lower limbs, 15.3% of the upper limbs and 1.8% combined and other localizations.

In the German Army on the Eastern Front in 1941-1942, lower limb frostbites also were predominant. According to Killian, they constituted 83.5% of all frostbite, 82.0% according to Koeler and 91.8% according to Frei (cited by Killian).

According to the data of F.G. Shkradyuk, all frostbites were distributed by localization in the following manner: 90.7% lower limbs; 6.2% upper limbs; 2.8% upper and lower limbs; 0.2% face; 0.1% other areas.

According to the fundamental characteristic chart data, 18.1% of all cases were single frostbites. This number did not include cases of simultaneous involvement of the big and other toes, since they were classified as multiple frostbites.

The distribution of all single, i.e., involving one area (hand, foot, etc.), frostbites by localization is presented in Table 32, from which it is evident that more than half of all cases were frostbite of the big toe.

The fingers are in second place. The total of the fingers and toes is 82.87%, i.e., the main bulk of lesions, frostbite of the lower limbs make up 75.04% and the upper, 22.26%. If cases of simultaneous involvement of the big and other toes of one foot are added to this, the total number of single frostbites in accordance with the material of the fundamental characteristics chart, increases to 32.6% of the number of observations, and isolated involvement of the big toe with frostbite, combined with the other toes of the same foot, amount to 72.3% of the total of all single frostbites.

In this case, the relationships of single frostbites are as follows: 85.4% lower limb; 13.0% upper limb; 0.4% face; 1.2% other parts of the body. It must be noted that other parts include frostbite of unusual localization, of which a considerable number occurred on the limbs.

Side of Frostbite

Significant prevalence of any side is not noted in the fundamental characteristics chart material. The poorer venous drainage conditions from the left lower limb, which was pointed out by a number of authors, is not reflected in the distribution of frostbites by side involved. Left side frostbite was noted in 50.2% and right side, in 49.8%.

Two Sidedness of Frostbites

Since frostbites are caused by those conditions of the combat situationsin which individual soldiers and small units find themselves because of performance of combat missions, which sometimes last a considerable time, bilateral lesions from the cold are rarely found.

P.S. Delevskiy (1941) noted bilateral frostbite in 14.0%, B.L. Kaz and A.F. Lukanov (1940) in 71.0%. According to the data of M.S. Ioffe (1941), bilateral frostbite of the feet was observed in 33.0% and the same in frostbite of the hands, in 9.0%. On one northern front during World War II in 1941-1942, 59.0% bilateral frostbites were noted. According to the materials of F.G. Shkradyuk, 53.0% of such frostbites are of the lower limbs and 50.9% of the upper. According to the fundamental characteristics chart data, 67.9% of the frostbites were observed in the lower limbs and 48.3% in the upper.

In the German Army on the Eastern Front, bilateral frostbites were found extremely often. Frei noted bilateral involvement of the limbs in 63.7% of 900 cases of frostbite. Almost 90.0% were frostbite of the feet and toes in this case. Partsch observed 55.0% bilateral frostbites (according to Killian). Killian in the 901st German Field Infirmary saw 28.7% bilateral frostbite of the feet.

The explanation of the frequency of bilateral frostbites, especially of the lower limbs, is that both limbs were under approximately equal cooling conditions in the overwhelming majority of cases, and the duration of exposure of the latter was the same for both limbs.

Frostbites of four limbs are the most serious lesions. According to the data of various authors, their frequency varied within quite broad limits. S.A. Grubina observed 1.4% frostbite of four limbs, N.A. Bogoraz (1940) 2.6%, M.S. Ioffe (1942) 4.0% and P.S. Delevskiy (1942) as much as 7.3%. Study of the fundamental characteristics chart showed that 2.8% of such frostbites were found. Of these lesions, 16.0% were IV degree frostbite on all limbs.

Multiple lesions frequently are caused by the combat conditions in which individual soldiers and units find themselves because of the combat situation. According to the fundamental characteristics chart data, the number of areas frostbitten is an average of 2.63 per man (Fig. 69).

Eighteen point one percent(of the number of all observations) frostbite was suffered by one section, 33.0% two sections, 13.8% three, 27.0% four, 3.6% five, 2.5% six and 1.0% seven; the number of sections was not calculated in 1.0% of the frostbites.

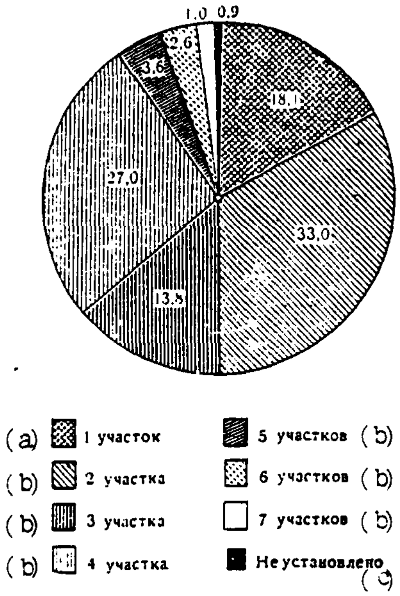

Fig. 69. Frostbite distribution by number of areas involved (in percent of total).
Key: (a) Area; (b) Areas; (c) Not determined.

Table 32. Frequency of single and multiple frostbites by localization (in percent)

Frostbite localization	Single frostbites	Multiple frostbites
Big toe	54.28	42.4
Other toes	6.83	37.5
Front section of foot	8.57	4.4
Heel region	2.75	3.7
Entire foot	2.34	2.7
Entire foot and shank	0.27	0.5
Fingers	21.76	7.1
Hand	0.50	0.35
Face	0.69	0.34
Sex organs	0.23	0.01
Other parts of body	1.78	1.0
Total	100.0	100.0

The relative frequency of different frostbite localization is represented in Table 32.

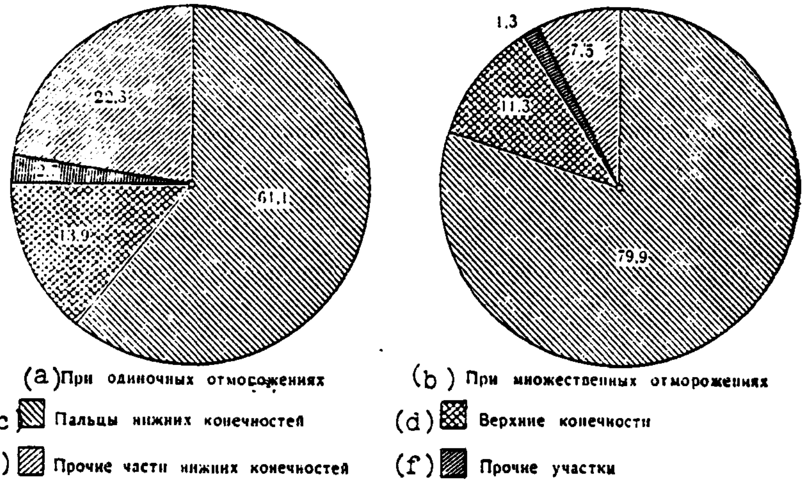

Fig. 70. Frostbite distribution by localization in single and multiple lesions (in percent of total). Key: (a) With single frostbites; (b) With multiple frostbites; (c) Toes; (d) Upper limbs; (e) Other parts of lower limbs; (f) Other areas.

The data summarized in Table 32 are presented in graphic form in Fig. 70.

The relative frequency of lesions of the fingers and toes is very significant with respect to other parts of the same limbs. The following figues were obtained in comparison of the fundamental characteristics chart data and the data of F.G. Shkradyuk (Table 33).

Table 33. Frequency of finger and toe frostbites with respect to number of all limb frostbites

Frostbite localization	Fundamental characteristics chart data	F.G. Shkradyuk data
Percent finger frostbites of number of all upper limb frostbites	95.5	91.6
Percent of toe frostbites of number of all lower limb frostbites	87.7	73.6

According to Table 32, approximately 1.0% of the frostbites are of the face. However, this percentage does not express the actual frequency of involvement of the face, floor of the auricle and nose.

Despite the fact that blood supply of the skin of the face is considerably better than that of the skin of the limbs and that heat regulation of these regions is more thorough, the actual frequency of frostbites of individual areas of the face is quite high. It must be stated that frostbites of the face occupy a more significant place among ambulatory patients than among hospitalized patients. As a rule, these lesions undergo ambulatory treatment and, therefore, they are not included in reports.

Besides, it is known that frostbite of the face rarely reaches high degrees.

According to the fundamental characteristics chart data, single frostbites of the face constituted a little more than 0.5% of all frostbites. Among the single frostbites, two cases of frostbite of the ears were noted, which were accompanied by necrosis of the floor of the auricle (degree IV).

Study of case records showed that, with severe frostbite of the limbs and, the more so, with wounds, frostbite of the face escapes the attention of the treating physicians as the lightest lesion, and it frequently is not recorded in the case records at all. In many cases, the first record of frostbite of the face appears in the case records 2-3 weeks after the time of the frostbite. In this period, the lightest cases of frostbite of the face are healed and remain unrecorded in the case records.

In 1939-1940 at the hospital surgical clinic of the Military Medical Academy im. S. M. Kirov, of 100 cases of frostbite, there were 9 cases of frostbite of the face, including 5 cases combined with more severe frostbite and 4 cases of wounded.

Cases of necrosis of the nose (V.S. Gamov) and injury to the eyelids and cornea (A.I. Kravtsov, Carrol) based on frostbite are known.

Ye.Ye. Shimakovskaya observed a case of IV degree frostbite of the nose of a private who broke out of encirclement in a severe frost. Several days after the frostbite, the nose turned black and dropped off before the patient was admitted to the hospital. The same author presents a case of frostbite of the cornea of a soldier with severe frostbite of all limbs who died. The autopsy results confirmed frostbite of the cornea.

Severe frostbite of the ears and nose, accompanied by necrosis of the cartilage (IV degree frostbite), have been noted in clinical practice.

Frostbite of the sex organs of men is found quite rarely, and it does not exceed a few fractions of a percent. Isolated cases of frostbite of the penis and scrotum have been described by I.A. Krivorotov, N.I. Gerasimenko and a number of foreign authors.

During World War II, according to the data of F.G. Shkradyuk, only 0.02% frostbite of the sex organs was observed. According to the fundamental characteristics chart data, 0.2% isolated frostbite of the penis and multiple frostbites in the same percent of cases were found. Isolated third degree frostbite of the penis, accompanied by necrosis of the prepuce was noted in only one case. In the majority of cases, the circumstances under which frostbite occurred proved not to be precisely specified, with the exception of two cases of isolated frostbite due to wet clothing.

Frostbite of unusual localization. Various protruding areas are among sections of the body subject to frostbite, besides the distal sections of the limbs and face. For the most part, they correspond to the condyles of the bones, which are usually covered with a minor layer of soft tissues which become frostbitten, since they are easily subjected to pressure, which is reflected in their blood supply. Besides projecting areas located above condyles, soft tissues can be frostbitten, for example, the buttocks if, because of a prolonged fixed position, they are subjected to squeezing and bleeding, especially in contact with a cooling medium (snow, etc.).

Frostbite of projecting areas usually develops either in a fixed position, frequently due to wounding, or in prolonged creeping over snow, when snow is packed into the sleeves or beyond the boot tops. Several such cases were noted during the Finnish War. In this case, frostbite was localized in the following areas: outer malleolus of the ankle, condyle of the radius, inner condyle of the arm, in the regions of the costal arch, scapula, anterior superior iliac spine and sacrum, as well as on the buttocks.

The region of the kneecap is involved more often. In 300 frostbites, V.S. Gamov noted this localization in 11 cases, in which the frostbite was bilateral in 8 cases. These frostbites usually are associated with crawling on the knees. Ye.Ye. Shimakovskaya presents 3 cases of frostbite in the kneecap region in 900 frostbites.

As has been noted by many authors, in contrast to the big toe, the thumb suffers frostbite considerably less often than the remaining fingers. This is not explained by better blood supply of the thumb, but the possibility of its protection by other fingers as they flex.

Frostbite of the proximal interphalangeal joints of the hands occupy a special place. Upon squeezing the hands into a fist in order to warm the fingers, the ungual phalanges come into contact with the palms, but the region of the interphalangeal joints become most peripheral and, therefore, they undergo the greatest cooling. V.S. Gamov has described similar frostbites of up to III degree and associated necrosis of the joint capsule, with subsequent involvement of the articular joints of the phalanges in a purulent inflammatory process.

The so called sandal form of frostbite is frequently found which, due to wetting of the footwear, involves the sole of the foot (Fig. 71). The surface of such frostbites can vary from 1-2 cm in diameter to extensive sections of 10-12 cm or more in extent.

Fig. 71. Sandal III degree frostbite; preparation VMM [Military Medical Academy] No. 1327/1355; artist Ye.V. Tymnyak.

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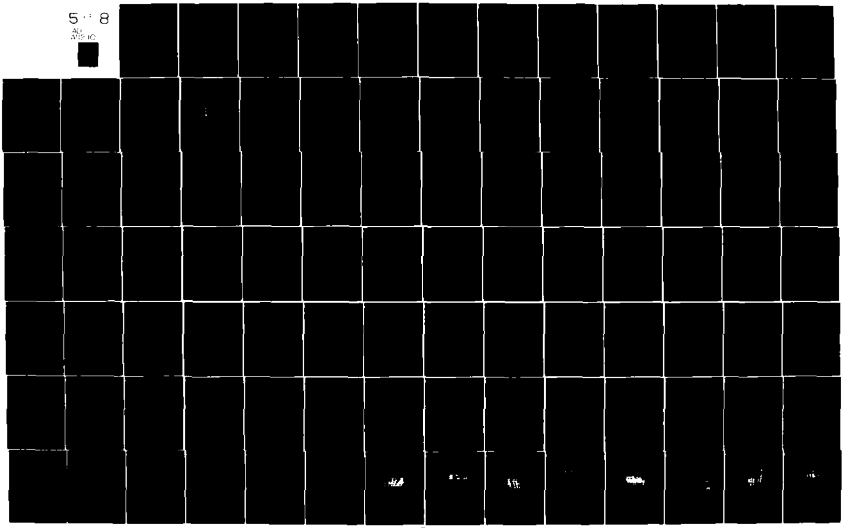

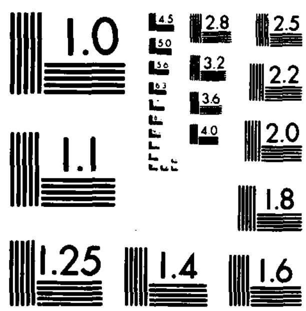

MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

The depth of tissue necrosis is considerably less than the area of the lesion, and it rarely reaches 1 cm. As a rule, it is limited to involvement of the soft tissues. In isolated cases, the underlying bone obviously can be involved, i.e., IV degree frostbite can develop. However, such frostbites have not been observed, with the exception of the heel region, where IV degree frostbite is frequent.

According to the fundamental characteristics chart data, frostbites of unusualy localizations have been observed primarily on the lower limbs, in 92.1% of such frostbites. Isolated portions of the foot are involved most often. Frostbites on the upper surface of the foot constitute more than 1/5 of all unusual localizations. The soles and sides of the feet are frostbitten equally often. These frostbites together constituted nearly 1/3 of the frostbites of unusual localizations. Frostbites of the medial border of the foot were found one third as often as those on the lateral surfaces. In this case, the natural arch of the foot was never impaired. Of the projecting bone condyles, the region of the malleolii was frostbitten most often. Their involvement was noted in 6.7% of all frostbites of unusual localizations. Frostbite of the kneecap region was found just as often as that of the malleolii. Other projecting parts of the body were frostbitten only in exceptionally cases, for a total of 5.0-6.0%. Frostbite in the region of the elbow joint (outer condyle of the brachium), wrist joint, above the greater trochanter and in the region of the heads of metacarpals I and V. In one case, frostbite occurred in the region of the greatest bulge of a deviated big toe (hallux valgus). This happened in May 1945 to a soldier who wore wet but not tight footwear for a long time.

Isolated areas of frostbite were noted on the shanks, thighs and forearms. Frostbite on the shanks constituted 10.0% of all frostbites of unusual localization. They were located predominantly along the crest of the tibia. Seven point five percent of the frostbites were noted on the thigh, buttocks and forearm. In one case, frostbite of the buttocks covered an extensive surface 10x15 cm in size, and it was combined with other severe frostbites of the lower limbs.

Isolated frostbites of the heel region were not found so rarely as might be concluded from data in the literature. According to Ye. Ye. Shimakovskaya, this localization was noted in 1.0% of the cases. According to the fundamental characteristics chart data, 2.75% of all single frostbites were frostbites of the heel region.

Frostbite of the heel combined with frostbite of the toes or anterior section of the foot were found considerably more often.

O.A. Levin noted special conditions of compression of the heel and deterioration of blood circulation in this region in patients lying in bed. With insufficiently careful primary examination, if a slight degree of frostbite of the heel region remains unrecognized, lesions can develop subsequently for the same reason that bedsores occur on the heels of the seriously ill.

According to the data of Killian, in the 901st German Field Infirmary in 1941-1942, 9.8% of all frostbites were frostbites of the heel region combined with other frostbites.

Frostbite Distribution by Degree

The severity of frostbites is determined by the degree of injury, its extent and the nature of the clinical course. Other features (general condition of the patient, presence of a wound or disease) also affect the severity of frostbite.

The nature of the clinical course usually is associated with the form of gangrene, in which moist gangrene always aggravates the course. To a certain extent, the size of the frostbitten sections, especially with moist gangrene, predetermines the course. If necrosis extends above the ankle joint, the severity of the lesion increases sharply.

The severity of frostbite is considered here mainly in connection with its degree. Other circumstances which aggravates the process will be discussed in the corresponding sections.

There is a basis for thinking that degree I frostbite should make up the absolute majority of all frostbites. However, degree I frostbite occupies an extremely insignificant place in the wartime statistics. A portion of the victims do not apply for medical aid at all, because of the insignificance of the anatomical injuries and functional disorders.

In peacetime, degree I frostbite constitutes a considerable number even among inpatients. In the materials of the Petersburg Hospital for the period from 1884 to 1895, V. Zagoryanskiy-Kisel' noted 83.5% degree I frostbite. In 1933-1934, Brendi found 33.0% light frostbites in 388 cases of frostbite in New York, which did not entail loss of capacity for work. The majority of them evidently should be classified as degree I.

The number of light frostbites is extremely significant. At a conference of the sanitary services of the allies in 1918, it was noted that there were 70.0-80.0% light, 13.0-20.0% moderately severe and 2.6% severe frostbites.

It did not appear possible to establish the actual ratio of frostbites of all degrees during World War II among hospitalized patients with frostbites, i.e., that portion of them who were inc[illegible] in the combat loss statistics.

The division of frostbite into four degrees still was not widespread in the first year of the war. The medical bookkeeping forms did not provide for separation of degree IV frostbite. Therefore, even in those cases when these frostbites were diagnosed, there were mechanically classified as degree III.

The main obstacle to accurate accounting for frostbites by degree, however, is that the degree of injury is not revealed at once, but frequently only during the next 3-6 days. Because of the brief stay of such patients within stages, a smaller number of degree III and IV frostbites than actually occurred are included in the reports, since diagnosis of these frostbites can only be established after several days in the majority of cases. The victims usually are evacuated to subsequent stages in this time, where the degree of frostbite and the relative increase in number of frostbites of higher degrees are established corresponding to the clinical picture. Besides, some portion of patients with degree I and II frostbites were held until recovery in DMP [division aid station] and in mobile surgical hospitals, which also changes the ratio of the degrees of frostbite in more distant stages.

Data presented by Ye.M. Salkindson indicate how difficult it is to diagnose the degree of frostbite in the forward stages. In a front hospital upon primary examination of 61 patients with degree IV frostbite, degree I frostbite was established for two, degree II for 20 and degree III for 17. Only 4 patients were immediately found to have degree IV frostbite.

V.I. Zharkov presents similar information on degree IV frostbite observed in a front hospital of the Karelian Front. At aid stations and in medical battalions, 8.5% degree IV frostbite was established, 17.5% in mobile surgical hospitals, and 44.6% were diagnosed only in the army field hospitals. It should be noted that there were specialized sections for frostbite treatment in the army field hospitals on this front. On other fronts, degree IV frostbite was basically found only in the front area.

The ratio of the degrees of frostbite by medical evacuation stages on different fronts in different years of the war are represented in the diagram presented. The number of frostbites observed in each stage was assumed to be 100 (Fig. 72).

Comparison of the front report materials with data obtained by special study of frostbite permitted the following conclusions to be reached:

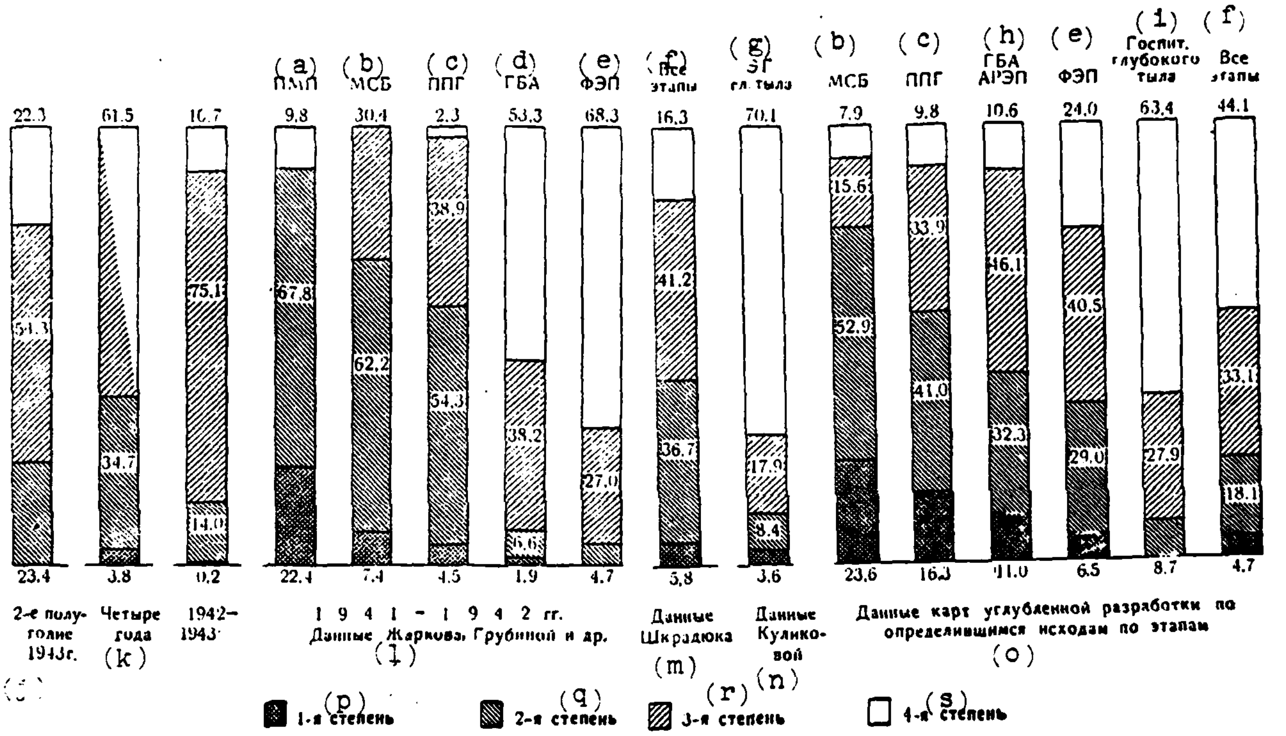

Fig. 72. Frostbite distribution by degree at various evacuation stages in percent of total).

Key: (a) Aid station; (b) medical battalion; (c) mobile field hospital; (d) Army base hospital; (e) frontline evacuation station; (f) all stages; (g) main rear EG [evacuation hospital]; (h) Army base hospital, AREP [evacuation station motorized company]; (i) deep rear hospitals; (j) second half 1943; (k) four years; (l) 1941-1942, data of Zharkov, Grubina, et al; (m) Shkradyuk data; (n) Kulikova data; (o) data of fundamental chart study to determine outcomes by state; (p) 1st degree; (q) 2nd degree; (r) 3rd degree; (s) 4th degree.

1. the change in ratio of the degrees of frostbite occur due to a relative increase in III and IV degree lesions in different medical evacuation stages from the front to the rear;

2. in a specially conducted study, the relative number of III and IV degree frostbites at the corresponding stages proves to be considerably greater than indicated in the medical reports.

In the second group of the graph,(Fig. 72), fundamental characteristics chart data also are presented, which were obtained both by breaking down all frostbites studied by degrees and by compilation of the definitive outcomes at different stages.

Wounding and Frostbite

There are no sufficiently reliable data in the literature which characterize the frostbite rate with wounding. The individual observations of the authors are based on random material, and they do not give an idea of the frequency of wounds combined with frostbite.

The data of the pathological anatomists cannot be considered to represent the rate of frostbites of the wounded, since they concern the severely wounded who died in various evacuation stages. For example, Killian notes that, according to 1941-1942 data of pathological anatomists, 1/3 of those who died of wounds on the Eastern Front had frostbite.

Approximately 1.0% of injuries were accompanied by frostbite; it increased to 2.0-3.0% during severe frosts and stubborn battles, as occurred during the Finnish War in February-March 1940. However, in the forward stages of the medical service, including division aid stations where only the basic data are recorded in the medical documents, frostbite of the wounded frequently was not considered. As a rule, the case records in the front area and deep rear hospitals were kept with proper completeness, but light frostbites were already healed by this time.

Therefore, only the most severe frostbites accompanying wounds were represented in the statistical reports, which reduces the total percent of frostbites of the wounded.

According to front report materials, the percent of frostbite combined with wounds to the number of combat losses in World War II were extremely insignificant and, by the last year of the war, they decreased more than tenfold from those of the first two years.

However, if the percent wounded among those with frostbites, i.e., the number of frostbites combined with wounds, is taken into account, these figures constitute a significant quantity.

In materials on the Finnish War, B.L. Kaz and A.F. Lukanov established the combination of wounds with frostbites at 6.5%, M.S. Ioffe at 7.5% and P.N. Mazayev at 10.5%. According to the data of P.S. Delevskiy (19.5) and A.I. Kulikova (22.0), the percent of wounds combined with frostbites is still larger.

In connection with the above mentioned reasons, the percent of wounds combined with frostbites in medical institution reports in World War II was somewhat less than actual. According to report data, for years of the war on one front, this percent was 10.0.

Fig. 73. Frequency of frostbites combined with wounds vs. total number of frostbites (in percent) by year of war.
Key: (a) Year of war.

Data on frostbites combined with wounds as a percent of the total number of frostbites are presented in Fig. 73.

In individual armies, these variations were highly significant. They depended on the tactical situation and, in particular, on the intensity of actions.

In one front during the same period, the number of wounds combined with frostbites with respect to the total number of frostbites in army A was 3.1% but, in army B, 32.0%.

In the material of F.G. Shkradyuk, 14.1% of the wounds were combined with frostbites. According to the fundamental characteristics chart data, this percent is considerably lower at 4.8. The explanation of this is that the case records were studied, and the basic diagnosis in them was frostbite. Frostbites combined with wounds were not included in this figure.

Among the recorded frostbites combined with wounds, frostbite was observed in 32.2% of the wounded limbs.

Freezing

Cases of freezing and general chilling are counted as cold trauma. The main bulk of them are local lesions or frostbite proper. Some idea of the relationships of these losses can be obtained by familiarization with the data on the number of dead from the effects of cold presented below.

Among the tremendous losses of the Napoleonic Army in 1812, the number dead of cold was extremely impressive but, unfortunately, we do not know what percent were cases of freezing. Idelson, for example, reports that Dr. Roussy saw 300 frozen soldiers in a pile of the dead at Smolensk. The large number of dead on the retreat roads is mentioned in other descriptions, but no figures are given.

During the Crimean War in 1854-1855, of 5,215 in the French Army who were frostbitten, 1,178 or 22.7% died (Sonnenburg and Tschmarke).

In the English Army in this same war, of 1,914 cases of frostbite, 457 or 23.8% died (N.I. Pirogov). According to Sonnenburg and Tschmarke, there were 2,898 cases of frostbite in the entire campaign, and 463 or 16.0% died.

It is clear that not all lethal cases can be attributed to freezing, but there is no doubt that a considerable number who died of freezing are included among the number dead.

In December 1877, during the march through the Balkans, 69 cases of freezing were recorded in the Russian Army, which is 15.0% of the number who died of accidents (L.S. Kaminskiy and S.A. Novosel'skiy), or nearly 1.3% of the number of recorded cases of frostbite.

In 1887, in the column of Gen. Gurko, 813 men were lost due to frostbite in two days, and 53 men (6.1%) froze completely (P. Abramov).

In the Russian Army during the Russo-Japanese War of 1904-1905, 15 cases of freezing were noted (L.S. Kaminskiy and S.A. Novosel'skiy), which is 1.0% of the number of recorded frostbites.

Tremendous losses suffered by the Turkish Army in the Sarakamysh operation in December 1914 are known. The 9th Turkish Corps lost up to half of its personnel, primarily because of freezing and frostbite. More than 10,000 frozen in one night were recorded in the 10th Corps.

In areas with a relatively warm climate, cases of general freezing also are noted. In December 1937 at Teruel, there were 5 cases of freezing in 500 cases of frostbite in the Spanish Republican Army, which is 1.0% (Ducuing, D'Harcourt et al).

During the battles for Moscow in 1941, as well as during our attack at the beginning of December 1941, it was found that the number of both wounded and unwounded Germans who died of freezing was extremely high. Collection of the bodies of frozen Germans along the entire route of attack of our troops continued right up until the snow melted. There was a particularly large number of bodies in the woods in the direction of Mozhaysk. There were no prophylactic measures by the German command for protection of the German Army troops from cold. Therefore, the destroyed and disorganized retreating groups lost communication and died of cold.

Isolated indications of death for this reason are found in medical institution reports, but these figures are not a hundredth of a percent of the total number of losses due to frostbite in particular.

Cases of freezing which ended in recovery remain unreported.

Freezing should be understood to be that pathological condition which is due to a progressive decrease in body temperature as a result of the chilling effect of the external medium, when the protective heat regulating capabilities of the body can prove to be insufficient. In a number of cases, the body succeeds in coping with heat regulation disorders, and body temperature increases to limits which depend on the possibility of performance of vital functions. However, these cases with a favorable outcome usually are wrongly classified as shock or intoxication, and they are not considered freezing.

CHAPTER III

ETIOLOGY AND PATHOGENESIS OF FROSTBITE

The most widespread form of peacetime frostbite, which is encountered extremely often in war, is frostbite which develops as a result of dry frost, i.e., at temperatures below 0°. Frostbite which develops at temperatures above zero, the so called "trench foot," also is significantly common among troops in combat activity. A third form of frostbite develops upon contact of bare skin with chilled metal objects and, finally, the fourth, chilblains, is mainly a chronic form of frostbite. The latter develops extremely often as a result of brief exposure to cold and, as a rule, with predisposition to the pathological condition described.

There also are rare forms of frostbite with an unusual pathogenesis, which are not discussed here.

Frostbites which develop upon exposure to dry frost are the overwhelming majority of peacetime frostbites. In wartime, they frequently are observed in pilots. These frostbites are localized almost exclusively on the most peripheral sections of the body (ears, nose, superciliary arch, finger and toe tips). In the majority of cases, the process is limited to soft tissues. If bone is involved, it is mainly the ungual phalanges. Recent studies have not answered the question of what temperature is generated in the tissues in frostbites of this type. The constantly observed blanching of the skin in such cases evidently was the basis for the hypothesis that the tissue fluid freezes in frostbite of this form and, thus, the tissue temperature drops below zero. It is to the point to state that this point of view, which is not confirmed by experimental or clinical observations, has a number of objections. The principal ones are the following.

1. Freezing of tissue fluid can occur only as a result of complete stopping of the biological processes in the tissues, in particular, with the complete cessation of blood circulation, innervation, cell metabolism, i.e., in those severe cases when the tissue is no longer a biological, but becomes a physical object of the effect of cold. Natural heat regulation is excluded in these cases. Nevertheless, the physical properties of skin and subcutaneous tissue (their poor heat conductivity) are an obstacle to the penetration of cold into the tissues.

2. The abundant capillaries in the tissue structure and the high mineral salt content of the tissue fluids are the cause of a reduction of freezing temperature of the tissues of warm blooded animals by at least -5 to -10°. Thus, tissue freezing occurs only in a hard frost.

3. A long period is required to damage tissues as a result of freezing of tissue fluids, since brief freezing does not cause cell death. It is known that the skin of man does not necrotize in brief freezing by means of ethyl chloride, that despite freezing of a frog heart a heartbeat appears after thawing, that the conductivity of nerves which are subjected to freezing for a short time recovers after thawing, etc.

4. As experimental data have shown, disorders of metabolism,

circulation and cell nutrition begin at tissue temperatures very much above zero.

If it is considered that a decrease in tissue temperature occurs very slowly and is accompanied by biological "resistance" of the tissues, the hypothesis can be expressed that serious pathological processes and death of cells occur before freezing and, thus, tissue which is already dead is subjected to freezing. In any case, it is valid for an intact organism, since the death of warm blooded animals occurs at body temperatures of +22° or +23°, and a corpse undergoes freezing.

In any case, freezing deep in tissues is scarcely significant, since statistical studies show that frostbite as a result of dry frost is nearly always superficial.

Trench foot is frostbite which develops at above zero temperatures. There is no doubt that the tissue temperature in this frostbite does not decrease below the freezing point of tissue fluid, since the outside temperature at which trench foot is particularly common always is above zero. A required condition of the development of trench foot is dampness, when the air temperature excludes freezing of not only tissue fluid, but atmospheric precipitation. Experimental studies (laboratory directed by Prof. G.L. Frenkel) have shown that the complete cessation of blood circulation in tissues occurs at +10° tissue temperature, and significant disorder of it is observed at +19°. If one of the basic assumptions of theoretical medicine is taken into account, namely that a circulatory disorder results in necrosis and tissue degeneration, many aspects of the mechanism of development of trench foot under conditions which exclude freezing become clear. The actual tissue temperature in trench foot, its variation and the principal mean times in which a different subnormally low tissue temperature results in pathological symptoms can be explained.

The conditions for the production of trench foot are not only the constant exposure to a moderately low temperature (wet cold), but during frosts when, in attempts to heat the feet, the footwear gets wet and a more or less prolonged exposure to wet cold begins. Under winter combat conditions, there frequently is no possibility of properly warming the feet and drying the footwear and, thus, exposure to dry frost and wet cold alternates. The latter, although it causes a smaller tissue temperature decrease, contributes to the deep penetration of cold and increases the heat conductivity of the skin. It must be thought that this alternation of conditions contributed to severe penetrating frostbite in dry frosty weather.

As a rule, the pure form of trench foot develops in static warfare in the fall and spring. However, varieties of it are possible in dry frost and during mobile warfare, during patrols in particular, and during combat actions on the ice of lakes and rivers. The feet and exposed parts of the body are not frostbitten at above zero outside temperatures as a rule.

Frostbite as a result of exposure to a critically low temperature is possible, but the corresponding critical low temperature for animal protein has not been exactly determined. It is known that protein does not coagulate even when it freezes. The freezing of some protozoa, as well as brief freezing of human and animal skin is not fatal. Nevertheless however, there is a low temperature which causes instant death of cell elements. As observations show, this temperature is 45 to 50° below zero. However, a necessary condition is establishment of this temperature inside and not outside of the tissue, and its conductor usually is highly chilled metal objects. The pathological processes which develop in tissues in this type of frostbite are reduced to necrosis and reactive inflammation after a "latent" period.

Chilblains is a pathological condition which indisputably is associated with the effect of cold. In a number of cases, chilblains occur even with a negligible decrease in temperature. Therefore, the describable clinical syndrome has been explained and is explained by various causes which assign a secondary role to cold. However, since the most diverse forms of dermatosis which can be associated with the term "chilblains" never develop without a decrease in the ambient temperature, it must be considered that chilblains, like frostbite, is a type of injury caused by cold. Chilblains most often are either the first stage of a more serious frostbite or an aftereffect of frostbite already suffered. However, an apparent primary chronic chilblain is possible.

The basic clinical signs of all forms of chilblains are edema, cyanosis and diverse paresthesias.

There is no doubt that a chilblain is a pathlogical reaction, which develops due to weakening of natural heat regulation. People who have suffered frostbites develop chilblains most often. If it is considered that, at a +19° tissue temperature, their vital activities are abrubtly disrupted, the tissue disorders which develop even with very little cold become clear. By contrast, with normal heat regulation, as is known, a man is capable of tolerating very hard frosts.

Chilblains like trench foot do not only occur in frost, but on cold, damp spring and fall days as well. Like frostbite, which develops due to exposure to dry frost and as a result of exposure to the critical low temperature, chilblains are localized on any part of the body. However, they are primarily on the feet, hands, face and ears.

Tables 34 and 35 as well as a graph (Fig. 74) characterize the relationship between low temperature exposure time and the onset of frostbites of various degrees. Fundamental characteristics chart data are summarized in them. Chilblains are not considered, because of the easy clinical course, which is reflected in combat readiness to a negligible extent.

It follows from Table 34 that various forms of pathogenesis are found at different times in degree IV frostbite. Thus, frostbites as a result of exposure to the critical temperature develops in a day in 100.0% of the cases, 57.5% of frostbites due to dry frost and only 32.7% of all cases of trench foot develop in this time. If the time for development of the syndrome is not a day but the first 6 hours, the proportions will be 75.0%-17.5%-8.5%. A detailed analysis of Table 34 demonstrates the same regularity of degree, which is directly proportional to time. Thus, 67.3% of the cases of trench foot developed in from one to ten days or more. Frostbites which developed at the critical temperature in this time are not recorded at all, and it develops in 42.5% of all cases upon exposure to dry frost.

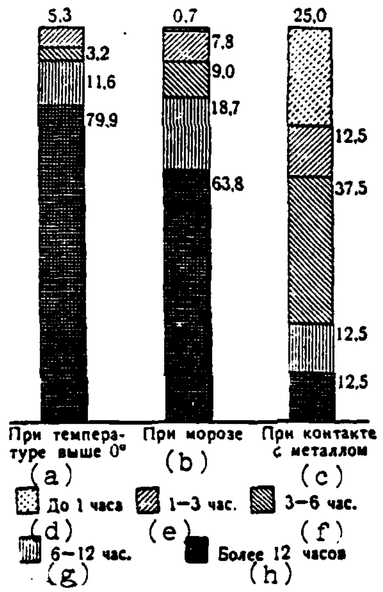

Fig. 74. Distribution of frostbites resulting from various conditions vs. duration of chilling.
Key: (a) At above zero degree temperature; (b) In frost; (c) In contact with metal; (d) Up to 1 hour; (e) 1-3 hours; (f) 3-6 hours; (g) 6-12 hours; (h) More than 12 hours.

Upon exposure to dry frost, 57.5% of all degree IV frostbites develop during one day, while only 42.5% occur in the remaining periods. In this case, the number of degree IV frostbites which develop due to dry frost progressively decreases with the passage of time.

Thus, in the first 12 hours after exposure to cold, 36.2% of all cases occur and only 18.6% in 5 to 10 days or more.

Table 34. Relationship between low temperature exposure time and onset of degree IV frostbite in wet and dry cold

(a) Продолжительность действия холода	(b) Всего при температуре выше 0°				(c) Всего при морозе				(d) Всего при контакте с металлом			
	(e) процент отморожений											
(f) До 1 часа	—				0,7				25,0			
(g) От 1 до 3 часов	5,3	8,5	20,1		7.8	17.5	36,2		12,5	75,0	[illegible] ~~67,5~~	100,0
» 4 » 6 »	3.2			32,7	9.0			57,5	37,5			
(h) До 12 часов	11,6				18.7				12.5			
(i) » 1 суток	12.6				21.3				12,5			
» 2 »	9.5				14.2				—			
» 3 »	12,6				9.7				—			
» 5 »	13,7			67,3	8.3			42,5	—			
» 10 »	18.9				4,7				—			
(j) Более 10 суток	12,6				5.6				—			
(k) Всего	100,0				100,0				100,0			

Key: (a) Cold exposure duration; (b) Total at above 0° temperature; (c) Total in frost; (d) Total in contact with metal; (e) Percent of frostbites; (f) Up to 1 hour; (g) From 1 to 3 hours; (h) Up to 12 hours; (i) Up to 1 day; (j) More than 10 days; (k) Total.

Table 35. Relationship between low temperature exposure time and onset of degree I-II-III frostbite in moist and dry cold

(a) Продолжительность действия холода	(b) Всего при температуре выше 0°				(c) Всего при морозе			
	(d) процент отморожений							
(e) До 1 часа	—				0,6			
(f) От 1 до 3 часов	5,9	11,8			6,0	15,6		
» 4 » 6 »	5,9		17,7		9,0		34,6	
» 7 » 12 »	5,9			32,15	19,0			53,6
(g) 13—24 часа	14,45				19,0			
(h) 1—2 суток	20,8				14,0			
2—3 »	5,9				13,0			
4—5 »	5,9			67,25	8,0			47,4
6—10 »	14,45				6,4			
(i) Более 10 »	20,3				6,0			
(j) Всего	100,0				100,0			

Key: (a) Cold exposure duration; (b) Total at above 0° temperature; (c) Total in frost; (d) Percent of frostbites; (e) Up to 1 hour; (f) From 1 to 3 hours; (g) 13-24 hours; (h) 1-2 days; (i) More than 10 days; (j) Total.

The same regularities are still more clearly seen from analysis of Table 35 for degree I, II and III frostbites which develop from exposure to dry frost and wet cold.

Thus, 53.6% of frostbites due to dry frost develop in up to one day and 32.15% at below zero temperatures. By contrast, a total of 47.4% of frostbites due to dry frost and 67.85% of trench foot develop in one to ten days.

Thus, World War II experience confirmed the existence of different forms of pathogenesis of frostbite and the presence of regularities between the time of development of the clinical syndrome and the time from the beginning of exposure to cold.

The effect of the time factor is very important, if not decisive. Figure 74 demonstrates this quite clearly. The explanation of the decisive effect of this factor is that low in distinction from high temperature usually does not cause pathological changes instantaneously, but as a result of prolonged exposure, and they are the greater the longer this exposure.

Theory of Frostbite Pathogenesis; Disseminated Necrosis

The opinion that frostbite develops upon cooling tissues to a below zero temperature as a result of their freezing or congealing was widespread until recently. However, a number of studies of both Soviet and foreign authors have proved that, although the frozen state of tissues can be achieved experimentally (S.T. Pavlov and K.K. Smirnov), it is almost never found in practice. Therefore, it does not play a part in the pathogenesis of frostbite. T.Ya. Ar'yev and then S.T. Pavlov and K.K. Smirnov have shown that very limited superficial sections freeze upon freezing rabbit ears in a special chamber. In this case, frostbite symptoms occur only in those cases when the duration of the cold exposure reaches several hours. Brief freezing as also is known from clinical practice (freezing with ethyl chloride) does not cause frostbite.

On the other hand, in the tests of K.A. Milner et al, it was noted that such pronounced hypothermia of the entire body frequently occurs in mass freezing of peripheral sections of limbs that the animals die with symptoms of heat regulation disorders.

Numerous experimental studies demonstrate beyond doubt that frostbite can develop with a decrease in tissue temperature to a point which does not freeze water. Frostbite was successfully obtained experimentally at ambient temperatures from +1° to +2° (Smith) or even +5° (Lewis).

F.S. Belitskaya determined that the tissue temperature deep in the affected limbs of people who received frostbites varies from +4° to +6° at the time the cold exposure ends (cited from G.L. Frenkel).

Experience in World War I in 1914-1918 confirmed the possibility of development of mass frostbite at an outside temperature above zero (the battles in Flanders in November 1914). However, until recently, the number of authors who considered the development of frostbite possible only at below zero temperatures was highly significant, especially abroad.

World War II experience again demonstrated the possibility of frostbite at above zero temperatures. Specific examples are presented in the section on factors which contribute to frostbite.

The present day progress in the field of study of the pathogenesis of frostbite achieved by Soviet scientists in the World War II years and after it permit the statement that pathoanatomical changes observed in frostbite are a consequence of profound, complex disturbance of the vital activity of tissues due to a decrease in tissue temperature. The direct damaging effect of low temperatures on body cells and tissues is not of foremost importance and, moreover, it is found extremely rarely.

In the frostbites usually observed, which constitute more than

99.3% of all cold lesions, the low temperatures which cause direct thermal damage to tissues do not have to occur. As a rule, exposure to only moderately low outside temperatures occurs. If the duration of this exposure is negligible, no pathological symptoms characteristic of frostbite usually do not develop.

Only when the cold exposure time is lengthened to several hours or sometimes days do those pathological processes arise which determine the clinical pattern of frostbite. All else being equal, the severity of the lesion proves to be directly proportional to the low temperature exposure time.

On the question of the mechanism of development of frostbite, until recently, foreign authors have expressed biased artificial views which do not satisfy the present level of knowledge. The foremost position among them is occupied by the theory of tissue death from freezing which, as was mentioned above, is devoid of any scientific value.

Just as unsatisfactory are opinions which reduce the essence of the process in frostbite to disruption of the colloid equilibrium of the tissues (Schade), primary inflammation of the vascular wall (Marchant), etc.

Precisely as unconvincing are the opinions of the majority of most recent foreign authors, who point out the leading role of the nervous system in frostbite and simply and mechanistically reduce it to disorders of vasomotor innervation, which cause the development of spasm and disruption of circulation. Consequently, they interpret frostbite as simple ischemic gangrene, and they completely fail to take into account the circumstance that the diversity and specificity of the processes in the clinical and pathoanatomical pattern of frostbite cannot be explained at all in such a simplified way.

The most significant position established on this question should be considered to be the secondary nature of the changes which develop in the body to stop the effect of cold. These changes cannot be evaluated as some stable pathological condition which suddenly replaces it, but they should be considered a process which begins in the body at the time of tissue cooling and which sometimes ends after a very substantial segment of time, which is measured in months or sometimes more.

"Latent" Period, Period of General and Local Tissue Hypothermia

A distinctive feature of the so called "latent" period of frostbite is that the extent and nature of the cold induced injury are determined only at the end of the exposure to the latter. During low tissue temperature exposure, the color of the skin of the extremities changes, but no normal signs of injury (necrosis, degeneration, etc.) are noted in this period. The life of a warm blooded animal as a whole is interrupted at a specific body temperature level, when the correlation of functions of the internal organs performed by the central nervous system becomes impossible. However, the normal signs of tissue and cell death (destruction of nucleus, clouding of the protoplasm) cannot be detected even microscopically. Micropreparations of frozen skin, if they are taken from an unthawed corpse, show no signs of tissue death.

The lack of pronounced external signs of death of chilled tissues gave rise to the term "latent period."

Nevertheless, signs of the "latent period" include extreme blanching of the skin, its cooling and loss of sensitivity.

It is completely obvious that injury and destruction of cells occurs in the "latent period," because the longer the "latent period" lasts, the more substantial the destruction detected in the period after warming. However, the essence and nature of these changes still have not been studied sufficiently.

However, since there is no doubt that the essence of frostbite is determined by the reduction in tissue temperatures which occurs in this period, it is more nearly correct to call this period the period of general and local tissue hypothermia.

The period of general and local tissue hypothermia is observed in all four forms of frostbite. However, it is most distinct in frostbite induced by dry frost.

The period of general and local tissue hypothermia usually is an extremely short period, but it is observed with all the characteristic signs in frostbites due to the effect of critically low temperatures.

This period is observed in trench foot and in chilblains, but the frequent change of tissue temperature characteristic of these conditions apparently obliterates the boundary of both phases of frostbite. With drop in temperature, the reactive inflammatory process fades or even stops, but the inflammation breaks out again with increase in tissue temperature. With a subsequent reduction in tissue temperature, all the processes, including the inflammatory and degenerative processes, apparently are recorded again. Thus, in the production of trench foot, the period of general and local tissue hypothermia and the period after tissue warming alternate. However, in this change, the external signs of the reactive inflammation do not reverse.

The symptoms of severe necrosis, degeneration are only found under constant heat conditions, when the tissue warming period occurs conclusively.

Fundamentally the same thing occurs in chilblains. However, since chilblains develop at incomparably higher tissue temperatures, its symptoms are not comparable in severity to the symptoms of trench foot.

The pathoanatomical changes and functional disorders found in the second, so called period after tissue warming are distinguished by extreme diversity, both in the sense of the topography of the lesions and in the essence of the processes observed here. Different tissue resistance to harmful effects, including the effect of cold, the non-uniformity of tissue chilling dependent on their heat conductivity and depth cannot completely explain the topography of the pathological changes. A characteristice of these changes is their disseminated nature. This means that either completely undamaged or insignificantly changed tissues are found in the chilled sections, together with degeneratively and necrotically changed tissues. The theory of disseminated necrosis (S.S. Girgolav) which emphasizes this has been confirmed in a whole series of observations. In histological studies of tissues 10-12 days after frostbite, N.I. Gol'dshteyn found small arteries with open lumens together with completely thrombosed arteries in the demarcation zone. Foci of necrosis were found in the veins. Small foci of necrosis and degeneration in muscles and connective tissue were noted in the zone above the demarcation. Similar data were obtained in histological study of tissues by I.A. Moldovanov, T.Ya. Ar'yev, V.S. Gamov, V.A. Militsin and N.F. Lyudvinskaya, as well as by D.G. Rokhlin in an X-ray study. Leriche, Kunlin, V.S. Gamov and others observed isolated sections of arteries which retained a distinct pulsation in a zone of continuous necrosis.

Areas of disseminated necrosis vary in size from micronecroses, identified only in histological preparations, to large foci, seen in an X-ray photograph and during surgical treatment for degree IV frostbite. It should be kept in mind that various transitional forms are possible in the foci scattered in the tissues of the region of the lesion, from the initial stage of tissue degeneration to necrosis. The type of tissue, topographic characteristics of the foci of necrosis, the time factor and other circumstances which determine the course of the frostbite are of importance here.

In summarizing the results of the individual histological studies carried out in different frostbite zones, a quite distinct picture can be obtained. In the most peripheral sections which underwent necrosis, no viable tissues are found. Closer to the demarcation line, but still in the necrosis zone, individual large or small size sections of tissue are found in a state of degeneration and, in the immediate vicinity of the demarcation line, patches of living tissue are found quite often. In the band of the demarcation zone formed, together with necrotic tissues, there are tissues which are in a state of degeneration, as well as isolated particles of outwardly unchanged tissue.

However, everything described characterizes only the morphological signs of advanced changes in damaged tissues, and it does not represent those functional changes in them which precede and cause these morphological changes.

In exactly the same way, based on these morphological changes, the real mechanisms of their development are not found. They are associated with damage to the body as a whole in frostbite, and they consist of both mediated effects on the tissues through the central nervous system and the opposite effects of processes which develop in the frostbitten area on the body as a whole.

It should be remembered that the effect of cold on the body always is general and local. In some cases, the general symptoms prevail (freezing). In other cases, they retreat into the background and are frequently overlooked (frostbite).

In the necrobiosis zone located proximal to the demarcation strip, the number of cell elements without visible changes increases with distance from the demarcation strip, and the number of individual necrotic and degenerated areas decreases and become smaller and smaller, sometimes microscopic.

The vessels and nerves also undergo focal necrotic changes. Their damage can spread both peripherally and centrally. A.F. Verbov and S.N. Davidenkov have described hypoesthesia and paresthesia in zones located considerably more central to the frostbitten areas, as well as weakening and extinction of the deep reflexes. Ya.K. Braul and D.I. Panchenko noted changes in the intervertebral ganglia in various degrees of frostbite of the lower limbs.

A zone with a large number of foci of necrosis and degenerative changes is characterized by reduced activity, slowing down of the regenerative processes and a reduction in tissue resistance to infections. The relative frequency of development of degenerative and inflammatory processes of an ascending nature can be explained by this.

Present day Soviet opinions on the pathogenesis of frostbite reject all theories which assign exclusive importance to lesions of some one tissue or function of the body or interpret frostbite as a purely local lesion.

It is considered that the mechanism of development of pathological symptoms in frostbite is a complex process in which, as a result of tissue chilling, disorders of neuroreflex and humoral regulation occur, which result in disturbance of tissue metabolism.

These diverse functional disorders, which are the subject of study by Soviet authors and are the real essence of the frostbite process, still have not been studied sufficiently completely. However, it can be stated now that a signfficant part among them is played by disturbances of tissue metabolism regulated by the nervous system. They consist of the development of conflicts between the supply of nutrients and the capabilities of their uptake and disturbances of the relationships between assimilation and disassimilation and disorders of metabolite removal.

Tests by T.A. Achkasova found sharp fluctuations of carbohydrate metabolism, which developed in the "latent" period in local chilling.

In studies by colleagues of P.I. Bykov and G.L. Frenkel, it was determined that chilling of a limb of an experimental animal is accompanied by slowing down and then, stopping of blood circulation. This slowing down is established with approach of the tissue temperature to 30°, and it stops completely at temperature of +4° and +11° (V.A. Chernigovskiy, I.N. Kurbatova). Vascular spasm which causes stasis was noted in a number of tests on the side not subjected to chilling (G.L. Frenkel). However, the symptoms of frostbite which develop on the test side are never noted on this side. Consequently, ischemia is still not sufficient to cause the characteristic symptoms of frostbite.

The studies of A.L. Izbinskiy on general cooling established marked disruption of the oxygen supply of chilled tissues. This prompted him to propose anoxia as the basic cause of vital activity disorders in chilling. However, it should be considered that, with a reduction in tissue temperature, both the oxygen uptake capacity of the tissue (and its delivery time) and the need of the tissue for it are reduced. Clinical practice still does not have available sufficient data for a decision on oxygen starvation of tissues in various phases of the frostbite process.

The stimulation of the sympathetic nervous system which develops in a cooling focus causes vascular spasm in the suprajacent segments (N.N. Burdenko, M.N. Sandomirskiy) and even on the opposite side (S.N. Davidenkov, V.A. Chernigovskiy and I.N. Kurbatova), and it also increases the release of adrenalin into the blood (N.I. Pankov). In the initial cooling period, alternation of stimulation of the sympathetic and parasympathetic nervous systems is noted (B.B. Koyranskiy, M.A. Goloshchekina, L.Ye. Drizina et al), which affects vascular tone in the cooling focus and probably also endocrine gland function. Disturbance in the conditions of internal secretion release contributes to change in the ion ratio and colloid equilibrium. In a focus which has suffered cooling it also apparently is disrupted as a result of tissue metabolism disorders and oxygen insufficiency. The accumulation in a chilled area of various metabolites, among which histamine like compounds have a significant position (Lewis et al), contributes to paresis of the capillary network, increases the permeability of their walls and leads to the development of edema.

The correlation of the entire endocrine system is disrupted in frostbite, and the accumulation of insulin, which is capable of retaining water in the body, makes the tissues more hydrophilic.

As a result of the complex interaction of these factors, most often in the most distal and, therefore, the more severely and longer chilled areas, necrotic changes of a greater or lesser extent occur. The viability of tissues immediately adjacent to these areas is significantly disrupted. Clinically established inflammation with pronounced exudative symptoms, degenerative foci and necrosis develop. This is the zone in which the demarcation develops.

The topography of the pathological changes which develop as a result of chilling cannot be exactly recorded. However, in all cases, the most pronounced changes occur in the most superficial and distal areas, i.e., in those places where the longest and greatest tissue temperature reduction was observed. Because of this, the damaged areas are arranged in the form of a cone with the apex in the distal direction or a wedge with a double base if these changes are examined in longitudinal section (Fig. 81).

The most typical changes in IV degree frostbite, when the tissues undergo necrosis, are at great depth, including the bone.

Tissues subjected to chilling experience two stages, the clinically expressed "latent" period and the tissue warming period. With the onset of the "latent" period, a gradual decrease in intensity and a qualitative change of all vital processes occur. These processes reach the maximum level and remain at it during the entire "latent" period corresponding to the extent of the decrease in tissue temperature. With the end of chilling, tissue temperature begins to increase, metabolic processes intensify, and the nutrition conditions change. This corresponds to the beginning of the tissue warming period.

Disproportion occurs in the tissue metabolism sphere with the onset of cooling. Our present level of knowledge does not permit a precise answer to the question of exactly when these disproportions begin. Their development during both of the periods in question is most likely. It is permissible to think here that different kinds of both quantitative and qualitative disproportion do not occur at the same time. Some of them develop in the "latent" period and others later.

It is noted that the origin of development of the processes which result in disproportions is precisely in the period of tissue hypothermia, so it must be considered that these disproportions occur in later stages. An increase in the area of spread of necrosis or, conversely, the restoration of vital activity of those tissue areas which appear to be nonviable and doomed to death at the beginning of the tissue warming period is the clinically expressed presence of these disproportions. Since the beginning of disturbances of cell metabolism is in the "latent" period, the intensity and duration of chilling becomes of decisive importance. Thus, the practical tasks consist of the most rapid warming of the area which is involved, in order to reduce the chilling time.

On consideration that these disturbances can develop in the warming period, the principal attention must be given to the warming procedure, so as not only to reduce this period but to achieve the most nearly simultaneous possible warming of the chilled area. Chilling duration evidently is of importance in the sense that the size of the area in which metabolism and blood circulation are disturbed increases in parallel with prolongation of the effect of cold. Therefore, a more substantial period is required in its subsequent warming, during which disproportion develops.

There is no doubt of the presence of disproportions in the tissue metabolism sphere, which are manifested by necrotic degenerative processes only in the tissue warming period. Dependence of frostbite on duration of the effects of cold, just like the favorable effect of rapid warming, has been established.

Study of tissue metabolism processes in chilled and warmed tissues, determination of the conditions under which given quantitative and qualitative changes in vital activity of tissues and cells occur, exact determination of the time of development of disproportions and exact determination of the mechanisms of development of these disorders (neural first and foremost) are the tasks of further research in the field of frostbite pathogenesis.

Frostbite Development Conditions

Low temperature, in the absence of additional factors which augment its effect on the body, is tolerated by man without harmful consequences. The experience of living in high latitudes and, in particular, the experience of polar (and mountain) research are evidence of this.

Clothing adapted for winter and distinguished by low heat conductivity serves man as protection from cold. More complete equilibrium between heat production and heat transfer is maintained by means of clothing.

Under normal peacetime conditions, a decrease in heat transfer is achieved by reducing stay time in frost and the utilization of warmer clothing. Heat production is increased by active movements of man and by the intake of high calorie nutrients into the body.

In a combat situation, heat equilibrium frequently can be disrupted, because both reduction of the stay time in the cold and an increase in heat production due to active movements and nutrition become difficult. Man remains for hours on the battlefield in a fixed position, without the possibility of warming up and frequently deprived of warm clothing. Under these conditions, the duration of a forced stay in the cold begins to play a significant part. The longer the effect of cold, the more noticeably thermal equilibrium is disrupted, and the more the chilling suffered by the entire body and individual parts of it, first and foremost the limbs, which have a relatively large surface area and therefore lose more heat. Low temperature combined with the time factor can be of decisive importance in the etiology of wartime frostbite, even in the absence of the so called contributing factors.

There are no convincing criteria which permit determination of the relationship of mass frostbite among troops to air temperature and duration of its effect, since it is impossible to exclude the effects of other factors here which augment and lessen the effect of cold.

According to the data of Killian, in the 16th German Army, which was in action in the Kholm-Lake Il'men'-Schlisselburg area, there were more than 19,000 frostbites in 1941/42, which greatly exceeded the cold losses in all succeeding winters. However great the dependence of frostbite on contributing factors, there is no doubt that low temperature and the duration of exposure to it are the basic factors which determine the possibility of the development of mass frostbites (Fig. 75).

The distribution of frostbite by month obeys a specific regularity, which can be found in much wartime material and with a quite long period of observation, which includes the winter period and covers at least 9-10 months.

Study of peacetime frostbites, even over a large segment of time, cannot reveal the effective distribution of frostbite by months of the year, because of the significant effect of a number of supplementary circumstances in each separate case.

The literature published before World War II does not deal with the question of the monthly distribution of frostbite. Thus, the materials of World War I 1914-1918 have not been developed in this respect. The statistics of individual authors usually were based on a small number of observations and, if they cover a significant number of cases, they concern a short period. The Finnish War also cannot be used to study frostbite in the area indicated above, since it lasted less than four months.

According to the fundamental characteristics chart data, the totoal number of frostbites observed during World War II per 100 in each year of the war is quite regularly distributed by month (Table 36, Fig. 76 and 77).

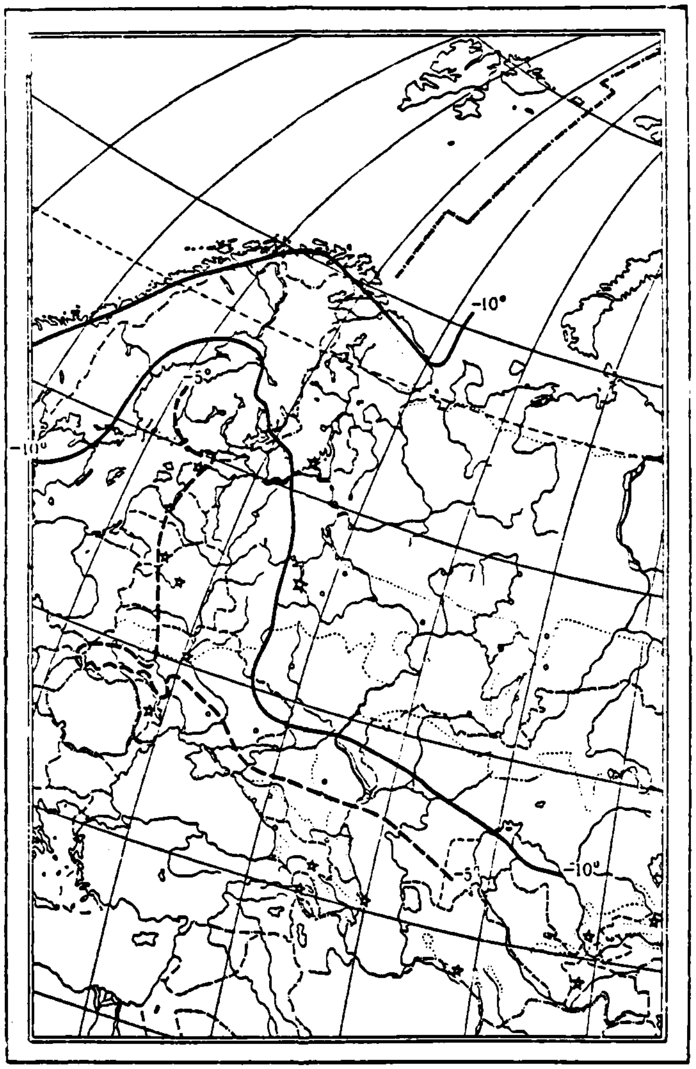

Fig. 75. Average monthly temperatures in January.

Both in this table and graph and in the following percent of frostbites which occurred in each separate month, they were obtained by computation of the daily average number of frostbites and calculation of their percentage fraction of the total average daily values for all months in which frostbites were recorded in a given year.

Table 36. Distribution of all frostbite cases by month from fundamental characteristics chart data (in percent of number of frostbites for the year)

(n) Год войны / Месяц (a)	(b) Июль	(c) Август	(d) Сентябрь	(e) Октябрь	(f) Ноябрь	(g) Декабрь	(h) Январь	(i) Февраль	(j) Март	(k) Апрель	(l) Май	(m) Июнь
(o) Первый	0	0	0,2	1,7	9.0	24.5	34,95	10,7	15,2	2,7	1,0	0,05
(p) Второй	0	0	0,1	1,91	1,0	28.8	30,3	14,3	12,6	0,9	0,1	0
(q) Третий	0	0	0,1	0,71	0,0	21.8	15.7	35,4	13.3	2,0	0,1	0
(r) Четвертый	0	0	0,1	1,2	4,7	15,5	38,1	22,5	16,8	1,0	0,1	0
(s) За все годы войны	0	0	0,15	1,6	9,4	24,7	31,15	15,7	14,6	2,2	0,5	0,03

Key: (a) Month; (b) July; (c) August; (d) September; (e) October; (f) November; (g) December; (h) January; (i) February; (j) March; (k) April; (l) May; (m) June; (n) Year of war; (o) First; (p) Second; (q) Third; (r) Fourth; (s) For all years of war.

Frostbites recorded on the individual fronts generally duplicate this regularity, only with the difference that the number of months per year in which frostbites occur is reduced from 10 to 6 toward the south, and the relative number of frostbites per month increases.

The number of frostbites by month is distinguished by some non-uniformity. More or less marked rises are observed in those months when combat operations occurred on a given front on a substantial scale.

The distribution curve of all cases of frostbite by month of the year (Fig. 78) basically corresponds to the total number of wounded, distributed according to the same principle.

The separate increases in number of frostbites observed in different winter months during the entire war, both in the overall material and in the data of certain fronts (Fig. 76-77), are not only explained by meteorological conditions, but they can be associated with the combat operations conducted on the fronts.

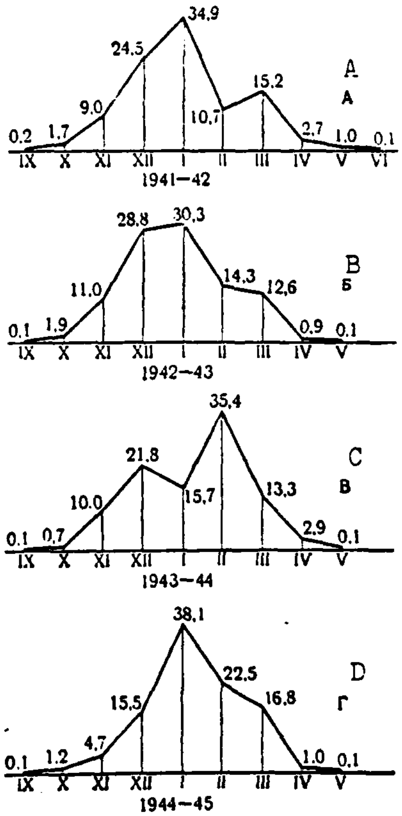

Fig. 76. Distribution of all frostbite cases by month (in percent of number of frostbites for the year).

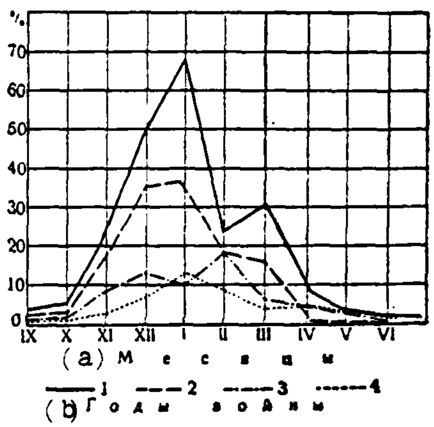

Fig. 77. Distribution of all frostbite cases by month in different years of war.
Key: (a) Month; (b) Year of war.

In the first year of the war, the greatest number of frostbites occurred in December 1941, January and March 1942 (Fig. 76). As is known, the strong attack of the Soviet Army developed, ending in the destruction of the Germans at Moscow, in December 1941 and January 1942. This attack also entailed losses due to frostbite.

Some increase in the number of frostbites in March 1942 may be associated with combat operation to encircle the Sixteenth German Army in the Staraya Russa region, as well as with piecemeal operations on the northern sections of the front.

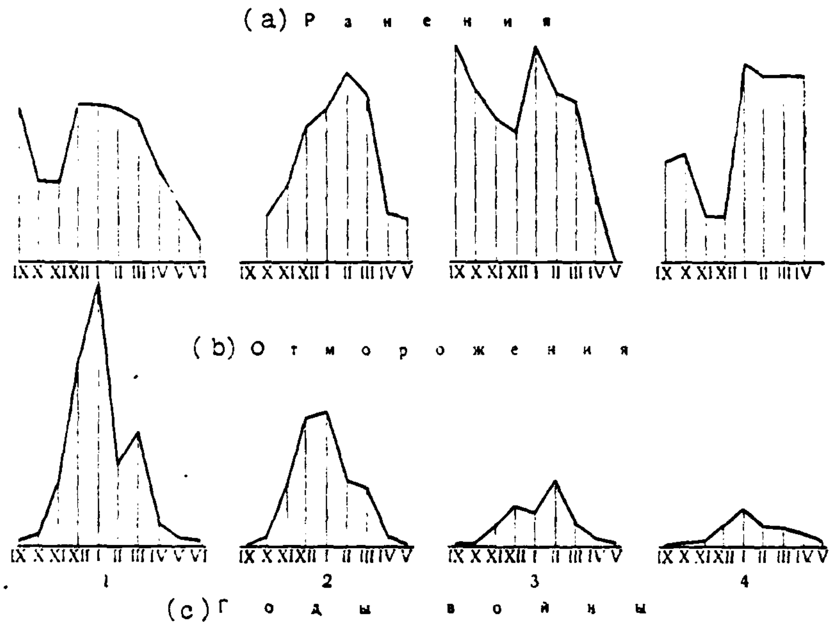

Fig. 78. Average daily losses due to wounds and frostbites in different months (1941-1945).
Key: (a) Wounded; (b) Frostbite; (c) Year of war.

The Kesten'ga combat operations of one army of the N-sk front, which was of a local nature, was not reflected in the frostbite distribution which characterized the Soviet Army losses as a whole, but it was accompanied by a marked increase in number of frostbites in May 1942 immediately on the N-sk front.

In the second year of the war, the primary combat operation was the encirclement and elimination of the Stalingrad group of German troops (Fig. 76-77). According to the fundamental characteristics chart data, this operation was distinguished by an increase in number of frostbites recorded in December 1942 and January 1943. This is reflected in the data of the corresponding fronts.

During the third year of the war, stubborn battles occurred in December 1943 in the Ukraine, in the area of Kremenchug, Cherkassy and Korosten', as well as battles to sieze Nevel and Gorodok in the direction of Vitebsk in the second half of December.

In February 1944, the attack of part of the Soviet Army developed, which ended with the surrounding and destruction of German troops in the Korsun'-Shevchenko region (Fig. 76-78).

In 1945, the greatest losses due to frostbite occurred in January and February. This coincides with the attack of the Soviet Army in the Visla-Oder region (Fig. 78).

Factors Conducive to Frostbite

Factors which increase heat transfer and cause cooling of both individual parts of the body and the entire body should be classified as factors conducive to frostbite. All conditions which increase the heat conductivity of clothing, as well as of the air around the body, which is a heat insulating layer, are such factors. Conditions which reduce the heat regulating capacity of the body are among them.

All the diverse conditions which augment the effect of cold and contribute to frostbite can be reduced to four groups. The first group includes meteorological factors, the second group factors which mechanically hinder blood circulation in the limbs, the third group factors which reduce local resistance and local heat regulation of tissues and the last are factors which reduce the general resistance of the body.

The isolated effect of any factor in one of the groups on the body is found extremely rarely in practice. As a rule, a combination of their effects occurs. Therefore, the division of all the frostbite favoring factors into four groups is artificial to some extent, and it is tolerated only for convenience in reporting.

It must be emphasized that all the factors conducive to frostbite, acting separately or combined with each other under conditions of high tissue temperature, even with considerable prolongation of their effects, never cause frostbite symptoms. Squeezing a limb with considerable force and duration can result in gangrene, but the characteristic symptoms of frostbite never develop in this case.

Keeping a limb in dampness at high temperature for a long time can cause maceration of the skin, with simultaneous difficulty in the outflow of blood, as well as intumescence, but symptoms of necrosis never occur in such cases as in trench foot.

The following meteorological factors should be included in this group: air humidity, wind and an abrupt change of weather.

The moisture of clothing is unavoidably increased by prolonged exposure to moist air, and its heat conductivity increases sharply. The loss of heat by the body increases, heat regulation is disrupted, and overcooling begins, of the limbs first and foremost. At low temperatures, the absolute humidity of the air is negligible but, with the air temperature approaching zero, it increases considerably. At an air temperature only a few degrees below zero, the possibility of still greater dampening of the clothing and footwear increases, not only due to the humidity of the atmospheric air, but also due to snow, which melts easily and soaks moist clothing. Precipitation at a temperature close to zero dampens clothing. If bad weather lasts for several days, the air is saturated with water vapor, which prevents drying out of clothing and results in conditions which favor an increase in heat transfer. The heat conductivity of moist air also is elevated. Therefore, the loss of heat by the body under these conditions increases considerably, and it can reach limits which persistently reduce tissue temperature in the peripheral sections of the limbs.

At low temperatures, the wind can be an additional factor which contributes to the development of frostbite. In this case, primarily exposed parts of the body (ears, nose and other parts of the face) suffer, since the warm layer of air around the surface of these sections of the body is carried away into space by the force of the wind and is continually replaced by cold air, which increases heat absorption. With substantial wind strength and duration, other parts of the body, primarily those which are peripheral and inadequately protected by wind impermeable clothing, turn out to be under conditions similar to those of the exposed parts. Among them are the fingers and sex organs. The latter frequently are injured in cavalrymen by the wind blowing in the slit of the trousers, which contributes to the situation of the rider. Frostbite of the sex organs of athletes develops under similar circumstances, in particular, in skiers on long trips over open terrain.

Frostbite of the fingers, which develops due to wind exposure during work without gloves can be included here, if it is not associated with chilling because of direct contact with metal objects which have a low temperature.

The factors which are conducive to frostbite can include an abrupt change of air temperature, on condition that this is understood to be a rapid change from low temperatures to temperatures above zero or only a few degrees below zero. Changes of the opposite order, from high temperatures to low, also should be included among these factors.

There are no indications of harmful effects of even a sudden drop or increase in temperature within substantially below zero limits in the literature.

Practically, sudden temperature changes rarely occur without change of other meteorological factors in the complex which constitutes the concept of weather. Therefore, it always is more nearly correct to consider the combined effect of meteorlogical factors, while keeping in mind that their isolated effect also contributes to the development of frostbite.

A sudden increase in temperature to nearly thawing limits, as a rule, is accompanied by a drop in atmospheric pressure, an increase in cloud cover, precipitation and an increase in wind strength. In this case, the humidity of the air increases substantially and, as a result of the combined effect of the factors specified, the loss of heat by the body increases increases sharply, since it fails to adjust its heat regulation because of the rapid change in conditions. The increase in number of frostbites systematically noted in the spring months should be assigned in part to the effect of these factors (Fig. 78).

A number of examples are known from the literature when a sudden change in weather resulted in mass frostbites.

Larrey mentions several persons who suffered a shipwreck at the end of 1788, who spent 9 days on Belle Isle in severe frosts which did not cause any frostbite symptoms. A thaw occurred the day before these people left the island. After this, two died of cold, and several men received severe frostbites. Examples of mass frostbite are known: at Preysish-Eylau on 10 February 1807 (Larrey); in Algeria in November 1836, when a blizzard arose four times after a heavy rain with snow (Castalleneta) and many others.

V.S. Gamov describes a mass frostbite which occurred on the night of 10 January 1934 among personnel of a troop unit which spent the night in the steppes in Kazakhstan, in the area called the Dzhungara Pass. A wet snow storm raged during the day. The temperature fell toward night, and the clothing was covered with an ice crust. A wind of tremendous force blew all night. It turned out the next day that approximately half the personnel of the unit received frostbite.

A mass frostbite, described by D.G. Gol'man and V.K. Lubo, was observed in February among a group of Red Navy athletes making a ski and foot crossing over the Gulf of Finland. This group was exposed to a wind with a speed of from 3 to 5 m per second and temperatures which fell from -8.4° to -21.8° during a day, with a simultaneous increase in humidity to 90% and the formation of fog.

A sharp change in weather as a basic factor in the d elopment of frostbite during World War II was noted in 0.2% of the cases, according to the fundamental characteristics chart data. Of course, this figure does not represent the actual situation, since other factors operate in a change of weather, namely, wetting of footwear and clothing, which the victims themselves notice more.

On one front, a substantial number of frostbites was connected with sharp fluctuations of the meteorological situation, in particular with abrupt cooling down and snow storms in May. These cases were reported at a front conference on frostbite.

During a combat operation conducted from 28 April to 18 May 1942, a large number of frostbites was observed in the N-sk Army. At the beginning of this period, there was warm spring weather, but a severe snow storm raged 5 and 6 May accompanied by an abrupt decrease in air temperature. In connection with this, the number of frostbite victims admitted to the army hospital in May was five times the number of admissions in April (S.A. Grubina).

In January and March 1942, according to report data, a certain number of frostbites was associated with an abrupt change in weather on the Bryansk front.

Factors Which Mechanically Hinder Blood Circulation

The importance of circulatory disorders caused by local pressure in the etiology of frostbite has been noted by nearly all authors involved with these questions.

When wearing tight footwear, conditions are created which disrupt circulation in the area subjected to the greatest pressure. The lateral sections of the foot and mainly toes I and V, as well as the dorsal surface of the foot (rise) frequently suffer frostbite. The opinion that the rate of frostbite of toes I and V depends on the worst conditions of blood suppy is rejected by P.N. Mazayev, who noted no peculiarities of their blood supply in arteriography of the limbs. T.Ya. Ar'yev observed a case of isolated frostbite which occurred at the site of projection in hallux valgus. One such case also was noted in the fundamental characteristics chart material.

The next feature in the development of frostbite cannot be ignored. For people who do not take off their footwear for a long time, are forced to rest in the footwear or spend many days on their feet, in trenches, etc., because of hampered outflow of blood, the volume of the lower limbs increases and the footwear becomes tight.

Drying footwear by wood fires and stoves can cause disruption of its elastic properties and the formation of wrinkles and folds, which then exert pressure on individual areas of the foot and contribute to the development of frostbite. Therefore, it is particularly important to adhere to the established rules of drying footwear.

During the Finnish War, T.Ya. Ar'yev noted that, of 40 victims whose medical history was successfully verified, 21 men indicated tight footwear as the cause of frostbite and 11 men, squeezing of the foot by ski bindings. In 55 cases of V.S. Gamov, tight footwear was the cause of frostbite in 11 cases. B.L. Kaz and A.F. Lukanov who had much questionnaire material available connected 8.5% of frostbites with tight footwear. In 250 frostbites observed by D.T. Prokopchuk, the footwear of 39.6% was tight and in bad repair. According to the data of F.G. Shkradyuk, tight boots were the cause of 16.6% of the frostbites and tight felt boots, of 7%. According to the fundamental characteristics chart data, tight footwear caused 11.9% of the frostbites.

Tightly tied puttees, shoelaces, pants bindings, etc., are of the same importance as tight footwear, which many authors have pointed out.

One case of IV degree frostbite with necrosis of half the foot and heel was described by S.A. Grubina. This frostbite was associated with squeezing the limbs and injury of the soft tissues of the thigh.

Convulsive, prolonged squeezing of any object (ski poles, controls, etc.) with the fingers contributes to frostbite.

Various objects of incorrectly adjusted weapons and equipment can cause difficulty of blood circulation, which contributes to frostbite.

Factors Which Reduce Local Tissue Resistance

In a number of cases, frostbite leads to trophic disorders, which are expressed by hyperhidrosis, acrocyanosis, etc. Disruption of peripheral circulation, which is a consequency of frostbite, is accompanied by vasomotor disorders. Local heat regulation suffers in particular. Repeated frostbite develops relatively often at this location.

Mignon noted that 2/3 of those frostbitten in 1914-1915 were frostbitten again the next winter.

According to the fundamental characteristics chart data, repeated frostbites were noted in nearly 10.0% of those cases in which the medical history was successfully determined.

As S.A. Grubina points out, repeated frostbites were observed in 140 cases (14.0%). Of them, the first frostbite developed in the same year in 24 cases, a year later in 36 and 2 years later in 27 cases. In the remaining cases, the first frostbite occurred at an earlier time.

Moreover, triple frostbite of the same area was observed in two victims: III and IV degree frostbite of the fingers of one in 1941, after frostbites in 1938 and 1940; IV degree frostbite of the big toe of the other in 1942, after frostbites in 1937 and 1940.

Disorder of limb movements caused by nerve lesions, as well as the presence of scars and contracture contributes to frostbite by degrading circulatory conditions. Frostbite was observed in paralysis of the median nerve.

S.A. Grubina noted frostbite at the location of previous wounds in 1.1% of the cases. D.T. Prokopchuk (1944) established a connection of frostbite with previous wounds in 1.6% of the cases. According to the fundamental characteristics chart data, in 6.3% of frostbites of a limb, wounding and injury of this limb occurred earlier.

According to all data, chronic inflammatory processes in the limbs also contribute to the development of frostbite. Local symptoms of general diseases should be classified here. According to the data of P.S. Delevskiy, some local disease contributed to 2.4% of the frostbites.

Nearly all authors who have observed a considerable number of frostbites note that an increased tendency of the legs to perspire contribute to it. In the material of M.S. Ioffe, an increased tendency of the legs to perspire was observed in 53.0% of all victims. According to the data of Ye.A. Mariyeva (1941), a tendency of the legs to perspire was recorded in 17.0% of all frostbites she observed. D.T. Prokopchuk (1944) noted the effect of this factor in only 6.7% of the cases.

A fixed position of the body, so frequent in a combat situation, causes a reduction in heat production and, therefore, could be considered a factor which reduces the general resistance of the body. However, in a fixed position, the limbs are cooled first and foremost and their circulation is disrupted. Therefore, it is more nearly correct to classify immobility among the factors which reduce local resistance if, of course, the effects of other factors which cause squeezing or mechanically hinder circulation is excluded.

According to the data of one mobile field hospital, during the Finnish War, 77 frostbite victims were not wounded, but approximately half of them lay on the battlefield for more than a day and many were forced to be immobile (V.S. Gamov). As P.S. Delevskiy noted (1941), the latter was the cause of 22.4% of the frostbites.

According to the fundamental characteristics chart data, the fixed position as a basic contributing factor of frostbite was noted in 8.0% of all observations. In 1/5 of these cases, immobility was associated with wounding. The effect of other factors was not noted in 7.0% of these cases.

The conditions under which disorders of local heat regulation occur also should be classified in the group of factors in question. Local heat regulation can be disrupted due to a sharp increase in heat transfer in an isolated part of the body, most often in the feet as a result of the footwear getting wet, as well as by the loss of gloves and other items of equipment. Conditions frequently are created in a combat situation, in which the basic cause of frostbite is the footwear getting wet and the prolonged effect of low temperature. Falling down in an unfrozen swamp, getting the footwear wet while marching through streams, in airborne operations and in fording are such cases.

The likelihood of soaking the footwear increases considerably at relatively high air temperature, when wet snow which has gotten into the footwear melts and the footwear soaks up the moisture. Its heat insulating properties suffer severely as a result.

For this same reason, felt boots, which are the best footwear during frosts, easily get wet in a period of thaws and rise in temperature, and they completely lose their heat insulating properties. According to the data of Ye.A. Mariyeva, 63.0% of all who were frostbitten wore felt footwear, and their legs were thoroughly wetted in connection with an increase in air temperature.

At above zero temperatures with the footwear in direct contact with mud or melting snow, the most favorable conditions for rapid cooling of the limbs are produced.

Similar conditions arise for the upper limbs when mittens or gloves become soaked, with the only difference here that prolonged contact with the cooling medium usually is not noticed. However, in the forced prone position while crawling, the cooling conditions begin to approach the conditions of the lower limbs. It is true that it is possible in a number of cases here to warm the hands, for example, by rubbing, as a result of which local circulation is increased.

It is difficult and sometimes impossible to isolate those cases when soaking of the footwear and clothing is not associated with the action of other contributing factors. Soaking of the footwear is more easily taken into account as a factor which contributes to frostbite. Therefore, sufficient attention is not given to the other factors. In evaluating the data of various authors, it must be kept in mind that the figures they present represent only the relative rate of soaking of the footwear or clothing and that the parallel action of the other contributing factors occurred here in many cases.

There are numerous indications in the literature of the exceptional importance of soaking the footwear in the etiology of frostbite.

M.S. Ioffe (1944) noted soaking of the footwear in 80.0% of all frostbites. B.L. Kaz and A.F. Lukanov (1941) associated 85.4% of frostbites with this circumstance. T.Ya. Ar'yev presents several cases in which wetting of one foot played a decisive role in the development of severe frostbite.

On the N-sk front, where the terrain is particularly swampy, in the first year of World War II, soaking of the footwear was of primary importance. According to S.A. Grubina, the shoes were wet in 81.0% of the cases at the time of the frostbite. Ye.A. Mariyeva established soaking of the footwear in frostbites in 21.7% of the cases on the same front. According to the data of F.G. Shkradyuk, wetting of the limbs was noted as a factor contributing to frostbite in 31.0-35.0% of frostbite of the legs and in 15.8% of frostbite of the upper limbs. According to the fundamental characteristics chart data, soaking of the clothing and footwear was observed in 33.5% of all frostbites. In this case, the effect of any other factor was absent in 85.8% of the cases. Wounds and soaking of the footwear were established in only 3.0%.

Frostbite which developed at above zero temperatures is associated primarily with two factors: prolonged exposure to moisture and limitation of movement. Trench foot develops under just these conditions, but the prolonged exposure to moisture at low temperatures is the basic factor here. In 1854-1855, Delorme observed frostbites at above zero temperatures. In the 1870-1871 war, frostbite accompanied by gangrene was noted, which developed at temperatures between +6.1° and +7.9° (Killian). There are a large number of observations on the war in the Balkans. Thus, according to the data of Yakobson, among the Bulgarian troops in 1912-1913 on the shores of the Sea of Marmora and the Aegean Sea, frostbite was observed at a temperature of +4°; Folkes and Shtifler noted the development of frostbite at temperatures from +4° to +9° (according to Killian).

L. Kaplan and M. Gol'dshmidt observed a considerable number of chilblains of the floor of the auricle, as well as three cases of II degree frostbite of the feet, hands and floor of the auricle, in peacetime in camps in the spring and fall, at air temperatures from +8° to +12°.

The greatest number of frostbites at above zero temperatures was noted in World War I in France. Hecht points out that mass frostbites occurred in October-November 1914 during the battles in Flanders, at temperatures from +6° to +8°. In the 5th French Corps, which was located in wet, swampy terrain, 4,258 frostbites were recorded in the winter of 1914/15 but, in the adjacent 15th Corps, which occupied positions on dry, elevated terrain, there were only 2,004 frostbites in the same period.

In the period of intensive aircraft attacks on England in 1940-1941, Knight observed frostbites of the trench foot type. They occurred among the inhabitants of London, who spent the night in chaise longues in damp, cold shelters. In this case, squeezing of the vessels in the popliteal region, caused by the cross rod of the chaise longues, was connected with the immobile position. It is characteristic that there were no such symptoms among the caretakers of the same shelters, who spent the night on their feet (cited from Green).

T.Ya. Ar'yev observed frostbite among a group of English sailors, who were shipwrecked in July 1942 and stayed at sea in wet clothing for 5 days.

During World War II, the development of frostbite at above zero temperatures was observed repeatedly on almost all fronts.

In September 1941, units of the Soviet Army were on the defense on the shore of a river for a long time. The trenches were damp, and the personnel were unable to dry their footwear. In this period, a considerable number of cases of trench foot and primarily I and II degree frostbite were noted. The majority of persons with I degree frostbite were treated as outpatients. Nevertheless, 41.4% of those who came to the division aid station were evacuated further.

Frostbite occurred under similar conditions in March and April 1943, in some other sections of the front located in swampy terrain.

According to the fundamental characteristics chart data, frostbite at above zero temperatures was established in 1.89% of all frostbites and in 1.5% of IV degree frostbites.

It should be considered that there actually were considerably more of them, since there was no information as to the outside temperature at which the frostbite developed in 85.0% of the cases.

In the etiology of frostbite, there may be some importance to wetting of the legs, which was not the result of hyperhidrosis or other diseases, but the result of the air impermeability of the footwear and the accumulation of condensate in them. Therefore, rubber shoes and boots contribute to frostbite by making ventilation difficult.

It also has been observed that, when wearing felt footwear with galoshes, more favorable conditions are created for chilling of the legs than when wearing felt boots alone. After removing the galoshes, the surface of the felt boot proves to be wet.(V.S Gamov).

When individual items of equipment, footwear in particular are in bad repair, the part of the body located next to the faulty place is sometimes subject to frostbite.

For example, isolated forstbites of the heel region were observed when wearing footwear torn in the corresponding place. In other cases, with partial soaking of felt footwear, frostbite developed in just the place of greatest wear, frequently in the heel region.

Various equipment defects in intensive combat activity by troops could not always be corrected in good time, and they played a significant part among other factors contributing to frostbite in some armies in separate months.

Frostbite because of loss of individual items of equipment was rarer. Cases of losses of oxygen masks by pilots during high altitude flights are known, which resulted in severe frostbite of the nose and other parts of the face. Cases of frostbites of parachute jumpers, who lost footwear from one foot at the time of the jump have been described. The loss of gloves while performing various tasks at low temperature are classified as the same kind of circumstance.

Factors Which Reduce General Body Resistance

The frequency of development of frostbites among troops is connected with the general condition of the body of a soldier, in which the general condition should be understood to be not only the physical condition, but the state of morale as well.

It is known from this history of war that mass frostbites have been observed mainly during retreats and withdrawal of troops, when their physical condition and morale deteriorated.

The hasty retreat of the Napoleonic armies from Russia in 1812 was accompanied by mass freezing and frostbite. The allied armies in the Crimea suffered considerable losses in 1854-1855, when the stubborn defense of Sebastopol and the lack of success for a long time undermined the morale of the besieging troops.

In World War I, the greatest number of losses due to cold of all the allied forces was observed in the Italian Army, which made no advances.

A high political and morale state of troops favors a decrease in all types of combat losses, including losses due to cold.

Exhaustion and Fatigue

Prolonged combat operations require the maximum effort of all physical and moral forces. This causes a gradual increase in fatigue, and it decreases resistance to cold. The importance of fatigue in the etiology of frostbite was noted by many authors in World War I.

In modern war, there frequently are difficulties in food supply connected with a specific combat situation, prolonged separation from the supply base, deep raids in the enemy rear, and sometimes complete separation from their units (partisan actions, encirclement). In connection with this, degeneration of nutrition may develop in part of the troops, which absolutely contributes to the development of frostbite.

Infectious and acute diseases reduce the general resistance of the body, which decreases resistance to the effect of low temperatures. Previous wars right up to the beginning of the current century were accompanied by a considerable increase in epidemic diseases, among which typhus and intestinal infections were predominant. Among the French who died of cold in 1812, as Ye.B. Idel'son notes, was a considerable number ill with typhus, of which autopsy data and the clinical pattern are evidence. S.P. Botkin and N.I. Pirogov found in the Russo-Turkish War that acute infections, including cholera, increase the predisposition to frostbite.

During the Balkan War of 1912-1913, K.F. Hefting described mass frostbites, which developed mainly during gastrointestinal infections, as "dystrophic necrosis of the limbs." In the opinion of this author, "the main etiological feature is a nutritional disorder because of fatigue, regardless of whether it occurs from cholera or other acute gastrointestinal diseases or from overfatigue and starvation." "The predisposing features are cooling, as a result of being in wet footwear for a long time, difficult circulation due to bandaging the shanks, etc."

A peripheral circulation disorder in acute infections with general weakening of the body, as well as because of involvement of the vascular system, creates conditions for the development of severe frostbite. A number of authors have described cases of frostbite they observed during World War I of persons ill with acute epidemic diseases.

During World War II, infectious diseases were not widespread in the Soviet Army. Nevertheless, it occurred sometime among the contributing factors of frostbite.

In frostbites which involve the entire foot as well as the shanks, i.e., in the severest frostbites, the presence of infectious and acute diseases was noted in 4.2% of all frostbites and in 4.7% of IV degree frostbites.

Hypovitaminosis

The effect of hypo- and avitaminosis in the development of frostbite has been given more and more attention in recent years.

Many domestic authors propose agents which contain various vitamins, including A, B, C and D, for the treatment of frostbite, based on their insufficiency in frostbite. No sufficiently convincing studies in this area have been published in the literature.

According to the data of S.A. Grubina, who worked in the north, hypovitaminosis was observed in 0.9% of frostbites. According to the fundamental characteristics chart data, hypo- and avitaminosis were noted in 2.0% of all frostbites studied.

Wounds and the greater or lesser blood loss associated with them not only has a debilitating effect on the body, which results in loss of consciousness and prolonged immobility in a number of cases, but also increases the local effect of cold because of deterioration of circulation of the peripheral sections. In this case, both exsanguination of the limb and frequently their wetting with blood, which soaks the clothing and footwear, have an effect. The state of shock which occurs as a result of wounding and the associated drop in blood pressure reduces the resistance of the body still more. It is most nearly correct to consider wounding as a factor which contributes to frostbite and has both a general and a local effect.

Despite the great importance of factors which reduce general body resistance in the development of frostbite, during World War II in the Soviet Army, according to the fundamental characteristics chart data, the effect of factors which reduce general resistance was not noted in 80.0% of all cases of frostbite (including IV degree frostbites). This circumstance cannot fail to be noted, since it indicates that the Soviet Army preserved good physical condition and a high level of morale during the entire war.

Effect of Tactical Situation

The conditions of the combat situation under which frostbite develops are very diverse but, unfortunately, they are rarely taken into account by either the victim or the physicians in filling out the case records.

The corresponding analysis of the tactical situation, which should have merited attention, is not presented in the literature sources.

In the front and army report materials, insufficient attention also was given to the conditions of development of frostbite as a function of the combat situation. At a conference on frostbite in Arkhangel'sk, S.A. Abramovich gave an analysis of the development of frostbite in 1941-1942 in one army of the Karelian front. Thus, 4.2% of the frostbites set in during combat, 30.0% on reconnaissance and patrols, 26.8% in the enemy rear (raids, encirclement) 0.1% on observation routes, 4.4% on sentry posts, and the circumstances of 34.5% of the frostbites were not established.

In one unit of the Karelian front, 181 cases of frostbite among the soldiers of a ski brigade on a 50 kilometer march were recorded in January 1942. Considerable fatigue was a contributing factor to frostbite here.

S.A. Grubina, in analyzing the material of an army hospital, noted the following conditions of the combat situation under which frostbite occurred in 1000 cases: 40.1% in combat, including 24.5% on the attack and 15.6% in defense; 20.1% on reconnaissance; 8.4% on the march; 0.6% during evacuation; 12.3% at sentry posts; 8.1% during work; 8.3% under other circumstances; the circumstances were not established in 2.1% of the cases.

According to the materials of T.D. Prokopchuk (1944) 15.2% of all frostbites considered developed during the attack and 7.6% on reconnaissance.

According to the data of F.G. Shkradyuk, 60.0% of the frostbites occurred during execution of combat missions on the battlefield (attack, defense, guard duty). To this should be added 14.2% of frostbites which developed on the battlefield in connection with wounds. Ten point four percent of the frostbites occurred on the march and during crossings, 2% of the frostbites developed on reconnaissance and 7.2% during various tasks. Six point two percent of the frostbites were under other cirsumstances.

In study of the fundamental characteristics chart, the conditions of development of only 42.6% of the frostbites were established.

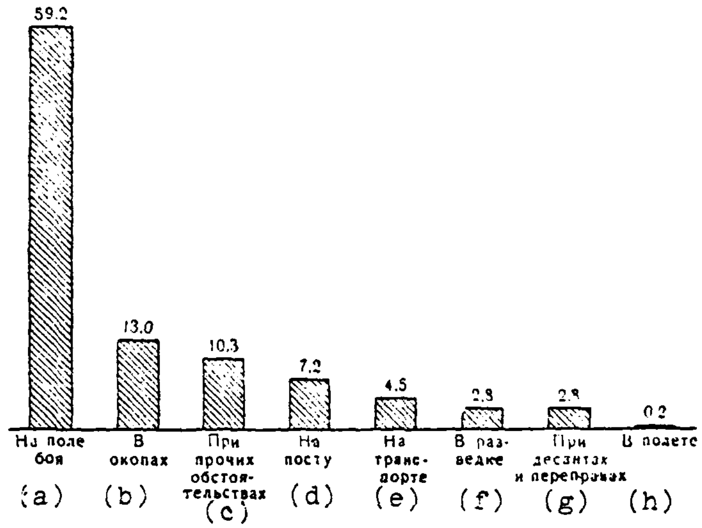

Fig. 79. Conditions of development of frostbite (from fundamental characteristics chart data).
Key: (a) On battlefield; (b) In trenches; (c) Under other circumstances; (d) On sentry duty; (e) During transport; (f) On reconnaissance; (g) During airborne landings and crossings; (h) In flight.

The frostbites received during attack, defense and in breaking out of encirclements made up the "on the battlefield" group. There were no more detailed indications of the circumstances. This group, which constituted 59.2% of the number of cases in which the circumstances of the frostbite were taken into account, should essentially include frostbites received in foxholes and trenches, on reconnaissance and partly on sentry posts (Fig. 79).

In comparing the conditions under which frostbite developed, it should be noted that a relatively greater number of IV degree frostbites set in on the battlefield. The explanation of this may be that the percentage of persons with IV degree frostbite who were wounded was nearly twice that in other degrees of frostbite, since the wound itself and events connected with it (footwear and clothing becoming blood soaked, immobility of the limbs, frequent deterioration of blood supply to the tissues, decrease in general resistance of the body to cold) contributed to increasing the severity of the frostbites.

It can also be noted that 46.0% of those frostbitten during crossings and at sentry posts were exposed to the cold for from one to 6 hours, while there were no more than 18 0% of the number frostbitten under other circumstances at the same time in any of the groups.

Frostbites which develop during the evacuation of wounded and ill constitute a small percent of the total number of frostbites, but, nevertheless, they should be considered an inadmissible phenomenon, since they depend on overlooking or insufficiently taking the situation into account in the majority of cases. The most frequent cause of such frostbites is a wet dressing and inadequate warming of the limb. There was squeezing of a limb, especially of debilitated wounded, in other cases.

The distribution of frostbites by categories of personnel and type of troops gives no basis for conclusions as to the frequency of frostbite among the different categories.

S.A. Grubina noted a substantial number of frostbites in ski units which, however, cannot be proof of greater susceptibility of skiers to frostbite, since the percent of ski units of all troops on a given front at a given time was unknown.

CHAPTER IV

SOME DATA ON TISSUE CHANGES IN FROSTBITE

Correlation of the pathological anatomy of frostbite is the task of morphologists. However, some tissue changes in frostbite can be decided from clinical observation data.

The morphological changes observable in the period after tissue warming are reduced basically to aseptic necrosis and inflammation, which is more pronounced in III and IV degree frostbites. There are descriptions of pathoanatomical changes in the literature, based mainly on an experiment which reproduced frostbite by freezing tissues, on study of the frostbitten limbs of patients who died from other causes (most often in combat) and limbs amputated due to gangrene caused by frostbite.

Material taken from frostbitten limbs of people who died of other causes should be considered most representative of reality. A shortcoming of material obtained in experimental frostbite is the gross mechanical changes in tissues which occurred as a consequence of freezing of the tissue fluid.

A deficiency of pathological anatomy data based on study of amputated limbs is th incompleteness of the information, since completely mortified limbs are most often subject to amputation in frostbites. It is clear that the picture of terminal necrosis adds little to our knowledge.

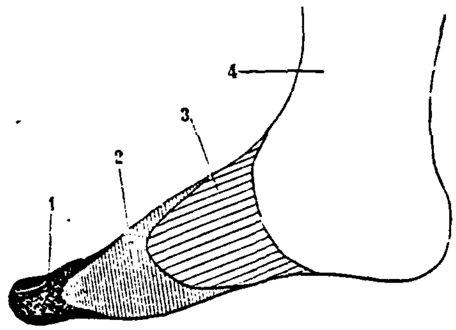

Fig. 80. Diagram of zones of pathological processes in frostbite (from T.Ya. Ar'yev): 1. total necrosis zone; 2. irreversible degenerative process zone; 3. reversible degenerative process zone; 4. ascending pathological process zone.

The following zones can be differentiated in severe frostbites: 1. total necrosis zone, which has the typical shape of a split wedge and can be more or less extensive (Fig. 80); 2. irreversible degenerative process zone immediately adjacent to the total necrosis zone; necrobiosis processes predominate in this zone; in grossly conservative treatment, trophic ulcers and ulcerating unstable scars develop right here after the necrotic portions drop away; 3. reversible degenerative process zone; reactive inflammation processes develop in the tissues here, which are eliminated subsequently as a result of treatment. Besides these zones, the presence of which can be decided from direct clinical signs, a fourth zone should also be distinguished in frostbite, of ascending pathological signs. Frostbites extremely often are accompanied by ascending endarteritis, neuritis and osteoporosis. A tendency of frostbites to recur also is known, which can be explained only by disorder of the natural heat regulation as a consequence of frostbite. In turn, this may be due only to disorders of the neural trophism at the frostbite sites, as well as disseminated necrosis.

The scheme presented above represents only qualitative changes, and the pathological process zones can have the most diverse quantitative relationships.

In this scheme, morphological elements of the overlying zones exist in the underlying zones (with the exception of the total necrosis zone). There also is no doubt that a sharp boundary cannot be drawn between these zones. Thus, in describing the pathoanatomical changes in frostbite, the degree of frostbite and its level and stage must be taken into consideration.

As the statistics show, the limbs, face and ears suffer frostbite in the overwhelming majority of cases. Based on the unquestionable fact that frostbite very rarely covers a limb above the ankle or wrist (totally), it can be assumed that the conditions which favor more extensive frostbites result in lethal hypothermia. Therefore, the pathological anatomy of frostbite can consider practically only changes in the skin, bones, nerves, vessels and muscles, i.e., the tissue elements of the limbs. Frostbites of the internal organs do not occur in nature. Therefore, they are not subject to consideration. However, this does not mean that frostbite does not affect their condition.

Tissue damage in frostbite is of an extremely regular nature from the point of view of size and shape. In this case, as was mentioned above, the altered tissues are located in the shape of a split wedge, the base of which is parallel to the center and the apex to the periphery. Thus, relatively damaged limb tissues appear to envelop relatively preserved tissues on all sides. This location of damaged and especially necrotic tissues is the cause of incorrect diagnosis in a number of cases since, in analysis of the condition of the superficial dead layers, it is incorrectly assumed that the deep layers are necrotic. This same typical location of necrotic tissues defines the so called removal of the line of demarcation to the periphery which is frequently observed in frostbite. Actually, the surface necrotic tissues are detached in this removal, and the young epidermis beneath the scab is exposed. Of course, it must always be kept in mind that macroscopically detectable processes are concerned (Fig. 81).

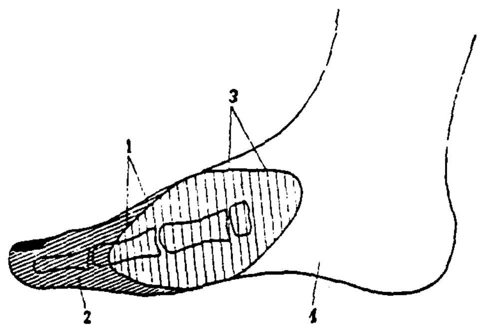

Fig. 81. Diagram of necrotic and secondary degenerative inflammatory processes in frostbite (from V.S. Gamov): 1. necrotic tissues; 2. primary frostbite cone; 3. secondary degenerative-inflammatory process development cone; 4. healthy tissues.

Based on a substantial number of clinical observations, a series of pathoanatomical studies and analysis of the data of other authors, V.S. Gamov concluded that the secondary degenerative inflammatory changes have a tendency to spread to a higher level in the deep tissues of a limb than in the superficial tissues. These changes usually are localized along the vascular-neural bundles at an extremely high level (Ya.Z. Braul, D.I. Panchenko). Bone changes also are noted considerably above the demarcation zone and, as a rule, in overlying segments of the limb. Necrotic foci, degenerative and inflammatory processes in the muscles, cellular tissues and, the more so in the bone do not spread as high as in deeper layers.

By schematically presenting the topography of degenerative-necrotic and, frequently, inflammatory changes in a frostbitten limb, it can be considered that these changes have a conical shape, with the apex of the cone toward the root of the limb (Fig. 81).

By contrast to the primary frostbite cone with the apex distal, a secondary cone forms with the apex proximal.

Any diagraming entails a certain deviation from the actual situation. Therefore, it must be kept in mind that there are no sharp boundaries between the zones in this case. Tissues embedded in each other, which retain various degrees of viability and form apparent transitional sections between the zones, in which slightly damaged or completely undamaged sections gradually begin to predominate toward the root of the limb. This is completely consistent with the theory of disseminated necrosis of S.S. Girgolav, according to which there always are foci of cells with severely attenuated viability in different sections of damaged tissue.

CHAPTER V

DIAGNOSIS

A diagnosis of frostbite is made on the basis of the medical history and objective examination. While the medical history is decisive for diagnosis in frostbite resulting from the effect of dry frost, it may be uncharacteristic of frostbite which develops at above zero temperatures (trench foot and chilblains). The fact is that in the last two forms the "latent" period is repeated again and again (trench foot), and it proceeds against a complicated background of predisposition to frostbite (chilblains). As a result, the patients may not detect either the beginning or end of exposure to cold, and it thus is extremely difficult to decide, if not on the period of cold exposure itself, in any case, its intensity. In isolated cases, this circumstance gives rise to confusion of gangrene due to cold exposure with gangrene resulting from vessel lesions following typhus, dysentery, etc. and, in the diagnosis of chilblains, to their confusion with various dermatitises and dermatoses. This kind of confusion has been noted repeatedly in the literature.

Objective study of the "latent" period of frostbite permits establishment of a characteristic pattern. It consists of a triad: 1. integument turns pale; 2. its cooling off; 3. loss or severe reduction of sensitivity.

With the corresponding medical history and the triad specified, the diagnosis of frostbite in the "latent" period becomes definite. This characteristic pattern is most often observed only in frostbite as a result of exposure to dry frost and the critical temperature, when the "latent" period is clearly expressed. In trench foot, the diagnosis of the "latent" period is extremely difficult, because of the uncertainty of the medical history, as well as because of the superposition of additional symptoms (cyanosis of the integuments, edema of the skin and subcutaneous tissue, signs of profound necrosis) on the objective picture described above. In chilblains as a rule, the "latent" period cannot be established because of the unusual pathogenesis of this form of frostbite. In diagnosis of frostbite in the period after tissue warming, the degree, stage and zone of the frostbite are taken into account (see classification).

The following are characteristic of I degree frostbite: 1. diffuse nature of damage; 2. absence of blisters; 3. variegated skin color (red, violet, blue spots against a pale background); 4. edema of the skin. The diverse paresthesias characteristic of the degree of frostbite under consideration should be added to the picture described. Second degree frostbite is characterized by blisters which contain a clear transudate. The bottom of the bubble is the exposed germinative layer of the skin, which is extremely sensitive to contact with and irritation by various substances. The bubbles in III and IV degree frostbite are distinguished from the bubbles in II degree frostbite by the nature of the transudate and bottom. The transudate in III and IV degree frostbites is hemorrhagic, and the bottom of the blister is necrosed skin, which is completely insensitive to touch and irritation. In late stages of II degree frostbite, the bottom of the blister is covered with newly formed epidermis, by granulation in III frostbite but, in IV degree frostbite, the bottom of the blister is mummified or undergoes liquefactive necrosis.

It is clear from the abovementioned that the primary difficulties arise in early differential diagnosis of III and IV degree frostbites. In a number of cases, it is extremely difficult, and it only becomes possible to distinguish frostbite with bone damage (i.e., IV degree) after 5-7 days, upon getting rid of edema and the appearance of the first signs of demarcation. By means of some auxiliary procedures, the demarcation can be detected even before it is noted in the form of a distinct band. After finding the future demarcation zone early, the extent of damage can be established and, guided by the scheme of the spread of frostbite, III and IV degrees can be differentiated.

For early detection of the demarcation, a procedure proposed by Willroth can be utilized. For this purpose, the limit of complete anesthesia should be established. If this limit is determined within the same limits after a day and, in this case, not blood, but hemolyzed liquid escapes from pricks in the areas of anesthesia, the anesthetized sections are considered necrotic and their boundaries the future demarcation zone. The same end can be achieved less accurately by measuring the temperature of the region involved with a skin thermometer. Sections with interruped blood supply assume the ambient temperature (room temperature, i.e., 14-18°), and the temperature of the skin of the undamaged areas is nearly normal (30-32°). By moving the thermometer, a more or less broad band of skin can be detected with a temperature below 12-15°. This is the band of necrosis at the location of the future demarcation.

Diagnosis of the stages and zones, which are of particularly great importance in III and IV degree frostbite, is not complicated, and it can be considered in description of the clinical picture and treatment of frostbite.

The diagnosis of trench foot should be separated from the general diagnosis of frostbite. It is determined by a. medical history, b. greater extent of necrosis, c. the liquefactive nature of the latter, d. localization and e. disorder of general condition. Prolonged exposure to wet cold is characteristic of the medical history in trench foot. Besides, in the process of damage production, repeated warming of frostbitten feet, then reexposure to cold can be established. Such conditions frequently arise in the trenches in position warfare, which is responsible for the name of the form of frostbite in question.

As a result of frequent alternation of the "latent" period and the period after tissue warming characteristic of trench foot, in the next cooling, symptoms of edema and other symptoms of inflammation of damaged tissues on which new damage is superimposed appear to be registered. In this case, because of the decrease in sensitivity which is characteristic of the "latent" period, significant disorders and tissue damage become little apparent. As a result, upon final warming, very widespread total necrosis and liquefactive gangrene are detected. The entire foot or its anterior portion and the heel region usually are involved. Liquefactive gangrene of both feet (as a rule, suffering is symmetrical) causes considerable intoxication and, therefore, high fever of such patients is observed as a rule. They easily experience general infection and, because of the reduced body resistance, diverse complications.

The conditions for a very prolonged decrease in tissue temperature, not of high degree here (wet cold) which alternate with brief warming, for a number of reasons, are produced almost exclusively for the distal portions of the lower limbs. Therefore, the localization of the lesion in trench foot combined with the signs described above also are a differential diagnostic sign of the form of frostbite. Trench foot is the most severe form of IV degree frostbite.

Some forms of frostbite do not have characteristic traits described and they are manifested by diverse clinical syndromes. However, they have a common etiology of exposure to cold. Various arthritises, neuritises and late endarteritises are among these. The only symptoms of suffering sometimes are persistent edemas. It is evident that classification of these forms as frostbite is now based only on the etiological factor. Their diagnosis and semiotics are diverse, and they can be considered with great justification in the chapter on diseases of the joints, vessels and nerves.

X-ray Diagnosis

X-ray identification of the nature of a pathological process in bones and joints, of the initial changes and their localization and extent in particular was of positive scientific interest, and it was of unquestionable importance to earlier diagnosis and improvement of the results of therapeutic measures.

There are few words or no indications at all of the aftereffects of frostbite in the best foreign (in particular, German and English) manuals on roentgenology, which assist to any degree the identification of lesions of the bone-joint system as a result of frostbite.

German and Italian X-ray works (cited by Appelroth) published during the last war are evidence by their number and content, of what an unexpected disaster the numerous aftereffects of frostbite proved to be for our enemies. The X-ray observations on which these works are based were carried out with much delay, two months after the frostbite or later. The bone changes found here were already suppurative processes almost without exception. As Appelroth noted, "not only the military unity, but even the manpower of the German people was eliminated" by them.

Not knowing X-ray identification of the initial bone lesions which, as will be pointed out below, are aseptic processes, the German as well as the Italian radiologists cited by Appelroth attempted only to establish reference points which permitted a decision on the level of the lesion. Consequently, they attempted to help German and Italian surgeons avoid repeated operations in connection with an increase in extent of necrosis of the bones and suppurative processes. However, the frequency of reoperation in connection with these complications was substantial.

Before World War II, we used the X-ray method for determination of the severity of frostbite insufficiently or not in good time. Of the earlier X-ray detectable symptoms of frostbite, only osteoporosis or primarily osteoporosis attracted the attention of investigators. However, this symptom is found in many diseases. Therefore, osteoporosis is of little importance among the observable symptoms of frostbite, the more so that it can be absent in very significant damage of the bone and joint system after frostbite. However, the presence of sharply expressed, increasing, ascending osteoporosis deserves mention. The severity of frostbite is indicated by this symptom.

A number of Soviet radiologists and surgeons who studied frostbite during the Finnish War studied late or relatively late X-ray symptoms of lesions of the bone and joint system, osteomyelitis and the demarcation zone (F.R. Bogdanov, M.S. Shul'man et al).

In the early years of World War II, based on systematic clinical and X-ray studies of approximately 200 men with III and IV degree frostbite, as well as with prolonged II degree frostbite, it became possible to determine the frequency and sequence of both late complications and aseptic changes in the bone and joint system which occurred relatively early.

Comparison of clinical and X-ray data in frostbite showed that a number of aseptic trophoneurotic changes in the bones and sometimes purulent lesions of the bones and joints were detected by X-ray, when there still were no clinical symptoms which indicated involvement of the bone and joint system.

The X-ray symptoms of involvement of the bone and joint system in frostbite are as follows: 1. osteoporosis; 2. a number of aseptic trophoneurotic changes, namely osteolysis, osteonecrosis and pathological fractures; 3. sluggish osteomyelitis and suppurative arthritis.

One, several and sometimes all the symptoms specified can be observed in frostbite. Alternation of the symptoms listed is frequently observed in the order indicated above. Consequently, a given manifestation of aseptic trophoneurotic damage can be connected with osteoporosis in these cases, and a unique, sluggish suppurative process can subsequently be detected in the bones and joints.

Osteoporosis is a more or less widespread change in frostbitten regions (most often in the bones of the foot and less often in the hand). With osteoporosis in particular present, even when it is strongly expressed in some bones (of the foot or hand), no conclusion can be drawn on the possibility of onset or localization of subsequent lesions of the bones and joints. More than that, when such trophoneurotic changes as aseptic osteolysis and osteonecrosis have been identified, where a suppurative process can develop after some time can be precisely indicated at the same time.

All of the X-ray symptoms noted develop no earlier than the end of the second week, usually during the third or fourth week after the frostbite, but sometimes later. On the strength of this circumstance, X-ray study of frostbite in early stages of evacuation is useless, but it is timely in the army base hospitals and front base hospitals.

Osteoporosis is detected earlier than other X-ray symptoms. The presence of the initial manifestations of osteoporosis can only be made sure by comparison of the bones involved with the bones of the symmetrical limb. However, because of repercussion in the symmetrical limb changes of the same order occur early (Fig. 86). Nevertheless, osteoporosis is less marked in the unfrostbitten limb. Practically, it can be considered that osteoporosis is established by X-ray, as was mentioned above, no sooner than the end of the second week after the frostbite and more often later. Subsequent X-ray observation shows both a larger and a smaller increase in expression and extent of the osteoporosis. Even after clinically unquestionable recovery, osteoporosis is traced for several months.

Osteoporosis was found in more than half of all cases. Usually, osteoporosis initially is focal and punctate, and it subsequently becomes widespread and diffuse. There is no parallel between the presence and nature of osteoporosis and the presence and expression of the remaining symptoms. Severe changes in the bone and joint system are observed frequently with slight expression of osteoporosis. These circumstances permit it to be considered that osteoporosis in itself is of limited diagnostic importance (with the exception of the previously indicated progressive ascending osteoporosis).

Other symptoms which can be determined by X-ray are of great diagnostic and prognostic importance. They frequently can be observed in this sequence: trophic osteolysis, aseptic osteonecrosis (with pathological fractures) and suppurative lesions of the bones and joints. None of these complications is found earlier than 3-4 weeks after frostbite and frequently later. The clinical symptoms of lesions established by X-ray frequently are found considerably later.

However, at the present time, based on the X-ray symptoms of bone and joint lestions in frostbite established by D.G. Rokhlin, S.N. Davidenkov and A.F. Verbov have shown that, in many cases in the absence of the usual clinical data, a substantiated hypothesis of a lesion of the bone and joint system (without exact definition of the nature of these changes) can be proposed comparatively early, based on the presence of neuritises. Nevertheless, osteolysis, aseptic necrosis and pathological fractures are identified sufficiently conclusively only by X-ray, especially with respect to their extent and intensity. X-ray data become particularly important for deciding the pattern of the process and to establish recovery.

Aseptic osteolysis, in the form of resorption of the distal sections of the terminal phalanges, which is observed in many trophoneurotic changes (in syringomyelia, scleroderma, Raynaud's disease, leprosy), was found by D.G. Rokhlin in every third case of frostbite. Trophic osteolysis is initially an aseptic microscopically small focus of necrosis. Macroscopically and particularly X-ray almost imperceptible necrotic sections of bone are not found. However, it is soon established by X-ray by a certain extent of osteoporosis without its replacement by other tissue.

Trophic osteolysis begins in the distal section of the ungual phalanges with the disappearance of the closure plate of the section of bone involved, most often in the region of the ungual tuberosity of of the ungual phalanx of the big toe. The closure plate of the ungual tuberosity normally is either smooth, slightly undulating or a zigzag line, but it always distinctly protrudes, as though lightly highlighted with a pencil (Fig. 82 and 83). In osteolysis, disappearance of the closure plate is noted (Fig. 84-87), the medullary space of the distal end of the phalanx is exposed, and its infection becomes possible.

Since the big toe is most often involved in frostbite, pathological changes are found very often in the ungual tuberosity of the terminal phalanx of the big toe. The surface of the distal end of the ungual phalanx of the big toe toward the second toe has better conditions with respect to warming than the medial surface. Therefore, the surface of the ungual tuberosity of the big toe not warmed by the other toes suffers first (Fig. 84 and 85).

Because of the same circumstances, if the second toe is longer than the big toe, pathological changes are found earliest of all in the terminal phalanx of the second toe (Fig. 86). The little toe suffers frequently. The remaining toes, which are in the middle and are warmed by the outside ones to some extent, are involved less often.

If other sections of the skeleton are harmed because of a defect of footwear, clothing, etc., similar changes (osteolysis) and other changes described below can be found in the corresponding bones.

Trophic osteolysis, which begins with the disappearance of the closure plate (Fig. 84) and increases in its expression and extent, can result in the disappearance of half of a phalanx (Fig. 86 and 87). A phalanx in a state of marked osteolysis resembles sugar dissolving in tea, with typical resorption and exposure of the structure. The entire phalanx occasionally undergoes resorption.

Another aseptic process which develops in bones on the background of frostbite is necrosis, which usually accompanies or follows osteolysis (Fig. 88-90). Necrosis of a bone is characterized by an increase in intensity of the shadow of the corresponding section of the bone against a background of general or local osteoporosis. This aseptic necrosis is not accompanied by periostitis (in distinction from the sequestrum observed in destruction against a background of osteomyelitis).

Aseptic necrosis usually is not observed earlier than 3-4 weeks after frostbite. In nearly half of all cases, aseptic necrosis was accompanied by pathological fractures which were distinctly traceable on X-rays. These fractures were most often observed in a necrotized ungual tuberosity and less often in the diaphysis of the ungual phalanx of the toe or finger. The fracture plane usually was perpendicular to the long axis of the bone or at some angle to it (Fig. 87). The necrotized section of bone frequently was represented by several small fragments without a periostal reaction (Fig. 89). The fracture plane was occasionally along the long axis of the bone (Fig. 88).

Among the aseptic necrotic changes resulting from acute frostbite or continuous exposure to cold, unusual processes (osteochondropathy type), which developed in the joint ends of short tubular bones in those cases when the growth of bones in length still is not completed, should be noted particularly. This undoubtedly is found very rarely and, if it is observed, it is most often in the interphalangeal joints of the hand, more rarely in the metacarpophalangeal joints and still more rarely in the corresponding joints of the foot. The X-ray characteristics of the process are necrosis of the joint head and a decrease in its size, fragmentation, and an increase in height of the joint fissure, which can be detected on a X-ray photograph. After 1-3 years, the structure of the head is restored. However, it is deformed and its size increases irregularly. The joint cavity enlarges and is adapted to the deformed head to some extent. The height of the joint fissure remains increased. Movement is restricted, but is generally painless or with little pain (without a large load). The picture described is completely identical to multiple osteochondropathy of the phalanges. D.G. Rokhlin observed such changes as a result of frostbite in one case and S.A. Grubina in two cases.

Upon exposure of the medullary space associated with the disappearance of the closure plate, conditions are produced for infection of the bone. The presence of necrotic bone (and necrobiosis) favors the development of infection. This is observed in conservative methods of treatment, with long postponement of surgery.

Osteomyelitis with sequestration and periosteal reactions were described (Fig. 84-87) during the first year of World War II, when the X-ray symptoms of the bone and joint system in frostbite were still not sufficiently known, and the treatment measures applied were conservative. Osteomyelitis was then identified too late. The aseptic changes preceding osteomyelitis, which predisposed to it, were not diagnosed at all. Because of these circumstances, during the first year of World War II, according to the data of D.G. Rokhlin, osteomyelitis was observed in frostbites with great frequency (namely, in 47.0% of III and IV degree frostbites). It was frequently accompanied by suppurative arthritis. This is indicated by the data of S.A. Grubina, which were confirmed by surgery and partly by histological studies. In 71 cases of III degree frostbite, she observed no changes in the bone and joint system in 26.8%, only osteoporosis was found in 18.3%, aseptic osteolysis in 15.5%, aseptic necrosis in 1.4% and osteomyelitis in 38.0%. Of 182 cases of IV degree frostbite, no changes in the bone and joint system were noted in 19.7%, she found osteoporosis in 22.0%, aseptic osteolysis in 4.4%, aseptic necrosis in 1.7% and osteomyelitis in 52.2%.

However, during the second half of World War II, severe lesions, suppurative processes in particular, became a rare phenomenon. To a great extent, this was due to the timely use of X-ray studies and correct reading of the photographs, without which expedient surgery could not have been provided.

The osteomyelitis observed in frostbites has its clinical and pathoanatomical peculiarities. Most often, these are sluggish osteomyelitis. It frequently resembles aseptic processes and, in such cases, it is distinguished by the absence of cavities and sequestrums and the nature of the periosteal reaction (the presence of assimilated or rapidly assimilable periosteal layers) (frostbite osteoperiostitises). Therefore, the pattern of the X-ray changes merits special attention.

The more vigorous osteomyelitis (Fig. 91, 93, 95-101), with the prolonged presence of exfoliated or fringed periostitis and, all the more, cavities and sequestrums, is rarely found.

The joints sometimes are drawn into the purulent process. As in other arthritises, osteoporosis of the joint ends is found, and physiological sclerosis of the joint cavities disappears. In the absence of destruction of the joint ends, these data do not yet permit arthritis to be spoken of with confidence. In arthritises against a background of frostbite, no significant exudate is observed in the joints.

By contrast, in a specific phase of the process, a decrease in height of the joint fissure, most often nonuniform, as a result of destruction of the joint cartilage (frequently in the absence of clinical data) is found on the X-ray photograph.

Simultaneously or somewhat later, destruction of one or both joint surfaces is found. In the region of the diaphyses of the bones which form the joint involved in the purulent process, periostitises, initially exfoliated and later assimilated, frequently are observed (Fig. 94). Dislocations are sometimes found. These are destructive (but not distension) dislocations as a result of substantial destruction of the joint cartilage and joint ends.

Destruction of the joint ends most often occurs by their slow wearing away and inflammatory osteolysis.

Necrotic sections, sometimes extremely large, which can be distinctly traced on X-ray photographs, are observed considerably less often. They are sometimes thin and sickle shaped, covering a considerable area of the subchondral section of the head at a shallow depth (Fig. 91). These are sometimes large wedge shaped necrotic sections with distinct boundaries, and they are unquestionable sequestrums (Fig. 95). The presence of such bounded necrotic sections of bone always indicates a severe process, even if the clinical symptoms are sparse over a long period of time.

Several months after the frostbite, in those cases when there was osteomyelitis, massive embedded periosteal cases could sometimes be observed (Fig. 97). Such periosteal layers are subsequently either resorbed or assimilated. The bone thickens in the latter case (Fig. 98).

The outcome of osteomyelitis against a background of frostbite frequently is characterized by hyperostosis. In these cases, the bone sometimes becomes twice as thick as normal. Its structure changes. The entire bone becomes spongy, without a thickened cortical layer (Fig. 99).

Surgery, which is reduced to scraping and chipping the distal section of the ungual phalanx in which the osteomyelitis developed, frequently does not stop the process. Subsequent X-ray observation in these cases reveals spreading of the necrosis to a region of the remaining part of the bone with its subsequent infection. Therefore, those who insist on radical surgery within the unaltered bore are right. Consequently, depending on the extent of the process, amputation or even disarticulation of the phalanx involved is necessary. After any surgery, repeated X-ray examinations are necessary at 3-4 week intervals.

The presence of a bone stump after surgery which is not covered or inadequately covered with soft tissues (Fig. 101) results in necrotization of the distal section of the bone stump, as a rule. In the majority of such cases, the development of a suppurative process can be found subsequently.

Besides the relationships indicated between the soft tissues and the bone stump they cover, the trimmed region should always be examined attentively in the photographs (see Fig. 91 and Fig. 93-100, Fig. 101). The absence of a distinct closure plate 4-6 weeks after amputation permits the assumption that an aseptic necrotic or purulent necrotic process is developing in the distal section of the bone stump. The presence of the latter can be suggested if there is exfoliation of the periosteum (and all the more fringes on it), tissue splitting of the cortical layer and sequestration.

Only in those cases when X-ray examination after surgery shows that a closure plate has formed in the distal section of the bone stump (Fig. 100) and, consequently, the medullary space is no longer exposed and is not subject to the danger of infection, do we speak of effective amputation of part of the bone.

Moreover, it should be determined by X-ray examination that the bone stump is covered with soft tissues (Fig. 100).

With stalactite like projections after amputation, the foot becomes defective, even if the closure plate is well expressed.

The aseptic and purulent changes described are not only found in frostbite. Similar trophoneurotic changes in the bones with subsequent infection can be observed in syringomyelia and leprosy.

A number of authors have found deforming arthroses and exostoses several weeks after frostbite, which they considered complications following frostbite. However, this is a mistaken interpretation of previously existing pathological changes. Many months and even years must pass for those marginal growths and deformations to develop which are characteristic of deforming arthritises and exostoses.

Among other things, in those cases when aseptic changes (osteolysis, osteonecrosis, pathological fractures) are found by X-ray, the ESR is normal. With purulent lesions, the ESR was high. It slowed down with quieting down of the purulent process.

The frequency of X-ray detectable changes in the bone and joint system is unnecessary evidence of the necessity for distinguishing four degrees of frostbite. The X-ray detection of changes of the bone and joint system (osteolysis, osteonecrosis, pathological fracture, osteomyelitis, suppurative arthritis) is a necessary and significant supplement to the clinical diagnosis. Both the clinically established degree and stage and X-ray detected changes must be specified in the diagnosis.

Some changes in the soft tissues, edema, smoothness of the folds, as well as infiltrative changes in deep sections, are detected by X-ray. These changes are found early, and they are preserved a long time, expressed to some degree. X-ray traceable infiltration in front of the Achilles tendon in the supracalcaneal region deserves more attention than changes in those sections of soft tissue which it is easy to detect by clinical examination.

In frostbite of the heel region, involvement of the heel bone is found extremely rarely. At the same time, darkening of the normally distinct transparent triangle rising high above the posterior section of the heel bone in front of the Achilles tendon is frequently traced in lateral photographs. The normal transparency of this triangle is explained by the accumulation of fatty tissue in this place, which is easily penetrated by X-rays. Frostbite of the heel region is associated with infiltration of this buildup of fatty tissue, which causes darkening of this triangle. Recovery is characterized by restoration of the normal transparency of this triangle upon X-ray examination.

It should also be emphasized that the demarcation zone is easily traced on the X-ray photographs. It is located either proximal to the clinically demarcation zone or at the same level. The demarcation zone is characterized by a not very thin band of osteolysis. The demarcation zone in a bone is frequently associated with the demarcation zone in deep soft tissues. In these cases, both zones are one common clear band (Fig. 101). The section of bone proximal to the demarcation zone does not have significant structural changes. In particular, its periosteum is not exfoliated. Distal to the demarcation zone, the bone structure is changed, and both a decrease and an increase in the intensity of the shadow are observed, in the latter case as a result of necrotization against a background of osteoporosis (Fig. 101). The demarcation zone is a band of osteoporosis either perpendicular to the long axis of the bone or at an angle. It is curved.

The demarcation zone should be distinguished from a pathological fracture. In a pathological fracture, the plane of the fracture frequently is not perpendicular to the length of the bone but at an angle. It can be curved in an arch. It is important that, in a pathological fracture, the bone structure is pathologically changed both distally and proximally over a considerable distance from its plane (Fig. 87, 88 and 90). In the presence of the demarcation zone, no significant changes are noted in the proximal section of the bone. In the event of a pathological fracture, as in any fracture, the clear line which corresponds to the fracture plane is bounded by bone and does not go into the soft tissue. The latter is characteristic of the demarcation zone (Fig. 101).

The aseptic changes in bones, osteolysis (with disappearance of the closure plate) and necrosis, which develop early against a background of trophic and nutritional disorders merit special attention. The corresponding changes in bones cannot develop without damage to the vessels which supply the bone. Changes in the vascular network can depend on disorders of neural regulation.

Aseptic and purulent changes frequently are observed in several bones of the same man. These lesions are sometimes symmetrical.

The symmetry of aseptic trophoneurotic changes in those cases when the necessary conditions for frostbite were not present is explained by segmentary repercussion, i.e., irradiation of the irritation to the spinal cord and reflection in the symmetrical section of the skeleton to the frostbitten limb. In this respect, the frequency of terminal neuritises and various vegetative trophic changes in the soft tissues on the symmetrical side, noted by S.N. Davidenkov and A.F. Verbov, merit attention. However, in emphasizing the importance of segmentary repercussion, the frequency of primary chilling and subsequent damage to both limbs should not be forgotten.

In addition to infections, especially in the development of liquefactive necrosis, in sections which have undergone aseptic resorptive necrotic changes, a chronic purulent necrotic process develops. However, osteomyelitis and suppurative arthritis as a consequence of frostbite were observed rarely in the last years of World War II, because the conservative methods of treatment of frostbite became considerably less used, having given way to the principle of early surgical treatment.

Frostbite is accompanied by bone damage, most often of the foot, in which mainly the ungual phalanges of the big toe, then the little and second toes, rarely the medial and proximal phalanges and metatarsals and extremely rarely the heel bone suffer. The bone and joint system of the hand is involved considerably less often than that of the foot. As the observations of D.G. Rokhlin of the consequences of frostbite in lesions of the bone and joint system show, 92.4% are in the foot and only 7.6% in the hand.

The ungual phalanges are involved most often in the hand. Other sections of the skeleton suffer frostbite extremely rarely.

V.S. Rybkina compared clinical and X-ray data (in which osteoporosis was not considered) of 225 patients 30-60 days after frostbite of the foot. In clinical diagnosis of I degree frostbite, bone changes (osteolysis, osteonecrosis, osteomyelitis) were not detected once by X-ray. In clinical diagnosis of II degree frostbite, 40.0% bone changes were established by X-ray, 50.0% in a clincial diagnosis of III degree frostbite and 90.0% in IV degree frostbite. These data show what a large part X-ray examination plays. The right and left feet are involved just as often and both feet, in half of all cases in which changes were established by X-ray.

The role of X-ray diagnostics in establishing bone and joint system damage, the dynamic localization and extent of their changes, as well as the effectiveness of therapeutic measures is evident.

In this manner, a new chapter of X-ray diagnostics, X-ray diagnosis of frostbite, originated.

CHAPTER VI

CLASSIFICATION AND SYMPTOMATCLOGY OF FROSTBITE

The Finnish War experience showed that the old three degree classification of frostbite, based on the unfounded analogy of burns and frostbites, is extremely inconvenient. The four degree classification of frostbite showed its advantages, was generally recognized and was introduced in official documents during World War II.

The four degree classification is based on two fundamental assumptions: 1. classification of frostbite by degree is possible only after tissue warming; 2. the overwhelming majority of frostbites envelop nonmuscular sections of the body, primarily the fingers and toes.

The depth of damage determines the degree of frostbite (anatomical principle), since the extent of damage in frostbite is of a regular nature.

As has been pointed out, the clinical symptomatology of the "latent" period is extremely sparse. Physicians rarely observe patients in this period, and a decision on it is made mainly on the basis of the medical history, the collection of which extremely often is difficult. If the subjective feelings are considered, pains preceding the complete loss of sensitivity which occurs in the "latent" period is noted in the medical history in the majority of cases. The pains are the greater, the less intense and diverse they are (tingling, burning, specific feeling of cold), but the unquestionable fact that the pains and general subjective unpleasant feelings of many patients are so insignificant that frostbite frequently sets in unnoticed is important. This characteristic of the pathogenesis of frostbite explains the well known observation of the possibility of the onset of frostbite unnoticed by the victim. At the time of disappearance of sensitivity, blanching and "stiffness" of the skin of the section involved is noted, and this condition remains for an indefinitely long time, until warming of the frostbitten section occurs. A sign of a change of the "latent" period to the period after tissue warming is a reactive progressive edema. It should be particularly emphasized that, if the frostbitten section is not recooled, the edema has a tendency to increase while, in trench foot, when "immobilization" of the initial edema is possible, it remains stable.

From the time of development of progressive edema, speaking theoretically, it becomes possible to determine the amount of damage. However, experience shows that several days are required for this in a number of cases.

The following damage can occur in frostbitten sections of the body: 1. circulatory disorders of the skin without irreversible damage to it (necrosis); 2. edema and desquamation of the surface layers of the skin down to the germinative layer; 3. necrosis of all the skin including the germinative layer and subcutaneous tissue; 4. necrosis of the integument and bones. In accordance with this, the first type of damage is designated I degree frostbite, the second II degree, the third III degree and the fourth IV degree.

Damage to the tendons and joints occurs, as a rule, in IV degree frostbite. Therefore, this damage is "covered" by the clinical pattern of bone necrosis. In the relatively rare cases of involvement of the entire foot or hand, the observed muscle necrosis also does not make fundamental changes in the clinical pattern of total necrosis of the foot or hand. Therefore, necrosis of the tendons and muscles and damage to the joints are not considered separately and are not separated in the four degree classification.

In the four degree classification, for a complete representation of the lesions in establishing a diagnosis, besides the degree, the localization and stage of the process also are noted.

First Degree Frostbite and Chilblains

The clinical symptomatology of I degree frostbite differs from frostbites of the all the other degrees by two characteristics: 1. in I degree frostbite under combat conditions, the overwhelming majority of victims remain at the combat post; thus, the conditions which cause damage are prolonged in the presence of a pronounced clinical picture; 2. in the majority of cases, the objective symptoms do not permit a decision as to whether the first stage of a more serious process or a stable light I degree frostbite is present.

Despite the apparent lightness of I degree frostbite, the subjective sensations in it are extremely severe in a number of cases. Intolerable pruritis, which forces the sick persons to scratch the skin and thereby increase their suffering, shooting and burning pains, aches in the joints, a feeling of edema of the skin (its tension) and different types of paresthesias must be noted.

The objective symptoms of I degree frostbite are reduced to a change in color of the skin and edema. In this case, the skin color is extremely diverse: most often dark blue, purplish red; the entire skin sometimes has a marbled appearance because of a combination of white, blue and red in different sections. In distinction from the progressive edema in the initial stages of more severe frostbite, the edema of I degree frostbite is of a constant nature.

The changes in external appearance of the skin usually are uniform and cover the entire foot or hand or the greater portion of them. This is still another difference of I degree frostbite from the remaining degrees, in which the severity of the objective changes increase toward the periphery of the body.

The clinical picture of classical chilblains, i.e., caused by insignificant cold under conditions of predisposition to this suffering, is generally identical to the clinical picture of I degree frostbite. Thus, chilblains can be considered chronic I degree frostbite. In severe recent chilblains, ulceration of the skin and the development of various secondary dermatoses and dermatitises as a consequence of this are observed in a number of cases.

The pattern of development and disappearance of I degree frostbite, as distinguished from that of II, III and IV degree frostbites does not have distinct boundaries. The changes of skin color and edema appear and disappear extremely gradually. Therefore, if the stage of the disease is contemplated, only the stage of development of the process can be noted when all symptoms increase quantitatively and, correspondingly, the stage of its abatement.

As a result of I degree frostbite, the external appearance of the skin does not change and scars do not form. Insignificant desquamation of the epidermis is sometimes observed. However, there is no doubt that the disorders of circulation and innervation which occur in I degree frostbite do not pass without a trace, since increased sensitivity to cold develop after this frostbite.

Unaggravated I degree frostbite passes in 3-5-7 days after exposure to cold, while chilblains can become chronic.

Second Degree Frostbite

The subjective sensations (pains) in II degree frostbite are regular within certain limits as to time of appearance and disappearance. These sensations are qualitatively the same as in I degree frostbite, but they are more intense, they appear in the interval of time preceding the development of the "latent" period, they disappear in the latent period and, as a rule, they occur again in the development of edema. The pains usually last 2-3 days, but longer in some cases. The intensity of the pains is nonuniform. The pains are most often insignificant or even completely absent, but they are very intense in some patients.

The objective pattern in II degree frostbite is defined by blisters, which usually appear during the first two days, but can develop in addition up to days 7-8. As a rule, the greatest number of blisters appear on the most peripheral sections of the body. The number of them, just like the size, is small. Single blisters which occupy the entire back of the hand or foot are possible (Fig. 103). Such blisters are observed particularly often in a combination of frostbite and gunshot bone fracture of the same limb.

Blisters occur less often on the soles and palms. However, exfoliation of the epidermis occurs here. Because of the great thickness of the epidermis of the sole, this exfoliation is successfully diagnosed only at later times in a number of cases.

The contents of the blisters in II degree frostbite usually are clear. They are of a hemorrhagic nature in some cases. They sometimes have a gel like consistency. The rose colored epithelial integument, usually covered with a fibrinous deposit, constitutes the bottom of the blisters. The skin in the vicinity of a blister is changed, and these changes are the same as in I degree frostbite. Edema and redness of the skin spreads to a very much further blister covered region. In II degree frostbite, the nails usually are completely or partly raised by transudate. There very frequently is long lasting hemorrhage under the nails.

As a result of II degree frostbite in which there are practically no symptoms of necrosis, the skin structure does not change significantly. Granulation and scars do not develop, and the nails grow out again.

Two stages of the illness can be distinguished: the blister stage and the skin regeneration stage. The treatment affects the nature and time of healing. The average recovery time in II degree frostbite varies from 10 to 20-30 days. A distinct clinical pattern (blisters) permits immediate determination of II degree frostbite and dispensary treatment of the patients. After II degree frostbite, sensitivity of the frostbitten sections to the effects of cold remains elevated.

Third Degree Frostbite

The subjective sensations in III degree frostbite are generally similar to the sensations in II degree frostbite, but they are more intense and prolonged.

The objective picture in III degree frostbite is defined by necrosis of the skin and underlying layers. The development of the pathological process occurs in at least three clearly definable stages: 1. necrosis and blister stage; 2. the stage of resorption and rejection of necrotic tissues and development of granulation; 3. cicatrization and epithelialization stage.

The skin of the necrotic region is either covered with dark, nearly black blisters, or there are no blisters. In the latter case, it is deathly pale, sometimes cyanotic and cold to the touch. The contents of the blisters in III degree frostbite, as a rule, are hemorrhagic. The bottom of the blisters has clear signs of necrosis. It is not sensitive to pricking or the irritating effect of alcohol.

During the next 5-7 days, resorption and rejection of the necrotic tissues begins, extremely often with symptoms of suppuration and only occasionally under a scab. Pus most often collects at the base of the nails, since the pure form of III degree frostbite unaccompanied by IV degree frostbite usually covers only the region of the ungual phalanges.

The edema begins to decrease at this same time, and granulation, extremely often flaccid, becomes completely evident by days 9-10. After final resorption or rejection of the necrotic tissues, the granulating surface gradually clears up. Its epithelialization in unaggravated cases ends, depending on the area of the lesion, in from one to two months from the start of the damage. Efficient treatment can contribute to shortening the stages of frostbite. In these cases, granulation occurs under a scab. An epithelialized young scar is detected after it falls off. As a rule, subfebrile temperature is observed in III frostbite. There can be general catarrhal symptoms.

The typical localization of the pure form of III degree frostbite is the region of the ungual phalanges of the toes and fingers. A scar develops without fail as an outcome of III degree frostbite. If III degree frostbite occupies the entire bed of a nail, the nail does not grow out again, and a scar forms in its place. Extremely often, as a result of partial scarring of the nail matrix, the newly growing nail is severely deformed, which results in the development of various malformations, an ingrown nail in particular.

Fourth Degree Frostbite

The severity of the subjective sensations in IV degree frostbite is generally the greatest, and it depends on the depth and extent of damage. Obviously, the pains and other disorders in total necrosis of the entire foot, for example, will be considereably greater than in total necrosis of one or more toes. In a number of cases, there are pains in the region of the necrotic limb, which are observed after its spontaneous rejection or amputation. These pains are sometimes so strong and persistent that morphine has to be used systematically. As a rule, the patients in these cases do not sleep much at night. Nevertheless, no strict regularity between the intensity of the pains and the extent of necrosis can be noted. There sometimes are intense pains in a relatively small damaged section. There is no doubt that other subjective and objective factors are important here, for example, such as the state of the nervous system, associated neuritis, infections, the development of ascending endarteritis, etc.

Data on pains in frostbites of different localizations are presented in Table 37, according to fundamental characteristics chart materials for the entire period of World War II. As follows from Table 37, there were no pains at all in 61.6% of all I, II and III degree frostbites or in 42.1% of IV degree frostbites. In an insignificant number of cases (5.31% and 6.45%), there were observed before warming of the frostbitten limbs, and they primarily accompanied IV degree frostbite (51.5%).

Table 37. Pains in frostbites of different degrees

(a) Время появления болей	(b) Отморожения I, II и III степени (d) в процентах		(c) Отморожения IV степени (d) в процентах	
(e) Болей не было	61.6		42,1	
(f) Появились до согревания	5.3		6.4	
(g) Появились в момент согревания	0.7	33,1	0.7	51,5
(h) Появились позднее	0.8		0.6	
(i) Продолжались в течение всего срока лечения	31.6		50,2	
(j) Всего...	100,0		100,0	

Key: (a) Time of development of pain; (b) I, II and III degree frostbite; (c) IV degree frostbite; (d) In percent; (e) No pain; (f) Developed before warming; (g) Developed at time of warming; (h) Developed later; (i) Continued during entire period of treatment; (j) Total.

There is nothing specific in the objective signs of total necrosis in IV degree frostbite. The involved region is pale or cyanotic, cold to the touch and extremely often covered with dark blisters, the bottoms of which are purple and have a typical vascular pattern. The blisters are flaccid, and the number of them is small (Fig. 104). It has been noted that in extensive frostbites the number of blisters and their size is relatively smaller and that so called secondary blisters filled with an ichorous fluid form on days 8-11 in this case. The demarcation groove is noticed extremely gradually and is blurred, especially at the beginning of the reactive period. A distinct demarcation groove forms between days 9 and 17, on day 12 on the average. There is no doubt that, for a decision on the boundary of the necrosis in a number of cases, complete formation of the demarcation groove cannot be expected, and one is guided by personal experience in treatment of the frostbites in this case. Study of the pain, heat and deep muscle sensitivity, the persistent disappearance of which in 3-5 days, combined with other signs, indicates necrosis of the tissues, is of great assistance here. Thus, the boundary of the necrosis can be determined before formation of the demarcation groove during the 5-7 days immediately after the frostbite.

The tips of the toes and especially the fingers very quickly blacken and mummify. Mummification of the remaining sections of the hands and feet occurs very much more slowly and only on the surface. In the intervals between the metatarsals of a necrotic foot, the tissues are in a state of liquefactive necrosis as long as two months after the onset of frostbite. As a rule, reactive edema occupies a very much greater area than the necrotic area. Thus, in frostbite of the toes, the edema reaches the ankle. In total frostbite of the entire foot, the boundary of the edema is at the knee.

Regression of the reactive edema depends on a number of factors, first and foremost on the severity of the damage, treatment and complications, and it usually begins by days 5-11. The first sign of reduction of the edema is the appearance of small wrinkles in the region of the edema.

The pattern of local changes in IV degree frostbite is still more complicated.

Besides the necrotic stage just described, which lasts from the beginning of warming to the formation of a distinct demarcation groove, the stage of rejection of necrotic tissue, the stage of development of granulation and the stage of cicatrization and epithelialization of the scar also are clearly distinguished.

The local changes in the necrotic tissue rejection stage generally develop as follows. The most peripheral sections of the necrotic limb mummify. The skin of more central sections also undergoes mummification, especially if siccative treatment was applied. However, if such treatment did not precede surgical treatment of the frostbitten tissues, only the most superficial layers undergo mummification.

With the passage of time, the demarcation groove becomes deeper and deeper and reaches the bone. In this case, in the region of separation of necrotic tissues, suppuration develops usually with a large discharge of pus. The nature and duration of the necrotic tissue rejection stage differ, depending on whether the demarcation groove passed along the line of the joints or at the level of the diaphysis of the bone. In the first case, spontaneous disarticulation of the necrotic section (in conservative treatment) occurs, the joint surface of the proximal bone is exposed, extremely often partly covered with granulation, and the third stage (development of granulation) begins by the end of the second month. In the latter case, the demarcation process erodes the soft tissues and reaches the bone, and it lasts a very long time, and dropping off of the necrotic bone involves many weeks in a number of cases. In such cases, the necrotic tissue rejection stage and the granulation development stage appear to be superimposed on each other while, when the demarcation of the bone develops, granulation develops in it in parallel.

Thus, the periods of the third stage of IV degree frostbite are extremely diverse and long. The fourth stage, cicatrization and epithelialization of the scar, is still longer. If treatment is not performed, this stage lasts for months. The scar which forms in such cases is inclined toward ulceration. The majority of patients in this stage undergo corrective operations, since all types of treatment, including health resort treatment, usually do not lead to recovery.

Present day surgical treatment of IV degree frostbite reduces the stage of local symptom development. With successful treatment, only the necrosis stage and the scab stage are observed. The necrotic tissue rejection stage and the granulation development stage drop out in this case.

With IV degree frostbite of substantial extent, general symptoms develop as a rule: high fever, which lasts several days and is replaced by a long lasting subfebrile temperature; kidney irritation (proteins in the urine); leukocytosis; associated catarrhal diseases. However, in the majority of cases, the general symptoms die out during the first week. The outcome of IV degree frostbite in all cases without exception is rejection of the necrotic tissues and formation of a stump. In this case, part of a phalanx or a complete phalanx, two or three phalanges and part of the foot or the entire foot can be lost.

The stump either forms spontaneously or as a result of surgery, but its presence is certain and characteristic of all IV degree frostbites.

A special form of IV degree frostbite is trench foot. The characteristics of the pathogenesis of trench foot, mainly of its mass occurrence in wartime, has been the reason for repeated description of trench foot as an independent disease. However, the clinical picture of trench foot fits completely within the framework of frostbite. A distinctive characteristic, besides severity of the damage, is obliteration of the "latent" period and, therefore, the rapidity of development of necrosis after warming.

Besides the characteristic objective local changes, cold causes a number of atypical disorders in the tissues of the limbs. Thus, during the winter, spring and fall campaigns, mass illness developed with the onset of cold, the basic sign of which was edema of the lower limbs, sometimes nearly to the knee. After several days of bedrest, the edema disappeared completely, and the patients outwardly appeared recovered. The kidneys and heart did not suffer in this case. Necrosis of the skin, even of the surface, also was not observed. The disease described can be considered a serous form of frostbite.

In other cases, there is no edema, and only the sharpest pains are noted, especially at night and generally in the horizontal position, while the pains were insignificant or completely absent during the day while standing and walking. The pains are neuralgic, and they irradiate from the ankle to the knee. The joints do not suffer, and pains do not spread to the thigh. The disease lasts 2-3 weeks in the majority of cases. The absence of the Achilles reflex is objective confirmation of the suffering.

Fig. 82. II degree frostbite: photograph made 10 days after frostbite; normal bone structure, absence of osteoporosis; closure plate of ungual tuberosities zigzag but distinct as if lightly highlighted with pencil (normal); patient discharged to unit after a month (observation of D.G. Rokhlin).

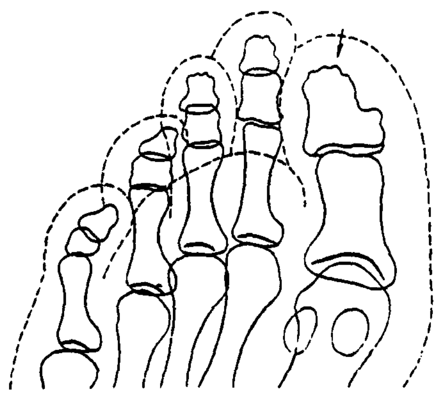

Fig. 83. Diagram of Fig. 82.

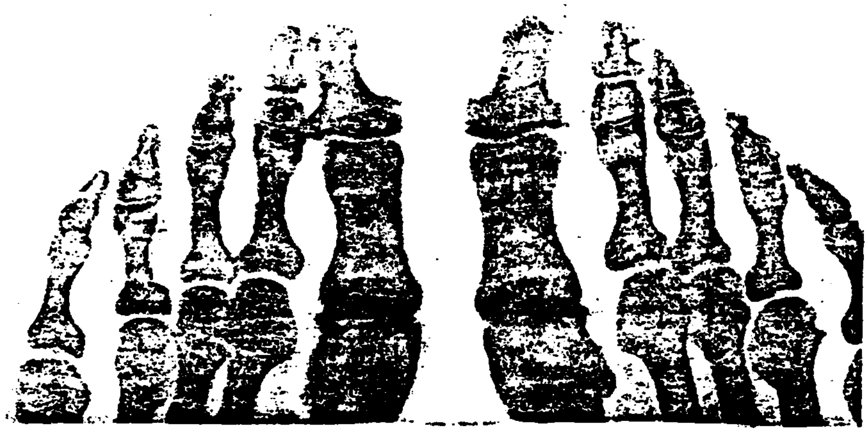

Fig. 84. III degree frostbite of big toe of right foot; photograph made 20 days after frostbite; osteolysis of inner surface of ungual tuberosity of big toe on right (spongy structure exposed); osteoporosis of unfrostbitten ungual turberosity of big toe on left as result of repercussion (observation of D.G. Rokhlin).

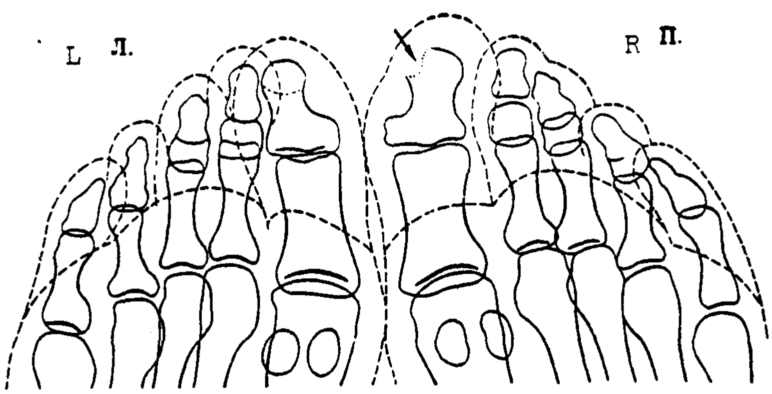

Fig. 85. Diagram of Fig. 84.

Fig. 86. III-IV degree frostbite; photograph made 16 days after frostbite; osteolysis of more than half of ungual tuberosity of second toe (which is longer than big toe); osteolysis of distal section of ungual tuberosity of middle toe, spongy structure exposed in phalanges involved; no noticeable osteoporosis (observation of D.G. Rokhlin).

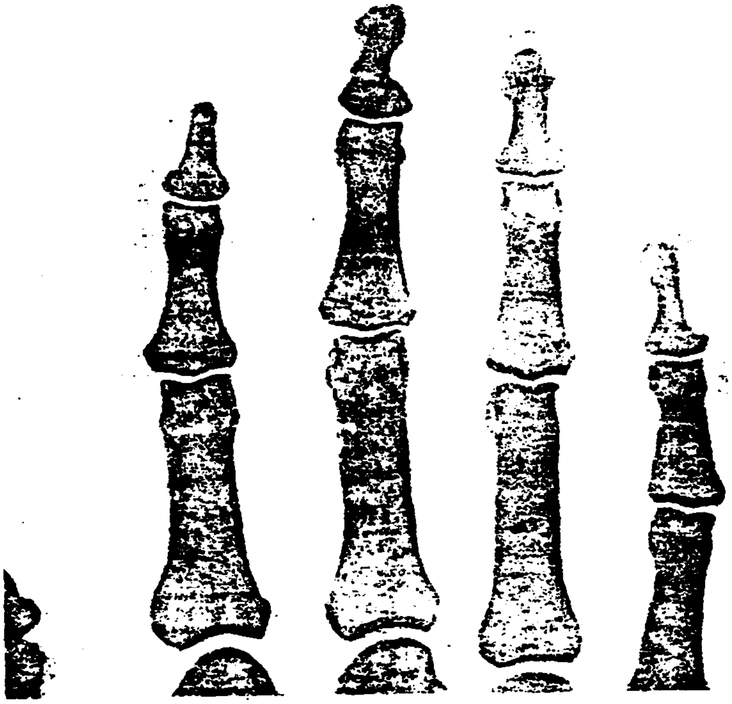

Fig. 87. IV degree frostbite: photograph made 8 weeks after frostbite; necrosis of diaphysis of middle finger phalanx with pathological transverse fracture of it; osteolysis of closure plate of ungual tuberosity of this phalanx; osteolysis of substantial portion of ungual tuberosity of index finger; osteoporosis (observation of D.G. Rokhlin).

Fig. 88. IV degree frostbite: photograph made 2 months after frostbite and 3 weeks after excision of middle, fourth and little toes; pathological fractures (longitudinal and simple); in necrotized proximal phalanx of middle toe broken triangular necrotic section was shifted laterally; stump of proximal phalanx of fourth toe stepped; stump of proximal phalanx of little toe has undergone osteolysis; osteoporosis; against background of osteoporotic ungual phalanx of big toe, compact island distinctly stands out (asymptomatic finding); stumps of proximal phalanges of middle, fourth and little toes not covered with soft tissue (observation of D.G. Rokhlin).

Fig. 89. Diagram of Fig. 88.

Fig. 90. III degree frostbite of right hand thumb: photograph made 2 months after frostbite; osteolysis of ungual tuberosity; pathological fractures in necrotized distal half of diaphysis of ungual phalanx; osteoporosis (observation of D.G. Rokhlin).

Fig. 91. III degree frostbite: photograph made 8 weeks after frostbite and 1 month after surgery; osteomyelitis of stump of proximal phalanx of big toe; necrosis in region of excision, corrosion of lateral surface; osteolysis of head of proximal phalanges of second, middle and fourth toes, periosteal layers on proximal phalanges of middle and fourth toes (osteomyelitis); necrosis and pathological fractures in head of V metatarsal, periostitis on medial surface of its diaphysis (osteomyelitis); moderate osteoporosis (observation of D.G. Rokhlin).

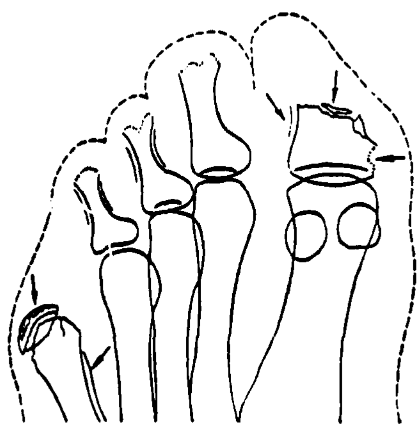

Fig. 92. Diagram of Fig. 91.

Fig. 93. IV degree frostbite: photograph made 7 weeks after frostbite and 3 weeks after surgery; osteolysis and periostitis in region of stump of proximal phalanges of all 5 toes (osteomyelitis); on proximal phalanx of little toe, sequestrum and exfoliated, fringed periostitis; marked reduction in height of joint fissure in fifth metatarsophalangeal joint, osteolysis of head, detachment of periosteum in region of diaphysis; suppurative arthritis and osteomyelitis; osteoporosis (observation of D.G. Rokhlin).

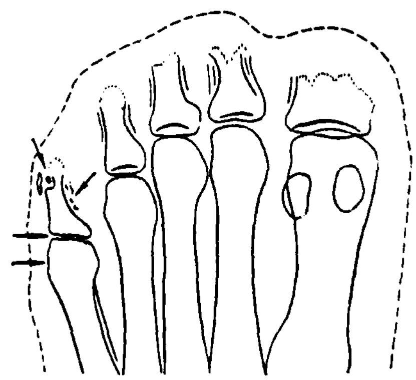

Fig. 94. Diagram of Fig. 93.

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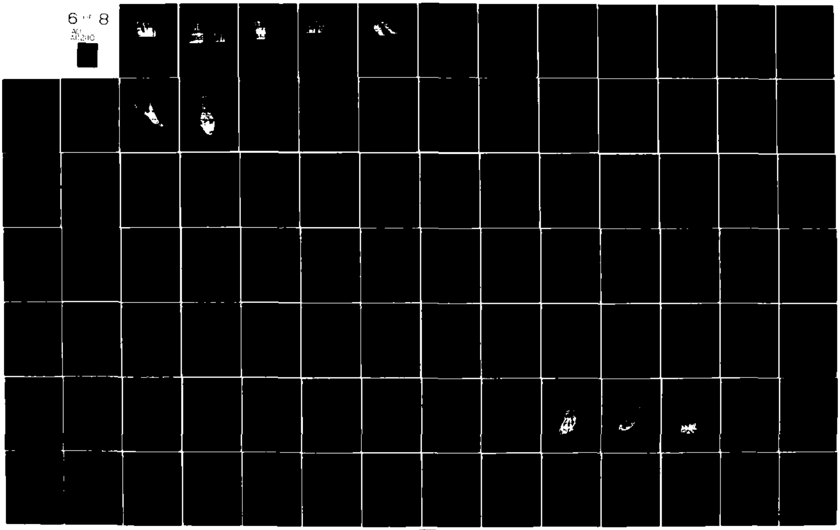

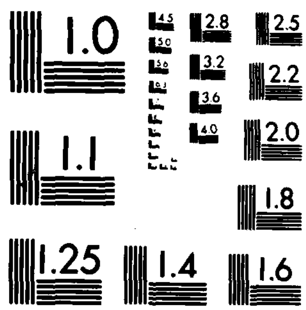

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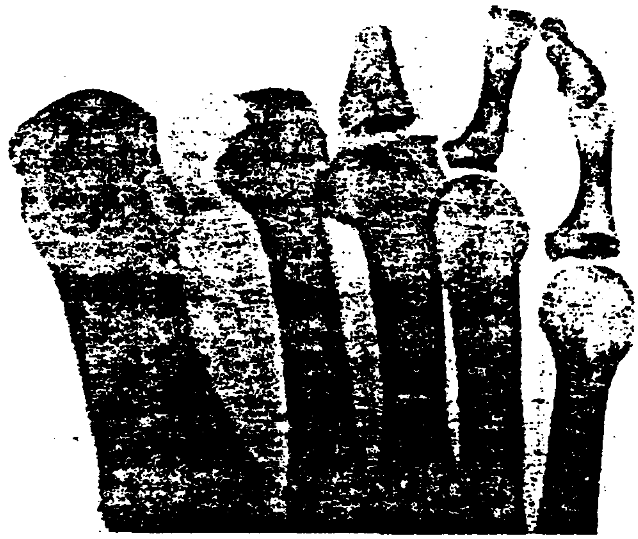

Fig. 95. III-IV degree frostbite: photograph made 55 days after frostbite and 1 month after surgery; osteomyelitis of I metatarsal (necrosis of head, corrosion and fringed periostitis on lateral surface); wedge shaped necrosis and sequestration in region of head of II metatarsal; osteomyelitis of proximal phalanx of fourth toe and stump of proximal phalanx of middle toe with suppurative arthritis (observation of D.G. Rokhlin).

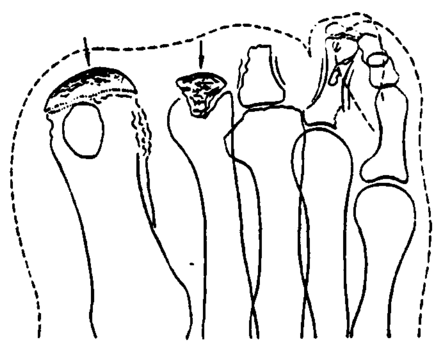

Fig. 96. Diagram of Fig. 95.

Fig. 97. III-IV degree frostbite: photograph made 4 months after frostbite and 2 and a half months after surgery; assimilating muff shaped periosteal layers on metatarsals (observation of D.G. Rokhlin).

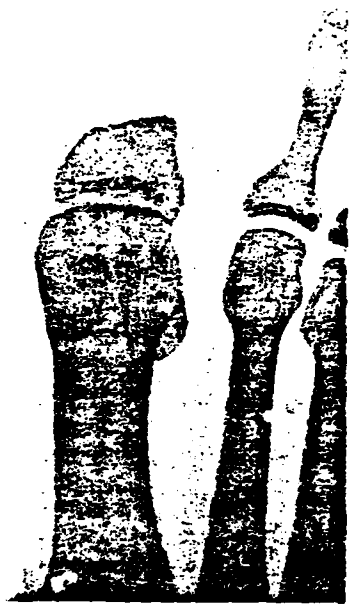

Fig. 98. III-IV frostbite: photograph made 1 year after frostbite; chronic osteomyelitis of I metatarsal with multiple fine sequestrums and assimilating periosteal layers; hyperostosis of metatarsal, as well as in region of stump of proximal phalanx of second toe (observation of D.G. Rokhlin).

Fig. 99. Recovery after amputation in connection with frostbite: in region of stump of proximal phalanx of big toe, closure plate stands out distinctly; medullary space closed (in distinction from that seen in Fig. 88, 91 and 93); sufficient amount of soft tissue covers stump (observation of D.G. Rokhlin).

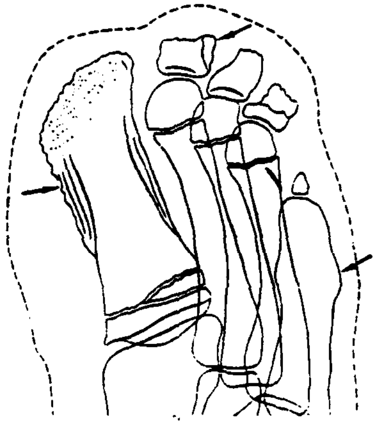

Fig. 100. Diagram of Fig. 99.

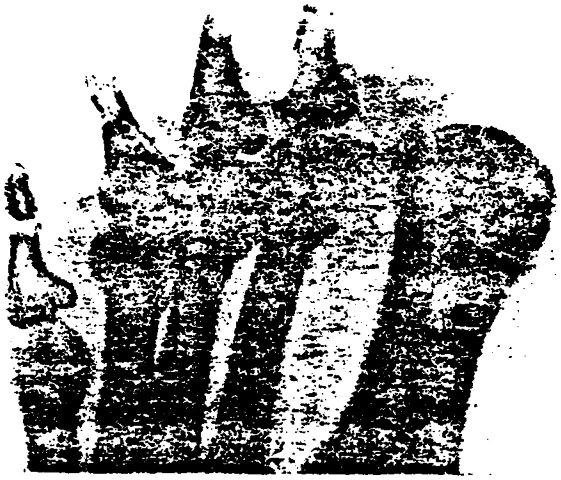

Fig. 101. IV degree frostbite: photograph made 2 months after frostbite and 3 weeks after surgery; demarcation zone in the form of a clear band passing through soft tissues and distal-medial part of head of I metatarsal; part of head separated by demarcation zone has undergone partial necrosis; distal sections of proximal phalanges of second, middle, fourth and little toes not covered with soft tissues; osteomyelitis of proximal phalanx of second toe (corrosion of lateral outline, detachment of periosteum from medial side); multiple pathological fractures of proximal phalanx of fourth toe; transverse pathological fracture of proximal phalanx of little toe; osteoporosis (observation of D.G. Rokhlin).

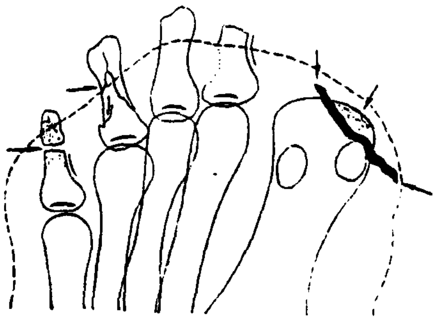

Fig. 102. Diagram of Fig. 101.

Fig. 103. II-III degree frostbite: formation of extensive blisters on foot (from dissertation of Grubina).

CHAPTER VII

COMPLICATIONS

Inflammatory processes in frostbite develop in sections subjected to cooling including sections in direct proximity to gangrenous tissue (third and fourth degree frostbite). Spread of the inflammation beyond the area of reversible degenerative processes and also the formation of limited suppurative foci localized in the zones directly adjacent to the demarcation band must be considered as complications of frostbite. These complications include a group of local inflammatory complications.

Besides the local, one must also isolate general complications and also complications of a trophic nature which develop primarily later on and can have both a local and a more extensive character. Frostbite (with a partial exception of first degree frostbite) is accompanied by a breakdown in the epithelial covering and the formation of an atrium for infection. Even when the blisters do not burst in second degree frostbite, as the studies of A.F. Verbov and A.V. Kudish showed, almost always one detects flora inside the blisters.

With third and fourth degree frostbite, as a rule, the presence of pathogenic microorganisms in the foci of necrosis were noted. Dry gangrene does not exclude the possibility of developing pathogenic bacterial flora in the necrosis zone. In just 10.0% of the studies made did one find an absence of pathogenic cocci (A.V. Kudish).

Moist gangrene also facilitates the growth of various flora. In the area of necrotic tissue lacking the immune properties present in live tissue, a thermostat condition is created where there is an adequate quantity of nutritive substances for microorganisms. The boundary between living and dead tissue begins with the first days after maturation and ends with the formation of a granulation torus.

As clinical studies have shown, the protected properties of the granulation torus are inadequate. A limiting band of granulation in the demarcation zone is formed simultaneously in different tissues. In denser tissues, for example, in the bone, this process lasts for a significant time period. As a result of nonuniform time development of granulation in certain sections of the demarcation band "weak" areas are created.

Besides the necrotic zone, as a result of the life activity of microorganisms and the elimination of gases during breakdown of tissue (which is particularly marked with moist gangrene), tissue pressure increases. At the same time with this, the gradual mummification of the surface of the necrotic tissues causes the formation of a crust on their surface and the drier they get and the more they become like armor the stronger is the tissue pressure. More than once we observed how near the demarcation zone under the crust of necrotic tissues blisters of ichorous fluid and gas formed.

The longer necrotic tissue exists in the organism the more dangerous it is for the organism as a whole because conditions arise during which the demarcation band becomes inadequate. Microorganisms and the products of tissue decay penetrate through it.

Degenerative-necrotic tissue with decreased vital activity scattered sometimes more compactly sometimes in separate sections in the zone of irreversible changes, and also to a lesser degree in the zone of reversible changes, is an anatomical substratum for the development of complications. The reactivity of these tissues, the nutrition and blood supply are broken down. In the first days after frostbite a period of anabiosis exists which is between life and death. If virulent microorganisms penetrate into this zone they encounter favorable conditions for development; toxic products of tissue decay which come in from the necrotic section deepen the degenerative processes which are already present in these tissues and facilitate their further change bringing the degeneration process to its limit and causing necrosis of the cellular elements.

All of these processes have a secondary character and a tendency to expand proximally to the root of the extremity. Degenerative necrotic changes occur at a higher lever than in the earlier period. The progessively ascending character of secondary degenerative inflammatory processes as they apply to the path of infection carry also an ascending character.

The frequency and intensity of ascending local and general complications, according to the data of different authors, vary considerably. This exists due to many factors and depends primarily on the character and degree of frostbite, the extent of its section, and also on the character of the gangrene and the methods of treatment.

The larger the segment of the extremities subjected to frostbite, the higher its degree, the more probable is the development of moist gangrene. The more conservative the treatment with heavily weighted circumstances the more acute is the danger for development and expansion of complications.

Complications of frostbite during World War II in the material in the chart of fundamental characteristics has a small percentage. In view of the fact that the history of the disease relates primarily to severe frostbite, calculation of the percent of complications for the entire quantity of observations is not of interest. According to the chart of fundamental characteristics, fourth degree frostbite is accompanied by complications four times more frequently than first and second degree frostbite and 1 1/2 times oftener than third degree frostbite (Fig. 106).

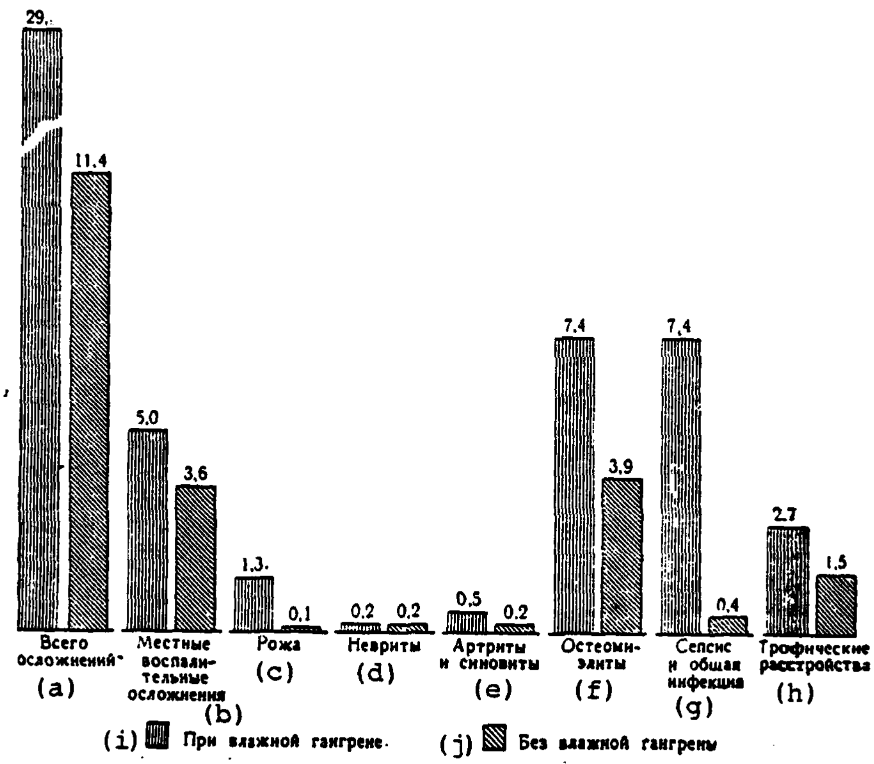

Fig. 106. Frequency of complications during frostbite with moist gangrene and without moist gangrene (for 100 cases of frostbite in each group).
Key: (a) Total complications; (b) Local inflammatory complications; (c) Erysipelas; (d) Nephritis; (e) Arthritis and Synovitis; (f) Osteomyelitis; (g) Sepsis and general infection; (h) Trophic dysfunction; (i) with moist gangrene; (j) without moist gangrene.

Fourth degree frostbite was accompanied by moist gangrene in 10.9% of the cases. Here in cases of frostbite of the toes, moist gangrene was noted only in 8.9% and basically with damage to the big toe. Frostbite extending to a higher level was accompanied by moist gangrene in 25.5%. With third degree frostbite the moist gangrene was encountered only in 2.0%.

With fourth degree frostbite if the gangrene extends to the proximal metacarpophalangeal or metatarsophalangeal vessels, almost always moist gangrene is observed. Special therapeutic measures (surgical and physical therapy) in a majority of cases can prevent the development of moist gangrene or facilitate changing it to dry gangrene.

With metacarpal frostbite or frostbite on surface sections located more proximally, the frostbite usually is accompanied by mummification and gangrene in these cases occurs in the dry type even with conservative treatment or in the absence of treatment.

In the frostbite zone the processes of moist decay of the tissues occurs as a result of death of certain groups of cells and sections of tissue. Then, as a result of the disseminated character of necrosis and untimely death of all cellular elements in the frostbite zone, total necrosis of the entire section sets in not immediately after the cooling but a few days later. Absorption of the products of tissue decay and the onset in the organism of pathogenic microorganisms and their toxins from the frostbite zone occurs, correspondingly, not immediately but after a certain time segment, in most cases adequate for the development of a frostbite boundary with a demarcation protective zone.

In a number of cases including rapid moist decay of necrotic tissues, the protective properties of the demarcation torus can be inadequate and toxic products of tissue decay, microbe toxins and virulent microorganisms penetrating through the zone of demarcation can cause, in a number of cases, local or even extensive separative and inflammatory complications.

During moist gangrene, the inflammatory phenomena in the zone lying within the band of demar ation al ys is more pronounced than during dry gangrene. However, the formation of boundary abscesses in this zone or the extension of inflammation to sections lying more proximally are not always observed. Therefore, the moist gangrene must be looked at not as a complication but as the course of frostbite during which conditions are created which facilitate the development of complications.

In the entire number of cases of moist gangrene with fourth degree frostbite, according to the chart of fundamental characteristics, one observes complications in 29.1%, that is almost 1/3 of the cases, which occur from moist gangrene and which had various complications. In those cases without moist gangrene complications occurred in 11.4% (Fig. 106). Moist gangrene with third degree frostbite was accompanied by complications in 20.0%.

Local Complications

In local complications one must primarily include suppurative and inflammatory processes which damage soft tissue, the osteoarticular apparatus and the neurovascular bundle.

Secondly, are complications with a predominant manifestation not of an inflammatory but of a degenerative-trophic character. These complications, as a rule, develop later on but elimination of the acute manifestations last for a long time after removing the injured areas on the surface. They are considered aftereffects of frostbite by some authors.

A clinical evaluation of local complications must start with the fact that during the uncomplicated course of frostbite there always exist inflammatory phenomena as the main reaction of the organism to the local cooling which has occurred. The degree of this reaction is subject to broad individual variation but inflammation, as a rule, is limited to seroinfiltration forms and is not accompanied by pronounced general reactions in the organism.

The appearance of suppurative inflammatory foci both in the zone of the reactive edema and higher must be evaluated as complications. This type of complication includes infiltrates which are limited or more diffuse located both in the thickness of the skin and in the subcutaneous cells in the deeper tissue. With transition of these processes to suppuration, phlegmons and abscesses are formed which are accompanied by the general reaction of the organism.

In view of the fact that these processes often have a torpid character and disturb the patient very little, not causing pronounced pain perceptions, particularly on a background of frostbite disorders in sensitivity which has been observed, diagnosis of the limited inflammatory complications presents well-known difficulties. Both the local and the general symptoms of the formation of suppurations can be inadequately pronounced.

Different authors, talking about the frequency of local complications, differ sharply in their figures. For example, according to Zuckerlandl's data the complications amount to 60.0% of the cases observed; K.I. Pikin (1941) notes complications in 20.0%; other authors have even lower percents. Apparently, the explanation for this can be found not only in the different severity of the frostbite cases but also in the different points of view of the authors as to the existence of complications.

Local complications in the material in the chart of fundamental characteristics with fourth degree frostbite were observed in 12.3% of the cases and for first and second degree frostbite in 2.8% of all observations. Local complications amount to 72.9% of all complications.

Damage to Soft Tissue

First degree frostbite rarely is complicated by suppurative processes. With second and third degree frostbite, separation from the epithelial layer of the epidermis is easily damaged which encourages infection of the blisters. Pathogenic microorganisms can be maintained in the epithelial layer causing a suppurative process in them which is usually not severe. With a virulent infection one observes death of the epithelial elements with subsequent development of granulation. In these cases, as a result of the transfer process, surface skin scars can develop with second degree frostbite which is not observed with uncomplicated frostbite of this degree.

Of 56 cases of second degree frostbite observed by S.A. Grubina during World War II, in 11 cases suppurative blisters were noted which were accompanied by more intense hyperemia in the environment of the blisters; this usually occurs during uncomplicated frostbite. Inflammatory phenomena were also detected in the lymph apparatus. The time period for treatment of these patients was considerably greater than in uncomplicated cases of second degree frostbite.

Besides the usual pathogenic microorganisms encountered in the blisters in the demarcation zone (A.F. Verbov, A.V. Kudish et.al.), in a number of cases Killian noted the presence of abundant pseudo-diptheria flora which did not give a picture of specific complications but considerably slow down regenerative processes.

Erysipelatous inflammation can complicate all degrees of frostbite. One should note that erysipelas in frostbite has a tendency toward a flabby course and is accompanied by low temperature and insignificant general phenomena. This complication is encountered fairly rarely and in literature there are only isolated mentions of it.

In the area of more reactive edema in the first days of frostbite one can observe manifestations of thrombophlebitis of the small subcutaneous veins and lymphangitis in a form with characteristic red bands and strips common for this complication without sharp outlines. Both with and without lymphangitis one notes swelling of the regional lymphatic nodes which show no particular characteristics in comparison with these phenomena in other diseases.

These manifestations are subjected to reversible development for a period of several days and only in rare cases does suppuration occur.

In A.I. Kulikova's material (1940) covering 273 cases of frostbite, lymphangitis is noted in 12.8%, and lymphadenitis in 8.8%.

Reactions of the lymphatic apparatus later on usually involve additional infection in the field of the frostbite or an increase in virulence of microorganisms introduced earlier.

Activation of infection can be observed after operative intervention which occurs at a fairly high level or with technical errors.

Phlegmons and abscesses are noted even oftener than lymphangitis and lymphadenitis. It is possible that their more frequent identification indicates greater severity in the course of these complications than was considered above.

In the material on the period of the war with the Byelofinns, complications were noted in no more than 3.0-5.0% of the cases.

As was already noted, the phlegmons and abscesses which develop in the field of the reactive edema occur without intense general manifestations, being first an infiltrate poorly shaped due to intumescence of the surrounding tissue. This type of complication which develops in the zone of healthy tissue usually is more acutely apparent which results in an earlier and easier identification of them. These inflammatory foci can be located in the subcutaneous cells, or in the deeper tissue and require surgical treatment according to general rules.

Thrombophlebitis and tenosynovitis which are encountered much more rarely than the complications listed above belong to this same group of inflammatory complications. According to A.I. Kulikova's data, thrombophlebitis of the large veins was observed in 4 patients; this was 1.4% of the number observed.

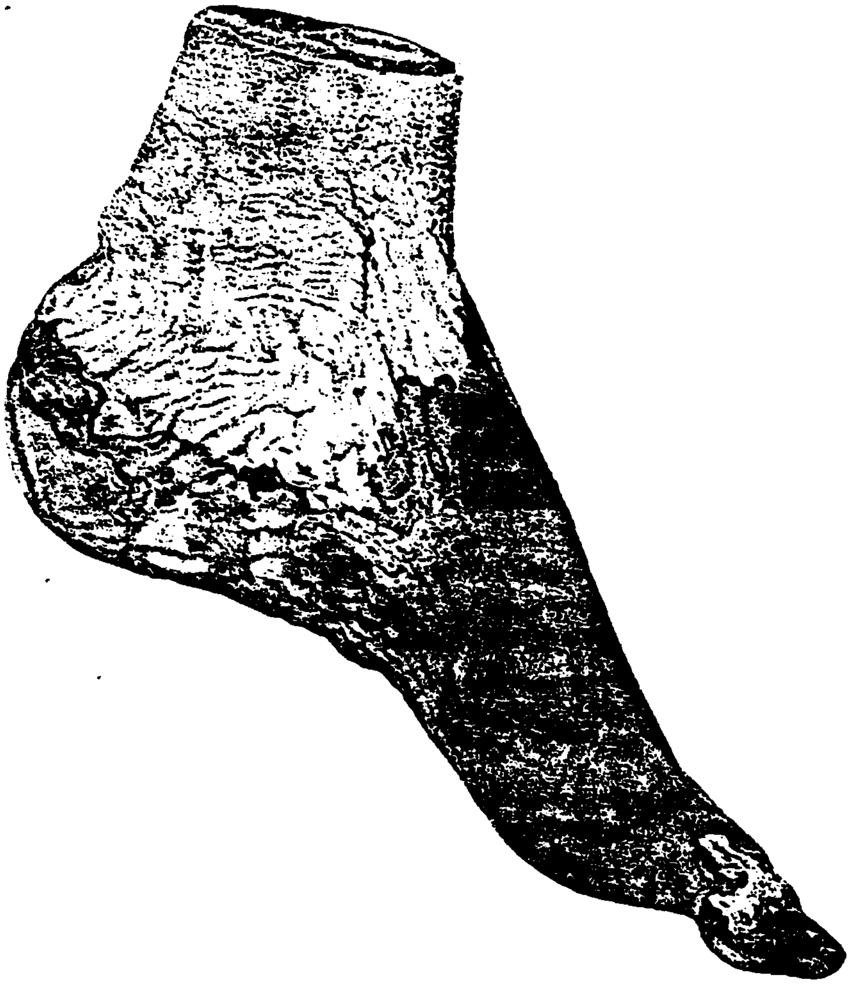

Fig. 104. Gangrenous stage with fourth degree frostbite. Specimen VMM No.4923/1852. (Artist L.V. Orlov)

Fig. 105. Gangrenous stage of necrotic tissue with fourth degree frostbite. Specimen VMM No.4277/1844. (Artist Ye.V. Tymnyak)

Inflammatory complications of the soft tissue, according to the data of the chart on fundamental characteristics, amounted to 1/3 of all complications; with first and second degree frostbite they were noted in more than half of all complications.

It is not always possible to take into consideration how often abscesses of blisters occur because in the history of the disease, as a rule, there were not the appropriate records. Clearly pronounced and obvious abscesses of blisters belong to the group of other complications. With first and second degree frostbite, other complications amounted to 0.9% of the number of frostbite cases of this degree.

Lymphangitis and inflammation of the regional lymphatic nodes were encountered in first degree in 0.2%, with fourth degree -- in 1.4%, comprising 29.0% of all local inflammatory complications. This complication is noted particularly often both in the upper and in the lower extremities if one considers the frequency of their being frostbitten. Lymphangitis with fourth degree frostbite and moist gangrene is observed twice as often as in all fourth degree frostbite cases.

As a rule, lymphangitis was developed fairly early: at the end of the first or the beginning of the second week after frostbite. Only in 4.5% of these cases did it develop later on after amputation.

In 5.0% of all complications with lymphangitis, abscesses occurred in the regional lymphatic nodes and required incision. In one case suppuration was noted with second degree frostbite and in the others with fourth degree frostbite.

One case of second degree frostbite of the entire left hand complicated by lymphangitis,later on ended in the development of elephantiasis of the forearm and part of the shoulder as a result of lymphostasis. 2 and 2 1/2 half months after frostbite this patient was treated twice with a circular novocaine blockade which was not effective. After 4 months of treatment there was still significant limitation of movement of the radiocarpal vessel and the fingers.

According to this same data, 43.3% of local inflammatory complications are abscesses. With first degree frostbite this complication is encountered in 0.4% and with fourth degree frostbite cases in 1.6% of the frostbite cases of the corresponding degree.

According to the data of the chart of fundamental characteristics with frostbite of the upper extremities abscesses were observed twice as often as during frostbite of the feet; this can involve slow or incomplete treatment with frostbitten hands.

Almost 1/3 of all cases of abscesses were observed much higher above the frostbite zone. Abscesses of the femur and buttocks amounted to 4.0% of all abscesses; in not one of these cases did frostbite spread above the foot. Abscesses on the crus were noted twice as often as on the femur and also mainly with frostbitten toes; only in 2 patients was the distal section of the foot frostbitten.

The ascending character of this complication is confirmed not only by localization of the abscesses but also by the clinical course. Often the formation of the abscess precedes the inflammatory state of lymphatic vessels, the appearance of the infiltrate and then its suppurative melting.

In one case with fourth degree frostbite of the distal part of the foot, even more than 2 months after frostbite an abscess was discovered on the heel. On the following day on the crus of this same extremity an open abscess was discovered. 10 days later on this same crus phlegmonous inflammation was discovered and as a result of this, incisions were made. 21 days later an abscess formed on the femur which was drained by incision.

In almost half of the cases the abscesses developed in regions next to the demarcation zone in sections of tissue changed by inflammation. According to the data of the fundamental characteristics chart, a number of cases of random opening of such abscesses was noted.

More than 1/5 of the abscesses developed later on primarily on the stumps after amputations were made.

Phlegmons during frostbite cases amounted, according to data of the chart of fundamental characteristics, to 24.7% of all inflammation complications which developed in the soft tissue. With first and second degree frostbite they were observed in 0.6% of the number of frostbite cases of this degree; with fourth degree frostbite it was 1 1/2 times more frequent. Frostbite accompanied by gangrene was complicated by phlegmons 2 1/2 times more often than frostbite without moist gangrene.

Among the cases of frostbite complicated by phlegmons, in a large percentage of cases (60.0 for the entire number of observations) surgical treatment was not made.

Phlegmons like abscesses, according to the data of the chart of fundamental characteristics, were mainly localized in the upper segments of the extremities, the proximal locations of frostbite and zones of reactive inflammation. Sometimes as a result of phlegmons, a double or triple incision was made each time at a higher level. All of this confirms the ascending character of complications during frostbite.

The development of phlegmons in a number of cases was preceded by thrombophlebitis and lymphangitis. In somewhat more than half of the cases the phlegmons developed in the zone of tissue changed by inflammation which, as was pointed out above, makes their timely identification difficult.

10.0% of all phlegmonous inflammations were observed on stumps basically after operative intervention not always done irreproachably.

Thrombophlebitis of the large veins which is more rare than the local inflammatory complications, according to the data of the chart on fundamental characteristics, amounted to 2.8% of the number of these complications. In the cases of frostbite encountered with varying serevity, thrombophlebitis was noted somewhat more frequently in fourth degree frostbite than in the lighter cases. In the majority of cases, thrombophlebitis developed 1-4 weeks after frostbite primarily in patients who were not subjected to surgical treatment.

In one case, the inflammatory process spread along the venous trunk after spontaneous breaking of the outside of the abscess located on the shin.

As a rule, the development of thrombophlebitis was accompanied by a temperature reaction within limits 38-39° and marked edema of the extremity. Conservative treatment was used in most cases. Over a period of 2-3 months in which relapses were often noted, thrombophlebitis usually was eliminated.

Of the other complications in this group one should note the 3 cases of bursitis in the area of the knee joint and 1 case of tenosynovitis of tendons of the second finger with fourth degree frostbite of all fingers.

According to the data of the chart for fundamental characteristics, in not a single case of local inflammatory complications listed was this the direct cause for a fatal outcome but sometimes sepsis set in which in a number of cases resulted in death.

Erysipelatous inflammation amounted to 0.2% of all frostbite cases. With second degree frostbite one case of erysipelas was noted; the others were noted with third and fourth degree frostbite.

In all of the cases considered there was frostbite of the toes and erysipelatous inflammation developed on the shin or femur. In some cases there was a creeping character to the process with an insignificant temperature or general reaction. Earlier than 2 weeks after frostbite the complication of erysipelas was not noted. The latest time period for the development of erysipelas was 4 months after the frostbite.

In 2 cases erysipelas had a phlegmonous character which required surgical intervention.

In one of the patients an erysipelatous inflammation of the stump was observed which was a complication of the amputation and stitches on the stump; the amputation occurred in the first month after frostbite.

In another case erysipelas flared up a day after necrectomy which was carried out with a great time delay in the third month after the frostbite.

Fatal cases with frostbite complicated with erysipelas were not observed.

The complications which arose in the vessels and nerves almost never showed suppuration. As is clear from the pathologoan tomical picture, they are only one aspect of complications developing in degenerative-trophic processes and are distinguished by a chronic course.

Showing vascular disorders and breakdown in sensitivity, these complications accompany not only the acute stage of frostbite; also remaining at the stage of scarring and epithelialization, the are basically late complications or the result of frostbite.

Damage to nerves which occurs due to local cooling has a subacute character. We are talking not about those nephritis cases which involve cooling of the distal section of the extremities subjected to frostbite but about inflammatory states of nerve trunks which are the result of cooling of the nerve along its length or the inflammatory process ascending along the nerve trunk.

Complications of the first magnitude were observed by T.Ya. Ar'yev and then by V.S. Gamov. In 1940, in patient P. who had been lying in the snow for more than 24 hours, characteristic manifestations of inflammation developed in the area of the ulnar nerve on this extremity which was subjected to great cooling.

Two cases of inflammation of the median and the ulnar nerves are described by I.B. Kibel (1941); A.I. Kulikova (1940) mentions two cases of paresis and paralysis without indicating their localization. In V.M. Agafonova's report (1941) cases of damage to the ulnar nerve are also noted.

The ascending order of nephritis was noted more than once in patients with a massive section of necrosis and prolonged conservative treatment. In these cases along the nerves one noted not only pain during examination but also spontaneous pain perceptions of a very severe character.

Damage to the Joints and Bones

If the demarcation line passes through a joint,arthritis develops which can be definitely stated only with histologic examination. However, clinically in these cases one does not successfully note the picture of arthritis because, as a result of breakdown in the joint capsule by the necrotic process, the cavity of the joint begins to open which usually is not accompanied by any pronounced inflammatory manifestations nor by a breakdown in its general condition. These cases essentially are not complications but they are the usual process of demarcation occurring.

In other cases,the joint capsules located close to the demarcation line can be subjected either to partial or very insignificant necrosis, or as the result of degenerative changes can be the site for microorganisms. In the absence of microscopically visible defects in the joint capsule, in the case of development in the joint of an inflammatory process, an inflammation exudate is applied and the picture of arthritis develops.

In view of the proximity of the infected zone these arthritis manifestations usually have a suppurative character and are accompanied by a pronounced general reaction. Arthritis similar in character occurs with third degree frostbite if the soft tissue covering the joint is subjected to necrosis; this is rarely noted in the upper extremities.

Arthritis occurring in the proximal zone of reactive inflammation sometimes at a considerable distance from it comprises a separate group; these cases have a metastatic character, for example, suppurative arthritis of the knee joint with fourth degree frostbite of the foot.

These manifestations of arthritis like other complications have an ascending character; they are caused by degenerative changes which create the foundation for infectious-inflammatory complications. However, development of similar arthritic manifestations on the side opposite the frostbite with single-sided damage was never observed.

Arthritis and synovitis, according to the data of the chart for fundamental characteristics, with different degrees of frostbite amounted to 0.1 to 0.3% of all frostbite of the appropriate degrees. In a significant part they were observed with frostbite of the fingers and ended with limited movement in the joints of the fingers.

Degenerative-trophic changes in the bone system also create the prerequisites for development of complications.

The process of demarcation in bony tissue is characterized by aseptic osteolysis along the line denoting rejection of the necrotic sections. Suppuration occurs fairly often in the soft tissue at this level. It is completely natural that the bone found in the zone of demarcation is subject to infection and in these cases one can state histologically that the picture is characteristic for osteomyelitis. However, if the inflammatory process in the bony tissue has a local character and does not have a tendency to spread, the clinical course remains favorable without a breakdown in the general condition of the patient and without pronounced local inflammatory symptoms. Therefore there is no basis for considering suppuration in the demarcation zone as a complication although in this process the bony tissue would be involved.

The osteomyelitic process which occurred in the zone of demarcation and spread proximally to the sections of bony tissue nearest to this zone usually have a chronic character with insignificantly pronounced clinical symptoms. In view of the closeness of the focus of osteomyelitis to the injured surface existing in the zone of demarcation, rarely one notes the formation of fistulas. Here, the number of suppurative discharges from the wound periodically increase greatly and fungiform granulation expands. The process of scarring and epithelialization is slowed down and generally stopped. X-ray study makes it possible to discover the changes which are described in the section on roentgenodiagnostics. Diagnosis of chronic osteomyelitis is established on the basis of a set of clinical and roentgenological data.

Osteomyelitis as histological studies in clinical observations by a number of authors show, develops no sooner than 2 months after frostbite. During this time period measures can and must be taken to decrease the danger of infection. These include early treatment including necrotomy and preparation of the stump for final operations. In many cases at this time amputations can be made with shaping of the stump. Thus, prevention of the development of osteomyelitis is a very urgent problem during correct treatment of frostbite.

The progressive and ascending chronic osteomyelitis undoubtedly has great importance for the further course of frostbite and to a well-known degree determines the treatment method.

The development of the osteomyelitic process closer to the demarcation zone is accompanied by more acute both local and general reactions. In the soft tissue surrounding the damaged part of the bone, infiltrates and abscesses can develop and later on fistulas can form. Usually after opening the fistula, the intensity of the inflammation manifestations drops and the course of the process takes on a chronic character. At times exacerbation can set in mainly with a delay in drainage. As was noted above sequestra hardly ever form.

Osteomyelitis with fourth degree frostbite is the most typical complication. One should differentiate osteomyelitis which complicates the course of the frostbite from the process which develops in the postoperative period and involves in a large number of cases incorrect selection of the level of amputation or defects in the techniques of the operation itself.

The frequency of complications of osteomyelitis in fourth degree frostbite is fairly high. However, before World War II there were no data in literature on this question based on a large number of cases and thorough study of the material. The published information stated the possibility of developing osteomyelitis with fourth degree frostbite but did not make it possible to judge its frequency. A significant number of cases of osteomyelitis noted by D.A. Novozhilov among patients who had undergone health resort treatment cannot characterize the state of this question inasmuch as these patients returned for treatment as a result of complications.

In the Hospital of the Surgical Clinic of the Military-Medical Academy im. S.M. Kirov in 1940 in 46 patients with fourth degree frostbite 3 cases of osteomyelitis were noted.

Of the 191 cases of fourth degree frostbite observed by A.I. Kulikova (1940-1941) 10 cases of osteomyelitis were noted which comprise about 5.0% of the number of fourth degree frostbite cases or 3.66% of the number of all frostbite.

The frequency of complications with osteomyelitis is directly connected to surgical tactics when treating frostbite. With conservative treatment osteomyelitis is often observed.

In one of the front hospitals (1943) where conservative tactics were followed and early treatment was not used, 69 cases of fourth degree frostbite had 8 cases of osteomyelitis of the foot, not counting 6 cases of osteomyelitis of stumps which developed after amputation.

D.G. Rokhlin notes that the frequency of complications from osteomyelitis in World War II was considerably reduced in comparison with the first year where modern methods of surgical treatment had not yet been adequately expanded.

In the first year of World War II, according to the data of a specialized hospital (S.A. Grubina) osteomyelitis with fourth degree frostbite was noted in 20.7% of the cases. This number included cases of osteomyelitis after operative intervention. This high percentage of complications with osteomyelitis cannot be explained by the severity of the condition of the patients who entered this hospital or by the use of conservative methods of treatment. It is more likely that cases of osteomyelitis in the demarcation zone were considered in which the histological picture was characteristic for this complication but which according to the reports presented above cannot be included in the complications because it is the process of demarcation in bony tissue.

Almost 1/3 of all complications, according to data of the chart of fundamental characteristics, are found to be osteomyelitis. With first and second degree frostbite there were no cases of osteomyelitis.

Fourth degree frostbite was complicated by osteomyelitis in 6.3%. This complication occupies the first place in fourth degree frostbite and is encountered somewhat more often with moist gangrene, namely, in 7.6% as opposed to 5.0% with dry gangrene.

There is particular interest in third degree frostbite which is complicated by osteomyelitis.

For third degree frostbite necrosis only of the soft tissue is characteristic. D.G. Rokhlin's studies showed that even in these cases as a result of a breakdown in the trophicity of the affected extremity, in the bones often one notes an ascending osteoporosis and onychoid tuberosity of the extreme phalanxes is subject to osteolysis with resorption primarily of the closed plate of the phalanx. The medullar channels are open which favors the penetration of infection. When infected necrotic soft tissue is next to it there is a real danger of the development of osteomyelitis. Prolonged lack of healing in third degree frostbite with luxurious fungiform granulation, sometimes club-shaped thickening of the fingers -- all of these are symptoms which indicate the probability of a chronic osteomyelitic process. Subsequent formation of fistulas makes diagnosis confirmed by roentgenography easier.

In certain cases one notes a sharp beginning to osteomyelitis complicated by the favorable course of third degree frostbite in the presence of a necrotic crust or a granulated surface.

A characteristic example of this complication can be the history of the disease in patient K who received symmetrical third degree frostbite of the toes in February 1943. At the end of April small granulated surfaces remained on his toes of approximately uniform size. On April 13 in the region of the frostbite toe I on the right foot showed intumescence, redness and pronounced pain; also manifestations of lymphangitis were apparent. This exacerbation was accompanied by elevation of temperature (see the temperature curve, Fig. 107). On April 20, the temperature dropped to normal but on May 2 to May 7 again exacerbation of the inflammatory manifestations was noted accompanied by a new elevation of temperature and the formation of a fistula on the medial-plantar side of the toe. On May 31 on a roentgenogram,clear destructive changes were apparent with periosteal stratification in the area of the base of the ungual phalanx and the middle of the basic phalanx, the abscence of a closed plate in the ungual tuberosity, a broad joint gap between the phalanxes. On June 10, the toe was amputated at the joint. Studies of the specimen showed the presence of osteomyelitis and suppurative interphalanx arthritis.

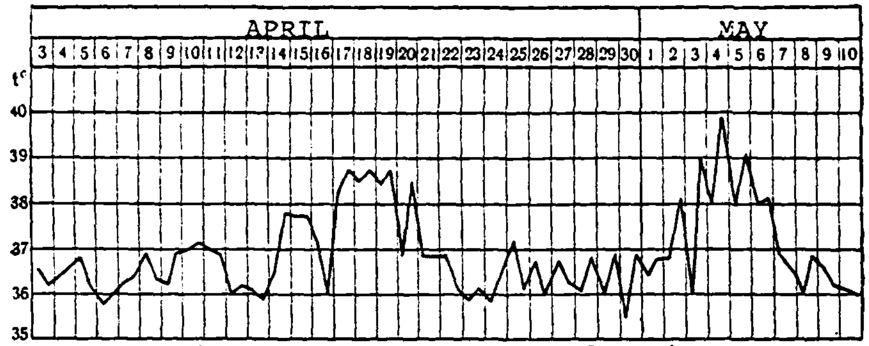

Fig. 107. Temperature curve of patient K. Third degree frostbite. Osteomyelitis.

S.A. Grubina noted osteomyelitis in 7.0% of all third degree frostbite from the material at the specialized hospital. This high percentage could be explained by a concentration in this hospital of persons suffering from severe frostbite, in particular, third degree with complications.

In certain cases, the development of osteomyelitis is possible in a much later period after frostbite, after scarring of the afflicted surface. Inasmuch as the regenerative processes in the bones are complete after 4-6 months from the day of frostbite, before this period has passed there is a real danger of infection penetrating to the bone.

Under conditions favoring it osteomyelitis can also develop in later time periods.

At one of the front hospitals in 1943 was patient N (history No. 1823) who had suffered third degree frostbite in 1940 of the first toe on the left foot which was scarred. A year later when walking the scar was irritated and began to swell and hurt. These symptoms disappeared after 3 months. Then a year and a half later on this same toe without any visible cause again there were inflammation symptoms and a fistula formed. In June 1943 the X-ray showed osteomyelitis and the ungual phalanx was amputated at the joint.

In the area of small finite defects of soft tissue on the fingers and toes in most cases one notes a long-term absence of epithelialization and scarring with a quiet clinical course. Several weeks after granulation they acquired a fungiform character and the ungual phalanx thickened; under X-ray examination the characteristic changes were successfully detected. The formation of fistulas were observed fairly rarely. In the smallest number of cases there was pain, temperature was elevated and local inflammation occurred. In these cases diagnosis was easier and finally confirmed by roentgenography.

Most typical was the following case. Patient R (history No.22/8929) received third degree frostbite of the first toe of the right foot in January 1945. Earlier surgical treatment was not carried out and on the ungual phalanx a section of moist necrosis formed; the subfebrile temperature lasted for 2 days. After 2 months of a smooth clinical course, a three-day temperature elevation was noted to 38° and there was pain in the foot. After 1 1/2 months, the temperature rose to 40°; sharp pain appeared, redness and excessive secretion from the wound; lymphangitis developed and rapidly a fistula formed which preceded a sharp increase in the size of the toe. Characteristic manifestations of osteomyelitis and arthritis were detected on the X-ray. The toe was amputated at the joint. Recovery.

More than half of the cases of osteomyelitis in third degree frostbite required amputation and exarticulation of the fingers and toes. Some of the patients were released who had not completed treatment.

With third degree frostbite osteomyelitis is in first place in complications comprising, according to the data of the chart on fundamental characteristics, 3.3% of the total cases of frostbite of this degree.

The treatment period for the patients with frostbite complicated by osteomyelitis is considerably longer in comparison with patients without this complication: with third degree frostbite -- 1.9 times; with fourth degree frostbite -- 1.3 times.

General Complications

Common diseases such as pneumonia, influenza etc. involving general cooling of the organism and a decrease in its immune strength have an indirect relationship to the complications of frostbite. The most frequent complication of frostbite is sepsis. This complication is directly related to the severity of the injury, that is, to the degree of frostbite, the dimension of the extremity segments subjected to the frostbite and also it depends on the course of the process encountering very often moist gangrene. In certain cases, the source of development of sepsis is local suppurative-inflammatory complications. According to literature put out in the light of World War II, it is difficult to judge the frequency of sepsis complications.

Losses from frostbite during the wars of the nineteenth century, according to the information available to us [N.I. Pirogov, Sonnenburg, Tschmarke, et al] were accompanied by a very high fatality rate considerably exceeding 20.0%. If one considers that the causes for death basically are freezing and sepsis, then one finds a significant number of deaths in the latter. It is natural that in the pre-aseptic period, frequency of complications and consequently fatalities were much higher than at the present time.

Peacetime frostbite at the end of the last century also was accompanied by a high percentage of general complications. Fremmert (1880) observed sepsis in 8.4%, V.I. Zagaryansiky-Kisel' (1896) in 12.3% of the total number of frostbite cases of all degrees.

During the war with the Byelofinns, A.I. Kulikova noted the development of sepsis in 6.3% of fourth degree frostbite and in 4.4% of the total number of observations.

In the material from the war with the Byelofinns and World War II, N.A. Shenk observed sepsis in 6.4% of 115 fourth degree frostbite cases.

At a specialized hospital on the Karelskiv front in the first year of World War II, sepsis from fourth degree frostbite amount to 5.2%.

However, S.A. Grubina separates from this number a group of patients who in his opinion had toxemia not sepsis.

In one of the specialized front hospitals in 1941-1942, sepsis with frostbite was the cause of death in 85.0%. Among patients with fourth degree frostbite 2.4% died from sepsis (V.I. Zharkova, Z.I. Roslyakova).

In 1943 at one of the hospitals at another front 6 cases of sepsis were observed in 69 cases of fourth degree frostbite. In all of the patients with sepsis there was massive frostbite of the lower extremities. In 6 of these the frostbite encompassed part of the crus. This group of patients is exceptional and can be used as an example illustrating the severity of the course with incorrect rough conservative treatment of severe frostbite. Almost all of the patients (14 persons) were subjected to moist and low temperature for an average of 8 days in damp trenches. In most of them frostbite developed occurring from trench foot and accompanied by moist gangrene. Earlier, surgical treatment was not used except for surface incisions in 10 persons which of course cannot be called full treatment. With progression of the gangrene intoxication occurred; later on all of the manifestations gradually increased and the temperature acquired a septic character.

In 5 cases excision along the demarcation line was done fairly late (on the average on the 24th day of the frostbite). In general active intervention was done by the 27th day and only in one case was amputation undertaken on the 4th day.

The time periods in which surgical intervention was carried out tell us that there is a possibility for its leading to the development of sepsis because the severe state did not develop immediately after frostbite.

In spite of undertaking operations, 6 persons died; moreover, one of the patients died on the 6th day of frostbite without being operated on.

In 540 cases of fourth degree frostbite in hospitals at the same hospital base, in all, only 7 cases of sepsis were recorded which ended in fatality (fatality rate 1.3%). Then in 2 of the patients there were severe wounds which accompanied the frostbite.

A much smaller number of cases of sepsis at one time in hospitals at this base in comparison with the hospital mentioned above is explained by the correct surgical tactics in treating the frostbite and is characteristic for all hospitals of the Soviet Army.

In a specialized army hospital, thanks to correct treatment, even with a significant number of cases of sepsis, the fatal rate with fourth degree frostbite amounted to a total of 0.2% (S.A. Grubina) which also is a characteristic manifestation.

In enemy armies on the Eastern front sepsis during frostbite, inasmuch as one can judge from isolated journal articles, was encountered often and had a high mortality. For example, Reimers indicates that in 80 cases of frostbite which occurred with necrosis (fourth degree according to our classification) 15 cases of septicopyemia occurred. This number included cases of a septic state in which suppurative metastases were not detected.

In our army, sepsis according to the data of the chart of fundamental characteristics with third degree frostbite was observed in 0.3%, with fourth degree -- 1.6% of the number of frostbite cases with this degree.

Sepsis involves mainly massive and multiple frostbite. In 12.0% frostbite of all four extremities was observed, in 7.7% -- of both shins. The most massive frostbite was noted in 25% of the patients with sepsis.

With third and fourth degree frostbite accompanied by moist gangrene, complications by sepsis amount to 8.3% whereas with dry gangrene it was only 0.83%, that is, was encountered 10 times less often.

The absence of surgical treatment and also the conduct of it in a later time period facilitated the development of a general suppurative infection. In 46.1% of the cases complicated by sepsis, treatment of the frostbitten sections generally was not carried out and in cases where it was done 65.5% occurred 10 days from the day of frostbite. In almost half of the patients with sepsis surgical intervention was done primarily with high amputations.

Sepsis was the basic cause of death in frostbite. In 3.5% of fatal results suppurative metastases were noted in different organs. A fourth part consisted of metastases in the lungs primarily from pneumonia with abscess formation. Much less often suppurative metastases were recorded in the lungs, kidneys, muscles, heart and other organs at the same time. Metastases in the kidneys was third in frequency. Moreover, in the slides phlegmons and abscesses were noted in muscles of the crus, femur, shoulder and in regions of the sternoclavicular articulation. In one case, suppurative coxitis was observed and as a result resectioning of the coxofemoral joint was done. In certain cases, sepsis was accompanied by suppurative meningitis and meningoencephalitis. In one patient abscesses of the brain were discovered.

In spite of the fact that death in persons who were not operated on set in on the average on the 27th day, two-thirds of those who died either had had no surgical treatment or the fact of such treatment has not successfully been established.

The average treatment time for those who recovered from sepsis amounts to 242 days.

Tetanus. During wars in the last century tetanus during frostbite, according to the data of Guterbach, amounted to 4.0% of all cases of tetanus. In the war of 1854-1855, in the allied armies we note 8 cases of tetanus during frostbite. Of 42 cases of tetanus during the Franco-Prussian war, 2 cases occurred with frostbite.

During the Balkan war of 1912-1913, also a number of cases of complications with tetanus were observed. According to the material of S.A. Novotel'nov, in 11 cases of tetanus 3 cases took place with frostbite. In the first World War, tetanus was observed by many authors. Lumier and Astier in 1914 observed 5 cases of tetanus during frostbite.

According to the data of A.A. Kudrinskiy (1936), the 39 cases of tetanus recorded in worldwide literature involving frostbite, had a mortality rate of 95.0%. A.I. Glagolev in 1938 reported to the All-Union Congress of Surgeons on 8 cases of tetanus.

Dyuken and d'Arkur recalled 3 cases of tetanus one of which ended in death out of 500 cases of frostbite observed in 1937 in the Spanish republic and army.

In the enemy army, according to Killian's information, all of the pathoanatomists noted cases of tetanus with frostbite: in the opinion of this author, the total number of cases of tetanus during frostbite in the German army exceeds 100.

Killian (1941-1942) also observed later cases of slowly developing tetanus which had an ascending character. The outcome in these cases was more favorable.

On the basis of published materials one can consider that tetanus during frostbite occurs severely and has a very significant mortality rate exceeding that for wounds. The severity of the course of tetanus during frostbite can be due to the presence on the path of penetration and extension of infection of tissues with decreased viability and resistance.

According to the chart of fundamental characteristics, among 11 cases of tetanus with frostbite, a fatal outcome was recorded in 7 cases. All of the fatal cases have two-sided and multiple frostbite. In 5 cases death set in from fourth degree frostbite; only in one patient were the distal sections of the foot frostbitten; in all of the other cases frostbite spread over the entire foot and even to part of the crus. In 2 cases of third degree frostbite which ended in death also multiple broad damage existed.

In most of the fatal cases the diagnosis of tetanus was established 1-2 days before death. Death set in on the 5-18th day after frostbite. In 3 cases tetanus developed during evacuation by railway.

In those who recovered from fourth degree frostbite also frostbite of the toes was noted. In one case recovery was from second and third degree frostbite.

The development of tetanus symptoms in those who recovered was noted on the 12-15th day of frostbite; in those cases, intensive specific and general treatment was quickly conducted.

The severity of the course and the fatal outcome for tetanus, according to the material in the chart of fundamental characteristics, were proportional to the extent and degree of frostbite and inversely proportional to the duration of the incubation period.

Anaerobic infection complicating the course of frostbite is encountered more often than one would think from the information in the literature. Except for Sheval'ye, other authors mention the complications in passing. In domestic literature also there is not an adequate detailed description of anaerobic infection during frostbite. However, almost all clinicians agree on the necessity for early and high amputation with complications of this infection.

Killian and Parch in the German army observed several cases of anaerobic infection during frostbite. The authors indicated that during frostbite the anaerobic infection occurs somewhat untypically: rarely one notes gas formation and elevated temperature reactions do not always exist, changes in coloration of the coverings also differ from changes observed during development of anaerobic infection in wounds.

Killian considers that the basic symptoms of anaerobic infection during frostbite could be considered to be increasing intoxication accompanied by a drop in cardiac activity. It is impossible to agree with this statement because intoxication is observed during a favorable course of frostbite and depends in these cases on a large surface of absorption.

The formation of toxic products in the necrosis zone occurs mainly due to life activity of putrefactive microorganisms. Contamination by anaerobic microorganisms, obviously, occurs often but as with wounds it does not play such a significant role in the development of later complications. Even the development of a virulent anaerobic flora in living tissue can be considered as a complication of anaerobic infection. According to bibliographical data such infection develops vigorously, progresses rapidly and in a short time period the patients die.

Anaerobic infection, according to the data of the chart on fundamental characteristics, was observed in a total of 3 cases. Not one of these showed typical gas formation.

In one case, surgical intervention was limited to incisions in the foot made at the DMP (Division medical station). The later course was favorable and at subsequent stages characteristics of anaerobic infection were not noted. It is possible that in this case there was no existing anaerobic infection.

Of the two patients who died, in one of them there was frostbite of both feet and parts of the crus and also the fingers of both hands and at the same time wounds in the chest with open pneumothorax, wounds of the buttocks and forearm. Moist gangrene of the foot and lower parts of the shin was accompanied by considerable intoxication and on the 19th day after frostbite the femur was amputated. Two days later anaerobic infection of the stump was observed accompanied by severe hemorrhaging. Death resulting from frostbite and anaerobic infection occurred on the 23rd day.

In another patient with frostbite of the foot an anaerobic phlegmon of the crus and femur was noted with considerable accumulation of pus. On the 21st day of frostbite the femur was amputated. Death occurred on the 46th day.

As is apparent from the facts presented, sepsis, anaerobic infection and tetanus are very serious complications developing mainly with severe massive frostbite and producing a very high mortality rate, particularly with inadequate or delayed surgical intervention.

The complication of diphtheria which develops on the site of frostbite, obviously, is rarely encountered. During World War II such complications were not observed. No appropriate literary data exist except for mentions by Killian on a few cases of diphtheria during frostbite observed by a few authors in the German army. These authors saw the original diphtheria of the wound during frostbite which was accompanied by toxic phenomenona and paralysis. Locally a change was noted in the character of granulation which became dry and covered with scabs. The specific treatment (serum) decreased the intensity of the general phenomena and improved the external appearance of the wound.

Later Complications and Aftereffects of Frostbite

In the group of long-term complications and aftereffects from frostbite are disorders primarily of a trophic character which remain after the processes of epithelialization and scarring are complete or which occur again in this period.

Pathogenesis and the clinical picture of the these long-term disorders have not been adequately studied yet. Anatomical and functional changes which develop as a result of cooling and involve a breakdown in blood formation and functions of the sympathetic nervous system are based on them.

N.N. Burdenko, T.Ye. Gnilorybov, Lerish et al, all note the important role of sympathetic innervation both in pathogenesis of frostbite and in the development of later complications. A state of stimulation of sympathetic nerves occurring due to cooling of the nerve endings is apparent in spasms of the vessels and later on is maintained by the pathological processes in sections of frostbite. The inflammatory process which is completed in severe frostbite by separation of the necrotic tissue and scarring of the wound surface shows the effect on the nerve endings causing overstimulation of the sympathetic nervous system.

Studies made by A.M. Geselevich, S.F. Gudunov, T.Ye. Gnilorybov et al.,also showed that in the pathogenesis of trophic ulcers of the extremities, in particular, after undergoing frostbite, a constant stimulation of nerve endings play a significant role.

Local frostbite, as a rule, is accompanied by disorders of skin sensitivity; many authors have considered this.

In 1941, M.I. Sandomirskiy, in 119 cases of frostbite, pointed out that these disorders are retained not only in the zone of frostbite but also spread considerably higher. One can truly state that after one and half to two months there is almost complete recovery. S.N. Davidenkov and A.F. Verbov in the material on World War II not only confirmed this fact but also indicated a number of special features in the character of disorders and their topography. S.N. Davidenkov noted the appearance of a segmental repercussion on the side which had not suffered frostbite.

M.I. Sandomirskiy observed disorders and sensitivity in light cases of freezing where changes characteristic for frostbite had not occurred in the form of reactive inflammation and called these manifestations an obliterated form of frostbite.

According to the data of the chart of fundamental characteristics, nephritis was encountered in 0.1-0.2% with all degrees of frostbite and occurred benignly in general.

Among the disorders indicated many were very persistent lasting for a long time after clinical cure of the frostbite.

Among the trophic disorders after frostbite one should include acrocyanosis, erythrosis of the skin, hyperkeratosis and hypertrichosis, changes in pigmentation, breakdown in growth of the nails, anhydrosis, and most often hyperhydrosis of the extremities. These are related to disturbances in lymph drainage caused by the phenomenon of elephantiasis and also sclerotic processes which developed in the skin and cells system and sometimes in the ligament-joint apparatus.

From patients examined by A.A. Sagal, in 6.2%, the trophic disorders were apparent in the scarring stage and in the others in earlier periods. Hypertrichosis was noted in more than half of the cases; also acrocyanosis was often encountered. Hyperhydrosis was noted in half of all observations (according to S.N. Davidenkov).

In 49 cases of frostbite observed by I.V. Zherdin in 3 cases after 1-2 months the phenomena of persistent cyanosis was noted and in 6 other cases -- hyperkeratosis. Among the patients D.A. Novozhilov often noted hyperhydrosis.

Delays in healing of wounds, if they did not depend on chronically occurring osteomyelitis, often were unidentified for a long time and could be considered also as a disturbance of the trophics. In certain cases of third degree frostbite scarring of the open surface did not occur for a long time; the edge of the area acquires a callous character, granulation is flattened and sometimes disappears completely; a typical trophic ulcer with scanty discharge and extremely torpid course is formed.

With osteomyelitis, the open surface does not have a lifeless appearance, granulation is more abundant even with a tendency toward fungiform growth and the quantity of secretion increases greatly with time.

The frequency of trophic ulcers, according to the data of S.A. Grubina, with third degree frostbite amounted to 3.9%. Roentgenography conducted on many patients made it possible to exclude the osteomyelitic process.

Absence of healing of the wounds can be observed with fourth degree frostbite after autorejection of the necrotic sections and after their excision along the demarcation line or close to it. If then a defect in the soft tissue is formed which does not cover the stump and scars appear adhered to the underlying tissue.

According to M.S. Ioffe's material, in 18.0% of the cases after excision along the demarcation line, these manifestations involved osteomyelitis; in other cases, the absence of healing could not be explained by the inflammatory process in the bones.

According to the observations of A.D. Postnov and R.M. Ryskin, in patients treated at health resorts, in connection with the frostbite suffered, ulcers of a callous type were noted in 37.0% of D.A. Novozhilov's 50 patients and 6 of these had trophic ulcers.

With adhering and nonfixed scars even with healing of the injured surface, after the patient was released from the hospital sometimes ulceration of the stump began, stubbornly resistant to treatment although the patient was not returned to bed.

Trophic ulcers which developed later in persons who had suffered frostbite are described by our authors and by foreign authors. T.Ya. Ar'yev observed a trophic ulcer of the shin 15 years after frostbite.

Trophic disorders in the material of the chart on fundamental characteristics were noted in 0.7-1.8% including complications with various degrees of frostbite. They developed mainly with a delay in healing and other disorders described above; some of the patients were discharged with ulcerated surfaces on the frostbite area.

Among the trophic disorders ulcers localized on the frostbite section are in first place. They comprised 46.4% of all trophic disorders and most often were encountered with third degree frostbite. Only one case of formation of ulcers was observed in second degree frostbite.

In almost half the cases the patients were released from the treatment institutions with healed ulcers. The time period for remaining in the treatment institutions for this group of patients exceeded the average time period by 20% for the stay of all patients with different trophic disorders.

Frostbite plays a definite role also in the etiology of spontaneous gangrene or obliterative endarteritis. Many similar patients indicate that they suffered frostbite earlier. In 1913, S.S. Girgolav, using Tsege-Manteyfel's classification, considered the thermal damage as the moment predisposing the patient to the development of spontaneous gangrene. V.A. Oppel' and other authors indicate a connection of endarteritis with frostbite.

In the surgical clinic hospital of the Military-medical Academy im. S.M. Kirov, in the postwar years, several patients were treated for obliterative endarteritis whose anamnesis indicated frostbite.

It should be noted that trophic disorders including obliterative endarteritis often develop after first and second degree frostbite.

Cyanosis and persistent cooling of the extremities was noted in 9.2% of all trophic disorders. Disturbances in blood formation and lymph drainage often accompanied by edema were recorded in 7.3%. Different nerve disorders of the "cooling" nephritis type, pain in the extremities, disorders in sensitivity, etc., amounted to 3.3% of the entire number of trophic disorders. A third of trophic disorders were a combination of disorders with disturbance of blood circulation, sweating and ulceration.

The average time period for treatment of first degree frostbite complicated with trophic disorders amounted to 53 days and second degree frostbite 82 days; this significantly exceeds the average time periods treating frostbite of the corresponding degree including those which occur with other complications.

According to the data of the chart on fundamental characteristics, out of 29 patients in which it was established that they were affected by cold, only one quarter were subjected to cooling for less than twenty-four hours. All of the others have been affected by cold for a considerably longer time period. In this example it is very clear that the duration of cooling for the development of trophic disorders is very significant. On the whole according to the group of trophic complications the average treatment time exceeds that for all frostbite cases studied by 1 1/2 times.

From Table 38 and Fig. 108 it is apparent that the frequency of complications under different degrees of frostbite increases in parallel with the degree of damage. The frequency of complications of third and fourth degree increases considerably especially due to osteomyelitis and sepsis which with other degrees of frostbite were not encountered in the material on the chart for fundamental characteristics.

A comparison of the indices presented in Table 38 of the frequency of complications with the bibliographical data indicates that in spite of the great severity of the cases studied the number of complications both as a whole and separately are considerably lower than data published at different times by different persons. It is impossible not to draw a connection with the general achievements of Soviet medicine and, in particular, the development of new methods of an active complex of surgical treatment of frostbite; we will be talking about this in the appropriate section.

As is seen from Fig. 108, local complications for all degrees of frostbite are an overwhelming majority particularly if one takes into consideration that a considerable number of other complications separated into a special group belong to them. With first and second degree frostbite these complications are developed primarily in the soft tissue; with third degree, the complications involve the bones and joints and take on great importance, developing even more than with fourth degree frostbite.

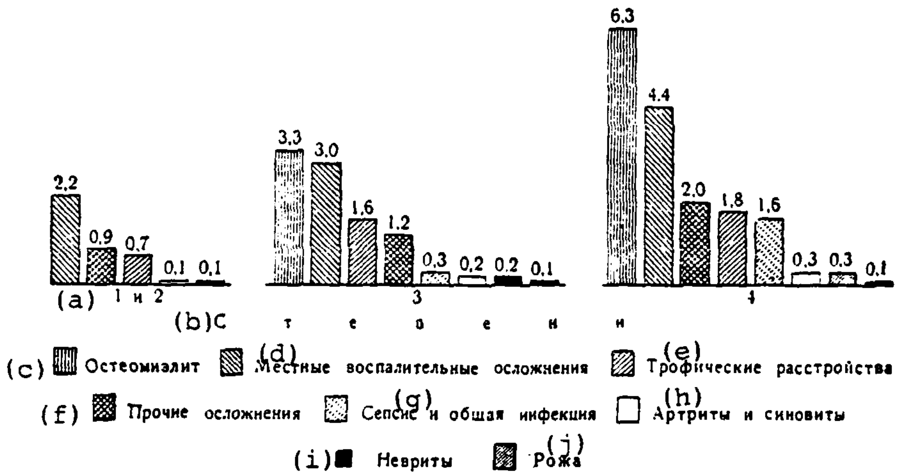

Fig. 108. Frequency of complications with different degrees of frostbite (in percentages of the number of frostbite cases of the appropriate degree).
Key: (a) and (b) degrees; (c) osteomyelitis; (d) local inflammatory complications; (e) trophic disorders; (f) other complications; (g) sepsis and general infection; (h) arthritis and synovitis; (i) nephritis; (j) erysipelas.

General complications with first and second degree frostbite occupy an extremely insignificant position, progressively increasing with third and fourth degree.

Delayed complications of trophic disorders play a significant role in first and second degree frostbite; with third and fourth degree frostbite they are even more important.

Table 38. Frequency of complications with different degrees of frostbite in percentages for frostbite cases of the appropriate degree.

Осложнения (a)	I—II степень (b)	III степень (c)	IV степень (d)
(e) Местные воспалительные осложнения	2,2	3,0	4,4
(f) Рожа	—	0,1	0,3
(g) Артриты и синовиты	0,1	0,2	0,3
(h) Остеомиэлит	—	3,3	6,3
(i) Сепсис	—	0,3	1,6
(j) Невриты	0,1	0,2	0,1
(k) Трофические расстройства	0,7	1,6	1,8
(l) Прочие осложнения	0,9	1,2	2,0

Key: (a) Complications; (b) first and second degrees; (c) third degree; (d) fourth degree; (e) local inflammatory complications; (f) erysipelas; (g) arthritis and synovitis; (h) osteomyelitis; (i) sepsis; (j) nephritis; (k) trophic disorders; (l) other complications.

CHAPTER VIII

TREATMENT

First Aid

Rendering first aid for frostbite involves creating conditions for raising the temperature of the frostbitten sections of tissue to the level where it is possible to have a normal course of biological processes. Particularly important here are the measures taken in the "latent" period of frostbite.

The character of intervention by a physician depends completely on what stage the frostbite patient is in. It is different for the latent period and for the period after warming. In the first case first of all it is necessary to restore the normal tissue temperatures; in the second place one must treat the pathological processes depending on the extent and the stage of the frostbite. In both cases, general measures are taken, primarily warming of the patient.

A patient who has been frozen or received frostbite should be placed immediately in a warmed room. Instructions by old authors as to the need for intermediate temperature stages for warming persons who were frozen, particularly those who are frostbitten, must be abandoned. To the large number of experimental works in clinical observations which confirm what has been said we can add that even the highest temperature of a warm room will be lower than the body temperature of a living person who dies from hypothermia. Thus, transition even of an extremely cold person to a very warm room under these conditions will not be sudden. As to patients with frostbite, as a rule these do not involve pronounced hypothermia and fear of damage by rapid warming is not well founded even from the point of view of the old authors. In any case, during World War II, with very weak patients who had been sharply cooled intermediate therapeutic measures were not recommended in the old textbooks (rubbing with snow, undressing the person completely in the street, in cold straw, etc.). In freezing, in a number of cases one must resort to artificial respiration which must be done in as warm a room as possible. Here one must not be afraid of increased brittleness in the tissue of the person afflicted and decrease the scope or force of movements. Along with general warming of the patient, tonic measures should be taken: the patient is given hot tea, coffee, alcohol, cordial, and also the frozen extremities are actively warmed. It is hardly necessary to discuss in detail the so-called rapid or slow warming of frostbitten extremities. It is adequate to point out that the traditional requirement for slow warming of frostbitten extremities has no scientific basis. It is clear that immersing the frostbitten extremities whose body temperature is relatively high (10-15° above 0) in an ice bath means subjecting them to further and additional cooling. This is why, according to existing instructions in the Soviet Army, one may decrease the temperature of the initial baths when warming frozen extremities to no more than 18° inasmuch as then the tissue temperature will begin to undergo serious disorders of circulation. In 20-30 minutes a water bath is heated to 37° and further warming of the water in the bath is not done. The water bath is accompanied by washing the legs with soap and lightly massaging them. After signs of circulation appear (the skin turns rose-colored, there is a rise in temperature) warming and massage of the extremities is stopped. The skin is rubbed with alcohol, aseptic and warmed bandages of sulfur cotton batting are applied to the affected extremity and the patient is evacuated to the rear. There must be no lubrication of the skin with oil, vaseline, fat or particularly dyes because this makes subsequent treatment of the frostbite more difficult. As experience has shown, the use of warm baths for heating frozen extremities is not always possible although undoubtedly in a number of cases, for example, when the PMP (Medical aid station) are located in buildings in conditions with a stable front this can be completely accomplished. If setting up warm baths is impossible, circulation is restored by massage. Of course these measures are carried out only in the "latent" period because after warming when acute dermatitis is possible (blisters) or necrosis, massage is not carried out. It is known that there are number of arguments against massage mainly the danger of infection when rubbing skin affected by cold.

However, in spite of the fact that all of the frostbitten sections of the body which have been rubbed at one time or another the quantity of infectious complications for these frostbites is not high as is indicated in the statistical data. Therefore in those cases where there is no possibility of using warm water baths and, consequently, rubbing is the only method of restoring circulation, massage must be used. Inasmuch as the first aid measures in the "latent" period of frostbite is carried out at BMP (Battalion medical station) or PMP or even at selfhelp or mutualhelp stations, equipment for these measures must be simple. Massage is best done with freshly washed hands dampened with vodka or alcohol according to the general rules (in the direction from the periphery toward the heart). It is recommended then that active movement at the joints be done. Rubbing with snow is not advantageous inasmuch as the effect of the snow with frostbite is not recommended. On the other hand, the snow can contain sharp pieces of ice which can abrade the skin opening it up to infection. Often the snow is contaminated and the temperature of the snow is always below 0°; frequent application of it cools the skin more and the use of snow for rubbing the frostbitten extremities is not advantageous. Also the use of vaseline, oil or fat for this purpose is not expedient. Vodka or alcohol moistening the skin however disinfects; moreover, these substances in winter combat operations are always available to the medical service in troop units. After completion of the rubbing (after circulation of the blood is restored) an aseptic bandage is applied and also heated bandages, the extremities are elevated and the patient is evacuated to the rear. Measures are taken for warming the patient during transportation (sleeping bags, fur coats, heating units, etc.).

It is necessary to take into consideration that in a number of cases the patients must be transported without warm foot gear, then they are bandaged as heavily as possible so that there would be no particular concern about warming their feet.

First aid after warming, in particular, with trench foot requires the use of at least general means for building up the organism inasmuch as essentially the treatment measures are applied locally. Removing the foot gear in this period, including the felt boots, can be difficult due to swelling. Frostbitten extremities,edematous and covered with blisters,are treated as described as below.

After the frostbitten section is warmed,further treatment is given regardless of whether or not warming occurred due to the first aid or occurred spontaneously without special measures.

Patients with frostbite usually see the physician after the "latent" period when there is no necessity for special measures for warming the cooled sections. Nevertheless, disorders of the peripheral circulatory system remain and the primary problems for treatment are elimination of these disorders and recovery of circulation. The following problem includes preventing the development of infection,conducting measures capable of rapidly eliminating necrotic tissue from the organism; the presence of this necrotic tissue characterizes high degrees of frostbite. Finally, the problem of treatment also includes coordination of the regenerative process.

In practice it seems that one or another of the treatment measures taken for frostbite facilitates solving not one but several of the problems indicated above at the same time. In particular the warm baths with disinfectant, application of solutions containing vasodilating and antiseptic substances on the frostbitten sections, the use of physical therapy procedures (sun lamps, ultrahigh frequency, quartz, etc.) and the effect on sympathetic innervation are all involved.

Treatment of first and second degree frostbite is carried out by conservative methods. The damage does not respond to operative treatment and the surgical methods used, for example removal of blisters, are not of particular value.

For third degree frostbite the operative methods of treatment are very important but other conservative measures play an important role in therapy of this damage.

Fourth degree frostbite accompanied by necrosis of segments of the extremities are the basis for operative treatment used in combination with other therapeutic measures.

Conservative Treatment

The simplest physical methods. Beginning with the oldest works on treatment of frostbite before reports published in recent years, restoration of circulation was given a great deal of attention. But many authors did not clearly differentiate the purposes of measures made in the "latent" period and after the period of warming the frostbitten area. Questions of giving first aid and subsequent treatment therefore are not sharply divided and certain authors look at them as a single time problem. This error depends on the absence of a precise understanding of the significance of the "latent" period.

Warming frostbitten sections is done with first aid. Consequently, in the time after warming the person it is impossible to talk about additional warming. However, full recovery of circulation with first aid does not occur in all cases. Restoring normal temperature to tissues does not mean that the necessity is lost for further improvement of blood supply which in many cases remains inadequate for a long time.

The oldest available widespread method of treatment is massage of the extremities. Taking into consideration the presence of damaged skin during frostbite, some authors recommend observing particular care during massage.

Rhythmic massage of the blood vessels with equipment with rapidly changing pressure is not widely used in practice. More widespread are active movements of the extremities carried out directly or using special devices.

Immersion of the frostbitten extremities directly into cold and hot water, the so-called mixed baths, changing vascular tonus facilitates improving the blood circulation.

Dry heated air was used to improve circulation and also as a means for facilitating mummification.

Ordinary electrical dry air baths are universally used.

Modern authors all agree that it is expedient to elevate the extremities.

Topical Use of Medicines

Before World War II and in the years preceding it, treatment of frostbite was universally conservative. Earlier radical operative treatment had been used only in war time. Actually this is why a large number of different liquids and oils used for the treatment of frostbite are described. It would be impossible to give a systematic survey of all of the medicinal substances used for treating frostbite or even to give a simple list of them in view of the fact that there are so many of them.

When using any of these it is necessary to take into consideration the decrease in regenerative capability and disorders of circulation, etc.

One should note that for treatment of frostbite there is no substance which would have a specific treatment effect just as none exist for treating wounds. Even with a correct evaluation of the character of the pathological processes occurring in sections subjected to frostbite one can name various medicinal substances which have a favorable effect on frostbite.

For example, antiseptic and tanning substances are as useless in the stages of scarring and epithelialization as it would be to use substances to speed up epithelialization in the stage of necrosis.

Alcohol solutions of aniline dyes are widely used, in particular, brilliant green, methylene blue, methyl violet, gentian violet, Rivanol etc.

Without negating the positive treatment effect of the dyes indicated, it is necessary to note that they do not have any kind of advantages over the colorless similarly acting solutions but do have the great disadvantage that the dyes put on to the damaged surface muffle the clinical picture and make it difficult for observation, and consequently, determination of the degree of damage.

Ethyl alcohol has practically complete satisfactory antiseptic tanning and vasodilating properties. Therefore, its use along with the substances listed above is completely correct.

The removal of necrotic sections during frostbite is done at the present time with primary treatment of frostbitten sections (necrectomy, necrotomy). Therefore, the medicinal properties used in the past to speed up separation of necrotic sections, at the present time, have lost their importance to a great degree. The substances which facilitates separation of necrotic tissue are pepsin, cresol baths, tricresol-formalin, often Vishnevskiy's ointment and fish oil and also solutions of ammargene, iodobromine water and certain mineral waters, for example, from the Matsestinskiy source.

Speeding up separation of necrotic tissue by systematic subcutaneous injection of Bogomol'ts's antireticular cytotoxic serum was noted by B.E. Linberg.

Various ointments which contain a slightly stimulating substance including Vishnevskiy's ointment, Mikulich's ointment and also, for example, xeroform and other slightly antiseptic ointments are some of the substances which primarily stimulate the regenerative processes, and in particular, speed up epithelialization.

Beginning in 1934 at the same time that vitamins were begun to be used for treating wounds, certain authors began to use similar substances for frostbite.

For treatment of frostbite also orange juice and tomato juice containing vitamin C were used topically.

To speed up epithelialization and decrease pain, I.A. Krivorotov (1937) recommended naphthalene.

The substances mentioned far from exhaust the list of all those proposed but make it possible to get an idea of the many forms from which the practicing physical must make a correct selection corresponding to the stage of the process and the problem of treatment.

Here symptomatic treatment which must be used during frostbite is not considered sufficient.

Effects on the sympathetic nervous system. The spastic state of the vessels during frostbite is caused by the corresponding impulses transmitted along the sympathetic nerve fibers.

As N.N. Burdenko indicates, the state of over-stimulation of the sympathetic nervous system which occurs during cooling is maintained at a later time period when cooling has already passed. In the opinion of many authors (N.N. Burdenko, A.V. Vishnevskiy), the causes for maintaining stimulation of a sympathetic nervous system are those pathological processes which are developed in the frostbite sections (inflammation, degeneration, necrosis).

In order to interrupt the reflector arc and remove the vascular spasm, A.V. Vishnevskiy and then also Lerish, proposed methods of temporary or permanent interruption with sympathetic innervation. Temporary switching off is achieved by introducing anesthetizing solutions in any section of the reflector arc which causes a functional interruption in the sensitive fibers and eliminates the cause for maintaining the sympathetic nervous system in a state of over-stimulation.

Vishnevsky's method, well known under the name lumbar novocaine blockade,was used for treatment of frostbite in 1933-1934, and in 1940 it was verified in the significant material of G.P. Kamenska, and also in the perinephric anesthetic tested by A.S. Korovin, D.N. Fyedorov, I.I. Kumin et al. P.I. Chulkov from the A.V. Vishnevskiy clinic experimentally showed the positive effect of lumbar and brief novocaine blocks on the course of frostbite both in the latent period and in the period after warming.

The authors who used a novocaine blockade (I.I. Kunin, D.N. Fyedorov, A.S. Kakhovskiy) noted that after injection, the blood supply to the frostbitten sections was greatly improved, local temperature was increased, severe pain was decreased and an acceleration of the processes of separation and regeneration was observed.

Later on the use of a novocaine blockade in certain cases has a favorable effect significantly speeding up processes of separation and regeneration but with early use the effect achieved was short term.

With frostbitten upper extremities sometimes they resorted to anesthetistization of the stellate ganglion of the sympathetic nervous system.

In order to achieve a more prolonged interruption of the reflector arc, surgical intervention was used on the sympathetic nervous system including periarterial sympathectomy, resectioning of the arteries, (Dyuken et al) and extirpation of nodes of the sympathetic nerve trunk. Observations indicated that the higher intervention was made the more prolonged its effect was.

In the French and English press, several tens of cases were published treated with the indicated methods. In recent years the German and Italian surgeons also have described a number of cases of frostbite treated by infiltration with anesthetics and the use of sympathectomy. These successes achieved with these methods expressed in a more favorable and somewhat accelerated course of processes in the frostbitten sections have attracted the attention of foreign surgeons to the question of operative intervention of severe frostbite and has facilitated the conduct of old conservative methods even in cases where active intervention was required. Certain surgeons have evaluated this method as auxiliary and have devoted most of their attention to the operative treatment.

In the Soviet Army during the war the Vishnevskiy method for treatment of frostbite had a fairly limited use. In a number of front hospitals it was used in order to speed up the reparation and rejection processes and also as an effective means of combating pain. In a specialized army hospital S.A. Grubina used a novocaine blockade in almost 8.0% of all the cases of frostbite, noting in approximately half of the cases analgesia and acceleration of healing.

According to data of the chart for fundamental characteristics, for the entire period of the war intervention in the sympathetic nervous system was carried out in 2.5% of all frostbite cases. Of the total number of interventions of this type only 6.1% were conducted before 6 days from frostbite had elapsed, that is, in the early period. The basic mass occurred at a later date. A fourth of the interventions in order to affect the sympathetic nervous system involved a local novocaine blockade carried out within the limits of the affected extremities. A lumbar novocaine blockade was used 3 times less often than a local blockade. Surgical operations on the sympathetic nervous system were very insignificant amounting to 1.0% of the total number of interventions. In the other cases the character and time period of interventions were not established.

A.V. Vishnevskiy's method, although it was not used widely for treatment of frostbite during World War II, was used with success by a number of authors (N.K. Blyum and M.F. Kuchin, D.N. Fyedorov and A.S. Korovin, V.M. Osinovskiy et al) on a comparatively small number of patients.

Evaluating this method it is necessary to note that a novocaine blockade which speeds up the process of rejection and improved blood supply to the damaged sections must be used as one of the effective treatment methods when treating frostbite in the period after warming. However it should be taken into consideration that it cannot replace effective surgical methods of treatment for third and fourth degree frostbite and therefore must be included in the auxiliary means for treating severe frostbite.

Physical therapy for frostbite. Soviet physical therapy was begun to be used for treating frostbite with physical methods during World War II using the experience acquired during the preceding war with the Byelofinns (1939-1940). The experience of this war and then of World War II with even greater confirmation indicated that the outcome of frostbite to a significant degree depends on the character of first aid.

Warming of the patient in the early "latent" period of frostbite is of basic importance. Warming can be done using a number of methods of physical therapy both with equipment and without. The physical therapy factors actively affect the tonus of the vegetative nervous system controlling the blood circulation which, during frostbite, usually breaks down particularly on the periphery.

In the "latent" period of frostbite the pathological state of circulation is still basically reversible. The importance of early active use of physical therapy methods is apparent from this.

Selection of a physical therapy method of treatment of frostbite and a combination of physical therapy methods with it is determined by the clinical picture of frostbite. The special features of the clinical picture determine also the individual dose of physical therapy stimulant in each particular case.

Active physical therapy treatment of frostbite usually was combined with surgical treatment. The role of the physical therapy factors in this complex treatment process is extremely large inasmuch as they are particularly the active stimulators for the vegetative nervous system, circulation of the blood and lymph, and decrease the danger of infection and accelerate regeneration.

Restoring temperature, circulation and metabolism in the "latent" period of frostbite, while it is not yet successfully been developed to combat the inflammatory process after warming, this is achieved both by simple and by more complex physical therapy methods. During warming,methods of light-electrical-water-heat treatment are used, besides mechanical stimulation of the vasomotor activity using massage. Massage used with its well-known precautions is a powerful therapeutic means in the prereaction period. In this period, the energetic use of heat in any form is necessary;achieved in conditions of front circumstances: bags with hot sand, heating pads, local hot water baths, and also methods of equipment physical therapy in the form of warming using radiant energy: sun lamps and Minin lights, infrared rays and local light baths.

Movable physical therapy cabinets constructed in the first years of World War II made it possible to make these physical therapy methods of treatment more available in the early stages and to give early assistance in certain cases in the "latent" period of frostbite.

The UHF electrical field occupied a leading position in physical therapy for frostbite as a result of the special features of the physical effect of the field on the one hand and the character of pathological changes which have developed in frostbitten tissue on the other hand.

The problem of warming in the "latent" period involves heating the entire thickness of the damaged extremity. When using the methods listed above of light-water-heat treatment, warming occurs from the surface toward the inside, that is, from the outside to the inside. When attempting to rapidly warm deeply with these methods of light and heat treatment, using large quantities of radiant heat, the danger arises of thermal damage to the surface tissues. Then deep sections are warmed slowly in view of the poor heat conductivity of the tissue through which the thermoflows must penetrate going from the surface to the depths.

The UHF electrical field is one of the means which provides a deep heating of the tissue. The "large coefficient of deep effect" (G.L. Frenkel') is inherent in this method of electrical therapy. For the UHF electrical field, the ohmic resistance of the skin is not a barrier; the skin is "transparent" for the force lines of the current and therefore the UHF field does not show a heated surface effect and the entire thermal effect is apparent in heating of the deep tissue. The latter is very important in therapy for frostbite particularly in the "latent" period when it is necessary to restore temperature and circulation in deep sections of all affected extemities. In view of this effect by the UHF field, deep heating occurs in the treatment conditions for the frostbitten tissue -- without the formation in them of "abrupt temperature gradients." The danger of peripheral overheating decreases. This is one of the great advantages of the UHF field used in order to achieve rapid warming during frostbite. The latter is accomplished through an air space -- a gap between the radiated surface and the electrode which is also an advantage in this method making it possible to have a noncontact effect on the damaged tissue.

The possibility of deep heating of frostbitten tissue exists when using diathermy but due to the fact that with diathermal frequencies ohmic resistance of the skin is not yet indicated, this method in comparison with the UHF field has a smaller coefficient of deep effect.

The UHF electrical field creates in the depth of the irradiated organ intense resistant hyperemia and establishes, in this way, a flow of blood in the field of frostbitten tissue. A vasodilative effect is achieved thanks to the UHF field on sympathetic innervation.

When warming the frostbitten extremities in the experiment the temperature both of the extremity itself and of the blood flowing from it is rapidly and stably elevated. Then the temperature of the tissue which at the lowest point of cooling is lower than the temperature of the blood is elevated more rapidly than the latter. At the same time with the heating one observes a rapid restoration of the normal turgor of the frozen tissues (F.S.. Belitskaya, G.S. Shatalova).

The vasodilative effect in the depth of the tissue is developed at doses which do not give a subjective perception of heat, the so-called oligothermal doses (about 0.5 W).

Inasmuch as the vascular system is affected during frostbite, each trauma to it facilitates increasing the pathological changes in the frostbitten tissue. From this the necessity arises for a basic measurement of the UHF field varying for the "latent" and the period after warming. In this period warming has already set in and the therapeutic value both when using the UHF field and other physical therapy factors, consists of decreasing or eliminating the inflammatory-degenerative and necrotic processes expressed differently depending on the degree of frostbite.

V.A. Militsyn, on the basis of personal experience in treating frostbite with the UHF field emphasizes that the smallest overdose results in increasing pain, increasing edema and with second degree frostbite leads to bleeding in the blisters, etc. An increase in these pathological symptoms with overdoses results in a secondary spasm of the vessels from overheating tissues after the use of the UHF field. Here it is possible also that continuing heating of the tissue after the use of the UHF field plays an important role.

This phenomenon of a subsequent increase in temperature of deep tissues after switching off the UHF field was established in an experiment: if the extremities reach a temperature up to +24°, +27° and the field is shut off, then a further increase in deep temperature occurs which is explained by the adequately restored flow of blood. Independent warming of the extremities occurs in a warm bath but its effect is not stable inasmuch as after the bath is stopped the temperature for a certain time continues to increase and then drops again. A pronounced and fairly stable deep independent warming is observed under the effect of the UHF electrical field in persons subjected to frostbite.

On the basis of the special features described for the UHF field effect on the thermal condition of tissue in comparison with other physical therapy factors, favorable results in the use of UHF for frostbite begin to be understood particularly in the early period when the pathological changes in the tissues have not yet been reversed to any significant degree. Thus, according to the data of I.V. Zherdin, in persons subjected to treatment with UHF field in the first two days after frostbite, third degree frostbite does not generally set in. This is confirmed by V.F. Yershov in material for use of the UHF field during the war with the Byelofinns and particularly: if radiation is begun early the percentage of first degree frostbite was high but the percentage of third degree was low; with late radiation, on the other hand, the percent of first degree is low and third degree is high. This, of course, cannot mean that when third degree frostbite sets in it can be converted to first degree. We are talking about the possibility with early radiation of a UHF field in the first hours and days to prevent a severe course of frostbite in some of the cases. I.V. Zherdin had the possibility of beginning radiation with UHF electrical field in the first days. In his observations, the "early use of UHF clearly changes the course of frostbite -- improving it; the process ends with the least loss of tissue or even recovery."

With the inflammatory-necrotic process developed, after warming with an UHF electrical field, the number of pathological symptoms primarily pain and swelling are considerably decreased or eliminated. However, one must take into consideration the negative aspects of the use of UHF including an increase in bleeding of the tissues, breakdown in granulation and disturbance of the barrier function of the demarcation ridge.

Physical therapists,both Soviet and foreign who have used this method of treatment for frostbite unaninously remark on the pain removing, antiinflammatory mummification effect of the UHF field.

The earlier physical methods of treatment are used,the more favorable is the outcome for all four degrees of frostbite.

Selection of the method and dose depends on the severity and extent of pathological changes. With first degree frostbite the physical therapy methods are using in order to decrease pain and combat dystonia of the vascular walls, as well as increase penetrability of it by stases.

With first degree frostbite, necrosis of the tissue is macroscopically absent; microscopically one observes marked disorders of the tonus of the vascular wall and circulation. Capillariscopically one observes phenomena of the so-called spastic-atonic symptomocomplex. The visible vessels are not outlined clearly as if immersed in pericapillary edema. In order to eliminate these reversible vascular changes ultraviolet radiation is used in massive doses -- 10-20-30 and even up to 60 biodoses. In the first days of radiation usually the treatment is conducted each day for four days. When using these massive doses the pain is decreased, stases are eliminated, the flow of blood is speeded up and dystonia of the vascular wall is decreased. This is explained by the effect of ultraviolet rays on the capillaries (the capillaries found in a collapsed state begin to circulate the blood). Then resorption of the edematous fluid is speeded up, the tissue becomes more elastic, edema decreases and functions improve.

Of the other methods, light treatment is used with topical light baths and the heat lamps, thermal topical water baths with temperature 36-37°, and also local baths with contrasting temperatures -- from 37° to 40° and from 22° to 18°. First degree frostbite during World War II was widely treated with topical darsonvalization,used for frostbite even in the first months of the war with the Byelofinns. This method also improves the tonus of the vascular wall, accelerates the flow of blood, decreases pain and swelling.

A rapid effect is achieved by early use of the VHF electrical field in oligothermal doses with a small gap of 1 cm lasting of 5-10 minutes daily. The course of treatment is very short -- 2-3 procedures.

If vascular disturbances of a stagnant character with the development of cyanosis predominate in the clinical picture,topical darsonvalization is indicated; with sharply pronounced manifestations of inflammation and edema, the VHF electrical field; with pronounced pain -- sequential use of VHF and ultraviolet radiation. If pain is due to arthritis and myocyotosis accompanying the results of cooling, methods of heat treatment are the most indicated.

Early treatment by physical exercise facilitates restoring functions of frozen extremities (V.V. Gorinevskaya et al.).

With second degree frostbite, physical therapy is used in order to affect the inflammatory reaction developing with death of the upper layers of the epidermis and the formation of blisters which are usually removed before physical therapy. Alternating changes in peripheral circulation are marked in the form of venous stagnation, foci of hemorrhaging, stases and edema.

In the first stage antiinflammatory measures are taken in order to protect the tissue from infection, accelerate regeration and decrease pain. Experience showed that it was advantageous to use the so-called open method of treatment of frostbite where the frostbitten extremity is put under a housing fitted with one or two incandescent bulbs of 40-60 W.

With second degree frostbite basically the same methods of physical therapy are used as with first degree but in a different dosage. In order to decrease pain, topical ultraviolet radiation is used once every 2-3 days, in 10-15 biodoses and also extra-focus radiation of the appropriate reflexogenic zones once every 4-5 days.

One should keep in mind that the photosensitivity of the skin during frostbite is sharply decreased which is evidence of the involvement of the vegetative nervous system.

After ultraviolet radiation in the indicated doses, the response reaction appears in the form of intense multiplication of the epithelial cells; this is one of the signs of an increase in the regenerative-reparation process. The extra-focus radiation (4-6-8 biodoses), besides decreasing pain gives a stimulus for increasing regeneration and this is desirable once every 4-5 days alternating with local radiation in view of the fact that the "focus ultraviolet radiation stimulates the regenerative process only in the first few sessions" (I.A. Piontkovskiy).

Of the methods of electrical therapy, electrophoresis of novocaine and dionine is used both for pain relief and stimulation of blood circulation.

The use of the UHF electrical field has an antiinflammatory effect. At first pain is reduced or it disappears during the session or is absent even for some time after it but then the light intervals are lengthened and in a large number of patients after 5-6 sessions the pain is fully stopped. In all of them without exception very rapid decrease in swelling occurs. The UHF electrical field is used also topically for foci of damage, encompassing a small section of the surrounding healthy tissue and also on the appropriate reflexogenetic zones. The expediency of combining the local effect of the UHF field with subsequent ultraviolet irradiation is established by a test method.

In order to suppress pain and stimulate blood circulation diathermia is used by longitudinal and lateral methods. The more proximal parts of the extremities are subjected to heating.

The methods of physical therapy used often make it possible from session to session to observe a favorable effect on the basic symptoms of frostbite; this is reflected in the capillaroscopic picture. Then the background of the fields of vision are apparent, the vascular loops are enlarged and more correctly positioned; aneurysmatic swelling disappears and the loops are more clearly enlarged which is a sign of the disappearance of the edems; this occurs with the change in rate, character and rhythm of the blood flow. According to Ye.A. Zakharova, the pathological state of the vessels, however, is not fully recovered in spite of the clinical improvement.

As is well known with third degree frostbite the entire thickness of the skin is damaged, the subcutaneous cells and other soft tissues as well. Necrotic tissue is covered with bubbles and one observes a granulated surface. The problem of physical therapy also envolves eliminating pain, accelerating rejection of the necrotic tissues with the formation of demarcation lines, improvements and acceleration in the development of granulated tissue and prevention of infection.

With third and fourth degree frostbite, among the physical therapy methods, the best is the UHF electrical field.

After the first radiation treatments, the pain and edema usually drop. The further problem is freeing the organism of the necrosis focus. By using the UHF electrical field it is prepared in the same way as preparation for surgical intervention. Oligothermal doses stimulate the growth and development of young granulation tissue.

Development of granulation tissue is activated also by ultraviolet radiation. The intensity of radiation must not exceed 2-3 biodoses locally and outside the focus on the reflexogenetic zone or on other undamaged surfaces of the body it is 3-6 biodoses at intervals of 4-5 days.

The development of granulation tissue is stimulated by other simple methods of light treatment particularly infrared radiation. With flabby granulation and inadequate epithelialization it is recommended that one use paraffin applications for 12-24 hours (Obrant). In order to combat immobility of the joints physical exercise methods are used.

For fourth degree frostbite physical therapy procedures usually call for the UHF electrical field for a period of 3-5 days after conducting necrotomy and necrectomy. After removal of the necrotic sections massive doses of ultraviolet radiation are indicated. When the process changes to the granulation stage again it is recommended that one use a UHF field and hypoerythermatous doses of ultraviolet radiation. When using the UHF field mummification occurs more rapidly as well as formation of the demarcation line.

Purulent-septic complications caused in the period of physical therapy require strict surgical intervention after which with the appropriate indications one can continue physical methods of treatment.

Treatment of stumps formed after incorrect treatment of frostbite is successfully done with a combined use of ultraviolet radiation in the UHF field. According to data of I.I. Levin, Ye.A. Zakharova et al., gray granulation covered with purulent encrustation, under the effect of massive doses of ultraviolet rays (300-800 ultraviolet units) completely changed its appearance; it became rosy pink and the growth in fungiform granulation decreased.

With the appearance of pronounced edema and pain in patients with stumps from frostbite, the authors used an alternating UHF field for 10 minutes with a gap of 1-2 cm and power up to 3 W. After 4-5 sessions, the clinical picture was considerably changed.

With an adequate dosage after 2-5 sessions, purification of the infected ulcers occurs and after 3-5 sessions swelling disappears and healing begins.

After completion of the formation of a demarcation zone and the beginning of mummification it is recommended that the extra-focus radiation with massive doses of ultraviolet rays 100-1000 ultraviolet units according to Zal'kindson be used.

The expediency of subsequent combined treatment of frostbite with UHF and ultraviolet radiation is confirmed by other authors.

With this combined therapy one notes a rapid elimination of swelling, a change of the moist gangrene to dry, acceleration of epithelialization and scarring. Alternating these methods gave the following results. First each factor gives a favorable effect and this effect decreases or disappears completely, apparently, as a result of the tissue becoming accustomed to the series of single stimuli. Experience in treating frostbite showed, in this way, that changing the stimuli is advantageous in spite of the long use of one or another method.

Positive results of treating first and second degree frostbite with combined use of the UHF electrical field and erythematous doses of ultraviolet rays were observed by Korolev and Rokitavskiy.

Experience in conducting functional therapy in hospitals by combining methods of physical therapy and treatment with gymnastics showed the advantages of this combination.

From what has been said above it follows that with treatment of frostbite positive results can be achieved by using separate methods of physical therapy and by combining them.

During World War II and then in the post war years also natural therapeutic factors were used in the form of health resort treatment mainly for the aftereffects of frostbite. Gas waters were used, mud packs, heliotherapy, climate therapy, and napthalene. The first experience in treating frostbite with natural waters containing sulfur and hydrogen goes by to 1940 (A.G. Pershin). A.G. Pershin observed 50 patients with frostbite received during the war with the Byelofinns. The most effective results were achieved with flabby granulated surfaces. In these cases, combined therapy was used: Matsestin'skiy baths, solar treatment, diet rich in vitamin C and potassium. The author emphasizes that Matsestin'skiy baths have a pain reducing effect and improve pulsation of arteries in the feet. An analysis of the dynamics of vasomotor disorders made it possible for the author to propose that treatment with Matsestin'skiy sulfur-hydrogen waters helps prevent endarteritis.

There are observations showing that water containing iron and carbon-hydro-carbonate-sulfate-sodium-potassium waters have a favorable effect on frostbite (I.A. Valedinskiy, V.A. Druleva). V.A. Druleva treated 100 patients with iron water baths. Most of the patients had suffered from third and fourth degree frostbite. 79 patients were treated early -- 8-10 days after frostbite. The duration of the treatment of the patients suffering from third degree frostbite equals 3-4 weeks and in certain cases 5-6. With fourth degree frostbite, 2-3 days after amputation of one or another part of the damaged extremity (48 cases) treatment with the baths was begun. Healing of the wounded surface occurred without complications (31 cases).

Also, a favorable effect was noted from "Yessentuki Narzan" gas waters used in 88 cases of third degree frostbite (A.S. Vishnevskiy). The baths made of "Yessentuki Narzan," in combination with therapeutic physical exercise and the generally used measures were very effective in these patients.

All-union type resorts were used for treating frostbite including the mud resorts at Saki, Yevpatoriya, Maynaki. V.A. Shturm observed 188 cases of frostbite 71 of which had wounds and frostbite. The author tended to use mud baths with average temperature. The high temperatures in his observations, not only did not have a favorable effect on healing of the ulcerated stump but caused an increase in ulceration and in a number of cases a relapse after healing.

V.G. Dik, on the basis of experience in treating frostbite with mud in the Caucasus mineral waters, also considers it advantageous to use decreased temperatures when treating the aftereffects of frostbite. A method of mud compresses was developed for treating frostbite cases.

V.A. Shturm and V.G. Dik explain the necessity for using average stimuli of a thermal magnitude in the presence of alternating and trophic changes for the aftereffects of frostbite.

According to Vishnevskiy, treatment with an open method using baths comprised of "Yessentuki Narzan" and a complex resort therapy gives outstanding results both anatomically and functionally.

A favorable effect of the Matsestin'skiy baths on the regenerative process can be explained by an improvement in the state of the peripheral circulation and tissue exchange. An important role probably is played by active histamine-like substances which are released in the skin. Positive results of using hydrogen sulfide Matsestin'skiy waters can also be explained by stimulation of tissue breathing by the hydrogen sulfide.

The very powerful effect of the Matsestinsky hydrogen sulfide waters on the regenerative process was noted by I.A. Valedinskiy, S.S. Girgolav and his school. K.M. Bykov, G.L. Frenkel' et al. turn their attention to the fact that local hypothermia, the pathological state of circulation and exchange of the distal part of the organism involve a number of aftereffects in the entire organism and, in turn, the opposite extremity. This position takes on importance when treating frostbite with physical factors. The necessity for using physical therapy measures not only in local procedures but for damaged extremities becomes fully obvious but it must be done outside the focus of general effect.

According to this method, as one sees from what has been presented above, during World War II, the physical therapy treatment with therapeutic waters for frostbite was accomplished. The positive results obtained are evidence of the correctiness of this complex treatment process preceding and following the ordinary operative intervention.

Due to the fact that the reactive phenomena on the part of frostbitten tissue are detected very soon after warming with the help of mobile physical therapy units, it appeared possible where military circumstances permitted to provide the early use of the methods of physical therapy for frostbite which have been enumerated. Here differentiated instructions where established for each method separately and for a combination of them into a whole complex of physical therapy in surgical treatment of frostbite.

General treatment methods. General treatment for frostbite is directed at the fastest possible restoration of strength of the organism and support of its regenerative capabilities. It is carried out from the first days of frostbite. Later on a good deal of attention is devoted to the vitamin balance of the organism in order to begin appropriate nutrition.

General illness involved with the cooling of the body which often accompanies frostbite is treated according to the general rule like complications occurring during frostbite. Treatment of frostbite is accomplished depending on the character of the complications taking into consideration the tendency for most complications toward a flabby course.

Surgical Treatment

Frostbite accompanied by gangrene of a large or small segment of an extremity, according to modern classification belongs to the fourth degree which was given surgical treatment for a long time.

In the nineteenth century and earlier most surgeons maintained opinions as to the necessity for early amputation of the extremities particularly during frostbite in wartime. They had weighty evidence to base this on inasmuch as significant part of the frostbite occurred with moist gangrene with the development of septic complications and had a high mortality rate.

In the French army in the war of 1854-1855 more than 20.0% of all victims of the cold died as a result of complications. During the war in 1870-1871 in a single hospital 200 persons died as a result of frostbite. Brazhnevskiy in the Russo-Turkish war in 1877-1878 noted 52 fatal cases out of 800 cases of frostbite (6.5%).

As methods of aseptics and antiseptics were introduced into surgical practice the number of complications was reduced for severe frostbite and the death rate was reduced.

By the end of the last century certain surgeons proposed the use of conservative treatment recommending that early amputation be avoided waiting for the appearance of a clear line of demarcation. Certain authors recommended in general refraining from amputation waiting for the frostbitten area to reject the necrotic tissue. Nevertheless, at the beginning of the first world war 1914-1918 as in the preceding wars (1904-1905, 1912-1913) early amputation for frostbite was very widely used.

V.V. Gorinevskaya notes that unfamiliarity with the "conservative method of treatment of frostbite resulted in the fact that experienced doctors widely used primary amputation for frostbitten extremities and as a result a large number of invalids with amputations of two, three or sometimes four extremities exists."

Unsatisfactory results of early amputations, large numbers of suppuration, phlegmon and other complications on the one hand and a relatively favorable course with an insignificant number of complications during conservative treatment on the other facilitates reconsidering views for treatment of frostbite.

Beginning in 1915 a significant number of works appeared in the press propagandizing the use of conservative methods for treatment of frostbitten sections.

The overwhelming majority of the French and German authors favored conservative methods of treatment of frostbite. As a result of the publication of these works not only was the number of early amputations decreased but also surgical activity was sharply reduced for treatment of frostbite. In the French army according to Jacob's data, the number of amputations for trench foot compiled in January-April 1914 as 1.4% of the number of all injuries was reduced to 0.79% in December 1917 and in January 1918. This decrease in the number of amputations was noted in the German army.

Thus, the majority of surgeons supported conservative methods of treatment expecting spontaneous separation of the necrotic sections. However it should be pointed out that strictly conservative treatment was accompanied not only by long maintenance of the patients in treatment institutions but in a number of cases one noted the development of increasing inflammatory complications in the form of phlegmons, phlebitis and often severe increasing intoxications. As a result of conservative treatment, incomplete combinations appeared with scars joined to the underlying tissue which were easily ulcerated. Often one observed the formation of trophic ulcers. Such a situation satisfied neither the surgeons nor the patients and was a stimulus for taking more activity in treatment of frostbite.

However this activity in most cases was limited to measures which facilitated more rapid mummification of necrotic tissue and their separation. For this purpose different methods of physical therapy and medication were used.

Only a few surgeons undertook greater action; they removed necrotic sections sometimes along the line of demarcation and sometimes within the limits of the necrosis in the area near the line of demarcation of a joint, and sometimes along the proximal line of demarcation.

In certain cases incisions were made for the entire depth of the necrosis in order to cause an acceleration of mummification.

However, these operative interventions do not have the same character as had been developed and adopted in the Soviet army as necrectomy. In the post war years a certain amount of work was done in plastic surgery necessary as a result of frostbite; this is evidence of the unsatisfactory results with conservative treatment of frostbite. Among these works attention should be given to the report by N.N. Petrov as to 12 cases of plastic surgery for skin shredding with unhealed ulcers on the foot after frostbite.

The Civil War in Spain (1936-1938) during which there were a few cases of frostbite did not produce anything new in methods for operative treatment of frostbite if one does not count intervention in the sympathetic nervous system.

On the whole in the question of treatment of frostbite, in spite of separate attempts to conduct active treatment right up to the second world war, conservative views continued to predominate.

In the Soviet Union in the middle 1930's, the problem of frostbite was subjected to a basic reconsideration and complex study by the S.S. Girgolav school. In connection with new views on the existence of processes during frostbite, questions of treatment were reconsidered. As a result of practical work in this field which coincided with the war with the Byelofinns (1939-1940) a new method of treatment of frostbite was developed and scientifically founded.

An increase in the interest in treating frostbite could be noted in capitalist countries; this was due to the appearance of a considerable number of cases of frostbite at the beginning of the second world war. However, in the field of operative treatment it is impossible to note any kind of progress except for fairly broad use of operations on the sympathetic nervous system.

The general tactics of foreign surgeons could be anticipation of the suppuration of necrotic tissues; only with a prolonged process of suppuration did some of them advocate early amputations in order to speed up the formation of the stump and to achieve its full value. Other authors continued to stick with conservative positions using operative intervention only to correct stumps after self-suppuration.

The war with the Byelofinns attracted the attention of Soviet surgeons to the question of treatment of frostbite. However, a predominant conservative use in this field and lack of practical experience showed up in the surgical tactics for treating high degrees of frostbite.

Most surgeons continued to support conservative methods of treatment. Ya.M. Lurye indicates that among the surgeons the wait and see conservative approach predominated or the idea that "almost all patients should be treated conservatively up to the point where the demarcation line is defined at the level separating the nonviable part of the foot."

Treatment periods for fourth degree frostbite presented in the works of A.F. Lukanova, O.N. Bychkovoy, Ya.A. Naftoleva et al., based on observations relating to the war with the Byelofinns, in a number of cases were 120-150 days. One should take into consideration that the indicated time periods related only to patients who had completed treatment.

As a result of incompletely healed stumps which formed with conservative methods of treatment, frequent development of osteomyelitis, trophic ulcers and other disorders, some of the patients were readmitted to treatment institutions (A.I. Kulikova et al., 1940). This was in conflict with positions of Soviet physicians who required complete treatment in as short a time period as possible for the return of persons injured in the war to creative duty and the return of as many as possible to military service.

The unfavorable results and length of treatment lead to a reconsideration of old views. Certain surgeons began more active intervention for fourth degree frostbite but, as a result of the absence of adequate experience in treating frostbite, selection of the level and time period of operations in a number of cases was unsuccessful. Amputation sometime was conducted before eliminating acute inflammatory phenomena; this often showed up in the general condition of the patients and could not facilitate healing. In other cases, amputation was made along the line of demarcation which also often caused the development of complications, prolonged treatment and could not facilitate the formation of a stump.

Cutting off the limb along the line of demarcation as a method of operative treatment for frostbite was fairly widespread. In the material by O.N. Bychkovoy and Ya.A. Nafftol'eva amputation along the line of demarcation occurred in 2/3 of all operations. For 191 cases of fourth degree frostbite, A.I. Kulikova showed 94 cases of amputation along the line of demarcation and several above it.

The method of amputation at first glance appears to have low trauma and facilitate rapid healing. Actually amputation takes place in an area where the soft tissue is already demarcated by granulation from the zone of necrosis and where the bone to a known degree has been subjected to resorption. Therefore such intervention does not require much time; usually in these cases one can use short-term ether or cloroethyl anesthetic. Cutting of the tissue does not produce significant bleeding and the necessity for tying off the vessels is nonexistent. However, here these advantages are only illusory. Both the immediate results and the final outcome are far from satisfactory due to the fact that operative intervention is in a zone with very damaged trophic tissue.

Observations for 1940 and later indicated that this intervention did not leave the patient without effect. Usually an increase in temperature was noted lasting 1-2 days after the operation and sometimes continuing for many days; this could be explained by the breakdown in the granulated tissue and an increase as a result of this intoxication.

In one of the hospitals in 1943,52 amputations along the line of demarcation showed 3 cases of severe intoxication and 3 cases developed sepsis. In 16 patients a sharp rise in temperature was noted which had been normal or subnormal up until then and the development of different increases in complications including lymphangitis, osteomyelitis, phlegmons, etc.

Of 12 patients with amputations along the line of demarcation (1940) only two of the wounds healed with a fine scar attached to the bone on the average 117 days after the frostbite occurred. In 5 cases the patients were evacuated with unhealed wounds at an average of 207 days after the frostbite had occurred. 5 cases underwent reamputation.

N.F. Rupasov notes that in 29.0% of cases of fourth degree frostbite treated with methods of amputation along the line of demarcation, reamputation was required later on. Of 682 men with stumps, after frostbite treated with the indicated method, according to the report by Ya.M. Lur'ye, more than 40.0% were fitted with prosthetic devices only 5 months after the frostbite had occurred due to the presence of various defects in the stumps which required additional treatment.

A.D. Postnov and R.M. Ryskin stated that in 60.0% of the patients after frostbite showed granulation with suppurative separation on the stumps (health resort hospitals). D.A. Novozhilov observed in 1/3 of the health resort hospiatls fistulas and trophic ulcers.

The characteristics presented of intervention according to the type of amputation along the demarcation line indicates that this type of operation is irrational, is accompanied by a significant number of complications, does not reduce the time period for treatment adequately in comparison with the conservative treatment and does not produce good recovery. Mainly one concludes that cutting along the demarcation line does not turn out to be the final operation.

The experience in World War II, (see below) makes it possible to categorically oppose the method of amputation along the line of demarcation as being scientifically unfounded and not producing positive results.

During the war with the Byelofinns, certain surgeons, not satisfied with the results of conservative treatment, began to use typical amputations of the extremities not only with the development of complications and the threat of death for the patient but in order to decrease the time of treatment and decrease the danger of complications.

Under the direction of F.D. Bogdanov in hospitals in the deep rear, O.N. Bychkovoy and Ya.A. Naftol'yeva amputated above the demarcation line without suturing of the wound. In 191 cases of fourth degree frostbite, A.I. Kulikova reports 9 amputations of the toes and distal segments of the foot.

M.S. Yusevich and his coworkers amputated several tens of times above the demarcation boundary and in a number of cases obtained healing with good mobile scars which did not interfere with prosthetic treatment. In other cases after 6-7 months healing of the wounds had not yet been achieved.

Modern views on operative treatment. In the winter of 1939-1940, at a clinic in the surgical hospital of the Military Medical Academy im. S.M. Kirov, a method was developed for operative treatment of frostbite developed from the theoretical work considered above by the faculty and in subsequent years these were broadly used and recommended in official instructions and manuals. This method includes complex treatment including different medications and physical therapy measures.

Essentially the modern operative treatment for frostbite is made up of two types of intervention separated from each other by a certain time interval.

Early surgical treatment of frostbite. The first intervention includes a complex of measures known as early treatment. This includes the removal of blisters, making incisions and cutting off the necrotic sections.

Early treatment must be done only when one can be sure of determining the irreversibility of necrotic changes and to discover the gangrene in certain sections even before the appearance of a pronounced demarcation line.

Practice showed that 5-6 days from the time of frostbite one can determine the boundaries of gangrene.

A sign that gangrene has set in is the absence of pain and temperature sensitivity and also blood circulation during injections and incisions. In doubtful cases one can resort to using a skin thermometer which was discussed above. Then one should keep in mind in the first place that necrosis often affects only the surface of the tissue and secondly that as a result of the spastic state of the vessels immediately after injection or incision the blood flow is not possible. Taking into consideration the fact that during early treatment one must observe a certain sequence of actions, incisions are made by layers waiting a few minutes before making cuts into deeper tissue. With a certain amount of experience the danger of making cuts through living tissue is minimum. Inasmuch as all intervention is done on dead tissue, no anesthetic is required. This makes it possible to control the correctness of the intervention being conducted. One must only taking into consideration that the anatomic entirety of the tendon apparatus at this period is not broken down and the muscles located outside the necrotic zone perceive different motions, in particular, the moment of cutting a tendon. Depending on the manipulations, basically, dissection of necrotic tissue is called necrotomy and if tissues are removed, necrectomy.

With correct treatment all intervention is limited to the boundaries of dead tissue and does not include the zone where demarcation has formed or will form (Figs. 109-110).

Necrotomy is done when there is gangrene encompassing at least the entire phalanx of any toe. With the spread of necrosis, more proximal incisions are made for the entire extent of verified gangrenous tissue. In cases where it is verified that incisions were made within the limits of the zone of gangrene cutting is done as close as possible to the living tissue of the joints taking into consideration that a layer of necrotic tissue remains on the stump formed which should not exceed 0.5-1 cm in thickness (Fig. 111).

During necrotomy it is not recommended that one have recourse to sawing or chipping the bones in order to avoid opening the bone marrow cavity which would facilitate its infection and the spread of infection upward into the bone.

It is fully understood that early treatment is done observing all of the rules of aseptics.

In view of the fact that early treatment can be done before clear formation of the demarcation zone with immediate examination of the patient it is often found that the upper (proximal) boundary of the incisions after necrotomy do not go to the demarcation zone if it is clearly pronounced at this time. In such cases a secondary treatment is recommended. If the necrotomy was not done earlier or reduction was at a lower level if indicated one should increase the incisions and conduct reduction (necrotomy) within the limits defined by the level of expansion of necrosis.

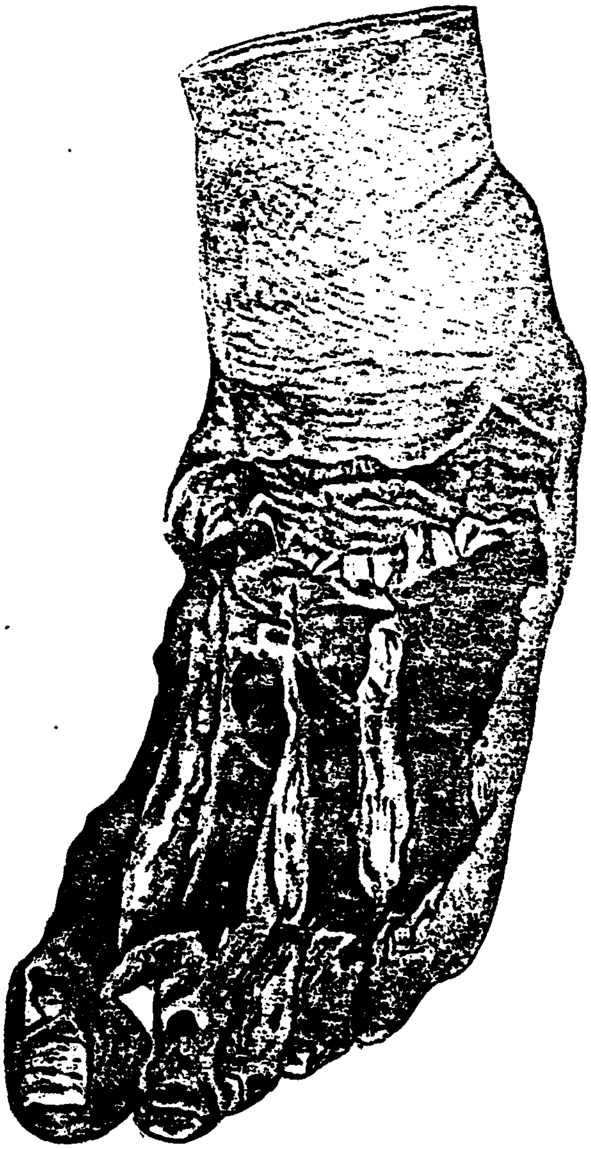

Fig. 109. Necrotomy with fourth degree frostbite of the foot. Section VMM No.4883/3596. (Artist Ye.S. Tymnyak)

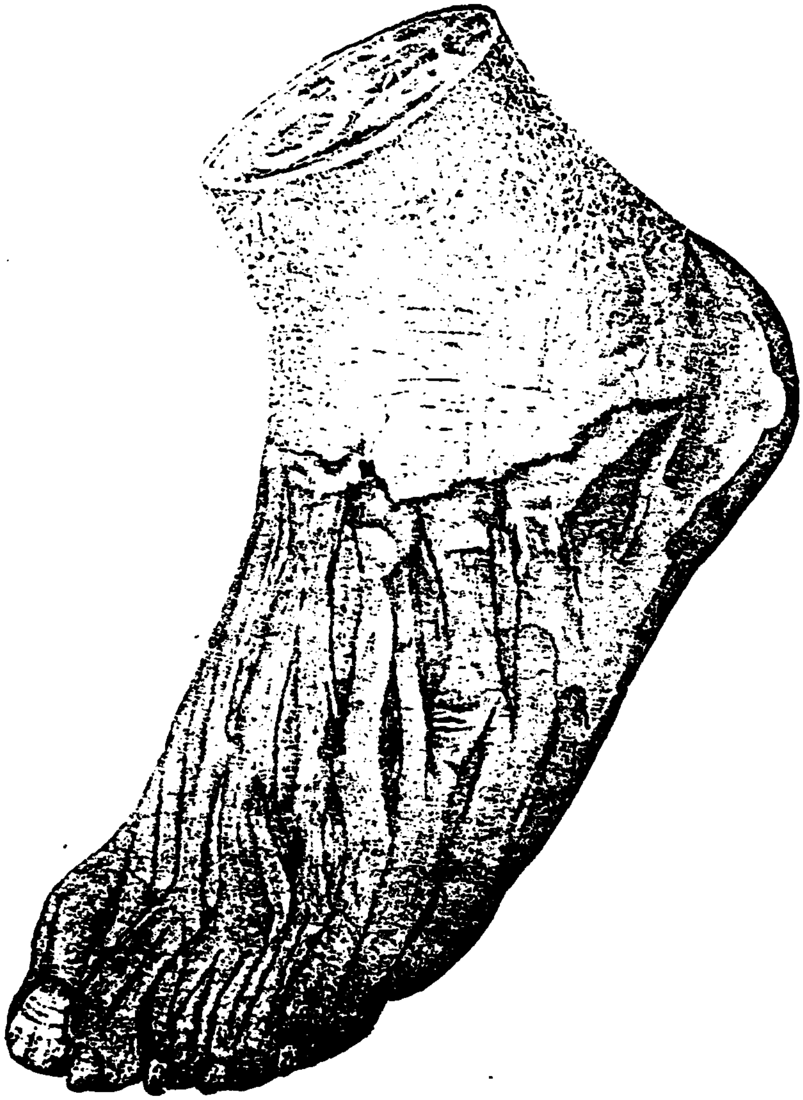

Fig. 110. Necrotomy with fourth degree frostbite of the foot. Section VMM No.9/3636. (Artist L.V. Orlova)

Fig. 111. Necrectomy with fourth degree frostbite of the foot. Necrotic tissue removed (reduced). Section VMM No.59/1171. (Artist V.S. Chumanova)

Thus, in a number of cases early treatment can be twofold or threefold. Its separate elements, removal of blisters, incisions and reduction, are done in sequence being separated in time.

Correct conduct of early treatment facilitates mummification, sharply decreases absorption from the necrotic tissue of the not yet demarcated zone, and decreases the danger of intoxication to the organism involved with this. Here unfavorable conditions are created for the development of the infection and for the appearance of inflammatory-degenerative increasing complications.

For the first 1-2 days after treatment, alcohol bandages are applied which facilitate drying and the extremities are elevated. Later on with the appropriate conditions one changes to open treatment or to systematic use of physical therapy means which increase mummification and in a number of cases soothe the pain.

As a result of the early treatment made and subsequent drying treatment, the necrotic parts of the soft tissues which were nearby during the treatment are dried and scabs form under which granulation develops. Sometimes this scabbing completely covers the stump and granulation remains under it without coming to the exterior. In other cases, pieces of the scab are separated revealing the granulation (Fig. 111).

The inflammatory process in the zone of reversible degenerative processes grandually decreases, the general state of the patient is improved, temperature becomes normal and after 1-3 weeks with fourth degree frostbite, the state of the tissues on the stump also gradually approaches normal; this makes it possible in the overwhelming majority of cases to complete final amputation without the risk of infection. This circumstance gives us the basis for applying the first sutures to the wound after amputation.

The conduct of the measures described significantly decreases the time period of treatment and as further observations indicated avoids numerous secondary complications in the patients. These complications, as a rule, have an ascending character and their development in turn can prolong treatment and require amputation at a level even higher than the level dictated by gangrene in the extremity.

At the beginning of World War II several works were published (T.Ya. Ar'yev, V.S. Gamov et al.) which showed the advantages of the method of early surgical treatment.

The idea of early surgical activity was recognized by many surgeons in our country; this showed up, particularly, in the adoption in hospital practice of a method of surgical treatment for frostbite. However, in comparison with the method of active surgical treatment of wounds put into practice during the war with the Byelofinns 1939-1940, treatment during frostbite was adopted much more slowly and required much more effort until it occupied its proper position.

In the first years of World War II, patients with frostbite sometimes entered evacuation hospitals on the 7th to 10th day or later. The victims had sections of the extremity at that time covered with dense "armor" which formed from the mummified surface tissue. Late entry of patients with frostbite who had not undergone treatment involved in part inadequate familiarity of physicians at the forward stages with methods of early treatment and in part the heavy load of wounded requiring more immediate first aid than the frostbite cases.

As a result of this, the character of treatment conducted at subsequent stages was changed somewhat because often it was impossible in practice to conduct not only the separation of the mummified tissue but also simple incisions of them could not be done without damaging the granulation which had developed. Nevertheless in these cases often one could successfully reduce the tissue and remove the crust to facilitate a more rapid drying of deep sections covered with necrotic shriveled tissue, decrease absorption and intoxication and thus achieve reduction or complete elimination of inflammatory phenomena in the area above the demarcation. In the final analysis this facilitated preparation of the extremities for early amputation and decreased the danger of complications.

In a further presentation, evaluating the quality of surgical aid when treating frostbite, but not always having the possibility of considering the time period for conducting the treatment, we will talking not about the early treatment but about treatment in general.

Amputation during frostbite. The second stage of operative treatment logically occurring from the principle and techniques of early treatment during fourth degree frostbite is amputation which has the purpose of creating a support stump or one with operating capability.

Naturally the final operation cannot be done immediately after the early treatment because to prepare a stump for operative intervention requires a certain known time during which the reactive inflammatory phenomena in the zone of reversible degenerative processes to a significant degree will be weakened and the state of the tissue of the stump will approach the normal.

Elimination or reduction of inflammatory phenomena is achieved by the systematic use of physical therapy procedures. Improvement in the state of the wound and skin surface around it is facilitated by periodic baths with disinfecting solutions, mechanical removal of suppurative bits from the granulation surface, accumulation of desquamation epidermis, and also bits of surface scab in the area of the damaged epidermis. It is necessary to treat cracks, abscesses and local inflammatory processes. As the inflammatory phenomena decrease and a scab forms on the stump the necessity disappears for energetic drying treatment, and in the first plan, means are introduced which facilitate the growth and reinforcement of granulation. For this purpose both physical therapy and medicinal means are used and to some extent means which speed up separation and improve blood circulation which can have an effect on the sympathetic nervous system.

The moment for final amputation is determined not by the time which has passed from the occurrence of frostbite or surgical treatment but by the condition of the tissue on which the operation will be made. Selection of the level of amputation also is very important. With a general stress on operating as closely as possible to the demarcation line one should take into consideration everything that is close to the zone of demarcation, how great the changes are in the tissue, how pronounced the inflammatory and degenerative processes are in them (a zone of irreversible degenerative processes) and how bad conditions are for sewing of the operation incision.

Moreover, it is necessary to take into consideration the state of blood supply and change in the bone system. Therefore before the operation it is absolutely necessary to evaluate the function of the blood circulatory vessels and the roentgenological examination.

In the majority of cases it is possible to amputate at a level so that the incision goes through skin which retains its normal structure without having any deep scarring changes and marked inflammatory phenomena. Here sawing at the bone must be free without stress ending with soft tissue. The requirement for subsequent prosthetic treatment forces one to take into consideration the position of the lines of the sutures in order that the scars formed afterwards will not be on the support surface of the stump.

In cases where early treatment was not complete and ascending degenerative inflammatory complications developed, the level of amputation often had to be raised and sometimes failed due to application of sutures on the stump due to continuing inflammatory processes and the danger of the flare-up of infection.

Usually in the absence of pronounced inflammatory phenomena, in the presence of a scab on the stump or healthy granulation, in the absence of foci of inflammatory-degenerative changes on the part of the bone, with generally satisfactory condition of the patient and the blood picture close to normal, one can amputate with sutures and even bone plastic operations of the Pirogov and Bir type.

When determining the proposed level of amputation always one takes into consideration not only the condition of the tissue but also the requirements for the stump, keeping in mind its support or operating capability.

During amputations on the upper extremities when even a fraction of a centimeter is very important for subsequent functions, one must make economical amputations attempting to retain as much tissue as possible. However, the basic demand for free covering of the bone cut with soft tissue must still be observed always. Ignoring this requirement results in the need for repeated intervention in order to correct defects in the stump.

On the lower extremities where retention of the tissue has almost the same importance it is preferable to amputate in typical locations. Here one must take into consideration the increase in static and dynamic load on the twisting effect of amputation on the foot; when a higher amputation is unavoidable one must be concerned that the stump will be formed by tissue which retains as much viability as possible and is practically healthy. For the lower extremities amputation at the interphalanx joints, exarticulation of separate toes or all of them together are typical. Where it is necessary to amputate the distal section of the foot, sawing off the metatarsal bones should preferably be done as close as possible to their base because during amputation in the distal sections of the metatarsus and immediately above the neck of these bones the diaphysis of the metatarsal bone remaining is sloped toward the fan-shaped origin which as a result causes deformation of the stump with the loss of its support (M.S. Yusevich). Cutting at Lisfranc's joint can be used as an example of a typical operation for frostbite of the foot.

Amputations made at the level of the sphenoid, cuboid, and scaphoid bones gives a poorer stump than stumps amputated at Lisfranc's joint but all are allowable in accordance with orthopedic training. Amputation at Chopart's joint is a functionally unsuitable stump and therefore cannot be recommended. With a high level of necrosis, with retention of the calcaneus region it is possible to conduct Pirogoff's high bone plastic surgery. If the healed region does not have full bone cover changed as a result of frostbite, then more radical amputation of the shin is indicated if a less crippling operation is impossible.

Syme's amputation to the ankle is not very widely used in the Soviet Union according to bibliographical data.

The postoperative period and questions of formation and rehabilitation of the stump must be given particular attention. With all amputations carried out with the application of sutures on the stump, it is necessary to provide drainage of the wound by using glass or rubber drainage tube for 1-2 days at the corners of the incision.

Any stump after amputation must immediately be immobilized. For this purpose it is completely adequate to apply a gypsum dressing which covers the stump both front and back but is positioned in such a way that the area of the surgery is under no pressure. Before immobilization of the extremity the foot is set in an average position. Also it is necessary to make a certain amount of correction keeping in mind the danger of developing contracture or tip foot with high amputations on the foot. The question of training and rehabilitation of the stump in the postoperative period is particularly important.

The method described of operative treatment was first used during the war with the Byeloffins. Observations were made of 45 patients with fourth degree frostbite in which a 142 amputations were carried out (including toes). The results of treatment are described by V.S. Gamov.

Sutures were used in more thar 48.0% of all the operations; 62.8% were healed with primary traction. In the group of patients operated on using sutures, the time periods for healing of the postoperative wound was 4 times less in comparison with patients who did not have sutures used. The average time period for healing in this group counting from the day that frostbite occurred, was 23 days less.

Reamputation in patients operated on with the use of sutures occurred in only 3.2%. In a group of patients where sutures were not used later on reamputation was required in 40.0%.

Experience was expanded for a number of treatment institutions in Leningrad and then generalized and popularized at conferences and meetings. The further adoption of a method of early treatment in radical final amputation for fourth degree frostbite was carried out in accordance with instructions by the chief surgeon of the Soviet Army and his assistants. By the fall of 1941 in the two most northerly armies, sections were organized in hospitals for treating the wounded and also a front hospital was set up for treating frostbite. A prevention and treatment system for frostbite was set up in parallel among the troops and at medical institutions in the combat region.

Observations of contingents of patients with frostbite made it possible by the middle of 1942 to draw the necessary generalizations and in August 1942 in Arkhangelsk a front conference was held on the question of frostbite. Later in Moscow an all-army conference was set up where materials were presented by physicians from the Karel'skiy front who had specialized in treatment of frostbite. At conferences in Arkhangelsk and Moscow, the main reports were made by physicians from the Karel'skiy front.

The generalized observations on the Karel'skiy front were used as the basic material for publication at the end of 1942 of "Instructions for prevention and treatment of frostbite" GVSU and by July 1941 the first edition of "Instructions on military field surgery" had formulated important positions and requirements for a new method of treating frostbite.

At the second plenary section of the Hospital Soviet of Narkomzdrav USSR, the question of treatment of frostbite was subjected to special consideration. As a result, the system of treatment of frostbite adopted at that time in medical institutions of the Red Army spread to institutions of Narkomzdrav USSR.

During World War II a considerable number of works appeared on practical surgery discussing treatment of frostbite. However, certain authors continued to retain their old conservative positions and they did not even mention operative treatment (N.I. Pankov, 1942; M.Kh. Gutiyev, 1943; D.T. Prokopchuk, 1944). Other authors, talking about operations, recommended waiting for amputation until the zone of demarcation was clear (M.O. Fridland, 1942) or even for spontaneous separation rarely speeding up the separation of tissue with a scalpel (V.D. Bantov, 1941; V.A. Drulev, 1943).

Finally, a number of authors not satisfied with conservative methods of treatment recommended certain surgical intervention in order to decrease treatment time and in certain cases improve their results. B.N. Khodkov, (1944) advised removing blisters and conducting a necrotomy. The necrotomy method with subsequent amputation along the demarcation line was supported by Ya.B. Ryvlin (1943). P.Ye. Trofimov and D.G. Kovalenko (1943) required the removal of necrotic sections in the limits of healthy tissue even before the appearance of the demarcation, that is, they returned to the method of early primary amputations which had been considered incorrect. Late amputations without sutures on the stump was recommended by V.S Levit (1941) with the exception of certain applications of sutures. M.S. Yusevich (1942) conducted amputation in areas of living tissue after the formation of the demarcation line and sometime sutured the surgical incision obtaining then a stump which was suitable from the surgical point of view for prosthesis. A.N. Druzhinina in 1943 supported amputation along the demarcation line as early as possible and changed according to his expression to a "radical necrectomy" essentially conducting typical amputation above the zone of demarcation with the application of a few sutures.

A large number of surgeons in the first months of World War II began to use a method of operative treatment recommended in the official instructions. In 1942 work was published by O.A. Levin and A.F. Verbov who supported the advantages of early treatment combined with physical therapy and as early as possible amputation with the use of sutures in indicated cases. In the same year at the front conference in Arkhangelsk in the reports by V.I. Zharkova, Ye.Ye. Shimakovska, I.K. Ptitsyna et al., experience in radical treatment of frostbite was generalized.

During 1943-1945 more than 15 works were published in the Soviet press which summarized experience in early radical amputation using sutures conducted after necrotomy and necrectomy. Data which characterize this method of operative treatment are presented in Table 39.

Table 39. Data which characterize early radical amputation using sutures done after necrotomy and necrectomy.

	Автор (a)	Год опубликования (b)	Процент заживления первичным натяжением (c)	Средняя продолжительность лечения в днях (d)
(e)	Жаркова	1942	54.1	72
(f)	Спиридонов	1943	100.0	—
(g)	Кимельман	1944	78.0	—
(h)	Дамперов	1944	26,2	—
(i)	Мирошников	1944	69,0	53
(j)	Богданов	1944	91,0	—
(k)	Гамов	1944—1946	60,4	74
(l)	Мангейм	1945	69,0	—
(m)	Дружинина	1945	42,4	—

Key: (a) author; (b) year of publication; (c) percent of healing with primary traction; (d) average duration of treatment in days; (e) Zharkova; (f) Spiridonov, (g) Kimel'man; (h) Damperov; (i) Miroshinkov, (j) Bogdanov; (k) Gamov; (l) Mangeym; (m) Druzhinina.

The expansion of the method of early radical operations led to improvement in the quality of operative treatment in the hospitals in the Soviet Army which was reflected in the material considered below. However, there were opposite results because in truth a certain insignificant number of surgeons began to conduct operations too early when the inflammatory changes in the period after warming had not yet been reversed. As a result of this in certain cases there was violent suppuration of the surgical wound, full separation of sutures and the development of ascending inflammation.

As a result of this premature intervention, healing of the wounds was delayed and the general length of treatment was increased and frequency of complications also grew. G.A. Rusanov and K.M. Zhivolova note that the period for healing of the postoperative wounds after amputation done from 10 to 30 days after the frostbite, amounts to more than 60 days, decreasing up to 34 days after amputation in the later time period. In operations which were done very early, that is, in less than one month, more than 40.0% had to undergo reamputation due to lack of healing of the stumps. In the operations made from the 40th to the 60th days reamputations were required only in 11.0-15.0%.

Similar data were obtained when analyzing the data of the chart on basic characteristics. Once again they confirm that the amputation time is determined not by the number of days which have passed since the frostbite event but by the state of the tissue on which operative intervention is to be made; early amputation can facilitate a decrease in treatment time and improve the results only with careful selection of the amputation level taking into consideration the state of the tissue and all special features of the preoperative period.

Study of the questionnaire materials from evacuation hospitals for different years in World War II indicated that an effective operative treatment for frostbite was put into practice in hospitals both gradually and suddenly.

An evaluation of operative treatment of frostbite according to materials from the World War II. During World War II a method of surgical treatment was widely used. For fourth degree frostbite only 18.5% of the patients were subjected to surgical treatment. Of the number treated surgically 32.0% were treated earlier than 10 days, that is, for early treatment.

With second and third degree frostbite cases, surgical treatment was carried out in 58.2% of the total number of all frostbite cases for this degree. This percentage should be completely satisfactory indicating a fairly high activity.

Moist gangrene during necrotomies was noted in 4.9% of the total number of cases of fourth degree frostbite subjected to necrotomy whereas in the absence of any treatment the moist gangrene was encountered in 11.4% and with open blisters in 11.3%, with removal of blisters -- in 12.3% (Fig. 112). Consequently, moist gangrene with fourth degree frostbite developed just as often both in the absence of treatment and with incorrect treatment; in the case of necrotomy, moist gangrene was observed 2 1/2 times less often.

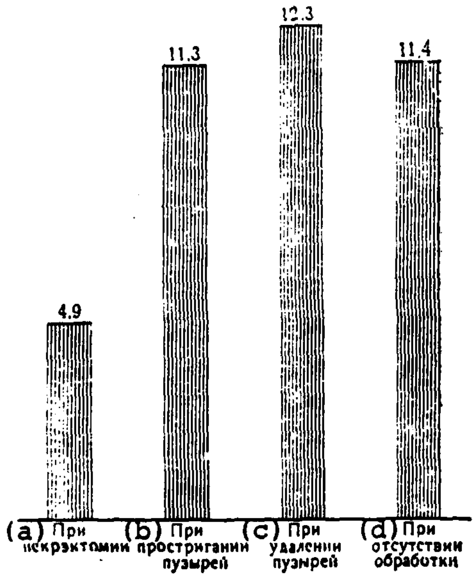

Fig. 112. Frequency of moist gangrene with fourth degree frostbite depending on the character of surgical treatment. Key: (a) during necrectomy; (b) during abrasion of the blisters; (c) during removal of the blisters; (d) in the absence of treatment.

During fourth degree frostbite occurring with fever, after surgical treatment in a number of cases one noted a drop in temperature to normal. This decrease was observed in 13.1% of the number of those treated after necrotomy, in 6.5% with the removal of blisters and only 2.0% with the abrasion of blisters.

With third and fourth degree frostbite, according to the data in the chart for fundamental characteristics, only in 32.0% for surgical treatment and up to 10 days; this number was 28.2% for all complications. In 68.0% treatment was done after 10 days from the time of frostbite and in this group complications were observed in 71.8% which exceeds the precentage of complications with early treatment.

With surgical treatment conducted with anesthetic, complications with these same degrees of frostbite were noted in 23.6% of the number of all surgical treatment; for treatment conducted without an anesthetic -- in 13.7%, that is, 1.8 times less often. This fact could be due primarily to the time period for surgical treatment; among those treated with anesthetic only 12.1% were done in the first 10 days; when treating without anesthetic in the same time period 32.6% of all interventions were for patients in the first 10 days.

One should also pay attention to the following circumstances. Inasmuch as no anesthetic was used one can assume that here there were areas of frostbite with massive damage and treatment obviously was done not only within the limits of the necroctic tissue but encompassed part of the living tissue as well. In other words, it is very probable that intervention was carried out not on the distal demarcation zone but in its limits. This circumstance could affect the frequency of complications because it was established that amputation along the demarcation line often is accompanied by different complications.

On the basis of what has been presented one must consider that the frequency of complications with third and fourth degree frostbite, to a considerable degree, depends on the time period for surgical treatment. Its conduct in the early period creates more favorable conditions for the future course than conduct in later time periods when there could be complications.

One can state that during World War II this method of surgical treatment became widespread; this is indicated in the decrease in the number of complications and severity of the course (moist gangrene, fever). At the same time one must note that early treatment was not always adequately used and a considerable number of frostbite cases had to be treated at later periods some of which had never been treated at all.

Unfortunately one cannot consider that the terminology used for designating manipulation during sugical treatment received the same recognition as the method itself.

Study of history of the disease showed a significant number of the surgeons called for necrectomy and even necrotomy amputations done along the line of demarcation and in certain cases above this line. When studying the history of the disease in those treatment measures to which the patient was subjected, the "imprecision" in descriptions were taken into consideration and the appropriate corrections were made: the intervention conducted was classified according to the type of operation depending on their character and not on the erroneous description in the history of the disease. In a number of articles (A.P. Druzhinina et al.) published during the years of the war, erroneous concept was noted by the authors of these works in the terms for certain concepts were applied.

The percentage of all frostbite cases operated on ir 1941-1942 was 38.8%; in the second year of the war it rose to 46.7. In the third and fourth years of the war this percentage dropped below the initial level. The change in percentage operated on cannot, however, fully reflect surgical activity inasmuch as the severity of the frostbite cases observed for the entire period of the war also dropped year after year.

A comparison by the year of the war of the number of fourth degree frostbite cases (by year of basic operation) with the number of those operated on and the percent of fourth degree frostbite cases of all cases of frostbite, according to the data in the chart on fundamental characteristics indicated a relative change in the severity of the frostbite and an increase in surgical activity (Table 40).

Table 40. Frequency of operations in fourth degree frostbite.

Год войны (a)	Процент оперированных к числу отморожений IV степени (b)
(c) Первый	82,0
(d) Второй	95,6
(e) Третий	99,1
(f) Четвертый	95,3

Key: (a) year of the war; (b) percent operated on out of the total number of fourth degree frostbite cases; (c) first; (d) second; (e) third; (f) fourth.

In order to judge the quality of operative treatment it is necessary to take into consideration the character of the amputations made and particularly amputations using sutures on the stump (Fig. 113). Below we present the ratio of amputations with sutures applied to the number of all amputations for frostbite according to the year of the war (Table 41).

Table 41. Distribution of amputations with sutures by year of the war.

Год войны (a)	Процент ампутаций со швами (b)
(c) Первый	11,9
(d) Второй	29,0
(e) Третий	40,3
(f) Четвертый	31,5

Key: (a) year of the war; (b) percent of amputations with sutures; (c) first; (d) second; (e) third; (f) fourth.

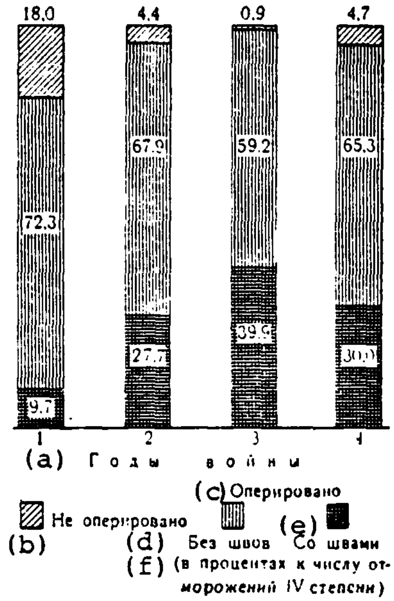

Fig. 113. Operability for fourth degree frostbite including frequency of operations using sutures according to the year of the war (per 100 cases of fourth degree frostbite).
Key: (a) years of the war; (b) non-operable; (c) operable; (d) without sutures; (e) with sutures; (f) in percentage of the total number of fourth degree frostbite cases.

A significant increase in the number of amputations using sutures for three years in the war is evidence of the adoption of the method of radical operation in treatment institutions.

A certain decrease in percentage of amputations using sutures noted in the last years of the war can be explained by the rapid shift in the front line and the frequency of repeated dislocation of treatment institutions in the winter of 1944-1945 which somewhat limited the possibility of using operations with sutures inasmuch as such operations require hospitalization of the patients for at least 10 days. Nevertheless in the fourth year the percentage of operations with sutures, in spite of its relative decrease, remained higher than in the second year of the war.

It is necessary to note that operations using sutures were widespread primarily in the rear hospitals. The total of such operations was 21.8% of the number of all amputations. In the majority of cases they were done in the second to fourth months of frostbite. In the third year of the war the average time period in which intervention took place was decreased by almost 25.0%. The average duration and treatment of this group of patients for the entire war was decreased by 13.0%, however it is not a limit.

The correspondingly broader adoption in practice of operations using sutures was increased in the number of patients subjected to this operation and fully completed treatment for 2 months from the day of frostbite. At the same time, almost twice the number of patients subjected to amputation with sutures and who completed treatment in 6 months was decreased.

For instance, of the number of those operated on with the use of sutures whose treatment was completed after 6 months were: in the first year of the war 28.7%, in the second year 26.9%, in the third year 16.9% and in the fourth year 15.3%.

Healing of the surgical incision after amputation with sutures with primary tension was noted in 24.5% of all operations. In various years of the war this percentage varied from 14.1 to 24.7. The figures presented are 2-2 1/2 times lower than bibliographical data published in several works. Nevertheless, the results obtained cannot be considered unsatisfactory because when developing histories of the disease only cases with full healing were taken into consideration without suppuration although in the area of a single suture. All of the other cases where partial suppuration was noted belonged to a group with healing with secondary tension.

The average duration for remaining in treatment institutions for patients who had undergone amputation with application of sutures which ended in suppuration was only 38.9% longer than for patients with primary traction healing of the wounds. It follows from this that with

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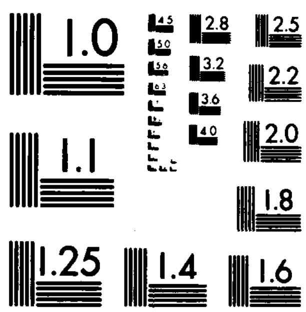

MICROCOPY RESOLUTION TEST CHART
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partial suppuration of the postoperative incision a desirable result in reducing treatment time is achieved.

One should note that not in all cases of amputation with sutures were there adequate consideration of indications for it. Undoubtedly premature operations were made in a period when inflammatory phenomena in the extremity had not yet calmed down. This is confirmed by a study of results of such operative intervention as was done in the first month after frostbite.

According to the data of the chart of fundamental characteristics, out of the several tens of operations with sutures made in the first month, the overwhelming majority of them ended in suppuration and the average period for remaining in the treatment institution was 8 days longer than in those operated on in the second month after frostbite with the same method. Even in some cases in which healing occurred with first intention, the average duration of the postoperative period was 17 days longer than in those operated on in the second month. With suppuration of the postoperative incision, the duration of the post-operative period exceeded duration of those operated on in the second month by 34 days.

In persons operated on in the second and subsequent month after frostbite, healing with first intention amounted to from 19.2 to 66.7% and duration of the postoperative period progressively decreased (Table 42).

Operative intervention should not be carried out earlier than the second to third month. This cannot be justified by the desire to cut down on the duration of the postoperative period and decrease the percentage of postoperative suppuration.

The percent of healing with first intention is increased in parallel with an increase in the time period for amputation but in the fourth month and later than the sixth month, one notes a certain decrease in it which is explained by the development at this time of complications, particularly chronic osteomyelitis. The presence of complications requires a higher level for the operation which is clearly not in the interest of the patient. At the same time a study of the data on the chart for fundamental characteristics confirms that a significant percentage of high amputations was done in fairly late periods and the indications for it in the majority of cases were various complications. Besides this, the late operations increase the total time period for treatment.

Table 42. Duration of the postoperative period and character of healing during amputation with sutures depending on the time period of the operation.

Срок ампутации с наложением швов (a)	Процент заживления первичным натяжением (b)	Средняя продолжительность послеоперационного периода в днях (c)	
		при заживлении первичным натяжением (d)	при нагноении (e)
(f) Первый месяц	(g) Весьма незначительный	80	122
(h) Второй »	19,2	63	88
(i) Третий »	26,6	54	81
(j) Четвертый »	25,9	48	65
(k) Пятый »	41,0	38	50
(l) Шестой »	66,7	40	66
(m) Более 6 месяцев...	59,1	—	—

Key: (a) time period of operation with sutures; (b) percent of healing with first intention; (c) average duration of the postoperative period in days; (d) with healing with first intention; (e) with suppuration; (f) first month; (g) very insignificant; (h) second; (i) third; (j) fourth; (k) fifth; (l) sixth; (m) more than 6 months.

On the basis of statistical analysis, and also observations of a number of surgeons, one can propose that the most favorable moment for amputation is the second or beginning of the third months after the frostbite occurred if the state of the tissue in the area of the proposed intervention does not prevent it.

The quality of surgical treatment for frostbite of high degrees to a known measure characterizes frequency of amputation made along the line of demarcation.

It was pointed out above that this intervention does not have either a theoretical or practical basis and gives unsatisfactory results; therefore it cannot be recommended.

In the first year of the war amputation along the demarcation line amounted to 66.1% of all operations and decreased in the following years to 45.2 and 36.9%. The decrease of almost twice the number of unfounded interventions, along with an increase in the percent of operations done with sutures, is evidence that effective methods of surgery for severe frostbite cases have become widely recognized.

Among the patients in whom amputation was done along the demarcation line, for the entire war period, the average duration of treatment and percent of persons treated after more than 6 months remained fairly stable, the duration of the postoperative period even increased somewhat (Table 43 and Figs. 114 and 115).

As was indicated above, 11.2% of the patients with fourth degree frostbite were not operated on. This precentage was the maximum in the first year of the war and then decreased to 1.0-5.0. Among the patients who did not undergo amputation, the majority were released from treatment institutions without completion of treatment. A very small part died.

Only in 0.7% of the number of fourth degree frostbite cases was conservative treatment carried with spontaneous separation of the necrotic sections. In 2.0% after the necrotomy was conducted, subsequent amputations were not undertaken before healing of the stump which took a long time.

As to the operative treatment, to a certain degree one can judge by the number of reamputations made. Experience showed that after amputation along the demarcation line as after spontaneous preparation of the necrotic sections, the stumps which formed were not fully useful.

The skin on their surface usually adhered to the underlying tissue and the scars degenerated; there were symptoms of trophic disorders. Such stumps under load carrying prosthetic devices and orthopedic foot gear often became ulcerated which made it impossible for the patients to use the extremity and required secondary intervention.

Table 43. Duration of treatment and the postoperative period with amputations with sutures and without sutures according to the year of the war (the duration of treatment for the first year of the war is assumed to be 100).

(A) Показатели / (B) Год войны	Первый (C)	Второй (D)	Третий (E)	Четвертый (F)
(a) а) Средняя продолжительность лечения (в процентах):				
1) при ампутациях по демаркационной линии	100,0	97,0	105,0	95,0
2) при ампутациях со швами, зажившими с нагноением	100,0	97,0	84,0	84,0
3) при ампутациях со швами, зажившими первичным натяжением	100,0	103,0	88,0	88,0
(b) б) Средняя длительность послеоперационного периода (в днях):				
1) при ампутациях по линии демаркации	97,0	103,0	118,0	110,0
2) при ампутациях со швами, зажившими с нагноением	100,0	79,0	78,0	75,0
3) при ампутациях со швами, зажившими первичным натяжением	54,0	55,0	57,0	52,0
(c) в) Процент лечившихся более 6 месяцев к числу всех лечившихся в данной группе:				
1) при ампутациях по линии демаркации	25,4	34,7	23,8	22,3
2) при ампутациях выше линии демаркации	29,6	39,5	27,7	20,5
3) при ампутациях со швами	28,7	26,0	16,9	15,3

Key: (A) indices; (B) year of the war; (C) first; (D) second; (E) third; (F) fourth; (a) average duration of treatment (in percentage): 1) with amputations on the demarcation line; 2) with amputations with sutures healed with suppuration; 3) with amputations with sutures healed with first intention; (b) average duration of the post-operative period (in days): 1) with amputation along the demarcation line; 2) with amputations with sutures healed with suppuration; 3) with amputations with sutures healed with first intention; (c) percent of persons treated after more than 6 months out of the number of all persons treated in this group: 1) with amputations along the demarcation line; 2) with amputations above the demarcation line; 3) with amputations with sutures.

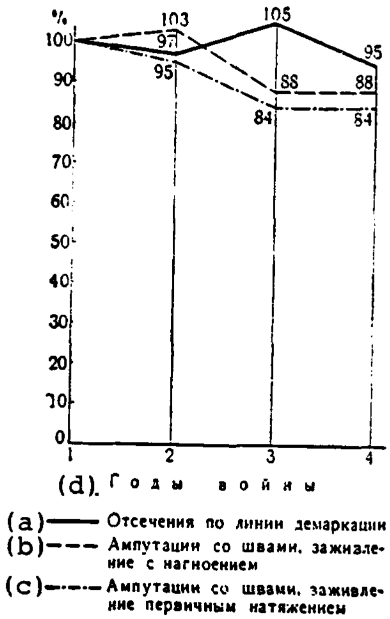


Fig. 114. Change in average duration of treatment depending on the character of the operation (data of the first year of the war assumed to be 100).
Key: (a) amputation along the demarcation line; (b) amputation with sutures healed with suppuration; (c) amputation with sutures healed with first intention; (d) year of the war.

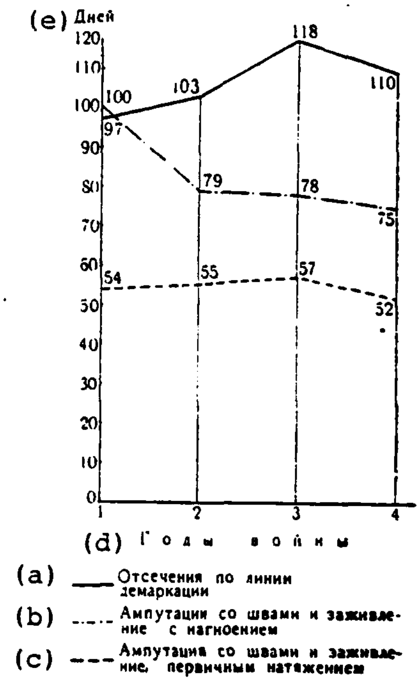


Fig. 115. Average duration of the postoperative period (in days) depending on the character of the operation.
Key: (a) amputation along the demarcation line; (b) amputation with sutures healed with suppuration; (c) amputation with sutures healed with first intention; (d) year of the war; (e) days.

During the war the distribution of reamputation by year was presented in the following form:

Год войны (a)	Процент реампутаций (b)
(c) Первый	42,0
(d) Второй	39,2
(e) Третий	13,4
(f) Четвертый	5,4
(g) Всего	100,0

Key: (a) year of the war;
(b) percent of reamputation;
(c) first; (d) second;
(e) third; (f) fourth;
(g) total.

This decrease in the percent of reamputations corresponded both to the decrease in total number of frostbite cases by year and to the decrease in number of fourth degree frostbite cases and, consequently, the percent of operations.

However, in relation to the total number of amputations one cannot note a decrease in frequency of reamputations amounting to about 20.0% in all the years of the war in spite of the significant decrease in the number of reamputations after operations using sutures. In the first year of the war reamputation after operations using sutures amounted to 19.4% and a decrease by the end of the war to 9.8%, that is, by almost two times. However, after amputation without the use of sutures their number was relatively higher than can be explained by the absence of decrease in frequency of reamputations for all the years of the war. In the last two years, according to the data of the chart on fundamental characteristics, no cases of reamputation were noted after an operation made with the use of sutures and which was completed with first intention whereas in the first and second years of the year such reamputations amount to 3.0% of the number of appropriate amputations.

The absence of a decrease and even a certain increase in frequency of reamputation after operations with application of sutures does not characterize negatively the quality of operative treatment inasmuch as, as was noted above, the precentage of such amputations decreased for the duration of the war. At the same time, the increasing demand for quality in postamputation stumps, the necessity for providing all completed treatment with prosthetic devices or orthopedic foot gear forced the surgeons to broadly recommend reamputation.

On a background of the quantity and percent of amputations along the demarcation line decreasing in absolute numbers, one notes an increase in the percentage of reamputation after these ineffective interventions. For instance, in the first year of the war, the percent of reamputation equaled 19.8% of the number of amputations along the demarcation line; in the second year it was 29.0; in the third year it was 31.2; and in the fourth year it was 33.3

When adding all of the material, the dependence of frequency of reamputation on the character of the operation primarily made appears to be completely true: reamputation with cutting along the demarcation line was done ten times more often in comparison with reamputation after operations which ended with primary healing (Table 44).

Table 44. Frequency of reamputation depending on the character of preceding amputations.

Характер операций (a)	Процент реампутаций к числу соответствующих ампутаций (b)
(c) Операции со швами, закончившиеся первичным натяжением	2,3
(d) Операции со швами, закончившиеся нагноением	13,2
(e) Операции без швов выше линии демаркации	20,1
(f) Отсечения по линии демаркации	24,5

Key: (a) character of the operation; (b) percent of reamputation to the number of appropriate amputations; (c) operations with sutures completed with first intention; (d) operations with sutures ending with suppuration; (e) operations without sutures above the line of demarcation; (f) removal along the line of demarcation.

The overwhelming majority of reamputations (91.7%) were done on the lower extremities. Reamputations carried out on two extremities in a single patient amount to 14.3% of all reamputations. In 9.2% two reamputations were made on the same extremity due to unsatisfactory results of the first operation.

Characterizing operative treatment of frostbite for the entire period of World War II it is necessary primarily to note an increase in surgical activity.

The frequency of operations with fourth degree frostbite is 88.8. This figure itself is adequate to truly indicate how the views of Soviet surgeons have changed.

As a result of the growing activity a decrease in the number of complications was noted and, in particular, with fourth degree frostbite a reduction in the length of treatment both for operable and nonoperable patients (by 13.7 and 14.5% of the duration of treatment for the first year of the war).

In 44.1% of those operated on, a single amputation was made; in 35.3% two amputations were made and 20.6% were subjected to three or more amputations. On the average for a single patient operated on there were 1.7 operative interventions not counting reamputations.

With third degree frostbite complicated by osteomyelitis in half of the cases amputations were made which is undoubtedly an achievement because up until World War II osteomyelitis with third degree frostbite generally could not be diagnosed.

When evaluating all of this it is necessary to keep in mind that in the overwhelming majority of cases we are talking about amputation of the toes, feet and part of the hands (Table 46).

During the first and second years of the war osteomyelitis with third degree frostbite was diagnosed at 3.0%, in the third year at

5.3% and in the last year at 8.0% which must be related to improvement in diagnostics and not to an increase in the frequency of osteomyelitis. Out of the number of amputations as a result of osteomyelitis with third degree frostbite, in 1/3 of the cases amputations were made using sutures. In 0.2% of the third degree frostbite cases also amputations were made as a result of different complications (sepsis, suppurative and anaerobic infection and trophic disorders).

Distribution of operations according to the level of amputation, the ratio of operations using sutures and not using sutures and also the percent of primary healing are presented in Tables 45 and 46.

Table 45. Distribution of amputations according to their level in persons who have recovered (calculation of the number of amputations and not the number of patients).

Уровень ампутации (a)	Процент ампутаций (b)		
	со швами (c)	без швов (d)	всего (e)
(f) Фаланги	56,5	59,7	58,6
(g) Плюсне-фаланговое сочленение	17,7	18,7	18,5
(h) Плюсна	11,4	9,1	9,9
(i) Операции Лисфранка	3,8	0,9	1,4
(j) » Шопара	0,3	0,2	0,2
(k) » на пятке	0,1	0,4	0,4
(l) » Пирогова-Сайма	—	0,1	0,1
(m) » на голени и бедре	2,5	1,4	1,6
(n) Верхняя конечность			
(o) Пальцы кисти	7,3	8,9	8,7
(p) Кисть, предплечье	0,4	0,6	0,6
(q) Итого	100,0	100,0	100,0

Key: (a) level of the amputation; (b) percent of amputations; (c) with sutures; (d) without sutures; (e) total; (f) phalanx; (g) metatarsal-phalanx articulation; (h) metatarsus; (i) Lisfranc operation; (j) Chopart operation; (k) operation on the heel; (l) Pirogoff-Syme operation; (m) operation on the shin and femur; (n) upper extremity; (o) fingers; (p) wrist, forearm; (q) total.

Table 46. The ratio of amputations and reductions with and without sutures and the percent of healing with first intention depending on the level of the operation.

Уровень ампутации (a)	Процент ампутаций к числу оперированных на данном уровне (b)		Заживление первичным натяжением к числу операций со швом в процентах (e)
	(c) без швов	(d) со швами	
(f) Нижняя конечность			
(g) Ампутации и вычленения на фалангах пальцев	79,0	21,0	26,3
(h) Вычленения в плюсне-фаланговом сочленении	79,3	20,7	17,4
(i) Операции на плюсне	74,2	25,8	18,7
(j) Вычленения в суставе Лисфранка	48,3	51,7	48,4
(k) Вычленения в суставе Шопара	77,8	22,2	25,0
(l) Операции на пяточной кости	92,9	7,1	—
(m) » Пирогова	100,0	—	—
(n) Ампутации на голени и бедре	67,5	32,5	27,0
(o) Верхняя конечность			
(p) Операции на пальцах кисти	82,7	17,3	23,7
(q) » » кисти, предплечье	84,0	16,0	28,5
(r) Всего...	78,2	21,8	24,5
	100,0		

Key: (a) level of amputation; (b) percent of amputations out of the number operated on at this level; (c) without sutures: (d) with sutures; (e) healing with first intention for the number of operations with sutures in percentage; (f) lower extremity; (g) amputation and reduction on the finger phalanxes; (h) reduction in the metatarsal-phalanx articulation; (i) operation on the metatarsus; (j) reduction in the Lisfranc joint; (k) reduction in the Chopart joint; (l) operation on the bone of the heel; (m) Pirogoff operation; (n) amputation on the shin and femur; (o) upper extremity; (p) operation on the fingers; (q) operation on the wrist and forearm; (r) total.

Selection of the level of amputation basically was determined by the location of the frostbite although one should note that the percentage of amputations on the foot and shin is somewhat greater than the frequency of frostbite cases in these sections of the lower extremity. This can be explained by the fact that in some of the cases indications for a high amputation were due to the level of necrosis occurring both as a result of frostbite and the development of complications, primarily sepsis. This was very clear when comparing the levels of amputation in persons who had recovered and patients who had died (Table 47, Fig. 116).

Table 47. Distribution of amputation and reduction according to the level in healthy persons and those who died.

Уровень ампутации (a)	(b) Процент ампутаций	
	в группе выздоровевших (c)	в группе умерших (d)
(e) Нижняя конечность		
(f) Ампутации и вычленения фаланг пальцев ног	58,6	22,5
(g) Вычленения в плюсне-фаланговых сочленениях	18,5	19,0
(h) Стопа (плюсна и предплюсна)	11,6	18,9
(i) Вычленения в области голеностопного сустава	0,1	1,8
(j) Ампутации голени и бедра	1,6	30,6
(k) Верхняя конечность		
(l) Вычленения и ампутации пальцев кисти	9,0	1,8
(m) Вычленения и ампутации кисти	0,6	4,5
(n) Всего	100,0	100,0

Key: (a) level of amputation; (b) percent of amputations; (c) in a group of persons who have recovered; (d) in a group of persons who died; (e) lower extremity; (f) amputation and reduction of the phalanx of the toes; (g) reduction in the metatarsal-phalanx articulations; (h) foot (metatarsus and tarsus); (i) reduction in the region of the talocrural joint; (j) amputation of the shin and femur; (k) upper extremity; (l) reduction and amputation of the fingers; (m) reduction and amputation of the wrist; (n) total.

In spite of the great successes achieved by the medical service in the Soviet Army in treating frostbite during World War II, far from all possibilities have been exhausted. With the existing organization of treatment, with the broad adoption of a method of early treatment and timely evacuation, it is possible to add even a broader use of radical operations using sutures. This considerably decreases the time period for treatment and increases the number of patients who after healing with first intention, having obtained a stump with full use of the toes and fingers, and who in a large percentage of cases, were returned to the army. Examples of such achievements can be seen in a specialized hospital and specialized departments of hospitals on the Karel'skiy front. Even in 1941-1942, V.I. Zharkova (front evacuation hospital) and S.A. Grubina (army evacuation hospital) had a considerable amount of material which showed the advantages of radical operative treatment for fourth degree frostbite.

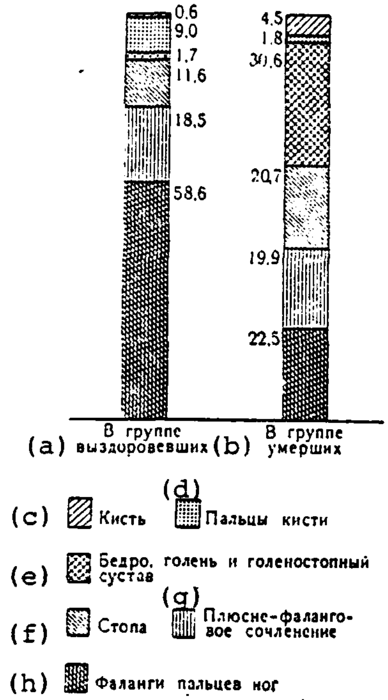


Fig. 116. Distribution of amputations according to level (in percentages of the total.
Key: (a) in the group of persons who have recovered; (b) in the group of persons who have died; (c) wrist; (d) fingers; (e) femur, shin and talocoural joint; (f) foot; (g) metatarsus-phalanx articulation; (h) phalanx of the toes.

Stage Treatment

Frostbite of any degree can cause serious damage both in severity and depth of pathological changes occurring due to the cold and in view of complications which in most cases occur as a result of incorrect handling and treatment. Therefore,the degree of frostbite without taking into consideration the entire clinical picture, cannot determine the volume of treatment and consequently, the location where it is accomplished.

First degree frostbite observed after a short-term exposure, as a rule, does not require any other treatment except first aid carried out at the stage where the patient is first admitted.

First degree frostbite which occurs due to prolonged cooling, for example, trench foot and chills is accompanied not only by inflammatory phenomena on the skin but also by a deeper breakdown in blood circulation in the form of the spastic state of the vessels, with the development of edema and difficulty in lymph flow. In these cases treatment could not be limited to first aid and, depending on further passage, could require special measures for restoring blood circulation in the extremities affected.

When first degree frostbite is established in conditions of the military medical service at the front, after rendering first aid, it is necessary to consider the possibility of placing the victims in warm rooms of dwellings until the inflammatory phenomena are eliminated because if this requirement is ignored secondary and probably more severe frostbite will occur.

In view of the fact that severity of frostbite does not show up immediately and frostbite of higher degrees upon first inspection could be assumed to be first degree frostbite, it would be necessary, taking into consideration the case history data and in particular the duration of cooling, to set up a second examination on the following day of all persons in which first degree frostbite has been established in order to hospitalize patients with higher degree frostbite.

All patients with complications for first degree frostbite including those occurring without pronounced inflammatory phenomena but with the development of vascular disturbances and intumescence with a stable decrease in skin temperature and disorders of the peripheral pulse, were hospitalized and evacuated from PMP (Medical aid station) to DMP (Division medical station) later on depending on the course and necessary treatment measures. Then also the best time periods for treatment were taken into consideration.

Treatment of first degree frostbite at the evacuation stages is carried out using physical therapy means depending on the equipment of the stages and also a novocaine blockade.

Study of responses to questionnaires at treatment institutions showed that a certain part of patients with first degree frostbite entered hospitals at the front base and the deep rear. If one excludes from this number patients with first degree frostbite in which the frostbite occurred at the rear and who entered the indicated hospitals at the first stage of evacuation, then there remains a certain number of first degree frostbite cases whose treatments ends at a point distant from the hospitals at the front.

According to the accounts of the chief surgeon of the Bryansk front in 1942, first degree frostbite amounted to 1.0-2.0% of all frostbite cases in hospitals at the front base. S.A. Grubina in the army hospital also had 1.9% of first degree frostbite cases.

According to the material of the chart on fundamental characteristics, the outcome (recovery) with first degree frostbite was determined at the following stages of evacuation:

Этап (a)	Процент выздоровевших (b)
(c) МСБ	2,5
(d) ХППГ	18,3
(e) Армейские госпитали	25,7
(f) Фронтовые »	38,1
(g) Госпитали глубокого тыла	15,4

Key: (a) stage; (b) percent of persons recovered; (c) MSB (Medical battalion); (d) KhPPG (Mobile surgical field hospital); (e) army hospitals; (f) front hospitals; (g) hospitals at the deep rear.

However, distribution of the outcome presented is not completely characteristic for first degree frostbite because a large majority of patients hospitalized suffered from accompanying diseases which made it necessary for hospitalization and further evacuation. As was indicated above, the overwhelming majority of first degree frostbite cases was not counted in the medical statistics which sharply changed the distribution of outcome by stage.

According to G.F. Shkradyuk's data, the outcome from first degree frostbite was determined at the first stage of evacuation in 30.3%, in the second for 33.0% and in the third for 21.1%. One should take into consideration that by the first stage we mean the medical institution where the victim was first admitted and not always the DMP.

The average time for treatment of hospitalized patients with first degree frostbite, according to the data of the chart of fundamental characteristics, amounted to 35 days and according to G.F. Shkradyuk to 45.6 days.

As is known, second degree frostbite is characterized by blisters. But for third or even fourth degree frostbite the formation of blisters is an ordinary phenomenon.

A general conservative approach to the treatment of frostbite which was widespread up until recently has been discussed in relation to blisters. Their removal was considered dangerous in view of the possibility of infection of the exposed surface. A number of authors propose only abrading or puncturing the blisters in order to release the fluid from them. Certain author advocated full removal of the blisters as with treatment of burns.

Blisters must be removed completely as they appear. The basis for this is the following statements:

1) in conditions of military activity of persons who have received frostbite often they were forced to proceed on foot for a considerable

distance before they were admitted to a medical aid post. The blisters then had been partially damaged and their inside infected. Also it is necessary to take into consideration that in the inside of an undamaged blister usually one finds microorganisms;

2) removal of blisters makes it possible to discover third degree frostbite which in a number of cases with the presence of undamaged blisters could not have been diagnosed;

3) the time necessary for complete epithelialization with the removal of blisters was significantly decreased;

4) the removal of blisters was not accompanied by the development of a progressive inflammatory process.

The removal of blisters was done at the PMP or even at the DMP depending on where they were detected. At this same stage, on the basis of the exterior appearance of the excoriated surface, the probable degree of frostbite is established.

Removal of blisters was preceded by disinfection of the skin; this was done by washing the extremity with soapy water with subsequent rubbing with alcohol twice.

After the blisters were removed and the second treatment of the entire surface with alcohol was done a sterile dry or lubricated bandaging was applied. In view of the decrease in pain sensitivity in the frostbite zone the patients did not suffer any distressing pain.

Further treatment carried out at the DMP or at the KhPPG included changing and repeated application of bandaging if it had become soaked. It is advantageous to use radiation with quartz alternating with dry air baths. Open treatment of second degree and particularly third degree frostbite in conditions of field treatment institutions, as a rule, was not done in view of difficulties in observing aseptics and the danger of infection. It is also necessary to take into consideration the need for further evacuation in a number of cases.

Without complications second degree frostbite later on usually was coated with inert lubricants to impart elasticity to the epithelial tissue.

Medication must of course correspond to physical therapy procedures.

Some of the patients remained in all MSB and KhPPG until release depending on the sanitary and tactical circumstances or were sent to AGLR (Army field hospital for minor casualties).

Patients with second degree frostbite complicated by pronounced infection or trophic disorders were evacuated to the hospital base of the army and the front.

According to the material on the chart for fundamental characteristics, the distribution of persons suffering from second degree frostbite at the evacuation stage where they had completed treatment are presented in the following form:

Этап (a)	Процент закончивших лечение (b)
(c) МСБ	1.3
(d) ХППГ	10,8
(e) Армейские госпитали	19,2
(f) Фронтовые »	40,6
(g) Госпитали глубокого тыла	28.1

Key: (a) stage; (b) percent of persons who have completed treatment; (c) MSP; (d) KhPPG; (e) army hospitals; (f) front hospitals; (g) hospitals at the deep rear.

Stage treatment of third and fourth degree frostbite. Because the degree of frostbite is not apparent immediately, at the PMP, a precise diagnosis cannot be established and all of the patients with high degrees of frostbite are evacuated to DMP and KhPPG where a diagnosis is established as soon as the depth and dimensions of damage are discovered.

The first treatment measures are common for all types of frostbite of second, third and fourth degree. The conduct of surgical treatment (removal of blisters) and further observations make it possible to establish the degree of damage and depending on this to differentiate the treatment and to designate the stage to which the patients should be evacuated.

The main mass of patients with third degree frostbite were evacuated to the army and front hospitals because they required prolonged treatment with the use of medication and physical therapy means and also often X-ray methods of diagnosis and operative treatment. The average time period for treating these cases of frostbite, according to the data of the chart of fundamental characteristics, amounted to 88.5 days.

For fourth degree frostbite, where the patients were held at the DMP and at the KhPPG, necrotomy was conducted if there was any doubt as to the gangrenous state of the tissue.

In the army evacuation hospitals where the patients usually were held for a few days, those suffering from fourth degree were discovered in the overwhelming majority of cases. Here early surgical treatment was carried out including necrectomy and also physical therapy procedures were used.

An open method of treatment which is usually completely effective, in the conditions of the evacuation hospitals, was used very little in view of difficulties in handling, lack of equipment, and also due to the necessity during evacuation to bandage and thus disturb the principle of open treatment.

In army evacuation hospitals final amputations could be carried out for frostbite of certain digits which usually did not involve moist gangrene (with the exception of the big toe). The frostbite which occurred with moist gangrene required longer time periods for treatment and relatively often was accompanied by complications. Therefore, the patients after measures directed at converting the moist gangrene to dry, were evacuated after a few days to the front hospitals. All patients with extensive fourth degree frostbite were sent there.

All patients with fourth degree frostbite who were not undergoing complications were operated on and remained in the front evacuation hospitals inasmuch as with radical intervention the time necessary for full treatment equal 2-3 months. Patients with complications from fourth degree frostbite were evacuated to rear hospitals.

The distribution of persons suffering from different degrees of frostbite according to stage, where the outcome was determined, is presented in Table 48 (Fig. 117).

Table 48. The stage at which the outcome of frostbite was determined depending on degree.

Степень отморожения (a)	МСБ (b)	ХППГ (c)	Армейские эвакогоспитали (d)	Фронтовые эвакогоспитали (e)	Тыловые госпитали (f)	Всего (g)
	процент отморожений (h)					
I	2,5	18,3	25,7	38,1	15,4	100,0
II	1,3	10,8	19,2	40,6	28,1	100,0
III	0,2	5,2	14,2	31,2	49,2	100,0
IV	—	1,3	2,4	13,8	82,5	100,0

Key: (a) degree of frostbite; (b) MSB; (c) KhPPG; (d) army evacuation hospitals; (e) front evacuation hospitals; (f) rear hospitals; (g) total; (h) percent of frostbite.

The table presented does not completely correctly reflect the results according to stage of evacuation for first and second degree frostbite inasmuch, as was noted, the material from the chart on fundamental characteristics does not introduce a significant number of patients with light frostbite cases treated ambulatorily and at the same time includes a certain percent of patients with frostbite received at the rear. This could indicate a certain increase in first and second degree frostbite whose treatment was completed in the rear hospitals.

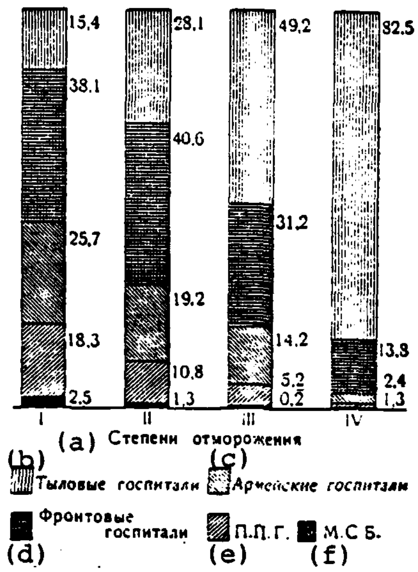


Fig. 117. Distribution of determined outcomes according to the stage of evacuation with different degrees of frostbite (in percentage of the total).
Key: (a) degree of frostbite; (b) rear hospitals; (c) army hospitals; (d) front hospitals; (e) PPG; (f) MSB.

It is effective on a scientific basis to have an organized system of treatment of frostbite as experience has shown, to create all the prerequisites or further significant decrease in the time period for treatment. The best example of this was achieved when creating at the army and front specialized hospitals or sections for treatment of frostbite. Specialized hospitals were organized at the hospital base of the army only when it was adequate or a quantity of patients with frostbite at a single base from hospitals for slightly wounded patients. As the need disappeared, the specialized hospital again could become a hospital for patients with light wounds. Specialized hospitals for patients with frostbite in the hospital base of the army, the front hospital base, and the deep rear had a number of organizational features which were determined by the character of their contingents. In these hospitals there were physical therapy departments, equipment for the open method of treatment, and well organized treatment physical exercise. In specialized hospitals of the front base and the deep rear a constant consultation with orthopedic surgeons was maintained and in the deep rear with hospitals for patients with frostbite prosthetic shops were set up. Certain features differentiated the equipment and internal organization of the specialized hospitals and also the contingent of patients treated there. Treatment of widespread second degree frostbite and all third and fourth degree frostbite cases was carried out in specialized hospitals or departments.

When observing certain conditions, the average time periods for treating the patients with extensive second degree frostbite was reduced to 2-3 weeks; patients with third degree frostbite were treated from 1 1/2-2 months. Patients with fourth degree frostbite of the terminal phalanxes and third degree frostbite were evacuated from the GBA (Army base hospitsl) and underwent final treatment in specialized hospitals of the front base organized when necessary also at the hospital base for slightly wounded patients. The time period for treating these cat gories of patients was from 1 to 2 1/2-3 months. Patients with significantly extensive fourth degree frostbite who were not returned to duty after recovery were evacuated to specialized hospitals in the deep rear. The average time period for treatment of these patients must not exceed 2-3 months.

CHAPTER IX

PROPHYLAXIS

Correct and effective prophylaxis of frostbite is accomplished with combined operation of the medical survice and the command staff. The junior command staff is involved in this work.

Frostbite in an active army in the northern regions of Europe can occur beginning at the end of August. Therefore, massive prophylactic measures and sanitary instruction work was begun in August and continued to the end of April and the beginning of May -- the time period for ending mass frostbite in the northern regions of Europe.

For correct identification and timely evacuation to the rear of patients with those types of first degree frostbite which should be treated at the rear, the senior physicians of the chast' took into consideration the soldiers and officers who have a tendency toward chilblains by an examination of every single person of the entire personnel of the chast'.

The means used in the army for prevention of frostbite can be divided into means of collective and individual prophylaxis. However, in army conditions a number of means for individual prevention, due to their mass, at the same time have become the means for collective prophylaxis. The means of collective prophylaxis is considered in detail in the section entitled "Epidemiology and hygiene."

In the conditions of the Soviet Army with the exception of the effective means for collective prophylaxis of frostbite, it was sanitary and instructional work. Organized by the medical service of the military soyedineniye, it included many forms of work: conversations, demonstrations on charts, models and other visual aids, which depict the results from incorrect or inadequate preparation for winter, spring and fall activities, different details of hygiene for footgear and clothing. The sanitation and instructive work was considered worthwhile at a high level only in a case where in setting up the military service chast' one could maintain the concept of avoiding frostbite as much as possible or in any case reducing it to a minimum with knowledge of modern means for collective and individual prophylaxis.

The means for collective prophylaxis of massive frostbite were expressed in orders by the command. Experience showed that the development of a syndrome of trench foot requires for this development about 4-5 days. Starting with this, the command attempted to give the troops in the trenches the possibility of warming and drying footgear etc. every 2-3 days. However, the detailed measures of the command were extremely difficult due to the varied conditions of tactical and strategic nature.

On order of the command,measures were taken directed for eliminating increased moisture and dampness in the trenches. For this purpose the trenches were drained, planking was put down in the foxholes, brushwood, branches and wooden flooring were set up with grating hatches.

Here where possible one set up safe areas in the shelters where footgear and clothing could be dried and in certain cases bonfires built.

To protect the wounded who were evacuated to the rear from frostbite, heating equipment should be set up. Strong cooling of the air in hospital trains in the wintertime particularly on the windy side during movement, required devices in the railway cars of the hospital trains with two walls and filling of the interwall space with materials which would not conduct heat. Setting up additional sources of heat in the railway cars was recommended (alcohol lamps, mobile stoves, etc.).

Other types of heating were used during transport in the winter, fall and spring evacuations. In vehicles a source of heat was the motor itself; when using horse drawn carts the patients were wrapped up, given hot pads, bedding and clothing.

Protection of the patients and wounded being evacuated from moisture penetration was considered (canvas hangings were set up, they were covered and equipped with waterproof raincoats, foot gear, straw covering for the legs, etc.).

Finally, as early evacuation of patients with frostbite as possible was a powerful means for preventing infection and other complications and as was pointed out above significantly improves the prognosis.

Means for Individual Prophylaxis

Frostbite frequently affects persons whose health has been weakened for any reason. Therefore, to prevent frostbite it is necessary to take measures directed at protecting the entire organism by toughening it. The importance of the latter for prevention of frostbite and freezing has been shown not only by the mass experience of people in the northern regions but also experimentally.

Toughening as a prophylactic measure against frostbite and freezing is particularly important for peoples who are constantly living in countries with a warm climate.

It is recommended that in the summer time they toughen the body by using air bags, gymnastics or massage. When the first symptoms of chronic frostbite appeared it is necessary immediately to begin massage, changeable baths, etc.

The great importance of getting used to the cold was noted; this makes it possible for the polar research worker to sleep without harm to the organism in the open air in strong frost.

The best prophylactic means against frostbite is systematic active exercise moving the hands and feet.

A general hygienic regime is very important for protecting the organism. There is no need to particularly emphasize the circumstance that sleep, rest, nutrition etc. do not always depend on the command of the chast' but often on the combat circumstances in general. However, the knowledge that providing it most of all is a factor in prophylaxis of frostbite is obligatory both for the command officers and for the physicians.

As has already been pointed out more than once, in battle, freezing of the legs is particularly important and therefore it is natural that prophylactic measures are directly mainly at protecting the soldiers legs from the effect of low temperatures. Most important here is supplying effective footgear. A number of innovative proposals directed at improving foot wear for soldiers exist.

The best of these with correct wearing are the high combat boots and valenki [felt boots]. To improve the waterproof character it is recommended that the boots be lubricated with fat.

In trenches where movement of the soldiers is limited it is very desirable to wear rubber boots. However it is known that on marches in general, the long term wearing of rubber boots is undesirable. On dry frosty days valenki are very suitable; however when a thaw sets in they can facilitate frostbite.

Special portable dryers have been set up for drying boots and footgear which is a very important preventive measure. Drying the boots on the feet later on leads to wrinkling of the boot leather and pressure on the foot from the sides of the boot and local frostbite. Moreover, without removing the footgear from the foot it would be impossible to dry it well. It is not recommended that one dry footgear directly in front of a flame (fire) because then the boots shrink.

It is important to change the boots, footgear, stockings, etc. as frequently as possible.

One should catagorically forbid lubricating the feet with vaseline because the experience of military chast' has shown that vaseline not only does not protect but facilitates the onset of frostbite. The use of the so-called prophylactic oils and greases which counteract frostbite is considered nonexpedient.

Among the folk preventive measures against frostbite are wrapping the feet in nonheat-conducting materials, in particular, paper. It should be remembered that this can protect one from frostbite only when the footgear is dry.

In order to protect the feet from loss of heat they are wrapped with foot cloths, several pairs of stocking are put on, etc. However, such measures can lead to opposite results because foot wear then often becomes too tight, presses on the feet, that is, conditions are created where frostbite can occur.

Also cardboard insoles are recommended. The boots should be wrapped with felt on the outside and overshoes made of straw put on; this is particularly important for sentry duty.

It is necessary to systematically combat perspiration of the feet bacause perspiration leads to frostbite; moreover, it facilitates contamination of the feet and itself is an infectious complication of frostbite.

Greasing of the feet with 10% Formalin is widely used followed by sprinkling with talc. Although these measures are of a palliative character they undoubtedly are a good idea because they temporarily retard perspiration and prevent frostbite from occurring.

Frequent washing of the feet facilitates preventing infectious complications and possibly frostbite itself. The feet of soldiers must periodically be examined by the junior commanders and sanitation instructors in order to avoid any problems in good time.

Sanitary clothing also is a means of preventing frostbite and therefore has been subject to an experimental study. The clothing of soldiers must be free, light and warm enough and if possible must have a waterproof covering on top. In windy weather and in frost it is recommended that a knitted helmet lining be worn.

The field-type straps should not be tightened because this could cause frostbite on sections of the body holding the strap.

The medical service observes the correctness of wearing metal helmets in order to prevent frostbite in the areas where the edge of the helmet comes into contact with the skin at the neck and on the face.

Cavalrymen, pilots and tank operators are equipped with mesh or wool liners for gloves. Snipers must be fitted with special clothing. Ties on underclothing must be replaced by buttons. It is very desirable to have pocket warmers particularly on marches.

CHAPTER X

RESULTS

According to the different types of damage, in particular, the basic damage in combat the gunshot wounds,results for frostbite also are divided into expert and clinical.

When studying results one encounters a single very important circumstance which has already been noted, namely: first degree frostbite whose number is always greater than frostbite of other degrees and very often is not taken into consideration in general. Those suffering from it are treated in the chast', without abandoning post, and therefore not recorded,at least in documents which are subjected to research. Each person who is wounded even with a very slight wound is recorded or if not this is considered an exception; in other words a slight frostbite does not prevent carrying out one's duties. Thus, when taking into consideration the results one should consider that the percentage of second and third and fourth degree frostbite is higher and in the same way its mortality rate and the percentage of healthy persons and those returned to duty is decreased. Consequently, our data presented below should be considered as a results of recorded cases of frostbite.

Finally, as study of the materials indicates, in a number of frostbite cases wounds or disease occurs at the same time; therefore, the results often are not counted with the frostbite but with disease or wounds.

For evaluating the results, special numerical data are presented which have already been cited (see page 104 and the pages following).

If one assumes all frostbite cases as 100, then obtain the following relationship according to year (Table 49).

Table 49. Frequency of frostbite by year of the war.

Год войны (a)	Первый (b)	Второй (c)	Третий (d)	Четвертый (e)
(f) Частота отморожений в процентах	51,3	30,6	12,0	6,1

Key: (a) year of the war; (b) first; (c) second; (d) third; (e) fourth; (f) frequency of frostbite in percentage points.

An analysis was given above of their interaction but it is necessary to note that widespread and effectively conducted prevention of frostbite both mass and individual had a definite effect on decreasing the number of cases.

In order to establish the relationship of results to the direct effect of the cold, a study was made of the history of diseases which could possibly affect similar patients.

First of all one should note that in the entire war the fatality rate for frostbite was very low and decreased year by year.

The cause of death with frostbite in the overwhelming majority of cases was not the frostbite itself but the diseases or wounds accompanying it. If one assumes that those who died from frostbite for the entire war has a figure of 100, then by year they are distributed thusly (Table 50).

Table 50. Distribution of persons who died from frostbite by year of the war.

(a) Год войны	(b) Первый	(c) Второй	(d) Третий	(e) Четвертый	(f) Всего
(g) Летальность в процентах	44,5	43,1	8,4	4,0	100,0

Key: (a) year of the war; (b) first; (c) second; (d) third; (e) fourth; (f) total; (g) fatality rate in percentages.

This is all related to the sharp drop in the number of frostbite cases, the decrease in percent of fatalities which by the fourth year of the war had decreased twofold in comparison with the initial period.

Finally, if one assumes 100 for all those who died, where there was frostbite involved, then it seems that 62.9% died not as a result of frostbite but from other causes (disease or wounds). In particular, all of the fatal outcomes with first and second degree frostbite are not the result of the frostbite. More than 1/4 fatal cases with third and fourth degree frostbite also do not involve frostbite. Only 37.1% of all fatal results have a causal relationship with frostbite or its complications.

Among those persons who completed treatment who have a single section of injury, healing with scars was noted in at least 92.3% with two sections of injury at least 90.1% and with three or more -- at least 87.5% and as a whole healing with a scar amounted to about 90.0% (89.4%) with a significant number of unestablished or indeterminant results.

From the data presented in the historical section it is apparent that in the preaseptic period the fatality rate from frostbite was very high. It is possible to make a comparison only with the first world war but these comparisons hardly can be considered as proven keeping in mind the differences in the climate in the Western and Eastern fronts and very significant differences in the character of combat operations. The Eastern and Western fronts in the winter of 1944-45 simply cannot be compared. It would be more correct to compare data of our enemies on the Eastern front. Here the local climatic conditions were similar and the conditions of military circumstances could be compared at least in a number of sections of the front. Precise information on enemy armies is nonexistent but on the basis of data published in literature in the materials related to it one can conclude that in the enemy army the number of persons injured by the cold was much greater, the fatality rate much higher, the treatment periods and in general the results much worse than in the Soviet Army. For the entire time of the war we used no treatment method for frostbite or medication which was used by our enemy or our allies. We found our literature and our instructions on prophylaxis and treatment of frostbite in the enemy literature and there is information that they also borrowed our method of treatment for frostbite.

Conclusions

In questions on frostbite there has been a large and significant shift relating both to the understanding of this pathological state and to practical measures.

The harmful effect of the cold is closely related to combat operations and therefore frostbite cases received in combat circumstances can relate to combat injury. The harmful effect of cold depends on the conditions in which the soldiers carrying out their combat assignments are found. When combat actions are stopped the cold is still a harmful factor and the number of frostbite cases sharply decreases; they are similar in character to frostbite arising under ordinary conditions. The connection of this factor with fulfillment of combat assignments is fairly great and even maneuvers in the cold part of the year involve a considerable amount of frostbite. The study of conditions during which cold becomes a harmful factor was facilitated by a correct understanding of the prophylaxis of frostbite and conduct of appropriate measures which, in turn, lead to a decrease in the number of frostbite cases. The uselessness of the prophylactic use of any type of lubricant was pointed out. The time factor was felt to be exceptionally important and consequently, the possibility of weakening and in certain cases avoiding frostbite by decreasing the action time in the cold. An important role involves providing soldiers with the appropriate clothing depending on their assignment (clothing of pilots, snipers, etc.), that is, those persons who are subjected to cold for longer periods of time; the importance of effective foot wear, its condition and fit was pointed out clearly. All these factors received attention and concern from the military command which undoubtedly had positive results. An important role was played by heating transportation equipment for the wounded, protecting them with furs, heaters, etc.

In spite of the special redistribution for frostbite in the lightly wounded, with a significant loss of blood, frostbite was rare among them and did not complicate the course of their wounds.

The prophylactic measures enumerated not only decreased the number of frostbite cases but also lessened the severity of damage in cases where the pathological phenomenon was not fully developed.

For frostbite clinics a new four-degree classification is important. It was proposed several years before World War II, tested during the war with the Byelofinns and finally adopted into everyday practice at the beginning of World War II. This classification which makes the severity of injury more precise was convenient for evacuation classification because, depending on the location and degree of injury, the further consideration of the victim was determined.

Study of the pathogeneses of frostbite resulted in a breakdown in all the old theories as to the effect of cold both locally and generally on the human organism. First of all isolation and description of the so-called "latent" period was noted; its importance is within the framework of problems of frostbite and is an object for research, in general,pathology. At the same time there is a basis for conducting a number of practical measures mainly therapeutic.

As to the lack of foundation of views involving the results of frostbite one can judge only by the following fact. A view as to the unusual brittleness of frostbitten tissue was very widespread and we constantly encountered it in text books; at the same time no one observed a "fallen off" finger or ear in frostbite cases and in experiments it was only with great difficulty that one could successfully break off a finger or toe in a frog frozen in liquid carbon dioxide.

Also there is little foundation for the fear of rapid warming both of separate frozen parts of the body and the victim as a whole. But temperature of the victim if he was alive could not be below 24-22° and immersion in an icy bath lead not to warming him but to further cooling; nevertheless the apprehension about putting a frozen person in a warm room remained. Putting a frostbitten person in an unheated room means that the frostbite continues.

Larrey reported that among French soldiers whose frozen extremities were warmed at bonfires, frostbite occurred more severely than among those who were not heated. However these observations were never confirmed and the "fact" was based exclusively on Larrey's authority.

Practice of World War II showed that in an overwhelming majority of cases heating a damaged extremity was done before the person saw a physician. Rapid heating was important in actual practice for persons rescued in cold water after ship disasters. The time factor was very important here. It is obvious for example that swimmers on a hot July day in water with a temperature of 20° or more will not suffer from cooling.

A breakdown in heat regulation after prolonged cooling, at least in experiments with animals, remains even with heating of the animal. Therefore a single real danger is excessive overheating. It is possible that such overheating could be the basis for the former views held as to giving first aid for the effect of cold.

With localized injury from the cold in cases of frostbite of high degrees, in the overwhelming majority of cases, necrosis occurs which encompasses the fingers or toes and less often the feet or hands. When frostbite of an even higher degree occurs,often the local effect of the cold is connected to a general effect and death or freezing sets in. Therefore, first and second degree frostbite with a fatal outcome is never involved. Equally, with third and fourth degree frostbite there are not fatal results directly based on it: death comes from complications, to a greater or lesser degree involved with damage from the cold, more accurately from the presence of a necrotic section which carries in itself the danger of infection. In other words, the surface developing as a result of frostbite in the patient has its own complications. Thus, the fight for life of the victim of frostbite involves a battle with infection primarily in the form of preventing it and then in the form of eliminating it. In a gunshot wound, the regenerative and protective functions of the tissue involve the suppression of the results of vibration from impact and the passage of a foreign body through the tissue as well as the effect of the blast wave. During frostbite these same functions are subjected to the effect of cold and the longer stronger,more intense the greater is the decrease in tissue temperature. Pathogenetic factors in both cases differ but the results in relation to danger of infection are similar. In the different cases the greater the focus of necrosis the greater the danger is.

Physical therapy methods were widely used for first and second degree frostbite. This helped cut down the time periods for treatment and decrease the subsequent trophic disorders particularly with repeated frostbite. However, the greatest successes were achieved when treating third and fourth degree frostbite cases.

In accordance with the views of surgeons which were prevalent up until recently,treatment of frozen sections during frostbite was particularly conservative: the frozen section was cleared of infection by drying it and then the necrotic tissue itself was separated along the demarcation line. The remaining granulation surface was brought to the stage of epithelialization by conservative methods and only then in aseptic conditions was amputation conducted. Under the most favorable conditions this process lasted for months and even in some cases treatment was not completed for a year or more. Many attempts to actively intervene in this process were avoided due to the fear of infectious complications.

Actually, early amputation within healthy tissue is not permissible because then, due to the lack of clarity of the demarcation line, it is done either in an area of tissue already damaged and later on the necessity for reamputation occurs or it is too high which is completely impermissible. Amputation along the demarcation line also gives poor results because here the granulation barrier is damaged which almost unavoidably leads to infection; moreover, the stump obtained only in very rare cases is suitable for carrying out functions and fitting with a prosthetic device.

Successful solution of the question was possible with early removal of necrotic sections but within the limits of the dead tissue, that is, during a necrectomy. Necrectomies and also necrotomies, are intervention of a special type. In their character they are similar to each other and at times having begun a necrotomy the surgeon will end with the use of a necrectomy. Both interventions are done without anesthetic because they occur within the limits of the necrosis zone.

Necrotomy makes it easy to dry deep sections and permits making the boundaries of the necrosis more precise; during necrectomy all of the dead tissue is removed except for a narrow band lying directly next to the demarcation line. This band rapidly forms scabs tightly covering the granulation. The danger of infection is kept at a minimum and after a short period of time amputation is done at the same level which is necessary in any patient.

Experience showed that the precise boundaries of necrosis are apparent 4-6 days after heating and therefore necrotomy is most expediently done in just this period. In this way, a month or a month and half after the frostbite occurs, the final amputation can usually be done and treatment under favorable conditions can bring it to a conclusion in 2-3 months. In the most severe cases in the presence of complications treatment can last for 1-2 months more. These time periods are much shorter than previously and therefore large number of victims complete treatment not far from the front region. It is necessary to keep in mind that in a large number of cases there is damage to one or two toes and sometimes only to their phalanxes so that after amputation the work capability of the victim is fully reestablished.

It should be pointed out that new methods of treatment for frostbite were not immediately mastered by surgeons working either at the front or in the rear. Often, particularly at the beginning of the war necrotomies and necrectomies were delayed.

Nevertheless, during World War II significant achievements were noted in the field of the study and treatment of frostbite. Soviet surgeons entered a multifaceted study of the effect of cold on the tissue of the human organism and on the organism as a whole. A study of the so-called latent period of the effect of cold was begun. The process of general reaction to cold was studied and in particular the apparatus of heat regulation and those resources which were used by the organism to combat cold.

On the basis of data existing at the present time one can primarily draw the practical conclusion that of the measures recommended both for general and local damage from cold, besides alcohol in moderate doses, sugar should be taken internally(hot sweet tea) or in severe cases intravenous injection of glucose should be given. Further, a general regime for the patient with frostbite is important (rest, heat, etc.) and a high-calory vitamin enriched diet. It is undoubtedly true that in the future for victims of cold a more scientifically based general regime will be established, in particular, a diet.

As is apparent from what has been presented above, the most dangerous complication for frostbite is infection and persons suffering from frostbite and wounds will be treated in the same way apropos of this. During World War II, also antibiotics were begun to be used for treating wounds; we have not had similar experience in using them for frostbite. Bacterial flora both during frostbite and for gunshot wounds are the same. This gives us a basis for using antibiotics in frostbite cases; here there is no doubt that they are just as effective as for wounds. At the present time one can talk about the advantages of giving a course of penicillin therapy to third and fourth degree frostbite cases in the initial period, particularly, before necrotomy and then again when amputation is done. Moreover, instructions for use of penicillin,like all other antibiotics,can be individual depending on location of the injury and the course of the process.

It is undoubtedly true that an intensive study of the effect of cold on the human organism begun during the war with the Byelofinns and continued in World War II will be conducted in peacetime particularly in relation to problems of mastering the tremendous areas of the polar region and particularly the study of this factor will make an understanding of a number of other processes both physiological and pathological easier.

PART III.

BURNS

Introduction

The use of fire in war as a means of injuring the enemy has been known for a long time. However, damage caused by a mechanical force so predominates in combat conditions that even up to the present time burns occupy a low position in the list of combat injuries.

In a German health report on the Franco-Prussian war of 1870-1871, there is mention only of 29 cases of burns on the head and in most cases these were caused by the explosion of powder; only in one case was the victim burned by hot water.

During the Russo-Japanese war of 1904-1905 burns in the active army and in the rear regions amounted to a total of 0.15% of the total list for the army and 0.9% for the list of all injuries; in relation just to wounds for the entire war the figure was 1.1%.

In spite of the fact that "conduct of battle with fire" was particularly widely used during the first world war of 1914-1918, Klavelen and Kariyon in 2,052,984 personal histories studied and treated in rear hospitals recorded only a total of 951 cases of burns from "inflammatory liquid" (about 0.04%); of this number 65.5% (623 cases) caused burns to the head. The actual number of burns in France during the first world war, finally, was much higher than that indicated by Klavelen because in his data he did not exclude all of the victims in the combat region and unusual cases (aviation, automotive transport, etc.).

In this period, the number of those who suffered burns in certain armies (France, England) was so significant that the military health command organized special hospitals for treatment of burn victims.

During combat action on the Khalkhin-Gol river,persons suffering from burns amounted to 0.36% of all wounds; during the war with the Byelofinns (1939-1940) they amounted to 0.79% of all health loss (P.A. Kupriyanov and S.I. Banaytis, 1942). During this war among the wounded in the hospitals in the deep rear there were 0.59% who suffered from burns.

In the second world war on certain western and African fronts one observes a large number of burn cases. For instance, during combat in El Alamein and Africa 25.0% of all victims in the English hospitals were victims of burns. During the attack on Pearl Harbor there were many large-scale primarily first and second degree burns which as a rule affected parts of the body not protected by clothing. Many western European sources discuss the large number of victims from burns in the second world war at the front and in the rear.

Whereas in the land army the burns are only temporary and in certain locations and this can be of definite importance in the navy injury from fire has always been very important. Fires on ships during a naval battle are a frequent phenomena and those suffering from burns make up a very large percentage of the total number of persons lost. For instance during the Russo-Japanese war on Russian ships which participated in naval battles burns amounted to about 30.0% of all damage. For example, in the battle of 3/14/1904 on the Sil'nyy mine layer, 15 persons were burned by steam; 8 of these died immediately and 3 later on.

In the English navy after the Jutland battle out of 584 persons who were injured in one way or another, in 178, that is in 30.5%, there were burns and moreover 35 persons (6.0%) received burns and wounds at the same time (V.K. Lubo and B.V. Punin, 1942).

In the first world war a large part of the victims were injured by flamethrowers; at fairly short distances they can cause the most severe burns and even charring of certain parts of the body (Fig. 118). During combat on the Izer Kyuttner a significant number of victims of such burns were observed as a result of which they became comatose or at least lost consciousness and soon died.

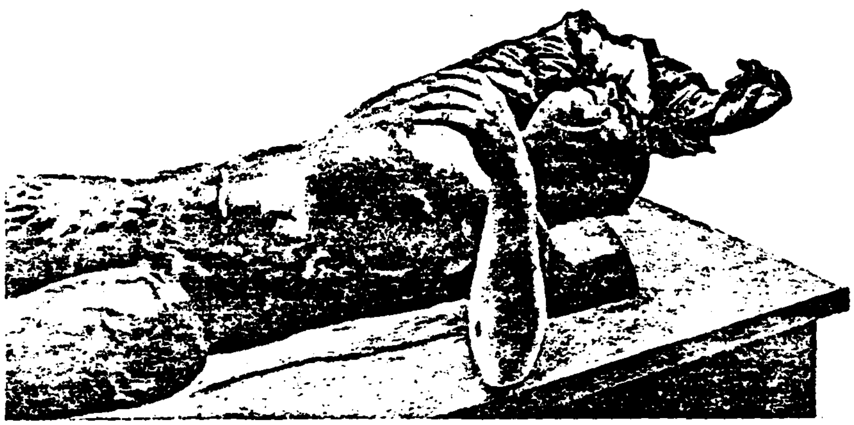


Fig. 118. Charring of the trunk, lower extremities and right hand when injured by a flamethrower. On the right forearm one can see the remains of burned clothing (from a collection belonging to Professor Yu.Yu. Dzhanelidze).

The stream of fire ejected by the flamethrower can penetrate through small apertures and therefore they are used for combatting tanks; the fire easily penetrates even through vision slits and machinegun apertures and injures the tank drivers.

In modern war burns also occur when using missiles, bombs from aircraft, incendiary bombs, fuel gases and vapors (with artillery firing); burns can be received with the explosion of combat engineer mines, with fires, with the explosion of gasoline and kerosene needed for the modern-day motorized army.

Moreover, in war often one observes the ordinary type of burns, for example, from the fire of bonfires, particularly in the winter time or as a result of the steam from boiling water or other liquids.

Finally,burns can occur as a result of chemical substances on the skin: acid, alkali and certain metal salts which are widely used in the army.

CHAPTER I

GENERAL DATA ON BURNS

Statistical Data

Burns were observed not only during combat (37.4%) but also in the front and near-front region. Often burns were received during enemy bombardment at the rear at a distance of many kilometers from the front line, etc.

Therefore, paying attention to the difficulty of discovering the purely combat burns, in further lists by the author we start with the total number of burns regardless of the circumstances in which they occurred.

The condition of the organism before the burn. Before injury 76.1% of all victims were healthy; 8.1% of the burns were combined with a wound at the same time; 1.0% remarked on fatigue; 0.5% had disorders in diet; 0.4% of the cases showed acute infectious diseases; in 13.9% of the victims there were other temporary disorders in the general condition of the organism.

A combination of burns and wounds. With a combination of wounds and burns the latter could be observed in the wound area in 3.9% of the total number of victims and outside the wound area in 4.2% of the victims.

These wounds can be distributed in the following manner according to the location of the burns (Table 51).

Table 51. Location of burns in the combination with wounds.

Локализация ожогов (a)	(b) Процент ожогов	
	в области ранения (c)	вне области ранения (d)
(e) Голова	42,7	38,6
(f) Туловище	7,1	10,6
(g) Таз	3,1	4,5
(h) Верхние конечности . .	17,8	19,9
(i) Нижние » . .	28,0	24,4
(j) Прочие области тела . .	1,3	2,0
(k) Всего . . .	100,0	100,0

Key: (a) location of the burn; (b) percent of burns; (c) in the region of the wound; (d) outside the region of the wound; (e) head; (f) trunk; (g) pelvis; (h) upper extremities; (i) lower extremities; (j) other parts of the body; (k) total.

One sees from Table 51 that a combination of burns with wounds was predominant in wounds of the head, lower and upper extremities, where generally most burns are located.

One can see the location of the burns in Table 52. Besides single burns, multiple burns occurred in a significant number of cases.

Among the victims with thoroughly established location of the injury only 35.3% was there damage in just one area, in 25.9% there was damage in two sections, in 18.0% in three sections; and in 20.8% in four or more sections. In other words, isolated (limited) burns were observed in a third and a multiplicity in two-thirds of the victims.

Table 52. Distribution of burns by location.

	Локализация ожогов (a)	Процент случаев (b)
(c)	Голова	32,3
(d)	Туловище	9,4
(e)	Таз	2,5
(f)	Верхние конечности	29,2
(g)	Нижние »	25,9
(h)	Прочие области тела	0,7

Key: (a) location of burns; (b) percent of cases; (c) head; (d) trunk; (e) pelvis; (f) upper extremities; (g) lower extremities; (h) other regions of the body.

Basically, injury to open parts of the body predominated and burns of the face themselves amounted to 95.8% in relation to damage to the head, hands and fingers -- 63.3% in relation to injury to all upper extremities; on the other hand, parts of the body covered by clothing (trunk, pelvis) were rarely burned. Regions of the joints were rarely affected from burns: on the upper extremities the burns of joints amounted to 2.8% of all burns of the upper extremities and on the lower extremities -- 8.8%; in other words, the regions of the joints on the upper extremities were subjected to burns two times less often than joints on the lower extremities.

Causes of burns. According to the material of the chart on fundamental characteristics, in the overwhelming majority of cases (69.8%) burns occurred from flames, in 11.6% -- boiling water or hot food, in 5.1% -- chemical burns, in 3.6% -- burns from incandescent or melted metal, almost the same portion (3.1%) by hot steam; 6.8% of the victims received their burns for other reasons including incandescent gases.

Burns from flame were often observed in fires, with explosion of high explosive or incendiary bombs (temperature then reaches 2000-3000°), and also with the explosion of gasoline in aircraft, in trucks, etc. These are the most severe and deeply penetrating into the tissue of the victim.

Incandescent gases, particularly those under high pressure cause injuries similar in character to the tissue damaged from flames; in a few seconds they can cause great damage to the body up to charring of those sections affected by the gases which are under very high pressure.

The effect on the human skin of hot water vapor under high pressure, for example, during explosions of steam boilers, can also result in severe broad burns particularly of open sections of the body; steam under pressure can penetrate into the nose, mouth and ears and eyelids which can explain the simultaneous burns of these regions.

The effect of hot steam without increased pressure on the skin of the body (for example in a bath) is characterized by the extent of the damage but is significantly less severe; here most often one noted second degree burns and only exceptionally did one encounter deeper damage to the tissue.

Contact of incandescent or melted metal with the skin usually cause limited third degree burns with all of the characteristic peculiarities of damage to the skin; a burn caused by an incandescent metal object makes an imprint of this object to one degree or another.

Boiling water does not have the capability of penetrating deeply into the tissue but coming into contact with the surface of the skin sometimes cause great damage more often second and less often third degree burns.

Boiling oil, milk, boullian, liquid kasha, etc. affect the skin much more strongly than boiling water as a result of the great heat exchange, the greater duration it is applied to the tissue and the lower capability for evaporation. The effect of these substances also depends on their boiling temperature.

Classification

The classification of burns has a tremendous practical and theoretical value.

Of the many classifications of burns the Boyer classification is most widely used dividing burns into three degrees.

However this classification is not devoid of disadvantages and does not fully satisfy the surgeon; it is generalized into third degree injury and surface necrosis hardly reaching the apex of the papillar layer and full charring of one or another organ.

Therefore Ziegler (1889) added fourth degree to the Boyer classification which includes charring of certain parts of the body or the entire person as a whole.

These classifications only reflect the pathological and anatomical changes according to the degree of penetration into the depth of the tissue leaving the area of the burn completely outside of its field. Moreover, the latter is no less important when determining the severity of the burn because the area of the injury and time death occurs are directly dependent on the extent of the burns.

The struggle by certain surgeons to produce a system of indices for burns into come kind of general easily recognized form, for example into tables, should be considered as an excellent and well founded concept; in this way one can create a fully inclusive classification for burns. Yu. Yu. Dzhanelidze at the XXIV All-Union Congress of Surgeons (1938) proposed recognizing the depth and dimensions of burns in the form of a fraction: in the numerator he puts the area of the burn in percentage and in the demoninator the degree of damage, for example, $\frac{17.0\%}{II}$; $\frac{20.0\%}{II+III}$ and so forth. Taking into consideration that at the first moment often it is impossible to more or less precisely determine the depth of the injury, he proposes later on with an appropriate method, correcting the numerator in this action.

Looking at the material studied from the point of view of the depth of injury, one can first of all note that in half of the cases there is damage of a single degree and in half of the cases combined burns, that is, a simultaneous combination of two or even three degrees. Taking into consideration the considerable variation in burns both of one degree and several, later on all variation in depth of damage was information for fourth degree (Table 53).

Table 53. Distribution of burns depending on the degree of damage.

(a) Степень ожога	I	II	III	IV	(b) Итого
(c) Распределение ожогов (в процентах)	0,6	54,1	44,7	0,6	100,0

Key: (a) degree of the burn; (b) total; (c) distribution of burns (in percentages).

As we see from Table 53, burns of the second and third degree were predominant among the patients, damage of first and fourth degree had the lowest percentage.

Measurement of the Surface of Burns

As is well known, among different factors affecting the course of outcome of widespread burns, the dimensions of the burn surface are particularly important. All surgeons have concluded that the area of the burn has greater prognostic value than its depth.

Measuring the surface of burns is done most conveniently according to B.N. Postnikov's method. To do this any transparent material can be used (cellophane, ordinary X-ray film with the emulsion washed off, etc.) and a grid ruled in square centimeters.

Sheets of transparent material with dimensions 18 X 24 cm, 30 X 40 cm and 40 X 50 cm usually are stored in glass cylinders with ground glass stoppers and are sterilized in Formalin vapors.

Method. A sheet of cellophane several times larger than the burned sections is laid on the burn surface. Because of the plasticity of the cellophane it adheres well to all the depressions and projections of the body. Then with a wax pencil or rod with felt dipped in 1% aqueous or alcohol solution of methylene glue, the boundaries of the burned surface are carefully drawn. With multiple small damaged areas of the skin, in order not to confuse the burn sections later on with the healthy skin it is recommended that the area of the burn on the cellophane immediately be hatched or marked with a +. Then the surface of the cellophane directly in contact with the burned skin is carefully wiped with a ball of gauze wetted in warm water or alcohol (for removing bits of epidermis and serous exudate which have stuck to the cellophane), and it is left for a few minutes for drying; then the cellophane is put on the grid (Fig. 119) and the burn is marked in this section as to the number of square centimeters. First it is recommended that one calculate the number of large squares(in 100 cm^2 or 25 cm^2) which are within the limit of the burn contours and then the number of separate square centimeters along the periphery of the latter. Using tables which are on the opposite side of the grid (Fig. 120) later on it is easy to establish the percentage and total surface of the body both for the area of each burn separately and the total of the burns.

With burns entirely encompassing certain anatomical regions, for example, the face, shoulder or extremity, one can for simplification calculate the percentage ratio using another table (Fig. 120) on which separate segments of the human are given in square centimeters and in percentage. With burns encompassing one or another segment as a whole, but with small multiple sections of damage to the skin, usually the area of the burns is measured and their total is calculated from the area of the entire segment using the tables mentioned above.

Finally, sometimes for small limited burns especially if there is no cellophane on hand or any other transparent material, the burned surface maybe measured by an ordinary method using a ruler with square centimeters as was often done in World War II and then the percentage of the area of the burn to the total surface of the body is established. The dimensions of each section of the burn separately and the total area of the burn surface of the skin are entered into the case history for the patient. The outline of the burn applied on the cellophane with a pencil is made more precise, wiping the cellophane with a dry gauze or a ball wetted in alcohol; then the sheets of cellophane are again put in the cylinder with Formalin.

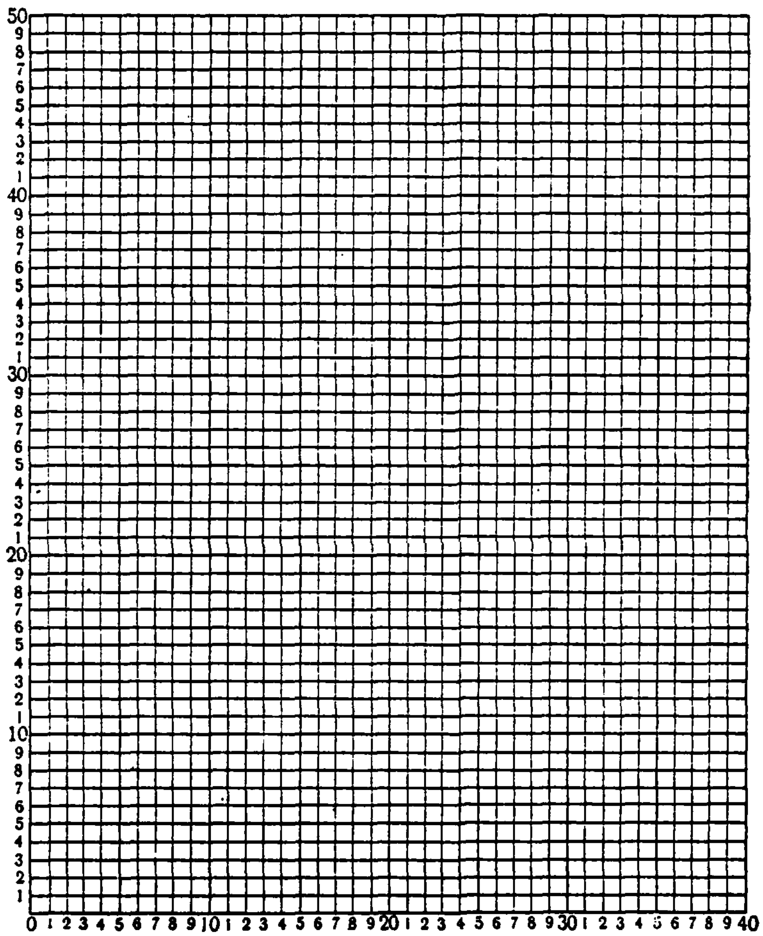


Fig. 119. Grid with divisions in square centimeters (reduced) (according to B.N. Postnikov).

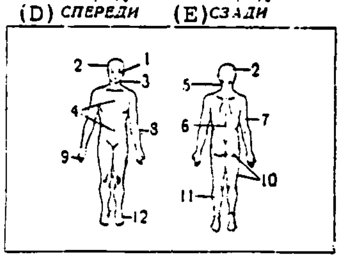
According to the data of World War II, a large part of the burns (90.0%) comprised damage which does not exceed 10% of the body surface; extensive burns were encountered much less often which lead to the necessity for putting them into large groups which can be used later on for guidance (Table 54).

(A) ПРОЦЕНТНОЕ СООТНОШЕНИЕ РАЗМЕРОВ ОЖОГА К ОБЩЕЙ ПОВЕРХНОСТИ КОЖИ ЧЕЛОВЕКА по Б. Н. Постникову

(B) ДЛЯ ВЗРОСЛЫХ

(C) ПОВЕРХНОСТЬ ТЕЛА

51,0% (D) СПЕРЕДИ   49,0% (E) СЗАДИ



(F) Размеры ожога в см²	(G) Процентное соотношение к общей поверхности тела
1	0,006
2	0,012
3	0,019
4	0,025
5	0,031
6	0,037
7	0,044
8	0,050
9	0,056
10	0,062
20	0,125
30	0,187
40	0,249
50	0,312
60	0,375
70	0,437
80	0,500
90	0,562
100	0,625
200	1,250
300	1,875
400	2,500
500	3,125
600	3,750
700	4,375
800	5,000
900	5,625
1000	6,250
2000	12,500
3000	18,750
4000	25,000
5000	31,250
6000	37,500
7000	43,750
8000	50,000
9000	56,250
10000	62,500
11000	68,750
12000	75,000
13000	81,250
14000	87,500
15000	93,750
16000	100,000

(a) Наименование областей	(b) Площадь в см²	(c) Процентное соотношение к общей поверхности тела		
(d) ГОЛОВА				
1. Лицо	500	3,12	6,11	
2. Волосистая часть головы	478	2,99		
(e) ТУЛОВИЩЕ				
3. Шея спереди	240	1,50	19,50	36,75
4. Грудь и живот	2900	18,00		
5. Шея сзади	200	1,25	17,25	
6. Спина	2560	16,00		
(f) ВЕРХНЯЯ КОНЕЧНОСТЬ				
7. Плечо	625	3,90	8,95×2=17,90	
8. Предплечье	450	2,80		
9. Кисть	360	2,25		
(g) НИЖНЯЯ КОНЕЧНОСТЬ				
(h) Ягодица	400			
10. Бедро с ягодичной областью	1625	10,15	19,62×2=39,24	
11. Голень	1000	6,25		
12. Стопа	515	3,22		

Fig. 120. Table for calculating the percentage relationship of dimensions of burns to the total surface of the body (according to B.N. Postnikov). Key: (A) Percent relationship of the dimensions of the burn to the total surface of the skin of the person according to B.N. Postnikov; (B) for adults; (C) surface of the body; (D) front view; (E) rear view; (F) dimensions of the burn in cm^2; (G) percentage of the total surface of the body. (a) region; (b) area in cm^2; (c) percentage of the total surface of the body; (d) head; 1) face; 2) hairy part of the head; (e) trunk; 3) front neck; 4) chest and stomach; 5) rear neck; 6) back; (f) upper extremity; 7) shoulder; 8) forearm; 9) hand; (g) lower extremity; (h) buttocks; 10) femur from the buttocks region; 11) shin; 12) foot.

Table 54. Distribution of burns depending on the percentage of their dimensions to the total surface of the body.

Распространенность ожога (в процентах) (a)	1—10	11—20	21—30	31—50	51—75	76—100
(b) Число наблюдений (в процентах)	89,9	5,8	1,9	1,5	0,7	0,2

Key: (a) distribution of the burn (in percentage); (b) number of observations (in percent).

CHAPTER II

PATHOGENESIS OF BURNS

Local Changes

As a result of the effect of high temperature on the human body a sharp stimulation of sensitive apparatuses of the nervous system occurs and a transmission of the stimulus to the central nervous system. With a lift in tissue temperature above 56-60°, coagulation of the albuminous colloid solution occurs and at an even higher temperature a breakdown in the albumin particles and the organic connection right up to charring. Along with the local changes which occur in different clinical forms, always there is a general reaction of the organism from clinically elusive with a small surface to the burn to the so-called "burn shock."

With first degree burns, the local reaction phenomena are essentially reduced to the appearance of an aseptic inflammation of the surface layers of the skin tissue as a result of the short term effect of a temperature which is not particularly high (50-70°). In the area of the damage immediately there occurs an expansion of the skin capillaries with transudation through the walls of an insignificant quantity of plasma in the form of a serous-fibrous exudate which results in edema in the crust of this section.

In the materials studied one notes only 0.6% of injuries classified as first degree burns.

In second degree burns, under the effect of a more prolonged thermal agent at the same or higher temperature a steady expansion of the blood vessels sets in. From the expanded capillaries and vessels in the burned regions comes a significant quantity of plasma (serous exudate) as a result of which more or less significant sections of the corneous layer of the epithelium are isolated. Accumulating the plasma forms a bubble limited by the upper corneous layer of the epidermis and below by the Malpighian layer. The granular layer of skin usually breaks down as a result of considerable pressure and its bits flow into the content of the blister. Under a microscope one can observe the degeneration of the cells of the Malpighian layer with multiple small hemorrhages in its crust.

These blisters can vary in size from insignificant (Fig. 121) to gigantic (Fig. 122); they can be single chamber or multichamber. At first they are filled with a transparent opalescent fluid which rapidly becomes cloudy and changes into a jelly usually rich in proteins (up to 5.03%), three-fourths of which comprises albumin (3.65%), and a fourth part globulin (1.36%) and a small quantity (0.01%) of fibrin. When the blister is open usually one finds fibrin in the form of a soft network and also a red corium, mottling and morbidity depending on the severity of the burn.

The transudated fluid rapidly penetrates the crust of the skin and even two hours after the burn in its environs forms significant edema reaching a maximum after about 24-48 hours. The quantity of fluid in certain cases amounts to 3.2 to 70% of the total mass of blood; in chemical composition it corresponds to blood plasma.

Second degree burns in pure form are observed fairly often.

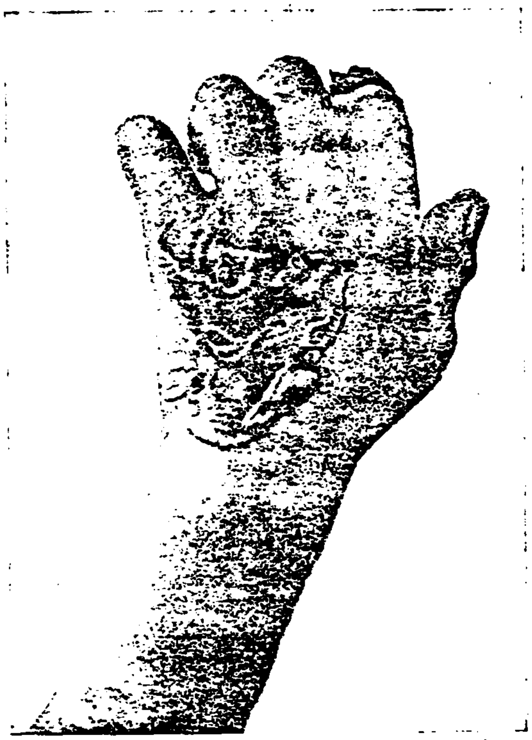


Fig. 121. Second degree burn. Small dimension of blisters (from the collection of Prof. Yu.Yu. Dzhanelidze).

Much less frequenty separate blisters spread into hyperemic swollen sections of skin with first degree damage. More often sections of second degree burns exist with deeper third degree damage. Finally, comparatively rarely one encounters combinations of all three degrees of burns.

Third degree burn usually occurs as a result of intense and prolonged effect of high temperature and is characterized by the entire thickness of the skin and underlying tissues dying; often this occurs with a full breakdown in sebaceous and sweat glands. The necrotic process during third degree burns occurs as a result of a sharp pressure on cells in a given section by an exudate particularly as a result of a breakdown in nutrition on a basis of stases and thromboses of vessels.

Fig. 122. Second degree burn. Gigantic blisters (from the collection of Prof. Yu.Yu. Dzhanelidze).

Third degree burns, according to the data of the chart on fundamental characteristics were observed in 44.7% of the cases and in combination with fourth -- a total of 0.6% of the cases.

With fourth degree burns accompanied by charring which usually is observed with the prolonged effect of high temperature (flames) on one or another part of the body or over the entire person, the fluid from the tissues evaporates, the skin itself except in the area of hair covering with a certain quantity of fat does not burn and dries out and becomes rigid and has wrinkled and less resistant areas (joint flexion, perineum) cracks and later on carbonizes; from the cracks come diluted fat of the subcutaneous cellular tissue. When the clothing catches on fire burning is facilitated by the heat of the clothing which is burning and carbonizing. In the case of death the corpse takes on a special position, the "boxer pose" or the fightning position where the hands and feet are more or less bent (Fig. 118); this phenomenon of death is the result of wrinkling and twisting of the muscles; bending of the extremities is due to the more developed flexed muscles. As a result of expansion of the Haversian channels of the bony tissue and also pressure of water vapors in the skull, cracks can form in the bones of the skull. Under the effect of high temperature the bony skeleton loses its organic basis, becomes brittle and therefore posthumous fractures are observed. With carbonizing of soft tissue it is often possible to encounter posthumous hemorrhaging; at a high temperature the blood is displaced and goes into neighboring regions whose blood filling is increased; this creates conditions favorable for break-down of the vessels with subsequent hemorrhaging; in particular, when opening the skull one discovers epidural hematomas. With severe carbonizing the corpse can be complete devoid of head and extremities with open cavities; then as a result of evaporation of fluid from the organism the volume of the body and internal organs which look like a child's is considerably decreased (V.V. Vladmirskiy, 1932).

Fourth degree burns were observed in a total of 0.6% of the cases.

General Changes with Extensive Burns

The general pathological and anatomical changes of the organism with burns are found depending on dimensions of the affliction and duration of healing.

With limited burns of any degree the general changes in different systems and organs often is absent; with widespread burns particularly of second and third degree, the changes in internal organs in the brain can be significant.

In cases of early death from burns, the brain is found to be plethoric. In the brain membranes also one observes clear arterial and venous plethora. A breakdown in blood circulation is accompanied by small hemorrhaging and edema. A number of authors describe the degenerative changes of the nerve cells; however there is no unified opinion on its cause.

Other internal organs soon after burns lose weight as a result of the decrease of the quantity of blood in them caused by a loss of the fluid part of the blood in the area of the burns. The blood thickens and due to this the quantity of prescribed elements per 1 mm^3 is increased. With a long term course of the disease and replacement for the loss of fluid, the total volume of blood is restored and in the internal organs one can observe a venous stagnation. In the lungs, moreover, often the phenomenon of edema develops (Davis, 1940).

The mucous membranes of the gastrointestinal tract during burns are full of blood; they contain point hemorrhages most of which are observed in the small intestine. On a background of hemorrhaging erosion can occur whose formation occurs due to thrombosis of small blood vessels. A number of authors have described the formation of ulcers of the twelfth cricoid of the intestine. An increased breakdown in erythrocytes leads to a significant output of bile. The degenerative changes in the parenchyme of the liver are very inconstant. In the liver one finds decomposed cells, pigments, exudates, phagocytoses, inflitration of the tissue around the bile flow with lymphocytes and sometimes the formation of fibrous tissue.

In the adrenal glands changes are not constant but are varied. In them one observes a decrease in quantity of lipoids, the foci of necrosis, thrombosis of vessels and hemmorhaging. The kidneys can become a grayish brown color. Elimination of hemoglobin by the kidneys is observed in the early periods after burns and is directly related to the dimensions of the burns. With a clearly pronounced decay in the blood the authors observed an obstruction of the channels with hemoglobin cylinders. Many authors noted blood filling of the kidneys and small hemorrhaging in them, part of which was localized in the Shumlyanskiy capsules (Boumen). The phenomenon of thromboses of small kidney vessels is described. In the kidney parenchyme one observes a turbid swelling often of fatty origin and in its indications sometimes glial-droplet regeneration and necrosis.

Changes in Hemodynamics

The reactions of the organism to burns basically depend on: 1) the intensity of stimulation of the skin pain receptors; 2) the poisoning of the organism with products of the decay of the proteins themselves coming from the focus of destruction and 3) the infection of the broad wound surface.

These changes in different organs and tissues of the victim often develop in a certain sequence.

Blood pressure. It was experimentally shown (D.Ye. Ryvkin, 1945) that in the first 10-15 minutes after a broad burn, the blood pressure in the animal (rabbit) increases on the average from 130 to 180 mm and in certain cases 200 mm Hg but after half an hour on the average it drops to 60 mm and remains at this level for 2 hours after which it returns to normal.

The initial increase in blood pressure can be explained by general overstimulation of the nervous system (skin stimuli according to I.I. Kiyanitsin, 1893); a subsequent drop of it lower than the normal level is due to the expansion of the blood channels and a certain decrease in mass of circulating blood as a result of transudation of plasma in the region of the burn. The necessity for measuring blood pressure in a person at the moment of catastrophe has caused some authors to consider that blood pressure in the severely burned usually at first can be decreased.

Changes in the red blood. a) Hemolysis. Under the effect of high temperature directly on the blood occurring along the vessels and in the region of the burn with widespread damage after several minutes there can be a considerable breakdown and dissolving of the red blood corpuscles. Decomposition of erythrocytes sometimes is fairly great;

having come from their stromata, the hemoglobin colors the plasma rose colored or even red (hemolysis). These hemolytic characteristics in the form of coloration of the serum usually disappear very rapidly (after 1-2 hours). In the observations of A.N. Spiridonov, Ye.A. Mironov, A.M. Dzhavadyan (1937) hemolysis was detected very late, after about 14 hours. Free hemoglobin of the blood is generated primarily through the kidneys and this is why in a number of cases one can establish hemoglobular undamaged kidney epithelium. However, in exceptionally severe cases, as a result of excessively generated hemoglobin, the kidney small channels can be twisted and because of this anuria of a purely mechanical character sets in. b) Coagulation of the blood. As was already mentioned above, in the area of the focus an excess generation of fluid occurs as a result of damage to the vessels and an increase in penetrability of their walls. The total volume of blood then is decreased and the loss of fluid leads to a coagulation of the blood.

Experiments on animals (S.M. Kalmanofskiy, 1938, et al.), pathologoanatomical studies on corpses (B.P. Uspensky, 1939) and daily clinical studies of blood and of burns indicates that with severe damage at first to the number of erythrocytes per 1 mm^3 in the blood increases to 6-10 million and even to 16 million (V.P. Vosnesenskiy, M.A. Vvedenskaya, 1939). Paralleling the increased quantity of erythrocytes the percentage content of hemoglobin of the blood increases (100-120-160%).

The maximum coagulation of the blood is observed after 60 hours and its restoration to normal volume occurs 135 hours after the burn. Morphologically then one observes a picture of poikilocytosis and breakdown of erythrocytes which take on the form of fragments (A.N. Spiridonov et al.).

However, certainly not always one notes a parallelism between the increase and the number of erythrocytes in the percent of hemoglobin on the one hand and the content of chlorides on the other hand.

Moreover, certainly not always one observes a correspondence between the increase in number of erythrocytes and the percent of hemoglobin.

The maximum quantity of erythrocytes and percent of hemoglobin practically never are found due to the fact that obtaining blood in the first hours after a burn as a result of the sharp drop in blood pressure is often extremely difficult. Therefore, the presence in patients of 165% hemoglobin in 1 mm^3 of blood (observation of Yu.Yu. Dzhanelidze) must be considered exceptional. In any case, there is no doubt that in spite of the significant breakdown in erythrocytes and pronounced hemolysis of the blood immediately following the burn, in the period of the first few days and more rarely in the next 24-48 hours after widespread burns, one can always state that there is a significant thickening of the blood.

Changes in white blood cells. Leukocytosis. Besides an increase in the number of erythrocytes, the number of white corpuscular bodies is increased. According to A.A. Zhuravlev (1934) et al., leukocytosis is observed soon after a burn occurs; A.N. Spiridonov et al. notes a gradual increase in the number of leukocytes in the blood.

In A.Ye. Norenberg's material, in the first days after burns occur, the number of white blood corpuscles varied within limits from 6,000 to 40,000 per mm^3 of blood. According to the data of V.P. Voznesenskiy and M.A. Vvedenskiy, leukocytosis even reached 50,000.

Light burns were accompanied only by slight leukocytosis. In a great majority of cases the leukocyte formula in the first days changes due to an increase in the percent of the segmented and then a shift to the left sets in. In severe cases with a sharply pronounced intoxication in a much later period (in connection with the related infection) one observes hyperleukocytosis with a sharp shift to the left until adolescent forms and myelocytes appear.

The presence of eosinophil in the blood can always be reevaluated as a prognostically favorable sign. With a prolonged form of burn, the eosinophils rapidly disappear in the peripheral blood. With a prolonged period of severe burns resulting eventually in death one observes a particular "play" of the eosinophils, that is, first they appear then disappear.

As to the lymphocytes and monocytes, in spite of the apparent lymphopenia and monocyteopenia, the reactive phenomena even with severe forms of burns is not observed; however, the number of lymphocytes usually increases until the day of recovery (M.P. Bogdanov, 1940). The precipitation reaction of the erythrocytes usually occurs with a great breakdown in the tissue.

The causes for increase in concentration of blood. There is no doubt that in the first days the victims lose much fluid through the epidermis of the burn surface which is destroyed. It is established that a person weighing 68 kg with a burn over 1/6 of the surface of the body can lose up to 4-5 l of plasma. Underhill considers that the decrease in quantity of plasma in the first 6-12 hours is particularly great and reaches 70% of the total volume of blood.

In patients with burns over much of the body more than once one observed a comparatively rapid soaking of massive bandages.

However, the increased concentration of blood is not always explained only by the loss of fluid through the burned surface. For example, in patients with third degree burn in the presence of thrombosis of the cutaneous vessels a loss of moisture outside occurs not only from evaporation but also from bleeding. The quantity of urine usually is decreased and anuria is even noted but nevertheless in this category of victims one always observes thickening of the blood although to no lesser degree than with widespread second degree burn.

It is obvious that thickening of the blood must be due to a decrease in the quantity of blood circulating in the organism as was established experimentally in animals by I.A. Mukhin (1939) et al.

With burns one observes the same picture as during shock: an increase in the number of erythrocytes and percent of hemoglobin, a decrease in volume of circulating blood, a drop in venous blood pressure, a decrease in the volume of the heart (proven roentgenographically) etc.

The presence during burns of erythrocytosis with an inadequate increase in the percentage content of hemoglobin and leukocytosis along with it many authors (A.N. Spiridonov, Ye.A. Mironov, A.M. Dzhavadyan) tend to explain by a true regeneration of the formed elements of the blood under the effect of stimulation of the hemopoietic system by products of decay of the blood which later on are a cause for toxemia.

Proponents of this point of view (A.A. Zhuravlev, M.P. Bodganov, et al.) note that polycythemia usually is observed with very severe burns leading either to death or at least to an extremely prolonged illness and often is accompanied by an increase in the content of reticulocytes -- a sign of significant stimulation of the bone marrow and its intoxication. In their opinion, only in the very early periods of burns is polycythemia the result of a depletion of fluid in the blood; in a much later period this is a result of sharp stimulation of the bone marrow so much so that intoxication in the burn received and set in very early,much earlier than one would expect in the general phenomena. The experiments of N.G. Korolenko (1897) reflects this; here he observed only a few minutes after the burn occurred,significant changes in the cells of the solar plexus.

However, this concept does not give the authors mentioned the right to reject the theory of dehydration or thickening of the blood due to loss of its fluid part; in other words, with burns both processes (poisoning and thickening of the blood) can occur at the same time and be the cause of severe reactions in the organism.

The increase in number of neutrophils with marked toxic granularity accompanied by the onset of a large number of adolescent forms including myelocytes is evidence of the sharp increase in leukopoiesis.

Secondary anemia. As a result of primary thickening of the blood and an increase in the number of red and white corpuscles even by the 3rd-4th day after the burn and sometimes earlier, the concentration of blood gradually begins to thin; the latter often passes the boundary of the standard and then the concentration of red blood is usually finally established at the initial level. In severe cases with clearly pronounced intoxication marked phenomena of low blood supply sets in: the number of erythrocytes varies in limits of 3-4 million with the appropriately low level of hemoglobin and clearly pronounced picture of poikiloanisocytosis.

With all the changes indicated in the blood,circulation is worsened, supply to the tissue breaks down, a breakdown occurs in the intracellular reaction and operation of the heart is extremely difficult. Transudation of plasma outwards is a very unfavorable factor which is even more aggravating to an already severe condition in the victim. Many of the victims are not able to overcome the disturbances and die.

After burns over large areas, in the first two days during which primarily the changes in the blood described occur, a maximum number of fatal outcomes occurs.

According to Yu.Yu. Dzhanelidze's observations (1939) out of 660 victims 63 died; most of these died in the first 3 days, that is 19 , then 14 of those with extensive burns died on the first day.

According to the data on the chart of fundamental characteristics, 24.5% died in the first two days out of all those who died. However,it does of course not follow from this that the changes in blood described are the single basic factor causing early death after extensive burns; later it was pointed out that in the organism of the victim at the same time that there is a breakdown in hemoconcentration, a number of other hemoral shifts develop.

Physical and Biochemical Changes

With large burns, besides the significant changes in hemodynamics, in the organism of the victim at the same time sharp breakdown in the exchange of substances develops. Most authors know that a breakdown in the exchange of substances after burns sets in only with comparatively broad disturbances; however, there are indications in literature that these changes in the exchange of substances can be observed with damage to 1/10 of the body surface (I.N. Ishchenko and M.N. Lebedeva, 1937).

Oxidizing processes in the first hours and days after the burn are of the greatest interest.

Starting with the suppositions that body temperature is the result of the relationship between heat production and heat exchange, it is completely true that a decrease in temperature in the burns received is explained by weakening of heat production immediately after the burn as a result of a sharp decrease in the oxidization processes in the organism (N.N. Burdenko, 1939). Sometimes this decrease in temperature sets in 4-5 minutes after the burn reaching a maximum in the first 2-8 hours. Clinical observations fully confirm that the larger the burn the lower is the temperature and the reverse.

It was experimentally established (S.M. Kalmanovskiy, L.G. Smirnova, 1939) that even during the first two hours after severe burns, gas exchange decreases significantly and only returns to its initial level after 24 hours. Clinically this is a drop in the respiratory coefficient with return to normal usually after 24 hours. In the experiments made by S.M. Kalmanovskiy, the absorption of oxygen by the liver tissue is decreased by 17.5% and according to L.G. Smirnova's material to 50% just 30 minutes after the burn occurs.

The decrease observed in the oxidization processes, undoubtedly, does differ with the organism. In a number of cases it reaches that stage which cannot be compensated and the body temperature drops.

In the organism of the victim with severe burns often significant biophysical-chemical and humoral changes occur which characterize a breakdown mainly in the carbohydrate and protein exchange of substances.

These changes are easily established by biochemical studies of the blood and urine of the victims.

In the blood of this type of patient one can find hyperglycemia, hyperadrenalemia, a decrease in the reserve alkalinity of the blood, azotemia, a decrease in proteins of the plasma, a high percent of polypeptides of the blood, hypochloremia, etc.

In the urine it is easy to capture hyperazoturia, an increase in the quantity of ammonia, ammonia and reduction indices, high tritration acidity, a decrease in pH of the urine, glycosuria and other changes.

Biochemical Changes in the Blood

Hyperglycemia. Depending on the severity and the area of the burns in a tremendous majority of the victims the sugar regulation function of the organism breaks down; one observes hyperglycemia reaching 155 mg% on an empty stomach (A.A. Zhuravlev and P.P. Rayevskiy, 1934).

With insignificant burns one notes an almost normal curve of the level of sugar in the blood. In severe cases, a breakdown in carbohydrate exchange occurs particularly strongly completely distorting the normal curve.

The origin of hyperglycemia can be interpreted in different ways: either a large quantity of epinephrine releases glycogen of the liver or hyperglycemia sets in as a result of deficiency in the liver and pancreas (Yu.Yu. Dzhanelidze). S.M. Kalmanovskiy considers that in the first hours after a burn occurs undoubtedly there is a connection between hyperglycemia and hyperadrenalemia. However, the simultaneous presence of hyperglycemia and a drop in blood pressure with broad experimental animal burns attests to the fact that hyperglycemia after burns does not involve adrenalinemia. Inasmuch as the curves of hyperglycemia and the depressors state precisely coincide with the curve of increase of erythrocytes, D.Ye. Ryvkina allows that the common cause of both processes is thickening of the blood.

Hyperadrenalinemia. A number of authors (Yu.Yu. Dzhanelidze, V.M. Kogan-Yasnyy, 1939, et al.) consider that at the first moment after burns in the blood channel a significant quantity of epinephrine comes in which causes a short term increase in blood pressure directly after the trauma. In the predeath stage, on the other hand, one observes hyperadrenalinemia already and death sets in as the result of atrophy of the adrenal glands and a number of other pathological manifestations. However,as was pointed out above, the primary increase in blood pressure in the burns received is caused by general overstimulation of the nervous system at the moment of trauma and its subsequent drop should be explained by expansion of the vascular channel and a certain decrease in mass of circulating blood as a result of transudation of the plasma in the area of the burn. Therefore, the question of hyperadrenalinemia with burns deserves further study.

Reserve alkalinity of the blood. As studies of a number of authors (F.N. Grinchar, 1935-1938 et al.) show, as a result of a sharp decrease in oxidation processes in the organism, the reserve alkalinity of the blood (being at a standard equal to 70-55%) with burns over large areas is significantly decreased and acidosis is apparent.

In the experiments of D.Ye. Ryvkina and A.R. Striganova (1945) a decrease in the alkali reserve of the blood was established and a simultaneous increase in protein breakdown in the tissues.

The drop in reserve alkalinity of the blood below 40% without a subsequent increase in the next 2-3 days, particularly in persons older than 50, must suggest a serious danger to the life of the patient.

Blood nitrogen. As a standard blood contains from 20 to 40 mg% of proteinless or residual nitrogen. The quantity of residual nitrogen in the blood soon after extensive burns is increased and maintained at high numbers for 7-10 days.

An increase in residual nitrogen in the blood with burns can involve: 1) thickening of the blood in the first days of the illness; 2) damage to the liver; 3) damage to the kidneys; 4) sharply increased nitrogen exchange involving absorption of a large quantity of products of decay of burned tissue; 5) proteolysis in the blood.

In the first days after large burns, when there is no basis for assuming damage to the liver or kidneys, an increase in the residual nitrogen must be due to thickening of the blood and proteolysis.

Blood Protein. As is well known, the total quantity of protein in the serum varies within limits of 6.6-9.1%. As a result of increased penetrability of the vessels even in the first hours after a burn, the quantity of protein in the plasma is decreased and in the fluid saturating the tissues surrounding the burn, on the other hand, the total quantity of protein of the serum is increased to 65-70%.

In subsequent days after the burn a breakdown in the physical and chemical state of colloids (a drop in the total quantity of proteins in the blood serum and an increase in residual nitrogen) involves saturation of the products of decay of the burn tissue. An increase in the total quantity of protein of the blood serum sometimes is noted even on the third day after large burns and on subsequent days, besides a decrease in residual nitrogen of the blood, there is evidence of a decrease in the autolytic processes and absorption in the burned sections of tissue.

Full recovery of the proteins of the plasma usually occurs very slowly and undoubtedly has an effect on other types of exchange of substances in the victims.

Hyperpolypeptidemia. One should note a high percent of polypeptides in the blood of persons who have suffered burns. Injection of these substances into experimental animals causes a picture similar to that observed clinically during burns. This is the reason V.P. Voznesenskiy and M.A. Vvedenskiy consider polypeptides the most toxic of the numerous products of decay of the protein molecule. However, the increased content of polypeptides D.Ye. Laynburg observed in certain cases of burns on the 15-20th days with good general condition of the patient and with full healing of the burn. He considers that this phenomenon involves, obviously, a prolonged suppression of the function of the liver during burns.

Blood chlorides. The quantity of NaCl both in the plasma and in the red corpuscles decreases particularly with severe burns when a drop in the chlorides reaches large dimensions.

Biochemical Changes in the Urine

Hyperazoturia. The normal 24-hour quantity of total nitrogen in the urine equals 10-15 g. As a rule, the quantity of total nitrogen increases in parallel with the severity of the burn and azoturia sets in; then variation in nitrogen in the urine in severe cases reaches 19-20 g or even 25.8 g. Usually the maximum azoturia is observed a few days after the burn occurs.

Ammonia. The quantity of ammonia in the urine also can increase in parallel with the severity of the burn reaching 1.8 g (with a normal 24-hour content of it at 0.3-1.2 g).

The ammonia index (standard 5%) both with very light burns and severe cases varies basically. The largest quantity of the ammonia index is noted usually in the first days after large-scale burns; the larger the burn area the higher the index; the highest indices in severe cases equaled 17.9%. With each subsequent study of the urine, the ammonia index gradually is decreased and after a few days reaches a normal level.

The reduction index. Determination of the reduction index in the victims is extremely important because it makes it possible for the clinician to judge the presence and degree of toxemia. The normal value of the reduction index for an adult person is 3-5 g; even with small burns amounting to 4-15% of the surface of the body, one can see a definite increase in the reduction index; with very severe burns it reaches 18.5 g with pronounced acidosis.

Titration acidity (standard from 224 to 422.5 cm^3 decinormal caustic alkali). High titration acidity (higher and 500 cm^3) was noted by A.Ye. Norenberg with severe burns which is evidence of the breakdown in acid-alkali equilibrium toward acidosis.

pH in the urine. In a large majority of cases with burns, the pH of the urine is maintained for the first days at low levels of the physiological standard between 5 and 5.5 (where the normal is from 5 to 7). The maximum decrease of pH in the urine was encountered with large burns where the pH equaled 4.2-4.4.

Creatinine. The 24-hour standard of creatinine generated by a healthy person is considered to equal approximately 1 g. With widespread burns the quantity of creatinine can be increased by 1 1/2-2 times.

Chlorides in the urine. Even small burns cause a decrease in the quantity of chloride in the urine and one notes a strict parallel with the degree of damage: severe burns usually are accompanied by a significant decrease in generation of chlorides (to 0.52 and even 0.22 g) which cause Dyuval to consider that with extensive burns, NaCl almost completely disappears from the urine. Such holding of chlorides in the organism is explained by the fact that with severe damage, a large quantity of common salt penetrates the tissue in the environs of the burns.

Glycosuria. With an increase in sugar in the blood to 180-190 mg% there are even traces of sugar in the urine -- glycosuria.

However, sugar in the urine in the burns received is not always detected. The studies made by A.A. Zhuravlev and P.P. Rayevskiy on sugar in the urine at the same time with a certain level of sugar in the blood did not show glycosuria in spite of the numbers significantly exceeding the "kidney threshold" (180 mg%) of a healthy person.

A breakdown in the acid-alkali equilibrium. A significant decrease in oxidation processes in the organism in burns is expressed in a breakdown of tissue exchange, namely: in a decrease in the reserve alkalinity of the blood, in an increase in total nitrogen, ammonia and the reduction index, in increased titration acidity, decrease in pH of the urine etc. which characterizes a shift in the acid-alkali equilibrium toward acidosis. According to A.Ye.Norenberg's material, even with burns amounting to 9-10% of the total surface of the body, separate toxemia symptoms were established in particular cases showing a picture of a shift toward acidosis. With burn damage on 15-30% of the surface of the body, one found a picture not only of toxicosis but of particularly pronounced acidosis. With burns on 30-45% of the surface of the body, marked acidosis was prevalent showing a direct life threatening situation. The burn with damage to more than 45% of the total surface of the skin, as a rule, is always accompanied by marked acidosis; fatal outcomes are more frequent here.

In this way, the degree of acidosis in large part parallels the severity of the burn; the greater the shift the more significant is the area and depth of the burn.

A change in the acid-alkali equilibrium usually can be seen fairly soon after the burn (in the first days); depending on the course of the process later on these disturbances in acid-alkali balance either continue to remain or are equalized.

F.N. Grinchar, I.M. Tyles et al. consider that the data of the study on acid-alkali equilibrium in the patients with burns can be used as an expected prognostic characteristic; with a significant shift the prediction is worse.

The Role of Infection in Burns

The question of infection in the burn process in recent times has attracted more and more attention from surgeons and bacteriologists. It is well known that infection of a burn surface can set in with damage to the burn blister even before the victim reaches a treatment institution; this occurs particularly often as a result of unreasonable measures taken in rendering first aid.

However, infection can develop due to microorganisms buried in the deeper layers of skin around the sebaceous and sudoriferous glands.

As observations by Yu.Yu. Dzhanelidze and B.N. Postnikova confirm, in the first hours after a burn occurs the damaged surface often remains sterile and only afterwards do hemolytic streptococci begin to grow on it.

M.I. Kanekevich (1939-1941) examined 80 victims of burns who had entered the clinic in the first 7 hours after the injury and established that in 54 out of 80 cases the fluid from the blisters after the burn had already become infected; on the second day, infection of the blisters was noted in 98.7% of the cases. The microflora detected belong to the ordinary pyogenic group. Streptococci and staphylococci or a combination of them are constantly observed in burn blisters in the very first hours after a burn occurs.

V.P. Voznesenskiy and M.A. Vvedenskaya in 50 cases studied the flora of blisters for burns and in 30 patients discovered hemolytic streptococci.

In the work of S.L. Tydman (1943) out of 24 burns only two cases were found to have sterile blisters. In 10 cases with inoculation of a transparent fluid the blisters in the first hours after the injury showed a growth in all blisters; in 4 of these streptococci were observed; other inoculations, half of the cases also showed the growth of streptococci either in a pure culture or in a combination with other pathogenic microorganisms.

As is apparent from what is presented in certain cases the burn can take on the form of a local suppuration and in others of a general suppuration process. The physician even at the time of the burn must take measures to prevent infection and combat it. The early appearance of excess microflora in the contents of the blisters and on the injured surface requires a broader introduction of a bacteriological method in the study of the burn surface.

CHAPTER III

THE CLINICAL PICTURE AND COURSE OF BURNS

Local Clinical Manifestations

It is well known that the most serious and difficult aftereffect of a burn is the agonizing pain. Usually it is localized in the area of injury and increases greatly even with the lightest contact.

The first and basic moment when pain occurs with burns is at extreme temperature or chemical stimulation of the nerve endings of the skin as a result of which a disorder of local blood circulation occurs with all its aftereffects. With an increase in intertissue pressure in the zone of the burn, the nerve endings are shifted and compressed; as a result of this, the pain perceptions last for a long time.

First degree burns are characterized by a diffuse redness which does not completely disappear under pressure from the finger and a slight swelling in the burned region. These signs are usually apparent at different time periods from the moment of trauma: from a few seconds or minutes (heat burn) to several hours (sunburn) and even days or weeks (burn from X-rays).

Intense redness and swelling is due to the expansion of the cutaneous capillaries and transudation of plasma through their wall; the latter, increasing the intratissue pressure presses on the nerve ending in the layer of skin and causes the stinging pain.

All of these manifestations after a few hours or days decrease somewhat; the serous exudate is absorbed and the epidermis begins to lose small scales; only in rare cases in the burn area does any pigmentation remain.

Second degree burns are characterized by more pronounced phenomena than those characteristic for first degree burn and, moreover, by the formation of blisters. The blisters occur immediately or a short time after the burn occurs and are of different sizes (Fig. 122); the large dimension blisters often are observed in regions with thin skin. In the presence of a large number of bubbles the organism loses much of its fluid and with continuing transudation of the plasma to the capillaries there can be thickening of the blood as was discussed before.

In the presence of infection the content of small blisters sometimes is absorbed or evaporated. The epidermis with surface burns 7-10 days afterwards thickens and the skin cover of the epithelium begins to have a rosy color. If bacteria from the deeper layers of the skin begin to infect the content of the blisters through defects in the walls or as a result of penetration, then suppuration occurs which can last for 3-4 weeks.

Second degree burns do not leave scars but the redness and pigmentation can last for several weeks or more.

Third degree burns are characterized by the formation of a crust on the injured area.

When burns were caused by a flame, the burned skin becomes dark, sometimes almost black with numerous whorls of slipped and burned epidermis (Fig. 123); the damaged surface usually is dry, solid to the touch and as a result of the breakdown in nerve endings completely insensitive to touch.

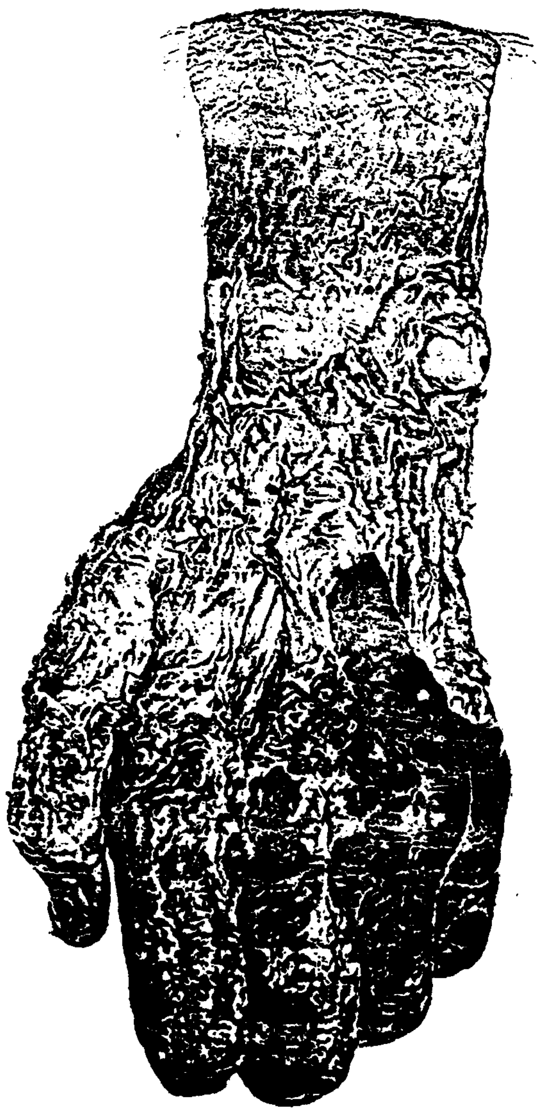


Fig. 123. Third degree on the hand. Preparation VMM No.1306/3645. (Artist T.V. Belyayeva.)

Further, on the boundary of the dead section a demarcation line forms which gradually separates the dead tissue from the healthy,which, as a rule, is accompanied by infection and suppuration. The dead tissue is sluffed off or thins out; the remainder is also removed from the wound surface or is absorbed by the lymphatic vessels. The fresh surface is covered with a fibrinogenous exudate which has an effect on the growth of the new tissue. The damaged ends of the blood vessels are covered with small thrombus stoppers; from these capillaries bundles of epithelial cells grow accompanied by fibroblasts; these cells participate in organization of a new granulation tissue. When only the epithelial covering and tips of the papillary layer are damaged layers lying deep under the epitheliam (in particular the sebaceous and sudoriferous glands) although they are partially whole, in such cases can be considered independently not only for edge epithelialization but also the island-like epithelialization (Fig. 124).

The new epithelium becomes more dense with time. A scar is formed unavoidably in the area of the injurv. These scars are whitish (Fig. 125), rough, less elastic, do not contain fibrous pockets and sweat glands and often are wrinkled and result in disfigurement and functional disorders (Fig. 126). In the area of the joints and in locations subjected to external effects (rubbing of the clothing, etc.), the scars are not very stable and easily irritated; this often leads to significant elongation of the treatment period.

Fourth degree burns which are characterized by charring of the tissue are observed not so rarely in combat conditions,for example, with damage from flamethrowers, when tanks burn up, aircraft, etc. In most cases such victims remain on the field of destruction; in isolated cases they reach treatment institutions and usually die in the first hours after admission.

General Clinical Manifestations

Limited uninfected burns, almost as a rule, are not accompanied by general symptoms in the organism; rarely one notes insignificant rises in temperature and the appearance of albumose in the urine as a result of breakdown of proteins.

Fig. 124. Edge and islandlike epithelialization with third degree burn in which the deep underlying layers of the epithelium remain whole (Yu.Yu. Dzhanelidze's collection.)

With more extensive second degree burns encompassing approximately 10% of the total surface of the body, often one observes a slight disturbance, unrest in the patient, quickening of the pulse and breathing, thirst, nausea, etc. Usually these signs last for several days and then pass on without aftereffects. It is necessary to note the powerful and prolonged course of the pain impulses caused by large burns. Further, such burns are accompanied by local damage to the blood vessels and lymphatic vessels and by excessive loss of plasma. Finally, the burns causing various degrees in depth of change in the tissue cause the formation in them of different active toxic products. In accordance with this, with large burns, the general clinical signs are very clear.

Fig. 125. Formation of white rough scars with low elasticity after a third degree burn on the chest (from Prof. Yu.Yu. Dzhanelidze's collection).

Fig. 126. Disfiguring scars on the face after third degree burns (inverted eyelids)(from Prof. Yu.Yu. Dzhanelidze's collection).

The clinical picture in this group of victims can advantageously be divided into the following stages:

A. Primary burn shock (0-2 hours from the moment of the burn).

B. Secondary burn shock (2-48 hours after the burn).

C. Acute toxemia (6-100 hours after the burn).

D. Septicotoxemia (100 hours after the burn).

Certain authors (A.Yu. Sozon-Yaroshevich and A.D. Anikhanova, 1943) do not separate burn shock into primary and secondary, apparently, from practical considerations because primary burn shock sets in immediately after the injury and almost always disappears by the time the patient is admitted to the treatment institution. However, recently, numerous experiments in the N.N. Burdenko school (M.A. Bubnov, 1939; I.A. Mukhin, L.G. Smirnova) and a number of other authors (I.N. Ishchenko and M.N. Lebedeva, V.P. Gorbatov, 1939; E.A. Asratyan, 1945, etc.) has firmly established that primary burn shock exists and has both isolated pathogenesis and a special clinical picture inherent in it. Clinically it is very difficult to precisely delineate the time of transition from one stage to another; however, it is undoubtedly true that toxemia sets in in the stage of shock, that is, the victim is still in the stage of shock and toxemia has already occurred and further, before the toxemia phase is ended the severe general suppurative infection can set in (V.I. Kazanskiy, 1939). Nevertheless, it is necessary to divide the whole course of the burn into separate stages. This system is very advantageous even for method accomplishment of such measures which must by used for severe burns.

A. The primary shock with burns is observed less often, develops more slowly and is less clearly expressed than with mechanical traumas; it can sometimes be caused experimentally.

The cause of primary shock is excruciating pain beginning in the burned area at the moment of the injury; apprehension, fear and overload both of the nervous and muscle systems; basically the pathogenesis of shock is overstimulation of the nervous system as the main regulator of hemodynamics. In this period this victim is usually unconscious; the patient is in a state of deep apathy, lies passively, preferring a horizontal position and does not participate in his surroundings. Sensitivity to stimulation is decreased. The pupils are the skin is cold and sticky and the perspiration is cold. Temperature drops to 35.2° or lower. In severe cases the pulse is hard to find, blood pressure drops but is rapidly returned to normal. Breathing is quickened and shallow.

In a number of cases the condition of the victim after some time improves somewhat and he becomes more active; sometimes exhaustion of the nervous system progresses and there is a fatal outcome.

B. Secondary burn shock. The pathogenesis of of secondary shock is defined by the three basic factors: a) changes in the nervous system -- its depletion, atonia and partial retardation (M.A. Bubnov, 1939); b) the changes in hemodynamics with a decrease in the quantity of circulating blood, a decrease in the rate of blood flow, a drop in arterial pressure, a breakdown in penetrability and weakening of the tone of the capillaries, etc.(V. Avdakov, 1876; I.A. Mukin, 1947, etc.); c) changes in the state and chemical composition of the blood in the tissues -- hemoconcentrations, acidosis, azotemia, anoxemia, hypochloremia and others(F.N. Grinchar, S.M. Kalmanovskiy et al.).

However, a significant loss by the organism of tissue fluid sets in here in the first level.

The main symptom in the stage of secondary shock often is unquenchable thirst. Pain in this period rarely begins in the first level even with damage to the face and hands. Nevertheless, often one notes restlessness of the patients, acute excitation, an increase in motility; sometimes, on the other hand, the patients are dull and apathetic but constantly ask for something to drink. They do not lose consciousness; the patient responds with one word answers to questions as if he does not really understand what is being asked. The skin is pale, cold, covered with sticky perspiration; the nose is keen; the eyes sunken; the area bluish; the face, teeth, and neck are pale with a grayish cyanic tinge. The extremities are particularly cold. The temperatures in the underarm and directly on the skin are below normal. The pulse is 100-120 beats per minute, filling is weak, blood pressure drops to 90-80 mm or even lower; venous pressure is decreased to the same degree so that venipuncture becomes difficult. Breathing is surface and shallow. With deeper shock state, along with greater discomfort, one observes movements indicating a deficiency of air. Vomiting is rare but drinking fluid sometimes triggers it. The amount of urine is usually decreased and sometimes anuria is observed.

The severity of the shock state is in direct relationship to the degree of extent of the burns, in other words, the number of pain points subjected to stimulation. Moreover, here the age of the patient is very important, the state of the nervous system and the psychic sphere at the moment of injury; physical fatigue, incomplete feeling, malnutrition and a number of other factors significantly obscure the prognosis.

Experience shows that often, thanks to the energetic conduct of a number of urgent therapeutic interventions, the appearance of shock gradually disappears further. Among surgeons here often the impression is created that in spite of large burn areas the threat to life of the patient is already avoided and that prediction in this case will be more favorable than at the moment the victim was admitted.

However, the phase of a relatively favorable state of the patient is fairly short-term and if all treatment measures are stopped at this moment then often the feeling of the patient again is worsened: pain is increased,general restlessness is apparent, vomiting, etc. Usually this is accompanied by the appearance in the organism of signs of hemoconcentration and the onset of toxemia.

According to the data of the chart on fundamental characteristics, shock during burn was observed in 2.0% of the cases in relation to the entire number of victims.

C. Acute toxemia. Acute toxemia can cause: absorption from the damaged section of the decay products of proteins which are toxic substances for the organism -- histamines, acetylcholine,etc. (V.P. Gorbatov, I.N. Ishchenko and M.N. Lebedeva, D.Ye. Ryvkina, etc.); infection of the burn surface (S.M. Kalmanovskiy et al); inadequate and lack of timely treatment of shock with the onset of the following changes in the parenchymatous organs; extreme loss of fluid by the organism both through the burn surface and from the vomiting and sweating with subsequent sharp dehydration of tissue.

Toxemia appears more rapidly the larger is the area of damage to the skin (P.A. Nalivkin, 1937).

On the basis of biochemical studies of the blood and urine during burns, A.Ye. Norenberg pointed out that all these phenomena develop approximately by the 12th hour after the injury and reach a maximum after 72 hours. This perid of so-called primary toxemia is caused by absorption of products of decay of protein bodies in the burn zone; in the primary toxemia bacterial toxemia which causes infection of the burn surface is not directly involved. However, distinguishing the burn toxemia from bacterial toxemia in practice is not possible and it is not so important; it is much more advantageous to divide the postburn state into phases depending on the treatment measures which are used in each given time segment.

Starting with the concept that surgeons and other specialists (pathophysiologists, biochemists,etc.) have not yet been able to develop objective indices for postburn intoxication of the organism, not yet knowing what substances cause it, and consequently real proof of its existence in general being absent, certain authors (S.M. Kalmanovskiy et al.) propose that worsening of the general condition of the victim following shock is due to infection and the question of toxemia is not yet completely solved. However, a great majority of surgeons (Yu.Yu. Dzhanelidze, V.I. Kazanskiy, M.A. Dikanskiy, 1939, et al) confirm that toxemia undoubtedly exists and that at this phase of the postburn period should be taken into consideration.

In the acute toxemia stage, more often attention is given to brain symptoms: it can be observed both as a stimulus and as causing drowsiness and sometimes causing twiching of the trunk and extremities. Restlessness of the patient who usually is not under any narcotic can go from a soporific state to a coma.

The high, persistent and progressing temperature in this period is characteristic for severe cases. The skin is cold, the color of marble, with reactive erythema around the burned section. The ash gray color of the gums, neck and ears is evidence of stagnation of the blood and capillaries and is a symptom of inadequate blood circulation. The low temperature and submuscular depression and particularly the tips of the ears and fingers carry a diametrically opposite high temperature directly on the skin.

In progressing cases of toxemia, the signs on the face are alert, the eyes drop, there are dark circles under them and the pupils are somewhat dilated. P.A. Nalivkin recommended paying attention to one extremely important symptom for toxemia -- this is the difficulty in opening the eyes even their complete closing while retaining consciousness.

The pulse becomes frequent and feeling is weak. Breathing is surface, irregular, accompanied by sighs. Blood pressure is usually normal.

As to the duration of the toxemic state, A.Ye. Norenberg, basing his conclusions on biochemical studies presented in the postburn period, established the following: 1) toxemia continues for an indefinite time depending on the general course of the basic illness; 2) the toxemic state with burns reaches a maximum not immediately after the injury but several days later.

According to the data of the materials studied,toxemia was observed in 11.9% of all burn victims.

D. Septicotoxemia is characterized by all of the characteristics of sepsis. The temperature has a wide range and death sets in with characteristics typical for sepsis. A clear picture of sepsis, according to the chart of fundamental characteristics, was apparent in 1.1% of the cases for all burn victims.

The latter two stages of the postburn period often are complicated by pneumonia, erysipelas, bedsores, phlegmons, which obscures the outcome even more. Even third degree burns which are small in area occurring without complication, for shortening the healing process, often need active surgical intervention (skin transplants); otherwise the healing period could be figured as many weeks. With complications and broad defects in the skin, prolonged fever exhausts the patients, significantly decreasing resistance of the organism to infection, increasing the recovery period to many months. Often in these cases rough disfiguring keloid scars (Fig. 127) and contractures, (Fig. 128) require further multiple operations.

Fig. 127. Deep keloid scars of the face, neck, chest, back and upper extremities after a third degree burn (Prof. Yu.Yu. Dzhanelidze's collection).

Depending on the severity of the burns, death can occur in different time periods: after a few hours or days from the moment of injury (early death) and even after many weeks and months (late death).

Early death (in the first hours after large scale burns) can be caused by neuroreflector shock or (in the first days) by autointoxicatioı from the burn sections; in later cases of death in the first stage infection sets in and a combination of a whole number of factors which lead to a fatal result.

Fig. 128. Scar contractures of the hand and fingers after third degree burn which have almost destroyed the function of the hand and fingers (from Prof. Yu.Yu. Dzhanelidze's collection).

Identification of Burns

The identification of burns almost never presents difficulties because the picture of burns is characteristic.

Differentiating burns from boiling water, steam, etc., from burns caused by flames in the absence of a case history is possible according to the character of local changes. When hair is scalded it does not remain curled whereas when burned it catches fire and curls up often giving off the specific odor of burning hair. When the skin is scalded usually it has an ash-like color and never darkens, is soft, and pasty; with burns from a flame, the skin often is dark,like the sole, dry, dark sometimes even black (Yu.Yu. Dzhanelidze, 1941).

If one does not know what caused the burn, flame or acid, it is necessary to remember that in the latter case blisters on the skin almost never form and coloration is uniform. With burns from flame, on the other hand, we find a variation in the burn particularly in the blisters which have remained whole and also those which are broken and form scabs are of various colors and shades (Fig. 129); often one encounters traces of carbon residue (soot) on the skin, traces of burnt hair, which are never observed with acid burns.

Fig. 129. Burn from flames. The skin has areas of dark almost black coloration; traces of blisters in the form of broken and often stripped epidermis (from Prof. Yu.Yu. Dzhanelidze's collection).

If discovering the causes of the burn is not too difficult then determining the actual depth of the burn at the initial time is often still impossible.

The intensity of the burn can be truly judged only after all of the dead tissue is detached.

CHAPTER IV

TREATMENT OF BURNS

Organization of Treatment of Burn Victims

In modern combat conditions where there are many different types of firearms, burns can be massive. In connection with the successful treatment of burns, primarily, there must be a precise organization both when giving first aid and transportation and at the time of admission into the treatment institution of a considerable number of victims. The early and correct rendering of first aid decides the fate of the burn victims.

Often first aid is given where the burn occurs where sometimes circumstances limit the measures to a minimum for preparing the victim for transportation to the treatment unit.

First of all, in order to stop spread of the burn one must rapidly and carefully remove smoldering and burning clothing. However, complete undressing of the victim in the area where he received the burn is not profitable because cooling him off is also harmful. The clothing should not be removed but cut along the seams so that it does not remain in contact with the burn surface. Then it should bother the victim as little as possible.

When giving first aid one should not attempt to clean the burned area or puncture blisters.

It goes without saying that it is necessary to forbid greasing a burn surface with vaseline or oil because to a significant degree this makes later primary treatment of the burn very difficult.

With limited burns it is necessary on location or at the nearest medical station (company section, BMP [Battalion medical station] etc.) to apply an aseptic dry bandage to the burn surface (Fig. 130).

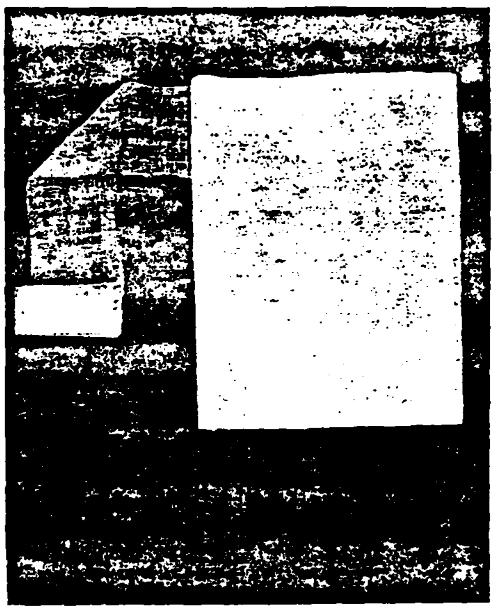


Fig. 130. A bandage for burns (according to T.T. Luk'yanov, 1937).

With extensive injury one should wrap up the victim in a sterile sheet and when possible inject 1-2 cm^3 of morphine (under the skin), cover him with a warm blanket and give hot tea or wine.

With burns of the extremity it is necessary to immobilize the damaged extremity and as rapidly as possible to move the victim on a stretcher to the DMP (Division medical station).

The victims must be moved in heated (in winter) closed vehicles accompanied by medical personnel. It is most advantageous in such cases to evacuate to the nearest DMP or to the KhPPG (Mobile surgical field hospital) on the front line; however, with extensive injury and with signs of shock in the victim, depending on his general condition he can be taken directly to the PMP (Regimental medical station) where he will receive the necessary rest and the first aid measures will be taken for combatting shock (for the details on this see "volume of medical care at stages of sanitary evacuation"). For improving the general state of victims when observing the cautions listed above they can be evacuated to the DMP or to the KhPPG of the first line for radical general and local treatment; the victims stay here for the next few days.

For final treatment of the burn,organization of a specialized section in the army or front hospital is advantageous with the equipment and special staff of physicians and average medical personnel where the victims will remain until recovered.

General Measures

The recommended measures for general care of burns are the logical result of concepts which various clinicians have maintained in the process of pathogenesis of burns. However, in spite of the theoretical agreement, a huge majority of modern surgeons consider it necessary to concentrate attention primarily on combating signs of nerve and reflector shock, on preventing or decreasing thickening of the blood, on creating a barrier against loss of plasma, on conducting primary treatment of the burn surface (Yu.Yu. Dzhanelidze). Therefore, general measures must be taken in a chronological sequence as laid out according to the system above. Only with the disappearance or significant weakening of the general characteristics can the physician go on to local treatment of the burn.

Combating Shock

In order to rapidly bring the victim out of a state of shock different measures are recommended including, in the first place, eliminating pain and subsequent warming.

Elimination of pain. The most widespread substance used to eliminate pain is morphine. The dose is injected under the skin or intravenously (Yu.Yu. Dzhanelidze, P.A. Nalivkin); a 1% solution of morphine is given usually of 1.0-2.0 and more. Ya.G. Puznyanskiy (1939), in order to eliminate pain from burn shock, widely used morphine in much larger doses (up to 6 cm^3 of a 1% solution of morphine per day) in combination with Ol. Camphorae and often an impressive effect was noted. However, using morphine for burns is disputed by some foreign authors. They have a negative view of this type of narcotic because supposedly suppressing the respiratory center increases the great oxygen demand of the tissue and decreases blood pressure.

Anesthesia on the burn surface. In the opinion of V.Ya. Vasil' kovan (1937), the significant healing effect of tannin plays an important role in combating shock. For instance, according to the data of this author, in 35 burn cases with dimensions over one third and half of the surface of the body, there were no fatal results.

V.G. Linnikov (1938) recommends using Rivanol with novocaine ground up in solution on the burn surface. In his opinion, when sprinkling the injured area with this solution it rapidly anesthesizes the wounded surface and the patients quiet down for a prolonged period; this is very favorable for them during shock.

M.A. Sarkisov (1941) recommends local narcotics for combating shock with 0.25-0.5% solution of novocaine using the latter in the form of an injection or compresses on the burn surface.

Going on to analyze the pain releiving methods listed above and the means proposed for combating shock after burn, one notes that if the local use of a solution of novocaine in a number of cases can have a certain value in decreasing pain perceptions from second degree burn, then also this is possible only with an effect directly on the corneous layer of the burn surface primarily with limited damage to the skin. Because it was recently known that in the first place even with second degree burns the epidermis locally often is retained and secondly that novocaine on undamaged skin usually is not absorbed it is completely natural that for deadening pain it would hardly be suitable for burns. The presence of simultaneous combinations of different degrees of burns once more narrows down the use of novocaine without even talking about the fact that the effect observed here usually is incomplete and short-term.

For combating shock after burns it is advantageous to use increased doses of morphine as a pain killing substance particularly in combination with 0.001 atropine (Atropini sulfurici).

Atropine which tones up cardiac activity facilitates an increase in blood pressure, decreases overstimulation of the parasympathetic nervous system, and has a pain suppressant effect on sensitive nerves. N.P. Kravkov, P.A. Nalivkin, A.Ye. Norenberg, M.K. Komissarov (1937) received a favorable impression of the use of atropine for burns. Yu.Yu. Dzhanelidze and B.N. Postnikov also never observed any kind of negative aftereffects from the use of morphine and atropine in severe burns and believe that the subcutaneous injection of these drugs rapidly improves the general condition of the victims.

Besides morphine, as a pain relieving substance for burn shock, at the present time, Pantopon is widely used as well as chloralhydrate, chlorethyl (in small doses), Hexenal et al. When 1500-3000 AE of anti-tetanus serum is injected along with the morphine, this should not be done before first aid is given.

Mobilization of the processes of soporific slowdown. The common conditions of pathogenesis of traumatic and burn shock forced E.A. Asratyan (1945) to test liquid which he had proposed earlier for treatment of traumatic shock in cases of burn shock. This fluid consists of two separately stored solutions: solution A in a dose of 500-550 cm^3 which is contained in one or two large ampoules and solution B in a dose of 50 cm^3 -- in a small ampoule.

Composition of the Fluid

Solution A	Solution B
Natrii chlorati 8,0	Uretani 1,2
Natrii bromati 0,75	Veronali 0,15
Natrii bicarbonici 0,6	Calcii chlorati 1,5
Aq. destill. до 500,0	Glucosae 17,0
	Spiritus Vini rectificati 15,0
	Aq. destill. 50,0

According to the author's material, injection of this fluid during traumatic shock causes a significant increase in arterial pressure, an increase in gas, organic and water-salt exchange, improvement in the pulse, breathing, the general condition and feeling of well-being of the patient and on this background -- a drowsy state which under favorable condition gradually changes to sleep lasting 2-4 hours. Clinical observations made by A.M. Dykhno on the use of this fluid for burn shock (1946) gave extremely favorable results: all 8 victims recovered.

One sees from Table 55 that first aid to burn victims basically is given at regimental medical stations (57.0%), at battalion aid stations for the wounded (17.2%), at regimental and battalion aid station (13.5%); in other words, first aid for burns for 87.7% of the victims was given in treatment institutions in the army region.

Comparing the relationship of general and local measures for giving first aid at different stages of evacuation, one can establish that at this time, as on the battle field, in the company section and at the battalion aid station first aid is given to victims of burns most often by applying bandages, at the regimantal aid station, at the regimental and battalion medical stations and the mobile surgical field hospital when giving first aid, on the other hand, general measures are predominant. This is completely understandable because the first bandaging applied in the location of the catastrophe or at the front aid station is certainly not always removed at the next stages of evacuation; in most cases here they are limited only to determining the general condition of the victim and when necessary giving further aid and sending him to an army evacuation hospital.

Table 55. Relationship of general and local measures when giving first aid for burns at evacuation stages.

Этап (b) / Характер мероприятий (a)	Поле боя (c)	БМП (d)	ПМП (e)	МСР — МСБ (f)	ППГ (g)	ГБА (ГЛР, ЭП, ЭГ) (h)	ГБФ, ЭГ (i)	Прочие учреждения (j)	Всего (k)
	(l) Процент случаев								
(m) Общие мероприятия	0,7	6.6	66.7	19.6	3.1	1,7	0,5	1,1	100,0
(n) Местные »	6,9	17,0	52,1	16,0	2,5	2,3	0,5	2,7	100,0
(o) Итого ...	4,9	13,5	57,0	17,2	2,7	2,0	0,5	2,2	100,0

Key: (a) character of the measure; (b) stage; (c) battlefield; (d) PMP; (f) MSR-MSB (MSR -- Motorized medical company); (g) PPG Mobile field hospital]; (h) GBA (GLR, EP, EG), (GLR -- Hospital for light calualties; EP -- evacuation point; EG -- Evacuation hospital); (i) GBF, EG; (GBF -- Base hospital of the front) (j) other institutions; (k) total; (l) percent of cases; (m) general measures; (n) local measures; (o) total.

Analyzing the time period for giving first aid for burns by the year of the war, one should note that in almost half of the victims (46.6%) it was giving soon after trauma: in 13.1% -- 1-2 hours after the burn; in 8.2% -- 3-6 hours; in 6.3% -- 7-12 hours; in 17.7% -- 13-24 hours and in 8.1% -- first aid was given more than 24 hours after the trauma occurred. In other words, in the first 6 hours after the burn,first aid was given to the victims in 67.9% of the cases.

When giving first aid on location where the incident occurred, most often a tetanus injection is given (88.0%), morphine (?2.4%) and cardiac substances (9.7%).

Most often these drugs are injected directly one after the other, for example, morphine and cardiac drugs (camphor, caffeine), anti-tetanus serum and morphine, etc.

Giving first aid usually involved applying bandages on the damaged area and here bandaging with various coagulation fluids predominated (weak solutions of potassium permanganate, 2-3% solutions of tannic acid, etc.); bandages with these substances were applied in 37.9% of the cases observed. Dry bandages were used in 36.6%; bandages with various lubricants (boric, xeroformic, Vishnevskiy ointment) in 18.0%, with powder type substances in 3.8% and in 3.7%; with small first and second degree burns open treatment without bandaging was used at first.

The study of the types of first aid showed that in the large majority of cases (91.1%) morphine, cardiac and antitetanus serum were injected in the burn victims by a physician.

The application of bandages on the burn surface fairly rarely was done by the victims themselves (1.8%) and by a comrade in arms (4.3%) the public health instructor applied bandages in 15.8% of the cases, the paramedic in 7.9% and the physician in 70.2%.

Thus, more than 2/3 of the burn victims were given first aid by qualified medical personnel.

Burns occur very suddenly, randomly, and therefore each soldier and officer at any time and under any circumstance must be able to give first aid before a physician comes.

Keeping the burn victim warm. Keeping the victim warm is the next important measure in combating burn shock.[1] In the first hours after severe burns always one can establish a certain drop in temperature in victims which is due to a drop in heat production of the organism as a result of the significant decrease in oxidiation processess and all

[1]Warming is considered to mean also prevention of cooling.

types of metabolism. The decrease in heat production emphasizes the particular importance of keeping the victim in warm rooms both immediately after the burn occurs and in the first days of subsequent hospitalization in treatment institutions. Therefore, it is necessary to put the victims immediately into specially heated (with temperature 23-25°) antishock rooms or tents where their clothing can be carefully removed, the burn sections can be covered at first and then the entire body with sterile dressings and they can be covered with warm (but light) bedding. The victim is given hot tea or coffee internally.

However, the energy of warming the body can lead to rapid expansion of cutaneous vessels and thus a breakdown in the extremely important compensatory process. Moreover, intense or prolonged warming can increase the loss of fluid by the organism in evaporation and increase perspiration. Finally, intensive warming accelerates oxidiation exchange of the skin and muscles, autolysis of the damaged tissues and absorption of the autolysis products. Therefore, starting with theoretical practical expressions one should emphasize that the more or less intense warming of burn victims is contraindicated and allowable only after restoring the volume of blood by transfusion. In no case should the victims be warmed until they perspire. Warming in combination with preliminary blood transfusions is useful but a single warming can result in expansion of the vessels, collapse and death of the victim.

Rest. Among the measures for combating shock after burns is seeing that the patient rests; this is particularly important. For this type of patient it is necessary to set up an isolated warm room where they can be admitted and observed. Here they can rest for half an hour to an hour or more.

Combating the drop in blood pressure. Epinephrine. Some authors point out that with burn victims very early the adrenal glands are damaged and, consequently, the effect of the cardiovascular hormone, ephinephrine, drops; in their opinion, this leads to the drop in blood pressure in the first hours after a burn. From this point of view they propose that it is expedient to inject epinephrine for burn shock in order to decrease the capacity of the vascular bed by using a vessel contracting drug on it and thus raising the blood pressure. However, even Kennon had established that: 1) disorders in blood circulation in burn shock basically affect the capillary system; epinephrine does not improve the flow of blood in capillaries; 2) the use of epinephrine in the first hours after a burn is not useful because raising the blood pressure for a short time here to a definite degree makes operation of the heart difficult and without it even temporary circulation of the very thickened blood; moreover, in the first hours after a burn often one observes a hyperfunction of the adrenal glands which is accompanied by an increase in blood sugar.

Therefore, P.A. Nalivkin considers it definitely incorrect and A.Ye. Norenberg unthinkable that one use epinephrine in the first hours after a burn; this is because the function of the adrenal glands during this time is increased; hyperglycemia is evidence of this.

G.F. Lang (1942) prefers the prolonged use of epinephrine in small doses in combination with injection of various fluids into the organism. Besides epinephrine, G.F. Lang recommends the use of ephedrine both subcutaneously and intravenously; the effect of the latter is less acute and less approximate than that of epinephrine. No less expedient during shock, in the opinion of G.F. Lang is Simpatol a synthetic ephedrine drug which replaces epinephrine. Simpatol acts vigorously, but less abruptly than epinephrine because it is 100 times weaker (the dose of Simpatol is 0.05-0.01). The use of epinephrine for burn shock needs further study.

Combating dehydration and hemoconcentration. Because the development of secondary burn shock is due not only to the intense and prolonged stimulation of the nervous system but also at the same time to increasing plasma loss and toxemia in the broad meaning of the word, combating dehydration during burns must pursue the following task: 1) rapid replacement of the actue lack of plasma to provide normal volume of blood; 2) restoration and maintenance at a definite level of the

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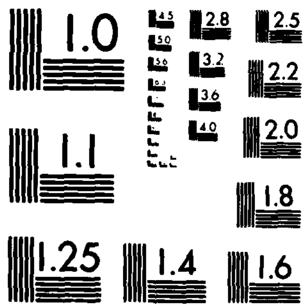

MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

blood hemoglobin and plasma proteins (at least 6.0 per 100 cm^3 of plasma); 3) prevention of a breakdown in the salt balance of the organism; 4) prevention of acidosis; 5) restoration and maintenance of the quantity of urine (2 l per 24 hours).

To quench the thirst of the patient he should be given an unlimited quantity of hot tea but taking into consideration the quantity of fluid drunk. Then it is necessary to see that one does not overfill the stomach and cause vomiting.

To speed up the elimination of dehydration and hemoconcentration usually it is recommended that fluid be put into the organism in every possible way: through the mouth, by enema, subcutaneously and intravenously (V.V. Gorinevskaya, 1942; A.I. Charugin, 1937; P.A. Nalivkin et al.). One should not rely heavily on the rectal method of injection because during burn shock the processes of absorption in the organism are extremely slow at first. It would hardly be expedient to inject fluid under the skin in such cases. Thus, the best method for getting fluid into the organism during shock is intravenously. In view of the fact that in persons with severe burns the large veins in the extremities, as a result of the drop in blood pressure, often are in a collapsed state and vein puncture in these cases is difficult, it is best at first to use one of the surface veins and put a glass or metal cannula into it (Yu.Yu. Dzhanelidze).

During shock, saturation of the organism with fluid in the first 48 hours is extremely important.

Transfusion of plasma. The best substance for intravenous injection is blood plasma which at the same time provides getting fluid and electrolytes into the organism.

At S.I. Spasokuktskiy's clinic, in burn shock transfusion of plasma is preferred. The basis for this is the following: thickening of the blood during shock, loss of plasma, a decrease in the quanity of protein in the plasma of the remaining blood, an increase in the number of erythrocytes and an increase in the percentage content of hemoglobin of the blood. Transfusion of plasma for burn shock was recommended by A.N. Spiridonov, G.A. Mironov and A.M. Dzhavadyan back at the VI Ukrainian Congress of Surgeons in 1936 and by V.I. Kazanskiy at the XXIV All-Union Congress of Surgeons in 1938.

The introduction of plasma is particularly expedient because proteins in the plasma facilitate a restoration of the normal condition of the capillaries, their tone and penetrability of the walls.

For determining the dose of plasma to be given, at the present time, there are a number of formulas based on hemoconcentration or the surface area of the burn:

a) injection of 100 cm^3 of plasma for each 100,000 red blood corpuscles over 5 million contained in 1 cm^3 of blood;

b) injection of 50 cm^3 of plasma for each percent of hemoglobin exceeding 100%;

c) injection, depending on the area of the burn, of 50 cm^3 of plasma for each percent of damaged surface.

It is adequate to consider transfusion at first of one third of the dose of plasma calculated and to inject the remaining fluid in equal proportions every 4-5 hours. With the injection of the initial dose of plasma also it is recommended that in the first 2-3 minutes 200-300 cm^3 be tranfused and then comparatively rapidly its quantity reaches 1000 cm^3; however, clinically this does not show a corresponding improvement. The remaining quantity of plasma is injected much more slowly. It is even more expedient in such cases to have a drop transfusion of plasma at least until plasma loss is stopped (36-48 hours after the burn).

Depending on the severity of the general condition of the victim and the capability of the treatment institution, it is fully permissible to replace part of the plasma with stored blood.

Blood transfusion. If the emergency transfusion of plasma is inadequate in any way (for example when there is a lack of it), then without losing any time one should immediately set about blood transfusion. In the opinion of many modern surgeons, transfusion for blood burn shock is the unsurpassed means; the results of transfusion are are better the earlier it is done.

Blood transfusion is particularly effective for a state of shock. L.A. Smolyaninova (1937) reports that for burn shock the timely transfusion of blood had very successful results. However, other authors withheld their comments on the effectiveness of blood transfusion for burn shock. For instance, D.N. Fyedorov, A.V. Gabay et al. did not record any kind of noticeable effect from the use of this method and V.I. Mushkatin (1937) for blood transfusion saw more cases of worsening than improvement.

While at the VI Ukrainian Congress of Surgeons (1936) many authors had very sparse numbers on blood transfusion for burn shock, two years later at the XXIV All-Union Congress of Surgeons many authors could report on hundreds of cases of blood transfusions for burn (M.A. Vvedenskaya reported on the use of hemotransfusion and [illegible] ses with a good effect and recommended this method enthusiatically). Observations made during the war showed that blood transfusion for burn shock does have a favorable effect.

Instructions for blood transfusion during shock. Yu.Yu. Dzhanelidze uses blood transfusion in order to increase blood pressure. In the opinion of I.N.Ischenko (1939) et al.,the basic indications for blood transfusion during shock are disturbances in blood circulation and neuroreflector shock in all its manifestations. S.I.Spasokukotskiy sees the greatest effect from blood transfusion during shock in the first days after the burn occurs.

However, M.A. Dikanskiy and a number of other surgeons consider blood transfusion in the first days after severe burns as contraindicated, proposing that with thickening of the blood and an adequate quantity of hemoglobin, stimulation of the hemopoietic system of the organism and the addition of new erythrocytes in the blood of the patient is not expedient.

Nevertheless, the overwhelming majority of surgeons used and continue to use successfully blood transfusion for burn shock. Inasmuch as thickening of the blood in persons who have received burns is accompanied by a drop in erythrocytes, an increase in new red blood corpuscles as carriers of oxygen can only be useful.

Finally, the blood not only acts as a substitute in the form of replacing dead erythrocytes; with the blood the victim receives enzymes and hormones in his organism and also nonspecific antitoxins which increase his resistance.

In cases of burn plasma loss it is necessary to introduce a large quantity of blood (up to 1 l and more) and to do so continuously by drop method, inasmuch as the loss of plasma by the organism with large scale burns contines for many hours and compensation of it requires continuous addition of blood. Single transfusion of small quantities of blood (200-400 cm), according to the observations of a number of authors, does not always have the desired results. Transfusion of more massive doses facilitates eliminating the most severe shock state in patients with extensive burns. Lack of observation of this condition, obviously, led part of the surgeons to deny the useful effect of blood transfusion for burn shock.

Injection of a physiological solution of common salt. The injection of a physiological solution of sodium chloride recommended by certain authors (P.A. Nalivkin, A.G. Puznyanskiy, A.Ye. Norenberg et al.) to combat clogging of the arterial channel and to decrease the sharply increased concentration of blood during shock seemed almost useless. Only a short-term effect could be obtained here because injection of a physiological solution during shock facilitates elimination of a larger quantity of proteins from the organism than the latter usually loses with large-scale burns and, moreover, this facilitates the development of edema in the burn region. According to the material of Yu.Yu. Dzhanelidze and B.N. Postnikov, the internal injection of a physiological solution of common salt in the period of shock, besides a short-term increase in blood pressure and a significant increase in plasma loss, improvement of the general condition of the organism did not result.

The injection of a hypertonic solution of common salt and of glucose. In attempting to turn the blood from the tissue into the vascular bed and also in order to combat hypochloremia, certain authors recommend the injection of hypertonic solutions of common salt and glucose. Experience shows that hypertonic solutions in a number of cases are more effective than isotonic solutions. However, it is necessary to take into consideration that far from all of the plasma lost in the tissue can be returned: a significant part of it with large scale burns is discharged and in such cases the use of hypertonic solutions will have little use.

The intravenous injection of hypertonic solution of common salt in the period of burn shock can be indicated only with the presence of acute hypochloremia particularly in cases where the patient for various reasons cannot be given plasma or blood.

In this connection, for each injection of common salt one should test the content of sodium chloride in the blood (Yu.Yu. Dzhanelidze).

The use of glucose for shock sometimes gives satisfactory results particularly with a simultaneous combination of it with insulin (twice a day in 15 units) which, along with morphine, makes the patient feel somewhat better and quieter.

Combating the drop in cardiac activity. Cardiac substances. In order to increase cardiac activity for burn shock different means are recommended: camphor, caffeine, Cardiazol, etc. All of these substances, undoubtedly, deserve attention for the treatment of shock but their use is not completely effective because during shock primarily the effect is on the capillaries. G.F. Lang considers that finding the best means will be among hormonal substances, for example, in hormones of the adrenal cortex and the anterior part of the hypophysis.

Oxygen and carbon dioxide. With signs of anoxia in patients during shock, the intravenous injection of plasma or blood is expediently combined with simultaneous giving of oxygen; the latter is introduced through a nasal catheter because with this method the organism receives twice as much oxygen. In cases where assimilation of oxygen by the lungs is decreased noticeably (in persons damaged by smoke or flame), S.L. Timofeyev (1936) recommends the injection of oxygen directly into the rectum where the latter is well absorbed.

G.F. Lang has the opinion that carbon dioxide must be used during a shock state.

Combatting the breakdown in acid-alkali equilibrium with burn shock. A breakdown in protein regulation under the effect of a breakdown in protein results in a change in the organism of its acid-alkali equilibrium which, basically judging from the determination of reserve alkalinity of the blood in the dynamics with burns most often appears in the form of acidosis and more rarely in the form of alkalosis. In order to reestablish the disturbed colloidal equilibrium it is recommended: with acidosis to inject 20 cm^3 of a 30% solution of sodium biosulfate (F.N. Grinchar) for a period of 2-3 days; for alkalosis -- 10 cm^3 of a 10% solution of calcium chloride. On the basis of experimental studies, V.V. Babuk considers the best means against shock to be a 5-10% solution of calcium chloride injected after transfusion with 5% glucose in a physiological solution (V.V. Babuk and A.N. Puzanova, 1939).

A detailed study of these drugs showed that their injection into the organism causes not alkalinity or acidity (particularly as a 30%

solution of sodium thiosulfate is slightly alkaline and calcium chloride has a neutral reaction), but prevents coagulation of colloids and moreover prevents the development of anaphylactic shock (A.I. Charugin).

Testing the effect of sodium thiosulfate on patients with burns at the Institute im. Sklifosovskiy (Moscow) showed a decrease in the fatality rate for burns from 26.0 to 10.0%.

The question of a breakdown of acid-alkali equilibrium in the organism with large burns deserves further study.

Measures for combatting shock, according to the material of the chart on fundamental characteristics, was carried out in relation not only to all of the shock patients but also 56.5% of the victims with a burn area greater than 10% of the total surface of the body in whom one could expect signs of shock.

Combatting a shock state basically, besides pain relief primarily with morphine, is done by the broad use of transfusion of 300-500 cm^3 of blood and an antishock fluid. In a number of cases two or even three transfusions of blood were carried out. General, including the antishock, measures wre conducted mainly at MSR-MSB (34.9%), somewhat less often at PPG (23.4%) still less often in treatment institutions of the hospital base of the army (20.6%) and the front (17.3), at other instituions (local hospitals, clinics etc.) a total of 3.8% were treated.

According to the material of the chart on fundamental characteristics, at treatment institutions antitetanus serum was widely used: in a generally compex infection, antitetanus serum is given for all burn patients.

Combatting Toxemia

It was noted above that acute toxemia can be caused by: a) absorption of products from the breakdown of proteins in the sections of the burn; b) infection of the burn surface; c) inadequate and incomplete treatment of shock; d) extreme depletion of the electrolytes of the organism.

The danger of the first two factors to a great degree is decreased with thoroughly carried out primary treatment of the wound surface with subsequent isolation of it from the environment by applying protective bandaging. Inadequate conduct of antishock measures also cannot have a great effect if the primary treatment in the burn area is done. Consequently, one of the serious causes for the development of acute toxemia can be the continuing extreme loss of blood plasma and electrolytes by the organism causing acute dehydration of the tissues.

Blood transfusion. During toxemia as during shock, blood transfusion is particularly important. A large majority of surgeons (S.I. Banaytis and T.T. Luk'yanov, 1936; V.I. Struchkov, 1939, et al.) note the extremely good effect of blood transfusion during toxemia. In this period, poisoning of the organism occurs from the products of decay of cellular elements and in the blood channels immediately large quantities of poisonous products from decomposition of proteins occurs; the phenomena of intoxication develop, etc.

It is possible that the erythrocytes which absorb toxins and poisonous products of protein decay from the blood channel play an important part here (S.I. Spasokukotskiy, 1938).

Only by blood transfusion can one successfully neutralize the toxins, maintain blood pressure at the prescribed level, deliver oxygen and plasma to the tissue, prevent hypoproteinemia, increase the volume of substances and specific functions of the organisms. On the basis of a number of experimental clinical works it was established that the effect of transfused blood in not limited to simple replacement of a blood deficiency in the organsim: moreover, there is a factor stimulating the function of the blood producing apparatus. A.A. Zhuravlev's studies indicate the decreased activity of the bone marrow, the slowdown in erthythropoiesis in patients with burns which is eliminated as the result of blood transfusion.

Blood transfusion, reducing toxemia, increases the activity of the secretory organs which even more decreases the possibility of poisoning of the organism giving it the best conditions for combatting the main injury (V.I. Struchkov). However, it is impossible not to mention here the opposite views held as to blood transfusion at the stage of toxemia. A.I. Spiridonov, Ye.A. Mironov, A.M. Dzhavalyan, proposing that in the period after the burn there are many erythrocytes in the blood of the ictim and to increase the existing stimulation of a hemopoietic system is irrational; they recommend no blood transfusions but on the contrary, blood-letting (100-500 cm^3), considering that this measure facilitates detoxification of the organism.

V.I. Kazanskiy at the XXIV All-Union Congress of Surgeons reported on good results observed in S.I. Spasokukotskiy's clinic in the use of blood-letting (600-700 cm^3) to combat toxemia: the patients are fully conscious, delirium and stimulation have passed, blood pressure, the number of erythrocytes and the hemoglobin have reached normal figures. The author considers that blood-letting during toxemia in cases of large burns always brings the victims out of severe states: out of 100 patients with burns at the toxemia stage not one died.

A.V. Gabay, M.K. Komissarov, A.D. Fyedorova (1938) et al.,in order to eliminate toxins and revitalize the blood during toxemia consider it most expedient to conduct blood-letting, but immediately to compensate for this with subsequent transfusion of fresh or citrate blood.

However, neither method has been widely used in the treatment institutions of the Soviet Union. A number of authors have expressed opposition to preliminary blood-letting on the basis that a new loss of blood in severely injured persons worsens rather than improves their general condition. Moreover, in spite of the blood-letting, toxins from the burn section later on can enter the blood stream. Daily observations confirm that due to thickening of the blood one cannot always get an adequate quantity of blood from veins; subsequent transfusion of blood will not be as effective as M.K. Komissarov points out.

In order to combat the signs of toxemia in military field circumstances, the injection of an antishock fluid is widely used consisting of a 5% solution of glucose and a physiological solution of common salt. But blood transfusion was the most valuable.

The quantity of urine during toxemia after a burn even in the first 48 hours must amount to 100 cm^3 per hour, that is, up to 2.5 liters per 24 hours. Therefore, the daily quantity of urine must obligatorily be measured in each case of more or less severe burns. However, even with an excess injection of fluid through the mouth, the quantity of urine is inadequate and it is recommended that one inject intravenously a physiological solution of common salt, particularly in the first 48 hours after shock, in such cases it only makes the blood more hydremic. In order to bring the daily quantity of urine up to 1.5-2 liters and more, the total quantity of fluid required must be at least 3-4 l per 24 hours (with healthy kidneys).

The injection of hypertonic solutions of common salt and glucose. With hypoglycemia and hypochloremia, in this period the injection of hypertonic solutions is indicated; with severe burns one injects intravenously 200-300 cm^3 of a 1.5% solution of common salt in combination with a 30% solution of glucose (from 75 to 100 cm^3). It is extremely favorable to combine the injection of hypertonic solutions with simultaneous transfusion of 200-300 cm^3 of blood.

In order to combat increasing acidosis the internal injection of sodium thiosulfate is continued (see above) or 40 cm^3 of a 4% solution of soda is used. A.A. Krylov (1938) for this purpose prescribed taking by mouth large quantities of alkali solutions.

The injection of a 10% solution of calcium chloride. As P.A.Nalivkin notes, good results were obtained in toxemia by the intravenous injection of a 10% solution of calcium chloride which compensates for the lack of calcium salts in the organism and decreases the turgor of tissues during burns.

Medicinal therapy. For maintaining vascular tone and blood pressure at certain levels camphor is prescribed and a 5% solution of ephedrine. With third degree burns it is recommended that one use sulfamide drugs in a quantity of 4.0-6.0 per 24 hours.

With septic manifestations penicillin is indicated 25,000-50,000 units every 3 hours for a prolonged period of time.

Combatting Postburn Anemia

Later on one must take measures to prevent postburn anemia and maintain the appropriate level of protein balance.

If burns cover 5 to 10% of the surface of the body, then the patient is given 125.0 proteins per day, from 10 to 15%-125.0 to 200.0 protein is given, with burns covering more than 20% of the body surface, 300.0 proteins is given per day.

In such cases, blood transfusion in large quantities with frequent interruptions rapidly eliminates anemia and proteinemia and is the best method for improving the resistance of the organism to infection. In this period, the victim is given as much blood as necessary in order that the quantity of hemoglobin will be at least 85% and erythrocytes up to 4,500,000 per 1 mm^3 of blood. The materials of different authors show that with large scale burns sometimes it is necessary to inject daily up to 1.5 liters of blood in order to eliminate the severe postburn anemia. The intravenous injection of electrolytes in the later stages of the burn is rarely done because patients at this time are able to take them in an adequate quantity by mouth. Only the intravenous injection of glucose in a physiological solution of common salt is advantageous in a quantity from 100.0 to 200.0 per day.

Among the groups of patients with burns covering more than 10% of the total body surface, postburn anemia was noted in 26.5%.

Nutrition for burn patients. During the first days, most of the patients with severe burns refuse solid food and prefer a liquid diet. Loss of weight in all of these patients must be considered as a serious complication of burns. Loss of nitrogen substances with the urine, with the exudate produced by the burn surface, along with a progressive drop in concentration of proteins in the plasma is a serious index of depletion of protein reserves in the organism.

Therefore, the diet of such patients must be rich in proteins and carbohydrates. High intake of fat must be avoided due to the possibility of a breakdown in liver function.

Certain authors have developed a special burn diet containing 2350 calories per day (Table 56).

The best method for diet of patients with burns is ordinary eating. However, with an increase in calories and protein in the food there can be a loss of appetite, nausea and even vomiting. In such cases, one should feed the patient through a probe. In the diet one must provide egg proteins (up to 6 pieces), milk (up to one liter), fruit juice (100-120 g), brewers yeast (3 tablespoons) and liver extract (125 g). The dietary mixture should be used in a quantity not exceeding 100-150 cm^3 per hour.

Table 56. Data on the composition of ordinary and burn diets.

Диэта (a)	Белки (b)	Углеводы (c)	Жиры (d)	Общая калорийность (e)
	в граммах			
Обычная ... (f)	103	250	50	1 800
(g) При ожогах ..	161	220	100	2 350

Key: (a) diet; (b) proteins; (c) carbohydrates in grams; (d) fat; (e) total calory content; (f) general; (g) with burns.

Also, it is necessary to give vitamins A and D, ascorbic acid, etc.

The appropriate diet, particularly proteins, carbohydrates and vitamins, is very important for preventing hypoproteinemia and hypovitaminosis during the entire period of treating the patients with severe burns.

A.Z. Kozdoba (1942) with an experimentally based vitamin therapy for burns produced the following results: 1) a full-value diet rich in vitamins is the basic factor for treatment of burns; 2) healing of burns with avitaminosis and hypovitaminosis A occurs more slowly (by 20-44 days) than in control animals; 3) avitaminosis and hypovitaminosis D slows down healing of burns by 8-24 days; 4) avitaminosis C is accompanied by a sharp breakdown in the regenerative processes. In such cases, in the burn area the necrobiotic process predominates. With hypovitaminosis C, healing of the burns is delayed for different time periods depending on the degree of development of the hypovitaminosis.

A.Yu. Sozon-Yaroshevich and A.D. Anikhanova, analyzing the course of burns in patients treated in the conditions of the Leningrad blockade, pointed out the role of avitaminosis. In patients with burns, as a result of avitaminosis and alimentary deficiency, one observed an acute areactivity preventing mobilization of the vitamin depots of the organism. Healing of the wounds here suddenly stopped, granulation began to bleed, hemorrhaging in granulation appeared and black mushroom-shaped blood tumors the size of a hen's egg occurred.

In 1945, the experimental work of D.Ye. Ryvkina appeared on the question of content of vitamin C in tissues after burns. On the basis of her experiments the author concludes that in the first hours after a burn local C-avitaminosis occurs in the area of damage and after 2-3 days, C-avitaminosis becomes generalized; this process is not related to the presence of a suppurative wound. The experimental studies of G.A. Uzbekov, (1937) also confirm that as the wound process develops after burns, the content of ascorbic acid in the organs decreases even more. For instance, in sailors 7 days after burns, the liver had lost 76% of its ascorbic acid and in the adrenal gland its quantity had decreased to 58% of normal.

Summarizing what has been presented above according to the results of general measures when treating burns, one can note that when treating burn shock, at the present time, large doses of morphine are widely used, average warming of the patient, abundant introduction of fluid (primarily blood plasma), cardiac substances, etc.

During toxemia, blood transfusion is indicated as well as injection of hypertonic (1.5%) solutions of common salt and glucose (5-40%) sulfamide drugs, penicillin therapy and other medicinal therapy.

In the period of burn anemia, abundant transfusion of blood is prescribed, injection of vitamins and frequent eating (every 2 hours). The food must contain a high quantity of protein and carbohydrate.

General care of patients with burns. With severe burns it is particularly important that the patient rest. This circumstance is often forgotten and the patient is put into a general tent.

It is necessary to take all measures to maintain the morale of this category of patient and to provide complete rest and individual care. The latter includes feeding (if the patient cannot feed himself), as frequent changes in body position as possible, assistance in personal hygiene, periodic washing of nonburned areas of the body, etc.

Local Treatment of Burns

Although treating burns began with learning general measures for large burns and themselves were put into the rear plan for local treatment of burn surfaces, this does not mean that local therapy for burns is of secondary importance. Such a view would be completely incorrect because each surgeon knows that local treatment of burns deserves less attention than general treatment.

However, even very insignificant local measures must not be used in the period of shock.

From widespread literature on this question it is obvious that that at the present time for purposes of local treatment of burns, many different substances and drugs are widely used which are often diametrically opposed in therapeutic properties and chemical structure. It was found here that the same substance, in the opinion of the same authors, gave positive results but others found it unfavorable.

Local treatment of burns which has the basic purpose of combatting the possible occurrence of infection at the present time must be: a) to relieve pain; b) to create rest for the burn area; c) to provide an aseptic state of the wound; d) to prevent or limit lymph and blood loss; e) to prevent or at least decrease as much as possible the absorption of toxic products of decomposition of tissue; f) to provide drainage of wound secretions; g) to speed up epithelialization.

At the same time treatment must satisfy the basic requirements which combat conditions dictate: availability and simplicity of the method used in field condition, the possibility of transporting the victim at any time and as a result providing the return of the greatest number to duty.

Treatment of the burn surface can be done by various methods. Selection of the method depends on a number of factors: the circumstances in which treatment is conducted, the location of the burn, its degree and extent, and finally the age and general condition of the patient. For instance, the severity of the course of burns varies when the injury is to the lower and upper extremities, the chest or the abdomen; the difference in time periods for healing of the feet and hands is particularly clear; this is due to the poor blood circulation of the foot and the greater frequency of occurrence of infection there. Finally, burns progress differently in children than they do in middle aged or old people.

All of the methods of local treatment of burns can be divided into four basic methods: covered, semi-open, open and combined.

A Covered Method of Treating Burns

The treatment of burns using bandages is the oldest and most widespread method. In World War II conditions, the closed method is used when treating half (50.8%) of all those who have received burns (data from the chart on fundamental characteristics).

Treatment of burns with bandages has the following advantages: 1) the bandage protects the burned section from infection and from anv external ffect; 2) it is used both in the hospital and in ambulatory circumstances; 3) it is convenient when burns are located circularly and when there is damage to adjacent surfaces of the body (submuscular ulcer, perineum, etc.); 4) using it one can avoid contracture because with burns to the joints one can always add a light splint to the bandages used; 5) bandages make it possible for the patient to change position.

The disadvantages of this method are: 1) the patient feels worse particularly in the summer time with extensive burns; 2) the bandages interfere with observation of the special features in the course of the burns; 3) it can act as a sort of thermostat for multiplying pathogenic organisms (M.I. Kanekevich, 1939); 4) the frequent change of bandages particularly with extensive burns is so painful that it requires the use of narcotics; 5) the secretion from wounds (blood, lymph, serum, etc.) are, according to Bir, a nutritive medium for regeneration and changing the bandages removes this; 6) stimulating the granulation surface, the bandage facilitates irritation of the granulation and the formation of disfiguring scars; 7) injuring the epithelium which is developing it considerably delays epithelialization.

The following types of bandages are used for the covered treatment method: a) dry; b) with a lubricant; c) with tanning, fixing and coagulating substances; d) with adsorption substances; e) with substances containing vitamins; f) with an embryonal extract; g) in combination with irrigation and h) in combination with physical therapy.

Dried aseptic bandages usually are applied after a timely and thorough primary treatment of the burn. Even extensive second degree burns can heal then under the dry bandage. However, a dry bandage is not devoid of negative aspects. Primarily it eliminates the feeling of pain except it is rapidly soaked with serum given off by the wound and becomes moist; with prolonged stay on the wound surface it looses its hygroscopicity. Removal of a dry bandage is very painful. Finally, a dry bandage can cause damage to granulation as a result of which rough and hardly elastic scars are formed. Therefore, there are few proponents to the use of dry aseptic bandages.

According to the data on the chart for fundamental characteristics, a dry bandage for treatment of burns was used only in 7.0% of all cases treated with the covered method.

At the present time, dry bandages are widely used for burns only when giving first aid where the burn occurred and for transporting victims to the treatment institution particularly in the wintertime.

Bandages with lubricants are the oldest and most widespread method for local treatment of burns. Different lubricants are used for this purpose.

The advantage of a lubricated bandage includes the fact that it decreases the feeling of pain, does not stick to the burned surface and does not irritate the tissue.

The disadvantages of this method are the following: 1) a bandage with lubricant in new cases is rapidly soaked through and this has to be changed which causes damage to the granulation tissue; 2) the lubricant which prevents discharge of bacteria from the sebaceous and sweat glands involved and from the hair sacs with second degree burns creates favorable conditions for multiplication of microorganisms; 3) any ointment which closes pores of the bandaging material very rapidly loses hygroscopicity which can facilitate intoxication of the organism.

Recently ointments which contain sulfanilamide drugs have begun to be widely used. Bandages with different ointments including Vishnevskiy ointment, according to the data of the chart on fundamental characteristics have become the most widespread (53.6% of all cases treated with the closed method).

Bandages with tanning, fixing and coagulating substances with the closed method of local treatment of burns are used concurrently with lubricated bandages.

Alcohol has been well-known for a long time as a pain relieving substance; we have propagandized this method as an abortive means for treatment of burns. Alcohol, besides its tanning effect has an antiseptic effect as well. Its disadvantages include the fact that although short-term it causes acute pain at the moment it comes in contact with the burn tissue and has a high evaporation capability. Iodine in local treatment of burns is used either by its vapors or by an ordinary lubrication of the burn surface with 5-10% tincture of iodine.

An advantage of treatment with iodine is that thanks to its tanning, fixing, coagulation and antiseptic properties the entire process of healing of the burn occurs in a very dry environment giving a good cosmetic effect. The burn surface does not require preliminary treatment except for puncturing of the blisters. In this way, the method of lubrication with tincture of iodine is extremely simple and permissible in all circumstances.

Even in the past century different coagulating substances were well-known (magnesium silicate, etc.), whose special features were rapid formation of scabs on the burn surface which: 1) resulted in a dry course for the burn, 2) prevented the occurrence of infection in the wound from outside; 3) prevented excessive loss of fluid by the organism.

Of the coagulation substances used in the closed method of local treatment of burns the most widely used are 2-3-5% solutions of potassium permanganate. In connection with the fact that potassium permanganate in contact with tissue easily releases its oxygen with an organic substance, it basically has an oxidizing effect.

One should note the following among the negative properties of potassium permanganate: 1) it causes acute pain when coming in contact with the tissue in second degree burns; 2) bonded with proteins of the tissue it cannot penetrate deeply and has only a surface effect; 3) due to pain in the burn surface a dark brown color, with this method of treatment one can easily overlook erysipelous inflammation of the skin.

Another coagulating substance, tannin, is basically used with the open method of treatment of burns which we will talk about later.

The use of bandages with different tanning, fixing and coagulating substances of which the most widely used are 3-5% solutions of potassium permanganate, according to the data on the chart of fundamental characteristics, was used in 24.9% of the cases of all patients treated with the closed method.

Bandaging with adsorbing substances. Another variation of the closed method which creates dry conditions for healing of the wounds after burns consists of the use of bandages with different powder type substances. Thanks to the hygroscopicity of the powder substances, absorption by the organism of toxic substances from the burn surface is significantly decreased, the crust formed is a reliable protection from infection getting in and favors the most rapid healing of the burn; as a result of the infrequent bandaging,the burn surface is less injured.

A chalk bandage proposed by T.P. Krasnobayev and modified by S.D. Ternovskiy has obtained the widest popularity. Its positive aspects are the following: 1) simplicity of preparation and convenience of use; 2) the possibility of keeping it in storage and its cheapness; 3) it does not darken the burn and does not increase the pain perceptions which occur during bandaging with potassium permanganate;

4) absorbing the serum secretion of the wound very well it stays easily and painlessly on the wound surface with bandaging keeping the quantity of bandage to a minimum; 5) it facilitates the rapid formation of a scab; 6) with a minimum percent of suppuration, the treatment is significantly decreased at the same time giving a good effect as to scarring of the burn tissue.

As to the negative aspects of this type of bandaging, one should note that with deep burns with necrotic tissue and with excess serum discharge, the powder sometime is rapidly soaked through and is converted to a gluey mass which has an unpleasant look and odor.

Gypsum can be used with burns in the form of gypsum bandaging or can be sprinkled on.

Advantages of the gypsum bandaging, the proponents of this method see as primarily that it gives a stable painless effect, protecting the burn surface from friction and that it creates quiet for the damaged section. A gypsum bandage having excellent absorbing properties, at the same time, prevents the burn surface from cooling greatly; it is a reliable protection from infection getting in and facilitates primary healing of the burn without complications, scars and contractures of the joints. The application and removal of such bandaging sometimes is painful but the pain rapidly becomes bearable.

The negative aspects of gypsum bandaging are: they are used only with burns of the first and second degree on the extremity; they do not provide primary treatment of the burn surface; the gypsum is not sterile and besides absorption and providing the quiet for the damage surface, in comparison with other treatment methods it has no advantages (V.V. Gorinevskaya, 1937; I.A. Gorban'). Gypsum, being unsterile, rapidly results in suppuration particularly with third degree burn; the removal of the bandages is painful. At the present time this method of treatment of burns is rarely used.

Bandages with powdered roasted gypsum were applied primarily to children and old people with second and third degree burns of the neck, chest and abdomen. P.P. Mitrofanov considers that dead tissue with third degree burns under a layer of gypsum dries out well, the necrosis region is demarcated more rapidly; the suppurative exudate is considerably less than with other methods. This method of treatment is not widely used.

Preparation ANT-17 (A.O. Berezin) had a certain popularity when treating second and third degree burns during the war; it was usually used with burns on not more than 20% of the total body surface. The method for use included sprinkling the powder on the burn surface in a uniform layer 2-3 mm after preliminary treatment of the skin; on top 1-2 layers of gauze cloths were applied with subsequent wrapping without padding. For second degree burn the bandaging was not removed for 8-9 days; for deeper burns it was removed in 3-4 days. The appearance of iodine in the urine which lasted for no more than 5-6 days after treatment did not present any danger. The good dehydration properties of the powder, in combination with the tanning and antiseptic properties of the iodine with full safety of the preparation for the organism puts it in first place for treating burns with adsorption substances.

Bandaging with adsorbing substances, according to the data on the chart for fundamental characteristics, is very little used; a total of 1.2% of the cases from all patients treated with the closed method.

Bandaging with substances containing vitamins. Even in folk medicine it was established that fruit and vegetable juices (carrot, gooseberry, etc.) facilitate the most rapid healing of burns. A positive effect on the wounds depends on the presence of vitamins A and D in these juices. The idea of treating burns with vitamins is based on local vitamin deficiency in the foci of the pathological process; whether or not this deficiency is the result of stopping or decreasing intake of vitamins to the damaged tissue, or is due to processes of regeneration increasing the demand for vitamins is difficult to decide. One of the basic conditions when treating with these drugs is rest of the wound; this is achieved by the simultaneous use of gypsum bandaging and by a method of infrequent bandaging (every 10-12 days).

Fish oil. Among all of the vitamin preparations recommended for treatment of burns the most widespread is fish oil. Under the effect of fish oil the decay products of necrotic tissue is dissolved and sloughed off; the quantity of suppurative discharge in the wound is decreased, epithelialization is speeded up and as a result treatment time is decreased.

AD ointment. Paying attention to the fact that fish oil is rapidly absorbed into the bandaging which to a great degree decreases its effect on the wound, V.I. Iost and I.G. Kochergin back in 1935 proposed putting it into an ointment used for burns. This paste has the following composition: fish oil -- 100.0,American vaseline -- 100.0, vitaminol -- 1.5, tserrozin -- 10.0. Vitaminol which contains vitamin D is included in the composition of the ointment in order to improve the vitamin content of the fish oil. The tserrozin (Japanese wax) is added in order to give the paste a thicker consistency. It has the same positive qualities as the fish oil: it stimulates the processes of healing with full-value regeneration of the skin even with third degree burn.

Vitaderm proposed by S.D. Balakhovskiy, L.A. Klimenkova, F.M. Cherkasov consists of paraffin (850.0-900.0), linseed oil (150.0-100.0), carotene (30.0-50.0), naphthol (5.0) and eucalyptus oil (10.0-15.0). The basic active initiator in Vitaderm is carotene, provitamin A; in view of its keratoplastic properties, it is necessary that it have a constant effect on the wound. Vitaderm lubricates the bandaging, lubricates the wound surface or is sprayed on with an atomizer.

Vitaderm has the following positive properties: 1) it has a painless and antiinflammatory effect; 2) it speeds up maceration of necrotic tissues and results in purification of wounds; 3) it facilitates rapid active epithelialization; 4) it decreases the suppurative odor and facilitates healing without disfiguring scars.

Although the production of Vitaderm was mastered for mass production, it is still not widely used.

Carotene in sunflower oil was recommended by S.A. Grukina (1944) as an independent method for treating uninfected burns of average dimensions. The best concentration is considered to be 0.55 mg of carotene per 1 cm^3 of sunflower oil. Carotene helps remove pus from the wound surface and results in rapid epithelialization of the wound.

Oil from the three-spine stickleback (M.S. Medvedovskiy, 1946) is a natural "karotinol," that is, a Carotene dissolved in fish oil; when using it to treat burns the basic properties of the vitamin preparations are apparent: it suppresses pain, facilitates rapid epithelialization, etc.

The vitamin preparations listed above except for fish oil are not widely used for treating burns, apparently, as a result of complexity in preparing them.

Bandages with substances containing vitamins, particularly fish oil, were used according to the data of the chart on fundamental characteristics in 8.8% of the total number of persons treated with the closed method.

Many of the substances mentioned which contain vitamins, in the opinion of some authors (A.A. Uspenskiy) in its effect on wounds belongs to the biological method of treatment of burns but the basic one is considered to be an embryonic ointment prepared by A.I. Gol'dberg (1944). The basis for this ointment is an embryonic extract which contains the maximum quantity of stimulators for growth and multiplication of cells.

This ointment, when treating burns, has a pain suppressing effect and counteracts inflammation as well as facilitating rapid epithelialization of the wounded surface. Scars when using embryonic ointment for the treatment, as a rule, were neglible and did not interfere with the functions of the extremities.

On the basis of the indicated properties of this ointment, the particularly rapid epithelialization of the wounded surface, this embryonic ointment is recommended for use in combat conditions primarily in the wintertime when one does not need a refrigerator for transporting it.

Bandaging in combination with irrigation. The closed method with constant irrigation of wounds, in the opinion of many authors, combines all of the advantages listed above of the closed method with the possibility of the constant effect of antiseptics which have bactericidal properties acting on the wound. The essence of this method is introduction into the deep layer of bandaging of thin drainage tubes which 2-3 times per day irrigate the burn surface with fluid with infrequent changing of bandages. Moist drying bandages are advantageous for third degree burns with deep necrosis of the skin.

Ammargen is used with this method (V.V. Babuk and A.N. Puzanov, V.V. Kovanov, 1940), Rivanol 1:1000 (A.A. Polyantsev, 1939; V.P. Gorbatov).

The advantages of bandaging in combination with irrigation include pain relief and the moistening effect of antiseptics; moreover, the antiseptics have a prophylactic effect in the prevention of infection. Thanks, to infrequent rebandaging, with this method one does not observe injury, or excess growth of the granulation tissue; epithelialization sets in rapidly and is not accompanied by the formation of disfiguring scars.

Of the negative properties of the closed method with constant irrigation one should note the local reaction of the healthy tissue often observed, in particular, when using ammargen (V.V. Kovanov); moist bandaging in patients causes a sensitivity to undesirable cooling, particularly in the first days after the burns occur. As a result of its extreme complexity, this method is rarely used in combat conditions. This method of treatment for burns, according to data on the chart of fundamental characteristics, is very seldom used -- a total of 3.7% of cases out of the entire number of persons treated by the closed method.

A closed method in combination with physical therapy procedures. The effect of physical therapy measures on a burn surface is based on the formation of inflammatory erythema in the focus of the injury and the bactericidal property of these procedures.

Ultraviolet radiation is the most widespread method of physical therapy for burns. The dosage is: daily or every other day radiation of the burn surface from 5 to 15-20 minutes at a distance of 40-45 cm.

The advantages of radiation with quartz include the fact that this method of treatment is primarily painless; after a few sessions, the moist necrosis is replaced with dry (a drying effect); thinning of the wound secretion usualy does not set in; the quartz stimulates the regenerative processes, healing occurs more rapidly and completely; the scars which form are delicate, soft, and completely satisfactory from the cosmetic point of view.

Paraffin therapy with the closed method of treatment of burns is used to relieve pain on the wound surface in combination with prevention of secondary infection in it. The essence of this method includes spraying or applying by hand on the burn surface paraffin heated to 50° laid out in the form of a thin film. Moreover, one can use paraffin applications in the form of sheets or paraffin treated bandaging (S.S. Sheykman).

The positive aspects of this method are: 1) the paraffin has a pain reducing effect, does not stick to the burn surface and is easily removed; 2) the environment created under the paraffin stimulates the regenerative processes in the underlying tissue.

Below, combined data are presented on the frequency of use of different variations for the closed method of treatment (Table 57).

Table 57. Distribution of the variations of the closed method used for treating burns.

	(a) Закрытый метод лечения	Процент случаев (b)
(c)	Повязки сухие	7,0
(d)	» с мазью	53.6
(e)	» » дубящими, фиксирующими и коагулирующими веществами	24,9
(f)	» с адсорбирующими веществами	1,2
(g)	» » веществами, содержащими витамины	8,8
(h)	» в сочетании с орошением	3,7
(i)	Не установлено, с чем были наложены повязки	0,8
	(j) Всего	100,0

Key: (a) closed method treatment; (b) percent of cases; (c) dry bandaging; (d) bandaging with lubrication; (e) bandaging with tannin, fixing and coagulating substances; (f) bandaging with adsorbing substances; (g) bandaging with substances containing vitamins in combination with irrigation; (i) not established what was used with bandaging; (j) total.

A Semiopen Method of Treatment of Burns

This method is intermediate between covered and uncovered methods of treatment of burns and basically is done by the application of washings from antiseptics mixed as they dry (3-4 times a day). For this purpose a 2% solution of soda was used mixed with lead washing, silver water, a solution of streptocide, and Vishnevskiy's ointment.

The application of the washings made up of a 2% solution of soda had a good effect in the observations made by P.M. Golenishchev (1911) for burns with steam on 3/5 of the surface of the body and 1/3 second degree burn. The bandages were changed daily. Complete recovery began after 28 days.

Starting with the suppositions that with burns the local tissue reaction changes from alkali to acid and in the entire organism acidosis develops, the use of saturated 10% solutions of soda on the wound after the burns, A.I. Charugin reevaluates as the local alkalization of the tissues.

A lead washing was recommended for use in compresses changed twice daily; pain relief and a moistening effect was noted with this washing for treatment of first and second degree burns and early stages of third degree (Z.I. Katsnel'son, 1935).

Silver water in the form of washings was used by P.F. Pechenevskiy (1936) for extensive second degree burns caused by steam; even on the next day in the patient suppurative discharge had disappeared, temperature had dropped, the patient felt better and by the 8th day full recovery had set in; the author ascribes recovery to the exceptional effect of this preparation.

The streptocide solution (white and red) was proposed for treating burns by V.V. Lebedenko (1939) in order to act on hemolytic streptococci in the burn section. In spite of the different degrees and extent of the burns not one fatal result occurred and always smooth epithelialization without scarring was obtained.

Vishnevskiy's ointment decreases the pain syndrome, acts as a bactericide, causes exudate and proliferative action in the tissue; healing occurs with the formation of rich granulation tissue, epithelialization of the surface of the burn accelerates and an elastic scar formed (V.I. Kryazheva, 1943).

The method of semiopen treatment of burns has not become widely used.

According to the data of the chart of fundamental characteristics, the semiopen method of treatment of burns is used in a total of 0.7% of the cases out of all burn cases; in 72.4% of the observations washings were used made from antiseptics and when treating 27.3% of the patients -- from other fluids.

An Open Method of Treatment of Burns

Numerous and in most cases well founded rejection of the closed method, on the one hand, and results which are not reassuring obtained with this treatment of burns on the other hand, have forced the surgeons to look for new ways of treating burns.

Our compatriot D.P. Nikol'skiy back in 1888 used an ester solution of tannic acid for treating 18 cases of burns; he recommended putting "on top of the lubricated area a thin compress but keep it as open as possible if the patient is remaining in bed."

However, this method of open treatment of burns was not widely used up to the first World War when a method of open treatment of wounds was developed in detail. The advantages of this method the authors see as the following: 1) there is the constant possibility of observing the wound; 2) light and air penetrating into the wound have a bactericidal effect; 3) stagnation and decomposition of the separate wound does not set in; 4) the process occurs better and more rapidly than under bandages; 5) with this method one does not require bandaging material.

In the USSR, the principal of open treatment of wounds began to be used by D.Ya. Levental' for burns. In his work published in 1921 he proposes for treatment of burns a "skylight" bandaging consisting of two roles made of gauze and batting and placed along the edge of the wound; a glass is then put on and attached with bandages.

The open method of treatment of burns during the World War II was used in 26.6% of the cases of all persons receiving burns.

The open method of treatment of burns without the use of medicinal substances. The maximum simplification of the open method of treatment of burns is the variation proposed by Ya.L. Povolotskiy (1924) and widely used in the USSR.

The technique of the open method of treatment used by Ya.L. Povolotskiy consists of the following: the skin covering surrounding the burn and sometimes the burned areas themselves are lubricated several times with alcohol, incisions are made in blisters at the base, bits of charred tissue are carefully removed and the undamaged covering is lubricated around the burn with vaseline or any kind of inert lubricant. Then the patient is put into bed in sterile clothing under a frame which covers the sterile bedding and then the blankets are put on. To keep the patient warm electric lights are used bringing the temperature of the frame up to 22-24°. To protect the burned person in the first few days from damage to the surface when he falls asleep one can use a netting made of wire covered with sterile gauze; it is possible to manufacture this for burns on the hands.

Later on the skin around the burn is cleaned daily with alcohol and again lubricated with oil so that one can remove secretions from the wound which adhere tightly to the healthy skin. The scab which forms as it dries drops off and does not require artificial removal.

The author pays particular attention to as careful handling as possible of the wounded surface (cutting and removing is only done when it can be carried out easily), and the necessity for using disinfected screens and sterile bedding is emphasized; different physicians for the patient in the bed are described in detail according to the location of the injury.

Also there is the open method of treatment of burns without the local use of medicinal substances.

The main advantages of this method of treatment for burns are: 1) the burned part of the body receives maximum rest: it is injured neither by the pressure of the bandages nor by changing them; 2) the patient feels much better when his movement is not limited by bandaging; 3) access of light and air, on the one hand, prevents multiplication of microorganisms and on the other facilitates the formation of granulation and speeds up epithelialization of the injured surface; 4) a crust is formed consisting of blood, lymph, fibrin and protein which penetrates the wound secretion along with the microorganisms; 5) with this method usually dry necrosis of dead tissue sets in and not moist necrosis; 6) removal of the necrotic sections occurs fairly rapidly and completely.

However, along with these advantages, with the open method of treatment of burns there are a number of important disadvantages due to which one cannot consider it perfect or usable in all cases under any conditions.

The basic disadvantage of this method is that it assumes primary thorough surgical treatment of damaged sections and later on inadequately protects them from infection; due to this from the first days, as a rule, one observes suppuration of the burned surface. In the first hours and days after extensive burns this method prevents plasma loss and thickening of the blood but does not prevent absorption of toxins. A very important disadvantage of this method is the absence of the pain releiving factor: strong occasionally unbearable pain on a background of a generally severe condition (intoxication) causes the patient considerable suffering particularly in the first days. The use of this method is difficult in middle-aged persons who are always concerned about the constant feeling of cold and who often have complications from respiratory organs and the cardiovascular system. Severe and extensive burns often force the patient into immobility for prolonged times which is very difficult. Damage to the contacting surface of the body (groin, submuscular regions, etc.) can lead to the formation of scar tissue. With extensive burns of the extremities it is difficult to avoid contracture. With all circularly positioned burns using this method is impossible due to the constant injury to tissues and unsatisfactory results both for early and late healing. This method is impossible to use in military field conditions particularly if further transportation of the victim is required.

An analysis of materials on treatment of burns during World War II indicates that the open method without use of medicinal substances (according to Ya.L. Povolotskiy) was used in 11.6% of all cases treated with the open method.

The open method of treatment of burns in combination with tanning, fixing and coagulating substances. These substances as an additional means for the open method of treatment of burns are very widely used.

Their topical use: 1) weakens stimulation of the pain receptors and consequently acts as a pain reliever; 2) provides comparatively pain free formation of the stump which: a) bonding the proteins and toxins decreases absorption of the processes of decay of the proteins and the aftereffects of such absorption (toxemia); b) prevents plasma loss and coagulation of the blood; c) prevents penetration of infection on the wound surface; d) provides a favorable course of epithelialization; e) permits more rapid evacuation of the wounded.

On the negative side one should note: 1) slow formation of scabs due to which, particularly in the first days, the coagulation procedure is repeated a number of times; 2) infrequent appearance of infection under the scab; 3) the means used for this purpose can aggravate damage to the islands of the epithelium which remain and which later on must be the foci of epithelialization (V.N. Promptova).

Of these tanning, fixing and coagulating substances the following were used: 1) various dyes in a water or alcohol solution, 2) iodine vapors, 3) potassium permanganate in various concentrations; 4) tannic acid.

The dyes which do not damage the tissue absorb products of their decomposition, coagulate proteins, act directly on microorganisms as strong antiseptics, stimulate regeneration of epithelium all of which facilitates a more rapid healing of the burned area under the scab.

The most widely used of these are: methylene blue in a 1-3-5% solution, brilliant green in a 1% solution, methyl violet, gentian violet in 3-5% solution.

The most effective solutions of dyes are those in ethyl alcohol.

A method of smoking the burned surface with iodine vapors proposed by V.I. Mushkatin (1937) is a successful combination of the bactericide and tanning properties of iodine. Under the effect of iodine vapors the dead or dying tissue elements coagulate and are converted into a medium which is unsuitable for the multiplication of bacteria both due to coagulation and as a result of admixtures of iodine particles. A certain part of the iodine which does not enter into the reaction of with the surface elements of the wound is absorbed more deeply and stimulates activity of the mesenchyma cells and cooperates in the immigration of microphages and macrophages into the wound. In appropriate dose the iodine vapors stimulate epithelialization.

In fresh burns the blisters are opened and the fragments of epidermis are removed. Further "fumigation" is done 1-2 times per day.

A number of surgeons (V.S. Strebeleva, 1939, M.S. Znamenskiy, 1940, et al.) tested this method; positive results in using it were noted.

Potassium permanganate has been very widely used for treating burns with the open method. The positive and negative properties of this tanning and coagulating means have already been discussed above. The simplicity of use and wide availability of this preparation at the present time have given it the right to exist among the substances used for treating burns.

In military field conditions lubricating the surface of the burn with other tanning, fixing and coagulating substances (a 3-5% solution of potassium permanganate is most often used) have been widely used for the open method of treatment of burns.

This variation of the open method was required in 55.5% of all cases treated by the open method.

Tanning as a means for treating burns was recommended by D.P. Nikol'skiy back in 1888; he proposed an ester solution of tannic acid,

A. F. Berdyayev in 1925 used a 10% mixture of tannin in alcohol and ester. Davidson in 1925, 37 years after Nikol'skiy, recommended an aqueous solution of tannin. Consequently, the priority for this method of treatment purely lies with our compatriot although reports on 18 cases of treatment of burns by him remained unnoticed.

The essence of the method consists of the fact that tannic acid forms, with glucosides and proteins, insoluble compounds as a result of which the toxic products of decay of proteins are fixed in the surface of the burn. They coagulate, dry, become inactive, and the bacteria deprived of its nutritive means multiplies only with difficulty. Moreover, the tannin robbing the cells of water facilitate their shriveling; intertissue gaps are decreased and become less permeable, the walls of the lymphatic vessels are compacted somewhat. Thus, tannin tans the tissue and in combination with its coagulating features prevents absorption of the decay products from proteins into the organism.

Method. After preliminary injection of morphine the skin around the burn is cleansed, the blisters are opened and in the first 24 hours dry bandages are applied,moistened in a freshly prepared warm 2.5-5% solution of tannic acid; the patient is put under a frame with electric lights. After 12, 18 and 24 hours the bandages are again soaked with the same solution and in those places where the burn surface due to the tannin has become brown or the color of redwood, the bandages are removed and the surface is left uncovered. Six days later when the burn surface has become covered with granulation, solar, electric light or quartz light treatment is used and at night bandages are applied with equal parts of Ol. Olivarum and Ol. Camphorae.

Materials of a number of authors indicated that the best results are obtained with a 2.5% aqueous solution of tannin. The weaker the tannin solution the longer it is effective and the deeper it penetrates into the tissue. Therefore with deep damage, V.Ya. Vasilkovan recommends a limit of a 3% solution and with surface areas he requires a 5% solution.

Moreover, the tannin has a certain pain relief effect and after removal of bandages the surface layer of the skin becomes insensitive. Finally, a 2.5-5% solution has an adequate bactericidal effect which, however, must never be strengthened.

One of the basic disadvantages of this method can be considered to be the process of tanning and coagulation of the tissue itself for formation of a strong scab lasting for several hours and, consequently, both absorption and plasma loss in the first hours after the burn cannot be prevented.

With this method it is necessary to use freshly prepared warm solutions of tannic acid; an aqueous solution of it is very unstable. Coagulation with the tannin is possible only in the presence of fresh burns when the wounded surface is comparatively free of microbe flora.

Because the tannin coagulates mainly the surface layers, toxemia which occurs from absorption of decay products cannot be eliminated completely.

Under the surface tight crust sometimes a coarse difficult to control granulation is formed which results in the formation of tight scars. In the scabs which form due to the tannin often cracks occur; with inadequate antiseptic care in various manipulations made in the area of the injury, infection can set in.

The tannin stains the bedding leaving dark spots.

An open method of treatment of burns in combination with lubrication or irrigation of the burn surface with a solution of tannic acid during World War II was used in only 1.5% of the cases of all burns treated with the method.

A variation of this treatment method of burns is the proposal made by A.S. Kan-Kogan (1939) to use a 2% solution of tannin in 70% alcohol. Then the scab forms more rapidly and suppuration under the crust is almost completely absent. A.I. Vedrinskiy and G.A. Orlov (1943) recommend an ointment made of tannin-alginic acid (a substance found in marine alge) called "algotan"; using an applicator it is applied in an even layer on the burn surface. The advantage of algotan, in the opinion of the authors, involves the formation not only of a rough scab, but also low consumption of tannic acid with a preparation which can be kept on the shelf because it lasts longer than solutions of tannic acid.

A number of disadvantages of the open method of treatment of burns in combination with tannic acid (see above) are eliminated when using the Bettme method (1935) which includes the following. After injection of 2-3 cm^3 of morphine, the skin surrounding the burn surface is disinfected, blisters are removed and dead epidermis is cut off; in the area of the burn using cotton balls the freshly prepared warm 5% aqueous solution of tannin is applied. The burn surface rapidly dries afterwhich it is wetted with a 10% solution of silver nitrate. Immediately a dark dense scab forms. Again the blisters which occur after this are removed and these sections are treated again as indicated above.

The rapid formation (in 15-20 minutes) of a tight crust is particularly valuable because a significant percentage of the victims die in the first 24 hours after burns as a result of loss of fluid by the organism or from absorption of toxins.

The scabs which form are elastic, last well and isolate the burn surface from penetration by infection. The patients even on the next day after treatment can lie in a dry bed without odor or discharge. With this method the care of the patient is simplified and the formation of scars and contractures are kept to a minimum.

However, even this method is not devoid of certain disadvantages, namely: 1) Bettman's treatment is extremely painful and often one has to resort to narcosis when using it; 2) with deeper damage under the tight scab often accumulations of pus form and rapid identification of them is not always possible; 3) the solution of nitric acid applied to the burn surface following the tannin, only in a 0.25% suspension is retarded by the layer of tannin and high concentrations of it, not even talking about a 10% solution, rapidly pass through the film of tannin and penetrate the tannin applied earlier in the deeper tissue coming in direct contact with the tissue cells. Being a powerful protoplasmic poison, Argentum nitricum burns the tissues and converts a second degree burn into a third degee burn. Certain foreign authors agree with this (Oldrich, 1938).

A.Yu. Sozon-Yaroshevich and A.D. Anikhanova, out of 103 burn cases, treated about one third with the Bettman method and proved that this method does not have particular advantages either from the point of view of decreasing treatment time or in the final results; moreover, it is impractical, complicated, and requires a great deal of time which is not always available.

Considering the disadvantages of the Bettman method, many surgeons (N.N. Samarin et al.) have recently stopped using it.

During World War II, the Bettman method was used in 4.7% of all cases treated with the open method. B.I. Brover (1942) used the Bettman method replacing the tannin with a 4% solution of potassium permanganate spraying the latter once or twice with an atomizer after which a 10% solution of silver nitrate was applied.

Besides the coagulating agents listed above (dye, potassium permanganate, tannin) used with the open method for treatment of burns, a number of authors recommend that one use: 50-70% ethyl alcohol, 70% alcohol in combination with linseed oil, tying up the scab in 70% alcohol, 5% camphor oil, 20% boiled tannin bark, boiled tannin bark with alum (4%) and glycerin (15%).

However, all of the means and preparations listed were not widely used for treatment of burns.

The open method of treatment of burns in combination with adsorbing substances. We have already discussed the basic properties of powder-type substances when treating burns. With the open method they are used much less often than when bandaging of burns is done.

The powders used are gypsum, burnt wool and sterilized peat.

As far as we can judge by bibliographical data, all of the absorbing substances mentioned for the open method of treatment of burns cannot become widely used.

The open method of treatment of burns in combination with sprinkling powder was used in World War II only in 3.5% of all burn cases treated by the open method.

The open method of treatment of burns in combination with physical therapy procedures. The open method of treatment of burns in any of its variations often is complemented by physical therapy methods and here the range of means used is very broad: from ordinary electric incandescent lights, quartz to infrared and X-rays. Radiation, particularly ultraviolet, has a large effect on a wounded surface and the organism as a whole. Its effectiveness is greater the sooner it is used. S.L. Gorelik considers that physical therapy methods can expediently be used in later periods when the scabs have fallen off.

Ultraviolet radiation is most widely used for treating burns. The proponents for using it for burns consider that: 1) ultraviolet rays incident on the surface of the burned area or skin devoid of epidermis, reached a network of capillaries and being absorbed by the blood facilitates healing inflammatory manifestations and also has a general antitoxic effect on the organism as a whole, decreasing the appearance of toxemia; 2) ultraviolet rays have a bactericidal, drying and deodorizing effect; the latter has a positive effect on the psyche of the patient facilitating his more rapid recovery; 3) ultraviolet rays for all degrees of burns decreases the pain, particularly in the first day; 4) ultraviolet rays stimulate the keratoplastic properties of the skin and provide almost unnoticeable scars in the area of the burn; thanks to this, limitation and movement of the victims extremities is hardly noticeable.

According to certain observations, the open method of treatment of burns in combination with the coagulating agent and radiant energy give very good results. However, A.I. Charugin in certain cases observed a harmful effect of radiant energy which sometimes is explained by overdosing.

The open method of treatment of burns in combination with physical therapy procedures was used advantageously in GBF (Base hospital of the front) in 16% of all burn cases treated with the open method.

X-ray radiation for burns, according to observations made by A.D. Fedorova, give pain relief and facilitate rapid drying up of the blisters which protect the burn surface from infection. As to the length of time required for healing, X-ray therapy does not have any advantages.

The open method of treatment of burns in combination with biological factors. Recently, in Soviet literature, material has been published on the first attempts to replace a chemically treated scab with a biological when using the open method of burn treatment; to do this, the burn surface has to be treated ahead of time covering it with fresh or citrate blood, which, gradually drying, forms a thin enamel like covering of a dark cherry color on the wound surface. If it is necessary to obtain a denser crust, application of the blood is repeated. With significant transudation of the plasma, the crust forms more slowly. For small burns it is adequate to take from the ulnar vein of the victim, using a hypodermic, 10-20 cm^3 of blood which can be applied in droplets directly from the syringe on to the wound (S.I. Voronchikhin), or poured into a test tube a[illegible]d of time where the erythrocytes are precipitated and then it is used for lubricating the surface of the burn (Ye.A. Ragozin). From the observations it is apparent that the erythrocyte mass dries more rapidly forming a dense scab. For treating the hand it is necessary to have no more than 10 cm^3 of blood and for treating all upper extremities 50-70 cm^3; on the average, for 10 cm^2 of burn surface, 1.5 cm^3 of blood is adequate. When observing the general rules it is possible to use not only the patients own fresh or citrate blood but the blood of relatives, patients who have been operated on or even blood from animals. Blood type is not important.

The use of a biological method is indicated with fresh uninfected second degree burns. In the presence of infection with discharge of pus the scab peels off in sections and therefore almost everyday new portions of blood have to be applied.

Advantages of this method include the following. With the effect of blood on the burn surface one notes a marked pain relieving effect; the scab which forms is more delicate than, for example, with Bettman method; epithelialization occurs more rapidly under the blood scab; scars almost never form.

Up until the present time 63 burns treated with the blood scab method have been reported on. The method deserves attention and requires further testing.

It is apparent from Table 58 that the open method of treatment of burns was most widely used in World War II in combination with application of tanning, fixing and coagulating the substances (55.5%), then in combination with physical therapy procedures (16.0%) and according to the Povolotskiy method (11.5%). The Bettman method was used much less often (4.7%) and the Nikol'sky-Davidson in a total of 1.5% of the cases.

Combination Method of Burn Treatment

In certain cases a combination method of treatment of burns is indicated (at first the open method, and then the ointment or other bandaging), namely: 1) with burns which uncover tendons, muscles, bones, joints, in which prolonged drying effects of light and air are harmful for tissue after scabs come off, it is necessary to change to lubricated bandages in order to provide growth of abundant granulation; 2) in extremely severe cases when the required position is unbearable for the patient or threatens the formation of contractures, it is expedient to change the treatment method and go to the covered method; 3) if the burn surface begins to produce an excessive amount of suppurative discharge, the latter must be absorbed and prevent irritation of neighboring healthy tissue so that temporarily one has to resort to treatment with bandaging; 4) in cases of flabby granulation or a weak tendency for epithelialization, particularly when subsequent transplants of the skin are required for stimulation of the process of healing or in order to prepare for plastic surgery it is necessary to change over to the closed method and apply bandages; 5) when the process of epithelialization is completed and the patient is able to walk; 6) when it is necessary to evacuate the victim .

Table 58. Distribution of the variations of the open method of treatment for burns which were used.

	Открытый метод лечения (a)	Процент случаев (b)
(c)	Без применения лекарственных веществ	11,5
(d)	Со смазыванием дубящими, фиксирующими и коагулирующими веществами	55,0
(e)	Со смазыванием таннином	1,5
(f)	Со смазыванием таннином + азотнокислое серебро	4,7
(g)	В сочетании с присыпками	3,5
(h)	В сочетании с физиотерапевтическими методами лечения	16,0
(i)	Вариант открытого метода лечения не установлен	7,8
	(j) Всего . . .	100,0

Key: (a' open method of treatment; (b) percent of cases; (c) without using medicinal substances; (d) with application of tanning, fixing and coagulating substances; (e) with application of tannin; (f) with application of tannin plus silver nitrate; (g) in combination with sprinkling powder; (h) in combination with physical therapy methods of treatment; (i) the variation for the open method of treatment was not established; (j) total.

In World War II conditions, the mixed method of treatment of burns was used in 21.9% of the total number of burn cases.

Modern principles of local treatment of burns. An analysis of Soviet literature on the question of local treatment of burns clearly confirms that in the last quarter century Soviet surgeons have successfully and continuously attempted to solve this problem. Up until 1925, local treatment basically was done with the closed method. The later open method of treatment of burns rapidly became generally recognized. However, soon surgeons discovered that even with very pedantic care of the victims with this method it is extremely difficult to prevent the burn surface from becoming infected and the subsequent complications involved with this; therefore, soon they began to use different bactericidal dyes, tannin, coagulating and absorbing substances which coated the uncovered surface with the expectation that a flim and scab would form which would protect the wound from the penetration of infection from outside.

At the VI Ukrainian Congress of Surgeons in 1936, V.Ya. Vasil'kovan in his report directed the attention of the surgeons to the necessity for early and thorough primary treatment of burns and having confirmed criticism of the open method of treatment, confirmed the expediency of the closed method in order to combat infection.

Nevertheless, the open method continued to be the predominant method for treatment of burns and at the XXIV All-Union Congress of Surgeons (1938) the latest variation of it was reported -- the Bettman method combining careful preliminary treatment of the damaged area and rapid formation of a dense film and scab which protects the injured surface from infection. Almost simultaneously attention of the surgeons was attracted by the positive results obtained by topical treatment of burns by vitamin preparations (fish oil, vitaderm, etc.), which require covered treatment. Also the question arose as to the need for broad individualization of the treatment method of burns.

The war with the Byelofinns (1939-1940) was a field test for the closed method of burn treatment and later on the number of proponents for this method increased sharply.

While the open method of treatment of burns during World War II was available in hospitals at the front and in the deep rear, it was completely unacceptable in the treatment institutions in the military and army regions because the necessity for transportation is one of the basic contraindications for treatment of burns with the open method.

Therefore, in military field conditions only the closed methods can be used out of all the existing methods for treatment of burns.

Primary treatment of burns. At the present time, preliminary removal of the patient from the state of shock and combatting various humoral changes which occur in the organism of burn victims have acquired great importance; only by eliminating shock and with improvement in laboratory indices can many surgeons consider it possible to begin primary treatment of burns.

"Primary treatment of a burn section is permissible only after eliminating or sharply reducing shock" (Yu.Yu. Dzhanelidze, 1941).

Just as first aid for wounds has a great effect on the further course of the wound, so with burns does the time, the content and quality of first aid have the same basic moments which in the vast majority of cases determine the further course and outcome of burns. Whatever method of burn treatment is used, basically always there has to be careful conduct of primary treatment of the burn surface which is the best preventive means against toxemia because here a tremendous quantity of burn cells are removed and thus the possibility of subsequent absorption of the decay products is eliminated; at the same time, primary treatment is the first stage in combatting possible subsequent infection.

Primary treatment of the injured sections has been given very little attention in recent years: 10-15 years ago, primary treatment basically involved wiping the areas surrounding the burn with alcohol and removing the torn bits of epidermis; a number of surgeons (Z.P. Samsonava et al.) generally did not use any mechanical cleansing of the burn surface.

After the statement by Yu.Yu. Dzhanelidze at the XXIV All-Union Congress of Surgeons that the "question of primary treatment of the burn section must be reconsidered in relation to greater activity," the primary treatment of the burn surface was proposed as basic for local treatment of burns.

As to the time periods for primary treatment, at the present time, many have concluded that the outcome is better the sooner the burn undergoes primary treatment.

Surgical treatment of the burn section in World War II basically was only partial or complete removal of blisters or tanning of the area damaged by the burn with coagulating solutions with removal of the blisters or their partial removal.

Surgical treatment of the burn section generally was not done in 30.7% of the victims. Frequent removal of blisters without subsequent treatment with tannic acid in the area of the burns amounted to 5.6% of the cases and complete removal of the blisters without subsequent tanning to 6.2%.

Tanning of the damaged section without removal of blisters and scraps of epidermis was done in 33.6% of the victims, with partial removal of the blisters in 9.0% and with full removal of the blisters in 14.9%.

The stages for carrying out surgical treatment can be seen in Table 55.

Pain relief. It is fully understood that thorough primary treatment of the burn surface is unthinkable without good and complete pain relief. Ether or hexenal narcosis of a patient who has just come out of shock is contraindicated as it depresses the already low blood pressure and has a harmful effect on the parenchymatous organs.

There are certain exceptions in the use of nitrous oxide as the anesthetic.

However, the vast majority of surgeons (V.Ya. Vasil'kovan, V.P. Gorbatov et al.) point out that even a subcutaneous injection of 1.5-2 cm^3 1% solution of morphine (depending on the severity of the burn, the age and constitution of the patient), particularly in combination with 1 cm^3 of a solution of atropine (1:1000), often is not completely adequate for the persons who has come out of the state of shock and for conducting subsequent surgical treatment of the burn surface which must be done no more than half an hour after the injection. Even in rare cases of the process of treatment one must resort to additional injections usually of 1 cm^3 of morphine which does not affect the general condition of the patients.

According to the data of the chart of fundamental characteristics, the character of pain relief during primary treatment of burns was successfully established for only 17.7% of all the observations. There is no doubt that in actuality the pain relief substances were used much more often; however, it is impossible to prove that they occurred in 100.0% of the cases of primary treatment because in many patients (72.9%) the burns extended over no more than 5% of the total surface of the body.

As a rule, as the pain relieving substance a 1% solution of morphine was used with a quantity of 1-2 cm^3; only in isolated observations was chlorethyl used as the pain relieving substance in pure form or in combination with ether.

The method of primary treatment. Surgical treatment of the burn surface requires a good deal of time, patience, particular care and cautious treatment of the tissue; this method can be used only in the appropriate circumstances, namely in a special warm (temperature at least 27°) room, with devices and equipment which guarantee aseptic completion of the operation. All of the medical personnel and the patients as well must be in hoods and masks[1]; moreover, those directly participating in the treatment must be dressed in sterile gowns and gloves.

At first the skin around the burn surface is carefully and thoroughly treated using warm soapy suds and the edge of a soft sterile piece of gauze. The most contaminated areas in the injured region first should be wiped with benzine or alcohol. Only after preliminary washing with warm water and soap on the skin surface in the area of the burn is the patient put on the sterile operating table where treatment of the burn surface begins. The area is carefully and thoroughly washed with a piece of sterile gauze with warm soap suds worked up with boiling water (temperature about 30°). The remains of dead epidermis and blisters are completely removed. After being sure that the burn surface is clean it is irrigated with the warm physiological solution and the area of the burn and the surrounding skin is carefully dried with sterile gauze; then bandaging is done.

The bandage must meet the following requirements: a) it must not stick to the burn surface, it must be easily removable; b) it must not harm the healthy tissue; c) it must absorb the exudate well; d) it must prevent loss of the vitally important component part of the blood, the plasma by creating uniform and gentle pressure preventing venous and lymphatic stases; e) protect the burn surface from infection.

Independent of the degree, extent and location (except for the face) of the burn, 3-4 layers of fine gauze which have been well soaked in vaseline are applied directly on the burn surface. The gauze is prepared ahead of time in strips with dimensions 30 X 7 cm and sterilized along with the lubricant in a glazed pottery container with a tightly fitting lid. These strips are put onto the burn surface evenly and smoothly without any kind of wrinkles. On top of the gauze saturated

[1]The need for masks on everyone around the patient and the patient himself is dictated by modern data which show that the nose, throat and mouth of humans contain virulent staphylococci and streptococci.

with lubricant, 3 to 6 layers of dry gauze are applied also made up of previously cut strips of gauze. All of these make up a smooth uniform thickness (about 1 cm) with a sheet of lignin or batting and is attached with soft bandages with slight pressure.

When the chest, abdomen or buttocks are injured an average uniform pressure is applied by wrapping ordinary bandages with a certain tension and subsequently fastening the bandages with a few stitches. In order to obtain uniform and average pressure, the extremities are fixed in a few layers of circulating gypsum bandaging.

When applying the gypsum bandaging on the upper extremity the elbow must be bent at an angle of 90° with average physiological position of the forearm and the radiocarpal joint and wrist must be in an average physiological position with opposition of the thumb. On the lower extremities, the gypsum is applied with slight flexing of the knee; the foot must be at right angles to the crus.

The basic purpose of this bandaging after the primary treatment of burns is the following: on the one hand, to a certain degree it prevents serous exudation from the damaged area and consequently prevents or limits plasma loss and thus decreases hemoconcentration; this has been confirmed experimentally.

On the other hand, it has been noted that even comparatively little pressure from outside on to the surface of an experimental wound significantly limits the development of intumescence. The decrease in edema with the use of pressure was noted even during the first and second halves of 6-hour observation.

The application of bandages after treatment of the wound hopefully protects the damaged surface from infection from outside; this is confirmed by materials of the authors: more than 400 cases of burns treated by this method ended without erysipelous inflammation which often complicates the open method of treatment of burns in any of its variations.

In all cases of first and second degree burns, active movement usually is reestablished immediately after removal of the bandages. In second and third degree burns after the first rebandaging it is necessary to gradually introduce early passive movement in all joints which sometimes during the first days requires a pain relieving substance.

It is necessary to emphasize that thorough treatment of the burn surface with second degree burns in the vast majority of cases provides primary healing of the burn within 8-10-12 days. Therefore, if the general conditions show no indications for early changing of the bandages, the first rebandaging is done no earlier than this.

Things have to be done differently with third degree burns where the entire thickness of the skin is involved in the process. Even with a burn area of 20-25 cm^3 it is difficult to expect self healing. Epithelialization of the burn surface can be achieved only by prolonged growth of the epithelium from the periphery of the wound surface or, much more rapidly, by free transplant of skin.

Therefore, with broad third degree burns the problem comes down to firstly accelerating removal of the necrotic scab and secondly plastic surgery as early as possible.

The first is achieved by frequent (every 1-2 days) rebandaging of the burn surface using 1.5-3-5% solutions of common salt, 2% solution of boric acid and 5% solution of magnesium sulfate.

With each change of the bandage it is necessary ahead of time (a half hour) to give pain relieving morphine with atropine. Bandaging before this, as it is removed, must be moistened with a physiological solution of common salt in order to easily, quickly and painlessly remove it.

At the present time, most surgeons consider that it is best not to expect independent healing of the scabs and accumulation of discharge under them. Only as the demarcation line becomes clear should the entire scab be removed. However, surgical removal of necrotic scabs with widespread burns (more than 10% of the surface of the skin) may involve a collapse. Therefore, removing the scab must be done partially every 4-5 days. Usually, the incision is made under anesthetic, 2-3 weeks after the burn occurs. At this time, there will no longer be significant blood loss and it can easily be stopped using pressure bandaging. After a few days, the burn surface is covered with a light layer of granulated tissue and becomes ideal for a skin transplant.

At this time, the earlier the skin transplant is done the better the chances will be for speeding up healing of the wounds and preventing the formation of disfiguring contractures. The longer plastic surgery on the skin is delayed the greater the danger becomes of infection of the burn surface and, consequently, the necessity arises for a number of additional measures.

With the admission of the patients with infected burns in the later period after injury, usually one observes on the burn surface the development of granulation tissue with significant suppurative discharges. In these cases, the problem comes down to protecting the burn surface from exterior damage, to combatting the infection and to drying out the wound. In this period it is recommended that one use for the granulation surface such means and preparations as will considerably slow down absorption at the same time without preventing regeneration of the cellular elements. Therefore, after treating the skin surrounding the burn and using lavish irrigation of the burn surface with the physiological solution of common salt it is recommended that one apply bandaging to the granulation with a 1.5-3% solution of common salt, 2% solution of boric acid, 20-50% of cane sugar, 50% solution of alcohol, 0.1% solution of magnesium sulfate or zinc sulfate so that, having adequately prepared the granulated surface, it will be ready to accept a skin transplant. Finally, in a number of cases when as a result of increasing regeneration it is delayed, nonspecific stimuli are indicated: sunlamps, quartz lights, etc.

It is fully understood that when conducting all of these measures it is necessary to strictly take into consideration the interconnection between the processes of general and local character in the organism.

Operative Treatment of Burns

Starting with an analogy between the burn and ordinary infected wound, a number of authors advocate operative treatment of burns. They propose primary removal of the damaged section and elimination of all necrotic tissue if necessary right up to the fascia which is an ideal solution to the question of prophylaxis of infection and reduction in the period for healing burn surfaces. The proponents of primary excision of burns confirms that with this method one can successfully not only prevent intoxication of the organism with products of decay of tissue proteins but also prevent the formation of subsequent scar tissue. However, from a second position one can agree that as to prevention of toxemia there are serious effects because the clinically pronounced toxemia can occur with burns over large areas where operative treatment cannot always be carried out.

In 1933, V.P. Gorbunov reported on tests with dogs and one observation of excision of the burn surface with dimensions 4 X 1.5 cm in man; all cases were completed with primary healing.

In 1935 and 1938, M.T. Fri man and L.I. Troshina experimentally showed that with excision of burned sections 1 1/2-6 hours after the injury, one could obtain primary healing by the 7-8th day after the operation.

In 1935-1937, this method of treating burns was widely advocated by F.L. Gektin. His method involves the following. Because on the day the injury occurs the boundaries of the wound are unclear, sterile bandaging is applied to the damaged section. Just after 24 hours with a third degree burn usually the necrotic tissue is sharply delineated from the healthy; it forms either a border of inflammatory erythemia or second degree burn at whose center there is a whitish section completely insensitive to pin pricks. The appearance of bleeding with incisions in this scab makes it possible to judge the depths of the damage.

The operation includes excision of the entire damaged section within the limits of the healthy tissue both on the surface and in depth and the criterion is bleeding when cutting the layers of tissue.

With deep but not broad damage to the skin, after excision usually it is easy to successfully suture the edges of the skin. With more widespread damage the excised sections are closed by a Tirsh skin transplant. Dry bandaging is applied to the transplant consisting of 10 layers of gauze and it is firmly fastened in order to put the desired pressure on it. With burns of the extremities one must immobilize them with a gypsum cast. On the 9-10th day of bandaging they are removed and often at this time full healing has occurred. With very deep but not large burns the author prefers the Tirsh method of skin transplant; he does not rule out transplant of the entire thickness of the skin or plastic surgery according to the Italian method.

Observations have shown that the rapidity of healing with primary treatment and plastic surgery exceeded this in the control cases by 3-4 times. While it is possible to agree with opponents of excision of burns (N.G. Dam'ye et al.), with broad burns this method of treatment is difficult to accomplish and with limited injury it undoubtedly has a number of advantages somewhat decreasing the healing time. For providing success when applying sutures or transplants of the skin one must operate within the limits of the healthy tissue. It is better to take some healthy tissue than to leave the nonviable tissue in the wound; this can worsen the results of surgical intervention.

Finally, the fear of shock also has no adequate basis because with limited burns and in cases where the degree and boundary of damage is clearly apparent, one need not talk about shock.

On the basis of everything which has been presented one can recognize that excision of burns is completely useful: 1) with limited third degree injury and 2) with clear boundaries of the burn surface. This method is widely used, of course, under the appropriate conditions.

Skin transplants. The advantages of excision of wounds after limited burns with subsequent deep suturing or plastic surgery of the skin has already been discussed. The early plastic surgery must be by a selective method and in cases of broad scale burns has the least possibilities.

At the present time, a single system of treatment must be set up for third degree burns comprising primary surgical treatment of the burn surface in the treatment institutions of the troop and army regions and the secondary active covering of it at subsequent stages of sanitary evacuation similarly to the application of primary postponed and secondary sutures with gunshot wounds in soft tissue.

The last measure must be available for methods of everyday work by surgeons in treatment institutions of the army and front regions where each injury after a third degree burn as soon as the patient is admitted must be given special consideration from the point of view of the possibilities and time periods for secondary closing of it. It has been confirmed many times that all who have received burns must be concentrated in special sections of army and front hospitals.

Practice shows that the overwhelming majority of third degree burns usually occupy a limited space (less than 5% of body surface). In this entire group of victims, with few exceptions, with favorable subsequent treatment of the wounds after the burns, it is permissible to have secondary active closing of it even 12-15-20 days from the time of the burn.

If the general condition of the patient will just permit using anesthetic, it is expedient to immediately excise the burn section with subsequent Tirsh plastic surgery. Experience shows that this method, eliminating the aftereffects of the burn, gives the best results and in the shortest time.

Methods of skin transplant. While early transplant of skin on a freshly wounded surface can best be done by the Tirsh method, when there are granulated surfaces after the burn it is fully expedient to use the Yanovich-Chaynskiy (Davis) transplant. For the latter method, the condition of the injured surface is considered clinically favorable when it is covered with a fresh moist granulation without edema of the wound where suppurative discharge is not excessive and where one notes a complete absence of necrotic sections and fibrous deposits on the granulation.

After using moist bandaging with a 10% solution of common salt, sometimes with alternation of physical therapy measures (sunlamp, quartz light), the granulated tissue usually is rapidly purified.

On the day before the operation the injured surface is covered with gauze soaked in a physiological solution of common salt and sterile bandaging is applied. Just before the operation the granulated surface is washed with a warm physiological solution and dried.

Usually local pain killers are used, less often other types. According to the data on the chart of fundamental characteristics, the form of pain relief is distributed in the following way (Table 59).

Pieces of skin for the transplant can be taken from all close sections of the body.

The equipment for taking transplants is not complex and any surgeon can do it under any circumstance.

The Yanovich-Chaynskiy (Davis) method is not devoid of certain negative aspects: 1) the cosmetic effect is not perfect: scars often have a pockmark effect; 2) islands of skin on the granulated surface are easily injured and often are washed by the wound discharge.

Table 59. Distribution of the methods used for pain relief with skin transplants related to burns.

(a) Вид обезболивания	Процент случаев (b)
(c) Местное обезболивание	84,8
(d) Эфирный наркоз	7,2
(e) Спинномозговая анестезия	2,4
(f) Хлорэтил и эфир	2,4
(g) Гексеналовый наркоз	1,6
(h) Хлорэтиловый »	0,8
(i) Местное обезболивание и наркоз	0,8
(j) Всего	100,0

Key: (a) type of pain killer; (b) percent of cases; (c) local pain relief; (d) ether; (e) spinal anesthetic; (f) chlorethyl and ether; (g) hexenal narcosis; (h) chlorethyl narcosis; (i) local pain relief and narcosis; (j) total.

In order to avoid these disadvantages, V.V. Moskalenko at the XXIV All-Union Congress of Surgeons (1938) recommended skin transplants by the Pyasetskiy-Al'gar method in the Krikent modification. The Pyasetskiy-Al'gar method includes excision of rectangular pieces of skin with dimensions 1 X 1 cm and in shifting these pieces into the depressions of granulated tissue preliminarily prepared carefully as a bed. The Krikent modification consists of the fact that for taking the transplant two cuts are made which penetrate to the subcutaneous cells; the skin is excised in the form of strips 0.5-0.6 cm wide and 10-20 cm long. If it is necessary to cover a large area, such strips are placed in a row. Having grasped one end of each strip with tweezers, gradually it is separated with a scapel without the subcutaneous fatty cells. After this, the skin strips are laid on the njured surface on dry gauze pads and gauze is applied on top soaked in a warm physiological solution and with the moisture well squeezed out. In the area where they are taken the strips of cells are excised to the fascia and sutures are applied at the edge of the skin and wound. The bed is prepared in the granulated tissue with care after which the strips of skin are cut into pieces 0.5-1 cm long and attached according to the Pyasetskiy-Al'glav method. The wound is covered with previously prepared cut gauze (in single layers) soaked in vaseline; this sheet of gauze remains on the wound for 4 days Its surface has a heated compress applied to it every day, then vaseline bandaging. The rebandaging is done daily for 5 days and all of the layers of gauze are replaced and the wound surface is irrigated well with a warm physiological solution; after this, vaseline bandaging is applied which is changed every day. In 31 cases of skin transplants after burns, the author found only 4 cases of unsuccessful results and in all of these patients it is explained as an unfavorable time for the transplant because the granulation was edematous. The average time period for epithelialization equals 20-25 days. With deep burns with pain relief, the best effect was expected from skin transplants according to the Filatov method.

Skin transplants according to the data of the chart for fundamental characteristics, in proportion to the number of all burns received amounted to a total of 2.5%. Most often the transplant was done with burns encompassing up to 10% of the surface of the body, in 69.9% of the total number of skin transplants; with burns from 11 to 20% of the surface of the body in 22.4%; from 21 to 30% -- in 6.3%; and with burns from 31 to 50% of the surface of the body -- in 1.4%.

The frequency of skin transplants in relation to the number of all third degree injuries amounted to 5.0%; in relation to the number of all burns of fourth degree it was 19.4%. 95.0% of all skin transplants were carried out for third degree burns and 5.0% for fourth degree.

As to the methods of skin transplants one can note that in 41.3% of the cases Tirsh skin transplants were carried out and Yanovich-Chaynskiy (Davis) skin transplants in 34.7%; other methods were used for the remaining 24.0%.

The maximum number (19.9%) of burns received were excised at 1 to 1 1/2 months (Table 60). The average duration of treatment of the injured including cases which ended fatally equaled 57.3 days. For first degree burns it equaled 16.2, for second degree burns 28.2 days, for third degree burns 82.1 days and for fourth degree burns 128.1 days.

Table 60. Distribution of the time periods for duration of treatment of burns.

Продолжительность лечения (a)	1—9 дней (b)	10—19 дней (c)	20 дней — 1 месяц (d)	1—1½ месяца (e)	1½—2 месяца (f)	2—3 месяца (g)	3—4 месяца (h)	4—5 месяцев (i)	5—6 месяцев (j)	6—9 месяцев (k)	9—12 месяцев (l)	1 год и больше (m)
(n) Процент пострадавших	5,9	15,0	15,8	19,9	11,4	14,6	7,2	4,1	2,3	2,6	0,9	0,3

Key: (a) duration of treatment; (b) 1-9 days; (c) 10-19 days; (d) 20 days-1 month; (e) 1-1 1/2 months; (f) 1 1/2-2 months; (g) 2-3 months; (h) 3-4 months; (i) 4-5 months; (j) 5-6 months; (k) 6-9 months; (l) 9-12 months; (m) 1 year and more; (n) percent of those injured.

The average duration of treatment according to the area of the burn is shown in Table 61.

Table 61. Duration of treatment depending on the area of the burn.

Площадь ожога в процентах к общей поверхности тела (a)	Средняя продолжительность лечения в днях (b)
(c)До 10	54.3
11— 20	96.9
21— 30	78,2
31— 50	44.4
51— 75	21.0
76—100	5,9

Key: (a) area of the burn in percent of the total body surface; (b) average duration of treatment in days; (c) less than.

The decrease in average number of days of treatment in victims with a damaged area from 21% or more is explained by the fact that in parallel with this the fatality rate increased among the victims. For instance with burns taking up 76 to 100% of the total body surface all the patients died, having lasted on an average of 5.9 days.

We will present the average duration of treatment (including those who died) depending on the causes of the injury (Table 62).

Table 62. Duration of treatment of burns depending on the cause of injury.

Ожоги (a)	Продолжительность лечения в днях (b)
(c) Химические	36,0
(d) Горячим паром	36,6
(e) Кипятком и горячей пищей	36,9
(f) Раскаленным и расплавленным металлом	57,0
(g) Пламенем	66,5
(h) Прочие + ожоги раскаленным газом	83,9

Key: (a) burns; (b) duration of treatment in days; (c) chemical; (d) hot steam; (e) boiling water or food; (f) red hot or melted metal; (g) flames; (h) other plus burns from incandescent gas.

One can conclude from this that the duration of treatment is directly proportional to the depth of the burn area and depends on the causes of injury; in particular, burns with flames require longer treatment than burns from a number of other causes.

The volume of medical aid at evacuation stages. Depending on the stage of sanitary evacuation and the general state of the victim, the following measures are used for burns.

Company level (paramedic). The victim is not undressed until he is admitted where he will be held for treatment. If first aid is to be given at the site of the accident the following are necessary: a) cutting of the clothes around the injured section; b) the pieces of underclothing stuck to the skin are not removed; c) no lubricant is applied to the burn surface; d) aseptic (dry) bandages are applied. With limited burns the patient is evacuated (lying down) to DMP (Division medical station).

With extensive burns, it is expedient to use special antiburn bandaging (of the T.T. Luk'yanov type). Emergency evacuation (lying down) to the PMP (Regimental medical station).

The battalion medical post (paramedic). Measures are the same as at the company level if first aid was not given there.

With extensive burns -- abundant warm drinks, wine, injection of morphine and a heart stimulant (camphor, caffeine).

Immobilization of the damaged extremity, emergency evacuation (lying down) at the PMP (Regimental medical station) and if this is not possible directly to the DMP (Division medical station).

In the cold part of the year it is recommended that the victim be warmly covered.

The regimental medical post (physician). The volume of medical assistance is the same as of the BMP (Battalion medical aid station) without examination of the burn sections. Antitetanus serum is injected.

For extensive burns -- keep the patient warm and give plenty of hot fluid to drink; when there are signs of shock give morphine, cardiac stimulants, transfusion of plasma or blood or injection of a 5% solution of glucose (300-500 cm^3).

Only with an improvement in the general condition of the victim should he be evacuated (stretcher) to the division medical station or the mobile surgical field hospital.

The division medical station. With admission of the victim with limited burns 1-2 cm^3 of 1% morphine is injected.

Surgical treatment of the burns is done: complete removal of clothing and bandaging, cleansing of the burn surface removing bits of underclothing; thorough washing of the skin surrounding the burn and the burn surface itself with soap suds using a gauze pad; abundant irrigation with warm hot water and then a physiological solution of common salt; drying of the skin surrounding the burn with gauze pads, application of bandages with sterile vaseline and fastening with average pressure over the area of the burn. On the extremities additionally a circulation gypsum bandaging must be applied to the three layers.

For broad burns primarily it is necessary to thoroughly examine the victim; with any signs of shock he must be put into an antishock tent where a whole arsenal of antishock measures can be taken; heating the patient, hot tea, wine, morphine, cardiac stimulants, transfusion of plasma or blood (300-500 cm^3), intravenous injection of a 30% solution of sodium trisulfate (20 cm^3) or a 4% solution of soda (40 cm^3). Only after the desired bringing of the victim out of the state of shock is primary treatment of the burn begun (see above).

With damage over large areas requiring prolonged treatment the victim who is suffering a general severe state is evacuated to a treatment institution of the army or front.

CHAPTER V

COMPLICATIONS

The course of burns, particularly in combat conditions, can often be extended due to various complications which basically are divided into two large groups: 1) early (general) complications and 2) later (local) complications.

The first group includes: a) shock, b) toxemia, c) septico-toxemia or sepsis, d) tetanus, e) complications in internal organs; of these primarily we should note diseases of the lung, cardiovascular system, kidneys, liver, and central nervous system.

The complications of the later period primarily of the burned surface include: erysipelas, phlegmons, bedsores, ulcers which do not heal, disfiguring scars and contractures.

An analysis of the data of the chart of fundamental characteristics indicates that a different type of complication was observed after the burns in 39.9% of the cases out of the entire number of victims.

If we assume that the total number of complications is 100, then in 42.0% of the cases early (general) complications are noted and in 58.0% later (local) complications. Distribution of the groups of complications is shown in Table 63.

Table 63. Distribution of different complications after burns.

(a) Ранние (общие) осложнения	(b) Процент	(c) Поздние (местные) осложнения	(b) Процент
(d) Шок	11,9	(m) Контрактуры	35,2
(e) Токсемия	71,0	(n) Длительно не заживающие язвы	27.6
(f) Сепсис	6.8	(o) Обезображивающие рубцы	24,4
(g) Столбняк	0,3	(p) Рожа	2,4
(h) Со стороны глаз	6,9	(q) Флегмоны	1,3
(i) » » легких	2,4	(r) Пролежни	0.9
(j) » » сердечно-сосудистой системы	0,2	(l) Прочие	8,2
(k) » » центральной нервной системы	0,1		
(l) Прочие	0,4		
(s) Всего...	100,0	(s) Всего...	100,0

Key: (a) early (general) complications; (b) percent; (c) late (local) complications; (d) shock; (e) toxemia; (f) sepsis; (g) tetanus; (h) involving the eyes; (i) involving the lungs; (j) involving the cardiovascular system; (k) involving the central nervous system; (l) other; (m) contractures; (n) ulcers not healing for a long time; (o) disfiguring scars; (p) erysipelas; (q) phlegmons; (r) bedsores; (s) total.

Variation and distribution of different complications were observed according to the year of the war (in percent) for instance, the frequency of shock among other complications amounted to 0.7% in the first year of the war and 2.3% in the fourth year of the war; toxemia -- 9.8% in the first year of the war and 13.8% in the fourth year of the war. Variation in frequency of other early and late complications was expressed only in tenths of a percent. This increase of basic complications for burns in the fourth year of the war can be explained by the fact that, in the first place, with the passage of time the physician can better diagnose shock and toxemia and secondly, the victims with burns were brought into the treatment institutions much more rapidly (from the moment of injury).

Basically one can note that: 1) the early (general) complications after burn trauma amounted to 16.7% of the number of burn victims for local (late) complications -- 23.2%; 2) the number of different complications after burns in relation to all burn victims in the first year of the war was minimum; it gradually increased with time which is obviously due to the experience acquired by the surgeons when diagnosing these complications.

Table 64 shows the distribution of complications depending on the cause of injury; from this it is obvious that in 4/5 of all cases of complications one observes the most severe with burns from flames; in second place are complications in burns caused by boiling water or hot food (4.7%); third are complications in chemical burns (2.9%) etc.

Table 64. Distribution of different complications in burns depending on the cause of injury.

(a) Осложнения (в процентах) / (b) Причина ожога	(c) Пламя	(d) Кипяток и горячая пища	(e) Химические ожоги	(f) Раскаленный и расплавленный металл	(g) Горячий пар	(h) Прочие (+ раскаленные газы)	(i) Итого
(j) Ранние (общие) осложнения	80,0	4,0	2,9	1,9	3,6	6,6	100,0
(k) Поздние (местные) осложнения	79,9	4,8	2,9	3,4	1,1	7,9	100,0
(i) Итого	80,1	4,7	2,9	2,8	2,1	7,4	100,0

Key: (a) complications (in percent); (b) cause of the burn; (c) flames; (d) boiling water and hot food; (e) chemical burn; (f) red hot and melted metal; (g) hot steam; (h) other (plus red hot gases); (i) total; (j) early (general) complication; (k) late (local) complications.

However, considering the frequency of early (general) complications in relation to the number of all victims from various causes, we see that the early (general) complications most often were observed with burns from hot steam (20.4%); the next largest part of complications were burns from flame (20.3%); with chemical burns they amounted to 10.0% and with the effect of red hot or melted metal -- 9.6%; with burns from boiling water or hot food this was 6.8% and from other causes (including red hot gases) -- 17.5%.

The relationship between early and late complications, depending on the cause of the burns is approximately the same with small exceptions; for example, with burns from red hot or melted metal, local complications were encountered twice as often as general complications and with injury from hot steam the early general complications were observed twice as often as the local late aftereffects of burns. This is so obvious that it does not require further explanation.

The frequency of different complications with burns, depending on the degree of injury, is shown in Table 65.

Table 65. Relationship of complications to the degree of damage.

(a) Степень ожога	(b) Процент пострадавших от ожогов	(c) Из них имели осложнения		
		ранние (общие) (d)	поздние (местные) (e)	всего (f)
I	0,6	2,6	5,3	7,9
II	54,1	8,7	4,5	13,3
III	44,7	25,8	45,3	71,1
IV	0,6	63,4	63,9	133,3
(g) Итого...	100,0	16,7	23,2	39,9

Key: (a) degree of the burn; (b) percent of victims, burns; (c) of these, the complications existed; (d) early (general); (e) later (local); (f) total; (g) total.

It is apparent from Table 65 that while first degree burns had complications of only 7.9% of the victims, during the course of second degree burns, 13.3% of the cases became complicated; with third degree burns this was 71.1% of the cases and with fourth degree all of the victims had one or another complication. However, if one looks at the frequency of early (general) complications in relation to the number of all burn victims of one or another degree, then we see that with first degree the early (general) complications were observed in 2.6% of the victims; in second degree only in 8.7%; with third degree -- in 25.8%; and with fourth degree burns -- even in 69.4% of the victims. While second degree burns most often cause general (8.7%) oftener than local (4.5%) complications, with third degree burns, on the other hand, the late (local) complications

(45.3%) exceed by almost two the general (25.8%) mainly because often limited third degree burns cannot have general complications and the local aftereffects of the burns are observed here almost as a rule.

As to the dependence of complications on the area of the burn, as we see from Table 66, with damage to 10% of the body surface, complications were observed in 31.8% of the cases; with burns over 11 to 20% of the body surface -- in 97.9%; with more extensive damage each victim on the average had more than one complication and only with burns from 76 to 100% of the body surface, as a result of rapid death was there only one complication (shock) from which the victim died.

Table 66. Dependence of complications on the area of the burn.

(a) Площадь ожога в процентах к поверхности тела	(b) Процент пострадавших от ожогов	(c) Из них имели осложнения		
		ранние (общие) (d)	поздние (местные) (e)	всего (f)
(g) До 10	89,9	10,9	20,9	31,8
11—20	5,8	51,8	46.1	97.9
21—30	1,9	79,5	51,8	131,3
31—50	1,5	83.9	26,4	110,3
51—75	0,7	100,0	14,6	114,6
76—100	0,2	100,0	—	100,0
(h) Итого...	100,0	16,7	23,2	39,9

Key: (a) area of the burn in percent of body surface; (b) percent of victims from burns; (c) complications which they had; (d) early (general); (e) late (local); (f) total; (g) less than; (h) total.

Considering the frequency of early (general) complications in relation to the number of all burn victims with various areas of the burn, it can be established that injury to 10% of the total body surface the early (general) complication set in in 10.9% of the victims; with burns over 11 to 20% this figure was 51.8%; with 21-30% of the body surface it was 79.5%; with areas covering 31-50% of the body surface it was 83.9%; with more extensive injury 100% of the victims died.

From a quantitive relationship between the onset of early and late complications, depending on the area of the burn, it is obvious that at the time of injury to 10% of the body, late complications exceeded by almost two the early; with more extensive burns beginning at 11%, one encountered significantly more frequent early (general) complications. For instance, with injury to 11-20% of the total body surface, early complications were encountered somewhat more often than the late; with burns over 21-30% of the total surface of the body it was almost 1 1/2 times more frequent; with injury to 31-50% of the body surface, the number of early complications in comparison with late, increased by almost 3 1/2 times; with burns covering 51-75% of the body -- by almost 7 times; with total burns, 100% of the cases showed only one early complication. The larger the burn area, the earlier death ensued long before local complications occurred.

If one attempts to explain the frequency of complications depending on the number of stages of sanitary evacuation the victim has passed through (Table 67), then it can be established that in parallel with the increase in number of stages passed, the total number of complications with burns gradually increased; in other words, the oftener the victim went from stage to stage the more the number of complications increased. Beginning with the fifth stage of sanitary evacuation, the number of complications gradually began to decrease.

This increase in the number of complications after extensive burns which parallels the increase in number of stages passed can be explained by the exceptionally severe condition of the victim immediately after injury and the necessity to take him as fast as possible in proper conditions for effective treatment both from the point of view of his general condition and from the point of view of the burn injury.

The possibility of a diagnosis in greater depth of different complications in the patients with burns which can be done at larger treatment institutions with high qualified surgical teams is not excluded here.

Table 67. Distribution of complications in burns depending on the number of stages passed.

(a) Этап эвакуации / (b) Осложнения (в процентах)	(c) Первый	(d) Второй	(e) Третий	(f) Четвертый	(g) Пятый	(h) Шестой	(i) Седьмой	(j) Восьмой	(k) Девятый	(l) Итого	(m) Всего
(n) Ранние (общие) . . .	19,0	15,9	18,5	17,3	15,3	7.7	3.4	2,1	0,8	100,0	42,0
(o) Поздние (местные) .	7.4	11.1	16,0	23.3	20,8	11,7	5.6	2.9	1,2	100,0	58,0
(m) Всего . . .	12,3	13,1	17,0	20,8	18,5	10.0	4.7	2,6	1,0	100,0	100.0

Key: (a) evacuation stage; (b) complications (in percent); (c) first; (d) second; (e) third; (f) fourth; (g) fifth; (h) sixth; (i) seventh; (j) eighth; (k) ninth; (l) total; (m) in all; (n) early (general); (o) late (local).

If we take the total number of victims treated for burns by various methods and attempt to establish the number in whom complications have occurred depending on the treatment method, then it seems that with the closed method of treatment for burns the number of complications was minimum (27.7%) and with the open it was considerably larger (35.6%); with a combination method it was twice as high as with the open (72.8%) or four times greater than treating burns with bandages (Table 68).

Table 68. Frequency of complications after burns depending on the treatment method.

(a) Осложнения (в процентах)	(b) Всего осложнений к числу лечившихся в процентах	(c) Метод лечения			
		(d) закрытый	(e) полуоткрытый	(f) открытый	(g) смешанный
(h) Ранние (общие)	16,7	9,7	20,4	21,1	27,4
(i) Поздние (местные). . . .	23,2	18,0	22,7	14,5	45,4
(j) Всего . . .	39,9	27,7	43,1	35,6	72,8

Key: (a) complications (in percent); (b) total complications out of the number of those treated in percent; (c) treatment method; (d) closed; (e) semiopen; (f) open; (g) mixed; (h) early (general); (i) late (local); (j) total.

The dependence both of the early and the late complications on different treatment methods for burns is presented in Tables 69 and 70.

Table 69. Frequency of different early complications after burns depending on the treatment method.

(a) Осложнения (в процентах) / (b) Метод лечения	(c) Шок	(d) Токсемия	(e) Сепсис	(f) Столбняк	(g) Со стороны (h) глаз	(i) легких	(j) сердечно-сосудистой системы	(k) центральной нервной системы	(l) Прочие	(m) Всего
(n) Закрытый	1,1	7,2	0,5	0,03	0 5	0,2	0,03	—	0,07	9,7
(o) Полуоткрытый	—	13.6	2,3	—	4.5	—	—	—	—	20,4
(p) Открытый	3,2	12.9	1,3	0,06	2.8	0 7	0,06	0,06	—	21,1
(q) Смешанный	2,6	21.2	2.3	0,07	0,5	0,5	—	—	0 1	27,4
(r) Итого...	2,0	12,0	1,1	0,05	1,1	0,4	0,03	0,02	0,1	16,7

Key: (a) complications (in percent); (b) treatment method; (c) shock; (d) toxemia; (e) sepsis; (f) tetanus; (g) involving; (h) eyes; (i) lungs; (j) cardiovascular system; (k) central nervous system; (l) other; (m) total; (n) closed; (o) semiopen; (p) open; (q) mixed; (r) total.

Table 70. Frequency of different late complications after burns depending on the treatment method.

Осложнения (в процентах) (a) / (b) Метод лечения	(c) Контрактуры	(d) Длительно не заживающие язвы	(e) Обезображивающие рубцы	(f) Рожа	(g) Флегмоны	(h) Пролежни	(i) Прочие	(j) Всего
(k) Закрытый	5,1	6,5	4,0	0,3	0,3	0,1	1.7	18.0
(l) Полуоткрытый	11,4	4,6	4.6	—	—	—	2.3	22.7
(m) Открытый	5.6	1,7	3.9	1.0	0,2	0,3	1.6	14.5
(n) Смешанный	18,5	11,6	11,5	0,6	0.2	0,3	2.6	45,4
(o) Итого...	8,2	6,4	5,6	0,5	0,3	0,2	2,0	23,2

Key: (a) complications (in percent); (b) treatment method; (c) contractures; (d) ulcers not healing for a long time; (e) disfiguring scars; (f) erysipelas; (g) phlegmons; (h) bedsores; (i) other; (j) total; (k) closed; (l) semi-open; (m) open; (n) mixed; (o) total.

Comparing the frequency of early (general) complications with different methods for treating burns (Table 69), one can note that these complications with a closed method of treatment are encountered much less often than with treatment by other methods; in particular, this applies to shock, sepsis, partically to toxemia and to complications involving the lungs.

A similar picture can be established for late (local) complications (Table 70). All of this makes it possible to conclude that the open method of treatment of burns, particularly in wartime, from the point of view of subsequent complications, is not correct and must in the future give way to treatment of burns using bandages.

A. Shock. Shock most often is the complication for extensive burns even from the moment of injury but sometimes it can set in later on especially as a result of prolonged or multiple transportation of the victim immediately after the burn occurs. At the time of hospitalization often one encounters a patient with burns who is in a state of primary shock; usually at this time the physician must most often work with secondary burn shock.

According to the material of the chart of fundamental characteristics, pronounced shock is apparent in 2.0% of the total number of burn cases.

Frequency of shock in relation to the total number of patients with burns for World War II is the following: in the first year -- 0.7% of the cases; in the second -- 1.9%; in the third -- 2.2%; in the fourth year of the war -- 2.3% of the cases.

Year by year the increase in the number of shock cases with burns can be explained, primarily, by more careful diagnosis of shock and, secondly, by earlier and more widespread hospitalization of victims in treatment institutions with highly qualified teams.

Most often shock was observed at the first stage of sanitary evacuation (36.2% of the total number of shock cases), burn cases in a state of shock are encountered twice as infrequently at the second stage (17.3%), even less often at the third (12.1%) and even at the fourth (12.9%) the stage of evacuation. At subsequent stages, shock was encountered much less. The essential point here is that complication after burns must be local only at the first stage because before this the victim was not brought out of the stage of shock and any transporting of him to another treatment institution is absolutely contraindicated. There is a basis for thinking that sometimes a shock state, absent or at a minimum immediately after the burn, occurring later on in certain cases could have been caused by transferring the victim to the treatment institution where he underwent surgical treatment and subsequent treatment. In a number of cases this was actually so; it is confirmed by data on the time first aid is given for shock: only in 42.8% was first aid for shock given immediately; in 19.5% of victims emergency measures were taken to bring the patient out of shock 1-2 hours after injury; in the same number of patients (19.5%) 3-6 hours after the burn; in 5.2% after 7-12 hours and in 11.7% of the patients 13-24 hours later; in the other patients it was even later.

Least often (0.8%) the appearance of shock was found with burns on less than 10% of the total surface of the body and 3.2% with an area of the burn from 11 to 20%; in 10.7% of the cases there was shock for burns covering 21-30% and 25.3% for burns covering 36-50%; in 41.5% of cases of burns covering 51-75% of the body surface, etc. In a tremendous majority of cases, the antishock measures (morphine, cardiac preparations, blood transfusion and antishock fluid) were conducted by a physician (72.5%); in the remaining cases it was done by average medical personnel.

Most often shock occurred with burns from flames (2.5%); in 2.4% of the cases shock was observed for other types of burns (including damage from red hot gases); in 1.2% of the victims the appearance of shock was noted in chemical burns.

As one would expect, most often (19.4%) the appearance of shock occurred in fourth degree burns; least often (3.2%) with third degree burns and only in 0.8% of those who had received second degree burns.

As to the connection between frequency of complication with shock and the method of treatment, with a closed method of treatment shock was observed only in 1.1% of the cases; with an open method of treatment shock was reported in 3.2%; with a combined method it was found in 2.6% of the cases. Remembering that the combined method first is open treatment and then treatment under bandages, one can consider that with the open method of treatment shock occurred in 2.9% of the cases or almost twice as often as treatment under bandages.

B. Toxemia. Toxemia usually develops or more acurately it is caught clinically as a result of the patient coming out of the state of shock.

Toxemia was observed as an early complication after burns in 11.8% of all victims.

In the first year of the war, toxemia was observed in 9.8% of all persons receiving burns for that period; in the second year it was observed in [illegible].9%, in the third in 11.1% and in the fourth in 13.8% of the victims.

A certain increase in frequency of this complication according to the year of the war is explained, like shock, by an improvement in diagnostics in the later years of the war. Particularly often toxemia was observed in the first stages of sanitary evacuation because it set in as a result of shock and clinically was often difficult to distinguish from shock.

As to the relationship of this complication to the cause of the burns, one should note that in 14.4% of the cases it was observed with burns from flames, in 12.1% from other reasons related to red hot gases, in 5.6% in cases of burns from boiling water or hot food and 40.4% in burns from steam; in 6.7% of the observations the appearance of toxemia was recorded for chemical burns.

In 30.6% of the victims toxemia developed with fourth degree burns; in 18.6% with third degree burns; in 6.2% with second degree burns.

And like shock, toxemia occurred least often (8.2%) with burns of less than 10% of the total body surface; in 39.0% of the cases it was encountered with burns from 11 to 20%, in 50.8% with damage to 21-30%; in 38.0% it occurred with damage to 31-50% of the body surface, etc.

Relative to the relationship of occurrence of toxemia to time first aid was given, it was established that in almost half of the victims (46.3%) with toxemia, first aid for burns had been given immediately after injury. Toxemia was observed in 18.0% of those who received first aid 1-2 hours after injury and in 9.5% in those receiving first aid 3-6 hours after the burn and in 15.6% who received first aid in the interval from 13 to 24 hours after injury.

As to the effect of various methods of treatment on the development of toxemia, it was established that with the closed method of treatment of burns, toxemia showed up in 7.3% treated with bandages; with a semiopen method this complication was observed in 13.6% of the cases and with an open method in 12.9%; with a combined method it appeared in 21.2%. Thus with an open method of treatment of burns toxemia occurred in 16.7%, that is, almost 2 1/2 times more often than with treatment in bandages.

C. Septicotoxemia or sepsis, has all the characteristics of a general acute suppurative infection. According to bibliographical data, the course of extensive burns is complicated by sepsis on the average in 1.7-2% of the cases.

This complication in the first year of the war was observed in 1.1% of all persons receiving burns in that period; in the second year in 1.2%, in the third in 1.0% and in the fourth 1.3% of all persons receiving burns.

As one see from what has been presented above, the frequency of this complication with burns is more or less constant and depends on the severity of injury.

The causes for the slight increase in the present of complications of burns from sepsis during the last year of the war is due to improvement in recognizing it with severe burns.

As to the effect of the number of stages which the victims have gone through for sanitary evacuation on frequency of sepsis, as one would expect, in only 13.2% of observations was sepsis noted at the first stage; the largest number of this complication with severe burns was reported in the third (26.5%) and fourth (23.5%) stage of sanitary evacuation; at the fifth and at the second stages sepsis was recorded for a total of 10.3% of the cases. With burns by flames and also from other causes including red hot gases, sepsis was observed in 1.0% of the cases and with chemical burns in 0.8%; least often sepsis was observed with injury by red hot or melted metal (0.6%) and also boiling water and hot food (0.2%).

Just like the other general complications, sepsis most often was encountered with fourth degree burns (16.6%); with third and second degree burns it was encountered much less often: in 2.1% with third degree burns and in 0.2% with second degree.

Sepsis was encountered most often with burn damage over 21 to 30% of the body surface (16.0%) and also from 31 to 50% (19.5%). It was established that with the closed method of treatment sepsis occurred only in 0.5% of the cases, with the semiopen in 2.3%, in the open method in 1.3% and with a combined method in 2.3%; with the open and combined method of treatment, sepsis was observed in 1.7%, that is, three times more often than with the closed method.

Complications involving internal organs. In elderly and exhausted patients with burns often one observes different complications of the internal organs particularly the lungs, kidneys, cardiovascular and central nervous systems.

Complications involving the lungs (bronchopneumonia, pneumonia, bronchitis, etc.) is the most frequent accompaniment for burns but with a severe condition of the victim they are rarely considered. Most often these complications are encountered with damage to the face and anterior part of the chest cage by flames, apparently, as a result of the direct effect of the vapor or smoke on the upper respiratory tracts and also as a result of limitation of respiratory movement of the chest cage. Complications involving the lungs, according to the material on the chart of fundamental characteristics, was observed in 0.4% of the cases.

Complications involving the cardiovascular system in relation to all persons who received burns, according to the materials on the chart for fundamental characteristics, amounted to 0.03%. With burns one fairly rarely encounters complications involving the central nervous system: only one case of such a complication was recorded which was diagnosed as intoxication psychosis ending in recovery of the patient.

Late (local) complications. The late (local) complications include contractures, ulcers which do not heal for a long time after burns, scars, erysipelatous inflammation, bedsores, phlegmons, etc. All of these complications are often encountered after burns.

Contractures. According to the material of the chart of fundamental characteristics, contractures after burns occur in 8.1% of all burn cases and of those who receive burns of the extremities in 14.8% of the cases.

According to the year of the war, these complications were observed (in percentage of the number of burns received for the appropriate period): in the first year of the war in 6.0%; in the second year -- in 7.3%; in the third year in 9.1% and in the fourth -- 9.7%.

The increase in number of contractures in the second and succeeding years of the war is explained by more careful diagnosis of these complications in the second half of the war.

The majority of contractures (10.9%) was observed after burns by flame; 5.1% of the contractures are due to burns from red hot or melted metal, 3.2% from chemical burns, 1.7% from burns by boiling water or hot food. As one would expect, the contractures most often were encountered with third degree burns (17.7%), and much less often with second degree burns (1.3%).

Least often, contractures (7.2%) were observed with burns over less than 10% of the total body surface; in 19.0% with burns from 11 to 20% of the body surface; in further parallel the increase in area of the burn, the number of contractures decreased because victims with more extensive burns died much sooner than contractures would develop.

With a closed method, contractures were observed in 4.9% of all those treated with bandages and with the semiopen -- in 11.3%; in those treated with the open method in 5.6% and with the combined method in 18.5% of all persons who had received burns.

An increase in the number of contractures when treating burns with an open method is one of the basic indications for transferring to treatment of victims with bandages.

Ulcers which do not heal for a long time are also one of the most frequent complications after burns. Usually they form from insignificant granulated surfaces after burns from which the victim often has been released for ambulatory treatment; in a number of cases these granulated surfaces change over to ulcers which do not heal sometimes requiring many months of treatment to eliminate them.

This complication was observed in 6.4% of all persons who had received burns.

We will show the distribution of ulcers which do not heal for a long time according to the year of the war: in the first year of the war they amounted (of the number of those who received burns for this period) to 7.4%, in the second year to 7.0%, in the third year to 6.3% and in the fourth year to 1.7%.

The decrease in frequency of this complication in the third and particularly in the last year of the war is explained by a number of prophylactic measures for combatting the ulcers formed, improving treatment of the latter and mainly keeping the victims in hospitals until complete recovery particularly after the battalions begin to return patients who had recovered from these complications for treatment in the hospitals.

In 9.4% of the cases of wounds which do not heal for a long time, various causes were established including red hot gases; in 9.0% with burns from red hot or melted metal, in 7.7% with burns from flame and 2.4% with burns from boiling water or hot food.

As one would expect this complication usually arose with third degree damage (13.8%). With burns over 10% of the body surface the ulcers which did not heal for a long time were observed in 6.1% of the victims; with the burn area 11 to 20% -- in 11.5%.

It was established that with a closed method of treatment of burns, ulcers which do not heal for a long time occurred in 6.6% of the cases, with a semiopen method in 4.5% and with an open method in 1.8%; with a combined treatment it occurred in 11.6% of the cases.

Disfiguring scars as a complication after burns were observed in 5.7% of all cases. This complication comprises the number of those who had received burns for a given period in the first year of the war at 5.5%, in the second year at 5.2%, in the third year at 6.7% and in the fourth year at 5.5%.

Most often it was observed in the last five stages of sanitary evacuation (23.0%) somewhat less often in the last four stages (20.3%), the last three stages (15.0%) and the last six stages(11.6%).

In the vast majority of cases disfiguring scars appeared after burns by flames (7.1%) just as they often occurred from other reasons including redhot gases (7.0%) and significantly less often in burns from boiling water or hot food (3.3%) etc. After third degree burns the scars were apparent in 11.7% of the cases and with second degree in 0.6%.

When the area of the burn was less than 10% of the total body surface, scars were observed in 5.0% of the cases; with a burn from 11 to 20% it was apparent in 13.0% of the victims.

With a closed method, the scars were noted in 4.0% of the cases and with a semiopen method in 4.5%; in an open method it was noted in 3.9% and with a combined method 11.5%.

There is a basis for proposing that the open method of treatment of burns is the cause of this complication no more often than other methods of treatment of burns.

Erysipelatous inflammation was observed just as often both in the first days after the burn and in the period of epithelialization of the burned surface. An analysis of literature available on this question shows that in the vast majority of cases erysipelatous inflammation occurred with the open method of treatment of burns. During World War II this complication was observed in 0.6% of all those who received burns and amounted to 2.4% of all late complications.

Phlegmons. Phlegmons in patients with burns were rarely observed, predominantly in severe cases. They are observed: 1) when treating burns with coagulation substances when on the injured surface a tight scab forms under which the suppurative content can form with gradual separating tissue; 2) after subcutaneous injection of different medicinal substances with an areactive state of the organism; 3) with the appearance of septicopyemia on different parts of the body.

Bedsores. Most often they are observed with the open method of treatment which makes release of the patient much more difficult; prolonged immobility and forced positions for the victim often result in this aftereffect during burns.

Bedsores were observed in 0.2% of all patients with burns. In the first year of World War II, bedsores occurred in 0.3% of the cases, and in the second year in 0.2%; in the third year only in 0.1% of the cases, in the last year of the war, bedsores were noted in 0.3% of the victims.

With the open method of treatment they were encountered only in a total of 0.06% of the cases; in an open method in 0.4%; with a combined method in 0.4%; in other words, with the last two methods of treatment of burns (and the presence of bedsores is an indication to change the patient to a closed treatment method) this complication is encountered much more often that with the closed treatment method.

CHAPTER VI

PROGNOSIS

The prognosis for extensive burns can be made only when taking into consideration a number of conditions, namely: 1) the general condition of the victim; 2) localization of the burn; 3) the character of the damage factor; 4) the degree of the burn and the dimensions of the affected surface; 5) the presence or absence of complications during the process; 6) age and sex.

The general state of the organism is extremely important for the outcome of the burn. Persons suffering from chronic diseases, particularly of the cardiovascular system and other organs, often die even with small burns.

The localization of the burn also affects the course and outcome of the illness. A poor prognosis is given to burns on the trunk and head as a result of the possibility of development of pneumonia, peritonitis or meningitis later on in them. Deep burns of the face are considered more serious than burns of the extremity as a result of frequent complications of the trigeminal nerve. Burns of the peritoneum, the genetal organs and the buttocks heal poorly and often become infected.

The character of the damaging factor often has a large effect on the course and outcome of the burn.

Burns by flame are considerably more severe than burns by boiling water. According to the material of the chart on fundamental characteristics, the fatality rate for burns from flames is 13 times higher than the death rate for burns from boiling water or hot food. Burns from explosions are particularly dangerous because their severity is exacerbated by contact and breathing of the poisonous gases formed during the explosions.

The deeper the damage to tissue during a burn the more severe the damage both of the directly affected organ and of the organism as a whole. A first degree burn is very dangerous if it covers two-thirds of the body; a second degree burn is very dangerous if it covers half; a third degree burn is very dangerous if a third of the surface of the skin is burned. With third degree burns the fatality rate is 5 1/2 times higher than with second degree burns. However, it must be considered that with extensive second degree burns often one observes an earlier death than with third degree burns because in the latter case the vessels are thrombosed and absorption occurs in smaller dimensions than with second degree burns where circulation in the damaged region is less disturbed.

At the present time, it has been established that burns covering one-third of the surface of the body are often fatal. Even with one-quarter of the body of the victim affected often he dies at a later time. With all burns covering an area of more than 10% of the body surface, one observes various symptoms of general affliction -- erythrocytosis, the appearance of necrotic pathological ingredients in the urine characteristic for disturbances in the oxygen processes in the organism as a result of which these burns can be considered as life threatening to the victims.

Clinical observations indicate that the presence of convulsions and vomiting after burns considerably darken the prognosis. Unfavorable symptoms are the appearance in the urine of albumin and particularly albumoses and also albumose. The presence of jaundice is considered very serious. Finally, the time and character of giving first aid has a significant effect on the outcome; also timely use both of general and local treatment is important. While earlier the fatality rate from burns according to literature and data in peace time reached 20.0%, at the present time it does not exceed 10.0%. The improvement in results is explained by the introduction of modern methods for treating burns.

Age and sex of the victim have a considerable effect on prognosis for burns. Recently it was established that children and old people withstand burns much worse than others and often d: with comparatively small burns.

CHAPTER VII

LETHALITY

Statistical data on fatal outcomes for burns are so contradictory that even with the greatest efforts it is impossible to obtain a more or less precise concept of lethality during burns mainly because it varies depending on a number of moments: on localization of the burn, the cause of the injury, the depth of penetration of the burn into the tissue, its dimensions in relation to the total surface of the body, the time periods when general and local measures in first aid were given to the victim and, finally, the method of treatment of the burns.

Dependence of Lethality on Different Factors

The effect of localization of burns. The dependence of the fatal outcomes on localization of burns is expressed in the following figures: if lethality of burns on the trunk which are the most dangerous for life are taken as one, then injury to the head has a lethality of 0.19 and burns of the pelvis 0.23, the upper extremities 0.05, injury to the lower extremities -- 0.16.

Lethality among victims depending on localization of burns is illustrated in Table 71.

Table 71. Lethality depending on localization of burns.

Область тела (a)	Процент умерших к числу получивших ожоги (b)
(c) Голова	2,9
(d) Туловище	14,6
(e) Таз	3,4
(f) Верхние конечности	0,7
(g) Нижние »	2,4
(h) Прочие области тела	—

Key: (a) region of the body; (b) percent of those who died out of the number of those receiving burns; (c) head; (d) trunk; (e) pelvis; (f) upper extremities; (g) lower extremities; (h) other regions of the body.

Burns on the trunk must be considered more dangerous to the life of the victim because its surface amounts to 36.75% of the entire area of skin of the person.

For this same reason damage to the lower extremities is 3 1/2 times more dangerous than to the upper extremities.

Lethality among victims, depending on the cause of injury, is indicated in Table 72.

It is apparent from the Table that lethality for burns from flames was maximum (4.0%) and exceeds by 13 times lethality from burns by boiling water and hot food (0.3%).

The effect of depth of the burn. It is long been known that the deeper the burn the more frequently different complications occur and consequently, the greater possibility there is for a fatal outcome. The effect of the degree of the burn on lethality is illustrated by the following data. With first degree burns, lethal outcomes were not observed. With fourth degree injury the most dangerous for the life of the victims, the lethality is taken as one and with second degree burns lethality is expressed as 0.03, with third degree -- 0.14.

Table 72. Lethality among burn victims depending on the cause of the burn.

(a) Причина ожога	(b) Процент умерших к числу пострадавших данной группы
(c) Пламя	4,0
(d) Кипяток и горячая пища	0.3
(e) Химические ожоги	1.6
(f) Раскаленный и расплавленный металл	0.6
(g) Горячий пар	2.0
(h) Прочие (+ раскаленные газы)	2.4

Key: (a) cause of the burn; (b) percent of those who died out of the total number of victims of a given group; (c) flames; (d) boiling water and hot food; (e) chemical burns; (f) redhot and melted metal; (g) hot steam; (h) other (plus redhot gases).

In this way, with third degree burns, in comparison with second degree, lethality is increased by almost 5 1/2 times and with fourth degree burns, in comparison with third degree burns, a fatal outcome occurs 6-7 times more frequently.

The effect of the dimensions of damage. At the present time, it is firmly established that lethality for burns is in direct relationship to the area of the injury. The critical boundary for dimensions of a burn which results in death is a third of the surface of the body; with burns of less than a third of the body surface the percent of persons who recover is increased; with the area of the burn 10-15% of body surface, the number of persons who recover always exceeds the number who die.

Below (Table 73) one sees the effect of the dimensions of the burn surface on lethality according to the data of the chart for fundamental characteristics. With burns with maximum extension, that is, within limits of 76-100% of the total body surface, lethality is taken as 100; with burns on 51-75% of the body surface it i xpressed as 87.0; with burns over 31-50% of the body as 64.0; with burns of 21-30%, as 31.0 and with burns on 11-20% -- as 5.0; with burns on less than

10% of the total body surface, lethality was minimum and comprised 0.5.

Table 73. Dependence of lethality on the area of the burn (lethality of a burn area of 76-100% body surface is assumed as 100).

Площадь ожога в процентах к поверхности тела (a)	Высота летальности в каждой группе (b)	Площадь ожога в процентах к поверхности тела (a)	Высота летальности в каждой группе (b)
(c) До 10	0,5	31—50	64,0
11—20	5,0	51—75	87,0
21—30	31,0	76—100	100,0

Key: (a) area of the burn in percent of the body surface; (b) maximum lethality in each group; (c) less than.

With a decrease in the burn surface, lethality decreases sharply.

The effect of the time first aid is given for burns. The dependence of lethality for burns on timely conduct of general and local measures of urgent aid is graphically illustrated by the following data.

While lethality with first aid for burns after 24 hours or more is assumed to be 100, when first aid is given 13-24 hours after the burn, lethality comprised 50.0, after 7-12 hours, 48.0; after 3-6 hours -- 31.0; after 1-2 hours -- 3.0; with immediate first aid the lethality rate for the burn amounted to a total of 1.0 (Table 74).

With later conduct of general and local measures for burns the number of persons who recovered decreases and the number of lethal outcomes increases.

When giving first aid to the victims after 24 hours or more from the time of the burn, half the patients die.

The effect of the treatment method. Closed method. N.N. Petrov (1942) notes that with treatment with gauze bandaging 7.6% died (13 persons). I.A. Gorban' reports a lethality of 24.0-30.0%.

Table 74. The dependence of lethality for burns on adminstration of first aid (100 is the number taken for lethality with first aid given after twenty-four hours or more).

	Срок оказания первой помощи при ожогах (a)	Процент умерших (b)
(c)	Немедленно	1,0
(d)	Через 1—2 часа	3,0
(e)	» 3—6 часов	31,0
(f)	» 7—12 »	48,0
(g)	» 13—24 часа	50,0
(h)	Свыше суток	100,0

Key: (a) time period for giving aid for burns; (b) percent of those who died; (c) immediate; (d) after 1-2 hours; (e) after 3-6 hours; (f) after 7-12 hours; (g) after 13-24 hours; (h) more than 24 hours.

However, as ointments were replaced by substances containing vitamins (fish oil, etc.) the lethality for burns decreased considerably. According to observations made by Kh.M. Trandofilov, it amounted to 10.4%; according to P.A. Nalivkin, the lethal outcome with this method of treatment was 3.3%. According to the data of the chart of fundamental characteristics, lethality with burn treatment by bandages with fish oil was expressed by a total of 1.5%.

The semiopen method of treatment according to literary data and material from wartime, was used comparatively rarely; it comprised 0.7% in relation to all other treatment methods. I.A. Gorgan' had a lethality rate of treating burns with irrigation by Rivanol equaled to 8.0-12.0%; according to the data of A.L. Polyantsev concerning 100 burn victims, it amounted to even 16.0% (according to peace time data).

According to the material of the chart of fundamental characteristics when treating burns with this method, a fatal outcome is noted in 2.3% of the cases.

An open method of treatment. According to the data of V.I. Struchkov, out of 182 burn patients treated with the open method 12 persons died (6.6%); S.L. Tydman reports 13 deaths out of 166 persons

(7.8%); S.I. Voronchikhin reports a death rate of 8.5% out of 250 persons; B.A. Varsav (1934) with an open method of treatment showed 19.0% lethality; according to M.K. Komissarov (1937) it even reached 23.8%.

According to the material of the chart of fundamental characteristics, with the open method of treatment the largest number of victims died in persons treated with this method. The open method of treatment of burns was used for almost one quarter of the victims and a high lethality from burns was observed during treatment according to the Bettman method.

A combined method of treatment of burns. According to the data of the chart of fundamental characteristics, the combined treatment method for burn victims give a lethality 2 1/2 times lower than the open method.

The total data on lethality with different treatment methods for burns based on the material of the chart of fundamental characteristics is given in Table 75.

Table 75. Lethality with different treatment methods.

Способ лечения (a)	Всего лечилось (в процентах) (b)	Летальность (c)
(d) Закрытый	50,8	0,3
(e) Полуоткрытый	0,7	0,4
(f) Открытый	26,6	1,0
(g) Смешанный	21,9	0,4

Key: (a) method of treatment; (b) total treated (in percent); (c) lethality; (d) closed; (e) semi-open; (f) open; (g) combined.

If one takes lethality with the open method of treatment of burns as one, then with the combined treatment method it is 0.4 and with the semiopen method 0.4; lethality was minimum with the closed treatment method for burns -- 0.3.

The causes and time periods for onset of death during burns. In the chapter entitled Complications it has already been mentioned that after a burn, the organism of the victim undergoes a number of changes caused both directly by the burn and by different complications. The latter often set in at the moment of injury and often are the basic cause of death.

A fatal outcome for a number of all victims with general complications amounted to 20.7%. In other words, 4/5 of all the victims who had general complications after burn trauma recovered and 1/5 died.

If we take lethality during sepsis as one, then second place for life threatening danger to the victim is pnuemonia whose lethality is expressed as 0.8.

During shock, lethality amounted to 0.47 and with toxemia, in spite of the predominant frequency among burn patients, the lethality was only 0.1.

Other complications (involving the heart, kidneys and other organs) observed in isolated cases, due to their insignificant number were not calculated.

Burn shock can be observed from the first to the fourth day of the injury; in the first 24 hours it depends exclusively on the severity of the burn; subsequently a shock state can be caused by inadequately active treatment of the primary shock or in a number of cases by premature transport of a severely wounded person to the next evacuation stage. In the first days after a burn, lethality during shock was observed in 58.0% of all cases; 24-48 hours later only 32.0% of the victims died from shock; by the third day this number was only 6.0% and on the fourth day -- 4.0%.

Toxemia can be the cause of death even on the second day after a burn (1.7%); however, the basic manifestation of this complication is observed on the third, fourth, and fifth and succeeding days after the burn when it usually is diagnosed as intoxication of the organism at first of protein and then of bacterial origin.

Lethality during toxemia even from the second day after the burn gradually progresses giving higher figures in the second ten days after the moment of trauma.

Sepsis can appear to be the cause of death even on the 6th to 9th days after injury (3.3%); much more often patients died from this complication between days 10 and 30 after the burn occurs or in subsequent times; maximum lethality during sepsis was observed in the period from the 10th to the 45th day of the illness.

Complications involving the lungs can be the cause of death at any time after a burn. With burns to the face from flames with simultaneous damage to the upper respiratory tracts, pneumonia can cause a fatal outcome even by the second day after a burn; however, more often this complication kills the patient on the 6-9th day of the illness and after 45 days death from pneumonia is considered a rare phenomenon.

Thus, the first 1 1/2 months after the trauma are an extremely dangerous period for persons who have received extensive burns; it is in this time that 85.0% of all fatal outcomes from burns occur; if the patient recovers from shock, then he risks dying from toxemia, and then from sepsis.

Moreover, the life of the victim during this period is threatened by pneumonia and other diseases of the respiratory tracts which, if you please, are no less fraught with sad results than the complications presented above.

Maximum lethality among the persons who have received burns is observed in the first 24 hours (14.3%); on succeeding days the percent of fatal outcome gradually decreases (8.9; 6.9; 4.9, etc.).

While in the first 24 hours 100% of burn patients die exclusively from shock and in the second 24 hours shock is the cause of death in only 88.8% of the cases while individual persons can die as a result of toxemia (5.6%) and complications of the lungs (5.6%).

On the third, fourth and fifth days, the main cause for death among those who have been burned is toxemia (64.3, 70.0, 100.0%).

From the 6th to the 9th days after a burn, more than half of those who have been burned (58.3%) die from toxemia and a considerable number (29.2%) from complications of the lungs; in isolated cases (8.3%) death comes from sepsis; later on the number of fatal results from sepsis increases and lethality from toxemia and pulmonary complications gradually disappears; after 1 1/2 month or more after the burn, the victim basically (75.0%) died from sepsis.

Thus, with extensive burns of the body, life threatening danger for the victim lasts for several months; establishing a prognosis at this time must be done with extreme care.

CHAPTER VIII

OUTCOMES AND CONCLUSIONS

With an analysis of the materials of the chart of fundamental characteristics, from the point of view of results of treatment of burns, the following clinical results were obtained. Complete recovery occurred in 92.7%. Recovery with contractures of varying degree occurred in 4.5% of the cases, recovery with disfiguring scars in the burn location occurred in 1.8%; recovery with trophic ulcers was established for 1.0%.

A clinical evaluation of the results of treatment depending on: a) the degree of the burn; b) the dimensions of the latter in relation to the total body surface and c) methods of treatment of the victims are illustrated in the Tables presented below.

Table 76 shows the clinical outcomes depending on its degree of burn.

Table 76 once more confirms the old truth that the deeper the burn the more rarely full recovery occurs the greater are the complications and the more often one encounters a fatal outcome.

Table 76. Clinical outcomes depending on the degree of the burn.

Степень ожога (a)	(b) Выздоровление: полное (c)	с контрактурами (d)	с обезображивающими рубцами (e)	с трофическими язвами (f)	Итого (g)
I	97,3	—	2,7	—	100,0
II	99,3	0,2	0,5	—	100,0
III	84,7	10,1	3,1	2,1	100,0
IV	12,3	19,3	58,8	9,6	100,0
(h) Всего . . .	92,7	4,5	1,8	1,0	100,0

Key: (a) burn degree; (b) recovery; (c) full; (d) with contractures; (e) with disfiguring scars; (f) with trophic ulcers; (g) total; (h) in all.

The dependence of clinical outcomes on the area of the burn are shown in Table 77: the larger the dimensions of the burn surface the more rarely one encounters full recovery and the more often complications lead to higher lethality.

Table 77. Dependence of clinical outcome on area of the burn.

Клинические исходы (a)	(b) Площадь ожога в процентах к поверхности тела: до 10 (c)	11—20	21—30	31—50	51—75	76—100	Итого (d)
(e) Выздоровление:							
(f) полное	93,8	4,6	1,1	0,4	0,1	—	100,0
(g) с контрактурами	71,9	21,3	4,8	2,0	—	—	100,0
(h) с обезображивающими рубцами	72,2	17,5	5,2	4,1	1,0	—	100,0
(i) с трофическими язвами	74,0	16,0	8,0	2,0	—	—	100,0
(j) Всего . . .	90,0	5,8	1,9	1,5	0,8	—	100,0

Key: (a) clinical outcome; (b) area of the burn and percent of the body surface; (c) less than; (d) total; (e) recovery; (f) full; (g) with contractures; (h) with disfiguring scars; (i) with trophic ulcers; (j) total.

A free table of different methods of treatment of burns in clinical outcomes here (Table 78) compiled on the basis of analysis of all material of the chart of fundamental characteristics, makes it possible to draw certain conclusions relative to the frequency of use of various methods with treatment of burns during World War II and also in relation to treatment results by various methods.

Table 78. Dependence of clinical outcomes on the treatment method.

Клинические исходы (в процентах) (b) / Метод лечения (a)	(c) Выздоровление: полное (d)	с контрактурами (e)	с рубцами (f)	с трофическими язвами (g)	Итого (h)
(i) Закрытый	95,8	2,6	1,1	0,5	100,0
(j) Полуоткрытый	93,0	4,6	2,4	—	100,0
(k) Открытый	94,7	2,3	2,5	0,5	100,0
(l) Смешанный	82,6	11,9	2,9	2,6	100,0
(m) Всего	92,7	4,5	1,8	1,0	100,0

Key: (a) treatment method; (b) clinical outcomes (in percent); (c) recovery; (d) complet ; (e) with contractures; (f) with scars; (g) with trophic ulcers; (h) total; (i) closed; (j) semiopen; (k) open; (l) combined; (m) total.

The closed method of treatment of burns was used in wartime in half of all cases (50.8%); twice as rarely (26.6%) the open method was used; during treatment of all other burns a combined method was used which was undertaken sometimes fairly late in cases where the open method of treatment proved to be unsuccessful where it was necessary to evacuate victims to other treatment institutions.

Complete recovery most often was observed with the closed treatment method (95.8%) and the very low percent of complete recovery (82.6) was observed with a combined method of treatment.

The maximally high percent of contractures (11.9), scars (2.9) and trophic ulcers (2.6) which occurred with a combined method of treatment should be explained not by the treatment method but by the circumstance that the occurrence of these complications during treatment of burns by the open or semiopen method was the basic indication for changing the victims to the combined treatment method in which it was possible to use different mechanical and therapeutic measures facilitating elimination of the indicated results of the burns.

Finally, lethality with treatment of burns by the open method is twice as high as treatment by other methods. Once again it is emphasized that the open treatment method for burns must not be used in combat field conditions.

Extensive burns of the body must be diagnosed not only as local damage to the skin but also as a severe general illness accompanied in a number of cases by significant changes in different systems of the organism. Therefore, for completely valuable treatment of burns, organization of specialized hospitals for the army and front is necessary with appropriate equipment, laboratories and standard qualified physicians as well as medical orderlies.

Fourth degree classification of burns during World War II was fully justified.

The severity of a burn, its course and outcome is directly proportional to the dimensions of the injury and therefore it is necessary to introduce a unified method for determining the area of the burn in percentage of the total body surface.

Effective treatment of burns consists of primary first aid, measures to combat shock and toxemia, surgical treatment of the affected surface and subsequent treatment of the victim.

When giving first aid lubrication of the burn surface with vaseline or oils is absolutely contraindicated because this makes it difficult to conduct subsequent primary treatment of the burn.

With extensive burns of a victim in a state of shock one must deliver him to emergency at the regimental medical station where primary measures must be taken for combatting shock and the patient must be given the necessary rest. Only after improving the general condition should this category of victim be evacuated to the division medical station or the mobile surgical field hospital.

The burned sections in all burn victims, independent of the time of injury, dimensions and degree of the burn, in the absence of shock must be subjected to careful surgical treatment. With signs of shock this must be done only after shock has disappeared or has sharply subsided. Further treatment should be done only by a closed method using fat and oil (fish oil, etc.) bandaging.

The open method of treatment in combat-field conditions is not correct because it gave a maximum number of complications and fatal outcomes.

Treatment of third degree burns was done according to a unified system which had been established and excluded primary surgical treatment of wounds in treatment institutions of the military and army regions and secondary active closed treatment by plastic surgery on the skin at subsequent stages of sanitary evacuation.

The latter measure must be part of the system of daily work of surgeons in treatment institutions at army and front subordinate institutions where each wound after a burn from the moment it is received must be given special consideration from the point of view of the possibilities and time periods for secondary closing of it.

With third degree burns it is expedient in the first days of hospitalization to conduct excision of the burn sections with subsequent application of closing sutures or plastic surgery closing of the wound.

With extensive third degree burns, skin transplants are done after a sharp improvement in the general condition of the victim and removal of the necrotic section.

Early skin transplants for burns significantly reduce the time period for treatment and prevent the formation of scars, contractures and other complications.

Success in treatment of burns during World War II was achieved thanks to the use of specialized treatment of burns adopted into the general system in the medical service of the Soviet Army.

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