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EXPERIENCE OF TREATING WOUNDS OF BLOOD VESSELS AT FIELD AND ARM--ETC(U)
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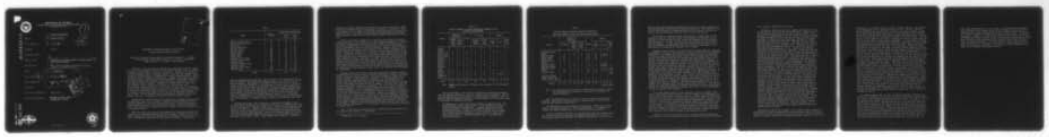

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EXPERIENCE OF TREATING WOUNDS OF BLOOD VESSELS AT FORCE AND ARMY DISTRICT LEVELS

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According to the experience of previous wars, especially the First Imperialist War, the incidence of wounds of blood vessels reached 2.5-5%, as reported by various authors (Bogoraz, Braytsev, and others). Because of the heavy use by modern fighting armies of automatic weapons, mines and hand greandes which produce an enormous number of fragments with a great penetrating effect, wounds of vessels are also frequently encountered. Although a large number of those receiving wounds of vessels remain on the battlefield, the wounded removed from the field of battle and receiving surgical treatment, nevertheless, include very many with vessel injuries. Diagnostics of these wounds is still not at the necessary level. According to the data of Force and Army level vessel wounds, unrecognized in life, are found in almost 9% of all autopsies. We cannot yet completely determine the frequency of these wounds, but according to preliminary observations they comprise 3%. During the Great Patriotic War we counted a total of 512 wounds of blood vessels; we personally operated on 203 of these. In the remaining cases operations were performed by other surgeons of our army. Information on these 512 cases is given in Table 1.

Recognition of vessel injury is not always easy, sometimes leading to serious diagnostic errors as, for example, unexpected severe bleeding in initial surgical treatment of the wound, erroneous opening of a pulsatile hematoma or false aneurysm, taken for an ordinary abscess. Finally, delayed detection of these wounds often leads to severe secondary bleeding, both at the hospital and on evacuation routes.

With any wound in the area of large vessels the surgeon must remember the possibility of simultaneous wounding of these vessels. Examination of an injured extremity must begin with examination of peripheral pulse; in case of absence or weakness in comparison with the healthy extremity, a simultaneous

Table 1

Vessel	Number of cases	Operation performed at	
		force level	army level
Common carotid artery	23	10	13
External carotid artery	6	2	4
Aortic arch	1	—	1
Subclavican artery	15	2	13
Axillary artery	18	4	14
Humeral artery	56	29	27
Radial artery	63	51	12
Ulnar artery	20	13	7
Palmar arch	26	14	12
External iliac artery	12	4	8
Internal iliac artery	10	5	5
Femoral artery	65	36	29
Inferior gluteal artery	4	—	4
Popliteal artery	44	14	30
Anterior tibial artery	81	26	55
Fibular artery	69	31	38
Total	513	241	272

wound of vessels must be suspected. The attention of the surgeon must also be given to extensive subcutaneous hemorrhages, though it is true they are not always encountered. The presence of diffuse swelling in the area of a wound, visible or palpated pulsation of this swelling, as well as noises heard over it (never forget to auscultate such swellings) leave no doubt about diagnosis of a wound of the vessel. All these signs are not always clearly expressed: some can be absent, but attentive, methodical examination of the wound and victim with mandatory palpation and auscultation of the area around the wound and study of peripheral pulse can prevent diagnostic errors. If a large blood vessel is wounded and it is not detected in the next few hours or, being detected, is not operated, — a pulsatile hematom begins to form and then false aneurysm.

Besides these basic signs, symptoms of circulatory disturbance are observed in distal sections of the extremity in the form of a change in the color of the skin (pallor or cyanosis), edema and in a number of cases gangrene, most often of the dry type. Gangrene is encountered most often with arteriovenous injuries. Pains in the distal section of the extremity are encountered most often with arterial false aneurysms. We have not observed changes in the heart in cases of arteriovenous pulsatile hematomas; with arteriovenous aneurysms they were found in 68% of cases. These changes were expressed in complaints of

shortness of breath, palpitations and pains in the area of the heart. Objectively an increase was noted in the bounds of the heart — in 31% of all cases to the right — and in a number of instances sounds were heard in the aorta and pulmonary artery. A symptom of slowing down was observed with arteriovenous false aneurysms in 95%, and with arteriovenous pulsatile hematomas in 1.5% of cases.

As soon as a wound is detected in a vessel the victim must be given the attention not only of the surgeon, but of all attendant personnel. If there is no external bleeding and an operation for some reason is decided against, before careful immobilization of the extremity, a tourniquet is placed under it which is tightened at the first signs of bleeding. Although times for surgical intervention are determined by the condition of the victim, we suggest that a vessel wound must be operated on at the stage of evacuation at which it is detected. Having data on injury to a large blood vessel, beginning with the MCB (Medical Battalion), initial surgical treatment of the wound must be performed in the operating room, a temporary sterile tourniquet must be applied and the vessel readied for tying or suturing. In tying a large artery, we feel it is mandatory to tie the like vein, which gives best results in the sense of preventing possible gangrene of distal sections of the extremity. With wounds in large blood vessels we use a vascular suture, whose role at force and army district levels is more significant than in the deep rear when we are dealing with an already-formed false aneurysm and have time to be concerned with development of collaterals.

Sapozhkov in his work, "Novyy sposob khirurgicheskogo lecheniya travmaticheskikh anevrizm"* (A new method of surgical treatment of traumatic aneurysms) writes: "We reject suturing an artery in pulsatile hematomas, taking into account the danger — in the presence of infection — of early breaking of the sutures with the subsequent threat of hemorrhage and the inevitability of severely narrowing the vessel with sutures. We also reject placing a ligature in the vessel above and below the site of damage." We cannot agree with this extremely categorical conclusion of Sapozhkov. Out of 107 cases of wounds in large blood vessels on which we operated using vascular suture, 67 involved pulsatile hematomas. We also transplanted veins to artery defects in the case of pulsatile hematomas and in observing the victims 2 to 4 weeks after surgery did not once note breaking of the stitches. Vessels are extremely resistant to infection and if a bullet wound is given correct surgical treatment, vascular suture applied in a technically correct manner, with strictest asepsis observed in the operation, the wound dusted with streptocide and not closed tightly, the fear of sutures breaking with subsequent bleeding and narrowing of the vessel is unfounded. Mandatory clamping of proximal and distal ends of the vessel is, in our opinion, indisputable. A verification of this is our personal data given in Tables 2 and 3.

Thus, in 107 cases of vascular suture, 3 amputations were performed and in 96 cases of tying vessels — 12 amputations.

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*"Khirurgiya," No. 5-6, 1943.

Table 2

CASES OF WOUNDS IN VESSELS SURGICALLY TREATED BY THE VASCULAR SUTURE METHOD

Vessel	Reason for operation		Total	Of these		Result		
	pulsatile hematoma	false aneurysm		arteriovenous injury	arterial injury	recovered	died	amputation
Common carotid artery	9	4	13	8	5	13	—	—
Aortic arch	1	—	1	—	1	—	1	—
Subclavical artery	6	5	11	5	6	6	5	—
Axillary artery	6	—	6	2	4	6	—	—
Humeral artery	4	17	21	11	10	21	—	—
External iliac artery	12	—	12	5	7	12	—	1
Femoral artery	15	17	32	20	12	30	2 (gas)	1
Popliteal artery	9	2	11	7	4	11	—	1
Total	62	45	107	58	49	99	8	3

Note. Amputations indicated in "Results" are included in the "Recovered" column.

As seen from Table 3, the majority of fatalities resulted from complications of anaerobic infection. We do not consider this a coincidence. All victims underwent surgery from 10 hours to 3 days after being wounded. Tying of vessels, severely hindering circulation in the extremity, in our opinion, aided in development of anaerobic infection.

We operated on a victim 3 days after wounding in connection with a pulsatile hematoma of the femoral artery. In the operation no signs of anaerobic infection were detected. A fragment was removed and the wound opened widely. In view of the extent of damage to the artery and the severe general condition of the victim as the result of bleeding occurring before the operation, we were limited to tying the femoral artery and vein. The wound remained open. Gas gangrene developed in 8 hours.

Table 3

CASES OF WOUNDS OF VESSELS SURGICALLY TREATED BY THE TYING METHOD AT FORCE AND ARMY DISTRICT LEVELS

Vessel	Reason for operation			Total	Result		
	bleeding	pulsatile hematoma	false aneurysm		recovered	died	amputation
External carotid artery	1	3	—	4	2	2	—
Humeral artery	2	6	8	16	12	4(gas)	1
Radial artery	14	—	—	14	14	—	—
Palmar arch	10	—	—	10	10	—	2
Internal iliac artery	8	—	—	8	7	1	—
Femoral artery	—	1	—	1	—	1(gas)	—
Popliteal artery	—	8	1	9	7	2(gas)	4
Anterior tibial artery	13	2	1	16	15	1(gas)	3 (gas)
Fibular artery	12	2	—	14	14	—	2 (gas)
Inferior gluteal artery (tying internal iliac artery)	2	2	—	4	4	—	—
Total	62	24	10	96	85	11 (3gas)	12 (5gas)

Note. Our abbreviation "gas" refers to complications of anaerobic infection occurring with operations in connection with bleeding and pulsatile hematoma.

Out of 12 amputations, in 5 cases the cause was rapidly developing gas gangrene. This is also verified by data of other surgeons of our army who used only the method of tying vessels.

As indicated above, they performed 310 operations. There were 24 fatal results, the cause of death in 7 cases was gas gangrene; of the 286 who recovered, 35 involved amputations, 11 in connection with gas gangrene.

In tying a vessel at the force or army district level, the extremity must not only be carefully immobilized, but 20,000-25,000 prophylactic units of anti-gangrene serum must absolutely be injected intravenously. Such a victim

must be placed under special observation for the next 3-5 days in order not to overlook incipient complications of anaerobic infections. With enforced evacuation of these wounded, a corresponding note about the need for observation must be made on the transfer district card or in the case history.

If the matter of when to operate in the case of a vessel wound is still debatable in the far rear where times are determined by development of collaterals, at force and army district levels the operation must be performed when the wound in the vessel is detected and the condition of the victim permits intervention. In rare cases, when the combat situation allowed, when a pulsatile hematoma had formed and there was no threat of hemorrhage, in the army district we postponed the operation for 2-3 weeks.

Vascular suture occupies a very modest place in recent articles concerning the treatment of wounds in blood vessels. Authors present their own individual observations. We suggest that vascular suture does not need to be defended. If tying of vessels is performed most often at force and army district levels because young surgeons have not yet mastered the suture method, then in the far rear vascular suture should be used much more widely than at present. In general, in selecting a method the surgeon must be guided by the condition of the victim and his own technical resources. Any method is good which each individual surgeon has completely mastered. But there are specific vessels, for example, the common carotid and popliteal arteries, where in the case of a wound vascular suture, from our point of view, is the operation of choice. Of 13 victims where we performed vascular suture on the common carotid artery, we did not lose a one, and of 10 victims operated on by other surgeons by the method of tying this vessel, 9 died. In 11 cases of vascular suture which we performed in the popliteal artery, gangrene of the shin occurred once, and of 24 cases of tying this vessel performed by other surgeons and 8 by us, in 19 cases the leg had to be amputated. Observation in our cases lasted at least 3 weeks, which makes it possible to evaluate results properly; even in the presence of an infected wound, vascular suture justified itself. With infected wounds, after vascular suturing we sprinkled the wound with white streptocide and put in a rubber drain which was removed in 3-4 days; in all cases immobilization is used after the operation.

If we feel vascular suture is the operation of choice in wounds of the common carotid and popliteal arteries, then with wounds of the subclavical artery in fresh cases we reject vascular suture. In these cases the operation is very severe and prolonged. The approach to proximal and distal sections of the vessel must be extensive and requires mandatory subperiosteal resection of the clavicle. With all care, operating in tissues soaked with blood among a mass of blood clots, it is difficult to avoid more or less traumatization of the humeral plexus. A prolonged and traumatic operation in victims, complicated by the wound and blood losses, often causes severe surgical shock from which they die. We lost 5 victims out of 6 and this forced us to reject use of vascular suture in fresh cases of wounds in the subclavical artery.

Suture of the aortic arch in the case of a bullet wound is, obviously, very rare; we found no description of such an operation in available literature.

Let us present a description of our case.

Patient S., female, 18 years old, hygiene instructor, entered the PPG (mobile field hospital) 25 December 1941. Wounded by a bullet in the front surface of the neck on 12 December 1941; after wounding lost consciousness; first aid (tying) at Medical Batallion, from which evacuated to first line PPG and then to second line PPG. Complaints of severe difficulty breathing. Examined 31 December with victim in semisitting position. Breathing was fast, with a whistling sound; the face, red edge of the lips and nails cyanotic; pulse 96 beats per minute, rhythmic, soft. Along the back edge of the right sternocleidomastoid muscle, 2 cm above the clavicle, a blind bullet wound measuring 1 x 1 cm. Wound filled with limp granulations with slight purulent discharge. On the front and side surface of the neck (more on the right) a large pulsating swelling, its edges: the upper reaching to the hyoid bone, the lower disappearing in the jugular notch, side — along the back edge of the left sternocleidomastoid muscle, middle — along the front edge of the left sternocleidomastoid muscle. Auscultation over the swelling revealed sharp systolic noise. During examination the condition of the victim worsened sharply, asphyxia intensified. It was impossible to perform a tracheotomy as the cut would pass through the pulsatile hematoma. That day we performed an emergency operation. Under local anesthesia we made a cut over the right clavicle. Subperivascular resection of the clavicle revealed the subclavicular artery and vein. By gradual preparation along subclavicular vessels we were able to reach the initial section of the common carotid artery, and then along it to its bifurcation. Nowhere did we find a wound in the vessels. At that time complete asphyxiation occurred. A cut was made along the midline of the neck over the swelling for the purpose of a tracheotomy. After opening the platysma we found a large number of blood clots and breathing reappeared. At this moment a large stream of blood gushed from behind the sternum. A finger inserted behind the sternum felt an opening approximately 0.5 x 0.5 cm and strong pulsation. Bleeding stopped. Without removing the finger, the manubrium was removed with a cutting pliers and then it was found that the wound was in the aortic arch. Four sutures were put in the wound above the finger and gradually tightened as the finger was removed. At the same time a blood transfusion was given. As the surgical wound was being sutured, breathing stopped and was resumed after 5-8 minutes of artificial respiration. Pulse fell sharply. 800 cm^2 of blood group O(I) was transfused. Blood transfusion was continued, but no pulse was felt and 30 minutes after the end of the operation death occurred.

Concerning the method and technique of the vascular suture operation in vessel wounds, we want to emphasize the great importance which we attach to preparation of suturing material; the latter must have no traces of alcohol or traces of sublimate; after usual treatment with ether, silk No. 0 or No. 1 is

sterilized in an autoclave and then stored in sterile vaseline. The approach to the damage site of the vessel must begin far away. We first reveal the vessel proximally and then distally to the site of damage, carefully prepare it and place temporary gauze bands under the extracted ends; then we prepare the vessel in the direction of the site of damage, gradually moving the gauze bands. We must spare all collaterals branching off from the vessel. Approaching the site of damage in the vessel, we tighten the temporary gauze bands and thus reveal the site of damage almost bloodlessly. In fresh cases in extremities we operate under the tourniquet, immediately revealing the site of damage, which significantly shortens the time of the operation. With a simultaneous wounding of artery and vein the chance of arteriovenous aneurysm or arteriovenous defect is especially increased. The arteriovenous anastomosis must absolutely be circumvented on all sides and the vessels carefully separated from each other. Only after making certain of their complete separation is a suture or ligature put into each vessel individually. With small wounds in the wall we put in transverse wall sutures. If the defect of the vessel is greater than its semicircumference, we resection the damaged part and stitch the vessel end to end. Often middle and inner coats are slightly contracted and, as a result, there is a certain excess of adventitia which is stretched behind the thread or rolled into the vessel. This makes the work much more difficult and affects the quality of the suture. Therefore, we always stretch the adventitia slightly with eye forceps and cut off the excess with a scissors. After this we begin to suture the vessel. We use Cappel or Jensen-Cappel sutures. At the time of suturing to avoid dessication the ends of the vessel must be moistened with warm physiological solution or a 4% solution of sodium citrate. Upon finishing the suturing first the distal end is freed and then the proximal end of the vessel. Insignificant bleeding from the line of sutures is stopped by pressing the bleeding place with a gauze sponge. Significant bleeding requires additional stitches, put in after clamping the vessel above and below the injury. Of late we have put in widely spaced sutures and have surrounded the line of sutures with a sleeve prepared from an adjacent vein. With a significant defect in the artery, when the ends cannot be brought together, we transplant a piece of vein into the artery defect. We usually use the like vein. Transplantation of a vein in cases of extensive injuries of the common carotid and popliteal arteries is, in our opinion, the operation of choice.

As studies conducted in the clinic of Bogoraz (Kartashov, Khenkin) have shown, the transplanted vein can cope completely with arterial pressure and in the course of time significant changes occur in its wall. The wall thickens, its muscular layer becomes stronger and the wall of the vein begins to resemble that of an artery. The operation itself is not much more complicated than the usual suturing of the ends of a vessel and differs from it only in that not one circular suture is needed, but two, as both proximal and distal ends of the vein must be sewn. We sew the proximal end of the transplantate to the distal end of the injured vessel and the distal end to the proximal in order to avoid any possible intereference of the blood flow by venous valves. The venous transplantate is taken 3-4 cm longer than the existing defect in the artery as after resection the vein contracts and in sewing it we must avoid stretching the sutures as the thin venous wall is easily broken. We

used venous transplantates 6 to 10 cm long. We performed such transplantation with wounds of the common carotid artery 5 times, with wounds of the femoral artery 7 times and with wounds of the popliteal artery 4 times; all 16 of these transplants concluded with recovery of the victims. In surgical treatment of a wound in a vessel we must also take into account that if 2 or more weeks have passed since the artery, we must never forget about the nerve, which is often in scars surrounding the vessel and often causes a number of later neurological disorders. We always carefully extract the nerve from scars and then wrap it with muscle. Observance of these technical requirements in operations in connection with a wound in a vessel have made it possible for us to achieve satisfactory results.