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IN THE PERIOD OF RADIATION SICKNESS  
(EXPERIMENTAL INVESTIGATION)

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INTRATRACHEAL ETHER ANESTHESIA IN OPERATIONS ON THE LUNGS  
IN THE PERIOD OF RADIATION SICKNESS

(EXPERIMENTAL INVESTIGATION)

Following is the translation of an article by Candidate of Medical Sciences A. D. Yarushevich entitled "Intratrakheal'nyy Efirnyy Narkoz pri Operatsiyakh na Legkikh v Period Luchevooy Bolezni (Eksperimental'noye Issledovaniye" (English version above) in Vestnik khirurgii imeni I. I. Grekova (Herald of Surgery imeni I. I. Grekova), Vol. LXXXIV, No. 5, 1960, pages 87-92.

From the Surgical Clinic for the Advanced Training of Physicians (Chief -- Professor P. A. Kupriyanov) of the Military-Medical Order of Lenin Academy imeni S. M. Kirov.

A considerable quantity of works has been devoted in the last few years to the problem of radiation injuries, both in the Soviet Union, and also abroad. These works include many investigations pertaining directly to the problems of practical surgery. However, little attention has been paid to the question of anesthesia during operations, the necessity for which can arise in individuals injured by radiant energy. The authors, in effectuating the investigations on irradiated animals, in their conclusions rarely give an evaluation of the selected method of anesthesia in connection with the course and results of their experiments and observations. We have not found any works in the literature pertaining to the evaluation of intratracheal ether anesthesia at the time of radiation sickness. Nevertheless, this anesthesia has found general recognition in the surgery of the organs of the chest and thanks to its undoubted advantages is being ever more widely introduced into other fields of surgery. There is no basis for doubting that intratracheal gaseous anesthesia is also finding application in the presence of operative interventions after radiation injuries.

With the object of studying the influence of this form of anesthesia on the course of radiation disease we have conducted observations on 40 experimental and 14 control dogs (Tables 1 and 2).

Table 1

Distribution of observations on the periods of anesthesia after irradiation, the severity of radiation sickness, and the results

Number of Experiments	Period after irradiations (in days)	Degree of severity of radiation sickness		
		latent period	initial degree	pronounced radiation sickness
14	1 - 3	12	2	-
8	4 - 7	1	6	1
15	8 -14	-	2	13
3	15 and greater	-	-	3
Total 40	--	13	10	17

[Continued next page]

The experimental animals were subjected to systemic irradiation with X-rays at a total dose power of from 350 to 500 r. The regime of irradiation was as follows: voltage 185 kV and 10 mA with a filter of 0.5 cm Cu. The power of the dose on the surface of the body fluctuated depending on the distance to the anode from 9,1 to 12 r per minute.

A gunshot wound of the chest was applied to 18 animals on the next day after irradiation. At various periods after the wounding thoracotomy was conducted under intratracheal ether anesthesia with inspection of the thoracic cavity and one or another intervention -- excision of the wound, resection of the lung, lobectomy.

At various period after irradiation and with a varying degree of severity of the radiation sickness, the other 22 dogs were subjected under this same anesthesia to the same operations on the lungs without preliminary wounding. All the animals were observed for two months.

The 14 control dogs were subjected to operations on the lungs under intratracheal ether anesthesia without pre-

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Recovery	R e s u l t s		
	Death		Total
	Directly after anesthesia	At remote periods after radiation sickness	
11	-	3	3
5	2	1	3
11	2	2	4
1	-	2	2
28	4	8	12

liminary irradiation.

Twelve of the 40 experimental animals perished, of which four perished in the next few hours after anesthesia and eight at remote periods from the radiation sickness. The causes of death will be considered in the discussion of the individual modifications of the anesthesia. According to the literature data (P. D. Gorizontov, Cronkite, Trum, and others), when dogs are irradiated with a total dose of 350-400 r without any interventions, the mortality amounts to 50% in the first 30 days.

In the basic series of observations (21 animals) 20 minutes before the beginning of the anesthesia the dogs received subcutaneously one ml of one per cent atropine and morphine in various dosages: in 13 experiments -- at a ratio of 0.01 morphine per one kg of weight, in eight -- in a dose of one ml of the one per cent solution. Neither dose of morphine removed the motor excitation of the animals when they were placed on the operation table and at the time of the mask supplying of ether before the onset of sleep, but

Table 2

Distribution of experiments by method of anesthesia

Premedication	Introductory anesthesia	Supplementary preparations	Number of experiments
Morphine / atropine	None (mask supply of ether)	--	21
The same	Thiopental-sodium or pentothal	--	5
The same / aminazine	The same	--	5
Morphine / atropine	The same	Ditilin	5
The same	The same	Hexonium and pentamine	4
Total			40

/Continued next page/

it was considerably more pronounced in dogs who had received a small dose of the narcotic. Awakening was as a rule accompanied by motor excitation. The predominant majority of cases of anesthesia and interventions were conducted in the latent period of radiation sickness (13 of 21), but some of the animals (eight) were already in a state of pronounced initial and severe manifestations of the sickness. Not a single animal perished directly after the anesthesia.

It should be noted that the animals which before the operation had received only one ml of one per cent morphine

Table 2 continued from page 47

Degree of radiation sickness			Recovery	Death	
latent period	initial degree of the disease	pronounced radiation sickness		Directly after anesthesia	at remote periods
13	4	4	17	--	4
--	2	3	3	1	1
--	1	4	3	--	2
--	2	3	3	2	--
--	1	3	2	1	1
13	10	17	28	4	8

solution, became sick with a more severe form of radiation sickness and specifically, four of these dogs perished on the 12th, 14th, 22nd (2 dogs) days after irradiation (the 9th, 13th, 15th, and 19th days after anesthesia). This observation should be noted, since the severity of the sickness and the high mortality (four of eight) may be associated with great motor excitation of them before anesthesia in comparison with dogs which had received massive doses of morphine. There are indications in the literature to the effect that physical loading accelerates and increases the

frequency of the perishing of irradiated animals (Brok [Brock], Dauli [Dowley] and Dyubua [Dubois] [cited] according to B. M. Khromov).

To diminish the motor excitation an introductory narcosis by the intravenous administration of a 2% solution of thiopental-sodium or pentothal in a dosage of from 0.03 to 0.06 g of substance per one kg of weight of the animal was used on five dogs in the presence of the usual premedication with morphine and atropine. Two dogs perished. They had been subjected to anesthesia and operation 10 days after the irradiation. One was found in a state of severe radiation disease with leukopenia -- 200 (2% of the initial quantity of leukocytes), dysentery, considerable emaciation. The dog satisfactorily underwent anesthesia one hour 10 minutes in duration and an operation of resection of a lobe of the lung, the respiration was restored directly after closing the pneumothorax, the animal woke up after 30 minutes. However, after 12 hours death ensued in the presence of phenomena of increasing cardiac weakness. The other dog was in a state of pronounced radiation sickness with a leukopenia of 40 percent of the initial quantity. The anesthesia and the operation of resection of a lobe of the lung lasted one hour 40 minutes. The respiration was restored directly after the termination of the operation. The animal woke up without motor excitation after one hour. Severe radiation sickness subsequently developed in the dog, from which it died on the sixth day after operation and on the 15th day after irradiation. The three remaining dogs operated on the third, fourth, and 15th days after irradiation, subsequently underwent a severe degree of radiation sickness, but recovered.

This series of experiments showed that introductory narcosis with thiopental-sodium and pentothal is endured by the dogs both in the latent stage, and also in the pronounced stage of radiation sickness without any complications in the immediate postoperative period. The death of one dog in the first day after anesthesia was associated with the severity of the state of the animal, in whom intervention, evidently, was in general contraindicated. The mortality from radiation sickness in the other experiments did not exceed that usual for dogs after irradiation with the doses which we had adopted.

Ganglion blocking and neuroplegic agents have found wide use among modern methods of anesthesia and, in particular, for potentiating narcosis. With the object of familiarizing ourselves with their action in the presence of anesthesia at the time of radiation sickness, in five experiments in addition to administration before the beginning of the anesthesia of one ml of a one percent solution of morphine

and a one ml solution of atropine 1:1,000, the dogs received intramuscularly one ml of 2% aminazine solution. This preparation according to clinical and experimental observations exerts a pronounced sedative and a peculiar soporific action and averts the reaction of the organs to stimulation both of the preganglionic, and also of the postganglionic sympathetic fibers (Yu. N. Shanin). The animals were in a state of pronounced radiation sickness on the 8th, 9th (three dogs) and 17th days after irradiation. The introductory anesthesia was effectuated by the intravenous administration of a solution of thiopental-sodium or pentothal. In one case a brief stoppage of the respiration occurred. The anesthesia lasted from one hour 30 minutes to 2 hours 30 minutes.

In all the experiments the anesthesia proceeded without complications. Motor excitation was absent in the initial period of anesthesia, the blood pressure remained stable. After closing the pneumothorax, independent respiration was immediately restored in all the observations and the animals woke up calmly.

The two dogs which had been subjected to operation on the 8th and 17th day after irradiation in a state of pronounced radiation sickness, perished from it four and 10 days after the operation. The three other dogs underwent radiation sickness in the postoperative period and survived. Not a single animal perished directly after the anesthesia.

With the object of diminishing the consumption of ether, of facilitating the intubation and of conducting controlled respiration in the clinic during intratracheal ether anesthesia, the muscle relaxants (curare-like preparations) are finding ever greater use. These preparations, which shorten to a minimum the time of administration in anesthesia, which facilitate the diminution of the motor excitation and which thanks to making intubation more easy, remove the danger of asphyxia in the initial period of anesthesia, have seemed to us very appropriate in anesthesia at the time of radiation sickness.

We have dwelt on ditilin as a preparation which has been sufficiently tested and approved on a large amount of clinical material and which has entered into the scheme of anesthesia which is being used during various operations. This preparation advantageously differentiated from other relaxants by the unprolonged effect of curarization, by the absence of a cumulative action and by rapid decomposition in the organism into substances which are harmless for it (M. S. Grigor'yev and M.N. Anichkov).

Observations on the course of anesthesia with the use of ditilin were conducted on five dogs which had been operated on 3, 4, 7 (two dogs) and 9 days after irradiation with



initial and pronounced symptoms of radiation sickness (leukopenia from 50% to 30% of the initial, rejection of food, diarrhea without admixture of blood in certain animals). Thiopental-sodium intravenously was used as introductory narcosis. Independent respiration was retained in all cases after the administration of thiopental-sodium. A 2% solution of ditilin in a quantity of from 0.02 to 0.03 g of the substance in the presence of a weight of the animals of from 7.5 to 9.5 kg was administered intravenously to a dog which had fallen asleep. This dose induced relaxation of the muscles after one to two minutes which substantially facilitated intubation. In two cases stoppage of respiration ensued. Anesthesia from one hour 10 minutes to two hours in duration was subsequently conducted.

The combination of introductory narcosis with thiopental-sodium with the use of ditilin before intubation with intratracheal ether-oxygen anesthesia reduced to a minimum the motor excitation at the beginning of the anesthesia and provided an even sleep through the entire operation. No acute excitation was noted in the presence of waking up. However, in three cases the respiration was not restored after closing the pneumothorax and it was necessary to resort to artificial respiration for the duration of one to two hours until it was restored. In one of these cases the respiration was not restored, and death of the animal followed after two hours. One dog perished directly after the operation due to hemorrhage. The three remaining animals underwent radiation sickness and recovered.

Although the quantity of observations is insufficient for any definite conclusion they do, however, provide a basis for suspecting in dogs which were in a state of radiation sickness, the presence of a raised sensitivity to muscle relaxants, in particular, to ditilin, the action of which is possibly longer than usual under these conditions.

In taking this into account one can assume that the use of muscle relaxants (ditilin) is not reflected in the course of radiation sickness, but requires a certain carefulness. The dosage of ditilin should be diminished to the strictly necessary minimum and the possibility of retarding the restoration of independent respiration after the termination of the anesthesia should be taken into account.

Practical interest is presented by the possibility of diminishing the blood loss by the use at the time of operations in radiation sickness of artificial hypotension which at the present time is considered indicated in the presence of various surgical operations which are accompanied by great blood losses, and which is effectuated by the use of ganglion blocking agents with a pronounced hypotensive effect

(N. A. Meshcheryakov).

The action of the Soviet hypotensive preparations -- hexonium and pentamin -- was tested on four dogs which were in the state of initial and pronounced signs of radiation sickness on the 9th, 10th, 12th, and 16th days after irradiation. A one per cent solution of hexonium or of pentamine was administered intravenously before the beginning of the operation in a quantity of 10-15 mg and repeatedly during the time of the operation in the same doses; the total quantity of substance administered amounted to 40 mg of hexonium and 60-70 mg of pentamine.

In one experiment on a dog five kg in weight which was in a state of severe radiation sickness (leukopenia, emaciation, diarrhea) 12 days after the irradiation, in the presence of a steady blood pressure, the administration of 60 mg of pentamine induced a considerable rise in the blood pressure which lasted three minutes. Repeated administrations of 20 and 40 mg of hexonium were not reflected in any way on the level of blood pressure. Although independent respiration was restored directly after the closing of the pneumothorax, the animal did not, however, wake up, and after four hours death ensued in the presence of the phenomena of a progressing fall in the cardiac activity.

In three dogs which were in a state of pronounced radiation sickness on the 9th, 10th, and 16th days after irradiation, the first administration of hexonium in a quantity of 10 mg and of pentamine up to 60 mg induced only a brief two to three minute pressor reaction. Repeated administrations of hexonium in doses of 20 and 40 mg were not reflected in any way in the level of the blood pressure. The animals underwent anesthesia and the operation without peculiarities. One dog perished from radiation sickness after 16 days; two recovered.

Thus, in not a single of the experiments conducted was a pronounced hypotensive effect obtained from the use of hexonium or pentamine. The hypotensive effect was either insignificant, or distorted, or was entirely absent.

### Conclusions

1. Intratracheal either anesthesia in an experiment on dogs, used in the presence of traumatic operations on the lungs in the latent, initial, and pronounced periods of radiation sickness, is not reflected unfavorably in its course and does not raise the mortality of the irradiated animals. The elimination of motor excitation during the entrance into narcosis improves the outcome of the operative intervention.

2. Morphine, atropine, and aminazine can be used with the object of anesthesia premedication without a negative influence on the course of the radiation sickness.

3. Introductory narcosis by the intravenous administration of thiopental-sodium or of pentothal also is not reflected unfavorably in the postoperative course of the irradiated animals.

4. The use of ditilin with the object of muscle relaxation in these animals requires carefulness, since they apparently possess a raised sensitivity to it. No hypotensive effect of hexonium and pentamine was obtained on animals sick with radiation sickness.

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