

# CHANGES IN THE ADRENALIN CONTENT OF THE BLOOD AND OF THE AQUEOUS HUMOR OF THE EYE OF THE RABBIT AFTER IRRADIATION

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The reaction of the endocrine glands to the action of ionizing radiation plays an essential role in the development of radiation sickness. Several features, beginning with changes in the blood picture and ending in trophic disturbances of complex origin, are explained by the action of ionizing radiation on the glands of internal secretion. Accordingly it is profitable to study these endocrine mechanisms [2, 3]. According to the ideas of modern radiobiology, the participation of the glands of internal secretion in these reactions is determined by nervous influences on the glands and also by interaction between them. Great importance in these interactions is attached to the reaction of the medullary substance of the adrenals [4]. Some time ago the opinion was expressed that under the influence of ionizing radiation the secretion of adrenalin is intensified [8]. On the other hand great importance must be attached to the increased adrenalin content of the blood as a factor stimulating the reticular substance and exerting an action on all divisions of the central nervous system, including the vegetative centers of the brain stem [5]. It is for this reason that in studying the reaction of the endocrine glands on the action of ionizing radiation, investigation of the adrenalin content of the blood is of particular interest.

## EXPERIMENTAL METHOD

The experiments were carried out on male rabbits weighing from 2.5 to 3.5 kg. As an index of the changes in the functional state of the medullary layer of the adrenals we made use of changes in the content of its hormone in the aqueous humor from the anterior chamber of the eye and in the blood. The eye is a convenient object for investigation since chemically active substances enter the aqueous humor via the ciliary processes of the uveal tract. Aqueous humor can be obtained by puncture of the anterior chamber of the eye. Aqueous humor was taken from one eye after 3-5 day intervals in order to avoid damage to the cornea. Before puncture the eye was moistened with a 2% tetracaine solution, and after puncture with a 30% solution of albucid. For quantitative estimation of the adrenalin content a polarographic method was used, as suggested by Henderson and Freedberg [6] for the determination of crystalline adrenaline and modified by us as described in detail in a previous communication.

The animals were irradiated with x-rays in a dose of 800 r under the following conditions: current strength 20 ma, tension 180 kv, focal distance 60 cm, dosage rate from 30.8-33.5 r/min, filter 0.5 mm Cu and 1 mm Al.

Experiments were carried out on the animals at 1-2 minutes, 1 hour and 6 hours after irradiation, and daily until the death of the animal. Altogether 30 rabbits were used in the work. In the rabbits which acted as controls, samples for testing for adrenalin were taken over a period of 10-15 days before irradiation. These samples were the controls. Variations in the adrenalin content in the same animal were insignificant, within limits of 0.01 to 0.035  $\gamma$  per 1 ml of blood, and from 1.1 to 0.5  $\gamma$  per 1 ml of blood in the aqueous humor.

## EXPERIMENTAL RESULTS

In this paper we took the mean values of the quantitative estimations of the content of adrenalin in the same rabbit obtained in 10-15 experiments. It was found that the mean value of the adrenalin content per 1 ml of aqueous humor was 0.82  $\gamma$ , and per 1 ml of blood - 0.020  $\gamma$ .

The numerical findings of the adrenalin content of the aqueous humor are given in Table 1.

After irradiation phasic changes were observed in the adrenalin content (Fig. 1).

From 1-2 minutes after irradiation a clearly expressed diminution in the adrenalin content of the aqueous humor was observed, and in the blood also (to 0.001  $\gamma$  in 1 ml of aqueous humor and to 0.001  $\gamma$  in 1 ml of blood, or even lower). In the course of 5-10 minutes the adrenalin content increased slightly — to 1  $\gamma$  per 1 ml of aqueous humor and to 0.2  $\gamma$  per 1 ml of blood. In the course of the first hour after irradiation the adrenalin content of the aqueous humor and the blood was observed to be maximum, reaching 15-20  $\gamma$  per 1 ml of aqueous humor and 25-30  $\gamma$  per 1 ml of blood. At the end of the first 24 hours the adrenalin content fell almost to the normal value (0.5-0.75  $\gamma$  per 1 ml of aqueous humor and 0.01-0.025  $\gamma$  per 1 ml of blood).

TABLE 1

Adrenalin Content of the Aqueous Humor and the Blood of Rabbits

Rabbit No.	Adrenalin content in $\gamma$	
	in 1 ml of blood	in 1 ml of aqueous humor
1	0.010	0.5
2	0.015	0.8
3	0.025	1.1
4	0.020	1.2
5	0.015	0.6
6	0.035	0.7

The second wave of increase in the adrenalin content was observed at later stages, preceding the death of the animal (to 20-25  $\gamma$  per 1 ml of aqueous humor and to 5-5.5  $\gamma$  per 1 ml of blood) [1, 2].

The numerical findings of the changes in the adrenalin content in the aqueous humor and in the blood during total irradiation are shown in Table 2.

By way of illustration we quote the results of experiments on rabbit No. 4.

The rabbit was kept under observation for 10 days before irradiation, during which time samples of blood and aqueous humor were taken 4 times for adrenalin estimation.

On May 31, 0.4 ml of aqueous humor was taken from the right eye, and the adrenalin content per 1 ml was found to be 1.275  $\gamma$ , and in the blood — 0.05  $\gamma$  per 1 ml.

On June 3, 0.3 ml of aqueous humor was taken from the right eye, and 1 ml was found to contain 1.05  $\gamma$  of adrenalin — and 1 ml of blood 0.0375  $\gamma$ .

Blood could not be taken from the marginal vein of the ear because of very strong spasm of the vessels.

On June 6, 0.3 ml of aqueous humor was taken from the right eye, and 1 ml was found to contain 0.7  $\gamma$ , and 1 ml of blood — 0.015  $\gamma$  of adrenalin.

On June 9, 1 ml of aqueous humor was found to contain 0.8  $\gamma$  of adrenalin, and 1 ml of blood — 0.02  $\gamma$ .

On the basis of the results obtained the mean value of the adrenalin content of 1 ml of aqueous humor and of blood was estimated. For the blood this figure was 0.0306  $\gamma$ , and for the aqueous humor — 0.958  $\gamma$ . These slightly raised values (in relation to normal) can be accounted for by seasonal variations in the adrenalin content, which reaches a maximum level in June-July [7].

On June 12, the rabbit was given total irradiation with x-rays in a dose of 800 r under the following conditions: current strength 20 mA, tension 800 kv, focal distance 60 cm, dosage rate 33.5 r/min, filter 0.5 mm Cu and 1 mm Al.

From 4-5 minutes after irradiation, 1 ml of blood was found to contain less than 0.01  $\gamma$  of adrenalin (or 50% of normal); at first it was impossible to puncture the eye since the rabbit was very restless. After 10 minutes the eye could be punctured, and 1 ml of aqueous humor was found to contain 12.3  $\gamma$  of adrenalin, which amounts to 1280% of the normal value. A second puncture was carried out one hour after irradiation and 1 ml of aqueous humor was found to contain 42.83  $\gamma$  of adrenalin (or 4471%).

On the first day, the adrenalin content of 1 ml of blood was 0.02  $\gamma$ , i. e. within normal limits, but on the second day this had decreased to less than 0.02  $\gamma$  of adrenalin, i. e. slightly below the normal level. On the 3rd day 1 ml of blood contained 0.08  $\gamma$  of adrenalin and 1 ml of aqueous humor — 0.8  $\gamma$ . On the 7th day after irradiation 1 ml of aqueous humor contained 7.65  $\gamma$  of adrenalin, and 1 ml of blood — 0.15  $\gamma$  (or 798% and 5000%).

TABLE 2

Changes in the Adrenalin Content of the Aqueous Humor and the Blood of Rabbits during Total Irradiation

Rabbit no.	Days after irradiation	Adrenalin content				Time after irradiation	in the aqueous humor of the eye		Adrenalin content in the blood	
		$\gamma$	%	$\gamma$	%		$\gamma$	%	$\gamma$	%
1	Normal	1.08	100	0.05	—	Normal	0.8	—	0.02	—
		—	—	0.0375	—		0.5	—	0.02	—
		—	—	0.0675	—		Mean 0.65	100	Mean 0.02	100
		—	—	0.02	—		12.45	1917	—	—
2	10 min.	61.725	5715.2	Mean 0.038	100	10 min	30.15	4638	—	—
				21.65	57000	6 hrs	0.65	100	—	—
						3- days	0.70	108	—	—
						5-e »	40.65	6269	—	—
						9-e »			Died on the 9th day	
	Normal	1.0	—	0.05	—	Normal	—	—	0.01	—
		0.5	—	0.02	—		—	—	0.02	—
		0.8	—	0.02	—		—	—	0.01	—
		Mean 0.75	100	Mean 0.03	100				Mean 0.13	100
	4-5 min	0.01	1.334	—	—	5 min	—	—	0.001	7.7
	1-e days	20.00	2666	0.02	66.6	7 hrs	—	—	0.1	100
	2-e »	—	—	20.001	66666.6	3- days	—	—	0.15	100
	3-e »	—	—	0.08	266.6	5-e »	—	—	0.20	153
	5-e »	0.20	26.6	0.002	6.6	7-e »	—	—	10.2	7846
	7-e »	10.00	1334	4.75	15833	2 hrs before death	—	—		
	Died on the 8th day									

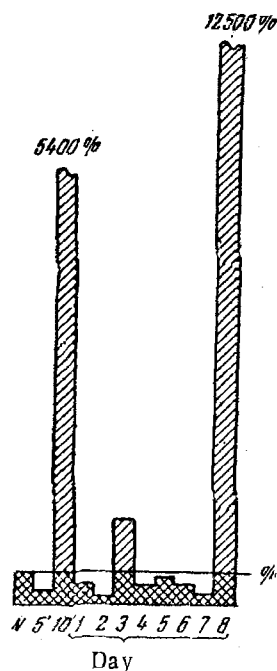


Fig. 1. Changes in the content of adrenalin in the blood of the rabbit (expressed as percentages) after total irradiation with x-rays.

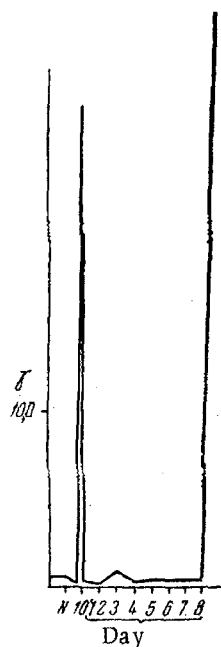


Fig. 2. Changes in the adrenalin content of the aqueous humor of the eye of the rabbit after total irradiation with x-rays.

The rabbit died on the 9th day after irradiation. Two hours before death 1 ml of aqueous humor of the rabbit contained 10.153  $\gamma$  of adrenalin (or 1059% of normal) and 1 ml of blood — 4.75  $\gamma$  of adrenalin (or 15.833% of normal).

Fig. 2 shows the variation in the adrenalin content of the aqueous humor of the rabbit after irradiation. From Fig. 2 it can be seen that after total irradiation with a dose of 800 r, clear and regular changes occur in the adrenalin content, which are phasic in character.

The following conclusions may be drawn from these experimental findings. The action of ionizing radiation on the animal is phasic in character: phase 1 — reduction in the adrenalin content of the aqueous humor of the eye and the blood (1st-7th minute after irradiation); phase 2 — increased adrenalin content in the aqueous humor and the blood (from the 8th minute to the end of the first 24 hours); phase 3 — temporary return to normal of the adrenalin content of the aqueous humor and the blood (second day and thereafter); phase 4 — increased content of adrenalin in the aqueous humor and the blood, preceding the death of the animal (from the second day before death and a sharp increase on the day of death).

## SUMMARY

The change of the content of adrenalin was studied in the blood as well as in the aqueous humor of the rabbit's eye after total irradiation with the dose of 800 r. The polarographic method was used for the quantitative determination of the adrenalin content. After total irradiation of the rabbit distinct and regular changes of phasic character take place in the content of adrenalin in the blood and in the aqueous humor of the eye.

## LITERATURE CITED

- [1] G. V. Bavro, *Med. Radiol.* 2, 2, 31-41 (1957).
- [2] A. V. Lebedinskii, *Med. Radiol.* 2, 1, 35-41 (1957).
- [3] L. V. Orlova and V. M. Rodionov, *Med. Radiol.* 2, 2, 54-59 (1957).
- [4] C. T. Anderson, H. Blaschko and I. H. Burn, *Brit. J. Pharmacol.* v. 6, 342-350 (1951).
- [5] Z. M. Bacq and P. Alexander, *Fundamentals of Radiobiology*, London (1955).
- [6] J. Henderson and A. S. Freedberg, *Analyt. Chem.* v. 27, 1064-1066 (1955).
- [7] R. A. Montagu, *Nature* v. 178, No. 4530, 417-418 (1956).
- [8] E. Zunz and J. La Barre, *Compt. rend. Soc. de Biol.* v. 96, 126-128 (1927).