EFFECT OF DOSE OF IONIZING RADIATION (γ-RAYS) ON ASCORBIC ACID CONCENTRATION IN RADIOSENSITIVE TISSUES

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Vitamins are essential for the synthetic processes of the body. Numerous experiments have demonstrated that ascorbic acid (AA) plays a part in anabolic reactions of protein metabolism, in the formation of collagen, chondromucoid, osteoblasts and odontoblasts, and of enzymes, in mitotic processes, in nucleic acid synthesis, and so on [2-5, 8-11].

Unlike other vitamins, AA is synthesized in the tissues of most animals. Both in the body as a whole and selectively in the organs and tissues, AA synthesis is under the control of regulatory mechanisms: the quantity of AA synthesized in a given tissue is that necessary to the body at a given moment in accordance with the demands presented by the conditions of interaction with the external environment [6].

In this investigation the course of AA synthesis in radiosensitive tissues was studied in animals normally synthesizing AA and irradiated with various doses of γ-rays.

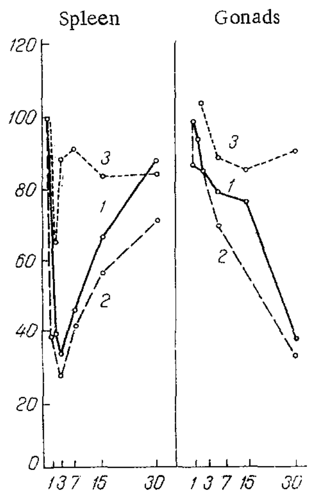

Fig. 1. Action of γ-rays in a dose of 600 R. 1) Weight of organ; 2) AA content in whole organ; 3) AA concentration in tissue. Here and in Figs. 2 and 3: AA concentration without irradiation 100%. Abscissa) days after irradiation, ordinate) percentages of unirradiated control.

EXPERIMENTAL METHOD

Whole-body irradiation from a GUBÉ-800 source was given in a single dose to 250 male albino rats weighing 180-200 g. Each group of 50 animals was irradiated with the following doses of γ-rays: 25, 50, 250, 500, and 600 R. Ten rats from each group were decapitated at the following times: 1, 3, 7, 15, and 30 days after irradiation. The AA concentration was immediately determined in the spleen, bone marrow, and testes by a method described previously by the authors [1]. The spleen and testes also were weighed. Controls were unirradiated animals. The numerical results were analyzed by statistical methods.

EXPERIMENTAL RESULTS

Spleen. The study of the action of γ-rays in a dose of 600 R on the spleen in the course of development of radiation sickness showed that the weight of the organ was reduced by 50% compared with the control on the day after irradiation. On the 3rd day the weight of the spleen had fallen by 69%, and one week after irradiation it was still only 45% of its initial weight. A small increase in weight was observed in the second week, but even by the end of one month after irradiation its weight was only 81% of the control value.

The decrease in the total AA content in the spleen was even more marked than the decrease in its weight. On the day after irradiation only 38% of the AA remained in the spleen, and this fell to 28% by the 3rd day. After one week a small increase in its content was observed, and this continued until the end of observation (one month after irradiation). Even at this time, however, the total AA content in the spleen was only 69% of the control value.

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TABLE 1. Action of γ-Rays in a Dose of 25 R

Day of observation	Weight of organ (in g)		AA content (in mg)		AA concentration (in mg%)	
	$M \pm m$	t	$M \pm m$	t	$M \pm m$	t
			Spleen			
Control	1,2198±0,1 (100)	—	0,606±0,05 (100)	—	47,5±1,0 (100)	—
3	0,8413±0,08 (68,9)	4,4	0,436±0,03 (71,9)	3,0	52,9±1,6 (111,4)	3,0
7	1,1180±0,09 (91,7)	1,1	0,480±0,03 (79,2)	2,4	43,3±1,2 (91)	2,7
15	1,2669±0,1 (104)	0	0,579±0,07 (95,5)	0	46,4±2,0 (97,7)	0
30	0,9647±0,06 (79,0)	2,2	0,433±0,01 (71,4)	3,4	46,0±2,2 (96,9)	0
			Testes			
Control	2,3825±0,1 (100)	—	0,698±0,03 (100)	—	29,4±1,0 (100)	—
3	2,3185±0,1 (97,3)	0,4	0,744±0,04 (106,6)	0,9	33,4±0,6 (113,6)	3,0
7	2,1857±0,07 (91,7)	1,6	0,632±0,02 (90,5)	1,8	27,4±0,2 (93,2)	1,9
15	2,3599±0,09 (99)	0	0,611±0,03 (87)	2,1	26,6±0,4 (90)	2,5
30	2,4805±0,08 (103)	0	0,679±0,02 (97)	0	27,7±0,3 (94)	1,7
			Bone marrow			
Control	—	—	—	—	28,7±1,1 (100)	—
3	—	—	—	—	35,0±1,0 (122)	4,2
7	—	—	—	—	24,6±0,9 (86)	2,9
15	—	—	—	—	27,5±1,4 (96)	0
30	—	—	—	—	29,1±2,1 (101)	0

Note. Here and in Table 2, percentages are given in parentheses.

TABLE 2. Action of γ-Rays in Dose of 10 R

Experimental conditions	Small intestine (AA in mg %)		Stomach (AA im mg %)	
	$M \pm m$	t	$M \pm m$	t
Control	39,3±2,03 (100)	—	21,3±1,17 (100)	—
10 R (single dose)	47,4±1,90 (121)	3,0	28,2±1,12 (132)	4,2
5 + 5 R (interval of 24 h)	51,4±2,05 (131)	4,2	29,5±1,17 (139)	4,9

The decrease in AA concentration in the spleen tissue was greatest (down to 64% of the control value) on the day after irradiation. Subsequently, the AA concentration in the spleen tissue rose slightly and after reaching a certain level it remained steady, with slight fluctuations, until the end of one month. Even at this time, however, the AA concentration in the spleen was only 84% of the control level (Fig. 1).

Bone Marrow. A sharp decrease in AA concentration in the bone marrow was found on the day after irradiation, when it was only 45% of its initial value. By the 3rd and 7th days the figure was 46 and 39% respectively, rising to 75% by the 15th day and to 80% of the original value after the end of one month.

The data given in Figs. 1 and 2 show that the disturbances produced in the spleen, just as in the bone marrow, by irradiation in a dose of 600 R were still not completely reversed one month after irradiation.

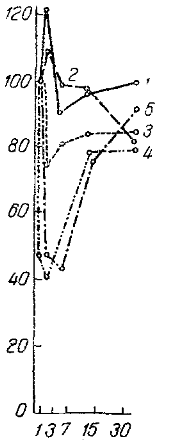

Fig. 2. Dynamics of AA synthesis in bone marrow after irradiation with various doses of γ-rays. 1) AA concentration after irradiation in dose of 25 R; 2) 50 R; 3) 250 R; 4) 500 R; 5) 600 R. AA concentration without irradiation 100%.

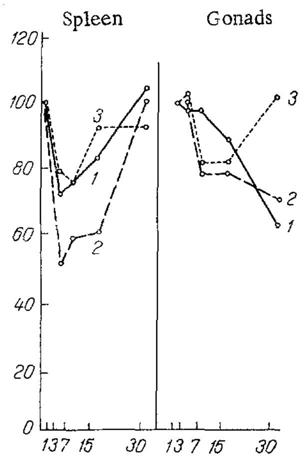

Fig. 3. Action of γ-rays in dose of 250 R. 1) Weight of organ; 2) AA content in whole organ (in mg); 3) AA concentration in tissue.

Testes. The weight of the gonads fell steadily throughout the period of observations and by the end of one month had fallen to 38% of the initial value. The decrease in weight was particularly rapid between the 15th and 30th days of the experiment. The decrease in total AA content in the gonads was almost parallel to the decrease in their weight, and by the end of the month the AA content in the testes was 33% of its initial value. Throughout the time of observation the AA concentration in the testicular tissues fell, although to a much lesser degree than the weight of the gonads and their total AA content (Fig. 1).

A similar investigation of the action of γ-rays in a dose of 500 R revealed changes in the studied indices in the course of development of radiation sickness which were qualitatively identical with those observed in a dose of 600 R, only the severity of the disturbances in a dose of 500 R was slightly less.

The same typical picture of disturbances, qualitatively speaking, was found during the study of changes in weight of the organ and its AA content and concentration after irradiation of rats in a dose of 250 R. In this case, however, compared with the experiments with the preceding doses, there was a marked difference in the intensity of the disturbances caused. Results obtained in experiments on rats irradiated in a dose of 250 R are given in Fig. 3. Comparison of the data in Figs. 1 and 3 shows that the action of a dose of 250 R differed from that of higher doses by the fact that the changes produced were quantitatively smaller and signs of their reversibility appeared earlier.

Consequently, large doses of γ-rays cause qualitatively similar changes in the indices studied, and the only difference lies in the intensity of the changes and the time of onset of regression of the disturbances produced, which depend on the dose. However, irradiation in doses of 25 and 50 R produced changes which showed certain qualitative differences.

Changes in the selected indices in the course of development of radiation sickness after a single whole-body exposure to γ-rays in a dose of 25 R are shown in Table 1. It will be seen from Table 1, first, that a dose of 25 R produces changes affecting these indices. It may therefore be concluded that this dose must be regarded as above the threshold for changes detectable by this method.

It will be noticed that, in contrast to the decrease in the AA concentration in the bone marrow observed from the first days after irradiation with large doses of γ-rays, small doses increased the AA concentration at these times (Fig. 2). A small increase in AA concentration was observed also in the spleen tissue, as Table 1 shows. This was also true of the AA concentration in the testicular tissues.

After irradiation in a dose of 10 R, one of the authors (Yu. M. Filippov) observed an increase in the extent of AA synthesis in the small intestine and stomach of rats. The results obtained 2 h after irradiation in these experiments are given in Table 2.

An explanation must be sought for the opposite direction of the changes in rate of AA synthesis in radiosensitive tissues after exposure, in one case to large doses (a decrease in synthesis) and in the other, to small doses (an increase in synthesis). We consider that in these circumstances it must be assumed that AA participates in synthetic processes in the body, and in particular in protein synthesis. From this point of view the stimulation of AA synthesis in the first days after irradiation is evidence in favor of the hypothesis that an active defensive reaction develops during exposure to small doses of ionizing radiation, possibly through compensatory reactions in the still intact cells of the investigated organs.

It is interesting to note tha analogy in the dynamics of AA synthesis in animals exposed to different doses of irradiation and in those receiving different doses of toxic substances. The same defensive reaction of an increase in AA synthesis develops when toxic substances of exogenous or endogenous origin are found in the body. A regular increase in the scale of synthesis is established up to a limit when the intensity of the toxic action is so great that, rather than increasing, the rate of AA synthesis decreases (functional exhaustion) [7].

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