DEVELOPMENT OF THERMAL INFLAMMATION IN ACUTE RADIATION SICKNESS

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In acute radiation sickness the course of inflammation evoked by various agents (turpentine, other foreign substances) has been found to depend on the stage and severity of the sickness. Investigations have shown that soon after irradiation the course of the inflammatory reaction is the same as in healthy animals, but in later stages weakening of the cellular reaction and intensification of the proliferative and exudative phase of inflammation is definitely inhibited in acute radiation sickness.

In the present investigation the course of the exudative phase of inflammation, caused by infliction of a thermal burn, was studied in rats with acute radiation sickness.

EXPERIMENTAL METHOD

Experiments were carried out on 56 Wistar rats (180-200 g) and 84 August rats (140-150 g). The animals were irradiated from a Co^{60} source in doses of 600 and 750 R (dose rate 77 R/sec). A thermal burn was inflicted on the animals 1, 3, 7, 14, and 21 days after irradiation. In the experiments of series I the burn was produced by immersing the left hind limb in water at 55° for 20 sec. The rats were sacrificed 1 h after burning (by decapitation), and both hind limbs were amputated at the level of the ankle joint. The intensity of edema was estimated from the difference in weight between the left and right limbs [9]. The results were expressed in percent.

In the experiments of series II a thermal burn was produced in anesthetized rats by applying a small copper vessel (diameter 1 cm), through which water was passed from an ultrathermostat at a temperature of 54±0.5°, to the inner surface of the ear for 60 sec. The increase in thickness of the ear was recorded radiometrically [5]. The rats were anesthetized with chloral hydrate (0.3 g/kg intraperitoneally).

EXPERIMENTAL RESULTS

The increase in weight of the limb of healthy Wistar rats after burning was 41±5%, and in August rats 15±1.5%. The increase in thickness of the ear was 250±16 and 520±48 μ respectively.

The dynamics of the increase in weight of the burned limb of Wistar rats (750 R) and of the increase in thickness of the ear of August rats (600 R) is shown in the figure. After 24 h there was practically no difference between the increase in edema of the ear and limb in the irradiated and healthy animals. After 3 days the edema reaction in the limb of the Wistar rats was inhibited by 78%, and that in the ear of the August rats by 79%. After 7 days the increase in edema in the limb and ear was the same as in the healthy animals. After 14 and 21 days the increase in thickness of the ear was again inhibited, by 89 and 87% respectively.

The method used to record the increase in thickness of the rat's ear, based on absorption of β-rays, has been fully described in earlier papers when applied to investigations on rabbits. In this particular case calibration was carried out by means of polyethylene films, assuming that they absorb β-rays in the same manner as skin. By continuous recording of the increase in edema of the rat's ear two phases in the development of thermal inflammation were distinguished: the 1st, initial, phase characterized by a continuous and linear increase in thickness of the ear, and the second, final phase, with an exponential slowing of the rate of increase of edema. Quantitative analysis of the two phases enabled the time of development of edema and the rate of the process to be determined and the absolute increase in thickness of the ear (in

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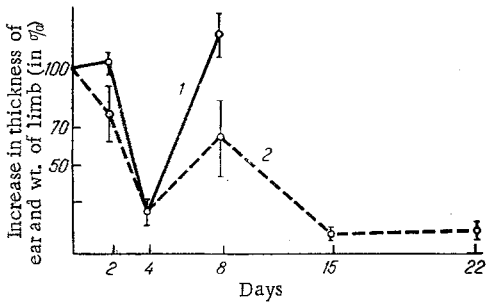

Development of exudation after burning, in relation to stage of radiation sickness. 1) Increase in weight of burned limb of Wistar rats; 2) increase in thickness of burned ear of August rats.

microns) to be calculated. The characteristics of development of thermal inflammation in the irradiated rats are given in the table.

In the irradiated rats the character of development of edema of the ear through these phases varied with the stage of the radiation sickness. After 24 h (see table) the total time of development of edema was shortened because of a reduction in duration of the 2nd phase. After 3 and 7 days the total time of development of edema again was shortened, also because of the 2nd phase. After 14 days the rate of increase of edema was slowed by comparison with the control, and the 2nd phase was absent. After 21 days a 2nd phase was recorded again, but it was marked by slowing of the increase of thickness of the ear and by a reduction of the time of development of edema. The 1st phase was characterized by slowing of the rate of increase of the edema.

The results demonstrate that the intensity of thermal edema in healthy animals depends on the site of injury and on the line of animal. In August rats, edema of the limb develops to a lesser degree than edema of the ear, while in Wistar rats the converse is true. If identical thermal stimulation is applied to the limb, the edema developed by Wistar rats is 2.7 times greater than that developed by August rats, while the increase in thickness of the ear is twice as great in August rats as in Wistar rats.

In radiation sickness inhibition of exudation after burning is observed, and is especially marked after 3, 14, and 21 days. This is in agreement with result obtained by other workers [1, 2, 8], who found inhibition of exudation in other types of inflammation on the 4th-6th day after irradiation. Inhibition of the development of thermal edema is characterized by reduction of the total increase of edema, a shortening of the total time of development of edema on account of the 2nd phase, slowing of the rate of increase of edema in the 1st phase and by absence of the 2nd phase after 14 days.

It is difficult at present to suggest the mechanisms involved in inhibition of the exudative phase of the inflammatory reaction in radiation sickness. It may be postulated that the inhibition of inflammation in radiation sickness is associated with exhaustion of the reserves of inflammation mediators (histamine, serotonin, kinins, etc.) in the tissues, with stimulation of secretion of corticosteroids, with an increase in the content of catecholamines, with changes in activity of the lysosomal factor of the leukocytes and endothelial cells, and also with dehydration of the blood and tissues. These hypotheses require further experimental analysis.

Thermal Inflammation of the Ear in August Rats Irradiated in a Dose of 600 R(M±m)

Index	Control rats (23)	Irradiated rats, Time after irradiation (in days)				
		1 (11)	3 (9)	7 (8)	13 (8)	21 (8)
Total time of development of edema (in min)	60±2.0	36±6,0*	26±8,0*	40±2,1*	10±1,4*	32±5,0*
Total increase in thickness (in μ)	520±47	400±80	110±41*	330±100	60±19*	70±20*
1st Phase of exudation						
Increase in thickness (in μ)	300±54	290±70	80±29*	160±78	60±22*	40±1,6*
Rate of increase of edema (in μ/min)	19±2,5	11±2,5*	8±2,7*	12±4,7	9±1,8*	3±1,0*
2nd Phase of exudation						
Time (in min)	44±2,0	17±4,0*	20±7,0*	30±6,0*	0	15±5,0*
Increase in thickness (in μ)	220±38,0	110±26,0	30±1,3*	170±46,0	0	30±10,0*

*Values differing significantly ($P < 0.05$) from those obtained in experiments on unirradiated rats.

Note. The number of animals in the experiment is given in parentheses.

LITERATURE CITED

1. É. R. Bagramyan, Med. Radiol., No. 8, 23 (1959).
2. T. S. Barkagan, Pat. Fiziol., No. 1, 19 (1958).
3. V. M. Dorofeev, B. V. Polushkin, and N. I. Tsyran, Vestn. Akad. Med. Nauk SSSR, No. 9, 78 (1965).
4. S. A. Dubrovin and L. V. Koroleva, Pat. Fiziol., No. 3, 75 (1966).
5. A. E. Ivanov, Arkh. Pat., No. 11, 34 (1962).
6. N. A. Kraevskii and A. E. Ivanov, Arkh. Pat., No. 11, 34 (1962).
7. V. V. Shikhodyrov, Proceedings of an All-Union Conference on Medical Radiology. Experimental Medical Radiology [in Russian], Moscow (1957), p. 170.
8. M. L. Beaumariage and J. Lekomte, Rev. Belge Path., Vol. 26 (1957), p. 124.
9. J. Calnan and A. E. Kulatilake, Enzym. Biol. Clin. (Basel), Vol. 3 (1963), p. 158.