EFFECT OF BURNS ON PERMEABILITY OF THE VASO-TISSUE BARRIERS OF SOME ORGANS OF RATS AFTER WHOLE-BODY γ-RAY IRRADIATION IN A SUBLETHAL DOSE

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The important role of disturbances of vascular permeability in the pathogenesis of radiation sickness [3, 6, 7, 11, 13] and of burns [2, 4, 5, 8, 12] has been emphasized in the literature. In burns, several authors [12, 14, 15] found changes in the permeability of the blood vessels only in the affected region, while others consider that these distrubances are generalized in character [1, 4, 5, 18].

It is logical to suppose that disturbances of permeability also play an important role in the development of the pathological process resulting from the combined action of radiant and thermal energy.

Because of the absence of information on this problem in the literature, the present investigation was carried out.

EXPERIMENTAL METHOD

Experiments were carried out on 170 male albino rats weighing 160-200 g.

The experiments consisted of 4 series: I—control, II—after whole-body γ-ray irradiation in a dose of 400 R, III—a third degree thermal burn covering about 10% of the body surface, IV—exposure to the combined action of γ-ray irradiation in a dose of 400 R and a burn. Irradiation was given on the GUT-Co-400 apparatus.

The indicator of permeability was I^{131}-labeled serum albumin (RISA, East Germany).

A solution of albumin-I^{131} in a dose of 20 μCi/100 g body weight was injected intravenously 2 h, and 1, 3, 7, and 14 days after exposure to these agents. The animals were decapitated 1 h after this injection.

The index of total vascular permeability was the rate of disappearance of the indicator from the blood stream, expressed as a constant [10, 20] determined from the formula:

$$K = \frac{\log C_1 - \log C_2}{0{,}4343\,(T_2 - T_1)},$$

where C_1 and C_2 are the concentrations of indicator in the blood and T_1 and T_2 the times of taking the blood. Blood was taken in a volume of 0.05 ml after 5, 30, and 60 min.

The permeability of the vaso-tissue barriers of the liver, spleen, thigh muscle, kidney, small intestine, heart, lung, the focus of injury, and the hemato-ophthalmic barrier was expressed as the ratio between the albumin concentration (in grams %) in the tissues and in blood plasma taken at the same time. The activity was determined by means of a scintillation counter on a type PS-5M apparatus ("Volna").

EXPERIMENTAL RESULTS

The results given in Fig. 1 show that after γ-ray irradiation in a dose of 400 R (experiments of series II) a higher rate of disappearance of the indicator from the blood was observed after 7 and 14 days ($P<0.05$). The concentration of labeled albumin was increased in the spleen and small intestine after 3, 7, and 14 days, in the thigh muscle after 7 and 14 days, and in the aqueous of the eye and in the liver after 7 days. In the kidney, heart, and lung the accumulation of indicator at all the times of the investigation was the same as in the control series (Fig. 2).

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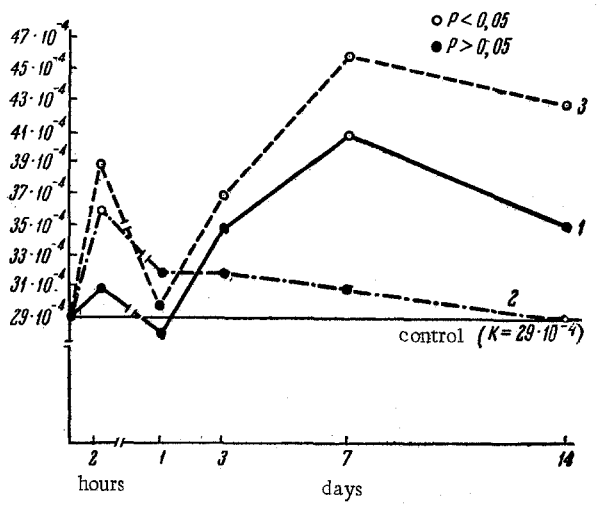

Fig. 1. Constants of the rate of disappearance of RISA from the blood stream of rats after whole-body γ-ray irradiation in a dose of 400 R (1), a burn (2), and the combined action of these factors (3). Along the axis of ordinates – constants; along the axis of abscissas – time of investigation.

In the experiments of series III (burn) the constant of removal of the indicator from the blood was higher after 2 h, but after 24 h and, in particular, at subsequent times it showed a return to normal. In the first 2 hours maximal removal of labeled albumin was observed in the burned organ, but after 24 h and later the amount of albumin passing into the wound fell sharply.

In this series an increase in the penetration of albumin was observed into the tissues of the liver (after 3 days), the kidneys (after 3 and 7 days), and the small intestine (after 7 and 14 days).

Following the combined action of γ-ray irradiation and the burn (experiments of series IV) the rate of removal of labeled albumin from the blood was increased after 2 h, but after 24 h it was not statistically distinguishable from the control. After 3 days and later, the removal of albumin again increased to reach a maximum toward the end of the investigation.

The dynamics of the escape of indicator into the burn in this series of experiments was the same as with a pure burn. In the liver, after 2 h and 3, 7, and 14 days, in the small intestine and the aqueous of the eye after 1, 3, 7, and 14 days, in the spleen and kidney after 3, 7, and 14 days, and in the thigh muscle after 14 days the concentration of labeled albumin was raised.

The results described show that by the action of γ-ray irradiation on the organism in a sublethal dose, by burning, and by the combined action of the two agents, the intensity of removal of labeled protein from the blood is changed.

In physiological conditions the vessel wall, the principal of the vaso-tissue barriers, is known to possess low permeability to proteins [16, 19]. Consequently, the increased removal of labeled protein from the blood and its accumulation in the investigated organs may be associated with the modified permeability of the capillary wall. The dynamics of the circulation in these circumstances has no significant effect on the removal of protein from the blood vessels [9, 17].

Consequently, following whole-body γ-ray irradiation in a dose of 400 R, disturbances of permeability are found mainly in radiosensitive organs such as the spleen and small intestine. In the course of development of radiation sickness changes in vascular permeability increased in intensity and are found also in other investigated organs (the liver, thigh muscle, and eye). The disturbance of the permeability of the barriers in the investigated organs reached its maximum 7 days after irradiation. This was also the time of the maximal rate of disappearance of labeled albumin from the blood.

The accelerated removal of the indicator from the blood in the first 2 h after the burn could be attributed to increased permeability of the blood vessels in the region of injury. Evidence for this is given by the maximal radioctivity of the burned tissues and the absence of any disturbance of vascular permeability in all the investigated organs at this period. The sharp decrease in the removal of labeled protein into the burn observed after 24 h led to restoration of the normal rate of its removal from the blood stream. Generalization of the increased permeability of the blood vessels after the burn took place later (after 3-7 days), and its severity was not great enough to cause the more rapid removal of proteins from the blood.

In the combined lesions due to burns and irradiation, the disturbances of the permeability of the barrier systems developed earlier and were more severe than after the isolated action of irradiation and of the burn.

Just as in the case of the pure burn, in the first two hours the more rapid removal of albumin from the blood was associated mainly with its removal into the region of the thermal injury, whereas the return to normal vascular permeability in the region of injury observed after 24 h led to a return to the normal

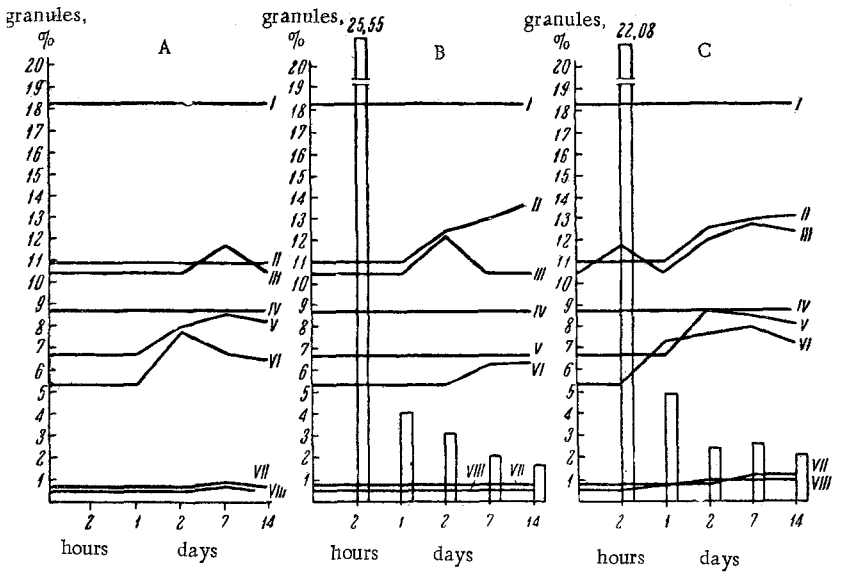

Fig. 2. Distribution of intravenously injected labeled albumin (RISA) among organs and tissues of rats after whole-body γ-ray irradiation in a dose of 400 R (A), a burn (B), and the combined action of these factors (C). Along the axis of ordinates – concentration of indicator in organs; along the axis of abscissas – time of investigation. I – lung; II – kidney; III – liver; IV – heart; V – spleen; VI – small intestine; VII – thigh muscle; VIII – eye; the columns denote the burned tissue.

rate of removal of albumin from the blood. Increased removal of labeled albumin in the later periods of observation was evidently due to the more rapid increase in permeability of the barriers of most of the investigated organs with a more extensive vascular system.

Differences in the resistance of the barriers of the investigated organs to protein were observed after the combined action of irradiation and thermal injury. Increased permeability was detected first of all in the liver. The barrier of the heart muscle was found to be most resistant.

It may be concluded from the results obtained that an important role in the phenomenon of mutual aggravation in combined lesions caused by burns and irradiation may be played by changes in the permeability of the barrier systems of the body.

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