REACTIVE CHANGES IN THE CENTRAL NERVOUS SYSTEM AND ENDOCRINE ORGANS IN COMBINED RADIATION AND BURN INJURIES

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Reports published in the literature on the question of combined burn and radiation injuries are mainly concerned with the surgical treatment of these lesions [3, 4, 7, 8, 11, etc.]. Only a few investigations have been made of certain pathological changes in the irradiated organism following infliction of additional thermal trauma [1, 2, 6,9, 10, 20]. Meanwhile, no references could be found in the literature to the problem of the reaction of the central nervous system and endocrine organs to combined injuries of this type. The solution of this problem is important for explaining the pathogenesis of the aggravating effect of thermal burns on the course and outcome of radiation sickness, which has been reported in the literature.

The object of the present investigation was to study the degree of nonspecific tissue changes in certain parts of the central nervous system and endocrine organs by the vital staining method in thermal burns, radiation sickness, and combinations of these lesions.

EXPERIMENTAL METHOD

Experiments were carried out on 135 male albino rats weighing 150-200 g: series I – control (30 animals), series II – irradiated with γ-rays from Co^{60} in a dose of 400 R, series III – with a thermal burn of degree IIIA B (10% of the skin surface), and series IV – with a combination of both injuries. The animals received a single whole-body irradiation on the GUT Co-400 apparatus at a dose rate in air of 24.3 R/min. The burns were inflicted with the flame of a gas burner on the skin of the back through an oval hole in an asbestos cover. In the animals of series IV the burns were inflicted immediately after the end of irradiation.

The quantity of vital dye absorbed by the tissues was determined by S. N. Romanov's method [19]. The investigations were carried out 2 h, and 1, 3, 7, and 14 days after the procedure. At each period experiments were performed on 7 animals. The animals at these times received an intravenous injection of the vital dye neutral red in a dose of 1 ml of the 0.5% solution per 50 g body weight. Two hours later the rats were decapitated. Pieces of the left cerebral hemisphere, the cerebellum, the medulla, the pancreas, and the pituitary, and also the adrenals and lobes of the thyroid glands from which all connective tissue had been carefully removed, were placed in test tubes for extraction of the dye with 4 ml of 70° ethyl alcohol, acidified with 2% sulfuric acid. The extracts were examined in the FEK 1M photoelectric colorimeter and the pieces of the organs were dried to constant weight in a muffle furnace at 70°. The amount of dye extracted in conventional extinction units was calculated per gram of the dry organ. The content of dye in the organs of the animals in Series II-IV was expressed as a percentage of the control figure.

Content of Neutral Red in Various Parts of the Central Nervous System and Endocrine Glands of Rats in Normal Conditions 2h after Its Intravenous Injection (in conventional extinction units/g weight of dry organ)

Organ	n	$\bar{x}$	S	$S_{\bar{x}}$
Pituitary	30	13,7	2,2	0,40
Adrenals	30	10,1	1,9	0,35
Thyroid	30	9,6	2,1	0,38
Pancreas	30	2,8	0,74	0,14
Cerebrum	30	3,4	0,97	0,17
Cerebellum	30	2,4	0,31	0,06
Medulla	30	1,6	0,11	0,02

The numerical results were analyzed by statistical methods. The differences were regarded as significant when $P < 0.05$.

EXPERIMENTAL RESULTS

The table shows that in normal conditions more of the dye accumulated in the brain than in the pancreas. This demonstrates

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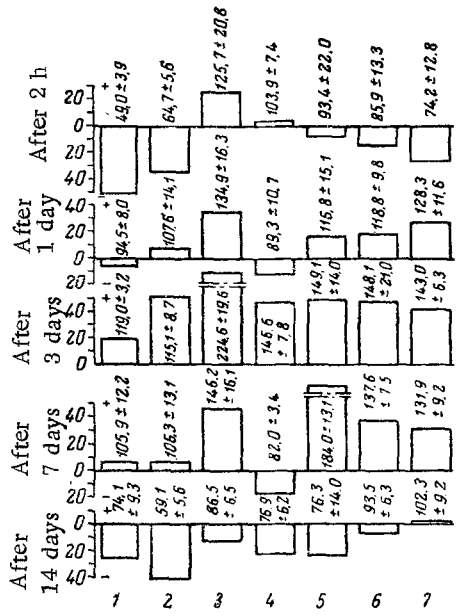

Fig. 1. Dynamics of absorption of neutral red by tissues of the regulatory organs of albino rats after whole-body irradiation in a dose of 400 R. Here and in Figs. 2 and 3: 1) adrenals, 2) thyroid, 3) pancreas, 4) pituitary, 5) cerebrum, 6) cerebellum, 7) medulla. Rectangles – values of $\bar{x} - 100$. The numbers by the rectangles represent – $\bar{x} \pm S_{\bar{x}}$.

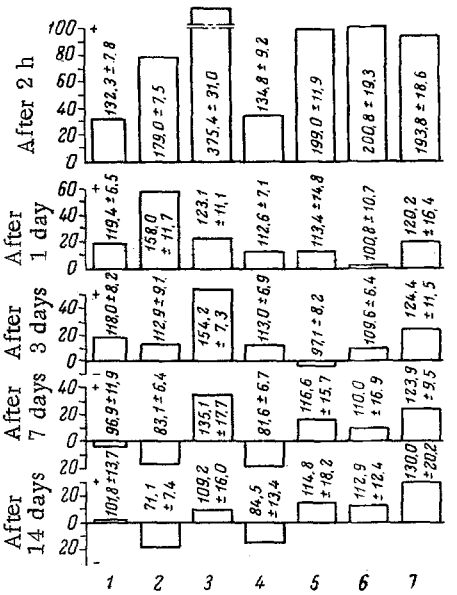

Fig. 2. Dynamics of absorption of neutral red by tissues of the regulatory organs of albino rats after a thermal burn.

that the most important factor for absorption of the dye in an organ in situ is the affinity of the tissue for the dye, and not the permeability of the vessel-tissue barriers (in particular, the blood-brain barrier), as has been reported in the literature [5].

In acute radiation sickness (Fig. 1) the absorption of dye by the cerebral hemispheres and cerebellum began to increase after 3 days, compared with after 1 day in the medulla. After 14 days the difference between the intensity of staining of the tissues of the central nervous system and its normal value was not statistically significant ($P > 0.05$). In these conditions the adrenals and thyroid showed fluctuating changes in their absorptive properties. After 2 h and 14 h the content of dye was significantly less than normal ($P < 0.05$), whereas after 3 days it was higher than normal. In the pituitary the accumulation of dye was increased 3 days after irradiation, but later the absorption indices showed a decrease. In the first 7 days the accumulation of dye in the pancreas increased (after 2 h the increase was not statistically significant, $P > 0.05$). After 14 days the absorption of neutral red by this organ was indistinguishable from normal.

An increased content of dye was found in all the investigated tissues and organs 2 h after burning, falling to the control levels in the brain, cerebellum, and pituitary after 1 day, and in the adrenal and thyroid after 3 days (Fig. 2). The pancreas and medulla absorbed an increased amount of dye for 7 days. After 7 days the accumulation of dye in the thyroid and pituitary was below normal ($P < 0.05$). Following the combined injury (Fig. 3), the accumulation of neutral red was increased in all the tissues and organs examined after 2 h, whereas irradiation alone caused no changes in the intensity of staining of the cerebral hemispheres, cerebellum, medulla, pituitary, and pancreas, while a smaller amount of dye was absorbed by the adrenals and thyroid at this time.

On the 14th day after irradiation, the thyroid, adrenals, and pituitary had absorbed less of the dye than in normal conditions, while the amount of dye absorbed by the other tissues and organs studied was indistinguishable from the control level. After the combined injury at this time all the tissues and organs showed an increased affinity for neutral red, except the adrenals, the absorption properties of which had returned to normal at this time, although in comparison with the experiments of series II, their intensity of staining was significantly higher ($P < 0.05$). After the combined injury, the increase in the staining properties of the tissues of the central nervous system thus began sooner and subsequently developed to a higher level than in the animals receiving irradiation alone. In these conditions the intensity of staining of the adrenals, thyroid, and pituitary showed a different pattern of change: the periods of diminished staining properties of these organs disappeared.

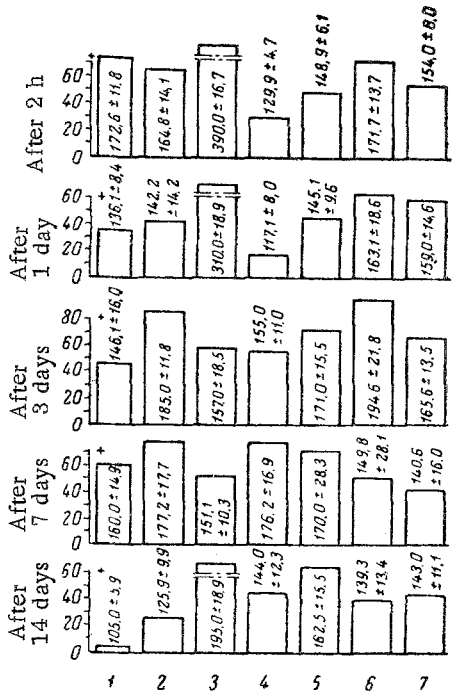

Fig. 3. Dynamics of absorption of neutral red by tissues of the regulatory organs of albino rats after whole-body irradiation in a dose of 400 R and a thermal burn.

Investigations by D. N. Nasonov and co-workers [12-15, etc.] have shown that the increase in the affinity of the cytoplasm of isolated tissue cells for vital dyes following the application of various harmful agents is evidence of the development of nonspecific changes in them. A stepwise relationship has been discovered between the severity of injury to the tissues and the quantity of dye absorbed [15]. It has been shown that a decrease in the ability of the tissues to take up the dye is associated with an increase in their resistance to injurious influences [17]. Recently these conclusions have been verified for the method of staining organs in the intact organism [5, 16, 18, 22, etc.]. The view has been expressed [22] that a change in the staining properties of animal tissues reflect the dynamics of their reaction to irradiation.

From the facts described above it can be considered that the increase in the staining properties of the tissues of the central nervous system and endocrine organs following combined injuries which was observed in most cases, is a manifestation of aggravation of their changes produced by irradiation on the addition of a thermal burn. This aggravation of the changes may be the cause of the disturbance in the regulatory functions of these organs, and, hence, the cause of the increased severity of the lesion. The reactive changes in the regulatory organs following combined injuries cannot be regarded as the result of the simple summation of the injuries developing by the action of the separate factors.

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