RECOVERY OF PERIPHERAL NERVES AFTER PROLONGED FRACTIONAL X-RAY IRRADIATION

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After prolonged fractional irradiation of the hind limbs of rats (twice weekly in doses of 60 R for 170 days, total dose 3,000 R) the peroneal nerve of the irradiated limb was traumatized. Regeneration in the traumatized nerve of the irradiated and unirradiated limbs followed a similar course.

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The ability of tissues to recover after radiation injury is reflected in their regenerative activity [4, 6]. If tissues possess weak proliferative activity, recovery is very slow and incomplete. The response of skeletal muscle in the limb of a mouse irradiated in a dose of 3,000 R, which takes the form of a well marked posttraumatic regeneration, is equally inhibited at early and late stages after exposure to ionizing radiation [8]. Because of the weak proliferative activity of the skeletal muscles of animals, injury resulting from exposure to x-rays may persist for a long period after chronic or fractional irradiation of the limb [2, 3]. Under these conditions of irradiation a summation effect of radiation injury to the muscle tissue is observed. Similar principles apply when bone tissue is irradiated [5]. After local fractional irradiation of an animal's limb with x-rays in total doses of 1,000 and 1500 R, regenerative processes in the bone are inhibited to approximately the same degree as after a single irradiation in the same doses.

Radiation injury to a peripheral nerve in rats also persists for a long time [1]. Ability of the peroneal nerve of rats to regenerate after single irradiation of the limb in a dose of 3,000 R remains inhibited in the cause of resection of the nerve 24 h and 20, 60, and 127 days after irradiation. Not until the 170th day does partial regeneration take place: by this time the regenerative power of the traumatized nerve has recovered to some extent.

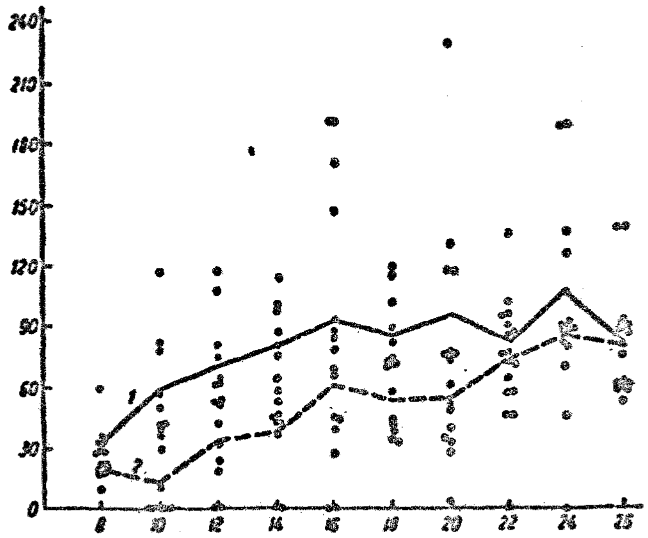

Fig. 1. Development of regenerative processes after resection of peroneal nerve of rats. 1) Size of connective-tissue capsule (black circles); 2) size of neuroma (white circles). Ordinate, relative units; abscissa, days.

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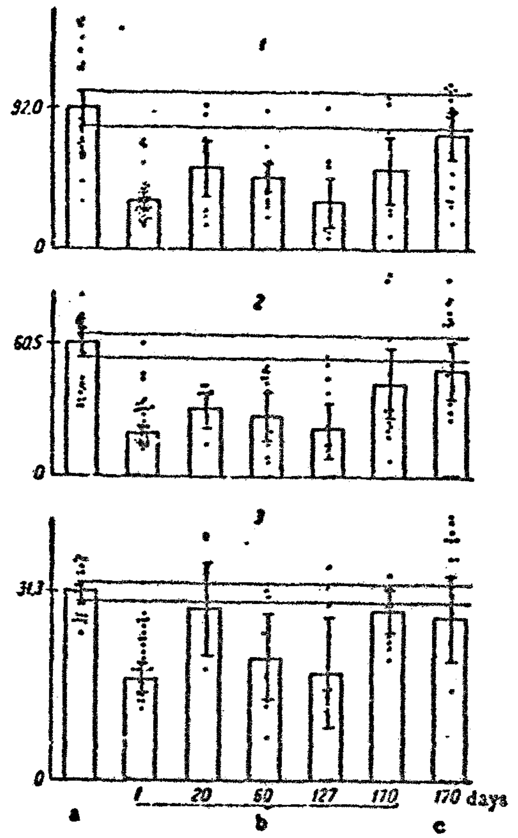

Fig. 2. Regenerative power of peroneal nerve after local single and prolonged fractional x-ray irrdiation of the limb in rats. 1) Size of connective-tissue scar; 2) size of neuroma; 3) density of neuroma; a) control; b) single irradiation of limb in dose of 3,000 R; c) fractional irradiation of limb in the same dose. Remainder of legend as in Fig. 1.

The object of the present investigation was to study the regenerative power of a nerve after prolonged fractional irradiation of an animal's limb.

EXPERIMENTAL METHOD

Experiments were carried out on 20 male Wistar rats weighing 160-180 g. The animal's hind limb was irradiated in a dose of 60 R twice weekly for 170 days. The total dose was 3,000 R. Irradiation was given by a type RUM-3 apparatus (voltage 180 kV, current 17 mA, dose rate 78 R/min, filter 0.5 Cu+1 mm Al, skin-focus distance 30 cm). Parts of the rat's body not to be irradiated were screened by a lead shield.

The development of regeneration of the peroneal nerve was studied after resection. The nerve was traumatized immediately after the end of irradiation (170 days from the beginning of fractional x-ray irradiation). The operative technique, the method of treatment of the material, and quantitative analysis of the regenerating nerve are fully described in earlier papers [1, 7]. All that need be said is that during quantitative analysis of regeneration the size of the neuroma and of the connective-tissue scar and also the density of the neuroma were determined.

EXPERIMENTAL RESULTS

To select the most suitable time for quantitative estimation of regeneration, the course of regeneration of the traumatized nerve was examined at regular time intervals. Results of quantitative assessment of the parameters of regeneration from the 8th until the 26th day after operation are given in Fig. 1. Quantitative analysis was difficult in the earlier or later periods, and until the 8th day only one or two young nerve fibers had invaded the connective-tissue scar, while after the 26th day most of the regenerating axons had already grown into the peripheral segment. A morphological and quantitative analysis of the neuroma in the animals of the control and experimental series was carried out on the 18th day after resection of the nerve. By this time the neuroma was well defined and most of the nerve fibers had not yet reached the peripheral segment, but filled almost the whole of the connective-tissue scar joining the two ends of the divided nerve.

On the 18th day, in animals undergoing prolonged fractional irradiation for 170 days in a total dose of 3,000 R, most of the regenerating nerve fibers had invaded the connective-tissue scar and reached the peripheral segment of the nerve. The young nerve fibers were still able to ramify, indicating the vitality of regenerative processes at the site of injury. The morphological picture of the neuroma corresponded to the intensity of regeneration as defined by quantitative indices (Fig. 2). The mean dimensions of the neuroma and of the connective-tissue scar and the mean density of the neuroma on the 18th day after resection of the nerve were about 9% smaller than in the animals of the control group. Regenerative processes after fractional irradiation of the animal's limb were much less inhibited than after a single irradiation in the same dose. It is clear from Fig. 2 that in the latter case regeneration was inhibited two or three times more strongly than in the control 24 h and 20, 60, and 127 days after regeneration.

The results of the experiments with prolonged fractional irradiation corresponded to the data obtained in experiments on animals undergoing operation 170 days after single irradiation. Both series of animals regeneration of the peroneal nerve on the 18th day after resection was almost equal in degree, and the difference between the mean dimensions of the neuroma and connective-tissue scar and of the density of the neuroma was not statistically significant.

Incomplete summation of the effect of injury after prolonged fractional irradiation and the weakening of regenerative processes evoked by resection of the nerve a long period of time after irradiation (170 days) demonstrates the ability of the tissue forming nerve trunks to regenerate after irradiation injury.

Comparison of our findings with those in the literature shows that nerve tissue possesses this property to a greater degree than bone or muscle tissue, but to a lesser degree than tissues with rapid renewal of their cells elements.

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