REGENERATION OF THE SCIATIC NERVE IN ACUTE RADIATION SICKNESS

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Degeneration and regeneration of peripheral nerves occurring under normal conditions has been very inadequately studied. The same thing is true also of these processes as occurring during the action on the organism of ionizing radiation. Studies of recent years on regeneration of nerves in acute radiation sickness [2,3,5,7,11] have not been pursued in any very thorough manner.

We have studied regeneration of the sciatic nerve in dogs during radiation sickness of moderate severity.

EXPERIMENTAL METHOD

Studies were made on 54 adult dogs weighing 10-12 kg. In a control group of 17 dogs the sciatic nerve was divided in the middle third of the thigh, and then sutured. In the experimental group consisting of 37 dogs, radiation sickness was first induced. A single total dose was given from a RUM-3 apparatus with conditions as follows: filters 0.5 mm Cu and 1 mm Al, potential 180 kv, current 10 ma, focus on skin at distance of 120 cm, time of irradiation 3 h; total 350 r. The sciatic nerve was divided and sutured 7 days after irradiation.

Material for study was taken 5, 10, 15, 20, 30, 45, 60, and 90 days after the operation. Histological studies were made of the central and peripheral cut ends. The material was fixed in 12% neutral formalin. Sections were stained with hematoxylin-eosin, and impregnated by the method of Bielschowsky-Gros and Campos. To reveal changes in the myelin sheath the sections were stained by Spielmeyer and Zolotova's method.

The degree of severity of the radiation sickness was inferred from the clinical picture, from changes in the bloodstream, the weight of the animal, and from other indices. In most other animals irradiated in this way a moderately severe radiation sickness is induced. We did not examine material obtained from animals with a more severe form of radiation sickness, which caused them to die at various times after irradiation.

EXPERIMENTAL RESULTS

On the 5-10th day after the operation, in the control group the fibers of the peripheral portion of the nerve had undergone considerable disintegration and fragmentation. In the experimental group only some of the fibers had fragmented in this way.

In the control group, by the 15-20th day in most of the animals the degeneration of the nerve fibers was complete. The myelin had clearly broken down long ago and was present in the form of fine grains. A very small number of "digestive chambers" were present. In the irradiated group, at this period there was a massive breakdown and fragmentation of the axis cylinders (Fig. 1).

By the 30-45th day after the operation the picture of residual degenerative changes was the same in the two groups.

Retrograde degeneration in the central end was less well marked in the irradiated animals than in the control group. The nature of the changes and their dates corresponded to those of the peripheral end.

By the fifth day after the operation, in both groups in the central end newly formed fine short nerve fibers growing out from the axis cylinders of the stump could be found. In the irradiated group they were much less numerous than in the control group. However by the 15-20th day the number of newly-formed nerve fibers in both groups had become approximately equal. Most of them had grown out into the connective-tissue scar which formed at the

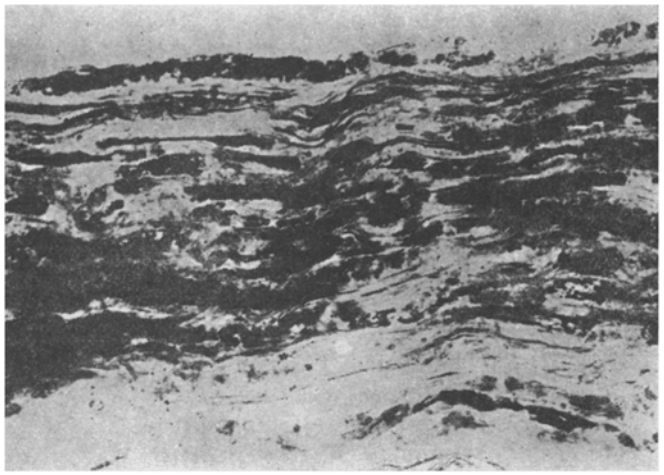

Fig. 1. Peripheral segment of sciatic nerve 15 days after the operation. Moderately severe radiation sickness. Fragmentation and disintegration of the axis cylinders. Micrograph. Campos silver method. Ocular 7, objective 40.

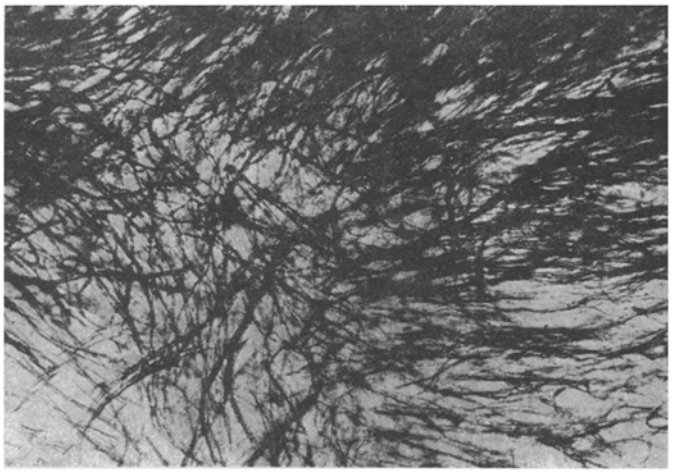

Fig. 2. A neuroma 15 days after the operation. Moderately severe radiation sickness. Micrograph. Campos silver method. Ocular 7, objective 20.

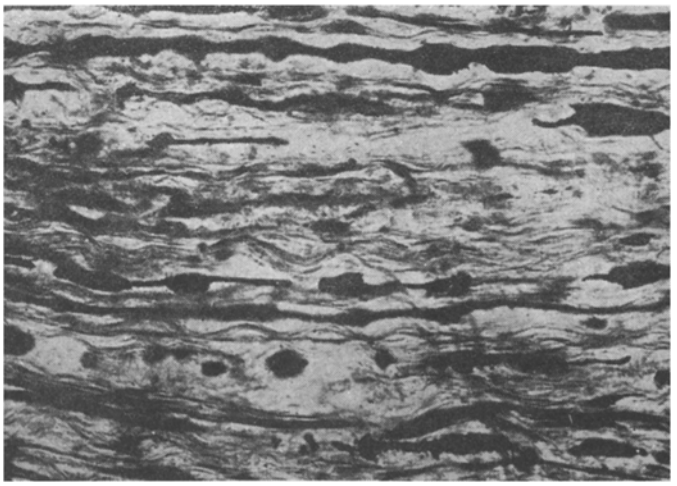

Fig. 3. Peripheral portion of the sciatic nerve 60 days after the operation. Moderately severe radiation sickness. Secondary degenerative changes in the newly-formed nerve fibers. Micrograph. Campos silver method. Ocular 7, objective 40.

junction of the central and peripheral cut ends. Usually by the 15th day after the operation in the irradiated terminals quite a large neuroma had formed in the connective-tissue scar, and it consisted of very fine tortuous repeatedly-branching unmyelinated nerve fibers, many of which contained "restricted cones" at the ends (Fig. 2). In the control group the neuromas were far smaller, and in several cases none were formed.

By the 30th day, in the control group a well formed bundle of nerve fibers entering the peripheral cut end of the nerve could be seen. In the experimental group the number and diameter of the nerve fibers entering the peripheral portion of the nerve was smaller, and they were noticeably less myelinated. At subsequent times in these animals the number of nerve fibers increased, but it was always smaller than the number in the control group.

Later, between the 60th and 90th days in the experimental animals among the newly-formed nerve fibers quite frequently secondary degenerative changes (hyper-impregnation, varicose swellings, disintegration and fragmentation of the axis cylinders) occurred. Sometimes the destructive changes were very profound and involved a large number of nerve fibers (Fig. 3), but in other cases there were only present the initial reactive changes (hyper-impregnation, varicose swellings of the nerve fibers).

In cases when the course of radiation sickness was more severe the changes described were more marked. The intensive regenerative processes did not occur until the 15-20th day. Secondary degenerative changes of the newly-formed nerve fibers were more extensive.

An analysis of the results obtained led us to conclude that at short times (5-10 days) after the operation in animals suffering from moderately severe radiation sickness the development of regenerative processes in the divided nerve lagged in comparison with those occuring in the control animals. Subsequently the regenerative processes (number of regenerating nerve fibers and their rate of growth) take place in a similar manner.

The delay in regeneration in the first days after division of the nerve in animals affected with radiation sickness is to be attributed to the direct influence of the ionizing radiation which delays the degenerative processes [1,4,6,10], and to many other reasons related to the development of the disease [8].

The delay in the regenerative process of the nerve fibers at early times after operation has the effect that at the time their growth is activated (10-15th day) quite a dense connective-tissue scar develops at the central and peripheral cut ends, and to a large extent prevents the outgrowth of newly-formed nerve fibers into the peripheral end. This effect is evidently related to the extent to which neuromas develop in animals with radiation sickness, and to the more complete functional recovery of the damaged nerve.

SUMMARY

A study was made of regeneration of the sciatic nerve in 37 dogs with radiation sickness of moderate severity.

Between 5 and 10 days after the operation the regeneration lagged behind that of the control animal. Later there was no difference between the two groups in the amount or rate of growth.

In the irradiated animals the development of neuromas was more pronounced, and fewer nerve fibers grew out into the peripheral portion.

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