CHANGES IN MONOSYNAPTIC REFLEXES DURING DEVELOPMENT OF NERVE DEGENERATION

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During their study of the mechanisms of development of nerve degeneration following trauma to the sciatic nerve or its branches, Speranskii and his co-workers frequently observed the development not only of local, but also of generalized degeneration of nerves [6]. Judging from the histological data, the primary changes were nearly always observed in the corresponding segment of the spinal cord.

The object of the present investigation was to study functional changes arising in the segment of the spinal cord connected with the injured nerve.

EXPERIMENTAL METHOD

Experiments were carried out on adult male cats. Degeneration was produced by crushing the tibial nerve and then dividing it distally to the place of crushing. The animals were investigated 7, 21, and 45 days after the operation. The reproduction of monosynaptic and polysynaptic reflex reactions was studied. On the day of the experiment the cats were anesthetized with ether and the spinal cord was divided at the level T_1; the subsequent dissection of the nerves and the nerve roots, and the recording of the responses were carried out on the anesthetized-spinal animal. Single or rhythmic stimulation with rectangular pulses 0.1 msec in duration was applied to the tibial nerve. The biopotentials detected from the divided ventral root of L_7 were recorded on motion picture film from a cathode-ray oscillograph. For the course of the experiment the animal was fixed to a frame and its body temperature was maintained at 36°. The experimental animals were divided into four groups. Group 1 (15) consisted of normal control animals, and groups 2 (12), 3 (16), and 4 (8) of animals in which the tibial nerve was injured 7, 21, and 45 days previously.

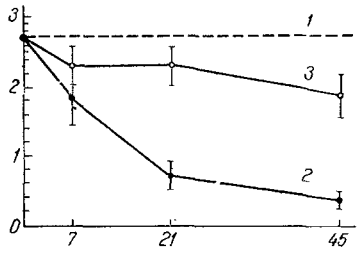

Fig. 1. Dynamics of changes in monosynaptic reflexes during development of degeneration. 1) Amplitude of monosynaptic reflexes arising during stimulation of tibial nerve in normal conditions (2.7 ± 0.2 mV); 2) on side of operation (1.8 ± 0.4 on 7th day, 0.7 ± 0.2 on 21st day, 0.3 ± 0.1 on 45th day); 3) on contralateral side (2.3 ± 0.3 on 7th day, 2.3 ± 0.2 on 21st day, 1.8 ± 0.3 on 45th day). The standard error for all observations is indicated. Ordinate – amplitude (in mV), abscissa – time after injury (in days).

EXPERIMENTAL RESULTS

At the stages of development of degeneration, the symmetry of the monosynaptic discharges was disturbed. Comparison of the monosynaptic reflexes arising during development of degeneration with the analogous responses obtained in normal control animals, showed that 7 days after injury a statistically significant ($P < 0.05$) decrease in the amplitude of all the responses took place on the side of the injured nerve. In the process of development of degeneration a further decrease in the monosynaptic reactions was observed, and after 45 days a decrease in the amplitude of the monosynaptic reactions compared with the normal level was found not only on the side of the operation, but also on the contralateral side (Fig. 1).

The decrease in the amplitude of the monosynaptic reactions during the development of degeneration of the nerve may be associated with disturbances in various parts of the reflex arc. The conductivity

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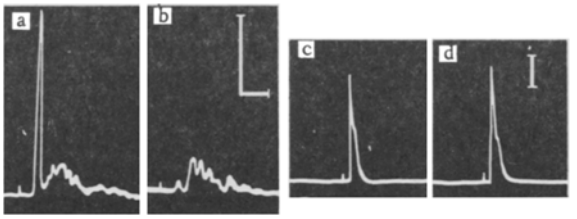

Fig. 2. Reflex reactions and action potentials of nerves 21 days after injury. Monosynaptic and polysynaptic reflexes during stimulation of the tibial nerve on the intact side (a) and the side of the operation (b). Action potentials in the intact (c) and divided (d) tibial nerve. Calibration 1 mV, 5 msec.

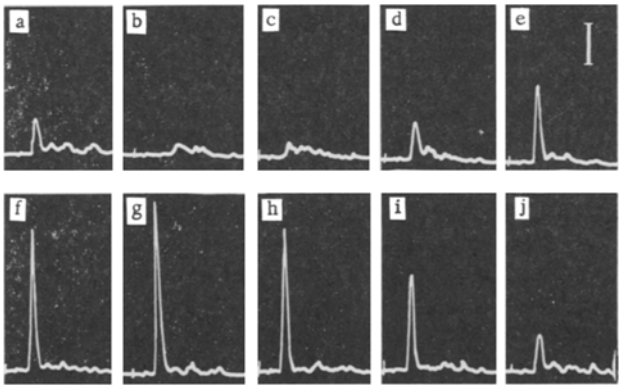

Fig. 3. Posttetanic potentiation of monosynaptic reflexes 7 days after trauma. a) Background; b-j) 10, 20, 30, 40, 70, 110, 180, 240, and 300 sec, respectively, after tetanization. Calibration 1 mV.

of the injured nerve had first to be determined. The results of the investigation showed that the amplitude of the action potentials of the tibial nerve on the side of the operation was not diminished, and in some cases it was actually greater than the amplitude on the intact side (judging by the conduction velocity these action potentials belonged to the fastest group of fibers), whereas the monosynaptic reflexes on the side of the operation were sharply reduced by comparison with those on the intact side (Fig. 2). Clearly, therefore, it was not the peripheral part of the reflex arc that was responsible for the decrease in the amplitude of the monosynaptic reflexes.

The observed phenomena could be due either to retrograde changes in the motor neurons or to disturbances of the functional state of the presynaptic endings. The method of posttetanic potentiation was used for the analysis. It has been shown [8, 11, 14] that in this condition the increase in the amplitude of the monosynaptic reflexes is associated with activation of the presynaptic apparatus, and the deeper the functional disturbances of the presynaptic apparatus, the more marked the increase in amplitude. For this reason, posttetanic potentiation is well marked after division of the dorsal roots, causing disturbances of the function of the presynaptic endings [3, 5, 9, 13], but it is unchanged after division of the ventral roots, causing retrograde changes in the motor neurons [7].

The investigations showed that during the development of degeneration of the nerve a marked posttetanic potentiation occurred. The following characteristic features could be noted: a decrease in the initial frequency at which potentiation of the monosynaptic reflexes began, for during the development of nerve degeneration this was 20 impulses/sec (normally 80 impulses/sec); a marked increase in the maximal value of the potentiated response, reaching on the average 450% of the initial value (normally 200%); delay in reaching the maximum of potentiation, for the maximal response was observed after 50-120 sec (normally after 10-30 sec; Fig. 3). The changes observed in the character of potentiation suggested disturbance of the functional state of the presynaptic apparatus.

It is important to emphasize that during the development of degeneration of the nerve a progressive and regular decrease in the amplitude of the monosynaptic reflexes was observed on the side of the injured nerve and on the contralateral side. Bilateral changes after nerve trauma have also been described in morphological investigations [1, 2, 4]. In the condition known as smooth division of a nerve, no changes are found in the monosynaptic reactions on the contralateral side [10, 12]. It may therefore be supposed that the observations described are associated with the development of nerve degeneration. It may be concluded from the analysis of these results that an important factor in the disturbances of reflex activity of the spinal cord during the development of nerve degeneration is the change in the functional state of the presynaptic endings.

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