THE STATE OF THE PERIPHERAL NERVOUS STRUCTURES OF THE HIND LIMB OF THE RABBIT DURING DEVELOPMENT OF A COLLATERAL CIRCULATION

Yu. I Denisov-Nikol'skii

Department of Normal Anatomy (Acting Head, Professor V. M. Godinov),
Order of Lenin S. M. Kirov Military Medical Academy, Leningrad
(Presented by Active Member AMN SSSR V. V. Parin)
Translated from Byulleten' Éksperimental'noi Biologii i Meditsiny, Vol. 56, No. 10,
pp. 110-113, October, 1963
Original article submitted June 23, 1962

As a result of extensive investigations of the formation and development of the collateral circulation, much information concerning the topography of the newly formed collaterals and their sources of formation has been obtained. There are also indications that the development of a collateral circulation gives rise to physiological changes in the tissues below the point of ligation or resection of the main arteries [5, 9]. A scrutiny of the extensive literature devoted to the study of the state of the peripheral nervous structures after disturbance of the blood flow showed that opinions differ regarding the range of spread of lesions of neural elements and regarding their severity. Workers in the laboratory directed by B. S. Doinikov have concentrated their attention on changes in the nerve fibers resulting from anoxia caused by disturbance of the arterial blood flow [6, 8, 14]. Other investigators have reported findings indicating that the motor nerve endings are highly sensitive to disturbances of the oxygen supply to the muscles [1, 3, 7, 10, 13].

EXPERIMENTAL METHOD

The present investigations were conducted on 25 rabbits of the Russian breed, weighing 1.7-2.4 kg. The arterial blood flow to the hind limb was interrupted by excision of the right femoral artery from the level of the inguinal ligament to the femoro-popliteal canal. The animals survived for 1, 2, 3, 5, 7, 10, 12, 18, 21, and 30 days, after which periods they were sacrificed by air embolism. Pieces of muscles of various groups, large nerve trunks and areas of the fascia lata from the lateral surface of the thigh were removed for examination. The material was treated by the Bielschowsky-Gros and Marchi methods and stained with hematoxylin-eosin.

EXPERIMENTAL RESULTS

The investigations showed that the ischemia developing immediately after excision of the main artery caused changes in the nerve fibers and nerve endings.

The changes in the motor nerve endings differed in intensity in the various groups of muscles. The severest changes were observed in the neural structures of the anterior group of femoral muscles. Two days after operation these nerves showed argentophilia, with swellings and gaps in the neuroplasm along the course of the individual nerve fibers, the development of pools of neuroplasm in the region of the preterminal portions of the motor endings, and coarsening of the terminal structures (Fig. 1). On the 3rd-4th day many of the motor nerve endings were disintegrating, while at the same time other motor end-plates could be observed with varicose changes in their terminal portions, and some motor endings were still normal in appearance.

In an absolute majority of the animals a focus of ischemic necrosis was formed on the 5th-7th day after the operation in the region of the middle third of the rectus femoris and vastus lateralis muscles. Impregnation of these areas of the muscles with silver salts showed that the nerve fibers were in a state of Wallerian degeneration (Fig. 2), and motor nerve endings were absent. At the periphery of the necrotic focus could be seen nerve fibers and motor endings with signs of irritation caused by the ischemia (varicose swellings of the nerve fibers, pools of neuroplasm in the region of the preterminal and terminal portions of the endings).

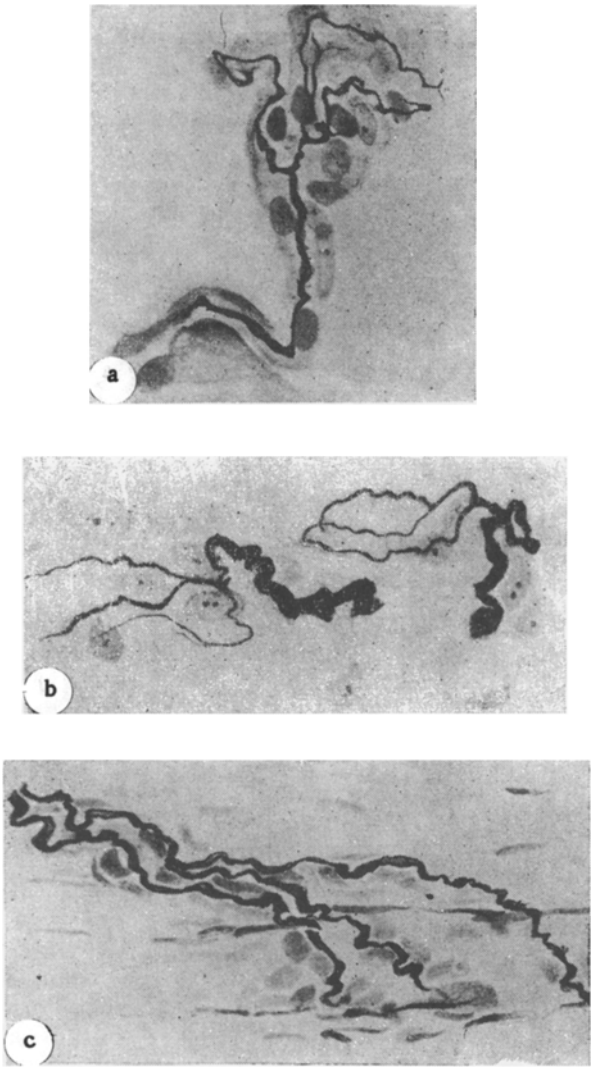

Fig. 1. Anterior group of femoral muscles of a rabbit. a) Motor nerve ending, normal; b) 2 days after excision of the femoral artery; pools of neuroplasm in the region of the preterminal portions of the motor endings; c) 5 days after operation; the preterminal portions of the nerve fibers show varicose changes and motor endings are absent. Photomicrograph. Bielschowsky-Gros. x 400.

On the 10th-14th day after the operation axon collaterals appeared at the periphery of the necrotic region. These collaterals possessed growth bulbs, facing the necrotic focus (Fig. 3). Restoration of the normal structure of the nerve fibers and motor nerve endings in the region of the anterior group of femoral muscles of the rabbit was largely complete at the end of the 1st month after operation.

So far as the changes in the motor nerve endings in the posterior group of femoral muscles are concerned, these were much less marked. After 1-2 days, changes appeared in the motor endings of the posterior group of muscles in the form of a coarsening of the terminals and pooling of neuroplasm in the region of the preterminal portions. No disintegration of motor nerve endings was observed in these muscles. Restoration of the normal structure of the myoneural apparatuses in the posterior group of muscles took place by the 10th-14th day after operation.

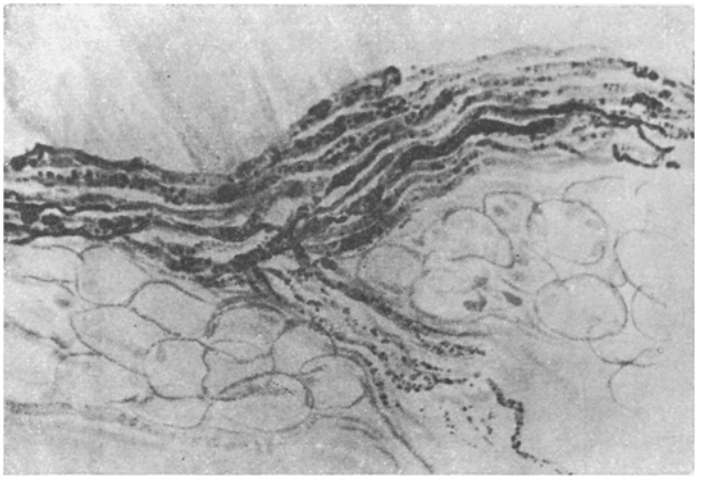

Fig. 2. Anterior group of femoral muscles of a rabbit 7 days after operation. Wallerian degeneration of the nerve fibers. Photomicrograph. Bielschowsky-Gros. × 280.

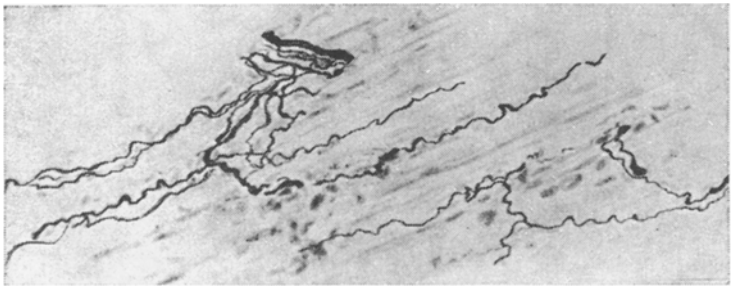

Fig. 3. Anterior group of femoral muscles of a rabbit 21 days after operation. Growth bulbs at the ends of the axon collaterals. Photomicrograph. Bielschowsky-Gros. × 400.

The study of the neural apparatus of the fascia lata showed that changes occurred here, too, as a result of the developing ischemia. After 1-2 days reactive changes developed in the medullated nerve fibers and receptors of the fascia in the form of pooling of the neuroplasm along the course of the nerve fibers and in the preterminal portions of the endings. The receptor apparatuses of the fascia, which have the appearance in the rabbit of delicate, diffuse arborizations with an extensive ramification zone, became coarser in their features. Later, on the 6th-10th day after the operation, nerve fibers could be observed in a state of cloudy swelling. The normal structure of the neural apparatus of the fascia lata of the rabbit was restored at the end of the 1st month after the operation.

The study of the large nerve trunks of the limb by Marchi's method showed that at the end of the 2nd and beginning of the 3rd week the number of Elzholz's bodies in the myelin sheath of the sciatic nerve fibers was considerably increased. These changes could be classed as periaxonal degenerative changes without disturbance of the integrity of the neurofibrillary skelton of the fiber. The study of the fibers of the femoral nerve showed that signs of periaxonal degeneration were accompanied here, at the same periods, by the picture of Wallerian degeneration.

The results demonstrate that the disturbance of the blood supply caused by excision of the femoral artery in the rabbit causes the development of changes in both the motor and the sensory nervous apparatuses of the limb. The degree of severity of the ischemic changes in the myoneural apparatuses differs in the anterior and posterior groups of femoral muscles, as a result of differences in the conditions of restoration of the blood flow in these regions. Whereas the posterior group of muscles, particularly the biceps femoris, is situated near the newly formed collaterals connecting the system of the hypogastric artery to the branches of the popliteal artery, the anterior group of muscles lies away from the main collateral channels, thus hampering restoration of the local blood supply.

It is known that the morphological and functional reorganization of the collateral channels during development of a collateral circulation is under the control of the nervous system [11]. Studies of the state of the receptors in the hind limb of dogs after excision of the femoral artery have revealed changes in the functional state of the sensory nervous apparatuses [2]. The changes we have discovered in the receptor apparatuses of the fascia lata in rabbits may provide morphological proof of a change in the flow of afferent impulses from the region of the hind limb during the development of a collateral circulation.

SUMMARY

Circulatory disturbances resulting from excision of the femoral artery in rabbits causes changes in the nerve structures of the muscles and fascia. Experiments staged on 25 rabbits demonstrated that the most pronounced changes in the nerve fibers and motor endings were observed in the anterior group of the femoral muscles. These are accompanied by proliferative-destructive changes in the receptor structures and medullated nerve fibers in the fascia lata of the femur. Restoration of the normal peripheral nerve structure follows development of collateral circulation, which begins to convey blood to the peripheral portions of the extremity.

LITERATURE CITED

1. V. V. Anisinova, Byull. éksper. biol. 19, 3, 37 (1945).
2. D. M. Gzgzyan and I. D. Lev, in book: Abstracts of Proceedings of a Conference on Functional, Anatomical, and Clinical Aspects of the Collateral Circulation [in Russian], Stanislav (1962) p. 20.
3. P. Z. Gudz', Arkh. anat., 12, 80 (1959).
4. B. A. Dolgo-Saburov and V. N. Chernigovskii, Trudy voen.-med. akad. (Leningrad) 38, 35 (1947).
5. B. A. Dolgo-Saburov and E. P. Mel'man, Proceedings of the Sixth All-Union Congress of Anatomists, Histologists, and Embryologists [in Russian], Vol. 1, Khar'kov (1961) p. 51.
6. Yu. M. Zhabotinskii, Arkh. pat., 6, 15 (1950).
7. E. K. Zhukova, Arkh. pat., 2, 107 (1956).
8. A. S. Kostenetskii, Changes in the peripheral nerves of the limbs during acute ischemia. Author's abstract of doctorate dissertation, Leningrad (1949).
9. A. A. Manevich, Effect of ligation of the main arteries of the lower limb on its viability and function. Author's abstract of doctorate dissertation, Moscow (1956).
10. G. A. Polikarpova et al., in book: Problems in the Morphology, Pathomorphology, and Reactivity of the Peripheral Parts of the Nervous System [in Russian], Kazan' (1961) p. 237.
11. M. G. Prives, Byull. éksper. biol., 12, 53 (1955).
12. M. G. Prives and R. A. Bardina, Trudy Inst. éksperimental'noi morfologii Akad. Nauk Gruz. SSR 6, 46 (1957).
13. L. I. Falin, Proceedings of the Fifth All-Union Congress of Anatomists, Histologists, and Embryologists [in Russian], Leningrad (1951) p. 647.
14. Kh. G. Khodos, in book: Problems in the Pathohistology of the Nervous System [in Russian], Moscow-Leningrad (1940) p. 265.

All abbreviations of periodicals in the above bibliography are letter-by-letter transliterations of the abbreviations as given in the original Russian journal. ***Some or all of this periodical literature may well be available in English translation.*** **A complete list of the cover-to-cover English translations appears at the back of this issue.**
