REPAIR PROCESSES IN THE CENTRAL NERVOUS SYSTEM IN DISTURBANCES OF MOTOR FUNCTION

G. N. Krivitskaya

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A study of the human and animal brain affected by various local lesions showed that destructive changes in the CNS are followed by repair processes aimed at restoring the disturbed functions. The repair processes were manifested by hypertrophy of single neutrons and of glial elements, the appearance of bulbs of growth on nerve fibers, and the formation of new nerve fibers.

Numerous investigations have demonstrated the close structural and functional relationships between the pyramidal and extrapyramidal systems. Clinical and experimental observations have shown that disturbances of motor function are accompanied by structural changes in certain components of these systems.

Information has been obtained on the morphogenesis and the comparative physiology of adaptive and regenerative processes in the peripheral nervous system and spinal cord arising in various pathological states [1-7].

With these findings as a background, and because of the questionable nature of certain views regarding the possibility of regeneration in the central structures of the nervous system, it was decided to investigate this problem in motor disturbances (parkinsonism, hemiparesis, and paralysis).

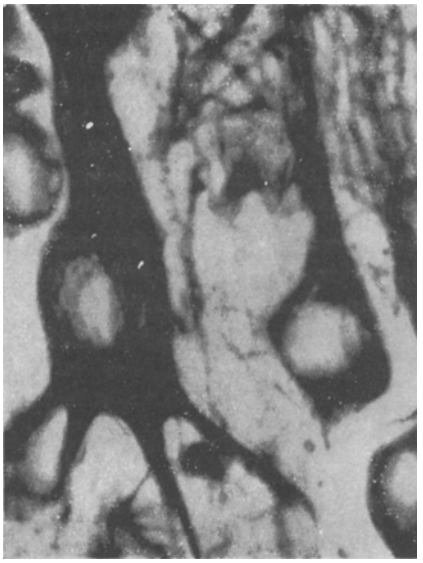

Fig. 1. Hypertrophy of neuron and apical dendrite in layer V of the motor cortex. Impregnation by Glees' method, 900 ×.

EXPERIMENTAL METHOD

Postmortem and experimental material from cases with local lesions of vascular and traumatic etiology were studied.

The postmortem material included lesions of various parts of the pyramidal and extrapyramidal system (area 4, the corona radiata, fibers of the internal capsule, and the strio-pallidary system). The time elapsing between the appearance of the lesion and death was 7 and 14 days, 1 month, 1 month 8 days, 2 and 3 months, 6 years, and 41 years (16 patients with local brain lesions and three control cases). In the experimental series, hemisection of the spinal cord was performed on ten dogs and total transection of the cord on another ten dogs. The animals were decapitated after 7 days and 14 days, 1, 2, 4, 6, and 9 months, and 1, 2, and 4 years (two animals at each time). Serial sections through the brain were studied after staining by the usual neurohistological methods (Nissl, Glees, Spielmeyer, Avtsyn, Marchi, Golgi, Golgi–Deineka, Horneţ, Miyagawa–Aleksandrovskaya).

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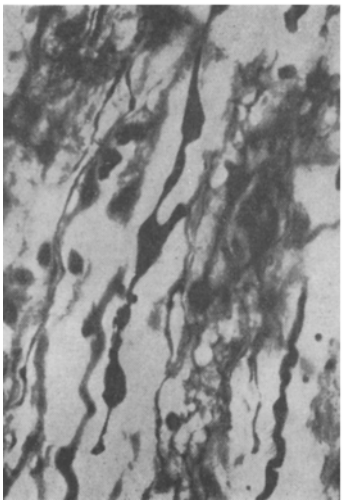

Fig. 2

Fig. 3

Fig. 2. Bulbs of growth and pools along the course of nerve fibers. Impregnation by Avtsyn's method, 900 ×.

Fig. 3. Formation of new fibers at the site of transection. Impregnation by Avtsyn's method, 400 ×.

EXPERIMENTAL RESULTS

Comparison of the disturbances of motor function and the signs of its recovery with the structural changes in the brain showed that both destructive and reparative processes were present. The latter include hypertrophy of various components of nerve tissue: neurons, especially Betz cells in layer V of the human motor cortex in the case of a long standing pathological focus, and spinal cord motoneurons of dogs (above the level of section; Fig. 1), an increase in volume of the apical dendrites and of individual synapses, and hypertrophy of bulbs of growths of nerve endings, nerve fibers, and spinal ganglia (after transection of the spinal cord; Fig. 2).

Clear evidence of hyperplasia of the nerve structures also was found: a) binucleolar and binuclear nerve cells; b) an increased number of nerve fibers and nerve endings (Fig. 3); c) an increased number of glial cells; d) increased argyrophilia of the granules.

Hypertrophy and hyperplasia of the nervous, glial, and connective-tissue elements constitute the structural basis of regenerative processes taking place at the submicroscopic level [5].

It is also possible to distinguish in the CNS regenerative processes which are aimed at strengthening and restoring disturbed functions and which develop mainly on account of the involvement of hitherto inactive (reserve) nervous structures or as a result of morphological and functional adaptation of individual nerve centers. These processes include hypertrophy of the Betz cells in layer V of area 4 after death of nerve cells in the other layers, hypertrophy of the apical dendrites of the cortical pyramidal cells (while the cell itself remains normal in volume), and an increase in the number of nerve fibers and of glial nuclei in layer I of these areas (the motor cortex).

The repair processes observed in the CNS pass through the same phases of development as those observed in the peripheral nervous system [2, 6]: a phase of establishment of compensatory processes, of unstable compensation, of stabilization, and subcompensation, and a phase of exhaustion or decompensation. Each phase is a combination of compensation and decompensation processes and it can be interrupted at the stage of compensation [4, 5], despite the actively continuing processes of intracellular regeneration: enlargement of the nucleolus, hypertrophy of the nuclei and an increase in their number, the appearance of bulbs of growth, and the formation of new nerve fibers.

A study of the dynamics of regenerative changes and of the factors leading to establishment of the phase of stable compensation is an essential preliminary to the search for methods of restoring disturbed functions.

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