CHANGES IN THE NUCLEI OF THE HYPOTHALAMUS DURING THE DEVELOPMENT OF NERVE DEGENERATION

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Many investigations have shown that following trauma to a peripheral nerve, histophathological changes develop not only in the injured segment of the nerve, but also in parts of the central nervous system remote from the site of injury [2-6,9,10]. The morphological data thus obtained characterized the movement of the degenerative process within the nervous system.

Work of particular importance was carried out by B. N. Doinikov [3], who studied the morphological changes in the nervous system following chemical trauma to a peripheral nerve. The idea of the "total" study of the nervous system, suggested by Doinikov, enabled the changes arising in different parts of the nervous system to be analyzed following what he called local trauma of the peripheral nerve. However, insufficient attention was paid in these investigations to the region of the hypothalamus with its differentiated nuclear formation. At the same time, the hypothalamic region, which plays an important role in the trophic function of the nervous system [7,8], deserves a special study.

The object of the present investigation was to examine the changes arising in the hypothalamic region during the development of nerve degeneration.

EXPERIMENTAL METHOD

As a preliminary step, in a special investigation [1], the cell structure of the various nuclei of the hypothalamic region was studied in the normal cat and a topographic map of the region produced, enabling a differential assessment of the experimental findings to be made. Experiments were carried out on cats. In one series, an injection (of 0.1 ml of 2% formalin solution) was given into the right sciatic nerve, while in the other series, the nerve was divided after injection of formalin below the point of injection.

The material for the present investigation consisted of series of frontal sections through the diencephalon of cats sacrificed 7, 21, 45, and 90 days after the operation. The sections were stained with Scharlach R – hematoxylin, with thionine by Nissl's method, and impregnated with silver by Bielschowsky's method.

EXPERIMENTAL RESULTS

The results of the morphological investigation of the hypothalamic region showed that, following this type of interference, changes took place not only in the nerve cells of the individual nuclei of the hypothalamus, but also in the neuroglial cells and the blood vessels. In all cases, the clearest histopathological changes were found in the supraoptic, paraventricular, and posterior and lateral mammillary nuclei. As a rule, not all the cells of the nucleus were affected; usually some nerve cells or groups of cells, showing abnormalities lay among nerve cells with no visible structural changes. The character and degree of severity of the histopathological changes were dependent on the duration of development of the degenerative process in the body. For instance, the severest changes were found in cats sacrificed 45 and 90 days after the operation.

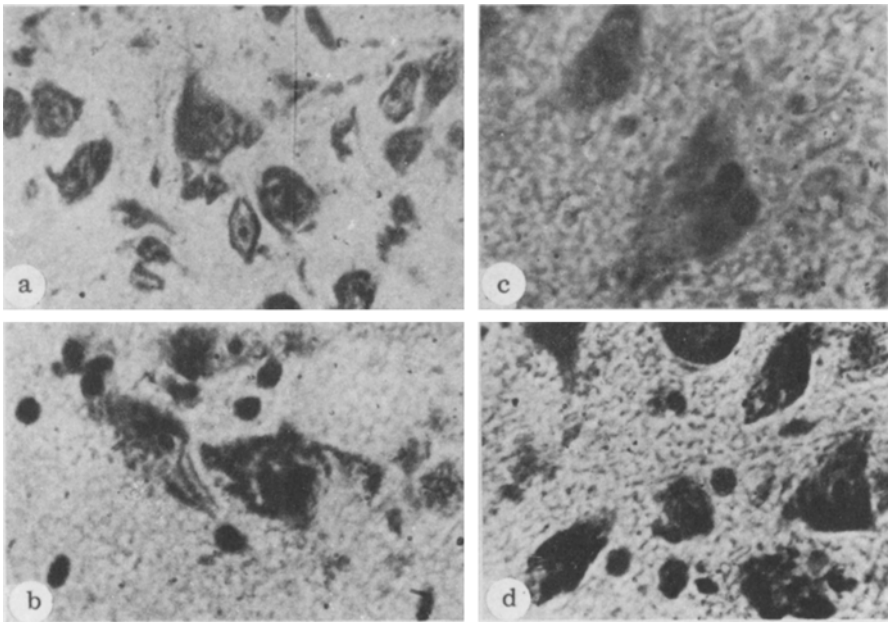

Fig. 1. Changes in nerve cells of individual nuclei of the hypothalamus: a) paraventricular nucleus 21 days after operation. Palely stained nerve cells with honeycomb-like cytoplasm and an eccentric nucleus. Photomicrograph. Nissl's stain, 600×; b) diffuse supraoptic nucleus 90 days after operation. Nerve cell with peripheral chromatolysis. Photomicrograph. Nissl's stain, 900×; c) posterior hypothalamic nucleus 90 days after operation. Pale nerve cell with dust-like residue of Nissl's substance. Cluster of neuroglial cells around a degenerating neuron. Photomicrograph. Nissl's stain, 900×; d) lateral mammillary nucleus 45 days after operation. Eccentricity of nuclei of nerve cells. Photomicrograph. Nissl's stain, 600×.

The study of the individual nuclei of the hypothalamic region in the experimental and normal (control) animals in serial sections revealed the following main types of changes in the nerve cells (Fig. 1): pale staining of the cytoplasm with a dust-like (instead of large granules) chromatophilic substance, an eccentric arrangement of the nucleus and nucleolus and the appearance of small vacuoles in the cytoplasm of many cells, giving this cell a honeycombed appearance (paraventricular nucleus); disintegration or lysis of the chromatophilic substance, the appearance of cells with indistinct borders and, in some cases, the complete lysis of the cell (diffuse supraoptic nucleus and posterior hypothalamic nucleus; the extreme ectopia of the nucleus in many neurons was a conspicuous feature of the lateral mammillary nucleus). As mentioned above, besides changes in the nerve cells, changes were also present in the neuroglia and vessels (Fig. 2). In the diffuse supraoptic nucleus and the posterior hypothalamic nucleus, an increase in the number of neuroglial cells and of clusters of these cells was observed, and frequently the nerve cells were surrounded by a more or less continuous ring of neuroglial cells, and sometimes the neuroglial cells were found actually among the nerve cells. Vascular disorders were seen in the meninges and the brain tissue. All the vessels in the hypothalamic region were considerably dilated and congested, and in some small vessels, swelling of the nuclei of the endothelium could be seen, and lipid droplets were present in the wall and the lumen of many vessels.

Hence, injury to the sciatic nerve caused marked morphological disturbances in the anterior and posterior nuclei of the hypothalamus. Injection of formalin into the whole nerve and division of the nerve after injection of formalin produced similar results, although in those cases, when the nerve was subjected to both chemical and mechanical injury, the changes were more intensive.

The severity of the histopathological changes was observed to be related to the duration of development of degeneration. This was because, in the later stages, the generalized degenerative changes in the tissues of the body progressed. By this period, the trophic ulcers on the corresponding limb were more severe, sometimes degenerative disturbances were observed to have developed on the contralateral limb, and the body weight of the animals fell progressively. All these factors characterize the degree of severity of the general degenerative process.

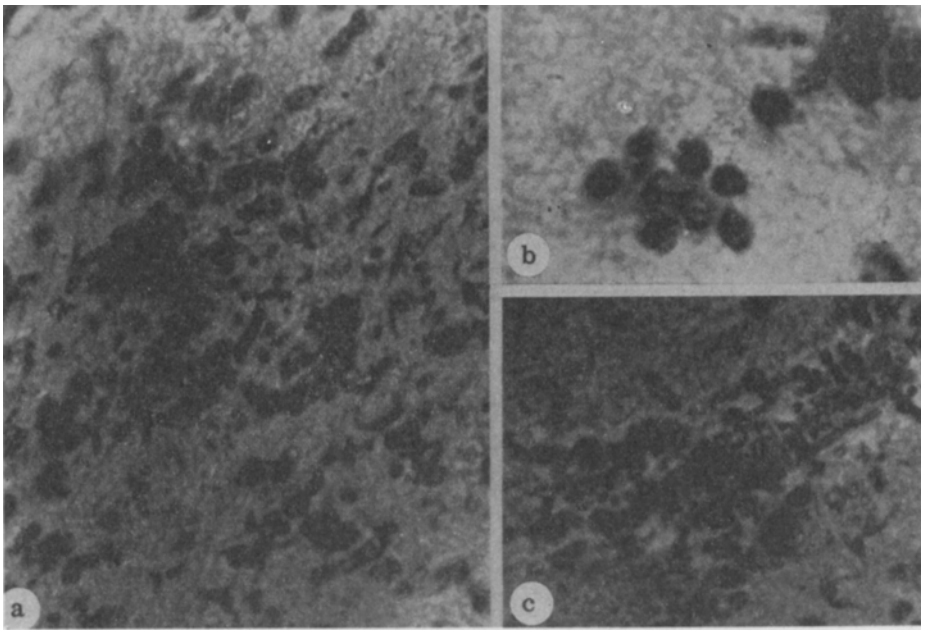

Fig. 2. Changes in neuroglia and vessels of the hypothalamus: a) posterior hypothalamic nucleus 45 days after operation. Residual neuroglial nodules. Photomicrograph. Nissl's stain, 300×; b) diffuse supraoptic nucleus 90 days after operation. Nerve cells surrounded by neuroglia. Photomicrograph. Nissl's stain, 600×; c) vessel from the hypothalamic region 21 days after operation. Lipids in wall and lumen of vessel. Photomicrograph. Deddi's stain, 400×.

There is reason to suppose that the slow course of the degeneration of the tissues after division of the sciatic nerve is due not only to the loss of function of this nerve, but also to disturbances of the central regulatory mechanisms becoming involved in the degenerative process as a result of its generalization. These must be taken into account when evaluating the pathogenesis of a trophic ulcer and when seeking methods of pathogenetic prophylaxis and treatment of this serious pathological condition. These conclusions become particularly evident when it is remembered that direct injury to the hypothalamic region, as A. D. Speranskii and co-workers showed, leads to the development of a general degenerative process involving many organs and systems of the body.

LITERATURE CITED

1. S. A. Babayan, in the book: Problems in the Physiology of the Autonomic Nervous System and Cerebellum [in Russian], Erevan (1964), p. 64.
2. M. L. Borovskii, Regeneration of the Nerve and Trophism [in Russian], Moscow (1952).
3. B. S. Doinikov, Arkh. biol. nauk, 37, 1, 51 (1935).
4. Yu. M. Zhabotinskii, Arkh. biol. nauk, 37, 1, 273 (1935).
5. E. K. Plechkova, Reaction of the Nervous System of the Organism to Chronic Injury of a Peripheral Nerve [in Russian], Moscow (1961).
6. V. V. Semenova-Tyan-Shanskaya, Problems in the Pathohistology of the Nervous System [in Russian], Moscow-Leningrad (1940), p. 91.
7. A. D. Speranskii, The Nervous System in Pathology [in Russian], Moscow-Leningrad (1930).
8. A. D. Speranskii, Elements in the Construction of a Theory of Medicine [in Russian], Moscow (1937).
9. B. A. Favorskii, Sov. psikhonevrol., 1, 33 (1941).
10. T. A. Chetchueva, in the book: Problems in the Pathohistology of the Nervous System [in Russian], Moscow-Leningrad (1940), p. 35.