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PATHOMORPHOLOGY OF THE SUPERIOR CERVICAL SYMPATHETIC GANGLIA IN BURNS

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The cervical sympathetic nerve is the superior part of the lateral vertebral ganglionic chain. Arranged vertically on the transverse processes of the cervical vertebrae, this chain consists of 2-3 ganglia, joined by connecting nerve fibers [5, 10]. The superior cervical sympathetic ganglion, as a peripheral center for nervous regulation, plays a very important role in the pathogenesis of various diseases of the cardiopulmonary system [4, 11, 13]. The efferent innervation of the lungs is provided by the parasympathetic and sympathetic nervous system, for it has been shown that some bodies of postganglionic neurons, located in the cervical and stellate sympathetic ganglia, are connected with effectors of various tissue formations in the lungs [7, 8]. The study of the structural changes in the superior cervical sympathetic ganglia in burns is accordingly of great theoretical and practical importance, more especially because burn trauma is known to be complicated frequently by pneumonia and with manifestations of cardiopulmonary failure [3, 6, 9]. Similar investigations have been undertaken in diseases of the cardiovascular system, essential hypertension, and so on [1, 11]. In spite of the very important role of the nervous system in the pathogenesis of burns, no systematic studies have yet been undertaken of the dynamics of the morphological changes in the peripheral nervous system during thermal burning, or of the reversibility of these changes. Analysis of structural changes in the superior cervical sympathetic ganglia in burn trauma by the use of classical neurohistological and modern neurohistochemical methods is still awaited, and the investigation described below was undertaken for this purpose.

EXPERIMENTAL METHOD

The investigation was conducted on autopsy material from 75 cadavers of patients dying at different periods of burns (shock, toxemia, septicotoxemia, burn cachexia.) The ages of the patients was between 19 and 85 years. Autopsy was performed at various times from 3 to 6 h after death. The test objects were the superior cervical sympathetic ganglia. After fixation in 12-20% solutions of neutral formalin the material was embedded in paraffin wax. Sections were stained with hematoxylin and eosin and picrofuchsine by Van Gieson's method and were impregnated with silver nitrate by the methods of Bielschowsky—Gros and Campos. Nissl's method and neurohistochemical methods of staining adrenergic structures by incubation of sections in a 2% solution of glyoxylic acid in the modification in [12] also were used. Cholinergic nerve structures were detected by the method of Karnovsky and Roots.

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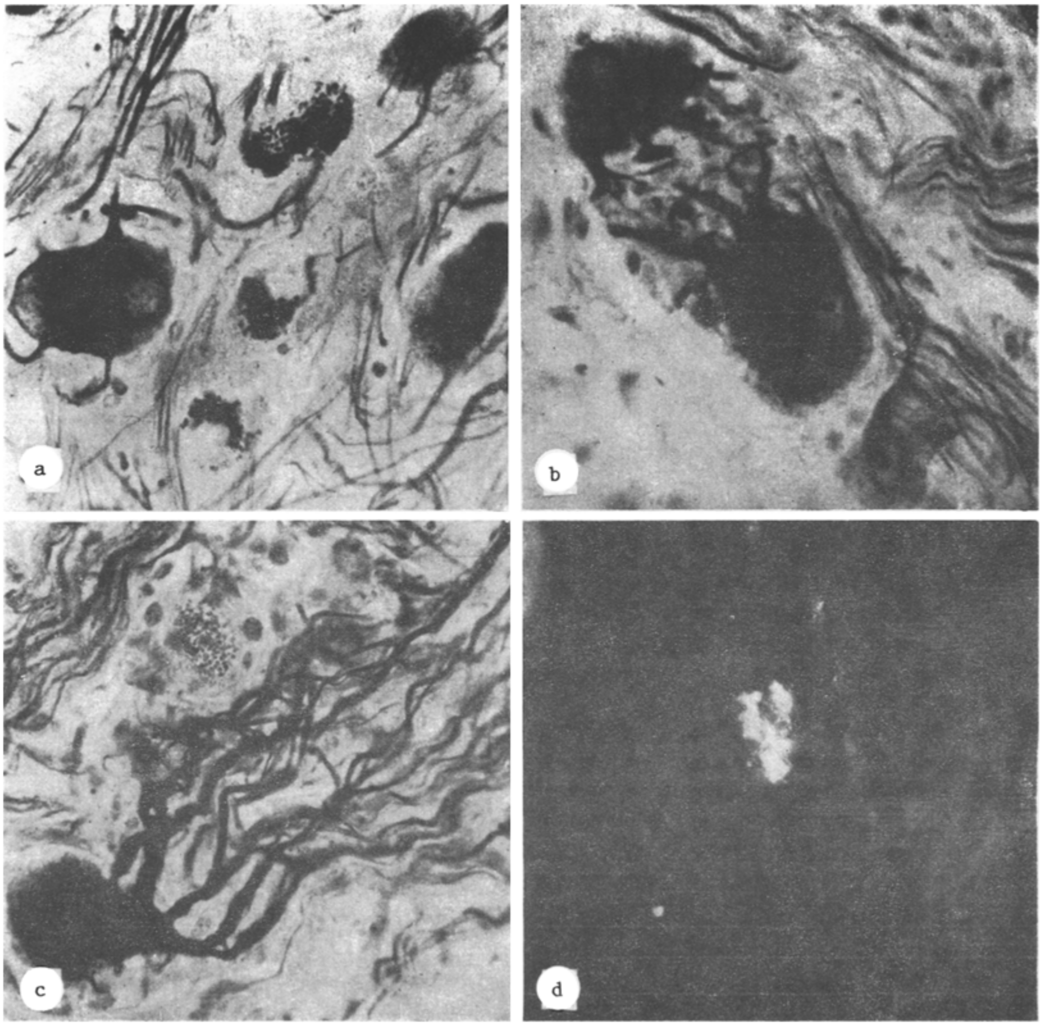

Fig. 1. Changes in superior cervical sympathetic ganglia in different periods of burns. a) Different stages of swelling, pigmented atrophy, necrosis, and neuronophagy of nerve cells (burn toxemia); b) partial atrophy of bodies and processes of some neurons and compensatory hypertrophy and appearance of binuclear bodies of neighboring neurons (burn septicotoxemia); c) hyperargentophilia of body and proliferation of dendrites of nerve cell (burn cachexia); d) bright fluorescence of catecholamines in cytoplasm of neurons (burn shock). a, b, c) Impregnation by Bielschowsky–Gros method; d) incubation of sections in 2% solution of glyoxylic acid. Magnification: a, c) 400, b) 600, d) 120.

EXPERIMENTAL RESULTS

Structural changes in the superior cervical sympathetic ganglia at different stages of burns are characterized by a wide variety of degenerative and regenerative processes. Congestion and edema of the stroma of the ganglia as a rule were found in sections stained with hematoxylin and eosin in the stage of burn shock and toxemia. Cells with signs of acute swelling were round and oval in shape and their cytoplasm was palely stained and had a finely granular appearance. In preparations stained by Nissl's method, a uniform dispersion of chromatophilic substance and diffuse but weak staining of the cytoplasm with thionine were found in such neurons. The processes of the cells also were swollen and readily visualized, being stained pale blue. Acute swelling of the nerve cells is a reversible process. However, some such neurons underwent necrobiosis and died. In this final phase of generative changes chromatolysis of the cells increased and the cytoplasm became completely colorless. Our observations show that acute swelling of the neurons appears particularly often in cases when severe hypoxia develops at the end of the disease and death is preceded by prolonged agony.

In preparations impregnated with silver changes were observed in the neurofibrillary system of the cells. Both in the perikaryon and in the processes of the neurons the neurofibrils were thickened, glued together, fragmented, and liquefied. These ganglions cells later compltely lost their chromatophilic substance, neurofibrils, nucleus, and nucleolus and were converted into cell ghosts, namely structureless formations, undergoing neuronophagy by proliferating pericellular glial cells and the surrounding connective-tissue cells. Often different stages of swelling, pigmented atrophy, necrosis, and neuronophagy of the nerve cells of the superior cervical sympathetic ganglia could be observed in the same section, especially during period of burn toxemia and septicotoxemia (Fig. 1a).

Together with degenerative and necrobiotic changes in neurons of the superior cervical sympathetic ganglia, signs of regeneration and compensatory hypertrophy also were observed in them. Simultaneously with these events, marked changes took place in the connections of the preganglionic fibers with bodies and processes of the nerve cells. In the later stages of burns, interneuronal connections could be preserved for a long time despite wasting and atrophy of the nerve cell body. The process of partial atrophy of one nerve cell can be seen to be accompanied by compensatory hypertrophy of the bodies of neighboring neurons and the appearance of binuclear neurons (Fig. 1b).

In some places the regenerative process was characterized by the formation de novo of islets of nerve cells and the appearance of collaterals on pre-existing processes, leading sometimes to the formation of an extremely complex structure of neurons and their connections. Hypertrophy of neurons is accompanied by an increase in size of their body, nucleus, and nucleolus and by thickening and hyperplasia of their processes. Sometimes the dendrites of a nerve cell surround its body in the form of a basket, intertwining with filaments of the pericellular apparatus. Excessive proliferation and thickening of the dendrites of the nerve cell sometimes resemble neuromatosis in character. Their regenerative and compensatory-adaptive processes mentioned above in the structural elements of the superior cervical sympathetic ganglia were often found in the later stages of burns (Fig. 1c). In some preparations, simple and more complex sensory endings in the interstitial tissue of the ganglion and on the capsule of nerve cells could be observed among the growing nerve fibers. The overwhelming majority of these endings had the appearance of sensory nerve tufts, but glomerular forms of receptor formation also were found among them. Their terminal branches frequently ended in the stroma of the ganglion, on its capsule, and on glial cells.

The results of the neurohistochemical investigation show that various adrenergic structures are represented in the human superior cervical sympathetic ganglia, and undergo characteristic changes in burns. Other changes in these structures depended on the age of the patient, the stage of development of the burns, and treatment given. Toward old age there is a marked decrease in catecholamine concentration in many adrenergic structures of the superior cervical sympathetic ganglia. The study of adrenergic nerve structures in the initial stages of burns revealed bright fluorescence of catecholamines in the cytoplasm of neurons of the superior cervical sympathetic ganglia, whereas terminals of nerve bundles in the ganglia were distinguished by a marked decrease or disappearance of luminescence (Fig. 1d). A prolonged agonal period in patients dying from burns was usually accompanied by a histochemical picture of more profound exhaustion of catecholamines. Nerve cell bodies had weaker acetcholinesterase (AChE) activity than the adjacent bundles of nerve fibers. Meanwhile high AChE activity was found on the walls of blood vessels surrounding the ganglion. In some sections areas of destruction of nerve cells with deposition of pigmented masses in many of them were observed. Damage to most of the sympathetic nerve cells also was observed, indicating a severe disturbance of adaptive and trophic influences on the specific function of the nervous system.

The results obtained by the aid of modern neurohistochemical methods of investigation are thus in agreement with those obtained by classical neurohistological methods. Exhaustion of catecholamines in the adrenergic structures of the superior cervical sympathetic ganglia is observed during the first day of burn trauma (the stage of burn shock). Some recovery of the neurotransmitter reserves in them takes place in the subsequent periods of burns. In our view, the fluorescence-histochemical method can be used to clarify some mechanisms of development of the burn syndrome and of its lethal outcome, and also to provide a solid basis for various therapeutic measures in the event of complications affecting the cardiovascular and other systems.

To conclude, extremely complex structural changes arise in the afferent and efferent components of the peripheral nervous system in different stages of burn trauma. The changes noted above are evidently monitored by the CNS with the aid of sensory nerve endings which we demonstrated in the ganglia.

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