MORPHOLOGICAL CHANGES IN GANGLIA OF THE CELIAC PLEXUS FOLLOWING MAJOR ABDOMINAL OPERATIONS

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KEY WORDS: celiac ganglia; gastrectomy; histologic changes; postgastrectomy syndrome.

The question of histologic changes in the celiac plexus after operations on organs of the gastrointestinal tract has been inadequately studied [5, 7]. Yet the celiac plexus is a most important autonomic structure which innervates nearly all the abdominal organs. It must be noted that many patients undergoing resection of the stomach suffer from a postgastrectomy syndrome, which can be characterized as a complex visceral vegetative neurosis in the pathogenesis of which an important role is probably played by structural changes in the celiac plexus [2, 3, 5, 6].

The aim of this investigation was to study the dynamics of histologic and ultrastructural changes in ganglia of the celiac plexus after resection of two-thirds of the stomach and to compare it with the dynamics of histologic changes at the light-optical level in ganglia of the celiac plexus after economical resection of the stomach, cholecystectomy, and resection of the large intestine.

EXPERIMENTAL METHOD

Experiments were carried out on 163 mature dogs and another 15 dogs formed the control group. Gastrectomy (61 dogs) was carried out by the Hofmeister–Finsterer method. Ganglia of the celiac plexus were fixed in 96° alcohol or 12% neutral formalin immediately after the animal's death (rapid exsanguination, electrocution). Histologic preparations were stained by Nissl's and Einarson's methods, with hematoxylin and eosin, impregnated with silver by Campos' method and by the Bielschowsky–Boeke method in Lavrent'ev's modification, by Van Gieson's method and the PAS reaction. Ganglion cells of the celiac plexus were counted in every 10th serial section under a magnification of 200. The total number of nerve cells, the number of neurons with a normal structure, and the number of altered neurons (in the same field of vision) were counted. Numerical changes discovered were expressed as percentages. An electron-microscopic study was made of 22 dogs. Pieces of celiac ganglia were taken for investigation by laparotomy under general anesthesia. Intravital and subsequent fixation were carried out in 2.5% glutaraldehyde solution and 1% OsO_4 solution, followed by embedding in a mixture of Epon and Araldite. Sections were stained in uranyl acetate and in Reynolds' solution and examined in the JEM-100B electron microscope.

EXPERIMENTAL RESULTS

Structural changes in ganglion cells of the dog's celiac plexus were observed from the 3rd day after the operation. They were classified as readily reversible changes (I degree), marked changes of dystrophic character (II degree), and destructive changes (III degree). The initial changes were characterized by signs of central chromatolysis, accumulation of RNA granules at the periphery of the perikaryon, and an irregular configuration of the nucleus. The number of modified neurons on the 3rd day after resection of two-thirds of the stomach was 20%. The number of ganglion cells with histologic changes of reversible character 1 week after the operation was 42%. During this period vacuolation of the perikaryon and ganglionic stroma was observed in some ganglion cells, evidence of marked edema of the parenchyma and

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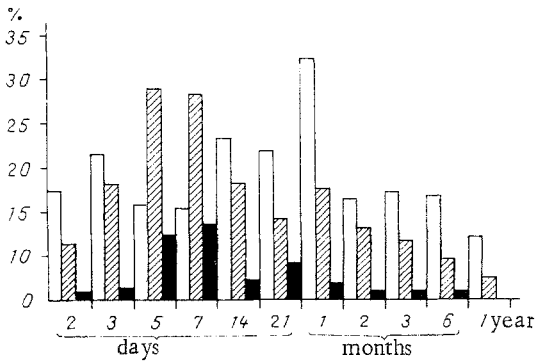

Fig. 1. Dynamics of histologic changes in ganglion cells of celiac plexus after resection of two-thirds of stomach. Abscissa, time after operation; ordinate, changes, in %. Unshaded columns — readily reversible histologic changes (I degree), obliquely shaded columns — marked histologic changes of dystrophic character (II degree), black columns — destructive histologic changes (III degree).

stroma of the celiac ganglia. Single shrunken nerve cells also were observed. Groups of shrunken neurons numbering 5-7 were found in the peripheral zones of the ganglia. Some ganglion cells had a perikaryon deformed at the periphery. The number of nerve cells with signs of evident destruction of cytoplasm and nucleus 1 week after the operation was 9.9% (Fig. 1). In many ganglion cells the glucosaminoglycan content was reduced 2 weeks after resection of two-thirds of the stomach, but the number of ganglion cells with signs of destruction was down to 6%. Degeneration of single myelinated and unmyelinated nerve fibers was observed. By the end of the 3rd week the number of neurons with irreversible changes was 5.3%. The number of shrunken nerve cells was increased whereas the number of ganglion cells with signs of intracellular vacuolation was appreciably reduced. Areas of intraganglionic stroma undergoing vacuolation were found less and less often. This indicatas a reduction of intraganglionic edema, which facilitates tissue hypoxia which, in turn, prevents more successful repair of affected tissue structures. Structural normalization was thus observed from the end of the 2nd week after resection of two-thirds of the stomach. It was characterized by a reduction in the intensity of histologic changes. In the course of 1 year after the operation the number of neurons with signs of reversible changes averaged 29%, and the number undergoing destruction was 2.4%. Repair processes were observed throughout the immediate and long-term postoperative period, starting with the end of the first week after the operation. These processes were manifested as structural and plastic changes in all the intracellular organoids without exception, terminating in gradual restoration of the normal structure. The clearest evidence of this is given by the results of electron-microscopic studies of ultrastructure of ganglia in the celiac plexus in the early and late postoperative period after resection of two-thirds of the stomach.

The results of these investigations showed that early changes in the celiac ganglia are found 1 day after gastrectomy. They consist of appreciable dilatation of cisterns of the rough endoplasmic reticulum in the perikaryon of ganglion cells and also of perisomatic gliocytes and neurolemmocytes. These changes are more marked on the 3rd day after the operation. Their intensity increases toward the end of the first week (Fig. 2) and then gradually decreases. Besides dilatation of cisterns of the endoplasmic reticulum, widening of the dicthyosomes of the lamellar complex (Golgi complex), disappearance of free and bound ribosomes from the perikaryon, peri- and intracellular vacuolation of the cytoplasm, and widening and deformation of the mitochondria and their cristae, which often undergo lysis, also were observed. Numerous groups of lysosomes, of the lysosomal complex type appeared in the cytoplasm of both ganglion and glial cells and the number of phagosomes increased appreciably. The concentration of synaptic vesicles near the presynaptic membrane decreased in the synapses, the vesicles were scattered and deformed, and vesicular conglomerates appeared. Cases of degeneration of myelinated and unmyelinated nerve fibers were frequent. The most serious changes, evidence of irreversible processes developing in some ganglion and glial cells were found from the 3rd day after operation. They took the form of the appearance of circumscribed areas of destruction of cellular organelles and the nuclear membrane, and changes in electron

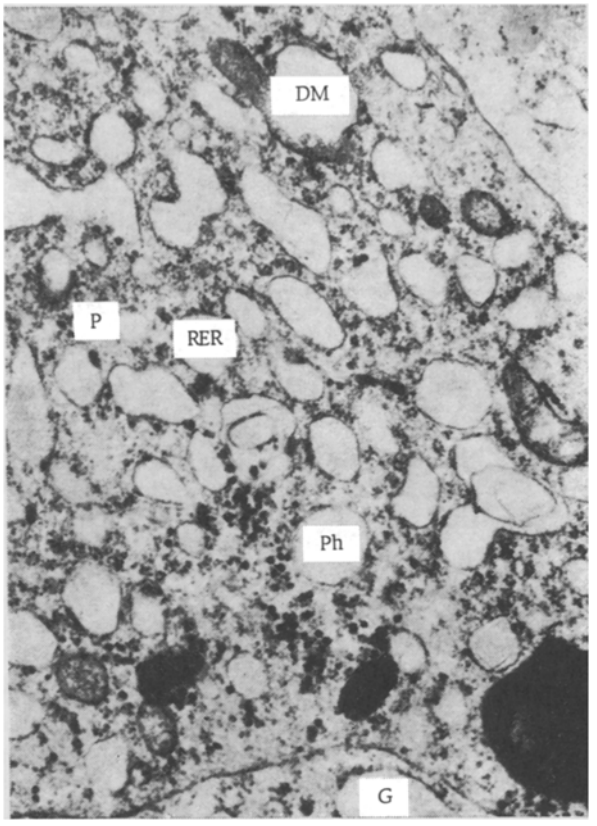

Fig. 2. Marked widening of rough endoplasmic reticulum in perikaryon of ganglion cell from celiac plexus, accumulation of osmiophilic bodies, destruction of mitochondria, and appearance of phagosomes (1 week after resection of two-thirds of stomach). 15,000 ×. P) Perikaryon of ganglion cell; RER) rough endoplasmic reticulum; G) pericapsular gliocyte; DM) destruction of mitochondrion; Ph) phagosome.

density of perikaryon and nucleus. Destruction of mitochondria accompanied by translucency of the matrix and fragmentation of cristae, was observed particularly often. Destruction of cisterns of the rough endoplasmic reticulum and the appearance of multiple large vacuoles in the cytoplasm were observed, evidence of commencing vacuolar degeneration of the cell. Degeneration of nerve fibers was of the pale or, less frequently, the dark type. Characteristically, besides ganglion cells with changes of reversible type, and of cells with signs of destruction, neurons with a normal histologic structure also were observed.

Histologic analysis of the celiac ganglia of dogs undergoing economical resection of the stomach (40 animals), cholecystectomy (34), and resection of the small intestine (28) revealed structural changes similar to those described above. However, the intensity of these changes was reduced by half compared with those observed after resection of two-thirds of the stomach, and structural normalization ended after shorter times (under 2 months after the operation).

It can thus be concluded from these results that a leading place in the pathogenesis of the postgastrectomy syndrome is played by pathological structural changes developing in the celiac plexus after the operation. Accordingly, it will be evident that preventive measures to protect the celiac ganglion against the action of harmful factors of various kinds on it during the operation must be worked out.

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LOCALIZATION OF CHOLINE ACETYLTRANSFERASE IN HUMAN BRAIN STEM NEURONS

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There is as yet no unanimity among research workers on the relative importance in the human brain of nervous connections along which impulses are transmitted during acetylcholine (ACh) secretion [1]. Identification of the mediator in brain interneurons proved particularly difficult. This difficulty was not overcome by the use of a radiometric method, such as is widely used to study cholinergic transmission [5]. Real opportunities for establishing the topography of Ach-synthesizing neurons have been provided by histochemical and immunohistochemical methods of investigation of choline acetyltransferase – CAT (E.C. 2.3.1.6). These methods have the important advantage that cholinergic and choliniceptive functions of the neuron can be diagnosed simultaneously in the same histologic preparation [7].

EXPERIMENTAL METHOD

CAT activity was studied in the medulla, pons, and midbrain of five human fetuses aged 6-8 lunar months. By this time, according to data in the literature [6], the enzyme has attained definitive activity. A full description of the histochemical method of CAT detection was given previously [3]. Transverse sections 10 μ thick of the brain stem were cut in a cryostat, and incubated at 37°C for 2.5 h in solution with the following final concentration: 25 mM cacodylate buffer, $1 \cdot 10^{-3}$ M DFP, 4 mM choline chloride, 1 mM lead nitrate, 5% sucrose, and 0.3 mM acetyl-CoA, pH 6.0. After incubation the sections were washed with water, treated with 5% ammonium sulfide, and mounted in balsam. The sections were studied under maximal resolving power of the light microscope, using an immersion system so that cytoplasmic and synaptic CAT could be determined.

EXPERIMENTAL RESULTS

The localization of CAT was determined by the precipitate formed as the result of the reaction, the color and extent of which indicated the level of enzyme activity [2]. The enzyme was discovered in the cytoplasm and processes of neurons and also in synaptic terminals (Fig. 1). On the basis of these signs, the choliniceptive and cholinergic functions of the neuron could be identified. The presence of CAT in the cytoplasm and processes is evidence of ACh synthesis in the given neuron and indicates that it has a cholinergic function. The localization of CAT in the synaptic thickenings proves, on the one hand that ACh is synthesized in them and, on the other hand, that the neuron with which these synapses make contact has choliniceptive function.

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