STATE OF THE SMALL INTESTINE AND ITS INTRAMURAL NERVOUS SYSTEM AFTER INTERRUPTION OF ALL NERVOUS CONNECTIONS WITH THE CENTRAL NERVOUS SYSTEM

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Central denervation of the small intestine causes sharply defined and prolonged disturbances of its structure and function. Reinnervation reduces the severity of these disturbances and hastens the return to a normal state of the intestine.

In connection with the clinical use of operations such as selective vagotomy and sympathectomy, and also with the development of operations to transplant the digestive organs, interest in the effects of interruption of central nervous influences on an organ has been aroused [2, 5, 7, 11, 15].

The object of the present investigation was to study the effects of complete division of the nervous connections of the small intestine with the central nervous system on the tissues of the intestinal wall, its intramural nervous system, and the nerves of the mesentery.

EXPERIMENTAL METHOD

Mongrel dogs of both sexes, weighing 12-25 kg, were used. In the experiments of series I (23 dogs) the central connections of the small intestine were severed [4]. The intestine was divided in its proximal and distal portions, and a wedge-shaped portion of the mesentery and its root, except for the cranial mesenteric artery, was excised. The artery was carefully freed from adventitia and the wall of the vessels was treated with 5% tincture of iodine or with a saturated solution of phenol. The continuity of the digestive tract was then restored. In the experiments of series II (16 dogs) the intestine was reinnervated by suturing the previously divided ends of the cranial mesenteric plexus by a method devised by the writers [10]. The completeness of denervation and reinnervation of the intestine was verified by the presence of a recto-enteral reflex and by testing the duration of the inhibitory action of the central cholinolytic methyldiazil on movements of the intestine [1, 3, 10, 12, 13].

Material for microscopic examination was taken 1-15 days and 1-15 months after the operation, either at autopsy or by resection biopsy. Pieces were excised from the small intestine at the level of loops 2-3 and also from the mesentery at different distances from its root. The material was fixed in 80% alcohol and in a 10% solution of neutral formalin. The sections were stained with hematoxylin–eosin and by Van Gieson's method. Neutral polysaccharides were detected histochemically, acid polysaccharides by Steedman's method with alcian blue, RNA by Brachet's method, and DNA by Feulgen's method. To study the intramural nervous system of the intestine, material was fixed in Carnoy's solution and in 10% neutral formalin, while to detect enzymes the fixative used was calcium–formol or the fresh material was frozen.

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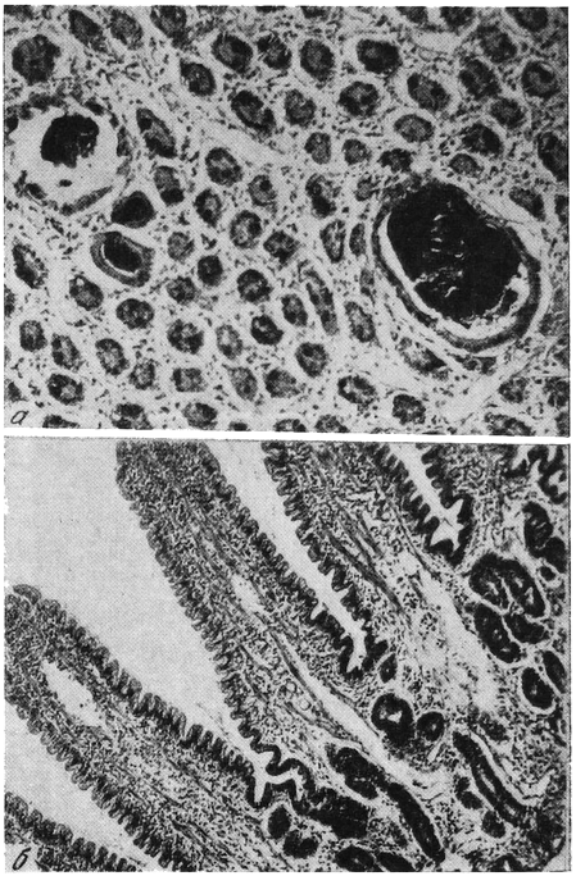

Fig. 1. Changes in lymphatics of mucous membrane of small intestine after operation: a) cysts in crypts and dilatation of lymphatics at the end of the first few days after operation. McManus. 100 ×. b) Subsidence of inflammatory process, persistence of ectasia of lymphatics 14 days after the operation. Hematoxylin – eosin. 70 ×.

Auerbach's plexus was detected by the Bielschowsky–Gros impregnation method, and succinate dehydrogenase (SDH) activity was determined by Nachlas's method and acid phosphatase activity by Gomori's method. The function tests used were described previously [4, 8].

EXPERIMENTAL RESULTS

During the first month after denervation of the intestine, acute catarrhal inflammation of the organ without necrotic changes was observed. This was accompanied by increased desquamation of the epithelium of the villi, by the formation of small cysts (Fig. 1a), by increased mucus formation, by marked edema of all layers of the intestinal wall, and by considerable ectasia of the blood vessels and lymphatics. In the second half of the month these changes subsided (Fig. 1b). In late stages after the operation (3–12 months) the normal structure of the mucous membrane was still not restored, and cystic dilatation of the crypts and flattening of the epithelium of the villi were observed. The lymphatic sinuses and vessels remained dilated. Fresh recurrent attacks of enteritis occurred periodically.

During the first few days after denervation strong argyrophilia of all the neurons and neuroglial cells of the intramural nervous system could be seen. This reached a maximum by the seventh day. Activity of SDH and acid phosphatase fell (Fig. 2). Starting on the 10th day, recovery of the structural and enzymic organization of the neurons was observed. Two months after the operation it was difficult to distinguish the intramural nervous system of the denervated intestine from normal.

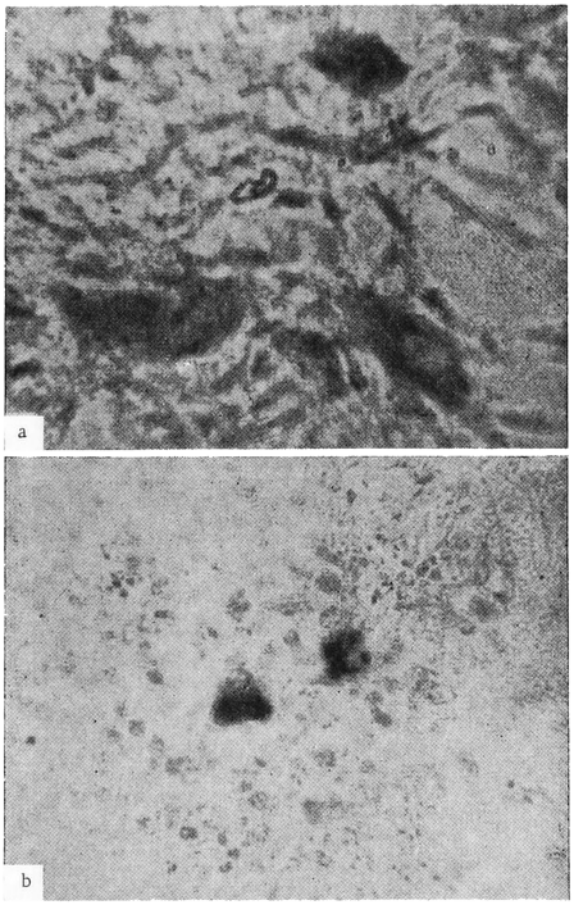

Fig. 2. Neurons of Auerbach's plexus of the small intestine 6 days after operation: decrease in SDH (a) and acid phosphatase (b) activity. a) Method of Nachlas et al.; b) Gomori's method. 400 ×.

At various periods after the operation slight disturbances of the structure of nerve fibers in the mesentery were found. By the 10th-11th day, signs of destruction of nerve fibers were accompanied by the appearance of bulbs of growth close to the root of the mesentery. Thirty days after operation they were also found at the edge of the intestine. At later periods after the operation, as a rule no substantial changes were found in the nerves of the mesentery.

In the experiments in which reinnervation was brought about surgically, the degree of ectasia of the lymphatics was less. Bulbs of growth could be detected in the nerves at the root of the mesentery 2-5 days later, and near the intestine 2 weeks later.

Investigations of the secretory and evacuatory-motor activity of the small intestine after isolation from the central nervous system showed that, starting from the first 2-3 weeks, an increase took place in the secretion of intestinal juice with a reduced content of solids, the periodic component of the motor activity was inhibited, the tonic component was sharply increased, evacuation of food was accelerated, and the stools were liquid and frequent. The intensity of these changes gradually diminished, but the normal state was not restored even 15 months after the operation. In the experiments of series II, the same changes in the structure and function of the small intestine were observed in the early periods as in series I, but these changes were less severe and they disappeared sooner. After the second week the secretory, and after the 4th-6th week the evacuatory, functions gradually returned to normal, which they reached by 6 months (Fig. 3), at the same time as the nervous connections of the intestine with the central nervous system were restored [8, 9].

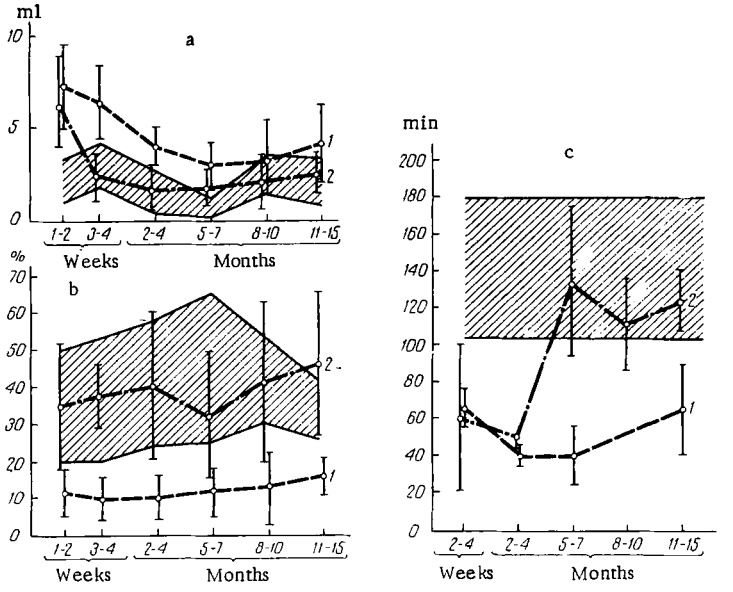

Fig. 3. Results of investigation of the secretory and evacuatory-motor functions of the small intestine ($M \pm \sigma$): a) total volume of intestinal juice secreted in 3 h; b) solids in juice, in%; c) time of passage of food along small intestine. 1) Central denervation; 2) central denervation followed by surgical reinnervation. Shaded area and broken line represent control (healthy animals).

Acute enteritis is observed not only after isolation of the small intestine from the central nervous system, but also after other procedures, such as temporary anemization of the small intestine [7, 8, 13]. However, after denervation the disturbances were more marked and they disappeared more slowly. This confirms the view that interruption of the central nervous connections is the severest form of trauma so far as the intestine is concerned [4]. The persistent lymphangiectasia, the cystic dilatation of the crypts, and the flattening of the epithelium of the villi are evidently characteristic of central denervation itself. Desympathization of vessels is known to cause them to dilate [5, 6], and this produces a disturbance of the secretion of mucus and certain disorders of the secretion of intestinal juice [14], and it obstructs the orifices of the crypts, thus leading to cystic dilatation of the crypts.

Despite restoration of the normal structure of the extramural and intramural nervous system of the small intestine in the late stages after denervation, the functional disturbances persisted until restoration of central nervous influences on the small intestine. The optimal conditions for restoration of the structure and function of the intestine were created as a result of surgical reinnervation.

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