EFFECT OF PROXIMAL RESECTION OF THE SMALL INTESTINE ON THE MORPHOLOGY
AND FUNCTION OF ITS ENDOCRINE SYSTEM

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The endocrine apparatus of the small intestine (SI) is a component of the diffuse endocrine system (DES). The role of the DES in the regulation of intestinal functions has recently been discussed in the literature [3 4]. However, there have been only isolated studies of morphological and physiological changes in the endocrine apparatus of SI after its partial resection [8, 9].

The aim of this investigation was to study the functional morphology of the endocrine cells of SI after its proximal resection.

EXPERIMENTAL METHOD

Experiments were carried out on 55 male albino rats weighing 180–240 g. At the operation 50% of SI was resected, starting from 2 cm away from the duodenojejunal flexure. The patency was restored by anastomosis of end-to-end type. Intact rats and rats undergoing laparatomy served as the control. The control and experimental rats were decapitated in pairs on the 7th, 14th, 30th, 90th and 180th days of the experiment, five rats at each time. Pieces of duodenum, jejunum, and ileum were taken from close to the anastomosis for investigation. Material was fixed in 10% neutral formalin solution and embedded in paraffin wax. The total number of argyrophilic cells was determined by Grimelius' method and the number of enterochromaffin cells (Ec) by the Masson–Hamperl method Cells were counted in 100 villi and 300 crypts. Electron microscopy was undertaken by the usual method. Endoerine cells were identified by their shape, size, and electron density of their secretory granules [10].

EXPERIMENTAL RESULTS

A proximal-distal gradient was discovered in the distribution of endocrine cells along the course of SI in the intact animals: 276.0 ± 11.0 in the duodenum, 129.2 ± 7.8 in the jejunum, and 77.6 ± 3.6 in the ileum. Most cells were located in the epithelium of the crypts, and fewer were found in the epithelium of the filli (Fig. 1a, b). Most of the argyrophilic endocrine cells were enterochromaffin (Ec) cells: 70% in the duodenum, 68% in the jejunum, and 55% in the ileum. In this investigation changes in ultrastructure were studied only in Ec cells, whose hormones play an important role in the restoration of functions disturbed after an operation [9].

After 50% proximal resection of SI the changes in the number of argyrophilic and argentaffin cells distinguished in the residual portion were fluctuating in character (Fig. 2). In the duodenum the greatest decrease in their number was observed on the 7th day ($p < 0.05$), followed by an increase on the 30th day ($p < 0.05$) of the experiment, whereas in the jejunum and ileum the peak increase was found on the 14th and 7th days, respectively ($p < 0.05$). The greatest decrease was observed on the 30th day after the operation ($p < 0.05$). Changes in the number of endocrine cells discovered in the jejunum were more marked than those found in the ileum. On the 90th day in the duodenum and jejunum, and on the 30th day in the ileum,
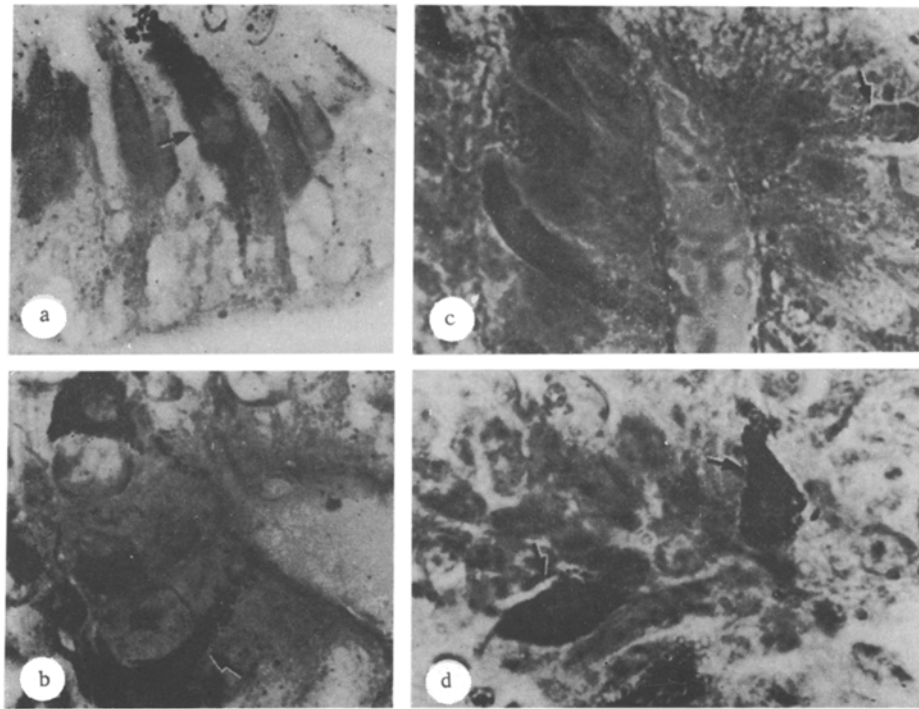
Fig. 1. Endocrine cells of SI of intact rats (a, b) and after proximal resection of SI (c, d). a) Argyrophilic cells of closed type in epithelium of a villus; b) argyrophilic cell of open type in a crypt; c) degranulated argyrophilic cell in duodenum, 7th day; d) in phase of deposition of secretory product (jejunum, 14 day after operation). Impregnation by Grimelius' method. 1000 ×.
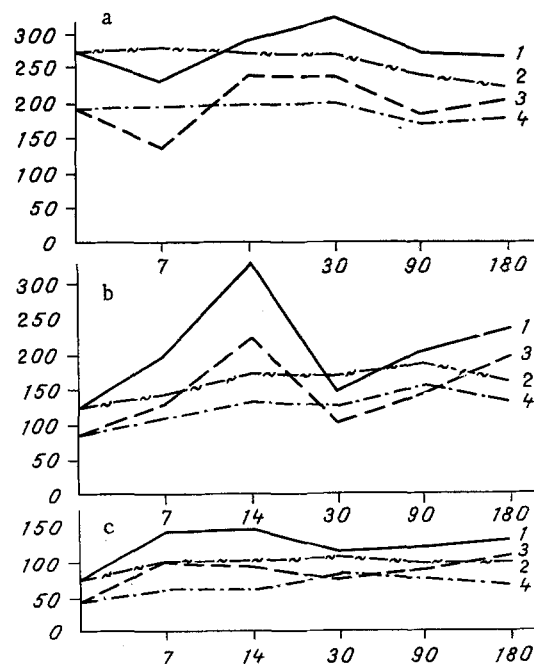

Fig. 2. Time course of number of endocrine cells after 50% proximal resection of SI. Abscissa, time after resection (in days); ordinate, number of cells. a) Duodenum, b) jejunum, c) ileum. 1, 3) 50% resection; 2, 4) control. 1, 2) Argyrophilic cells; 3, 4) argentaffin cells.
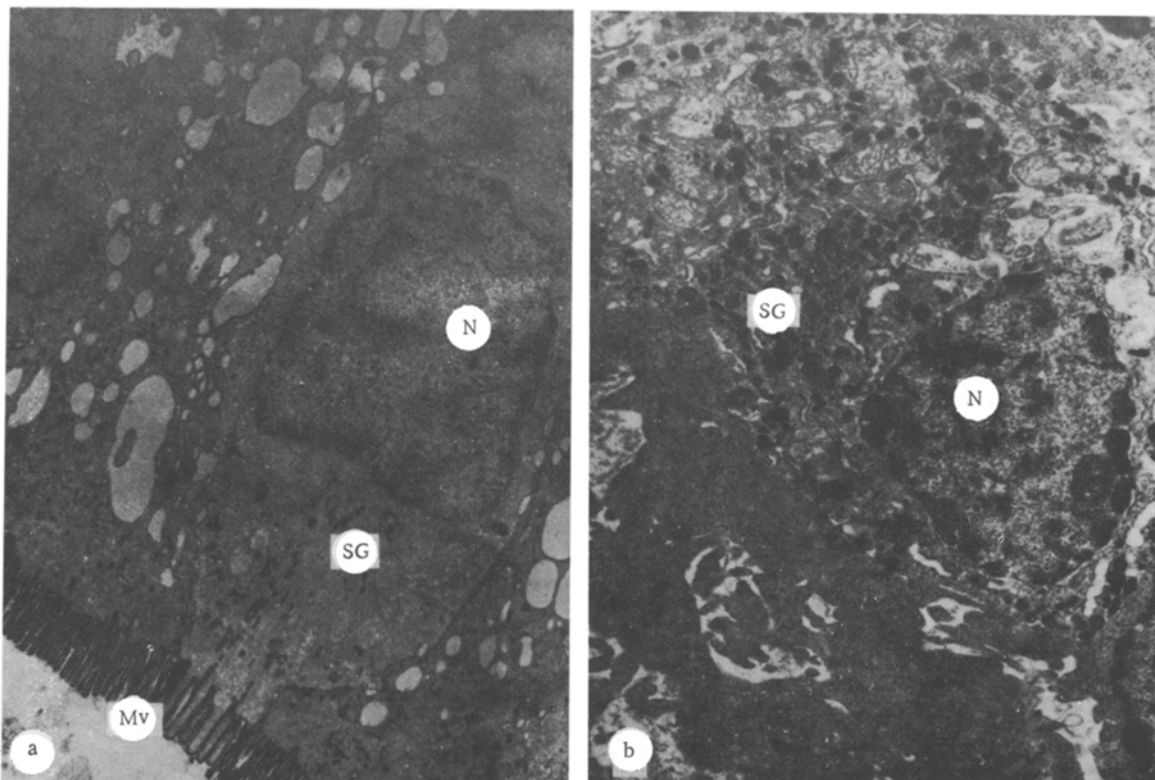
Fig 3. Enterochromaffin cells in mucous membrane. a) Villi of duodenum, 7th day, in stage of degranulation; b) crypts of ileum on 7th day in a state of deposition of secretory product. SG) Secretory granules, Mv) microvilli, N) nucleus. 7000 ×.

the number of cells detected differed only a little from the control values (p > 0.05). A parallel was noted in the response of the argentaffin and argyrophilic cells.

During the period of a decrease in the number of endocrine cells (on the 7th day in the duodenum) the density of distribution of their argyrophilic and argentaffin granules was reduced (Fig. 1c). Electron-microscopically, the majority of secretory granules of the duodenal Ec cells were reduced in density, with a heterogeneous matrix, and some cells were completely degranulated (Fig. 3a). The cells were in a phase of synchronization of secretory activity with respect to discharge of secretory products, and the presence of degranulated cells was evidence of active secretion of hormones by them. With an increase in the number of endocrine cells discovered in the jejunum and ileum on the 7th–14th day, the density of distribution of granules in them was increased (Fig. 1d) and an increase in the number of secretory granules of increased electron density was observed (Fig. 3b), evidence that the cells had entered into the phase of synchronization of secretory function with respect to accumulation of the hormonal product, and with transition into extrusion block. Analysis of the results showed that on the 7th and 30th days synchronization of secretory function of the endocrine cells in opposite phases was present in the duodenum, by contrast with the jejunum and ileum. This pattern of desynchronization of the secretory function along the length of SI, arising after the operation, can be described as a "proximal-distal sinusoid phenomenon."

According to data in the literature [1] after partial proximal resection of SI the rate of its motor evacuatory activity is increased, its enzyme-secreting function is disturbed, and the absorption and assimilation of nutrients and minerals are depressed. These changes are particularly marked on the 7th–14th day. By the 90th day restoration of the disturbed functions and the development of compensatory and adaptive processes are almost complete, as shown by the morphological findings [2]. According to the results of this investigation this period (7–90 days) corresponds to the most marked changes in the number of endocrine cells counted and, consequently, disturbance of their secretory function.

Serotonin, motilin, and substance P, produced by Ec cells, are known to stimulate motor activity of the intestine. Serotonin also stimulates secretion of mucus and of digestive enzymes, and it also inhibits the absorption of water and electrolytes [7].

It can thus be concluded from the results that after proximal 50% resection of SI changes are observed in the number of endocrine cells, evidence of changes in their secretory activity. The endocrine cells of the residual portion of SI evidently participate unequally in regulation of restoration of the functions disturbed after operation. This is confirmed by the oppositely phased character of accumulation and release of secretion by them (the "proximal-distal sinusoid phenomenon"). Two phases can be distinguished in the trend of processes as they develop: disturbances of secretory activity of the endocrine cells for 3 months after the operation and relative recovery, starting 90 days after the operation. Normalization of the secretory function of the endocrine cells along the length of SI takes place in the distal-proximal direction.

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