ENDOCRINE CELLS OF THE SMALL INTESTINE IN EXPERIMENTAL INTESTINAL OBSTRUCTION WITH STRANGULATION

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The problem of the structure and function of endocrine cells (EC) in the gastrointestinal tract is attracting the attention of an increasing number of research workers [1, 4, 6, 7]. EC are classified on the basis of the ultrastructure and chemical composition of their granules, and their detailed structure has been studied in various animals and man under normal conditions. Data on the state of EC in small intestinal pathology are scanty. Hyperplasia of EC during duodenitis [5] and their hyperactivity in patients with celiac disease have been described [9, 12]. Participation of EC in the pathogenesis of acute intestinal obstruction has received little study. The aim of this investigation was to study the structure and quantitative composition of EC in the small intestine in acute intestinal obstruction due to strangulation.

EXPERIMENTAL METHOD

Experiments were carried out on 25 adult cats of both sexes. Under ether anesthesia strangulation of a loop of the small intestine 10-15 cm long was produced by application of a rubber ligature in the form of a hernia ring for 3, 6, 12, and 24 h, causing complete cessation of the blood flow and the passage of food in it. Material was taken from three regions of the afferent loop (15, 30, and 45 cm orally to the strangulation) and efferent loop (20 cm aborally from the strangulation). Sections through the intestinal wall were stained by Grimelius' method and the number of EC per 100 crypts was counted. To estimate the degree of saturation of EC with granules, the suggestion in [3] was followed and three degrees of accumulation of granules (from 0 to 3) were distinguished. The ultrastructural investigation was conducted on a Hitachi-600 microscope.

EXPERIMENTAL RESULTS

In the wall of the cat small intestine EC were found in the composition of the epithelium of the mucous membrane of the crypts and villi. They were arranged with their wide base on the basement membrane and their narrow apex facing the lumen of the intestine. Granules of EC were located basally in the cells. EC were most numerous in the crypts and relatively fewer among the epitheliocytes of the intestinal villi. The Golgi apparatus and elements of the rough and smooth endoplasmic feticulum were well developed in the perinuclear zone. There were few mitochondria.

Counting EC in a loop of small intestine strangulated for 3 h showed an increase in their number to 21.9 ± 0.2 (from the normal 15.0 ± 0.3, $p < 0.001$). EC contained densely packed, confluent granules in the basal part of the cells, corresponding to saturation of the III degree. In some of them granules also were present with a less compact arrangement in the apical part (Fig. 1).

At a distance of 30 cm of the afferent loop, against the background of degenerative changes in the intestinal epitheliocytes an increase in the number of EC was observed up to statistically significant values (Table 1). At a distance of 31-45 cm orally to the strangulation, the increase in the number of EC was not statistically significant. In these regions EC were saturated with argyrophilic granules and they could be identified without difficulty both in the crypts and in the villi.

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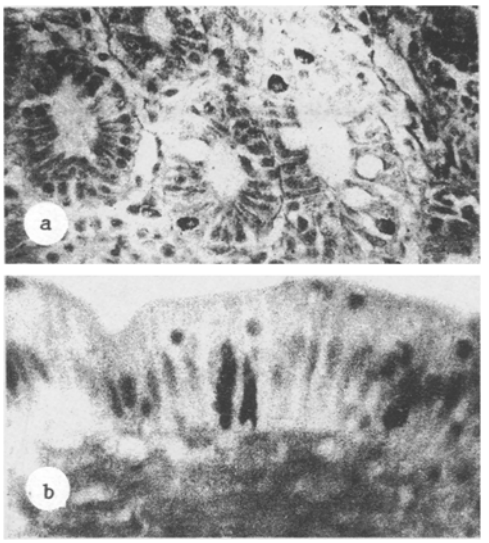

Fig. 1. EC (arrow) of mucous membrane of small intestine during strangulation of an intestinal loop for 3 h. a) High degree of saturation of EC by densely packed granules in crypts, 140×; b) argyrophilic granules in basal and apical parts of EC, 400×. Grimelius' stain.

TABLE 1. Number of Endocrine Cells in Epithelium of Crypts of Different Regions of Small Intestine during Strangulation of an Intestinal Loop ($M \pm m$, $n = 5$)

Experimental conditions	Region of intestine			
	afferent		efferent	
	15 см	30 см	45 см	20 см
Control 15.0 ± 0.3				
Strangulation, h				
3	24,7±0,6*	28,3±0,1*	20,6±0,7	23,7±1,5*
6	34,3±2,0*	29,5±0,8*	24,5±0,6*	27,4±0,1*
12	19,0±0,3*	18,0±0,7*	15,6±0,8	19,2±0,1*
24	13,5±0,1*	10,5±1,0*	15,1±1,0	12,2±0,4*

Legend. Asterisk indicates statistically significant results.

With an increase in the duration of the experiment to 6 h the number of EC in regions of the intestine studied increased to a maximum. In the strangulated loop it was 35.9 ± 1.0 ($p < 0.001$). The granules in EC were free-lying and their outlines could be clearly distinguished (the degree II of saturation). Orally, in regions of the intestine nearest to the strangulation, EC stained more intensely than in the more distant regions. At a distance of 31-45 cm the number of EC increased but the degree of their saturation was low and the granules lay separately. On ultramicroscopic investigation of EC, polymorphism of the granules was noted as regards the distribution of osmiophilic material in them. Most granules preserved a surrounding membrane. In addition, secretory granules with foci of absence of membranes were observed. The EC contained "dense" and "empty" granules in equal proportions, so that they could be classed as actively functioning cells [2].

By 12-24 h of experimental strangulation of the loop of small intestine, the number of EC in both afferent and efferent regions was reduced compared with the previous times of the experiment. After 24 h this parameter in regions nearest to the strangulation ring was below normal (Table 1). Saturation of EC with granules was minimal (from degree 0 to I), i.e., single granules were found in the basal part of the cell or they were absent altogether. On electromicrographs the secretory granules of EC were heterogeneous with respect to the accumulation of osmiophilic material in them. Most of them had a pale matrix and a small amount of granular material (Fig. 2). The presence of large, "empty" granules in EC is evidence that these degranulated cells posses no secretion. Large vacuoles, lysosomes, and myelinlike bodies appeared in the cytoplasm of many EC. The plasma membrane of the cells was ruptured in places.

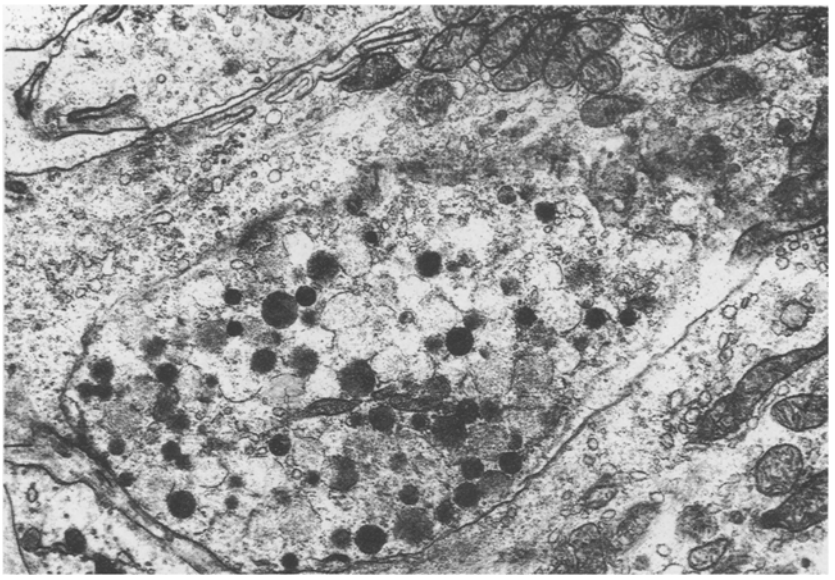

Fig. 2. Enterochromaffin cell of mucous membrane of small intestine 15 cm orally to strangulation. Period of experiment 12 h. Different degrees of saturation of secretory granules (SG) with osmiophilic material. E) Brush border epitheliocyte. 8000×.

The time course of the quantitative composition and degree of saturation of EC by granules during the course of experimental acute intestinal obstruction of strangulation type shows that the increase in number of EC with numerous granules in the first 6 h of the experiment was followed by a decrease of these parameters to the 12th-24th hour. Since the main mass of EC of the small intestine consists of cells of EC type, which are responsible for serotonin synthesis [4, 7], the biogenic amine released from them in the first 6 h of the experiment acts initially by the paracrine route, stimulated secretion of mucus and the change in its composition, and thus serves as protector of the mucous membrane [5]. The increase in the number of EC detected in the present experiments is in agreement with biochemical data [8, 14, 15] showing an increase in the blood serotonin level in experiments with ligation of the cranial mesenteric artery and obstruction of the small intestine in dogs. Serotonin circulating in the blood, it must be considered, exerts distant endocrine influences and regulates activity of the small intestine through its action on the musculointestinal (Auerbach's nerve plexus) [10] and on the blood flow in its individual segments [11].

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