EFFECT OF EXTENSIVE SMALL BOWEL RESECTION ON THE ENZYME SECRETORY FUNCTION OF THE STOMACH

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In investigations carried out in the laboratory of gastro-intestinal tract physiology and pathology it has been shown that an important role in the compensatory reorganizational activity of the digestive system after extensive bowel resection may be played by the increase in secretory and enzyme-secretory functions of the remaining parts of the small intestine or pancreas [9]. Data obtained previously [4, 6] show that extensive small bowel resection evokes changes in the quantity of gastric secretion, its acidity and pepsin concentration.

In this article are presented the results of investigation into the enzyme secretory function of the stomach in dogs after extensive (50-70%) resection of the proximal or distal section of the small bowel. Parallel studies of the pepsin in gastric juice and the pepsinogen in blood and urine (uropepsin) were used to study the possible application of "indirect" tests to assess the enzyme secretory function of the stomach.

METHODS

The investigations were performed as chronic experiments on 9 dogs with stomachs isolated according to Pavlov and Heidenhain and with large gastric fistulas. In control experiments the level of gastric secretion and the pepsin content of gastric juice obtained with meat (200 g), hematogen (200 ml of 12.5% and 20% solution), sham meat feeding (100 g in 25 pieces), histamine (0.5-1 mg subcutaneously) and alcohol (100 ml of 10% solution rectally). Measurement of the pepsin concentration in the gastric juice was made by a method described previously [5] and the blood pepsinogen and 24 h urine uropepsin contents by the hemoglobin method as modified by I. A. Mirsky et al. [14]. The dogs were kept in a metabolic chamber in order to obtain 24 h urines. Fasting venous blood was taken on the day of the study. The specific activities of pepsin, pepsinogen and uropepsin were expressed in pepsin units [5]. The amount of pepsin secreted in gastric juice during the experiment and the amount excreted in the 24 h urine were calculated by multiplying their specific activities (in pepsin units) by the volume of gastric juice or 24 h urine obtained (in milliliters).

After establishing the initial level of gastric enzyme secretory function, we subjected the dogs to extensive small bowel resection (50-70% of total length). Resection of the proximal bowel segment was done to 10-12 cm from the ligament of Treitz and the distal segment to 10-12 cm from the ileocecal valve. The observations were continued for from $4\frac{1}{2}$ months to 2 years post operation. The data obtained received statistical treatment [3].

RESULTS AND DISCUSSION

The data concerning the pepsin content of gastric juice from 5 dogs which had undergone extensive resection of the proximal part of the small bowel are presented in Fig. 1. As seen from the diagram, after removal of 50-70% of the small bowel (112-146 cm of its proximal portion), pepsin secretion in response to all stimuli used increased significantly (by 66-234%). With this the pepsin concentration in gastric juice after hematogen rose in 2 dogs (in dog Seryi from 10.3 ± 0.63 to 24.1 ±2.29 and in dog Prima from 20.0 ± 0.86 to 25.0 ± 1.24 units/ml) and after histamine in one (from 11.4 ± 0.77 to 17.3 ± 1.36 units/ml); in the remaining animals the pepsin concentration remained essentially unchanged. Increase in pepsin secretion after operation occurred mainly owing to an increase

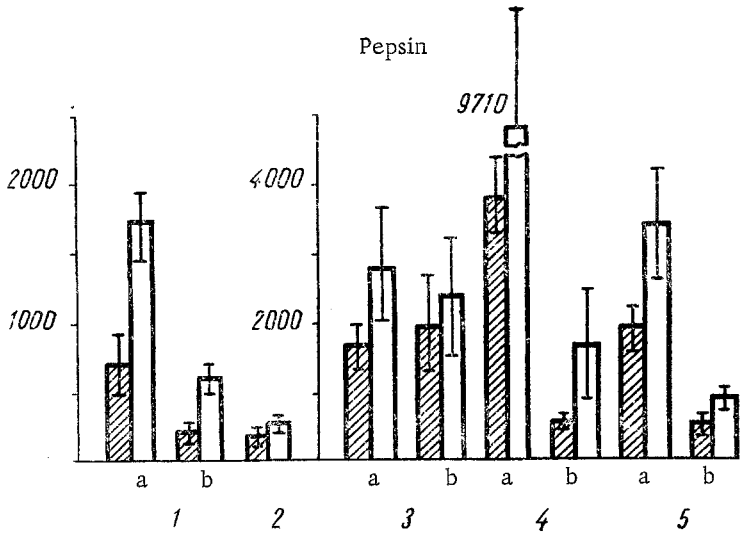

Fig. 1. Pepsin content (in units) in gastric juice of dogs before and after extensive resection of the proximal portion of the small bowel. 1) Dog Seryi with Pavlov-type isolated stomach pouch; 2) secretion with hematogen; 3) dog Pirat with gastric fistula; a) secretion with sham meat feeding; b) with histamine; 4) dog Laska with gastric fistula: a) secretion with sham meat feeding; b) with histamine; 5) dog Lord with gastric fistula: a) secretion with sham meat feeding; b) with alcohol. Vertical lines in each bar—limits of confidence. Dark bars—values before and white bars—values after operation.

in gastric juice production. It was most marked in those instances, when together with an increase in the quantity of juice which was secreted in the experiment the pepsin concentration also increased. Only in one dog (Pirat) was the increase in secretion after histamine injection (27.5%) not statistically valid. Increase in pepsin secretion was noted directly after bowel resection and continued throughout the entire observation period.

The fact that gastric enzyme secretory function increases after extensive resection of the proximal portion of the small bowel is in agreement with the results obtained by studying the blood serum pepsinogen content and the 24 h urine uropepsin content (see table).

Data concerning the studies of pepsin content of gastric juice, blood pepsinogen and uropepsin in dogs which underwent resection of the distal portion of the small bowel are presented in Fig. 2 and in the table. The changes in pepsin secretion resultant from this operation are distinguishable from those after removal of the proximal part of the small bowel.

The amount of pepsin secreted during the experiment in response to stimulation did not increase, but after sham meat feeding clearly decreased as the result of diminished gastric juice secretion. The pepsin concentration of the gastric juice in the majority of dogs remained within the limits of the initial values, but in dog Egoza fell after administration of alcohol (from 22 ± 0.86 to 16 ± 0.47 units/ml). In dog Tsygan histamine evoked a tendency toward increased pepsin concentration, in connection with which its secretion increased. The changes in gastric secretion in the dogs were observed immediately after bowel resection and continued during the entire observation period. The characteristic of gastric enzyme secretory function after resection of the distal portion was considerable variation in pepsin secretion on different days. The blood pepsinogen and urine uropepsin contents were not essentially different from the corresponding values in the control period (see table).

Thus, on the basis of the experimental data obtained, it can be concluded that extensive resection of the proximal part of the dog small bowel leads to increased pepsin secretion in the gastric juice and increased blood pepsinogen and urine uropepsin excretion. That there is increased pepsin secretion by the gastric glands is also confirmed by the data from morphological and histochemical studies performed by N. A. Nilova in the laboratory of Prof. A. A. Solov'ev, where it was established by necropsy of operated dogs that the stomach wall was thickened with an

Content of Pepsinogen in Blood Serum and Uropepsin in 24 h Urine after Broad (50-70%) Resection of Proximal and Distal Sections of the Small Bowel

Dog	Extent of resection (in cm)	Pepsin (in units/ml) before operation	Pepsin (in units/ml) after operation	Pepsin (in units/ml) Inc. or decrease (in %)	Uropepsin before operation (in units/day)	Uropepsin after operation (in units/day)	Uropepsin Inc. or decrease (in %)
	Resection of proximal section of the small bowel						
Seryi	146 (70%)	19	24	+23	17 420	33 390	+92
Proma	128 (65%)	18	27	+26	34 953	40 128	+15
Pirat	112 (50%)	13	16	+23	21 560	26 250	+22
Laska	137 (65%)	17	21	+23	19 920	23 750	+20
Lord	118 (50%)	15	18	+20	18 320	23 460	+28
For all groups	$m=1,11$		$P=0.02$		$m=2265$	$P<0,05$	
	Resection of distal section of the small bowel						
Egoza	188 (60%)	16	15	—6	25 200	27 500	+4
Tsygan	134 (50%)	30	28	—8	8 250	7 700	—7
Snezhok	128 (60%)	20	20	—	22 800	19 200	—16
Ryzhii	158 (70%)	18	19	+5	28 350	27 500	—3
For all groups	$m=0,85$	$P>0,25$			$m=1881$	$P>0,25$	

Note: Statistical treatment of the results of the investigation was performed by difference method (3) during observation of one group of animals.

increased number of mucous membrane folds, with glandular hypertrophy and increased glandular secretion [2]. At the same time, extensive resection of the distal portion of the small bowel did not result in increased gastric enzyme secretory function in the majority of the dogs.

A large number of articles [7, 8, 15] has appeared concerning the gastric proteolytic enzymes in blood and urine in the normal and in various disease states. Most authors consider that a known dependence exists between pepsin secreted in the gastric juice, and the pepsinogen content and uropepsin. The diagnostic importance given methods of studying these enzymes is explained by this. However, the importance of pepsinogen and uropepsin measurements in assessing the gastric enzyme secretory function, in our opinion, should not be overrated since the analysis of data from these tests still may not afford a sufficiently complete characterization of the proteolytic activity of gastric juice and thereby exclude the necessity of measuring the pepsin content. This conclusion is based on the results of our experimental studies and on the data in the literature.

As was mentioned above, in all dogs which had extensive proximal small bowel resection the blood pepsinogen and uropepsin content rose; however, the degree of such changes was not proportional, in all cases, to the increase in pepsin secretion in the gastric juice and the increase in the blood pepsinogen—to the urine uropepsin (see table and Fig. 1, dogs Seryi, Prima, and Laska, and Fig. 2, dogs Egoza and Tsygan).

This is explained by the fact that the amount of gastric secretion is related in large measure to the nature of the stimulation used. In addition, the following reasons may account for the main observed differences between pepsin secretion in gastric juice, blood pepsinogen content and urine pepsinogen excretion: the quantitative disproportion between pepsin secretion into the gastric lumen and the pepsinogen incretion [13], the considerable variability of pepsinogen content in the blood and uropepsin excretion into the urine [11, 12] and the dependence of these processes on the activity of a number of organs—the hypophyseal-adrenal system, renal function, etc [1, 10].

Thus, we may assess changes in the enzyme-secretory function of the stomach by data from "indirect" tests only in such cases where the original level of pepsinogen and uropepsin is known.

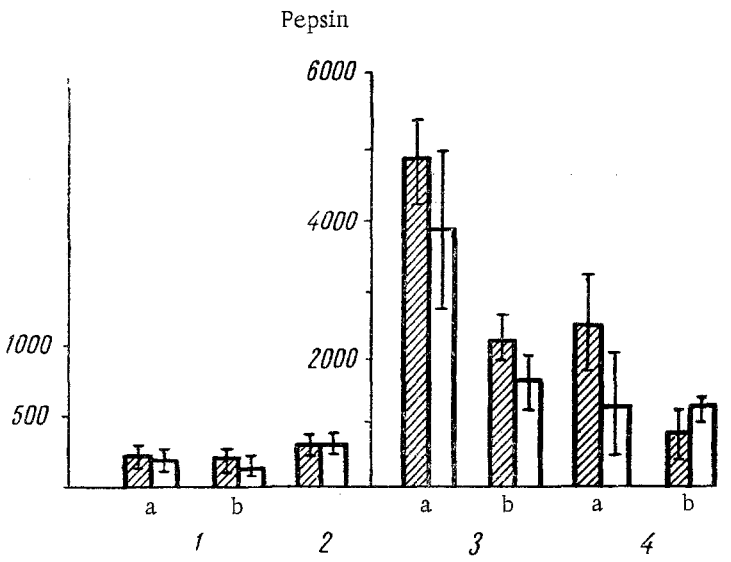

Fig. 2. Pepsin content (in units) of gastric juice in dogs before and after extensive resection of the distal portion of the small bowel. 1) Dog Snezhok with Heidenhain-type isolated stomach pouch: a) secretion with hematogen; b) with histamine; 2) dog Ryzhii with Heidenhain-type preparation: a) secretion with hematogen; 3) dog Egoza with gastric fistula: a) secretion with sham meat feeding; b) with alcohol; 4) dog Tsygan with gastric fistula: a) secretion with sham meat feeding; b) with histamine.

SUMMARY

In 9 dogs with stomachs isolated after Pavlov and Heidenhain and with stomach fistulas, a study was made on the secretion of pepsin with gastric juice in response to meat, hematogen, histamine and alcohol sham feeding with meat as well as on the pepsinogen content of the blood serum and secretion of uropepsin with 24 h urine before and after an extensive resection of the small intestine (50-70%). Following excision of the proximal portion of the small intestine in 5 dogs, the secretion of pepsin with gastric juice, the pepsinogen and uropepsin levels increased, while in 4 dogs, which had undergone resection of the distal portion of the small intestine, no substantial change in these responses was noted with regard to most of the stimulating agents. The possibility is discussed of using the determination of the pepsinogen and uropepsin content for conclusion on the enzyme-secretory function of the stomach.

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