

COMPENSATION OF PANCREATIC EXOCRINE INSUFFICIENCY AFTER PARTIAL,  
SUBTOTAL, AND TOTAL PANCREATECTOMY

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It is an undisputed fact now that disturbance of the functions of various parts of the digestive system is accompanied by the regular development of compensatory processes not only in the affected organ, but also in other organs of the gastrointestinal tract. The overwhelming majority of investigators at the present time hold the view that compensation of functions, disturbed by the course of a pathological process, is based on the functional interchangeability of different parts of the digestive system, i.e., that compensation of replacement type takes place [5, 6, 8]. As the results of many investigations have shown, the compensatory process by no means always ends with the development of decompensation [7].

It was shown previously [3] that the pancreas has very high regenerative capacity. Meanwhile partial, or even subtotal and total resection of this organ is not always accompanied by any marked disturbances of hydrolysis of food substances [10, 15]. Investigation of the compensatory powers of the digestive system in experimental forms of external secretory pancreatic insufficiency [1-4] has clearly demonstrated that the stomach plays a leading role in the development of these processes.

For the reasons given above the aim of the present investigation was to study, in chronic experiments on dogs, the possibility, in principle, of total resection of the pancreas, both normal and when modified by previous resection of the pancreas when affected by a pathological process.

#### EXPERIMENTAL METHOD

Experiments were performed on 48 male mongrel dogs weighing from 11 to 28 kg. There were four series of experiments (six animals in each series), in which 25% (the free end, 4-5 cm below the head, of the descending part of the pancreas), 50% (the whole of the descending and 3-4 cm of the horizontal part), 75% (the whole of the descending and half of the horizontal part), and 100% respectively of the weight of the pancreas was resected in dogs previously (10-14 months beforehand) undergoing the operation of total ligation of the pancreatic ducts. Intact animals (six dogs in each series) served as the control.

The following parameters of the secretory activity of the stomach were determined: the volume of gastric juice (in ml), total and free acidity (in titration units), and proteolytic and amylolytic activity of the gastric juice. The last two types of activity were studied by methods devised by the writers previously [9, 10]. In all animals both experimental and control, small gastric pouches were isolated by the Brestkin-Savich method 2 months before the experiments began. Regurgitation of the duodenal contents into the gastric pouch, and entry of enzymes into it with the saliva were thus completely prevented.

A 0.1% solution of histamine (0.1 ml/kg body weight) was used to stimulate gastric secretion.

#### EXPERIMENTAL RESULTS

The results of investigation of the basic parameters of gastric secretion in the dog Reks for 2 years after ligation of the pancreatic duct are given in Fig. 1.

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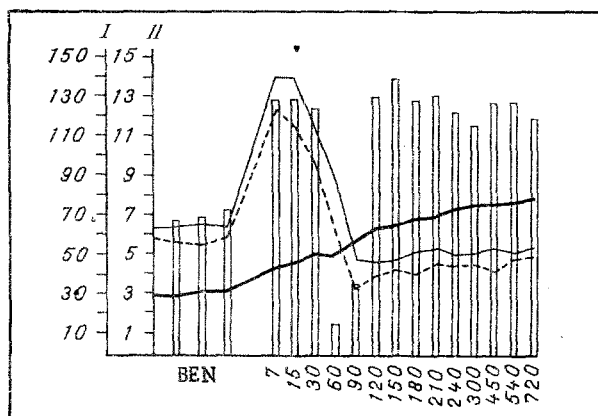


Fig. 1

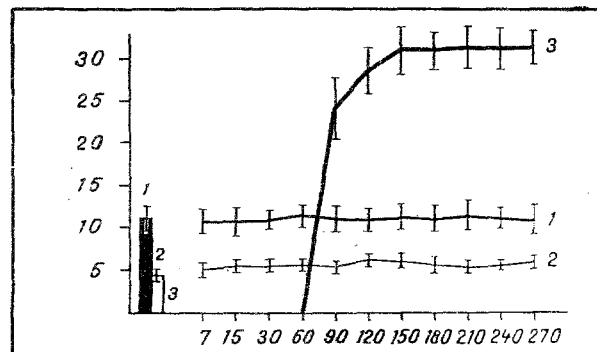


Fig. 2

Fig. 1. Time course of basic parameters of secretory activity of Brestkin-Savich gastric pouch in dog Reks at different times after ligation of pancreatic duct. Abscissa, time after operation (in days); ordinate: I) Digestive power (in units, bold line), total (thin line) and free (broken line) acidity (in titration units); II) volume I in ml) of gastric juice (columns). B) Background; E) experiment; N) normal. Here and in Fig. 2, arrow indicates time of operation.

Fig. 2. Time course of amylolytic activity of gastric juice of the same dog depending on pH and time elapsing after ligation of pancreatic ducts. Abscissa, time after operation (in days); ordinate, amylolytic activity (in % of starch hydrolyzed). 1) pH 7.0; 2) pH 4.0; 3) pH 1.5.

As Fig. 1 shows, a considerable increase in the volume of secretion and acidity of the gastric juice was observed in the early postoperative period. Meanwhile a tendency was noted for the proteolytic activity of the gastric juice to rise. Later, until the end of the 3rd month after ligation of the pancreatic ducts, there was a marked decrease in the secretion and acidity of the gastric juice. Incidentally, during this period the proteolytic activity of the gastric juice continued to increase a little. Starting from the 4th month, the parameters of gastric secretion again became established at a level much higher than initially. The same was true also of the proteolytic activity of the gastric juice. Acidity of the juice, however, both total and free, remained consistently at a lower level than normally. Stabilization of the parameters of gastric secretion at a level which differed considerably from the original value was virtually complete 8-12 months after ligation of the pancreatic ducts. Accordingly, all the remaining animals destined later for pancreatic resection were included in the experiment 3-4 months after gastric secretion had become established at a stable level, i.e., 10-14 months after ligation of the pancreatic ducts.

Some interesting data, in our opinion, were obtained by the study of amylolytic activity of the dogs' gastric juice in the late stages after termination of the external secretory activity of the pancreas (Fig. 2).

The results of determination of the amylolytic activity of the gastric juice at different times after ligation of the pancreatic ducts showed that under normal conditions there was no gastric amylase with a strongly acid pH-optimum of reaction (pH 1.5). Only very slight amylolytic activity was found at pH values of 4.0 and 7.0. Later, the amylolytic activity of the gastric juice at these pH values remained virtually unchanged. Meanwhile, toward the end of the 2nd and the beginning of the 3rd month after ligation of the pancreatic ducts, the appearance of amylolytic activity was observed at a strongly acid pH of the reaction. This amylolytic activity increased rapidly and reached a maximal level by the end of the 5th postoperative month. Later no significant changes could be found in this parameter of gastric secretion.

Removal of 25, 50, and even 75% of the weight of the pancreas in intact dogs was not accompanied by any significant changes in the parameters of gastric secretory activity studied (Table 1). Removal of 100% of the pancreas (total pancreatectomy), however, led to rapid death of the animals even if receiving replacement insulin therapy.

Resection of 25, 50, and 75% of the pancreas in animals which had previously undergone ligation of the pancreatic ducts likewise caused no significant changes in the parameters of gastric secretory activity. However, unlike in intact animals, all these parameters in the

TABLE 1. Parameters of Gastric Secretory Activity under Normal Conditions (I), 10-14 Months after Ligation of Pancreatic Ducts (II), and after Corresponding Resection of Normal Pancreas and of Pancreas Affected by Sclerosis after Ligation of the Pancreatic Ducts

Parameter	Before resection	Control	Resection of undermentioned amount of pancreas			
			25 %	50 %	75 %	100 %
Volume of gastric juice, ml/h	I	11,8±2,1	12,6±1,9	12,3±2,2	11,4±1,7	—
	II	21,9±2,4	22,6±2,9	20,8±2,2	20,5±2,6	21,7±2,0
Total acidity, titration units	I	72,2±7,8	70,5±5,9	75,1±6,6	76,3±6,8	—
	II	39,7±4,1	38,8±4,3	41,6±5,0	42,2±4,7	40,1±4,3
Free acidity, titration units	I	55,8±5,7	54,9±6,1	56,3±5,5	57,9±6,4	—
	II	30,4±4,8	32,7±5,2	30,5±5,1	31,8±4,2	30,1±4,3
Proteolytic activity, conventional units	I	29,9±3,5	30,6±3,3	30,5±3,8	32,6±3,6	—
	II	71,2±7,0	65,4±6,8	69,7±6,9	70,4±6,3	70,2±6,4
Amylolytic activity	I	—	—	—	—	—
	II	34,6±3,8	32,7±4,5	33,4±4,0	32,1±4,2	33,6±3,9
pH 1,5	I	5,2±0,9	5,6±1,1	5,2±1,0	5,5±1,7	—
pH 4,0	II	5,4±1,2	5,5±1,2	5,6±1,3	5,6±1,5	5,4±1,1
pH 7,0	I	11,8±1,9	11,7±2,3	11,8±2,1	10,9±2,3	—
	II	10,8±2,4	11,7±2,2	11,6±2,3	11,4±2,5	11,2±2,1

Legend. A dash in the last column (100%) indicates death of the animals, in all other columns a dash means that this parameter is not available.

experimental dogs were maintained steadily at the level which they reached by the 8th-10th month after ligation of the pancreatic ducts.

Total resection of the pancreas in dogs after ligation of the pancreatic ducts did not lead to death of the animals. Moreover, replacement insulin therapy was given to the animals only for 5-7 days after the operation (in a dose of 0.2 U/kg body weight). Just as after partial resection of the pancreas, total pancreatectomy was not followed by changes in the parameters of gastric secretion (Table 1).

These results are evidence of the important role of the stomach in the development of compensation in the digestive system in pancreatic exocrine insufficiency. These processes were so marked and well established that even total resection of the pathologically changed pancreas did not cause their collapse with the development of decompensation. Compensatory reactions of the stomach under these circumstances were not only quantitative and specific in character, but also included qualitative changes, for example, the appearance and long persistence of amylolytic activity of the gastric juice when the pH reaction was strongly acid. In this respect the results agree with those obtained by other workers [11], indicating a very small change in the serum "pancreatic" amylase level after resections of varied degree, up to subtotal, of the pancreas. More and more investigations have recently been published, in which it has been found that even total death of the pancreatic acinar apparatus is by no means always accompanied by disturbances of hydrolysis and of utilization of food substances incompatible with life [12-14, 16].

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