

ENZYME-SECRETING PROCESSES IN THE PANCREAS DURING STARVATION

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Experiments on dogs with a chronic fistula of the pancreatic duct showed that during periodic activity of the pancreas during starvation not only is the secretion of the liquid juice increased, but enzyme secretion is also sharply intensified. This leads to a considerable increase in the concentration of all the principal pancreatic enzymes in the juice. By contrast, during pauses very little juice is secreted and its enzyme concentration is sharply reduced. It follows from these results that the periodic secretion is the main source of the pancreatic enzyme in the intestine during starvation.

During periodic activity of the gastrointestinal tract the pancreas secretes a juice rich in enzymes [3, 4, 6-8]. However, the view is widely held [1, 2, 10, 14] that the secretion of liquid pancreatic juice during periodic activity is connected with contraction of the muscle elements in the wall of the pancreatic ducts; the spontaneously secreted juice with an unchanged enzyme content that has accumulated in the ducts is thereby expressed from them.

The results described below conflict with this view for they show that enzyme secretion in the pancreas, like other processes, undergoes periodic changes during starvation.

EXPERIMENTAL METHOD

Experiments were carried out on three dogs with a chronic fistula of the pancreatic duct [11], so arranged that the animals did not lose pancreatic juice between experiments (the juice was returned into the intestine). During the experiments, by inserting a cannula into the orifice of the main duct, completely pure juice was obtained. Preliminary investigations of the secretion of juice and enzymes in response to food stimuli confirmed that the pancreas of all the experimental animals functioned well. The experiments were carried out 18 h after a meal. The action of conditioned food stimuli was excluded as far as possible. During the experiment each portion of juice was collected for 30 min in a separate tube and kept on ice. The content of lipase [13] was determined on the day of obtaining the juice and for the subsequent investigations the juice was kept at 4°C until next day. Before the concentration of total proteinases was determined [12] the pancreatic juice was activated with enterokinase (30 units/ml) at 37°C for 30 min. Amylase was determined by the hydrolysis of starch [12].

EXPERIMENTAL RESULTS

The experimental results to begin with confirmed the results of classical investigations of the periodic secretion of pancreatic juice (Fig. 1). During periods of activity the dogs secreted 1.2-4.0 ml of juice in 30 min, whereas in the intervals between these periods they secreted 0.1-0.5 ml ($0.001 < P < 0.01$).

During periods of activity not only was an increased quantity of liquid pancreatic juice secreted, but enzyme production in the pancreas also rose considerably: with an increase in the volume of juice, the

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TABLE 1. Coefficients of Correlation (r) between Changes in Enzyme Concentration and Volume of Pancreatic Juice during Periodic Activity of the Gland

Index	Dog No. 1		Dog No. 2	
	r	P	r	P
Concentration of lipase	0,83	<0,001	0,87	<0,001
Volume of juice				
Concentration of amylase	0,71	<0,02	0,88	<0,001
Volume of juice				
Concentration of total proteinases	0,74	<0,01	0,87	<0,001
Volume of juice				

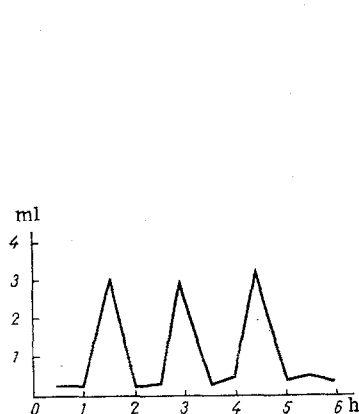


Fig. 1

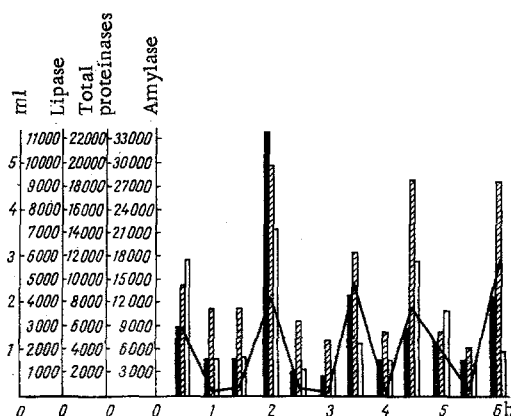


Fig. 2

Fig. 1. Periodic secretion of pancreatic juice during starvation in dog No. 3 with a chronic pancreatic fistula.

Fig. 2. Periodic increase in enzyme concentration (in units/ml) in pancreatic juice during starvation (dog No. 1). Black columns show lipase concentration, obliquely shaded columns amylase concentration, unshaded columns total proteinase concentration, curve represents volume of juice.

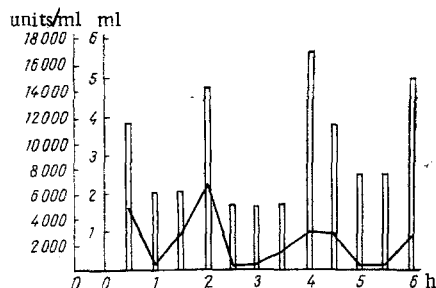


Fig. 3. Changes in interval between periods of increased enzyme production (dog No. 2). Columns show lipase concentration (in units/ml); curve represents volume of juice (in ml).

concentration of enzymes studied in it also rose sharply (Fig. 2). During the pauses the enzyme concentration fell again to a comparatively low level. Differences between the periods of activity and the pauses were statistically highly significant ($0.001 < P < 0.01$) for each enzyme tested. Hence it follows that only the periodically secreted juice plays an important role as a source of enzymes in the intestine during starvation.

The increased secretion of enzymes and also that of juice during periods of activity as a rule continued during one 30-min interval. If the period began at the end of the 30-min interval of juice collection, an increased enzyme concentration could be found in two adjacent portions of juice (Fig. 3).

The periods of activity in these experiments were usually resumed after 1.5–2 h, although sometimes in the same dog the interval between them varied slightly, in agreement with observations of other workers [5, 6, 9]. In all these cases

synchronized changes were observed in the secretion of juice and enzymes. The results of these experiments indicate close correlation between the volume of juice and the concentration of each enzyme tested (Table 1). This suggests strong stimulation of enzyme secretion during periods of activity.

Two liquid components participate in the formation of pancreatic juice: a neutral fluid secreted by the acinar cells, which dissolves the enzymes, especially enzymes accumulating in the form of secretory

granules, during extrusion of the secretion from the cell; and an alkaline liquid juice, rich in bicarbonate, secreted by the central acinar cells and cells of the initial part of the pancreatic ducts. The secretion of these components is regulated by different factors. For that reason, procedures such as injection of secretin or injection of hydrochloric acid into the duodenum, which stimulate increased secretion of liquid juice, lead to the dilution of the enzymes and to a decrease in their concentration.

During periodic activity, with an increase in the volume of juice there was at the same time a sharp increase in the enzyme concentration, suggesting that the stimuli acted not only on the secretion of the liquid component of the juice, but also to cause true stimulation of the enzyme-producing processes in the pancreas. The mechanism of this stimulation is not yet clear.

The periodic increase in the intensity of enzyme secretion in the pancreas during starvation is thus one manifestation of the general periodic activity of the gastrointestinal tract. These changes in pancreatic function are the principal factor determining the supply of pancreatic enzymes to the intestine during starvation.

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