Effect of feeding and sham feeding on pancreatic secretion of the rat

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SINCE COLWELL’S PUBLICATION (1) of a method for the collection of pancreatic secretion in the rat, the response of the pancreas toward various kinds of stimulation has been reported in several studies (2-4). In 1954, one of us (T. M. L.) collected simultaneously biliary and pancreatic secretion of the same rat, and maintained such rats alive for several weeks. This animal preparation was used as a classroom demonstration for medical students at the University of Illinois to show that an increase of bile and pancreatic flow occurred following the oral ingestion of a few grams of Pard (Swift). The total protein in the pancreatic juice, determined by means of Lowry’s micromethod (5), increased more than twofold after feeding. The present report extends our observations (6, 7) on the effect of feeding and sham feeding on pancreatic volume flow and amylase output in the chronic pancreatic fistula rat. To date the measurement of amylase output from rats with chronic pancreatic fistulas has not been recorded.

METHODS

Operation. Male rats of the Wilson strain, weighing between 350 and 450 gm, were used. The uncontaminated pancreatic secretion was collected by a modification of Colwell’s method (1). Ether anesthesia was used in all cases. Unless otherwise specified, the bile flow was not shunted (8) and a gastric fistula was not provided. In a number of experiments, both the biliary and pancreatic secretions were collected; in others a gastric fistula was made (9). Esophagotomy and vagotomy were performed as described in a previous publication (9).

Feeding and care. Immediately after exteriorization of the pancreatic secretion, the animals were put into a Bollman-type restraining cage. Ten ml of normal saline and 10 ml of 5% glucose were administered subcutaneously. Starting from the 2nd day after the operation, the rats were fed liberal amounts of a mixture of Gerber’s baby food plus egg yolk made into a thick paste with milk. Five to ten grams of Pard were fed once a day. Tap water or a 0.4% saline solution was provided for drinking when animals were not used in an experiment.

Collection of sample. During the first 24 hours after operation, the pancreatic flow was scant. The actual collection did not begin until 36-48 hours after the operation had been performed. Twelve to 16 hours before the experiment food was withheld from the animals. No drinking or parenteral water was supplied during the experimental periods. Hourly secretion was collected into a specially calibrated ice-cooled tube. The juice was diluted with an equal volume of glycerin and stored in an ice box before amylase measurements were made. Amylase was determined according to a slight modification of the method described by Schmidt et al. (10).

RESULTS

Volume flow and amylase output under fasting conditions. In 75 measurements from 17 rats, the basal secretion showed wide variation. The range was 0-1.0 ml/hr. and the mean volume ± standard error was 0.33 ± 0.078 and 0.32 ± 0.077 ml/hr. in two successive control periods. Amylase output likewise varied considerably in different rats. The means for two consecutive control periods were 4400 ± 2440 and 4700 ± 2400 mg maltose equivalents per hour in 18 determinations each.

Effect of oral feeding. Five rats were fed 3-5 gm of Pard. The volume flow during two control periods was approximately 0.5 ml/hr. The volume secretion increased significantly in the succeeding 4 hours in 10 tests (fig. 1).
TABLE 1. Effect of Gastric Feeding on Pancreatic Secretion

<table>
<thead>
<tr>
<th>Hr.</th>
<th>Volume (ml) ± S.E.</th>
<th>Amylase output (mg maltose Eq.) ± S.E.</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0.20±.04</td>
<td>2311±470</td>
</tr>
<tr>
<td>2</td>
<td>0.20±.02</td>
<td>2325±325</td>
</tr>
<tr>
<td>3</td>
<td>0.30±.04</td>
<td>2310±400</td>
</tr>
<tr>
<td>4</td>
<td>0.30±.04</td>
<td>2340±80</td>
</tr>
<tr>
<td>5</td>
<td>0.20±.04</td>
<td>3880±400</td>
</tr>
<tr>
<td>6</td>
<td>0.20±.04</td>
<td>5000±400</td>
</tr>
</tbody>
</table>

* P < 0.05.

In four determinations in two rats the amylase output also significantly increased for 4 hours following feeding.

Effect of gastric feeding. It has been shown that there definitely is a cephalic phase of gastric secretion in the rat (9). Part of the effect of oral feeding on pancreatic secretion may have been due to this cephalic component. In order to eliminate this possible cephalic influence, three rats provided with total gastric fistulas were fed by injecting 3-5 gm of a thick paste of dog food into the stomach via the fistula. Table 1 shows that in six experiments the introduction of food directly into the stomach slightly but significantly increased the volume flow of pancreatic secretion for 2 hours. The amylase output was measured in two rats; in both the increase was more than 30%, which was significant. In our hands the maximal error of amylase determination was less than ±15% in 49 duplicate samples.

Effect of sham feeding. Three sets of experiments were performed on three groups of rats in this study. Group 1: five rats without gastric fistula were sham-fed for 30 minutes; group 2: four rats provided with a chronic gastric fistula were sham-fed for 30 minutes; group 3: rats with double vagotomy were sham-fed for 30 minutes.

Results recorded in table 2 show that sham feeding significantly increased the volume flow and amylase output of rats in group 1. In rats with gastric fistula (group 2), whose gastric acid was drained away, sham feeding had no effect on volume flow in 10 tests. The increase in amylase output was significant in only one of four determinations. Seven experiments were done on vagotomized rats (group 3); in none of these animals was the change in volume flow significant after sham feeding. Amylase output was not determined in the third group of animals. Owing to wide individual variations in amylase concentration from rat to rat, the hourly values of amylase output were listed in table 2 instead of the mean and standard error of the hourly output of the group.

In one experiment sham feeding was performed twice, in each case an increase in volume flow followed immediately (fig. 2).

**DISCUSSION**

The spontaneous volume flow of pancreatic secretion obtained under fasting conditions was only 0.33 ml/hr. It is possible that these rats not been fasting for 12-16 hours their volume flow would have been greater.
We are struck by the high amylolytic activity of the pancreatic juice of the rat under basal conditions. The hourly amylase output ranged from 1,900 to 15,300 mg of maltose equivalents under basal conditions. Our enzyme samples were customarily diluted more than one thousand times before a satisfactory titrimetric reading was obtained; otherwise, the amylolytic activity was so high that the titration readings were far beyond the optimal range. In our experience with the anesthetized dogs continuously perfused (11) or repeatedly stimulated (12) with secretin after a fast of 16 hours, the total amylase output for a dog weighing about 10 kg was approximately 500 2000 mg of maltose equivalents for a period of 10 minutes, i.e. roughly 3,000-12,000 mg/hr. Taking into consideration the difference in body weight between a dog and a rat, the amylase output in the latter species may be considered 'abundant.'

We found Pard more effective than the ordinary rat diet for the stimulation of pancreatic secretion. Grossman, who first failed to get an increase of secretion by feeding a laboratory rat diet (13), later confirmed our findings by also giving his rats dog food (4).

REFERENCES


Although sham feeding definitely increased both the volume flow and the amylase output of the pancreas in group 1 (table 2), it failed to do so in most of the experiments in the animals of group 2, whose gastric contents were drained to the outside. This seems to suggest that the increased pancreatic response after sham feeding may not be a true cephalic phase but secondary to the HCl produced during the cephalic phase of gastric secretion. However, Grossman (4) found that the rate of secretion and the protein concentration were unaltered by introduction into the duodenum of 0.1 N HCl at the rate of 1 ml/hr. Moreover, our studies from insulin stimulation (14) suggest that a nervous component docs seem to play a role in the stimulation of pancreatic secretion; for after double vagotomy, insulin failed to affect the volume or the enzyme. However, we cannot state with certainty whether or not there is a cephalic phase of pancreatic secretion at the present. Our findings are suggestive but unequivocal evidence is still lacking. Further elucidation of a possible cephalic phase of pancreatic secretion in this species of animal is in progress in this laboratory.