

The Effect of Exclusion of the Pancreatic Secretion by a Pancreatic Fistula on the Reaction of the Gastric, Duodenal and Jejunal Contents*

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THE effect of the loss of the secretion of a gland is not necessarily the same as the effect of preventing the gland from secreting. The secretion of the pancreas is a pertinent example. The loss of pancreatic secretion produces a rapidly fatal result unless appropriate treatment is instituted. On the other hand, evulsion of the pancreatic ducts, preventing the production of pancreatic secretion, produces no untoward effects except those associated with the resulting decrease in intestinal digestion. The results of eliminating the pancreatic juice, by preventing the pancreas from secreting, on the reaction of the duodenal content were presented in the previous paper. It was the purpose of this investigation to determine what changes in the reaction of the content of the upper portion of the gastro-intestinal tract occur when the pancreatic secretion is eliminated by draining it to the outside of the body.

METHOD

Gastric, duodenal, and jejunal fistulas, as well as combinations of these fistulas, employing the transposed loop of intestine method, were made (3) and utilized in obtaining specimens of the content of the upper portion of the gastro-intestinal tract at half-hour intervals for an eight-hour period. The hydrogen ion concentration of this material was determined at once with quinhydrone gold electrode. Samples of the content of the various portions of the gastro-intestinal tract were collected during fasting and following the administration of the standard protein, carbohydrate, and fat test meals until representative figures were secured for each animal. Having obtained the necessary preliminary data, pancreatic fistulas were made using a technic similar to that of Elman and McCaughan. It was found advantageous to feed the dogs 50 gm. of meat about three hours before the operation. Thus the major pancreatic duct was more easily cannulated and secretion immediately began to flow through the tube, preventing the formation of blood clots that might lead to obstruction of the cannula. The same series of tests were then performed and similar observations instituted the day following operation. The animals were given daily 300 to 600 cc. of physiologic saline solution intravenously, depending on the size of the animal and the amount of pancreatic juice secreted during the preceding twenty-four hours. This procedure, so necessary for the maintenance of life, replaced both the fluid and salt which had been lost from the pancreatic fistula and by vomiting. The operations

were performed with animals under ether anesthesia and employing sterile technic.

RESULTS

Elman and McCaughan reported that death invariably resulted in from five to eight days when the entire external pancreatic secretion of dogs was excluded from the intestine by drainage to the outside of the body. However, the later work of McCaughan revealed that, if the whole pancreatic juice was returned to the dog by mouth or large quantities of physiologic saline solution were injected intravenously daily, no untoward effects were noted. The results of these experiments substantiated the findings of the foregoing authors. Although the dogs in this group ate fairly well, they gradually lost weight, and practically all of them developed a tendency to vomit occasionally. As in the case of evulsion of the pancreatic ducts, the stools became large, fatty, and rancid in odor.

Effect on the reaction of the gastric content.—The reaction of the gastric content (after establishing the pancreatic fistula) during fasting and following the ingestion of the standard test meals was always within normal limits.

Effect on the reaction of the duodenal content.—Specimens of the duodenal content during fasting usually had a pH between 7.00 and 7.78, but variations from 6.80 to 5.41 were sometimes observed. Nevertheless, when samples were taken at half-hour intervals for an eight-hour period, an occasional acidity as low as 3.07 was detected among these alkaline and slightly acid readings. A comparison between these findings and those from the normal dog revealed that, following the production of a pancreatic fistula, determinations below pH 7.00 were more frequently obtained and the levels reached were somewhat lower in the majority of cases.

The reaction of the duodenal content the first half-hour after a meat meal was found to be between pH 5.95 and 4.12, but during the next two or three hours it ranged from 4.50 to 2.50. Although there was then a tendency to return toward neutral, the majority of the subsequent determinations remained between 5.00 and 3.98. When the pancreatic secretion was eliminated by draining to the outside of the body, the results were similar to those obtained when the gland was prevented from secreting (Fig. 1).

One-half hour after the administration of a test meal composed of milk, syrup, and water, the pH of the duodenal content ranged from 6.60 to 5.88. A further increase in the acidity, fluctuating between 5.95 and 4.20, was detected during the following two or three hours, but a specimen with a pH as low as 3.69 was occasionally collected. Thereafter, although

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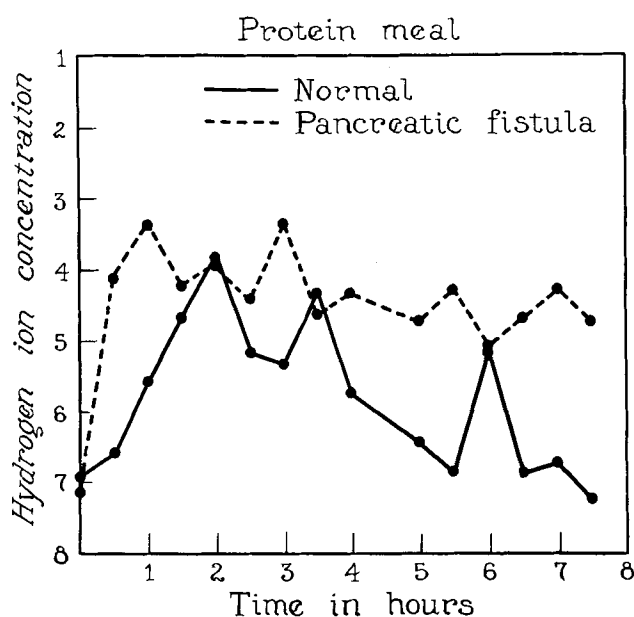


Fig. 1

the reaction usually returned to a higher level, varying between 6.50 and 5.06, a reading of 4.21 was sometimes obtained, which not infrequently was the lowest determination occurring throughout the day (Fig. 2).

After a fat meal, no deviation from normal could be detected in the pH of the duodenal content following the production of a pancreatic fistula.

Effect on the jejunal content.—By the time the gastric content admitted into the duodenum had reached the jejunum, its reaction was neutral or was slightly alkaline. The loss of pancreatic secretion did not appear to injure the mechanism accomplishing this change except when a protein test meal had been administered.

The ingestion of a protein meal was followed by a gradual decrease in the pH of the jejunal content until a level of 5.00 was reached about two and a half hours after the ingestion of food. Subsequent determinations closely approximated those of the normal dog, but acid readings as low as 5.78 were more frequently obtained. Thus the absence of the pancreatic juice did have a slight but appreciable effect on the reaction of the intestinal content below the duodenum with this diet.

Comparison of results obtained with pancreatic fistulas and evulsion of pancreatic ducts.—By careful selection of observations from each group the change in the reaction of the duodenal content could be made to appear more marked following either evulsion of the ducts or establishment of a pancreatic fistula. A reliable opinion concerning any real difference could only be formed when both series of dogs were considered in their entirety. It was then discovered that a few more acid determinations were obtained with a pancreatic fistula following protein and carbohydrate diets than after evulsion of the pancreatic ducts. However, the distinction was so slight that it should not be emphasized.

Fig. 2. Variation in the pH of the duodenal content following a carbohydrate meal before and after the establishment of a pancreatic fistula.

Fig. 1. Variation in the pH of the duodenal content following a protein meal before and after the establishment of a pancreatic fistula.

COMMENT

With the aid of daily intravenous injections of physiologic saline solution the dogs remained active and in apparently good health for many days although they continued to lose weight. One animal was kept in excellent condition for thirty-four days, but there was some evidence of leakage of the pancreatic juice into the intestine about the twentieth postoperative day, and this was verified on postmortem examination. Two dogs died after continuous secretion for seven and twenty-five days, respectively, and necropsy revealed no cause of death other than the pancreatic fistulas. The findings at necropsy of two other animals, both lost on the tenth day, revealed acute perforated peptic ulcers.

It was essential to maintain a continuous flow of secretion after establishing a pancreatic fistula. The development of leakage or infection had to be detected immediately and the dogs eliminated from the series. Owing to the extreme facility with which the pancreatic juice became infected in spite of a strict aseptic technic, the remainder of the dogs, although in fairly good condition and excreting pancreatic juice freely, were sacrificed from twelve to twenty-four days postoperatively because of the presence of bacteria in the pancreatic secretion. At times the material collected from the fistula was perfectly clear and was of normal appearance, and the existence of an early infection could be detected only by special technic.

SUMMARY

Specimens were obtained of gastric, duodenal and jejunal contents under normal physiologic conditions and their reactions were determined in the fasting state and after various test meals, before and after draining the pancreatic secretion to the outside of the body. The production of a pancreatic fistula caused no change in the reaction of the gastric content during fasting or after the various types of test meal used in the research. However, differences in the reaction

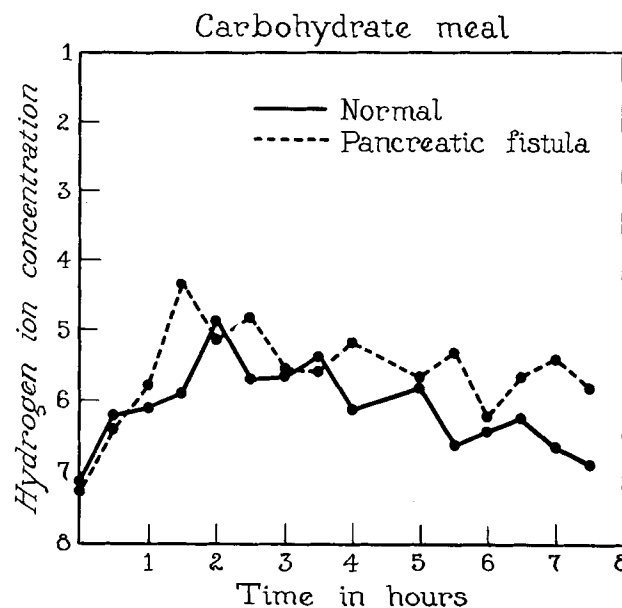


Fig. 2

of the duodenal content were observed after establishing a pancreatic fistula. Although the range of variation during fasting was quite within normal limits in the two conditions, low determinations were more frequently obtained for the animal with a pancreatic fistula. Protein and carbohydrate meals caused a more rapid decrease of the pH, and the reaction was usually maintained at a decreased level for a longer period before returning toward neutrality than was found be-

fore elimination of the pancreatic secretion. These same changes were also observed to a lesser degree with the jejunal content, but only after a protein diet. A comparison of the results following the production of a pancreatic fistula and evulsion of the pancreatic ducts revealed a few more acid determinations in the former after protein and carbohydrate diets. The distinction, however, was slight and should not be emphasized.

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The Buffer Capacity of the Pancreatic Juice *

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WHILE ascertaining the reaction of the intestinal content at various levels of the intestinal tract following elimination of the pancreatic secretion from the duodenum by means of a pancreatic fistula, it seemed desirable to determine whether the results obtained in previous studies could mainly be due to the absence of the secretion from the pancreas.

Bayliss and Starling stated that the alkalinity of pancreatic juice gradually fell as secretion continued. Anrep, Lush, and Palmer believed this was partly due to removal of available alkalies from the blood supply and partly to the slightly acid solutions of secretin which were used to stimulate the pancreas. Johnston and Ball noted that the pH of pancreatic juice varied from 7.16 to 8.04 during constant drainage of the secretion, and that a decrease of chloride ions was associated with an increase of bicarbonate. Ball (2, 3), also reported that the more rapidly the juice was secreted the higher its pH value, and that the bound carbon dioxide concentration of chloride and bicarbonate varied inversely. Gamble and McIver discovered that this decrease in chloride in the pancreatic juice was associated with a diminution in the chloride concentration of the blood.

Mellanby stated that secretin controlled only the alkaline fluid of the pancreatic juice, whereas the enzymes were produced by a nervous mechanism. This was in accordance with the views of Zucker, Newburger, and Berg. Dubois and Polonovski also supported this theory, for they observed that the reaction of the pancreatic secretion following the injection of secretin into five dogs varied between pH 8.4 and 8.6, and that following the injection of pilocarpine it varied between 7.8 and 8.2. Popow and Kudrjawzew found

the hydrogen ion concentration of pancreatic secretion to be inversely proportional to that of fluid introduced into the duodenum to stimulate the secretion of the juice. The work of Carnot and Gruzewska appeared to substantiate this observation, as they noted that the pancreatic secretion had a pH of 8.72 and, after injection of histamine, a pH of 8.90. In addition, Czubalski reported that the pH of the pancreatic secretion fluctuated between 7.06 and 8.64, and that the secretion was more alkaline following a protein meal (pH 8.23 to 8.64) than after the ingestion of milk (pH 7.06 to 8.45). He reasoned that since milk did not produce so high an acidity in the stomach, pancreatic secretion which had a reaction nearer neutral was produced. However, Jones felt that there was a compensatory reaction between the bile and pancreatic juice so that when the buffer action of one decreased the other tended to increase.

Under the conditions of their investigation, Elman and McCaughan found the buffering capacity of the pancreatic secretion to be very great, for 1 c.c. of the secretion would neutralize an equal amount of tenth-normal hydrochloric acid, and thus they considered it an important factor in the neutralization of acid chyme.

METHOD

In this experiment, 1 c.c. of the secretion secured from the pancreatic fistula was titrated with 1 c.c. of tenth-normal hydrochloric acid, a drop at a time, and the change in pH with each minute addition was determined. Samples of pancreatic juice were collected at half-hour intervals during fasting and after the ingestion of the various standard test meals and the fluctuation in the buffering capacity during the eight-hour period of observation was determined.

RESULTS

The pancreatic secretion was usually thin, watery, opalescent, and tasteless when flowing freely, but was somewhat more viscid and ropy in character after

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