A STUDY OF EXTERNAL PANCREATIC SECRETION IN MAN

BY BENJAMIN KOGUT, MILTON J. MATZNER AND ALBERT E. SOBEL

(From the Department of Gastro-enterology and Pediatric Research Laboratory, The Jewish Hospital of Brooklyn, Brooklyn)

(Received for publication February 17, 1936)

An opportunity to study pure pancreatic secretion in man is extremely rare. Wohlgemuth (1) reported his observations in a young man with an external pancreatic fistula. He found that the rate of secretion varied considerably with the diet, that no flow was observed with a high fat diet, that there was an increased rate of secretion with

Quantitative studies of the composition of the pancreatic fluid

While at the hospital, specimens were obtained daily from the pancreatic fistula. About 15 cc. were obtained during an interval of about 12 hours. The patient was fed various diets as indicated in Table I.

| TABLE I | Quantitative analysis of pancreatic secretion |
|-------------------------------|-------------------------------|-------------------------------|-------------------------------|-------------------------------|-------------------------------|-------------------------------|-------------------------------|-------------------------------|-------------------------------|-------------------------------|-------------------------------|-------------------------------|-------------------------------|
|       | CO₂ | Cl | Creatinine | Uric acid | Urea | Non-protein nitrogen | Total nitrogen | Total protein | Cholesterol | Sugar | Calcium | Phosphorus | Potassium | Total base | Phosphatase | pH  |
|-------------------------------|-------------------------------|-------------------------------|-------------------------------|-------------------------------|-------------------------------|-------------------------------|-------------------------------|-------------------------------|-------------------------------|-------------------------------|-------------------------------|-------------------------------|-------------------------------|-------------------------------|-------------------------------|
| C250 High carbo-     | 382  | Traces | Traces | 3  | 28 | 75 | 0.29 | Neg. | 18 | 3.7 | 2.2 | 16.9 | 12.7 | 8.6  |
|hydrate diet            | (April 24)                          | (April 26)                          | (April 26)                          | | | | | | | | | | | | |
| P 75 F 75 to May 3   | 383  | Traces | Traces | 4  | 40 | 137 | 0.61 | Neg. | 15 | 4.1 | 3.2 | 21.7 | 0.9  |
| (April 26)                  | (April 26)                          | (April 26)                          | (April 26)                          | | | | | | | | | | | | |
| C 60 High fat diet      | 390  | Traces | Traces | 3  | 35 | 70 | 0.22 | Neg. | 9.6 | 3.5 | 2.1 | 162 | 2.8  |
| F 200                   | 385  | Traces | Traces | 2  | 33 | 66 | 0.21 | Neg. | 12.5 | 2.2 | 17.4 | 158 | 8.8  |
|May 8                    | 391  | Traces | Traces | 3  | 30 | 65 | 0.22 | Neg. | 2.2 | 2.2 | 16.1 | 170 | 2.5  |
| Full ward diet          | 62.0 | 413  | Traces | 1  | 39 | 67 | 0.18 | 8.5 | 4.2 | 2.2 | 16.9 | 177 | 0.8  |
|                         | (May 12)                  | (May 13)                  | (May 14)                  | | | | | | | | | | | | |
| Blood serum             | 66.0 | 355  | 16.0 | 30 | 1225 | 7.5 | 257 | 94 | 10.2 | 3.7 | 13.9 | 156 | 2.8  |

* Total protein = 6.25 (total nitrogen-nonprotein nitrogen).

The results of the chemical analyses are shown in Table I. The last line represents the values found in the blood serum of the same patient.

All of the chemical determinations were carried out in duplicate. The agreement between the duplicates was well within the experimental error of the methods. The accuracy of the technique was also checked by means of known solutions. The urea values are somewhat inaccurate because of the small values found. The phosphatase was controlled by parallel determinations of bone and serum phosphatase of known activity.

METHODS

Total base was determined by the method of Van Slyke, Hiller and Berthelsen (5), and CO₂...
content according to Van Slyke and Neill (6) using the factors of Van Slyke and Sendroy (7). Chlorides were determined on 0.2 cc. of solution according to the Wilson and Ball's modification (8) of the Van Slyke (9) procedure except that 0.2 cc. of 0.15 N AgNO₃ was used and 0.01 N KCNS. Urea was determined by the method of Van Slyke and Cullen (10), and uric acid according to Benedict (11). Creatinine was estimated according to the method of Folin and Wu (12). Nonprotein nitrogen was determined by precipitating the proteins with 5 per cent trichloracetic acid performing a micro-Kjeldahl on an aliquot of filtrate. Howe's method was used for the determination of total protein (13). The Parnas and Wagner modification of Pregl's micro-Kjeldahl method was used for the final determination of nitrogen, except that the NH₃ was caught in boric acid and titrated with N/100 sulfuric acid (14). Cholesterol was determined by Sackett's modification of Bloor's method (15), calcium by the procedure of Kramer and Tisdall (16), inorganic phosphorus by the method of Fiske and Subbarow (17), and sugar by the Kramer-Gittleman modification of the Folin-Wu method (18). pH was determined in a colorimetric block by the method of Henderson and Palmer (19). Phosphatase estimations were made according to the procedure outlined by Bodansky (20) except that for the final colorimetric determination of phosphate the Fiske-Subbarow method was used. For the determinations on the pancreatic juice the pH of the substrate was adjusted to a pH of 8.8. A phosphatase unit is the amount of phosphatase which will liberate 1 mgm. of inorganic phosphorus in one hour from the buffered glycerophosphate substrate. Potassium was determined by the method of Sobel and Kramer (21).

Study of dye excretion

Our patient was injected intravenously with 5 cc. of indigo carmine on April 25, 1935, and intramuscularly on May 1, 1935, with 2 cc. of neutral red (2 per cent). These dyes were not perceptible in the pancreatic secretion over a period of two hours.

DISCUSSION

The relatively short period of observation did not permit drawing any broad conclusions as to alterations of composition or rate of flow under the influence of various diets. Daily total excretions could not be determined since our patient had an incomplete external fistula. It is of interest to note that there was a minimal secretion during fasting. Soon after the ingestion of food, there was an increased rate of secretion. It is also significant that the fistulous opening showed no evidence of digestion, owing to the fact that this juice was non-activated.

The results of the serum analyses are typically normal except for the potassium which is below the accepted normal value (22). The chemical analyses of the pancreatic fluid fails to reveal any definite relations to the diet. (See Table I.) The fluctuation in chloride concentrations are minor and are paralleled by a change of total base in the same direction. Both are somewhat above the normal values for blood serum. The potassium values of the fluid are within the range of normal established for serum, while the calcium values in the fluid are less than one-half of the values that are found in serum and are fairly constant. The inorganic phosphate values are also fairly constant, with one exception, and are lower than those of serum. The concentration of sugar is much lower here than in any of the other body fluids. Total protein concentrations with one exception are about the same as those found normally in spinal fluid.

The results of the nonprotein nitrogen determinations in the pancreatic fluid are at the upper end of the normal range for serum and are fairly constant. In view of this the low urea values and the almost negligible uric acid and creatinine values are surprising. The bulk of the nonprotein nitrogen must be different from that of the serum, in which urea, uric acid and creatinine constitute over 50 per cent of the total. Cholesterol is completely absent. This is usually the case for extracellular fluids in the absence of large amounts of proteins. The CO₂ determinations were usually omitted because the samples were not obtained under oil. The pH of this fluid varied from 8.6 to 8.8. Although these specimens were not taken under oil, it is unlikely that there was an appreciable change in the hydrogen ion concentration.
The phosphatase activity varied considerably in the various samples. The reason for this is obscure. The presence of phosphatase in the pancreatic secretion of man has not been previously reported. Umeno (23) established the presence of phosphatase in pancreatic juice recovered from experimental fistulae in dogs.

The sugar concentrations are in qualitative agreement with those of Nutt. No creatinine or uric acid values are available in the literature for comparison. The urea levels appear to corroborate the findings of J. B. Cohen (24) who observed that in animals the urea concentration of pancreatic fluid is considerably less than that of serum.

Crandall, Oldberg and Ivy (25) injected dogs intravenously with indigo carmine and neutral red. They also reported that these dyes were not recovered in the pancreatic juice. Ingraham and Visscher (26) concluded that all dyes eliminated by the dog’s pancreas ionize, with their chromogen electro-negative, under proper conditions. The rapidity of closure of the pancreatic fistula did not permit us to continue further investigations of dye excretion.

SUMMARY

1. Quantitative studies of the chemical composition of external pancreatic secretion were made.
2. Injected indigo carmine and neutral red did not appear in the pancreatic secretion.
3. An increased rate of secretion was observed after the ingestion of food.
4. Non-activated pancreatic secretion did not excoriate the fistulous opening.

BIBLIOGRAPHY

22. Kramer, B., Inorganic constituents of the blood. Cyclopedia of Medicine, 1932, 6, 487.