THE RELATIONSHIP BETWEEN GASTRIC SECRETION AND THE ALKALINE TIDE IN URINE

BY ROGER S. HUBBARD, SAMUEL A. MUNFORD, AND JAMES TYNER

(From the Clifton Springs Sanitarium and Clinic, Clifton Springs, New York, and the Buffalo General Hospital and the University of Buffalo, Buffalo)

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The theory that the alkaline tide in the urine is caused by the formation of hydrochloric acid in the stomach is one which has been advocated by many physiologists, but which has not been universally accepted. Since the literature dealing with the subject has been discussed by Munford and Hubbard (1926), Rannenberg (1926), and Davies (1929), it will not be reviewed further at this time. The authors believe that the question can best be studied by direct comparison of results upon normal subjects with those obtained under similar conditions upon patients with achlorhydria. A number of investigations of this type have been reported. While in most instances quite distinct differences have been noted between results on the two types of cases, such differences have not been invariably found (Watson, 1925; Hubbard and Case, 1930). It seems worth while, therefore, to report the rather extensive series of experiments described below.

This series is based upon the study of 273 sanitarium patients. None of them, as far as was known, was suffering from acute illness, apart from conditions closely associated with gastric secretion, and very few of them showed any signs whatever of cardiovascular-renal disease. The cases were selected and grouped for study on the basis of gastric analyses carried out by the fractional technique of Lyon, Barth, and Ellison (1921). These tests showed that in 125 hydrochloric acid was present in the gastric juice in approximately normal amounts, and that in 86 no acid was found. There were also two groups which were hard to classify in a satisfactory manner. The stomachs of twenty-three
patients apparently secreted less than the normal amount of acid, for either hydrochloric acid was present in less than half of the specimens obtained during the 105 minutes of the test or else the concentration of acid in all specimens was low, for titration to the end-point with Toepfer’s reagent gave values less than 10 cc. of 0.1 N acid per 100 cc. of gastric juice in each specimen. The thirty-nine cases in the fourth group have also been classified as hypochlorhydria, although in some respects a diagnosis of achlorhydria might seem appropriate, as no specimen from them gave a positive reaction when tested with Toepfer’s reagent. However, the total acidity determined by titration to the phenolphthalein end-point increased after the gastric test meal and reached values greater than 20 cc. of 1.0 N acid per 100 cc. of gastric juice in at least one specimen. Such increases probably do not take place unless some hydrochloric acid is secreted by the stomach. Since most of the errors in gastric analysis lead to results which are too low, patients upon whom a gastric analysis was carried out more than once have been classified according to the highest values obtained. Since histamine was not used in these studies, it is quite probable that some cases have been incorrectly called achlorhydric.

The reaction of the morning urine of these patients was studied on a different day from that on which the gastric analysis was carried out. The technique approximated physiological conditions closely, and was so simple that deviations from the regimen were infrequent. Each test began at 7 o’clock in the morning when the patient emptied his bladder. This specimen was discarded and hourly specimens collected thereafter until 1 o’clock. A meal consisting of a glass of milk, a glass of water, two slices of toast with butter, and an egg was fed between 8 and 9 o’clock. No other food was eaten during the test and water was withheld as far as was practicable. The reaction of each specimen was determined to the nearest 0.1 pH by a colorimetric method soon after it was voided. Since it was not practicable to take the precautions recommended by Marshall (1922), the loss of carbon dioxide undoubtedly caused some irregularity in the results.

The averages of all the results obtained are given in Chart I. These averages are based upon the number of persons studied and not upon the number of tests run, for when more than one test
was carried out upon a single patient, the results of all of them were averaged and the averages used in computing the values given. The chart shows clearly that there were marked differences between the results upon the two large groups of cases, and that those obtained upon the two small groups considered by us to be made up of patients with hypochlorhydria were essentially intermediate between the others. All the average pH values of

![Chart](http://www.jbc.org/)

**Chart I.** Curve I is based upon the average values for 86 subjects in which hydrochloric acid was absent from the gastric juice; Curve II is based upon the average values for thirty-nine subjects with traces of acid probably present in the gastric juice; Curve III is based upon the average values for twenty-three subjects with small amounts of acid in the gastric juice; Curve IV is based upon the average values for 125 subjects with normal amounts of acid in the gastric juice. The details of the method of classifying results are given in the text.

the other specimens collected from patients with achlorhydria were more acid than was the first one, while a majority of those from subjects with normal gastric juice was more alkaline than was the one obtained an hour after waking. The urine of the patients with normal gastric findings showed a well marked alkaline tide after the test breakfast which was absent in the control series of patients with achlorhydria. This evidence supports the
thesis that secretion of acid by the stomach causes the alkaline tide in the urine.

These average figures also show quite clearly the effect of the morning respiratory tide which has been previously discussed (Leathes, 1920; Hubbard, 1929), for the patients with achlorhydria showed an increase in the urinary acidity as the relative alkalinity found immediately after awakening (Hubbard, 1930) passed off. Chart I suggests that there was possibly overcompensation for this early period of alkalinity, for the urine of the achlorhydric subjects showed a fairly well marked acid peak during the 3rd hour of the test. It is quite possible, however, that this peak has no physiological significance, for since histamine was not used in differentiating the cases of achlorhydria, some patients may have been incorrectly included in this group, and the results upon them have so influenced the average figures as to cause the slight increase in alkalinity shown during the 4th and 5th hours. The authors believe that increases in acidity similar to those just discussed were not shown by the patients with normal stomach contents because they were obscured by the effect of gastric secretion induced by the meal.

SUMMARY

Comparison of results upon two extensive series of patients, one with normal gastric contents and one with achlorhydria, shows that the secretion of hydrochloric acid by the stomach is the main cause of the alkaline tide after the morning meal. There are a number of conditions which may affect either the reaction of the urine or the secretion of hydrochloric acid by the stomach, and the effect of such factors probably explains the lack of a relationship between gastric acidity and urinary reaction which has been reported from time to time. There is a fairly regular increase in the acidity of the urine of patients with achlorhydria which probably represents, in part at least, recovery from an early morning period of alkalinity due to respiratory causes.

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