THE EFFECT OF CHANGES IN REGIME UPON THE URINARY ALKALINE TIDES IN A NORMAL INDIVIDUAL

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In 1912 Henderson and Palmer (1912) introduced a technique for determining the pH of the urine and applied it to the study of twenty-four-hour specimens from 222 normal and pathological cases. Their observation showed a range of pH from 5.0 to 7.4. They also observed that the pH of the urine rises to some extent following a meal. The pH curve of normal urine was also studied by Hasselbalch (1912) who reported a fall in pH immediately after each meal followed by a rise to a maximum about three hours later. Fiske (1921) confirmed the existence of this rise in pH after meals and observed pH values during the alkaline tide as high as 7.7. He studied also the phosphate excretion during the period of the alkaline tide. Hubbard, Munford and Allen (1924) observed that the alkaline tide occurred only in individuals who showed presence of free HCl in the stomach during digestion. Higgins (1914) and Erdt (1915) found a rise of alveolar pCO_2 during digestive activity. Van Slyke, Stillman and Cullen (1917) confirmed this observation and found that the plasma bicarbonate in some cases increases slightly, in others not. Dodds (1921) and Dodds and McIntosh (1923) observed a rise in the CO_2 content of the blood and in alveolar pCO_2 about one-half hour after meals followed by a secondary fall in both at the time the urinary alkaline tide occurs.

Leathes (1919) found that normal active individuals given water without food at 8 a.m. showed an increased urinary alkalinity during the morning hours. He attributed the alkalinity to increased pul-

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monary ventilation incident to their activity. He observed also that in cases of acute and subacute nephritis this morning alkaline tide was diminished or absent. McCorvie (1925) has studied the morning alkaline tide following the ingestion of water by the method of Leathes and also the urinary pH and phosphate excretion in 8 normal and 74 pathological cases. He confirms the observation of Leathes that the morning alkaline tide characteristic of normal cases tends to disappear in nephritic cases.

The following study is presented because it furnishes data upon the pH curve of a healthy subject throughout the entire day under varying conditions as regards time of taking food and time of commencing the day's activities. First the curve of urinary pH is shown when in accordance with the individual's custom only two meals, morning and evening, were taken. Then the curve when three meals were taken and then with only a single meal at midday. Finally the curve is shown during a day when the subject took his usual breakfast, but remained quiet in bed until noon without any physical activity.

METHODS

The urinary pH was measured by the nitrophenol method of Michaelis. The preparation of the standards in this method depends upon the fact that the indicators are colored when alkaline and colorless when acid. The standards consist of a series of tubes containing alkaline aqueous solutions of the indicators in concentrations selected to give the same depth of color as that of a series of buffer solutions containing a uniform concentration of dye.

Two indicators are used: Paranitrophenol (pH 5.4 to 7.0) and metanitrophenol (pH 6.8 to 8.4).

The solutions employed are as follows:

No. 1. 0.1 per cent aqueous solution of paranitrophenol
No. 2. 0.3 per cent aqueous solution of metanitrophenol
No. 3. M/10 aqueous solution of $NaHCO_3$
No. 4. 5 cc. of no. 1 diluted to 50 cc. with no. 3
No. 5. 5 cc. of no. 2 diluted to 50 cc. with no. 3

The standard tubes are made as shown in table 1.

A pH determination is made as follows: To 2 cc. of urine is added

4 cc. of 0.9 per cent sodium chloride solution and 1 cc. of indicator solution 1 or 2. Comparison with the standard is made in a Walpole colorimeter block, a tube containing 2 cc. of urine plus 5 cc. of saline being placed behind the standard tube.

The same series of standards permits one to measure also the pH range from 5.2 to 5.0. For this purpose one takes 2 cc. of urine, 2.5 cc. of salt solution, and 2.5 cc. of indicator solution 1. A color matching the standard tube marked pH = 5.4 will then represent a pH of 5.0 and one matching the tube marked pH = 5.6 will represent a pH of 5.2.

TABLE 1

pH	SOLUTION 4	SOLUTION 3	pH	SOLUTION 5	SOLUTION 3
	cc.	*cc.*		*cc.*	*cc.*
5.4	0.16	6.84	6.8	0.27	6.74
5.6	0.25	6.75	7.0	0.43	6.57
5.8	0.40	6.60	7.2	0.66	6.34
6.0	0.63	6.37	7.4	1.00	6.00
6.2	0.94	6.06	7.6	1.50	5.50
6.4	1.40	5.60	7.8	2.30	4.70
6.6	2.08	4.92	8.0	3.00	4.00
6.8	3.00	4.00	8.2	4.20	2.80
7.0	4.05	2.95	8.4	5.20	1.80

The color of the standard tubes was checked by comparison with Sörensen's phosphate buffer solutions to which the nitrophenol dyes were added. The pH determinations were made within a few hours of obtaining the urine except that the evening specimens at 8 and at 10 o'clock were kept on ice until the next morning. The subject's urine kept even 24 hours on ice was never observed to show a change of pH greater than 0.1.

RESULTS

The subject was a healthy male aged 28 years. His urine was collected at two-hour intervals from 8 a.m. to 10 p.m. and its pH determined. His daily work was light in character in the hospital and laboratory and was constant from day to day.

The first period of study was of the urinary pH curve of the subject during twenty consecutive days during which as was the custom of the

subject only two meals morning and evening were taken. In the first four days the diet was as follows:

Breakfast at 8.30 a.m. A cup of coffee, two fried eggs, two slices of bread and butter.

Supper at 6 p.m. Vegetable soup, Hamburger steak, coffee.

During the next fifteen days it was approximately the same.

TABLE 2

Urinary pH at two-hour intervals for twenty days. Two meals daily

	8 A.M.	10 A.M.	12 N	2 P.M.	4 P.M.	6 P.M.	8 P.M.	10 P.M.
1st day	6.1	6.3	6.8	6.5	5.7	5.6	5.9	6.4
2nd day	6.0	6.0	7.0	6.5	6.5	5.8	5.9	5.9
3d day	5.7	5.9	6.6	6.0	5.6	5.8	5.9	6.2
4th day	5.7	5.9	6.4	6.3	5.4	5.3	6.0	6.3
5th day	5.8	5.6	6.4	6.2	5.6	5.6	6.3	6.0
6th day	6.1	5.8	6.6	5.4	5.4	5.5	6.2	6.3
7th day	5.9	5.9	6.6	5.9	5.6	5.9	6.2	6.0
8th day	5.6	5.4	6.4	5.6	5.3	5.8	6.3	6.2
9th day	5.5	5.4	6.3	5.8	5.3	5.2	6.0	6.0
10th day	5.2	5.3	6.2	5.2	5.2	5.6	6.0	5.8
11th day	5.6	6.1	6.4	5.2	5.4	5.4	5.8	5.8
12th day	5.4	6.2	6.3	5.4	5.5	5.9	6.0	5.8
13th day	5.8	5.4	6.3	5.4	5.2	5.4	6.0	5.8
14th day	5.6	5.4	6.6	6.0	5.8	5.8	6.3	5.9
15th day	5.6	5.4	6.2	5.8	5.3	5.4	5.9	5.6
16th day	5.8	5.8	6.3	5.8	5.4	5.4	5.8	5.8
17th day	5.9	5.7	6.3	6.1	5.5	5.3	6.0	6.2
18th day	5.5	5.7	6.5	5.6	5.2	5.3	5.9	5.7
19th day	5.6	5.4	6.3	6.0	5.8	5.8	6.0	6.2
20th day	5.7	5.7	6.3	5.9	5.4	5.3	6.0	6.1
Average	5.7	5.7	6.4	5.8	5.5	5.5	6.0	6.0
Minimum	5.2	5.3	6.2	5.2	5.2	5.2	5.8	5.6
Maximum	6.0	6.3	7.0	6.5	6.5	5.9	6.3	6.4

Breakfast, 8.30 a.m.—Supper, 6.00 p.m.

In table 2, and in figure 1 are shown the curves of the average, the maximum, and the minimum, of the pH at each time of day for twenty days. Each day's observations showed alkaline tides after the meals; the morning tide having its maximum about $3\frac{1}{2}$ hours after breakfast, the evening tide about 2 hours after supper. The morning alka-

line tide was followed by a period of maximal acidity. The curve also shows that the alkaline tide after breakfast was higher than that following supper.

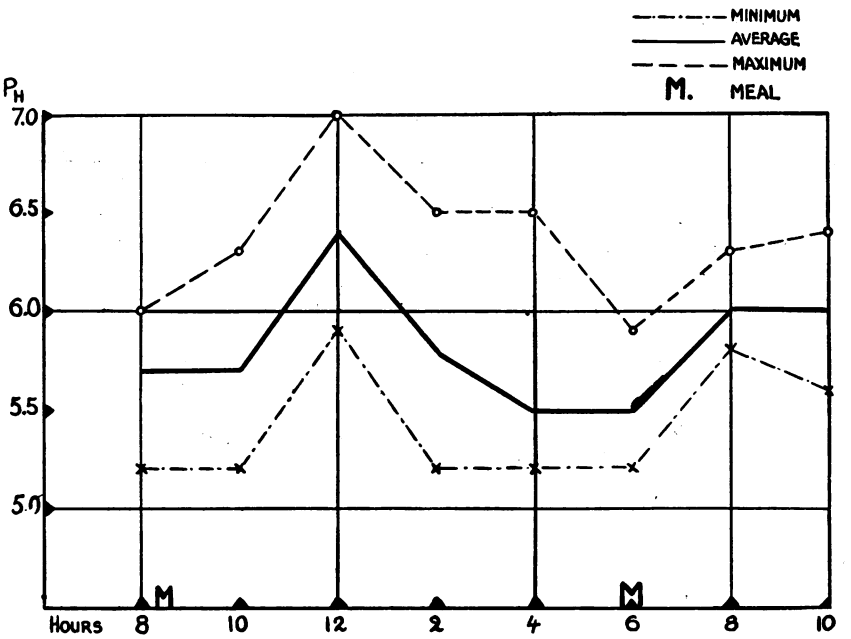

FIG. 1. URINARY REACTION CURVES THROUGHOUT THE DAY SHOWING TWO ALKALINE TIDES

Based on observation over twenty consecutive days. (The minimum at 12 is drawn to include the low figure from table 3, May 1.)

TABLE 3

Urinary pH at two-hour intervals on three days. Three meals daily

	8 A.M.	10 A.M.	12 N.	2 P.M.	4 P.M.	6 P.M.	8 P.M.	10 P.M.
April 29, 1925.....	6.0	5.8	6.0	6.6	6.6	5.6	6.8	6.5
May 1, 1925.....	5.8	5.5	5.9	5.4	5.5	6.2	6.2	5.9
May 5, 1925.....	5.5	5.9	6.8	6.4	5.4	5.6	5.7	6.1

Breakfast at 8.30 a.m., Lunch at 1.00 p.m., Supper at 6.00 p.m.

The second period of study was of the pH curve when the subject took three meals daily. The results on these days are shown in table 3 and figure 2. On each of these days there are only two alkaline

tides, never three and on only one of the three days is an alkaline tide seen after the noon meal when it occurs apparently as a delay of the tide usually occurring in the morning. The evening rise tends perhaps to be higher than during the two-meals-per-diem period.

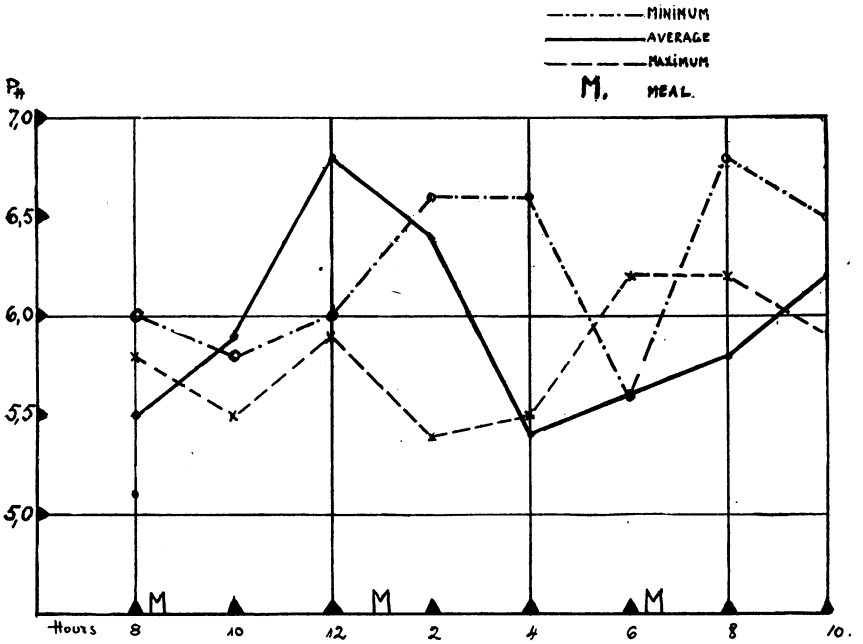

FIG. 2. SHOWING URINARY pH WITH THREE MEALS DAILY, WITH TWO ALKALINE TIDES

Very similar to those in figure 1

TABLE 4

Urinary pH at two-hour intervals on three days. One meal daily

	8 A.M.	10 A.M.	12 N.	2 P.M.	4 P.M.	6 P.M.	8 P.M.	10 P.M.
May 6, 1925.....	5.9	7.5	8.0	7.0	6.4	5.8	6.1	5.4
May 12, 1925.....	5.9	6.3	7.2	7.0	7.0	6.0	6.8	6.0
May 20, 1925.....	5.8	5.5	6.4	6.2	5.4	5.2	5.4	5.9

Meal at 1.00 p.m.

The third period of study was of the pH curve when the subject took only one meal per day at 1 p.m. The results on these days are

shown in table 4 and figure 3. Again two tides are in evidence. In two instances the morning tides without breakfast are very pronounced. In only one instance is there a suggestion of prolongation of a high pH following the one o'clock meal.

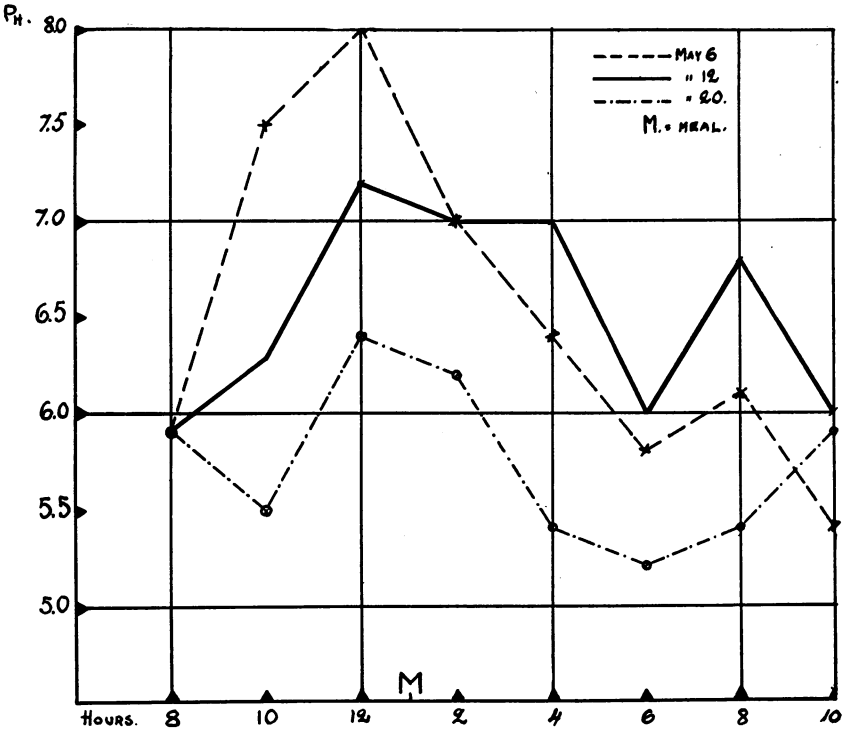

FIG. 3. SHOWING URINARY pH WITH ONE MEAL DAILY WITH TWO ALKALINE TIDES

Very similar to those in figure 1

The fourth study was to determine the effect of physical activity on the alkaline tide by keeping the subject in bed until noon. The result is shown in figure 4. Two tides are seen, timed approximately the same as upon other normal or experimental days.

These studies suggest that activity and the period of digestion while they may perhaps influence the urinary pH are not the sole cause of the rhythmic alkaline tides in the urine. They strongly

suggest a rhythm in the urinary pH characteristic for the individual and tending to persist in spite of quite striking alterations in his regime.

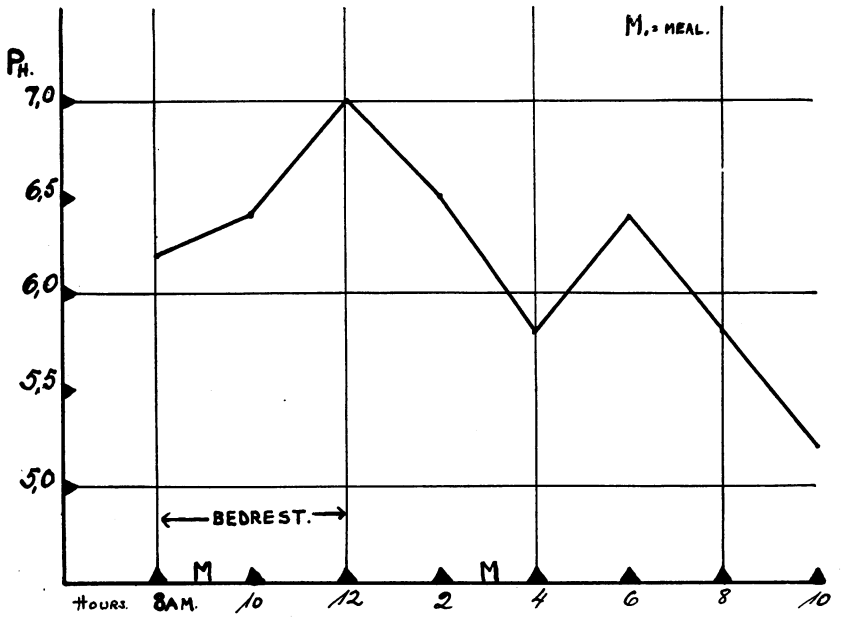

FIG. 4. SHOWING URINARY pH WITH REST IN BED UNTIL 12 NOON WITH TWO ALKALINE TIDES, UNAFFECTED BY ABSENCE OF ACTIVITY

SUMMARY

Determinations of the pH of the urine of a healthy subject were made at two-hour intervals throughout the day on twenty-seven days.

For twenty days the subject according to his habitual custom took only two meals, morning and evening.

For three days he took three meals daily.

For three days he took only one meal daily at 1 p.m.

On one day he remained in bed until noon, taking his usual breakfast but with no physical activity.

The curves of urinary pH on all of the days showed two alkaline tides, one with its maximum about noon and the second with its maximum about 8 p.m.

The intensity and timing of these alkaline tides was not conspicuously altered by the changes in the patient's regime.

The observations suggest a rhythm in urinary acidity characteristic for the individual and persisting in spite of marked variations in the individual's regime.

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