STUDIES ON THE MORNING ALKALINE TIDE OF URINE IN NORMAL PERSONS AND IN PATIENTS WITH NEPHRITIS[1]

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INTRODUCTION

The hydrogen-ion concentration of the urine has been the subject of much interesting study, by both pathologist and clinician, especially since the work of Henderson and Palmer. These investigators, using twenty-four hour specimens, studied the hydrogen-ion concentration of the urine both in normal persons and in patients with various diseases, including nephritis. They found that on the average the urine of nephritics was definitely more acid than that of normal persons. It has long been well-known that in normal individuals the urine is more alkaline during the morning. In 1919, Leathes investigated the changes that took place in the morning specimens in cases of acute and subacute nephritis in soldiers, and found that the alkaline tide, which was always normally present, was sometimes reduced or even absent in nephritis.

As there were such good opportunities at the Mayo Clinic to study cases of nephritis, it seemed important to discover what bearing Leathes' test might have on treatment or prognosis. Studies were accordingly undertaken with this object in view.

METHODS

The first series of cases was investigated according to a modification of Leathes' technic (table 1). His method of demonstrating the alkaline tide was as follows:

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A night specimen of urine was collected at 7:00 a.m. for the period from 11:00 p.m. to 7:00 a.m., and the second specimen at 8:00 a.m., immediately after which 500 cc. of water was given. Hourly specimens were then collected until twelve o'clock. No other fluid or food was taken by the patient after the evening meal preceding the test until its completion. By using suitable indicators, and titrating with tenth-normal acid and tenth-normal alkali, Leathes estimated the alkalinity per cent of the urine. Henderson and Palmer had previously described a similar method for obtaining the ratio of actual to total possible alkali excreted, by titrating with acid and alkali to a known hydrogen-ion concentration. It will be noted that by giving 500 cc. of water the ability of the patient to excrete water could be tested, and the range of specific gravity determined. In all the cases described the amount and specific gravity of each specimen was noted.

A series of buffer solutions were made up according to the method of Henderson and Palmer. At a later date these solutions were made up from Clark's tables. The accuracy of the pH solutions was checked by means of the electro-titration apparatus of Wendt, and in some cases the pH of the urine was estimated by this means as well as by the colorimetric method. The pH was estimated in all cases except those in table 1.

In the course of the work it became apparent that the hydrogen-ion concentration of the urine may change soon after it is voided. It has been shown by Gamble, and by Marshall, that on standing or shaking, carbon dioxid is liberated from the urine, and that the resulting change in pH may be quite marked, especially in the more alkaline urines. It was therefore decided to run a series of urine samples from normal and abnormal cases, estimating the carbon dioxid and phosphates in addition to the properties mentioned. The phosphates were of particular interest as they are largely responsible for the buffer action of the urine.

The carbon dioxid in the various specimens was estimated by van Slyke's method, and the phosphates by Doisy and Bell's colorimetric method. In this group of cases, all males, every precaution was taken to avoid any loss of carbon dioxid, and the consequent change in hydrogen-ion concentration. The urine in each case was passed by means of a funnel which emptied below a layer of toluene into an especially prepared narrow cylinder. This was at once corked, and, care being taken to avoid any shaking, carried to the laboratory in a neighboring room, where the carbon dioxid was at once estimated and the pH determined; immediately after this the alkalinity per cent was estimated. The complete study as outlined was carried out in all the normal cases (table 2) and in certain of the abnormal cases included in tables 3 and 4. The carbon dioxid and phosphate results for both normal and abnormal cases are shown in table 4.

One of the simplest tests for changes in the acid-base equilibrium in the individual was the direct determination of the alkali reserve of the blood plasma by van Slyke's method. It seemed important to determine at the onset whether there were not definite abnormalities in the excretion of acid by the kidneys, with little or no decrease in the carbon dioxid combining power of the blood plasma. Accord-

ingly, in a group of both normal and abnormal cases, I determined this factor, using samples of blood obtained both before water was given and at the time the diuresis should be at its height (table 7).

RESULTS IN NORMAL CASES

The minimal excretion from 8:00 a.m. to 12:00 m., after 500 cc. of water had been given at 8:00 a.m., was 260 cc., the maximal 1066 cc., and the average 699 cc. The minimal specific gravity at the height of diuresis varied from 1.003 to 1.012, while the maximal varied from 1.024 to 1.035. The smallest range difference was 0.020 in a case in which the specific gravity varied from 1.012 to 1.032. The greatest range difference was 0.030, the specific gravity varying from 1.005 to 1.035. The average range difference was between 0.024 and 0.025. The initial alkalinity per cent varied from 21 to 56, and the maximal from 64 to 96. In every case there was a definite and unmistakable rise in the alkalinity per cent during the morning, under the conditions of this test. The initial pH ranged from 5.35 to 6.2, with an average of 5.65, the maximal pH from 5.9 to 7.7, the average being 6.95. The phosphates always showed a decrease during the morning, the night specimen always containing the maximal amount. Following the early initial decrease there was a definite though slight increase later in the morning, even though the urine became more alkaline.

The results in these normal cases are in accord with those of Leathes, showing in every case a definite diuresis and a definite alkaline tide during the morning. Leathes also performed the test with varying amounts of water, even less than 500 cc., and found that the change in the alkalinity per cent still persisted. In one normal case I tried the test without administering water, and obtained a normal curve for the alkalinity per cent, and an increase in the pH figures as in the other normal cases in which water was given.

The change in the pH toward the alkaline side during the morning showed a definite but not exact parallelism to the curve of the alkalinity per cent. The carbon dioxid increased relatively with the increase in alkalinity. In every case it was found that a higher pH figure, that is, a change to the alkaline side, was accompanied by relatively increased carbon dioxid, and correspondingly an increased acidity was always accompanied by a fall in the carbon dioxid. In other words,

the carbon dioxid always varied directly with the figure of the hydrogen-ion concentration. This is in accord with the work of Gamble and Marshall. The total carbon dioxid naturally does not follow the pH so strikingly. The decrease in the phosphates during the morning and the later increase correspond to the findings of Fiske.

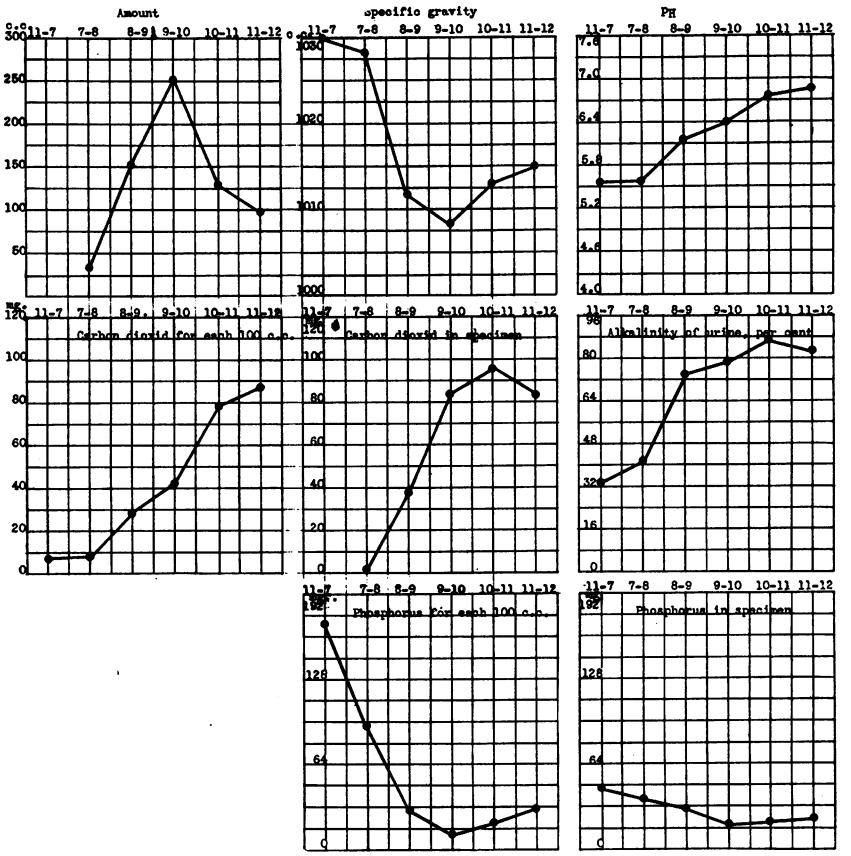

FIG. 1. AVERAGE CURVES FOR TEN NORMAL CASES

The average curves of the various factors determined in normal cases are shown graphically in figure 1.

RESULTS IN ABNORMAL CASES (TABLES 1, 3 AND 4)

Similar types of cases are grouped together and those in which the complete study was made are indicated. From a study of these

tables it will be observed that, while in some cases the test shows that all the factors are within normal limits, in others there are marked deviations from the normal. Leathes divided the cases which reacted abnormally into three groups: (1) those with little or no diuresis, but a normal alkaline tide; (2) those with diuresis, but no alkaline tide, and (3) those with neither a diuresis nor an alkaline tide.

The alkalinity per cent findings which are corroborated by the pH figures show that most of the cases in this series belong in one or another of these groups, although there are very few in group 1. To these three groups of cases, however, I would add a fourth small group, in which there was a definite acid tide during the morning, a reversal of the normal alkaline tide. This group will be discussed later at greater length.

It is to be noted that, even though the urine may react fairly normally with regard to diuresis, alkaline tide, or both, the range of the specific gravity may still be very limited.

The carbon dioxid in all cases, as was to be expected, varied inversely as the acidity.

In cases without an alkaline tide, there is a tendency, which may be very marked, to a fixation of the amount of phosphate excreted each hour. A study of the tables showing the phosphate estimation in the night specimens of normal and abnormal cases brings out an interesting fact. Under the conditions of this test the maximal night concentration of phosphates in abnormal cases, estimated as milligrams of phosphorus for each 100 cc., is less than the minimal normal night concentration. The average figure for the abnormal cases likewise was much below the normal average. The maximal figure of total phosphates for the abnormal cases was the same as for the normals, but this was very exceptional, as the next highest figure, 244.9 mg., is almost the same as the minimal figure for the normals. On the whole, in abnormal cases, the phosphates, both total and relative, in the night specimen were definitely below normal.

DISCUSSION

In studying renal function from a new viewpoint, it is, of course, necessary that the results obtained be correlated with previously accepted standards. In this study seventy-four hospital cases were

investigated, the majority of which were suffering from definite renal disease, although a few other conditions were included. In tables 5 and 6 the main clinical and functional findings are correlated together with the results of the present studies with regard to the morning alkaline tide.

The tendency toward a lack of diuretic response is evident, although in some cases the response is well within normal limits. In comparison with the minimal normal excretion of water, 260 cc., it will be noticed that in a large number of cases this function is limited, sometimes very markedly. The marked tendency toward fixation of the specific gravity in the urine of many of the cases is very striking, especially in table 1.

A study of the alkalinity per cent figures in tables 1 and 3 will show in what a large proportion of cases of chronic glomerulonephritis there is an abolition, either partial or absolute, of the alkaline tide. To be well under the standard set by normal cases, I have considered that all with a difference between the initial and maximal alkalinity per cent of less than 15 should be considered in this class. In figure 2 a number of curves of the cases of this group are shown with the normal curve superimposed. The flattening of the curves is at once apparent.

Very few cases other than those of chronic glomerulonephritis and subacute diffuse nephritis fall below this standard, the exceptions including two cases of malignant hypertension, two of arteriosclerosis, two of focal nephritis, one of gout, one of bilateral polycystic kidneys, and one of bilateral hydronephrosis. This last case, in which there was an acid tide, is discussed with that group.

Figure 3 represents the curves found in a case of chronic glomerulonephritis which was clinically severe (case 49); the patient has since died. In each section of this figure the normal average curve is also given for comparison. As will be observed, the hourly output of urine is almost constant, the specific gravity is virtually fixed, and the alkalinity per cent shows very little change. The pH figure is the same for each specimen and is at a high acid level for urine. All these indicate a fixed acid urine. The carbon dioxid, in accordance with the pH, remains very low and fixed, and the phosphates also show a marked tendency toward fixation.

Thus it would appear that in such cases of chronic and subacute

glomerulonephritis the kidneys excrete a more or less fixed urine with the amounts of the main elements little changed from hour to hour. These facts indicate that the kidneys in such cases constantly excrete their maximal amount, and have lost that reserve excretory function so characteristic of normal kidneys. The kidneys in this case (case 49) were unable, even at the height of their function, to eliminate the normal waste products, which therefore accumulated in the blood, as

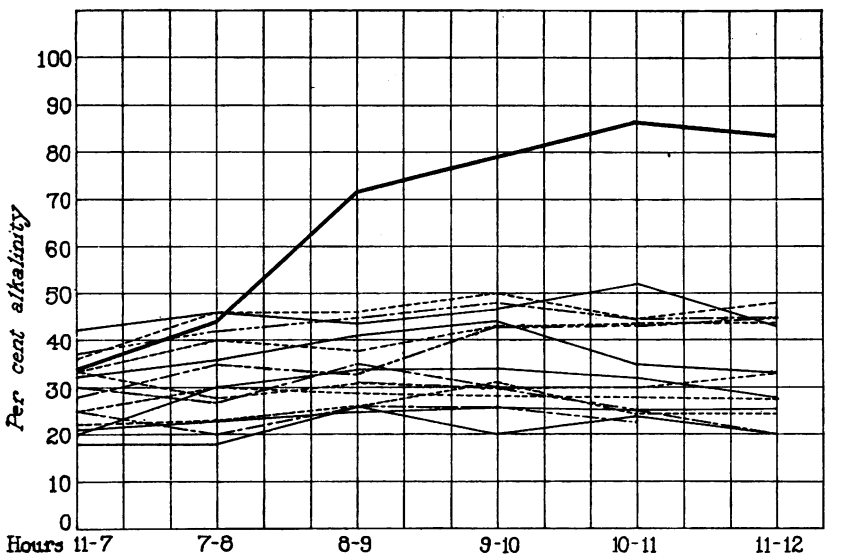

FIG. 2. CURVES IN CASES WITHOUT ALKALINE TIDE CONTRASTED WITH CURVE IN CASE WITH ALKALINE TIDE

——— Composite normal. Other curves, cases without alkaline tide

indicated by a blood urea of 345 mg. for each 100 cc., and a blood creatinin of over 12 mg. for each 100 cc.

By studying the clinical findings given in tables 5 and 6, and by observing the number of patients in groups 1 and 3 who have died, an indication of the severity of some of the cases will be obtained. Included in these groups, of course, are other patients in whom the nephritis was clinically comparatively mild. Although the urinary findings obtained in different cases by this test vary considerably, as would be expected, in general it may be said that only in cases of

clinically severe nephritis is there an abolition of the alkaline tide. These cases also show that there may be marked fixation of the specific gravity in spite of an alkaline tide, a diuresis well within normal limits, or both. As indicated in the results with abnormal cases,

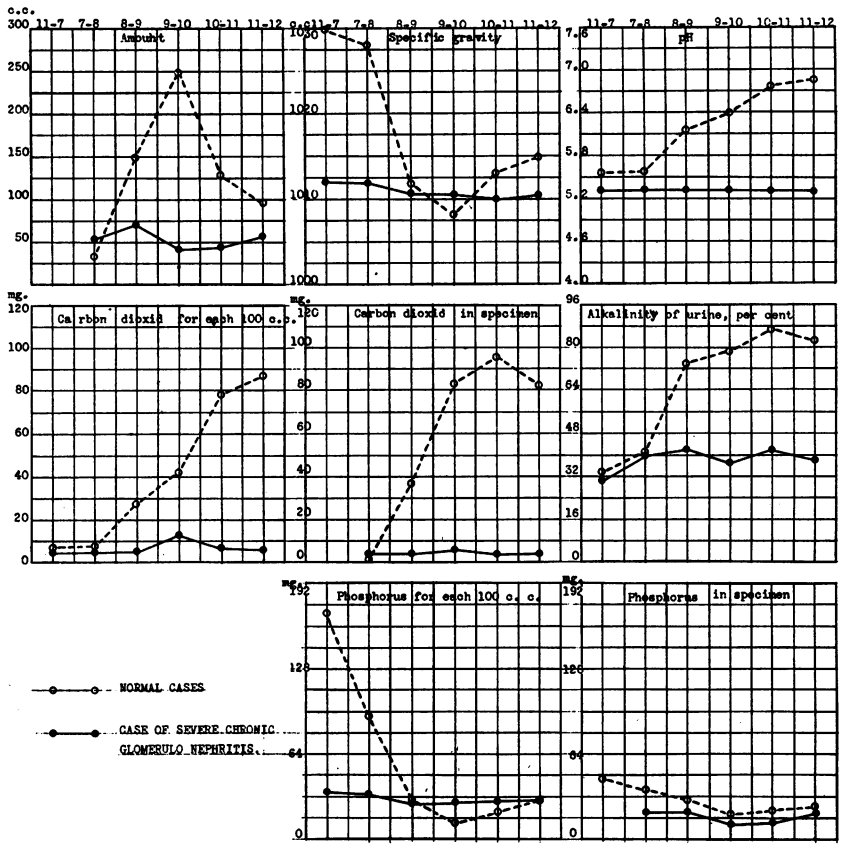

FIG. 3. CURVES IN CASE OF SEVERE CHRONIC GLOMERULONEPHRITIS CONTRASTED WITH CURVES IN AVERAGE NORMAL CASE

o- - - - -o Normal cases. ●———● Case of severe chronic glomerulonephritis

some of the patients who were tested (besides those already mentioned) showed limitation of function in some respects, but these findings were not constant or marked enough to require particular comment.

Since the carbon dioxid in the urine depends on the acidity, it would

seem that the estimation of the carbon dioxid had no practical value. The tendency of the phosphates to be fixed in the cases with no alkaline tide is significant, but the lowering of the phosphate content of the night urine in cases with renal involvement would appear to be even more so. I have never seen any record of such a lowering of the phosphate content in the night urine of nephritic patients, and such an estimation may prove of practical value. However, further investigation along this line must be carried out. Variations may depend on the diet and on the partition of the phosphate excretion between urine and feces. All the abnormal patients in which this was found were on a limited, controlled diet, while the normal subjects were not restricted.

Table 7 gives the results of the estimation of the carbon dioxid combining power of the blood plasma in a number of normal and abnormal cases. In none of the abnormal cases studied in regard to this point were there symptoms suggesting acidosis. As was to be expected, the alkali reserve of the blood of normal subjects showed no significant change during diuresis. In the group of clinical cases of nephritis studied, there was no diminution of the reserve alkalinity of the blood, and, as in the normal cases, there was no significant change during diuresis.

An acid tide was encountered in four cases, and in these there was a definite increase in the acidity during the morning. The first case in which this phenomenon was encountered was case 10. The result was thought at first to be incorrect, but the test was repeated three times without variation in the result. It is true that in this case the specimens were not examined as soon as they were passed, but, as this acid tide was an isolated phenomenon among the large group of cases and as it occurred so persistently, its presence may be considered as established. This case was one of chronic glomerulonephritis. The clinical findings were: blood pressure 150 systolic and 90 diastolic; albumin 2; no casts or red blood cells; blood urea 289 mg. for each 100 cc.; blood creatinin 6.2 mg. for each 100 cc.; no edema, normal eye-grounds and a phenolsulphonephthalein return of 5 per cent. The patient died later.

This acid tide was next observed in case 70. The diagnosis, bilateral hydronephrosis, was confirmed at necropsy. The albumin varied

from 1 to 3 while the patient was in the hospital; the maximal blood urea was 327 mg. for each 100 cc.; the maximal blood creatinin was 22.6 mg. for each 100 cc.; edema was present; the eye-grounds showed a pallor of the discs but were otherwise negative; there was no return of phenolsulphonephthalein, and the blood pressure was 158 systolic and 94 diastolic. The pH in this and the remaining two cases confirmed the presence of an acid tide.

The third patient (case 40), was a young man, aged twenty-three, with a diagnosis of chronic glomerulonephritis. His urine contained albumin varying from 1 to 3, and microscopically showed a few casts, and a considerable number of red blood cells. The blood urea was 74 mg. for each 100 cc., and the blood creatinin 1.8 mg. for each 100 cc.; edema was present; the eye-grounds were normal; the phenolsulphonephthalein return was 40 per cent, and the blood pressure 194 systolic and 122 diastolic. This patient felt well enough to be up and about. His death occurred shortly after leaving the hospital.

In the fourth case (case 46) the disease diagnosed chronic glomerulonephritis. His blood pressure was 200 systolic and 140 diastolic; his urine showed albumin 1 to 2, a few casts and red blood cells. His blood urea was 154 mg. for each 100 cc., and his blood creatinin 2.7 mg. for each 100 cc. There was slight edema. The retinal arteries showed a reduction of caliber, and there was a suggestion of edema of the discs with a small, diffuse hemorrhage above the left one. The phenolsulphonephthalein return was 5 per cent. This patient had a long and severe illness while here, his condition being considered very critical. The patient lived a short time on a reduced diet, and with limited activities. Following indiscretions he rapidly became worse, and died fourteen months after this test was made.

In this case each specimen was examined at once, and every precaution taken to avoid any change in hydrogen-ion concentration.

A summary of the findings in these four cases will be found in table 8 and figure 4, which gives the curves of the alkalinity per cent figures, the normal curve being superimposed for comparison. They show graphically how little variation there is in the hourly output of urine, the virtually fixed specific gravity, and the unmistakable acid tide. The crossing that occurs between the normal curve and those of the acid tide cases is also striking. The abnormal urine shows first a

relatively high alkalinity but becomes progressively less alkaline until noon, while in normal urine, the reverse is true.

So far I have been unable to find any record of an actual demonstration of an acid tide in the urine. This occurred only in severe cases, and in three of the four cases bacterial infection of the lower urinary tract could be excluded. No alkaline treatment was being employed. I believe, therefore, that such an acid tide occurs only in the end stages of some cases with marked involvement of the renal parenchyma. Thus it would seem, no matter what the apparent

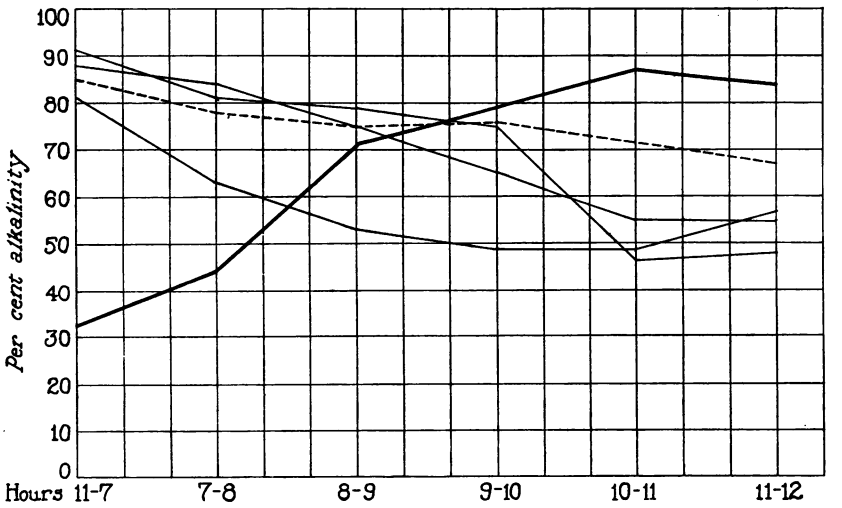

FIG. 4. CURVES IN ACID TIDE CASES COMPARED WITH CURVE IN NORMAL CASE

——— Composite normal. Other curves, cases with acid tide

general condition of the patient at the time of the test, that the presence of an acid tide is of grave prognostic import.

It is suggested that a test similar to Leathes' test might with advantage be used instead of the water test of Volhard and Fahr, for the former shows not only the ability of the kidney to excrete water, and the range of specific gravity, but also the presence or absence of the normal alkaline tide. Any objection to a titration test could be overcome by substituting for the estimation of the alkalinity per cent the determination of the pH as done by Henderson and Palmer. Moreover, patients find it much easier to take the comparatively small

TABLE 1

The alkaline tide of the urine and associated factors in abnormal cases

Case	Date	Urine																			
		Amount							Specific gravity						Alkalinity						
		Night	Morning					Total	Night	Morning					Night	Morning					
		11–7	7–8	8–9	9–10	10–11	11–12	8–12	11–7	7–8	8–9	9–10	10–11	11–12	11–7	7–8	8–9	9–10	10–11	11–12
Chronic glomerulonephritis																					
	1920	*cc.*	*cc.*	*cc.*	*cc.*	*cc.*	*cc.*	*cc.*							*per cent*	*per cent*	*per cent*	*per cent*	*per cent*	*per cent*
1*	11–3	390	33	43	52	45	57	197	1.014			1.012		1.012	37	42	45	48	45	45
2*	12–11	950	44	65	92	110	73	340	1.008	1.009	1.010	1.011	1.011	1.009	46	64	62	68	63	70
3	12– 9	220	440	60	53	105	91	309	1.014	1.012	1.013	1.012	1.012	1.013	30	23	35	23	29	28
4*	12–15	465	55	100	95	92	70	357	1.010	1.009	1.008	1.008	1.009	1.009	33	28	31	30	30	33
5*	11–16	380	38	45	45	36	32	158	1.012	1.011	1.011	1.013	1.012	1.013	52	63	69	71	63	67
	1921																			
	1–27	325	38	35	44	55	47	181	1.009	1.009	1.008	1.008	1.007	1.008	87	88	90	91	95	91
	5– 4	716	48	47	66	77	27	217	1.010	1.012	1.010	1.009	1.010	1.010	71	59	65	65	72	63
6*	2–12	216	38	30	30	34	28	122	1.012						49	52	56		51	50
	2–15	320	53	52	63	53	54	222	1.013	1.012	1.011	1.010	1.009	1.010	67	73	72	69	72	56
	2–17	255	24	38	48	25	12	123	1.013	1.012	1.009	1.010	1.010		45	51	53	50	46	41
7	*1920*																			
	11–24	325	40	42	128	77	44	291	1.013			1.005	1.006		97	89	81	82	68	63
	11–26	248	36	45	130	34	35	244	1.017			1.004			82	73	75	78	85	75
	11–18	190	30	26	65	27	24	142	1.018			1.007			75	68	70	70	62	64
8	12– 7								1.011	1.017	1.004	1.004			73	56	76	80		82
9	11–18	885	155	125	130	130	113	498	1.007	1.007	1.008	1.007	1.007	1.007	36	46	46	50	45	48

	1921																		
10*	1– 4	460	92	95	65	80	65	305	1.008	1.007	1.007	1.008	1.00[illegible]	1.007		97	94	85	71	71
	1– 6	245	100	75	60	60	70	265	1.009	1.008	1.008	1.008	1.007	1.008	93	95	73	62	52	52
	1– 8	385	64	55	60	75	80	270	1.008	1.008	1.007	1.007	1.007	1.007	98	98	92	69	58	58
	1–12	360	41	47	40	31	37	155	1.009	1.009	1.008	1.009	1.009	1.010	60	44	41	44	40	39
11*	1–31	920	44	35		82	58	175	1.012	1.012	1.013		1.013	1.012	36	34	42		44	36
12	2– 7	290	125	65	60	105	30	260	1.008	1.008	1.008	1.007	1.007	1.008	51	50	55	58	65	72
13	2–15	155	22	55	160	23	16	254	1.020	1.016	1.008	1.003	1.011		14	23	20	14	11	7
14*	2–18	575	60	100	40	57	56	253	1.010	1.009	1.010	1.007	1.008	1.010	59	71	68	70	68	65
15	3– 4	295	112	45	95		130	270	1.010	1.012	1.010	1.006		1.012	21	23	25	26		25
16*	3–10	645	185	75	140	92		307	1.007	1.006	1.007	1.006	1.006		24	20	26	25	23	
	Malignant hypertension																			
17	1–25	290	60		156	148	210	514	1.013	1.009		1.004	1.003	1.005	67	77		85	86	87
18*	2– 5	150	90	23	24	40	14	101	1.017	1.017	1.017	1.015	1.015		28	35	33	43	44	45
19*	2–15	275	22	77	115	29	35	256	1.017	1.017	1.008	1.005	1.010	1.015	16	28	32	38	29	37
20	2–19	68	20	26		38	14	78	1.028	1.026	1.026		1.023		24	28	39		46	39
	Arteriosclerosis with renal changes																			
	1920																			
21	11–30	200	35	168	165	90	31	454	1.020		1.005	1.003	1.007		38	60	85	83	83	56
	1921																			
22	2–25	285	15	69	115	56	44	284	1.010		1.006	1.003	1.008	1.011	32	36	41	44	35	33
23	1–25	360	49	76	88	98	46	308	1.005	1.006	1.003	1.003	1.003	1.004	66	81	80	80	84	77
24	3– 2	505	26	210	215	70	23	518	1.008	1.015	1.005	1.002	1.008	1.014	63	86	93	88	87	90
25	2– 4	205	21	61	142	25	37	265	1.020	1.020	1.017	1.005	1.012	1.014	15	24	41	67	28	22
	Essential hypertension																			
	1920																			
26	1– 6	96	32	23	255	25	45	348	1.021	1.015		1.002	1.010	1.011	34	54	36	45	35	43
	1921																			
27	2–17	80	55	100	108	170	90	468	1.019	1.018	1.007	1.002	1.004	1.007	18	30	57	75	63	66
28	3– 8	260	67	53	24	145	27	249	1.020	1.016	1.013	1.015	1.011	1.012	39	97	98	45	86	52

TABLE 1—*Continued*

Case	Date	Urine																	
		Amount							Specific gravity						Alkalinity					
		Night	Morning					Total	Night	Morning					Night	Morning				
		11–7	7–8	8–9	9–10	10–11	11–12	8–12	11–7	7–8	8–9	9–10	10–11	11–12	11–7	7–8	8–9	9–10	10–11	11–12
Nephrosis																				
	1920	*cc.*	*cc.*	*cc.*	*cc.*	*cc.*	*cc.*	*cc.*							*per cent*	*per cent*	*per cent*	*per cent*	*per cent*	*per cent*
29	12–17	280	91	41	46	50	45	182	1.025	1.026	1.024	1.021	1.022	1.024	58	74	90	92	93	91
Chronic endocarditis with cardiac insufficiency																				
	1921																			
30	3– 2	155	24	38	75	74	25	212	1.020	1.018	1.016	1.007	1.007	1.014	36	92	93	93	82	77
Focal nephritis																				
31	3–11	237	22	32	46	21	23	122	1.019	1.018	1.017	1.015	1.017	1.019	22	22	42	50	39	37
32	1–25	255	30	65	70	36	34	205	1.015	1.015	1.009	1.007	1.011	1.012	20	30	34	34	32	28
Gout																				
33	1–26	165	15	95	50	70	40	255	1.019		1.008	1.007	1.009	1.013	27	37	37	33	41	42
	2– 1	135	16	11	7	12	12	42	1.021						30	35	37	32	44	36
Bilateral polycystic kidneys																				
34	1–28	265	84	33	34	42	46	155	1.013	1.012	1.011	1.011	1.011	1.011	22	23	26	31	25	25

* Patients who died.

TABLE 2

The alkaline tide of the urine and associated factors in normal persons

Case	Date	Urine																							
		Amount							Specific gravity						Alkalinity						pH					
		Night	Morning					Total	Night	Morning					Night	Morning					Night	Morning				
		11–7	7–8	8–9	9–10	10–11	11–12	8–12	11–7	7–8	8–9	9–10	10–11	11–12	11–7	7–8	8–9	9–10	10–11	11–12	11–7	7–8	8–9	9–10	10–11	11–12
	1922	*cc.*	*cc.*	*cc.*	*cc.*	*cc.*	*cc.*	*cc.*							*per cent*	*per cent*	*per cent*	*per cent*	*per cent*	*per cent*						
A	1– 5	148	24	135	438	125	75	773	1.030	1.029	1.008	1.003	1.010	1.016	21	26	70	85	93	95	5.4	5.6	6.1	6.4	7.3	7.7
	1–28	187	30	55	304	122	86	567							25	28	87	86	92	93	5.4	5.4	6.8	6.8	6.98	7.25
B	1– 9	164	18	100	240	62	196	598	1.034		1.016	1.011	1.020	1.012	37	35	65	80	94	85	5.7	5.6	6.0	6.0	7.3	6.9
C	1–21	210	15	25	62	208	88	383	1.035	1.032	1.032	1.018	1.005	1.012	56	76	76	85	80	71	6.2	6.2	6.2	7.1	6.8	6.7
D	1–17	298	76	380	484	102	100	1066	1.024	1.018	1.004	1.003	1.013	1.017	38	40	74	79	94	96	5.7	5.6	6.1	6.2	7.0	7.5
E	1–27	154	30	136	220	140	106	602	1.027	1.030	1.006	1.008	1.010	1.012	23	61	86	91	93	90	5.3	5.4	6.75	6.55	6.8	7.5
F	2– 4	235	24	70	88	60	42	260	1.032		1.018	1.012	1.020	1.022	35	39	48	48	66	64	5.8	5.8	6.0	6.1	6.3	6.2
G	3–27	254	62	226	254	74	72	626	1.028	1.032	1.010	1.008	1.020	1.020	26	41	75	76	77	70	5.4	5.7	6.35	6.4	6.75	6.6
H	4– 2	182	34	152	176	102	68	498	1.030	1.030	1.010	1.007	1.016	1.020	41	62	82	93	96	84	5.65	6.05	6.4	6.8	7.3	7.25

TABLE 3

The alkaline tide and associated factors in abnormal subjects

Case	Date	Urine																							
		Amount							Specific gravity						Alkalinity						pH					
		Night	Morning					Total	Night	Morning					Night	Morning					Night	Morning				
		11–7	7–8	8–9	9–10	10–11	11–12	8–12	11–7	7–8	8–9	9–10	10–11	11–12	11–7	7–8	8–9	9–10	10–11	11–12	11–7	7–8	8–9	9–10	10–11	11–12
Chronic glomerulonephritis																										
	1921	*cc.*	*cc.*	*cc.*	*cc.*	*cc.*	*cc.*	*cc.*							*per cent*	*per cent*	*per cent*	*per cent*	*per cent*	*per cent*						
35	3–18	188	54	64		50		114	1.017	1.015	1.009		1.014		24	30	29		28		5.3	5.2	5.1		5.1	
36*	4–27	468	77	47	45	48	54	194	1.010	1.012	1.011	1.010	1.011	1.009	42	46	44	47	52	43	5.5	5.7	5.7	5.7	5.8	5.6
37	4–27	152		152	59	24	23	258	1.021		1.008	1.010	1.016	1.017	22		45	48	33	25	5.4		5.8	5.8	5.2	5.4
38	4–28	310	145	55	67	107	58	287	1.013	1.014	1.012	1.012	1.012	1.012	33	40	38	43	44	44	5.1	5.3	5.2	5.4	5.4	5.4
39	4–29	180	18	102	262	77	76	517	1.018		1.006	1.004	1.007	1.010	19	29	58	67	56	72	5.3	5.6	5.9	5.9	5.8	6.8
40*	5– 8	292	40	48	48	32	16	144	1.014	1.014	1.011	1.011	1.013		81	64	53	49	49	57	7.2	5.9	5.5	5.4	5.35	5.5
41	5–11	468	95	41	42	8	20	111	1.019	1.018	1.017	1.019		1.019	19	23	26	33	30	33	4.9	4.9	5.0	5.1		5.05
42*	5–25	382	62	104		55	52	211	1.013	1.011	1.009		1.013	1.013	35	36	41		42	40	5.0	5.1	5.2		5.4	5.4
43	5–30	196	20	76	215	42	22	355	1.023	1.022	1.008	1.003	1.009	1.022	28	43	84	87	83	82	5.1	5.7	6.8	6.8	6.9	6.8
44*	5–31	296	28	32	39	54	32	157	1.015	1.017	1.017	1.013	1.015	1.014	26	29	34	42	36	32	5.0	5.1	5.2	5.3	5.2	5.2
45*	6–30	210	14	12	70	13	18	113	1.015			1.006		1.015	72	73	71	81	67	69						
	1922																									
46†	2– 3	254	35	35	40	32	34	141	1.016			1.015	1.014	1.015	69	71	69	65	67	63	6.9	6.6	6.4	6.1	6.1	6.0
47†	2– 7	184	34	45	58	45	50	198	1.031		1.024	1.019	1.023	1.026	45	74	89	90	93	91	5.8	6.3	6.7	6.8	7.0	6.9
48†	2–10	238	80		66	48	48	162	1.020	1.020	1.018			1.019	16	17	16		19	18	4.55	4.55	4.55		4.55	4.55
49*†	2–15	314	54	65	44	46	58	213	1.012	1.012	1.011	1.011	1.010	1.011	31	39	41	36	41	38	5.3	5.3	5.3	5.3	5.3	5.3
50†	2–24	285	45	56	40	35	32	163	1.017	1.015	1.011	1.013	1.018	1.018	37	63	78	67	61	50	5.4	6.0	6.6	6.25	5.9	5.65
Subacute diffuse nephritis																										
	1921																									
51	3–12	325	100	58	105	62	47	272	1.013	1.013	1.013	1.008	1.010	1.010	18	18	26	20	24	20	4.7	4.7	4.7	4.7	4.7	4.7
52	6–10	135	26	31	32	29	27	119	1.028	1.026	1.025	1.026	1.026	1.025	48	37	36	34	37	42	5.7	5.5	5.5	5.5	5.5	5.6

Nephrosis

	1921																							
53	3–12	145	16	100	62	48	26	236	1.014		1.005	1.005	1.010	1.010	60	89	94	90	97	92	5.7		6.9	6.7	7.38	6.9
	1922																									
54†	3– 7	292	150	84	75	70	52	281	1.016	1.010	1.012	1.013	1.014	1.016	36	43	73	65	64	64	5.9	5.95	6.3	6.3	6.3	6.4

Malignant hypertension

	1921																							
55	3–18	68	17	42	28	23	17	110	1.027	1.025	1.014	1.009	1.011	1.025	30	27	35	30	26	20	5.4	5.3	5.5	5.4	5.2	5.0
56*	4–21	136	31	143	72	44	40	299	1.028	1.022	1.008	1.010	1.015	1.021	36	80	88	71	61	61	5.7	6.8	6.9	6.85	6.85	6.7
57†	4–26	320	37	38	185	215	62	500	1.015	1.012	1.011	1.005	1.004	1.011	20	41	38	73	63	57	4.8	5.8	5.2	5.9	5.85	5.8
	1922																									
58†	2– 8	200	26	82	186	42	34	344	1.018		1.008	1.005	1.012	1.016	36	47	56	55	41	50	5.5	5.75	5.8	6.1	5.85	5.8
59*†	3– 1	440	135	45	7	80	6	118	1.018	1.016	1.018		1.017		38	66	66		62		5.3	6.1	5.95		5.6	

Essential hypertension

	1921																							
60	4–26	420	55	72	94	63	31	260	1.010	1.009	1.009	1.004	1.007	1.008	27	40	46	55	44	34	5.1	5.3	5.4	5.8	5.4	5.25
61	5– 5	305	30	155	174	50	22	401	1.015	1.015	1.004	1.003	1.009	1.020	24	27	50	67	40	32	5.1	5.3	5.85	5.9	5.6	5.4

Focal nephritis

	1921																							
62	3–19	230	30	140	40	29	29	238	1.015	1.013	1.005	1.011	1.015	1.011	39	93	97	86	76	93	5.6	6.8	7.0	6.9	6.7	6.8
63	3–24	455	24	285	200	190	25	700	1.011	1.010	0.003	1.003	1.007	1.014	35	51	85	93	96	98	5.5	5.4	6.7	6.8	7.38	7.7
64	4–16	350	67	35	155	56	65	311	1.014	1.010	1.010	1.007	1.013	1.012	22	67	60	69	49	49	5.0	6.1	6.2	6.7	5.8	5.9
65	4–28	108	18	117	79	76	30	302	1.028		1.007	1.010	1.017	1.019	27	33	83	92	91	85	5.5	5.5	6.8	6.9	6.9	6.9
66	5– 7	162		200	307	122	34	663	1.016		1.006	1.004	1.003	1.012	23		90	85	87	82	4.9		6.8	6.4	6.8	6.9
67	5–28	166		46		76		122	1.030		1.024		1.021		33				41		5.1		5.5		5.6	
	1922																							
68†	2–27	114	32	44	26	24	18	112	1.026	1.030	1.018	1.022	1.025	1.028	51	64	79	67	44	39	5.5	6.4	6.75	6.3	5.6	5.4
69†	3–22	300	38	80	92	56	42	270	1.016		1.013	1.011	1.011	1.017	18	43	46	36	25	26	4.95	5.55	5.6	5.2	5.0	5.0

TABLE 3—*Continued*

Case	Date	Urine																											
		Amount							Specific gravity							Alkalinity							pH						
		Night	Morning					Total	Night	Morning						Night	Morning						Night	Morning					
		11–7	7–8	8–9	9–10	10–11	11–12	8–12	11–7	7–8	8–9	9–10	10–11	11–12		11–7	7–8	8–9	9–10	10–11	11–12		11–7	7–8	8–9	9–10	10–11	11–12	
Bilateral hydronephrosis																													
	1921	*cc.*	*cc.*	*cc.*	*cc.*	*cc.*	*cc.*	*cc.*								*per cent*	*per cent*	*per cent*	*per cent*	*per cent*	*per cent*									
70	3–31	165	130	65	14	34	52	165	1.007	1.008	1.009		1.008	1.008		91	80	79	75	46	48		7.2	6.85	6.8		5.9	5.8	
Arteriosclerosis																													
	1922																												
71†	2–21	142	98	90	82	106	56	334	1.025	1.024	1.014	1.006	1.007	1.008		24	28	31	38	38	32		5.0	5.0	5.15	5.25	5.25	5.1	
Achylia gastrica																													
	1921																												
72	5–13	382	96	330	275	226	77	908	1.014	1.011	1.005	1.005	1.007	1.013		70	98	96		97	96		6.8	7.6	7.0		7.0	7.1	
	5–15	368	78	140	332	98	105	675	1.015	1.015	1.014	1.005	1.008	1.010		47	88	94	94	95	94		5.9	6.8	6.9	6.85	6.9	7.2	
Polyuria																													
73	3–31	140	15	34	155	185	60	434	1.015		1.012	1.004	1.005	1.011		25	32	69	67	64	76		5.4	5.8	6.5	5.85	5.9	6.7	
Orthostatic albuminuria																													
74	3–25	122	27	110	275	65	33	483	1.021	1.018	1.007	1.003	1.011	1.015		23	46	86	92	98	96		5.2	5.8	6.8	6.8	7.6	7.38	

* Patients who died.

† Cases in which the complete study was made.

amount of water required in this test. The estimation of the carbon dioxid in the specimens would not seem to be of practical value since it varies in amount directly as the hydrogen-ion concentration.

CONCLUSIONS

1. In this paper are reported the results of investigation of the night specimens and hourly morning specimens of urine in a series of normal and abnormal subjects. At 8:00 a.m., 500 cc. of water was given on an empty stomach. Most of the abnormal cases were of renal lesions.

2. Normal subjects, as demonstrated by Leathes and confirmed by my experiments, always show a diuresis and an increase in alkalinity during the morning, while abnormal subjects may react like the normal, or show limitation, either partial or complete, of either or both.

3. In addition, among the abnormal subjects examined, there were a few with a high initial alkalinity and an acid tide during the morning.

4. The specific gravity may show little variation even with a diuresis within normal limits, an alkaline tide, or both.

5. Cases with no alkaline tide are usually severe clinically. An acid tide is of grave prognostic import.

6. The curve of the pH figures parallels that of the alkalinity per cent.

7. In the cases reported here, both normal and abnormal, a higher pH figure was always accompanied by increased relative carbon dioxid, and a more acid urine by a decrease in carbon dioxid.

8. The phosphates of normal subjects, as demonstrated by Fiske, have an initial drop followed by a late rise during the morning. In the present series the night specimen was found to have a much lower phosphate content in abnormal than in normal subjects.

9. The results of these investigations show that this test may be of clinical value from the point of view of diagnosis and prognosis.

TABLE 4

Carbon dioxid and phosphorus content of urine in normal and abnormal subjects

Case	Date	Carbon dioxid: Milligrams for each 100 cc.						Carbon dioxid: Milligrams in specimen						Phosphorus: Milligrams for each 100 cc.						Phosphorus: Milligrams in specimen					
		Night	Morning					Night	Morning					Night	Morning					Night	Morning				
		11–7	7–8	8–9	9–10	10–11	11–12	11–7	7–8	8–9	9–10	10–11	11–12	11–7	7–8	8–9	9–10	10–11	11–12	11–7	7–8	8–9	9–10	10–11	11–12
Normal																									
	1922																								
A	1– 5	10.0		17.4	21.0	69.0	107.8	14.7		23.5	91.9	86.3	80.8												
A	1–28	5.0	3.1	66.8	38.1	78.5	124.6	9.2	0.9	36.8	115.9	95.8	107.1	161.8	98.5	40.2	5.0	12.9	35.7	302.6	29.6	22.1	15.2	15.7	30.8
B	1– 9	5.9	3.2	22.4	68.1	88.8	55.4	9.6	0.6	22.4	43.4	55.0	108.5	212.8		14.3	5.1	16.3	12.9	348.9		14.3	12.2	10.1	25.3
C	1–21	17.4	32.5	30.7	65.4	45.4	38.3	36.4	4.9	7.7	40.5	94.4	33.7	194.2		82.0	34.48	11.9	31.6	407.8		20.5	21.4	24.8	27.8
D	1–17	7.7	5.1	19.1	28.8	136.5	203.2	23.0	3.9	72.7	129.3	139.3	203.2	133.7	43.1	20.0	2.0	8.9	13.9	398.4	32.8	76.0	9.6	9.1	13.9
E	1–27	5.0	5.0	47.8	44.2	53.1	62.9	7.7	1.5	65.0	97.2	74.4	66.7	154.3	113.1	13.7	5.4	12.1	23.0	237.6	33.9	18.6	11.9	16.9	24.3
F	2– 4	6.6	4.0	8.4	7.5	18.1	13.7	15.6	1.0	5.8	6.6	10.8	5.8	156.3	90.9	39.0	23.2	42.0	45.4	367.2	21.8	27.3	20.4	25.2	19.0
G	3–27	6.7	7.6	34.9	39.0	43.1	40.4	16.9	4.7	78.9	99.1	31.9	29.0	158.7	119.0	20.8	15.4	44.2	52.6	403.2	73.8	47.1	37.2	32.7	37.9
H	4– 2	6.7	19.1	36.8	87.7	221.4	175.4	12.2	6.5	55.9	154.2	225.8	119.3	224.7	98.0	12.6	10.5	26.3	39.4	409.0	33.3	16.1	18.4	26.8	26.8
Chronic glomerulonephritis																									
46†	2– 3	33.9	18.9	18.0	11.9	12.8	15.4	86.2	6.6	6.3	4.7	4.0	5.2	66.6	57.8	47.6	44.0	41.0	42.5	169.3	20.2	16.6	17.6	13.1	14.3
47†	2– 7	9.5	31.4	87.1	149.0	188.8	174.2	17.5	10.6	39.2	86.4	84.9	87.1	115.2	51.4	37.4	27.6	31.2	45.0	212.0	17.5	16.8	16.0	14.0	22.5
48†	2–10	4.7	4.7		4.7	3.8	2.9	11.2	3.8		3.1	1.8	1.4	80.0	72.4		62.1	60.9	58.8	190.4	57.9		41.0	29.2	28.2
49*†	2–15	5.0	5.0	5.0	13.1	6.8	5.9	15.8	2.7	3.3	5.8	3.6	3.4	34.4	33.3	30.67	30.7	30.9	31.8	108.1	18.0	19.9	13.5	14.2	18.5
50*†	2–24	14.0	23.9	45.5	37.1	17.6	10.4	40.0	10.8	25.5	14.8	6.2	3.3	80.6	54.3	31.3	45.5	59.5	94.6	68.5	24.4	17.5	18.2	20.8	23.9

Nephrosis																									
54†	3– 7	27.4	27.4	25.6	48.4	50.2	53.7	80.0	41.1	21.5	36.3	35.1	27.9	65.4	58.1	18.4	21.0	25.3	34.7	190.8	87.2	15.4	15.8	17.7	18.1
Malignant hypertension																									
58†	2– 8	4.9	6.7	10.2	19.1	6.7	6.7	9.8	1.7	8.4	35.6	2.8	2.2	97.0	97.0	27.7	15.4	48.0	75.7	194.0	25.2	24.4	28.6	20.2	25.8
59†	3– 1	19.4	26.6	14.9	5.3	12.2	5.0	85.5	35.9	6.7		9.8		92.9	50.6	45.9	51.5	46.3	62.5	408.9	68.3	20.6		37.0	
Focal nephritis																									
68†	2–27	12.0	27.5	41.0	33.5	16.7	9.5	16.0	8.8	18.1	8.7	4.0	1.7	125.0	85.5	38.5	51.0	90.9	105.2	142.5	27.4	16.9	13.3	31.8	18.9
69†	3–22	6.8	7.7	9.4	11.2	5.9	5.0	20.4	2.9	7.6	10.3	3.3	2.1	81.6	46.7	23.8	21.3	34.0	52.6	244.9	17.8	19.0	19.6	19.0	22.1
Arteriosclerosis																									
71†	2–21	13.1	8.4	14.9	12.1	11.2	13.0	18.6	8.3	13.5	9.9	11.9	7.3	104.2	95.4	45.9	16.7	21.7	32.1	147.9	93.5	41.8	13.7	23.0	17.9

* Patients who died.

† Cases in which complete study was made.

TABLE 5

Clinical and functional findings in abnormal subjects

Case	Date	Clinical findings							Findings in test			
		Blood pressure	Albumin	Maximal blood urea	Maximal blood creatinin	Edema	Eye-grounds	Phenolsulphonephthalein	Diuresis	Specific gravity range	Alkalinity	
											Initial	Maximal
Chronic glomerulonephritis												
	1920							*per cent*			*per cent*	*per cent*
1*	11- 3	218	1–3	119	5.6	0	Marked retinal edema with many hemorrhages and exudates	5	197	1.012–1.014	37	48
2*	12–11	230	2–3	173	4.9	+	Edema of disc and retina with many hemorrhages and exudates	10	340	1.008–1.011	46	70
3	12- 9	190	2–3	41	1.7	0	Arteriosclerosis	35	309	1.012–1.014	30	35
4*	12–15	180	2	231	7.2	0	Normal	5	357	1.008–1.010	33	33
5*	11–16	196	2–4	139	7.4	+	One hemorrhage; arterial changes	10	158	1.011–1.013	52	71
	1921											
	1–27							5	191	1.007–1.009	87	95
	5- 4								197	1.009–1.012	71	72
6*	2–12	175	2–3	88.6	2.4	0	Normal	20	122		49	56
	2–15								222	1.009–1.013	67	72
	2–17								123	1.009–1.013	45	53
7	*1920*											
	11–24	140	1–3	44	1.58	+	Normal	45	291	1.005–1.013	97	97
	11–26								244	1.004–1.017	82	85
	11–18								142	1.007–1.018	75	75
8	12- 7	158	2–4	30	1.39	+	One small hemorrhage	40		1.004–1.017	73	82
9	11–18	135	2–3	169	5.9	0	Normal	15	498	1.007–1.008	36	50

	1921											
10*	1– 4	150	2	289	6.2	0	Normal	5	305	1.007–1.008	Acid	tide
	1– 6								265	1.007–1.009	Acid	tide
	1– 8								270	1.007–1.008	Acid	tide
	1–12								155	1.008–1.010	Acid	tide
11*	1–31	160	2–3	84	2.48	0	Edema of nerve with few hemorrhages	20	175	1.012–1.013	36	44
12	2– 7	120	1–2	128	5	0	Slight arteriosclerosis	10	260	1.007–1.008	51	72
13	2–15	220	0–1	36.2	1.35	Slight	Marked arterial changes	55	254	1.003–1.020	14	23
14*	2–18	240	1–2	75.6	2.59	+	Discs swollen, many hemorrhages and exudates	10	253	1.007–1.010	59	71
15	3– 4	165	1–2	51	2.1	0	Normal	30	270	1.006–1.012	21	26
16*	3–10	165	1–2	186	11.2	0	Edema of discs; few exudates	5	307	1.006–1.007	24	26
							Malignant hypertension					
17	1–25	230	1	53	1.54	0	Arterial changes with hemorrhages	45	514	1.003–1.013	67	86
18*	2– 5	220	1–2	4.8	2.0	0	Violent neuroretinitis; nerve heads swollen; hemorrhages and exudates	30	101	1.015–1.017	28	45
19*	2–15	210	1	40	1.7	0	Arterial changes; edema of nerve and retina; few exudates and hemorrhages	45	256	1.005–1.017	16	38
20	2–19	200	0–1	38.7	1.37	0	Marked arterial changes with few exudates and hemorrhages	60	78	1.023–1.028	24	46
							Arteriosclerosis with renal changes					
	1920											
21	11–30	152	2–3	35	1.6	0	Old inflammatory changes; marked arteriosclerosis	60	454	1.003–1.020	38	85
	1921											
22	2–25	150	1	32	1.36	Slight	Marked arteriosclerosis	35	284	1.003–1.011	32	44

TABLE 5—*Continued*

Case	Date	Clinical findings							Findings in test			
		Blood pressure	Albumin	Maximal blood urea	Maximal blood creatinin	Edema	Eye-grounds	Phenolsulphonephthalein	Diuresis	Specific gravity range	Alkalinity	
											Initial	Maximal
Arteriosclerosis with renal changes—Continued												
	1920							*per cent*			*per cent*	*per cent*
23	1–25	240	2–3	45.6	2.02	+	Marked arterial changes; edema of nerve and retina; hemorrhages and exudates	45	308	1.003–1.006	66	84
24	3– 2	190	1	56.8	1.43	0	Arteriosclerosis with hemorrhages	60	518	1.002–1.015	63	93
25	2– 4	165	1	38	1.5	Slight	Normal	50	265	1.005–1.020	15	67
Essential hypertension												
	1920											
26	1– 6	180	0–2	31.2	1.53	Slight	Arteriosclerosis	40	348	1.002–1.021	34	54
	1921											
27	2–17	150	0	45.9	1.43	0	Normal	60	368	1.002–1.019	18	75
28	3– 8	170	0–1	27		0	Moderate arterial changes	65	249	1.011–1.020	39	98
Nephrosis												
	1920											
29	12–17	130	2–4	36	1.5	+	Normal	40	182	1.021–1.026	58	93
Chronic endocarditis with cardiac insufficiency												
	1921											
30	3– 2	150	1–2	26	1.47	+	Normal	30	212	1.007–1.020	36	93

							Focal nephritis					
31	3–11	132	2–3	41.9	1.66	0	Normal	60	122	1.015–1.019	22	50
32	1–25	140	1–2	32	1.8	0	Normal	72	205	1.007–1.015	20	34
							Gout					
33	1–26	150	0–1	49	1.86	Slight	Normal	62	255	1.007–1.019	27	42
	2– 1								42		30	44
							Bilateral polycystic kidneys					
34	1–28	150	1–2	47.5	1.76	0	Normal	61	155	1.011–1.013	22	31

* Patients who died.

TABLE 6

Clinical and functional findings in abnormal subjects showing fluctuation of alkalinity and hydrogen-ion concentration

Case	Date	Clinical findings							Findings in test					
		Blood pressure	Albumin	Maximal blood urea	Maximal blood creatinin	Edema	Eye-grounds	Phenolsulphone-phthalein	Diuresis	Specific gravity, range	Alkalinity		pH	
											Initial	Maximal	Initial	Maximal
Chronic glomerulonephritis														
	1921							*per cent*			*per cent*	*per cent*		
35	3–18	210	1–2	50.6	2.68	0	Marked arterial changes with edema and hemorrhages	30	114	1.009–1.017	24	30	5.3	5.2
36*	4–27	194	1–2	198	8.92	0	Arteriosclerosis	10	194	1.009–1.012	42	52	5.5	5.8
37	4–27	260	1	47.8	1.77	+	Arterial changes, recent edema, hemorrhages and exudates	30	258	1.008–1.021	22	48	5.4	5.8
38	4–28	222	3–4	110.5	7.06	+	Fundi anemic	20	287	1.012–1.014	33	44	5.1	5.4
39	4–29	120	1	33.6	1.36	+	Normal	55	517	1.004–1.018	19	72	5.3	6.8
40*†	5– 8	192	1–3	74	1.8	+	Normal	40	144	1.011–1.014	81	Acid tide	7.2	Acid tide
41	5–11	210	1–3	51	1.76	+	Arteriosclerosis	45	111	1.017–1.019	19	33	4.9	5.1
42*	5–25	170	1–3	101	2.9	Slight	Acute neuroretinitis with edema, exudates and old hemorrhages	30	211	1.009–1.013	35	42	5.0	5.4
43	5–30	175	1–2	41.5	1.6	+	Pigmentation of retina; slight arteriovenous compression	65	355	1.003–1.023	28	87	5.1	6.9
44*	5–31	210	1–3	64	1.8	0	Marked retinitis with exudates and hemorrhages	35	157	1.013–1.017	26	42	5.0	5.3
45*	6–30	242	0–2	56	1.9	+	Intense neuroretinitis with exudates and hemorrhage	40	113	1.006–1.015	72	81		

	1922													
46†	2- 3	200	1–2	154	2.7	+	Reduced caliber retinal arteries; old hemorrhages	15	141	1.014–1.016	69	Acid tide	6.9	Acid tide
47†	2- 7	166	3	22		+	Normal	55	198	1.019–1.031	45	93	5.8	7.0
48†	2–10	100	1	62	1.7	+	Acute retinitis with edema, hemorrhages and exudates	30	162	1.018–1.020	16	19	4.55	4.55
49*†	2–15	200	1–2	345	12.3	0	Arterial changes with edema, few hemorrhages and old exudates	0	213	1.010–1.012	31	41	5.3	5.3
50†	2–24	130	1–2	28		+	Normal	55	163	1.011–1.018	37	78	5.4	6.6
							Subacute diffuse nephritis							
	1921													
51	3–12	130	2	69	2.1	0	Normal	50	272	1.008–1.013	18	26	4.7	4.7
52	6–10	120	0–3	64	1.6	+	Normal	45	119	1.025–1.028	48	42	5.7	5.5
							Nephrosis							
53	3–12	138	2–4	26.8	1.5	+	Normal	40	236	1.005–1.014	60	97	5.7	7.38
	1922													
54†	3- 7	110	1	37	1.5	0	Normal	50	281	1.010–1.016	36	73	5.9	6.4
							Malignant hypertension							
	1921													
55	3–18	220	1	33.8	1.25	0	Slight arterial changes	45	110	1.009–1.027	30	35	5.4	5.5
56*	4–21	260	2	46	1.48	0	Severe neuroretinitis with hemorrhages and exudates	50	299	1.008–1.028	36	88	5.7	6.9
57*	4–26	240	1	67	1.97	0	Arterial changes with retinitis, exudates and hemorrhages	35	500	1.004–1.015	20	73	4.8	5.9
	1922													
58†	2- 8	235	1–3	51	1.6	0	Arterial changes, slight edema, exudates	45	344	1.005–1.018	36	56	5.5	6.1
59*†	3- 1	234	1–3	30		0	Arterial changes, edema, exudates and hemorrhage	30	138	1.016–1.018	38	66	5.3	6.1

TABLE 6—*Continued*

Case	Date	Clinical findings							Findings in test					
		Blood pressure	Albumin	Maximal blood urea	Maximal blood creatinin	Edema	Eye-grounds	Phenolsulphone-phthalein	Diuresis	Specific gravity, range	Alkalinity		pH	
											Initial	Maximal	Initial	Maximal
Essential hypertension														
	1921							*per cent*			*per cent*	*per cent*		
60	4–26	236	1	53.5	1.58	+	Arterial changes	50	260	1.004–1.010	27	55	5.1	5.8
61	5– 5	186	1	41.7	1.58	+	Negative	50	401	1.003–1.020	24	67	5.1	5.9
Focal nephritis														
62	3–19	165	1–3	35.6	1.48	+	Negative	50	238	1.005–1.015	39	97	5.6	7.0
63	3–24	120	1–2	35.7	1.54	0	Peripheral pigmentary retinitis	55	700	1.003–1.014	35	98	5.5	7.7
64	4–16	140	1–3	36.5	1.46	0	Normal	45	311	1.007–1.014	22	69	5.0	6.2
65	4–28	130	1	27	1.43	0	Negative	60	302	1.007–1.028	27	92	5.5	6.9
66	5– 7	160	0–1	35.1	1.52	+	Negative	55	663	1.003–1.016	23	90	4.9	6.9
67	5–28	155	1–3	40.7	1.76	0	Normal	60	122	1.024–1.030	33	41	5.1	5.6
	1922													
68†	2–27	132	1–2	19		0	Normal	65	112	1.018–1.030	51	77	5.5	6.75
69†	3–22	182	1	26	1.7	0	Normal	40	270	1.011–1.016	18	46	4.95	5.6
Bilateral hydronephrosis														
	1921													
70*†	3–31	158	1–3	327	22.6	+	Pallor of disc; otherwise negative	0	165	1.007–1.009	91	Acid tide	7.2	Acid tide

							Arteriosclerosis							
71	*1922* 2–21	108	0–1	26		0	Normal	50	334	1.006–1.025	24	38	5.0	5.25
							Achylia gastrica							
72	*1921* 5–13	174	0	41	1.3	0	Normal	50	908	1.005–1.014	70	96	6.8	7.6
72	5–15	174	0	41	1.3	0	Normal	50	575	1.005–1.015	47	95	5.9	7.2
							Polyuria							
73	3–31	130	0–1	25.4	1.39	0	Normal	65	434	1.004–1.015	25	76	5.4	5.9
							Orthostatic albuminuria							
74	3–25	120	0–2	45	1.45	0	Normal	60	483	1.003–1.021	23	98	5.2	7.6

* Patients who died.

† Cases in which complete study was made.

TABLE 7

Carbon dioxid combining power of blood plasma

Case	Diagnosis	Before diuresis	After diuresis
A	Normal	58.9	56.0
		59.8	55.1
B	Normal	62.6	59.8
C	Normal	60.7	60.7
D	Normal	67.3	67.3
E	Normal	67.3	67.3
F	Normal	59.6	59.6
G	Normal	71.5	70.6
46	Chronic glomerulonephritis	55.9	55.9
47	Chronic glomerulonephritis	61.4	63.3
48	Chronic glomerulonephritis	50.8	50.8
54	Nephrosis	66.0	67.8
58	Malignant hypertension	62.6	62.6
59	Malignant hypertension	77.0	74.0
68	Focal nephritis	67.3	67.3
69	Focal nephritis	71.6	67.8
71	Arteriosclerosis	69.6	69.6

TABLE 8

*Findings in cases with an acid tide**

Case	Date	Urine: Amount: Night 11–7	Amount: Morning 7–8	8–9	9–10	10–11	11–12	Specific gravity: Night 11–7	Specific gravity: Morning 7–8	8–9	9–10	10–11	11–12	Alkalinity: Night 11–7	Alkalinity: Morning 7–8	8–9	9–10	10–11	11–12	pH: Night 11–7	pH: Morning 7–8	8–9	9–10	10–11	11–12
Chronic glomerulonephritis																									
	1921	*cc.*	*cc.*	*cc.*	*cc.*	*cc.*	*cc.*							*per cent*	*per cent*	*per cent*	*per cent*	*per cent*	*per cent*						
10	1– 4	460	92	95	65	80	65	1.003	1.008	1.007	1.008	1.008	1.007	98	97	94	85	71	71						
	1– 6	245	100	75	60	60	70	1.009	1.009	1.008	1.008	1.007	1.008	93	95	73	62	52	52						
	1– 8	335	64	55	60	75	80	1.003	1.008	1.007	1.007	1.007	1.007	98	98	92	69	58	58						
	1–12	350	41	47	40	31	37	1.009	1.009	1.008	1.009	1.009	1.010	60	44	41	44	40	39						
Bilateral hydronephrosis																									
70	3–31	165	130	65	14	34	52	1.007	1.008	1.009		1.008	1.008	91	81	79	75	47	48	7.2	6.85	6.8		5.9	5.8
Chronic glomerulonephritis																									
40	5– 8	292	40	48	48	32	16	1.014	1.014	1.011	1.011	1.013		81	64	53	49	49	57	7.2	5.9	5.5	5.4	5.35	5.5
	1922																								
46	2– 3	254	35	35	40	32	34	1.016			1.015	1.014	1.015	69	71	69	65	67	63	6.9	6.6	6.4	6.1	6.1	6.0

* All patients died.

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