URINE CHLORIDES AS AN INDEX OF ADRENAL FUNCTION

SARA DUBO

UNIVERSITY OF MANITOBA

MARCH, 1940

Prince 1940

URINE CHLORIDES AS AN INDEX OF ADRENAL FUNCTION

INTRODUCTION

There is much about the metabolism of water and salt that is still a matter of speculation. In recent years investigation has suggested that the adrenal glands have a profound effect on the retention of sodium chloride. The work of Loeb and Cutler in particular, suggests that adrenal function might possibly be measured by changes in salt metabolism. They state tentatively, that in a normal person on a salt free diet the urine chlorides should fall to a concentration of less than 125 milligrams per 100 c.c. in the course of a few days, and that in definite Addison's disease the chlorides remain higher than 225 milligrams per 100 c.c. They feel that figures between 125 and 225 are of doubtful significance. Cutler, et al, have set up a routine procedure, which will be described later, by which it is hoped that cases of adrenal insufficiency can be identified.

The investigation presented here was undertaken to determine the value of the Cutler procedure.

The establishment of such a test would be of great value since the diagnosis of Addison's disease on present criteria is impossible except when it is far advanced. There are no specific signs or symptoms. Asthenia is common in a great number of other conditions - especially in functional diseases; even ergographic records help very little to determine its origin. Hypotension is found in normal people

and is also associated with many organic disorders unrelated to the adrenals. Pigmentation when well-marked is the only convincing objective finding and in its early stages there is always room for doubt. Minor grades of localized pigmentation especially about the forehead are common in healthy people. Pigmentation of mucous membranes has been said to be pathognomonic. This is probably true in people whose immediate ancestors were all white; in those with any admixture of Indian, Negro or Mongolian blood it is not true. Patients with part Indian blood very frequently show definite pigmented spots about the lips and mouth which are identical to those found in Addison's disease. As a result of these clinical difficulties adrenal failure can never be diagnosed clinically until it is far advanced. In addition to all this, gross destruction of adrenal tissue has been found on autopsy in patients who had no suggestive signs or symptoms during life. From the foregoing it is evident that a dependable chemical test would be of great practical value.

HISTORICAL

Some of the main discoveries leading to the present problem are indicated below:

1. In 1849 the adrenal glands first assumed clinical and pathological significance. In that year Addison[1] in an address to the London Medical Society said:

> "It will hardly be disputed that at the present moment the functions of the supra-renal

capsules, and the influence they exercise in the general economy, are almost or altogether unknown. The large supply of blood, which they receive from three separate sources; their numerous nerves, derived immediately from the semi-lunar ganglia and solar plexus; their early development in the foetus; their unimpaired integrity to the latest period of life; and their peculiar gland-like structure - all points to the performance of some important office: nevertheless, beyond an ill-defined impression, founded on a consideration of their ultimate organization, that, in common with the spleen, thymus and thyroid body, they in some way or other minister to the elaboration of the blood, I am not aware that any modern authority has ventured to assign to them any special function or influence whatever."

2. Nothing of clinical importance was added to the knowledge of the disease until Dr. A. L. Muirhead[2] published the result of the treatment of his own case in 1921, with epinephrine by various routes and dessicated cortex by mouth. This method produced improvement in some cases but was too expensive and elaborate to be of general use.

3. The subject of adrenocortical insufficiency was greatly elucidated by the classical contribution of Robert Loeb, et al, in 1933.[3] They described clearly the changes

in balance of electrolytes in the blood of patients with Addison's disease and in the blood and urine of adrenalectomized dogs. The major disturbance of the mineral metabolism, in patients with severe adrenal insufficiency, was shown to be in the balance of sodium and chloride ions. An increased excretion of these ions occurred in the urine together with a decreased concentration in the blood. The loss of sodium ion usually exceeded that of chloride.

In 1935[4] he reported that the sodium concentration in the blood is not an infallible criterion of the presence of adrenal insufficiency, as low values have been found in a few critically ill patients without structural changes in the adrenal glands.

4. In 1938, H. H. Cutler,[5] et al, undertook to determine whether the rate of excretion of sodium and chloride on a salt free diet might serve as a diagnostic index of adrenal insufficiency. They concluded that the chloride concentration in the urine on the morning of the third day was diagnostically more significant than the volume of urine, or changes in concentration of sodium, chloride or potassium in the blood or changes in concentration of sodium or potassium in the urine.

> "If the concentration of chloride in this specimen of urine exceeds 225 mg. per cent., Addison's disease or adrenal insufficiency is

strongly suggested, if it is less than 125 mg. per cent., adrenal insufficiency is made unlikely."

Cutler suggests that these limits may not be accurate and that more prolonged periods of observation on salt free diet may alter these standards of normal. The present investigation was undertaken to test the reliability of the urine chlorides as a measure of the efficiency of the adrenal gland.

MATERIAL

It was considered that the most promising field for investigation was among tuberculous patients, because it was thought that possibly some borderline or subclinical cases of Addison's disease and also some established cases might be found; it was hoped that clinical signs and symptoms and possibly pathological findings could be correlated with the chloride output. Accordingly, two hundred tuberculous patients under treatment in Sanatorium have been studied. For various reasons (mostly because of failure to adhere to instructions) many tests were discarded. The final group consisted of one hundred and thirty-six individuals, some of whom were tested more than once.

As controls, nine apparently normal individuals were used. These included four internes and five nurses. They were selected as likely being perfectly healthy in all respects and with no symptoms or signs suggesting tuberculous or adrenal disease.

TECHNIQUE

The details of the test were as proposed by Cutler, described below. The only modification was that much less potassium citrate was given. In the majority of cases the period of examination was fifty-two hours. On the day preceding the first day of the examination any drugs containing salt were discontinued.

FIRST DAY. Patients were put on a diet which is estimated to contain 0.95 gm. of chloride ion, 0.59 gm. of sodium and 4.1 gm. of potassium. The fluid intake of the first day was not restricted and free drinking of water was encouraged. In the afternoon extra potassium was given, as potassium citrate, (0.033 gm. of potassium citrate for each kilogram of body weight). All urine passed during the day was collected and measured and the twenty-four hour specimen examined.

SECOND DAY. The diet was the same, but 40 c.c. of fluid for each kilogram of body weight was given. The same dose of potassium citrate was given in the morning. Two twelve-hour specimens of urine were collected, (8.00 a.m. to 8.00 p.m., and 8.00 p.m., to 8.00 a.m., of the third morning).

THIRD DAY. The diet was the same but 20 c.c. of fluid per kilogram of body weight were administered before 11.00 a.m. Urine was collected from 8.00 a.m. to 12.00 noon.

In some cases the period of examination was extended to one hundred and twenty-four hours in order to ascertain whether longer periods of salt deprivation would give additional or more valuable evidence. A dose of potassium citrate (0.033 gms. per kilogram) was given every day except the last in all cases. Fluid intake was not controlled until the last two days when it was given as described under "Second" and "Third" day above. Twenty-four hour specimens of urine were collected on the first, second, third and fourth day of the test. On the fifth day two twelve-hour specimens were collected and on the sixth day urine was collected for four hours from 8.00 a.m. to 12.00 a.m.

Each sample of urine in all cases was examined quantitatively for sodium chloride by the method of Volhard and Harvey. This has been expressed in the graphs and tables as chlorides per 100 c.c. of urine.

RESULTS

The controls and the patients were divided into the following groups:

1. Four normal controls were subjected to a fifty-two hour test. (Group A.)

2. Five normal controls were given a one hundred and twenty-four hour test. (Group B.)

3. All patients had a preliminary fifty-two hour test. One hundred and thirty-six in all. (Group C.)

4. A group of six patients who were among the highest in the tuberculous group were re-tested for a period of one hundred and twenty-four hours. (Group D.)

NORMAL CONTROLS - GROUP A.

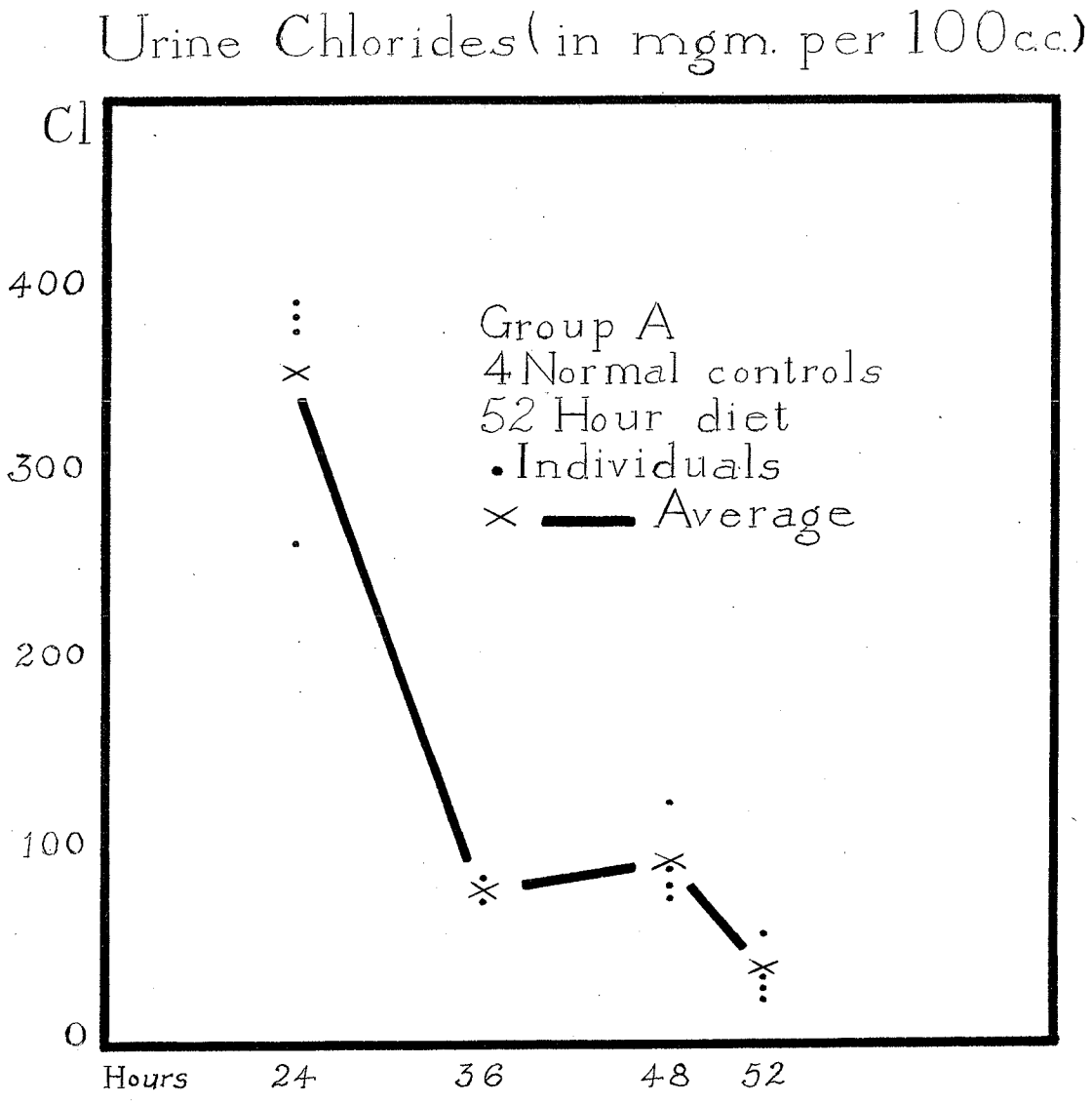
The complete results are shown in Appendix A; the average is indicated in Graph No. 1.

It will be seen that the average figure falls well below 100 milligrams within thirty-six hours; at forty-eight hours three individuals and the average are below 100 and after fifty-two hours all individuals are below 55, the average being 39 milligrams per 100 c.c. The rather rapid fall in the final four hours is no doubt due to dilution resulting from the large fluid intake prescribed in the standard test.

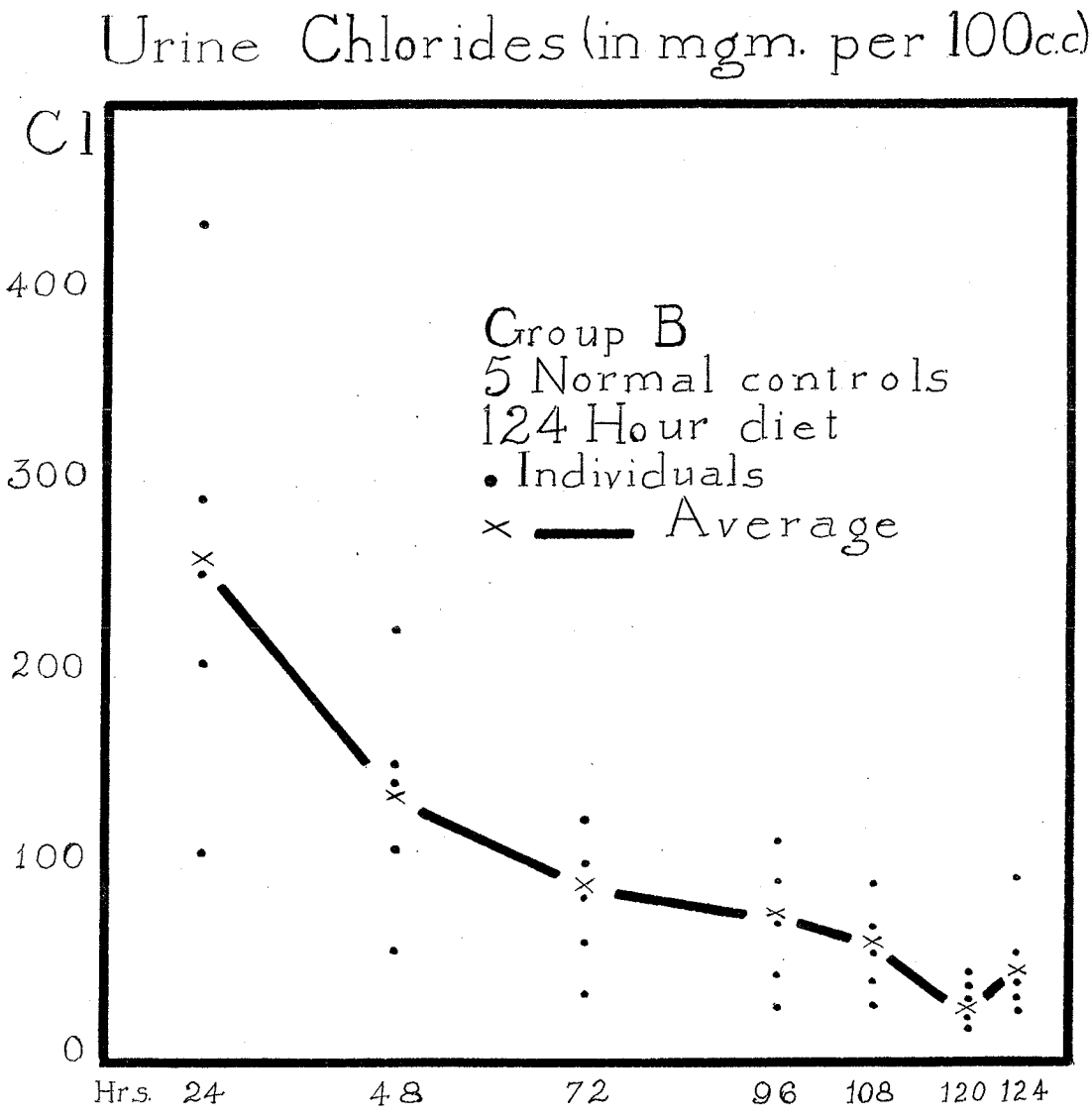
NORMAL CONTROLS - GROUP B.

Graph No. 2 shows the urine chloride concentrations and the mean of five nurses (normal controls) on a hundred and twenty-four hour diet. (Complete figures appear in Appendix A.) This shows that the average concentration at the end of the test (when fluid is forced) is comparable to that found in Group A, who were on the standard test. (Fifty-two hours.) This suggests that prolongation of the test beyond fifty-two hours has made very little difference in the final result in these normals. It will be shown later that this does not apply to borderline cases. These figures show

Graph 1


Urine Chlorides (in mgm. per 100 c.c.)
Cl
400
300
200
100
0
Group A
4 Normal controls
52 Hour diet
• Individuals
× —— Average
Hours
24
36
48
52

Graph 2


Urine Chlorides (in mgm. per 100c.c)
Cl
400
300
200
100
0
Group B
5 Normal controls
124 Hour diet
• Individuals
× —— Average
Hrs. 24
48
72
96
108
120
124

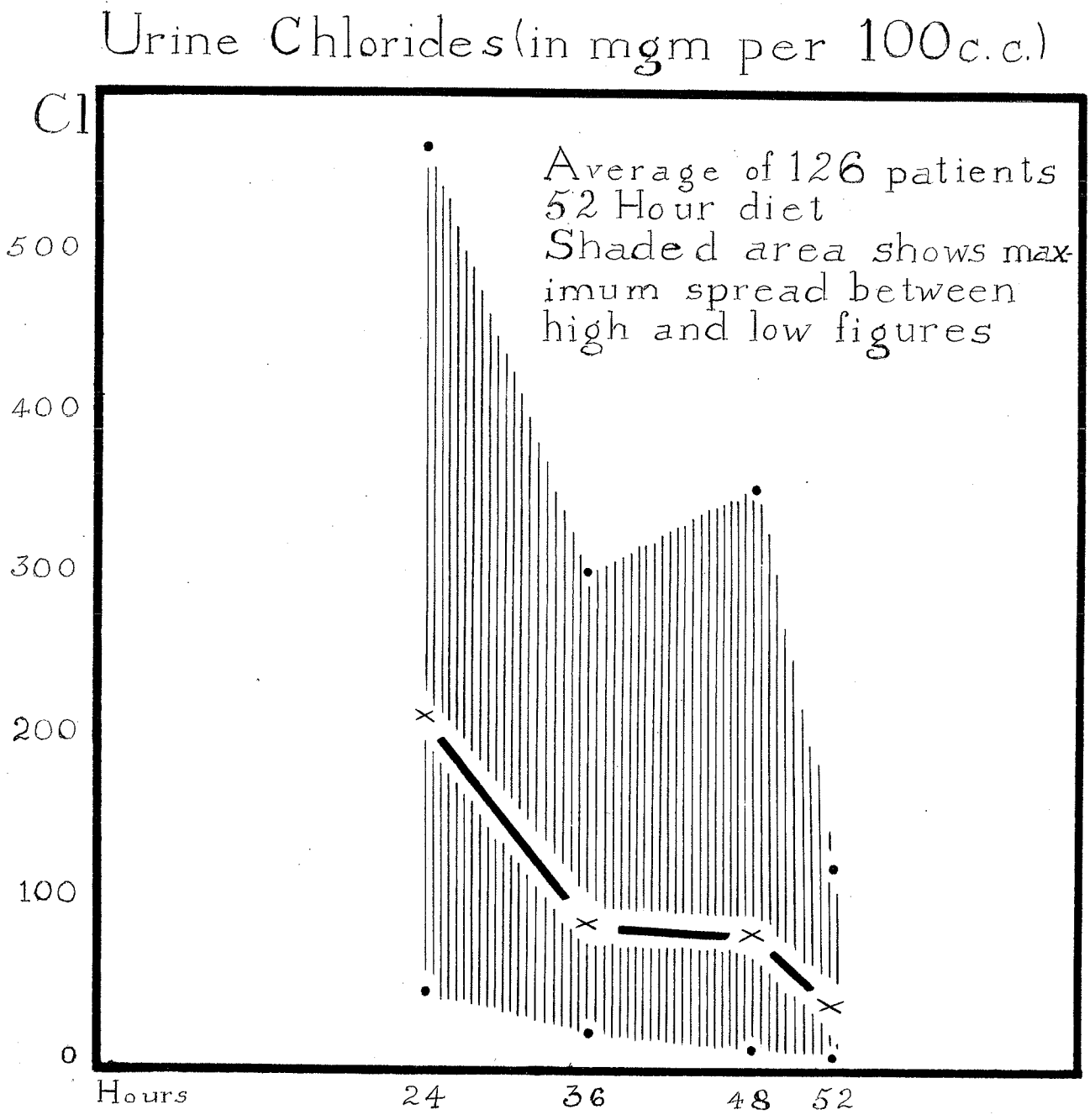
that by Cutler's standard test, or a more prolonged test, the chloride concentration in these normal people becomes less than 100 milligrams per 100 c.c.

FINDINGS IN PATIENTS.

1. Tuberculous Patients. (Group C.) Graph No. 3 shows the average for one hundred and twenty-six patients who were examined for fifty-two hours. The shaded area indicates the maximum spread between high and low figures at each period. It will be seen that the average comes down to 42 milligrams per 100 c.c. at the end of the test, and that the general form of the curve is the same as found in normal cases (Graph No. 1.) Even the outside figures do not suggest an impairment of adrenal function according to Cutler's standards. (Details for each case are given in Appendix B.)

Clinical examination of all these cases showed only one case in which Addison's disease might be seriously considered. This man, No. 2066, (who had no native blood) showed definite abnormal pigmentation even on mucous membranes of the lips and cheeks, and marked weakness; his blood pressure, however, ran between 125/85 and 140/80, and the urine chloride values were 160, 75, 41 and 29 milligrams per 100 c.c. This man's general appearance and deportment did not suggest the asthenia of Addison's disease; his weakness might be accounted for by the fact that besides pulmonary tuberculosis he had active rheumatoid arthritis and pulmonary emphysema and showed definite senile changes

Graph 3


Urine Chlorides (in mgm per 100 c.c.)
Cl
500
400
300
200
100
0
Average of 126 patients
52 Hour diet
Shaded area shows maximum spread between high and low figures
Hours
24
36
48
52

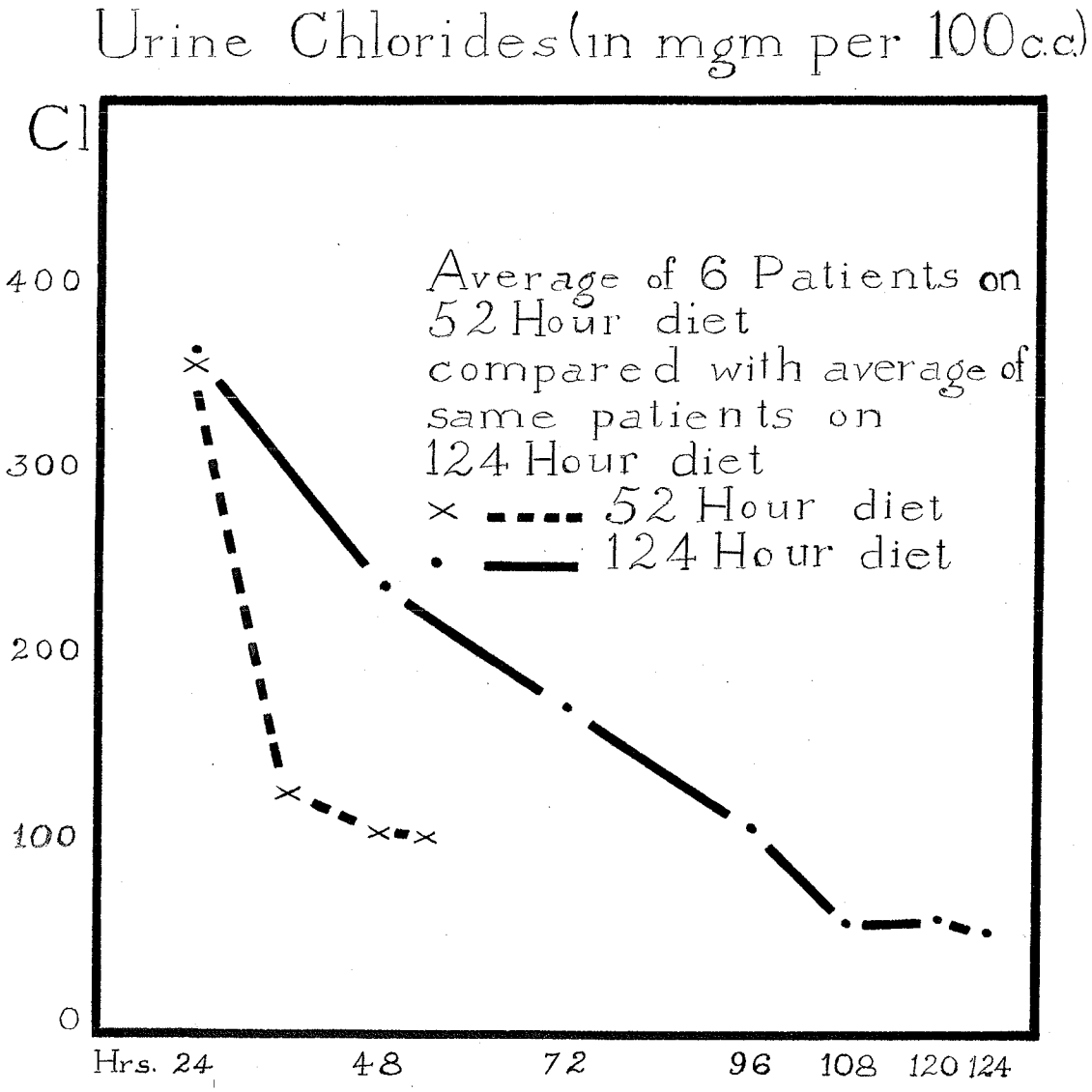
(aged 64). He had not noticed any recent change in the color of his skin having always been inclined to be dark with pigmented spots here and there. The pigmentation of the mucous membrane may possibly have been due to admixture of eastern blood, since he was a Roumanian Jew. It is likely that in this case the urine chlorides are to be depended upon in eliminating the possibility of adrenal disease.

Many other cases in this group, as will be seen in Appendix B, had some pigmentation, hypotension and weakness. Very few had these signs so well marked as to give a strong clinical suggestion of true Addison's disease. The chloride findings in all cases were within normal limits and no co-relation could be seen between these minor signs and urinary chlorides.

Though no patient in this group showed figures outside of what is arbitrarily regarded as normal, it was considered of value to check six of the higher cases (Group D) with the more prolonged test. Graph No. 4 shows a comparison of the long and the short test in these cases. It is seen that prolongation of the test makes a very definite difference in the final figure and brings it within normal limits (average 52.16).

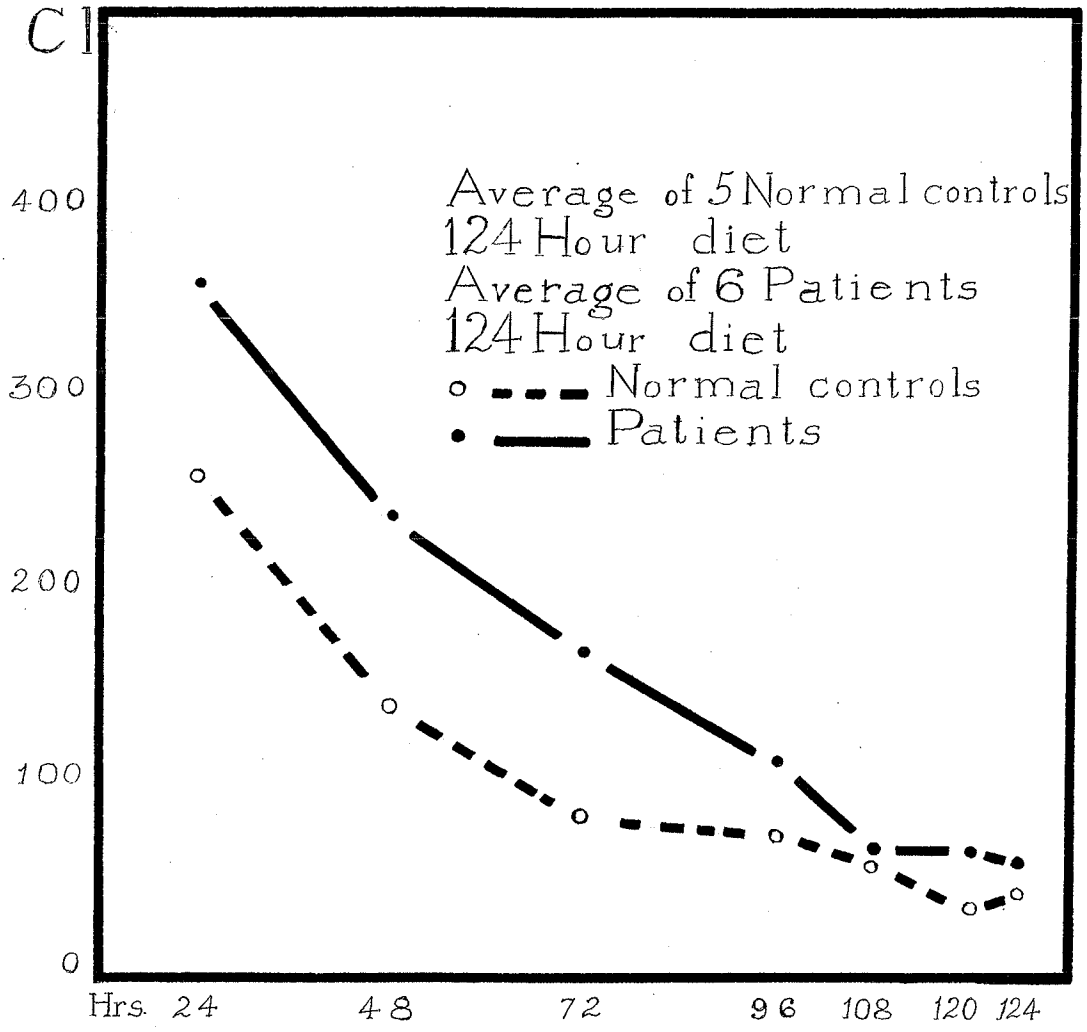
Graph No. 5 shows this same group compared with five normal controls on a long test. Both groups converge to the same low level at the end of one hundred and twenty-four hours. But throughout the earlier part of the test

Graph 4


Urine Chlorides (in mgm per 100 c.c.)
Cl
400
300
200
100
0
Hrs. 24
48
72
96
108
120
124
Average of 6 Patients on 52 Hour diet compared with average of same patients on 124 Hour diet
52 Hour diet
124 Hour diet

Graph 5

Urine Chlorides (in mgm per 100 c.c.)



the tuberculous cases remain higher than the normals. This lag is not any greater than what is sometimes found in apparently normal cases. In our present state of knowledge it must be regarded as normal though there is a possibility that it may represent some adrenal deficiency. Further tests and the ultimate clinical outcome in this group may serve to clarify the matter.

Up to date three cases have come to autopsy. They had all shown normal urinary concentration of chloride and the adrenal glands were normal on gross and microscopic examination.

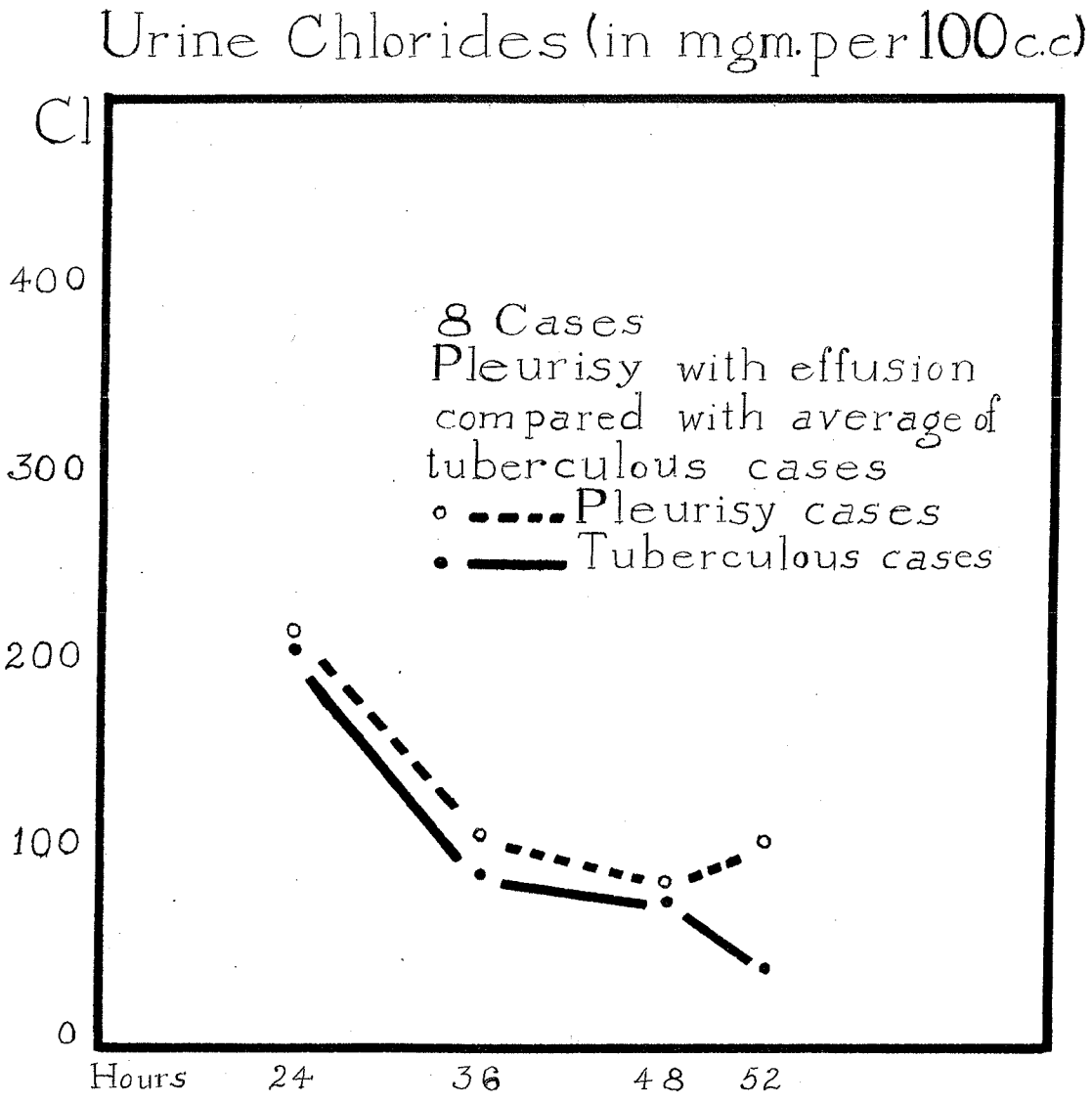
2. Pleurisy with Effusion: Early in the investigation, it was found that patients who had pleurisy with effusion as the primary disease or as a complication showed results which were inclined to be high. For this reason a separate group was made of those cases in which pleurisy with effusion was considered to be active. These cases are not included in the tuberculous group, (Group C). The individual findings in these eight cases are shown in Table 1.

TABLE 1.

No.	Onset of Pleurisy	Date of Test	Urine Chlorides in Mgms. per 100 c.c. 24 Hrs.	36 Hrs.	48 Hrs.	52 Hrs.
2072	Dec. 1939	Dec. 1939		108	39	53
1962	June 1939	Sept.1939	218	121	102	124
S.B.H.	Sept.1939	Oct. 1939	199	138	121	107
1954	June 1939	Jan. 1940	250	131	48	114
2068	Dec. 1939	Jan. 1940	126	65	109	29
2017	July 1939	Nov. 1939	266	86	81	156
1919	March 1939	Jan. 1940	257	97	92	61
2031	July 1939	Nov. 1939	327	143	102	223

Graph No. 6 shows a comparison of the pleurisy cases with the tuberculous cases. The striking contrast is in the last figure; with the increase in fluid intake during the last four hours the concentration of chlorides in the urine unexpectedly goes up in the pleural cases; this is in striking contrast to the normal and to the pulmonary cases. The final concentration in the tuberculous group is 41 milligrams per 100 c.c. and that in the pleurisy group is 108 milligrams. This final rise in concentration takes place in five of the eight pleurisy cases. A similar rise is found in only eight of the 126 pulmonary cases. In going into the history and findings of these eight pulmonary cases, it is found that seven of them are having pneumothorax treatment and that six of these had pleural fluid at the time of the test, and the other one had gross pleural adhesions. The eighth

Graph 6


Urine Chlorides (in mgm. per 100 c.c)
Cl
400
300
200
100
0
8 Cases
Pleurisy with effusion
compared with average of
tuberculous cases
Pleurisy cases
Tuberculous cases
Hours
24
36
48
52

case has had a recent pleural effusion complicating pulmonary tuberculosis.

This failure to dilute chlorides seems to be peculiar to pleural cases. There is no good reason to associate it with adrenal insufficiency on clinical grounds. It is more likely associated with distortion of water metabolism which may be central in origin. (Possibly pituitary). It is well known to clinicians that pleurisy at some stage is frequently associated with polyuria and sometimes even with diabetes insipidus. No satisfactory explanation for this has been encountered in the literature. It is possible that when the blood chlorides tend to become low the organism may be able to draw on the salt in the pleural effusion. No information as to the chloride content of these effusions can be found. Research in connection with this phase of the problem will be continued.

3. Cases with Well Advanced Addison's Disease.

Two cases of classical Addison's disease have been under observation in the past year. Both came in a condition of crisis and have never been well enough to tolerate the standard test. Each of these excreted very high concentrations of chloride. One was put on a salt free diet, but in the course of a few hours his condition became so serious that intravenous salt and cortin had to be administered. The other was put on a modified diet. The result of which will be described later.

4. Criticism of Test.

The great practical difficulty about the test is that it is too severe to be applied to very sick patients. It is unpleasant, even for a healthy person, to subsist on a salt free diet and for those who have anorexia or nausea it is quite impractical. In cases of Addison's disease it is most devastating and hazardous. Also the method is unnecessarily complex and confusing. Besides salt deprivation the patient is given abnormal quantities of potassium and also a very large quantity of water in the final four hours. Either or both of these may confuse the issue. In order to confine the investigation to sodium chloride alone, and to make it more generally applicable by reducing its rigors and dangers the following test has been instituted.

The patient is put on a salt free diet but in addition is given two grams of sodium chloride to be used each day as desired. This quantity of salt was chosen because it appears to approximate the basal requirement, as was shown by Falconer and Lyall.[6] In normal controls on a salt free diet the daily output of sodium chloride falls to about this level in the course of the test and can be maintained at that level by feeding an average of 2 grams. The addition of even this small quantity of salt renders the diet much more acceptable to patients.

2. No additional potassium is given because it is not clear that it is necessary to the efficiency of the test, but it is certain that it increases the hazard for those who may be on the verge of an adrenal crisis.

3. Fluid is allowed "ad libidum". This removes the confusion created by abnormal dilution.. Fluid intake and output is carefully measured.

4. Chloride output is measured in mgm. per 100 c.c. of the urine and also in mgm. of sodium chloride in each twenty-four hours.

Table 2 below shows the result of a test in the case of well advanced Addison's disease compared to a normal person. The patient had been taking an ordinary diet with no extra salt and was showing some evidence of an impending crisis.

Each of these subjects was allowed fluids as desired. There is a very striking contrast in the amount taken. The patient took less than a third of the quantity taken by the control. The concentration of sodium chloride in the urine was from three to four times as great in the patient; but because of the disparity in output the total quantity of sodium chloride excreted was actually less in the patient. It appears that the patient conserved her chlorides by refraining from fluids.

By further experience with this test it is hoped that a simple and dependable test may be evolved.

TABLE 2.

PATIENT WITH ADDISON'S DISEASE

Day	Fluid Intake	Output	Cl. Mgm/100 c.c.	NaCl. Mgm/24 Hrs.	Diet
0		300 c.c.	360	1764	Ordinary diet.
1	540 c.c.	290 c.c.	357	1694	Salt free plus 2 grams NaCl.
2	600 c.c.	600 c.c.	330	3240	Salt free plus 2 grams NaCl.
3	500 c.c.	360 c.c.	246	1447	Salt free plus 2 grams NaCl.
4	1560 c.c.	960 c.c.	267	4186	Ordinary diet plus 900 c.c. of 5% glucose in normal saline.

CONTROL.

1	2320 c.c.	2940 c.c.	115	5452	Salt free plus 2 grams NaCl.
2	1840 c.c.	2100 c.c.	73	2520	Salt free plus 2 grams NaCl.
3	1840 c.c.	2200 c.c.	56	2024	S alt free plus 2 grams NaCl.
4	2230 c.c.	2700 c.c.	76	3348	Ordinary diet.

- - - -

SUMMARY

1. Estimation of urine chlorides according to the Cutler plan, in nine normal people shows that they all fall within his standards of normal.

2. The test on one hundred and twenty-six tuberculous patients disclosed no evidence of adrenal insufficiency; this corresponded with clinical findings in these cases.

3. Some cases of pleurisy with effusion and some cases with hydro-pneumothorax showed an unexplained concentration of urinary chloride in the last four hours of the test, which is likely not due to adrenal disorder.

4. The standard test is too rigorous for application to those who are seriously ill.

5. A modified test is suggested and will be further investigated.

ACKNOWLEDGMENTS

The work was done while I was employed as a teaching fellow in the Department of Medicine of the University of Manitoba.

I wish to thank Professor J. D. Adamson, under whose supervision the investigation was conducted, for for much advice and help throughout.

I wish also to acknowledge my indebtedness to the Sisters of Charity of St. Boniface Sanatorium and St. Boniface Hospital for having provided the material and laboratory facilities for this work.

It has been a matter of considerable labour for the staff in the diet kitchen and the nursing staff; their co-operation is much appreciated.

The interest shown by the members of the medical staff at St. Boniface Sanatorium and St. Boniface Hospital was a source of great encouragement to me, and I wish to thank especially, Miss Victoria Charnecki for technical assistance.

- - - - -

REFERENCES

1. A collection of the published writing of the late Thomas Addison. London, The New Sydenham Society, 1868, 239 PP.

2. Muirhead, A. L.: An autograph history of a case of Addison's disease.
J. Am. M. Ass., 1921, 76: 652.

3. Loeb, R. F., Atchley, D. W., Benedict, E. M. and Leland, Jessica:
Electrolyte balance studies in adrenalectomized dogs with particular reference to the excretion of sodium. Jour. Exper. Med. 1933, 57: 775.

4. Loeb, R. F., Atchley, D. W., and Stahl, Jules: J. Am. M. Ass., 1935, 104: 2149.

5. Cutler, H. H., Power, M. H. and Wilder, R. M.: Concentrations of chloride, sodium and potassium in urine and blood: J. Am. M. Ass., 1938, 111: 117.

6. Falconer, M. A., and Lyall, A.:
The requirements of sodium chloride.
British Medical Journal 1937, 12: 116.

APPENDIX A.

Group A.

No.	Sex	Age	24 Hr.	32 Hr.	48 Hr.	52 Hr.
A.	F.	23	389.26		93.03	53.86
B.	M.	23	394.16		129.75	36.72
C.	F.	25	384.37	83.24	85.69	31.83
D.	M.	23	269.30	85.69	84.46	34.27

Group B.

			24 Hr.	48 Hr.	72 Hr.	96 Hr.
E.	F.	19	210.54	154.24	68.55	97.93
F.	F.	23	111.39	61.20	36.72	31.83
G.	F.	19	440.68	231.35	127.31	118.74
H.	F.	26	258.28	117.51	82.01	48.96
I.	F.	20	293.78	149.34	100.38	73.45

Key to abbreviations
on page 36.

108 Hr.	120 Hr.	124 Hr.
90.58	24.48	53.86
29.38	44.07	24.48
63.65	42.84	44.07
41.62	29.38	26.93
53.86	36.72	95.48

APPENDIX B.

Chlorides in Mgms. per 100 c.c.

GROUP C.

Number	Sex	Age	Diagnosis	24 Hrs.	36 Hrs.
2066	M	64	M.A.Act.	160.13	75.21
2046	F	40	F.A.Act.	223.21	63.08
1892	M	47	F.A.Act.	174.84	66.96
1099A	M	52	G.U. Tbc.	171.12	48.36
1897	M	22	Tbc. Hip Act. Min. Healed	114.08	38.44
1184B	M	32	M.A.Q.	150.42	
1625A	M	41	F.A.Q.	218.36	84.92
1814	M	61	F.A.Act.	49.74	185.60
1865	F	25	M.A.Act.	570.16	303.27
1996	F	22	Min. Act.	155.28	87.34
1739	F	14	M.A.Q.	109.12	57.04
1988	M	28	F.A.Act.	363.93	114.03
1981	M	22	M.A.Act.	169.83	58.23
1745A	M	51	M.A.Act.	291.14	72.79
1624	F	42	M.A.Q.	181.96	121.31
1521	F	16	F.A.Q.	218.36	115.24
1620	F	21	F.A.Act.	164.98	126.16
1688	F	32	F.A.Act.	140.72	38.82
1671	F	30	F.A.Act.		106.75
1372	F	34	F.A.Act.	97.05	121.31
1951	M	51	M.A.Q.	283.86	87.77
236C	M	32	F.A.Act.	164.98	72.79
388D	M	58	F.A.Q.	141.93	48.52

48 Hrs.	52 Hrs.	B. P.	Pigment	Weakness	G. I. Symptoms
41.24	29.11	135/80	+ + +	+ + +	0
99.47	27.90	105/68	0	0	0
81.84	21.08	106/84	0	+	0
60.76	17.36	110/85	0	0	0
28.80	12.40	125/90	0	0	0
76.42	48.52	122/82	0	0	0
88.56	16.98	125/92	0	0	0
111.60	38.82	110/75	+	+ + +	0
208.65	58.23	118/74	0	0	0
104.33	70.36	116/84	0	+	0
65.72	65.72	112/88 N.B.	+ +	0	0
48.52	43.67	110/80	0	0	0
50.95	25.47	100/75	+	0	+
42.46	31.54	130/75	0	0	0
155.28	50.95	140/94	0	0	0
88.56	25.47	115-65 N.B.	0	0	+
104.33	67.93	88/70 N.B.	0	0	0
46.10	14.56	104/78	0	0	0
	31.54	84/70	0	0	0
118.88	38.82	118/82	0	0	+
58.23	43.67	130/85 N.B.		0	+
147.10	48.52	120-80		0	0
	58.23	130-80	0	+ +	0

Chlorides in Mgms.per 100 c.c.

Number	Sex	Age	Diagnosis	24 Hrs.	36 Hrs.
1425A	F	25	F.A.Act.	230.49	54.59
674A	M	56	F.A.Q.	457.34	72.79
1751	F	27	M.A.Act.	145.57	101.90
110B	F	27	F.A.Q.	194.10	77.64
1987	M	27	Tbc.Skin	202.59	89.77
2062	M	44	M.A.Q.	157.70	60.65
1434	F	28	F.A.Q.	133.44	72.79
537	F	24	F.A.Q.	194.10	72.79
1610	F	20	F.A.Act.	201.37	60.65
1953	M	27	M.A.Act.	111.60	33.48
1926	F	26	F.A.Act.	131.44	79.36
991	M	25	M.A.Q.	133.44	84.92
1327	F	14	F.A.Q.	293.57	97.05
1838	F	28	M.A.Q.		58.23
869B	M	49	F.A.Act.	232.91	242.62
1964	M	52	M.A.Act.	236.55	104.33
1976	M	61	M.A.Act.	160.13	75.21
1974	M	24	Pl.E.(Q)	169.83	52.16
1643	F	31	F.A.Act.	361.50	131.01
1915	F	16	F.A.Act.		82.49
1839	F	20	Pl.Healed Bones	243.83	80.06
1768	M	29	F.A.Act.	186.00	158.72
1775	M	36	F.A.Act.	293.57	128.59

48 Hrs.	52 Hrs.	B. P.	Pigment	Weakness	G. I. Symptoms
77.64	29.11	106-74	0	0	0
128.59	6.06	118-94	0	0	0
58.23	41.24	130-88	0	0	0
97.05	31.54	110-86	N.B. / /	0	/
48.52	26.69		0	0	0
145.57	36.39	100-65	0	/	0
72.79	48.52	126.84	/	0	/
63.08	48.52	98-78	N.B.	0	0
	26.69	145-90	0	0	0
45.88	23.56	112-86	0	0	0
50.84	22.32	100-82	N.B. 0	/	0
69.15	90.98	120-80	N.B. 0	0	0
120.10	60.65		N.B.	0	0
72.79	43.67	116-80	0	0	0
247.47	27.90	100-70	/	/ /	0
35.18	59.44	110-70	/	/	0
41.24	29.11	130-80	N.B. 0	0	/
81.28	64.29	125-82	0	0	0
65.51	48.52		0	0	0
70.36	29.11	120-84	N.B.	0	0
106.75	46.10	108-70	0	0	0
59.52	68.20	100-74	0	0	0
53.38	14.56	110-84	0	0	/

1454

Chlorides in Mgms. per 100 c.c.

Number	Sex	Age	Diagnosis	24 Hrs.	36 Hrs.
1990	M	31	F.A.Act.	272.95	103.11
1420A	F	23	F.A.Q.		109.18
2041	F	19	M.A.Act.	300.85	55.80
1428	M	29	F.A.Act.	269.31	72.79
1796	F	16	F.A.Act.	159.96	40.92
2020	M	29	M.A.Act.	128.96	39.68
210	M	56	F.A.Act.	213.50	84.92
707B	M	27	F.A.Act.	185.60	72.79
2004	F	19	F.A.Act.	104.16	45.88
1985	F	14	M.A.Act.	229.40	88.04
1047A	M	26	F.A.Act.	110.36	62.00
1983	F	37	F.A.Act.	235.60	57.04
1787	M	23	F.A.Act.	156.24	52.08
1586	M	26	F.A.Act.	164.98	65.51
1909	M	21	F.A.Act.	439.16	107.96
1380	M	24	F.A.Q.	232.91	72.79
1365A	M	80	F.A.Q.	218.36	111.60
1058	M	23	F.A.Q.	191.67	72.79
2034	M	25	M.A.Q.	132.47	111.60
1041B	M	44	F.A.Act.	274.16	81.28
1457A	F	25	M.A.Q.	138.29	41.24
1514A	M	31	F.A.Act.	215.93	133.44
1710	F	39	F.A.Act.		55.80

48 Hrs.	52 Hrs.	B. P.	Pigment	Weakness	G. I. Symptoms
76.42	75.21	110-74	0	0	0
97.05	55.80	110-82	0	0	0
36.39	46.10	120-82	0	0	0
53.38	48.52	130-110	/	0	/
28.52	14.88	140-88	N.B.0	0	0
29.76	13.64	128-76	0	0	/
101.90	76.42	100-70	0	0	/ /
29.11	16.98	120-75	N.B.0	/	0
50.84	9.92	124-90	N.B./ /	0	0
55.80	32.24	116-64	N.B.0	0	0
53.32	26.04	130-90	0	0	0
66.96	17.36	118-98	N.B./	/	0
75.21	30.33	115-90	0	0	0
41.24	24.26	125-90	0	0	0
46.10	43.67	110-60	N.B.	0	0
145.57	48.52	170-82	0	/	0
	37.61	110-74	/	0	0
65.51	53.38	140-85	N.B.	0	0
44.86	21.83	136-100	0	0	0
32.75	27.90	118-70	0	0	0
99.47	50.95	132-84	N.B.	0	/
84.92	14.58	184-110	0	0	0

Chlorides in Mgms. per 100 c. c.

Number	Sex	Age	Diagnosis	24 Hrs.	36 Hrs.
1956	F	21	Tbc.Hip	169.83	55.80
1939	F	14	F.A.Act	201.37	60.65
1923	F	26	M.A.Q.	194.10	133.44
1568	F	30	F.A.Act.	194.10	97.05
1908	F	27	F.A.Act.	186.82	48.52
1959	F	22	M.A.Act.	152.85	
1800	F	28	M.A.Act.	528.91	148.00
2026	M	43	F.A.Act.	558.03	87.34
1978	F	43	M.A.Act.	183.18	234.13
1559	M	24	F.A.Q.	166.19	64.29
2023	M	55	F.A.Act.	207.08	96.72
2042	M	49	F.A.Act.	271.73	106.75
749A	M	50	F.A.Act.	110.36	65.72
1464	M	17	F.A.Q.	86.80	42.16
1910	M	30	F.A.Act.	149.28	40.92
1812	F	30	F.A.Act.	220.78	77.64
54B	M	44	F.A.Act.	252.32	94.62
1966	F	18	Min.Q	363.93	109.18
1862	F	24	F.A.Act.	254.75	72.79
1704	M	26	Skin Tbc.	88.04	31.00
409A	M	48	F.A.Act.	254.75	63.04
1589A	M	45	F.A.Act.	520.42	129.80
1507	F	27	F.A.Act.	296.00	97.05
1891	F	16	F.A.Act.	133.92	39.68

48 Hrs.	52 Hrs.	B. P.	Pigment	Weakness	G. I. Symptoms
123.74	80.06	180-120 N.B.	0	0	0
75.21	41.24	112-78	0	0	0
109.18	24.26	120-86	0	✓✓	0
97.05	31.54	116-78	0	0	0
36.39	19.41	116-80	0	0	0
60.65	41.24	118-74	0	✓✓	0
177.11	65.51	122-90	0	✓	0
70.36	33.97	110-70	0	0	0
	33.97	125-58	✓	0	0
26.69	20.62	120-84 N.B.	✓	0	0
47.12	13.64	114-66	0	0	✓
63.08	38.82	120-72	0	0	0
50.84	18.60	126-86	✓	0	0
24.80	21.08	104-80	✓	✓	✓
32.24	8.48	128-78	✓	0	0
	29.11	114-78	0	0	0
116.46	36.39	114-84	0	✓	✓
97.05	36.39	124-78	0	0	0
133.44	48.52	124-90	0	0	0
49.60	28.52		✓✓	✓	0
145.57	26.69	105-60 N.B.		0	0
354.22	58.23	123-70 N.B.		0	0
97.05	60.65	116-82	0	✓	✓
47.12	22.32	N.B.		0	0

Chlorides in Mgms. per 100 c. c.

Number	Sex	Age	Diagnosis	24 Hrs.	36 Hrs.
2029	F	28	M.A.Act.	128.96	52.08
1542	M	30	Bone & Jt. Tbc.	171.12	74.40
1504A	M	43	F.A.Act.	89.28	22.32
1816	M	14	M.A.Act.	137.08	114.03
2058	M	30	F.A.Act.	145.57	70.36
1937	F	15	F.A.Act.	368.78	53.38
1857	F	15	M.A.Act.	262.03	109.18
1970	F	29	M.A.Act.	150.42	116.46
2033	M	50	F.A.Act.	262.88	173.60
1646	M	18	F.A.Act.	176.08	71.92
1799A	M	49	M.A.Act.	109.12	50.84
1851	M	25	F.A.Act.	230.49	97.05
1746	M	27	F.A.Act.	215.93	95.83
2010	M	29	Pl.Eff.	161.20	74.40
1938	M	24	Min.Q.	133.44	63.04
980	M	49	F.A.Act.	243.83	93.41
1673	F	20	M.A.Q.	101.90	101.90
2039	F	16	F.A.Act.	309.34	72.79
1972	M	34	Pl.Eff.Q.	155.28	115.24
1819	M	19	F.A.Act.	226.85	52.16
1806	M	23	F.A.Act.	223.21	138.29
1965	F	26	Min.Q.	170.83	121.31
1748	F	20	Min.Q.	198.95	140.72
1843	F	22	Min.Q.		77.64

48 Hrs.	52 Hrs.	B. P.	Pigment	Weakness	G. I. Symptoms
47.12	37.20	120-84 N.B.	∕	0	0
43.40	17.36	116-92	∕	0	0
59.52	22.32	118-78	0	0	0
101.90	43.67	120-80 N.B.	0	0	0
70.36	30.33	125-75	∕	0	0
169.83	46.10	140-90	0	0	0
16.98	38.82	124-80	0	0	0
101.90	38.82	100-65	0	0	0
156.24	96.72	115-72			
11.16	4.96	126096	0	0	0
17.36	22.32	106-86	∕	∕ ∕ ∕	0
78.85	33.97	126-78	0	0	0
92.19	20.62	115-80	0	0	0
76.88	29.76	140-92 N.B.		0	0
72.79	36.39	115-75	0	0	0
86.13	40.03	126-86	∕	0	0
41.24	60.65	96-60	0	0	0
60.65	53.38	116-72	∕	0	0
111.60	38.82	90-70	0	0	0
12.13	30.33	150-84	∕ ∕	0	0
53.38	42.46	110-92	∕ ∕	0	∕
97.05	109.18	112-74	0	∕	0
121.31	77.64	132-80	0	0	0
65.51	63.08	110-80 N.B.	0	0	0

Chloride in Mgms. per 100 c. c.

Number	Sex	Age	Diagnosis	24 Hrs.	36 Hrs.
1640	F	20	F. A. Act.	220.78	94.62
1949	F	19	F. A. Act.	356.65	
	F.	34	M. A. Act.	128.59	84.92
	F			206.23	97.05

PLEURISY WITH EFFUSION

2072	M	38	Pl.Eff.		107.96
1962	F	18	Pl.Eff.	218.36	121.31
S.B.H.	M		Pl.Eff.	198.95	138.29
1954	M	19	Pl.Eff. & Peritonitis	249.90	131.01
2068	M	42	M.A.Act.Pl.	126.16	65.51
2017	M	34	F.A.Act. Pl.Eff.	265.67	86.13
1919	M	46	F.A.Act. Pl.Eff.	257.18	97.05
2031	M	28	F.A.Act. Pl.Eff.	327.36	142.60

48 Hrs.	52 Hrs.	B. P.		Pigment	Weakness	G. I. Symptoms
109.18	67.93	100-60		0	0	0
126.16	77.64	90-80		0	/	0
89.77	72.79	118-70		/	//	0
106.75	48.52	112-70		0	0	0
38.82	53.38	140/90		0	/	0
101.90	123.74	120-86	N.B.		0	0
121.31	106.75		N.B.		/	/
48.52	114.03	120-85		/	0	0
109.18	29.11	105-80		0	0	0
81.28	156.49	122/70		0	0	0
92.19	60.65	100/75		0	0	0
101.68	223.20	114/73		/	///	0

APPENDIX C. 6 patients on 52 hour and 124 hour.

Chloride in Mgms. per 100 c. c.

Number	Sex	Age	Diagnosis	24 Hrs.	36 Hrs.	48 Hrs.
				24 Hrs.	48 Hrs.	72 Hrs.
2031	M	28	F.A.Act.	327.36	142.60	101.18
				509.50	315.41	238.98
1821	M	60	F.A.Act.	157.70	117.67	93.41
				266.88	203.80	110.39
1390	M	56	F.A.Act.	359.08	101.90	181.96
				327.54	218.36	173.47
1817	M	56	F.A.Act.		103.11	
				424.58	271.73	183.18
1465	M	37	F.A.Act.	558.03	196.52	80.06
				484.03	206.23	175.90
1881	M	59	F.A.Act.	395.47	121.31	89.77
				183.18	240.19	167.41

52 Hrs. / 96 Hrs.	108 Hrs.	120 Hrs.	124 Hrs.	B. P.	Pig-ment	Weak-ness	G.I. Symp-toms
223.20				114/73	+	+++	0
140.72	59.23	81.28	70.36				
82.49				135/83	0	0	0
88.56	38.82	46.10	53.38				
84.92				137/80	0	++	0
122.52	76.42	66.72	53.38				
72.79				130/80	0	++	0
94.62	50.95	104.33	72.79				
67.93				95/70	+	++	0
109.18	75.21	40.03	46.10				
84.92				120/85	Q	+	0
109.18	60.65	29.11	16.98				

KEY

F. A. - Far Advanced

M. A. - Moderately Advanced

Min. - Minimal

Q. - Quiescent

Act. - Active

Pl. Eff.- Pleurisy with Effusion

N. B. - Native Blood