

BLOOD CHEMISTRY STUDIES IN INFLUENZAL PNEUMONIA *

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Heretofore studies in blood chemistry have chiefly been confined to cases presenting evidences of renal involvement. Cases of pneumonia and other infectious diseases have received little attention in this direction. This is due to the assumption that such studies would be of little value, and partly also to the relative newness of the subject of blood chemistry.

This report sets forth the findings in 131 specimens of blood from sixty-one cases of influenzal pneumonia, representing various degrees of severity, and obtained on various days of the disease. The results were obtained from forty-two nonfatal cases and sixteen fatal cases, thirteen patients receiving intravenous injections of hypertonic glucose solution and six cases receiving intravenous injections of foreign protein.

Nonfatal Cases: Table 1 includes the blood chemistry findings in forty-two nonfatal cases, arranged according to the day of the disease on which the blood was examined. In a few of these cases incomplete urinary findings are included. In seventeen cases the average excretion of chlorids per twenty-four hours was 2.98 gm.; in only one case was the finding in this regard normal. The above finding is in accord with the reported diminution of the urinary chlorids in pneumonia of the lobar type, and gives evidence that the same condition holds for influenzal pneumonia. In eleven cases the urinary urea averaged 21.46 gm. per twenty-four hours, which is within normal limits. In only one case was the amount subnormal, the blood urea in this case being slightly increased. In other cases in which the blood urea was considerably higher the content in the urine was normal. Unfortunately in the three cases in which the blood urea was highest the urine content was not determined. The severity of the pneumonia apparently had little influence on the amount of urea in the urine.

With the diminution of the chlorids in the urine one might expect to find an increase in the blood. Our findings in this regard coincide with those of Gettler,¹ in that we consistently failed to find an increase. In five cases, classed as mild and moderately severe, the blood chlorids averaged 0.70; the average for the forty-two nonfatal cases being 0.57 per cent.

* The results of observations made at the Base Hospital, Camp Travis, Texas.
1. J. A. M. A. **71**:2033 (Dec. 21), 1918.

The results of blood sugar determinations are included in the tables, but in the light of our present knowledge have little significance. It is to be noted, however, that a number of the cases gave findings toward the upper limits of normal. This may be caused by the injected glucose solution.

TABLE 1.—BLOOD CHEMISTRY DETERMINATIONS IN NONFATAL CASES OF INFLUENZAL PNEUMONIA

Case Number	Urine					Blood Chemistry Findings								Remarks
	Albumin	Casts	Day of Disease	Chlorids, Gm.	Urea, Gm.	Day of Disease	Chlorids, per Cent.	Sugar, per Cent.	Creatinin, Mg. per 100 C.c. Blood	Urea Nitrogen, Mg. per 100 C.c. Blood	Urea, Mg. per 100 C.c. Blood	Uric Acid, Mg. per 100 C.c. Blood	CO ₂ Combining Power of the Blood Plasma	
1*	N	N	1	...	...	1	0.48	0.14	1.4	13.0	27.82	5.0	..	Very severe
2	N	N	...	...	...	1	0.49	0.12	1.75	15.75	31.705	2.95	..	Moderately severe
3	P	P	...	...	...	1	0.46	0.12	2.5	53.0	113.42	7.7	..	Very severe
4	P	P	...	...	...	1	0.60	0.17	2.1	17.2	36.8	6.1	..	Very severe
5	P	P	3	1.7	...	2	0.74	0.12	0.85	18.0	38.52	2.2	..	Moderately severe
6	P	P	3	1.6	22.4	2	0.68	0.13	1.0	16.7	33.75	2.45	65	Very severe
7	N	N	2	1.2	...	2	0.61	0.14	3.06	19.5	41.73	4.06	55	Moderately severe
8	N	N	4	6.8	20.6	2	0.64	0.13	0.85	20.7	44.29	2.2	52	Moderately severe
9	P	P	...	...	...	2	0.56	0.14	1.35	16.3	34.88	5.8	..	Moderately severe
10	N	N	...	...	...	2	0.60	0.16	2.10	47.1	100.79	18.1	..	Moderately severe
11*	N	N	27	...	17.0	2	0.57	0.14	1.2	12.2	26.1	5.2	..	Mild case
12	P	P	2	8.7	33.2	2	1.27	0.13	1.0	18.0	38.52	0.96	..	Moderately severe
13	N	N	3	4.2	9.29	2	0.63	0.16	1.35	18.0	38.52	2.9	56	Moderately severe
14	P	P	2	3.6	16.56	2	...	0.14	2.0	32.2	65.48	3.42	54	Moderately severe
15	P	P	...	...	...	2	0.44	0.10	2.6	16.25	34.77	1.72	..	Moderately severe
16	N	N	...	...	...	2	0.51	0.09	1.1	16.3	34.88	1.2	..	Moderately severe
17	P	P	...	...	...	2	0.46	0.12	2.5	53.0	113.42	7.7	..	Very severe
18	P	P	19	2.47	40.85	2	...	0.11	1.6	22.27	47.65	6.6	..	Very severe
19	P	P	3	1.4	11.6	3	0.61	0.17	1.7	25.2	53.92	14.3	..	Moderately severe
20	P	P	...	...	...	3	0.56	0.15	1.58	19.3	41.30	12.1	..	Mild case
21	P	P	3	2.1	...	3	0.49	0.15	1.9	16.2	34.66	2.5	..	Moderately severe
22	N	N	4	2.9	...	3	0.70	0.10	0.85	15.1	32.31	1.77	54	Mild case
23	N	N	...	...	...	3	0.44	0.13	1.5	19.5	41.73	2.6	..	Moderately severe
24	P	P	...	...	...	3	0.46	0.11	2.55	26.5	56.71	5.7	..	Very severe
25	N	N	...	...	...	3	0.49	0.11	1.55	19.5	41.73	3.2	..	Moderately severe
26	P	P	12	3.1	29.07	3	0.44	0.13	1.0	20.75	44.4	6.4	..	Very severe
27	...	...	...	...	...	4	0.68	0.11	1.5	28.0	59.92	2.7	..	Moderately severe
28	P	P	7	1.2	...	4	0.70	0.14	1.1	32.2	68.9	6.0	..	Moderately severe
29	N	N	...	...	...	4	0.48	0.10	1.1	13.0	27.82	3.2	..	Very severe
30	P	P	6	4.3	...	4	0.46	0.06	1.2	16.75	35.84	0.71	..	Moderately severe
31	P	P	6	0.6	...	5	0.64	0.13	1.05	32.0	68.48	4.2	45	Very severe
32	N	N	...	...	...	5	0.65	0.14	1.1	22.2	47.5	4.4	..	Mild case
33	N	N	6	3.2	20.8	5	0.53	0.13	1.1	17.5	37.45	...	..	Mild case
34	N	N	...	...	...	5	0.46	0.07	1.2	15.75	33.70	1.22	..	Moderately severe
35	N	N	...	...	...	5	0.45	0.09	0.55	16.75	35.84	0.66	..	Moderately severe
36	N	N	...	...	...	5	0.48	0.16	1.35	15.75	33.70	5.1	..	Moderately severe
37*	P	P	4	1.8	...	6	0.68	0.16	1.0	31.2	66.76	1.71	47	Moderately severe
38	P	P	4	...	14.7	6	0.74	0.11	0.75	15.2	32.52	2.65	62	Mild case
39	N	N	...	...	...	8	0.66	0.11	1.4	40.0	85.60	2.9	..	Moderately severe
40	P	P	...	...	...	10	0.58	0.12	2.2	13.0	27.82	2.9	..	Moderately severe
41*	N	N	...	...	...	11	0.70	0.09	3.5	19.0	40.66	1.7	..	Moderately severe
42	N	N	...	...	...	26	0.55	0.14	0.85	15.3	32.74	...	..	Very severe

* Cases in which pleurisy or empyema occurred.

Abnormal amounts of creatinin in the blood usually indicate renal involvement. Meyers and Lough² state that creatinin of 2.5 mg. or more per hundred c.c. of blood almost without exception indicates involvement of the kidneys. Five of the cases in this group had find-

2. Arch. Int. Med., 16: 536, (Nov.), 1915.

ings above this amount, the highest being 3.5 mg.; two of these cases had neither albumin nor casts in the urine. The severity of the pneumonia apparently influenced little the retention of creatinin. In six mild cases the average was 1.09 mg. per hundred c.c. of blood, and in eleven very severe cases 1.57 mg., both figures being within normal limits.

Retention of urea nitrogen and urea occurred frequently in this group of cases, the degree apparently bearing some relation to the severity of the disease. The following averages were obtained. In six mild cases, 16.9 mg. per hundred of blood; in twenty-five moderately severe cases, 21.87 mg., and in eleven very severe cases, 25.7 mg. (Table 2). The findings in relation to the day of the disease are given in Table 4. The average in four cases on the first day of the disease amounting to 16.03 mg. per hundred c.c. of blood. The figures for urea parallel those for urea nitrogen.

TABLE 2.—BLOOD CHEMISTRY FINDINGS IN RELATION TO THE SEVERITY OF THE DISEASE

Clinical Type of the Disease	Number of Cases	Chlorids Average, Per Cent.	Creatinin Average Mg. per 100 C.c. of Blood	Urea Nitrogen Average Mg. per 100 C.c. of Blood	Uric Acid Average Mg. per 100 C.c. of Blood
Mild.....	8	0.62	1.06	16.9	3.75
Moderately severe....	24	0.60	1.58	21.92	3.75
Very severe and fatal cases.....	26	0.56 ¹	1.49	25.17	4.98 ²

1. Average for 24 cases.

2. Average for 20 cases.

Uric acid being the most difficult of the nitrogenous waste products for the kidneys to eliminate, it might be expected to be found increased in the blood, under certain circumstances, even when the urea and creatinin are normal. In the group of cases under discussion an increase of blood uric acid was frequently encountered. As a rule, this increase was proportional to the severity of the disease. In eight mild cases an average of 3.5 mg. per hundred c.c. of blood was found; in twenty-four moderately severe cases 3.75 mg., and in twenty very severe cases it was increased to 4.98 mg. (Table 2). The highest findings for uric acid were on the third day of the disease, the lowest on the fourth and fifth days (Table 3). The highest figure for uric acid encountered in this series was in Case 10 (Table 1), a moderately severe case, with 18.1 mg. per hundred c.c. of blood.

The blood of sixteen fatal cases was examined on various days of the disease (Table 4). In these cases a greater reduction in the urinary chlorids was found. In general, the blood chlorids and sugar were normal. Urea and urea nitrogen were usually increased. In cases 4, 10 and 15, in which the determinations were made one and

two days before death, these products were decidedly increased. Uric acid was increased in practically every case, averaging 4.46 mg. per hundred c.c. of blood. In this group of cases such factors as the day of the disease, duration and complications had little influence on the degree of retention.

The original plan of this investigation was twofold: to study the retention of the nitrogenous waste products in the blood of pneumonia cases uninfluenced by any special form of treatment, and to determine any possible alteration in the degree of retention resulting from the intravenous injections of foreign protein and hypertonic glucose solutions. In the reaction which frequently follows the intravenous injection of a foreign protein profuse sweating occurs; that this reaction might have a modifying effect upon the degree of retention seemed possible, especially in view of the marked improvement which frequently followed such injections.

TABLE 3.—BLOOD CHEMISTRY FINDINGS IN RELATION TO THE DAY OF THE DISEASE

Day of the Disease	Number of Cases	Chlorids Average, Per Cent.	Creatinin Average Mg. per 100 C.c. of Blood	Urea Nitrogen Average Mg. per 100 C.c. of Blood	Uric Acid Average Mg. per 100 C.c. of Blood
First.....	4	0.51	1.94	16.08	4.59 ¹
Second.....	16	0.64	1.62	19.85	4.53 ²
Third.....	9	0.52	1.54	21.16	6.06
Fourth.....	5	0.58	1.22	23.54	3.02
Fifth.....	9	0.56	1.06	22.14	3.11

1. Includes 5 cases.

2. Includes 17 cases.

Thirteen cases of pneumonia are cited in which one or more blood chemistry determinations were made before and after the intravenous injection of a hypertonic glucose solution, including a total of sixty-three determinations (Table 5). The results in these cases were not as striking as we had hoped. It was thought possible that an appreciable reduction might occur following the injection of large quantities of glucose solution. There was a slight reduction of urea nitrogen and urea in Case 3. In Case 4, uric acid was reduced on the second day, creatinin on the third day, and urea and urea nitrogen on the fifth and seventh days; on the second day, however, the latter product was slightly increased. In Case 8, on the third day uric acid was reduced from 6.4 to 2.5 mg. per hundred c.c. of blood four hours after the injection of 250 c.c. of glucose solution. In Case 10, on the sixth day there was an appreciable reduction in urea five hours after the injection of the glucose. In Case 3, on the second day urea nitrogen, urea and uric acid were slightly increased four hours after the injection. In Case 6, on the third day the uric acid doubled in

amount two hours after the injection. In Case 8 urea was increased on the third day, and on the sixth day uric acid was greatly increased, three and eighteen hours after the injection.

Six cases are included in the foreign protein group (Table 5). Only two of these permitted satisfactory chemical examinations of the blood with reference to the injection of the protein. In Case 5, four hours after the injection of 0.5 c.c. of a typhoid vaccine, sufficient to cause a moderate reaction, there occurred a moderate reduction in all the nitrogenous waste products in the blood. In Case 6, there occurred on the first day a considerable increase in the uric acid content of the blood four hours after the intravenous injection of the protein. In three cases in this group uric acid retention was found present following the injections.

TABLE 4.—BLOOD CHEMISTRY DETERMINATIONS IN FATAL CASES OF INFLUENZAL PNEUMONIA

Case Number	Urine				Blood Chemistry Findings								Day of Death	
	Albumin	Casts	24 Hour Specimen			Day of Disease	Chlorids, per Cent.	Sugar, per Cent.	Creatinin, Mg. per 100 C.c. Blood	Urea Nitrogen, Mg. per 100 C.c. Blood	Urea, Mg. per 100 C.c. Blood	Uric Acid, Mg. per 100 C.c. Blood		CO ₂ Combining Power of the Blood Plasma
			Day of Dis- ease	Chlorids, Gm.	Urea, Gm.									
1	P	P	3	...	...	1	0.69	0.14	1.0	18.2	38.94	1.51	57	7th
2	N	N	3	...	19.0	2	0.63	0.16	1.7	21.3	45.58	...	54	3d
3	P	P	6	8.0	38.0	2	0.64	0.16	1.5	22.1	47.29	2.2	58	10th
4	N	N	3	...	...	2	0.42	0.14	1.1	27.25	58.81	8.8	...	4th
5*	P	P	3	1.3	...	2	0.69	0.13	1.01	20.7	44.29	3.65	51	18th
6	N	N	...	...	...	3	0.48	0.15	1.85	28.5	60.95	6.0	...	6th
7	P	P	...	...	...	4	0.53	0.11	0.9	27.75	59.28	2.5	...	4th
8	P	P	3	1.0	...	5	0.63	0.12	0.9	16.3	34.88	3.15	54	11th
9*	N	N	...	...	...	5	0.58	0.15	0.9	19.0	40.60	...	...	6th
10	N	N	...	...	...	5	...	0.14	1.4	44.1	94.37	...	...	7th
11	P	P	...	...	...	6	...	0.15	1.05	21.3	45.58	...	...	7th
12	P	P	3	1.0	...	6	0.63	0.13	1.05	31.2	66.76	5.0	52	11th
13*	N	N	...	...	...	7	0.56	0.15	1.5	19.0	40.66	T	44	9th
14	N	N	...	...	...	7	0.5	0.16	1.5	19.2	41.08	...	...	8th
15	N	N	...	...	...	7	0.58	0.18	1.55	34.1	72.97	3.9	...	8th
16	..	..	10	1.3	...	9	0.71	0.15	1.1	27.5	58.85	7.9	...	19th

* Cases in which pleurisy or empyema occurred.

Case 8 (Table 5) is sufficiently unusual to merit some discussion. A graphic presentation of the retention curve for the various nitrogenous waste products is given in the accompanying chart. This case was of the type in which clinical experience had taught us to expect a fatal termination. The patient was delirious and irrational for several days, presented marked cyanosis and dyspnea, rapid and thready pulse, and high fever. On the ninth day of the disease, the blood chemistry findings were, creatinin, 5.1 mg.; urea nitrogen, 148.0 mg.; urea, 315.7 mg. and uric acid, 9.6 mg. per hundred c.c. of blood. An acute kidney involvement was present but cleared rapidly with convalescence. In Case 4 of the glucose series an equally severe clinical

TABLE 5.—BLOOD CHEMISTRY BEFORE, AND AFTER THE INTRAVENOUS ADMINISTRATION OF GLUCOSE SOLUTION AND FOREIGN PROTEIN

Urine		Blood Chemistry Findings														Number of Cc. of Glucose Injected	Remarks									
24 Hr. Spec.		Before Glucose Injections							After Glucose Injections																	
Albumin	Casts	Day of Disease	Chlorides, Gm.	Urea, Gm.	Day of Disease	Hours Before Injection	Chlorids, per Cent.	Sugar, per Cent.	Creatinin, Mg. per 100 Cc.	Urea Nitrogen, Mg. per 100 Cc.	Urea, Mg. per 100 Cc.	C.C. Blood	Uric Acid, Mg. per 100 Cc.	CO ₂ Combining Power of the Blood												
1	N	..	...	19.0	2	6	0.68	0.15	1.7	21.3	45.58	...	...	54	4	24	0.57	0.20	1.5	22.1	47.29	2.2	58	800	Severe case with death, showing no reduction in retention
2	N	8	1.7	....	2	1	0.74	0.12	0.85	18.0	38.52	2.2	...	..	5	1	0.58	0.26	2.55	41.2	87.95	2.42	52	250	Moderately severe case, showing slight reduction
3	N	..	....	....	2	2	0.51	0.09	1.1	16.3	34.88	1.2	...	..	3	4	0.50	0.11	1.1	18.0	38.52	1.31	..	250	Moderately severe, showing slight reduction
4	P	19	12.4	40.85	3	1	0.45	0.09	1.05	19.0	40.8	1.21	...	..	3	6	0.53	0.13	1.05	18.2	38.94	1.3	..	250	Very severe case, slight uric acid reduction, after first injection. Recovery was very slow
					3	1	0.56	0.11	1.6	22.27	47.05	6.6	...	..	2	4	...	0.15	1.7	23.75	50.825	5.7	..	250	
					3	1	0.56	0.12	2.85	26.5	55.71	4.4	...	..	2	6	0.54	0.12	2.1	26.0	55.6	6.1	..	250	
					4	1	0.51	0.11	2.4	25.0	53.5	...	...	..	4	6	0.50	0.12	1.85	22.0	47.08	...	..	250	
					5	1	0.53	0.12	1.85	20.25	43.38	3.05	...	..	5	6	0.50	0.12	1.75	19.2	41.08	3.85	..	250	
					6	1	0.55	0.13	1.75	18.0	38.52	...	...	..	6	5	0.52	0.11	1.05	17.5	37.45	2.25	..	250	
					6	1	0.55	0.13	1.75	18.0	38.52	...	...	..	7	5	0.49	0.11	0.70	13.5	29.104	1.80	..	350	
					7	1	0.50	0.13	1.1	15.3	32.74	1.93	...	..	8	18	0.51	0.11	1.0	12.0	26.68	1.21	..	..
															10	68	0.55	0.11	1.1	13.0	27.82	1.0	..	..
															11	80	0.53	0.10	0.55	18.0	38.52	1.725	..	..
															32	..	0.52	0.09	1.7	12.0	25.68	0.82	..	..
															50	..	0.49	0.15	0.9	10.6	20.084	1.48	..	..
5*	P	..	....	....	1	6	0.56	0.15	1.55	19.3	41.30	12.1	...	..	4	24	0.60	0.15	1.9	30.0	64.2	4.8	..	250	Mild case
6	P	6	8.0	38.0	2	24	0.64	0.16	1.5	22.1	47.29	2.2	58	..	3	2	0.54	0.16	1.25	20.1	43.01	3.7	..	250	Severe case with death	
					3	9	0.60	0.13	1.05	20.0	42.8	1.61	49	..	4	18	0.49	0.15	1.6	19.5	41.73	2.0	55	500	Shows increased retention and decrease of CO ₂ combining power of blood plasma	
															5	48	0.71	0.15	2.10	35.2	75.32	2.75	38	500		
7	N	3	7	0.48	0.15	1.85	23.5	60.95	6.0	250	Severe case with death
					6	12	0.47	0.17	2.2	22.0	211.86	8.8	500	

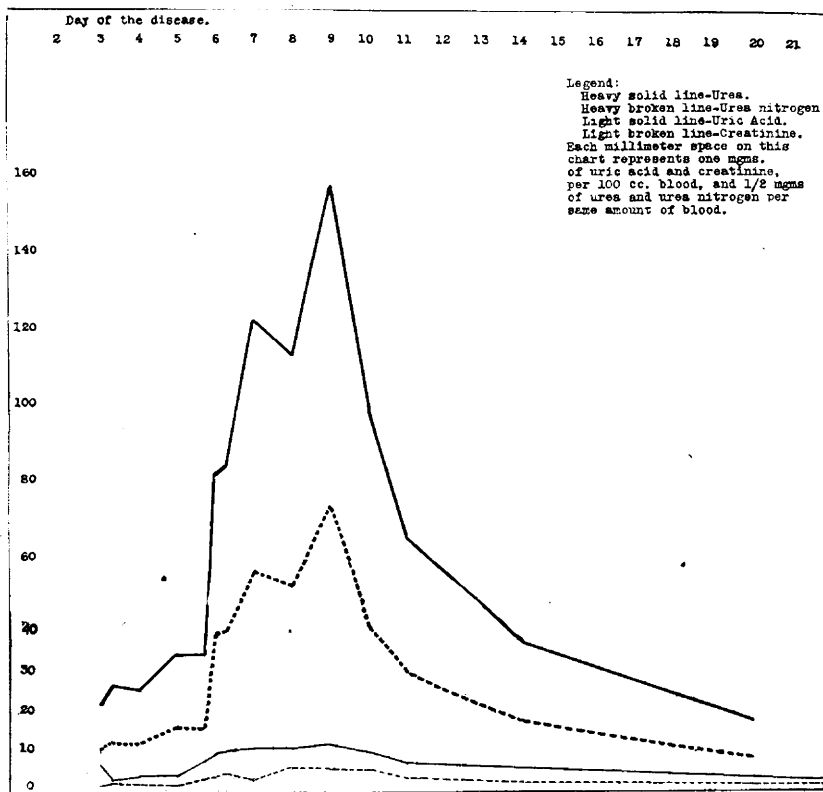
8	P	P	12	16	3.0	29.07	3	2	0.44	0.13	1.0	20.75	44.4	6.4	..	2	4	0.46	0.16	1.4	25.5	54.57	2.5	..	250	Unusually severe, with recovery			
					1.5	31.0	4	7	0.49	0.13	1.5	24.25	51.896	3.1	..	6	15	0.48	0.16	0.9	32.75	70.065	3.5	..	250	Showing high degree retention			
							6	4	0.44	0.12	0.9	32.75	70.065	3.5	..	6	18	0.51	0.14	3.1	81.0	173.34	9.2	..	250	Glucose per rectum			
															..	6	26	0.51	0.15	2.2	114.0	243.9	10.0	..	..	..	Glucose per rectum
															..	7	8	0.50	0.14	5.8	106.0	226.8	10.6	..	..	..	Glucose per rectum
															..	9	10	0.52	0.13	5.1	148.0	315.7	11.8	..	..	..	Glucose per rectum
															..	10	10	0.51	0.11	5.0	85.0	181.9	9.6	..	..	..	Glucose per rectum
															..	11	11	0.47	0.15	2.7	61.0	130.54	6.7	..	..	..	Glucose per rectum
															..	14	..	0.57	0.21	1.5	36.0	77.0	5.4	..	..	..	Glucose per rectum
															..	20	..	0.67	0.10	0.9	16.3	34.88	..	..	..	..	Glucose per rectum
															..	23	0.11	1.2	1.28	Glucose per rectum	
9	N	N	2	..	1.2	..	2	72	0.61	0.14	3.05	19.5	41.73	4.07	55	4	22	0.59	0.17	1.85	23.7	50.71	3.15	..	275	Moderately severe, with recovery			
															..	..	..	..	..	..	..	..	..	..	..	250	Showing slight reduction
10	N	N	5	1	0.54	0.09	0.55	16.75	35.84	0.66	..	6	Moderately severe, with recovery	
							6	1	0.46	0.10	1.1	15.25	32.63	1.42	..	7	24	0.49	0.10	1.1	11.5	24.6	2.2	..	250	Showing slight reduction			
11	P	N	..	..	..	..	4	1	0.53	0.11	0.9	27.75	59.285	2.5	..	4	4	0.45	0.09	0.9	27.5	58.85	2.65	..	250	Very severe, with death	
12	N	N	..	..	..	..	7	6	0.50	0.16	1.5	19.2	41.08	..	..	9	24	0.56	0.13	0.9	19.5	41.73	..	..	650	Very severe, with death	
13*	N	N	15	13	1.3	..	15	1	0.71	0.15	1.1	27.5	58.85	7.9	..	15	22	0.63	0.13	0.9	23.7	50.71	5.7	51	500	Very severe, with death			
															After Foreign Protein Injection														
1	N	N	3	1.2	..	..	..	..	..	..	..	..	..	..	..	2	24	0.80	0.11	1.35	18.2	38.94	3.92	51	..	..	Moderately severe, recovery
2	N	N	..	..	..	..	..	..	..	..	..	..	..	..	..	1	3	0.58	0.17	1.1	16.7	35.7	2.65	..	..	..	Moderately severe, recovery
3	P	N	6	8.0	2	1/2	0.04	0.16	1.5	22.1	47.29	2.2	58	Very severe, with death	
							3	7	0.60	0.13	1.05	20.0	42.80	1.61	49	Very severe, with death	
4	P	N	3	1.0	3	24	0.63	0.12	0.9	16.3	34.88	3.15	54	Very severe, with death	
5	P	N	1	1	0.60	0.16	2.10	17.2	36.8	6.1	48	..	4	0.61	0.15	2.05	16.3	34.88	5.0	Very severe, with recovery	
6	P	P	1	1/2	0.69	0.14	1.0	18.2	38.94	1.51	57	1	4	0.60	0.12	1.75	18.0	38.52	4.0	46	Very severe, with death	
							3	1/4	0.55	0.14	1.0	12.0	25.69	..	57	3	24	0.54	0.24	3.4	12.0	25.68	..	47	Very severe, with death

* Cases in which pleurisy or empyema occurred.

picture was presented with slightly less retention. Case 7, terminating fatally, also presented marked retention (Table 5).

COMMENT

The literature dealing with blood chemistry findings in pneumonia is limited, and the reports available are inconclusive as to their value in this disease. Gettler¹ explains the retention of nitrogenous products in the blood to an accompanying renal involvement, stating,



Blood Chemistry Findings in Case 8, Table 5.

"we can safely assume, therefore, that the complicating nephritis was the chief cause of the retention, and not pneumonia." Matz³ claims the retention is due to "protein injury, disintegration and autolysis accompanying excessive lung inflammation." Both writers are undoubtedly correct, but other factors may also be contributory; particularly, impairment of the circulatory function, as found in cases with extreme cyanosis and rapid pulse. Nor need the protein injury be confined to the pulmonary inflammation, for other tissues of the

3. Am. J. M. Sc., 158:723 (Nov.), 1919.

body may be subject to more than normal insult and catabolic changes, with a resulting increase in the nitrogenous waste products. The influence of diet as a factor furthering retention may be eliminated from this study, since all these patients were on liquid diet during the period of the blood examinations.

Tileston and Comfort⁴ report fourteen cases of pneumonia in which blood urea determinations were made; finding 36.0 mg. per hundred c.c. of blood as the highest retention, and 11.2 mg. as the lowest. They conclude that there is no relation between retention and prognosis. Schwartz and McGill⁵ report forty-four case determinations of blood urea in pneumonia, finding as their highest 104.4 mg., and their lowest 12.0 mg. per hundred c.c. of blood. Thirty-six of their determinations were above normal. Some of the patients were cyanotic at the time the blood was obtained. Seventeen had a definite toxic nephritis; and it was to the latter they attributed this increase. Only one of their cases having blood urea over 60.0 mg. per hundred c.c. of blood recovered. They therefore concluded that cases with marked retention offer a bad prognosis. They noted that the maximum retention occurred about the time of crisis in the lobar type of pneumonia, although in several it occurred on the first and second days of the disease. Foster⁶ states that uric acid has been consistently found increased in pneumonia, but that in his experience an increase in the nonprotein nitrogen has been exceptional and associated with marked evidence of circulatory disturbance. Gettler and St. George⁷ found little or no chlorid retention in the blood of pneumonia cases. Meyers and Lough² claim that the retention of creatinin practically only occurs in cases having an associated renal involvement, and that values of 5.0 mg. or more per hundred c.c. of blood indicate a fatal termination; and that values for urea nitrogen of 40.0 mg. or more indicate a bad prognosis.

In most of the fatal cases in this study an increase in blood uric acid was shown (Cases 4, 6 and 16, Table 4; Cases 7 and 13, Table 5; Cases 10, 19 and 20, Table 1, and two nonfatal cases, 4 and 8, Table 5). The average uric acid found in thirty-nine nonfatal cases was 3.14 mg. per hundred c.c. of blood, while in ten fatal cases the average was 4.45 mg. Four cases in this series had uric acid values over 10.0 mg. All these patients recovered. Uric acid is stated to be the first of the nitrogenous waste products retained and the most difficult to eliminate. Creatinin, on the other hand, is the most readily eliminated and the last retained (Meyers and Lough).² The serious significance of the retention of over 5.0 mg. of creatinin per

4. Arch. Int. Med., **14**: 620 (Nov.) 1914.

5. Arch. Int. Med., **17**: 42, (Jan.) 1916.

6. Arch. Int. Med., **15**: 356, (March) 1915.

7. J. A. M. A., **71**: 2053, (Dec. 21), 1918.

hundred c.c. of blood has been cited above. Case 8 (Table 5) is a case of this character. It also gave findings of 148. mg. of urea nitrogen, yet recovery occurred. Seven of the nonfatal cases, and three of the fatal cases gave findings of urea nitrogen over 40.0 mg. per hundred c.c. of blood.

The carbon dioxid combining power of the blood plasma in cases of pneumonia has not been dealt with in this paper, although a few such readings have been included in the tables. From the few cases examined in this respect, the conclusion is warranted that a lowering of the carbon dioxid combining power of the blood plasma is very apt to be found in patients seriously ill, and particularly when there is also extensive pulmonary involvement or marked circulatory disturbance.

No conclusions relative to the effect of the crisis in pneumonia on the degree of retention can be drawn from this study, since the majority of the cases terminated by lysis.

The relation of the day of the disease to the degree of retention is shown in Table 2. At no time was there found an increase in the chlorids, although the urinary chlorids were greatly diminished. Creatinin appeared to be slightly increased on the first day of the disease. This might be construed as contrary to the conclusions of Meyers and Fine that creatinin is the last of the nitrogenous products to be retained. The increase in our cases is too small to warrant definite conclusions in this regard. Urea nitrogen and urea retention were most marked on the third and fourth days of the disease. The highest average figures for uric acid occurred on the third day. The two latter findings were to be expected.

A very definite relation is evident between the severity of the disease and the degree of retention of urea nitrogen, urea, uric acid and to a lesser degree creatinin (Table 3). The occurrence of empyema and pleurisy had little or no influence on the findings in this series.

Among the students of blood chemistry there seems to be a tendency to minimize its value when applied to cases of pneumonia. Certainly as far as reported studies are concerned, such conclusions are not warranted, especially in view of the few observations on record. Before the value of the application of blood chemistry studies to pneumonia can be decided, there is need for more extensive application of its use in these cases. These studies should take into consideration such factors as diet, drug therapy, serum therapy, kidney function, extent of lung involvement, type of infection, etiologically and pathologically; the condition of the circulatory apparatus, presence of complications, and the severity of the disease. I do not care to draw more definite conclusions in this regard than have been intimated, leaving such for a more intensive study.