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ON THE ELIMINATION OF PHOSPHORIC ACID IN URINE IN FEVERISH ILLNESSES

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No 1, 1874, pages 673-688

W. Zuelzer

In the course of a study of the elimination of phosphoric acid in urine, it appeared that the next task was to consider illnesses involving fever, since the resulting change in metabolism must find expression in this important component of the urine.

Previous investigations have produced no unanimity of findings.

Vogel reports that phosphoric acid declines in the first days of acute illnesses of moderate intensity, "probably as a result of the meager diet," and then rises gradually in relation to increased feeding. It even exceeds the norm occasionally during convalescence when food consumption rises. (/Note/ Vogel and Neubauer: Anleitung zur qualitativen und quantitiven Analyse des Harns /Introduction to Qualitative and Quantitative Analysis of Urine/, 1872, page 363.)

In illnesses of short duration, even when accompanied by high fever, the diminution of phosphoric acid is sometimes insignificant and hardly noticeable. In some cases -- with more intense suffering, prolonged withholding of nourishment, or on the eve of death -- the phosphoric acid sinks significantly, though it can also exceed the norm even at the peak of acute illness. Only in individual instances did the phosphoric acid rise appreciably during the feverish stage -- up to 8.4 g in 24 hours in one case of pneumonia.

Beneke inquires, "Whence this notable difference for which there is no explanation?" (/Note/ Grundzuge der Pathologie des Stoffwechsels /Principles of the Pathology of Metabolism/, 1874, page 341.)

"In six cases of illness with fever, in which Schulte studied phosphoric acid elimination under the direction of Beneke, there was no reduction in the total phosphoric acid in the urine, but a decline in those acids that were earth-bound and thus a relative increase in those that were alkaline-bound."

"The investigations of Salkowsky also lead us to such assumptions, for he makes the interesting observation that the absolute quantity of kali in the urine is 3- 4 and even 7 times greater in time of fever than otherwise. A part of this kali is bound to the sulphuric acid of the urine, but a reduction in phosphoric acid content does not necessarily follow." (/Note/ Centralblatt fur die medizinischen Wissenschaften, No 19, 1871.)

"The phosphoric acid kali is contained largely in muscle and blood corpuscles, both of which undergo more rapid turnover during fever. The organism would have to have a particular retention capacity for phosphoric acids during fever if they were not in fact eliminated in greater quantity then."

"Such retention is possible, but more study is required to demonstrate it."

For the assessment of these relationships, the view has prevailed that the conditions regulating nitrogen substances also govern the phosphoric acids in terms of the close relationship to albuminates when these are destroyed through metabolism or elimination of end products.

From this standpoint particularly, the amounts of phosphoric acid appearing in urine were evaluated. One expected that, during increase in metabolism as it occurs in fever, the phosphates (except for certain conditions) would go into the urine as rapidly and in corresponding amounts as nitrogen substances. The many deviations observed under various conditions thus remained unexplained.

Several scholars, including E. Bischoff, have maintained that under normal conditions the elimination of phosphoric acid is parallel to that of nitrogen. (/Note/ Bischoff, "Ueber die Ausscheidung der Phosphorsaure durch den Thierkorper," Zeitschrift fur Biologie, III, page 309.) But Engelmann and others draw contrary conclusions. (/Note/ "Schwefelsaure und Phosphorsaure-Ausscheidung bei korperlicher Arbeit," Archiv fur Anatomie und Physiologie, 1871, page 14.)

Although the latter conclusion is extreme, the former has not been proved; and precisely the conditions of fever afford suitable material for testing.

Clearly fever effects an elimination of phosphates in excess of the norm. But it must be checked whether this increase corresponds to the substances containing nitrogen.

To decide this question it is necessary to investigate whether nitrogen and phosphoric acid appearing in urine maintain a stable relationship or whether they vary under different influences.

It must then be determined whether or not a corresponding amount of phosphoric acid is eliminated in a constant relationship to the fixed amount of nitrogen.

The best approach is to determine what weight of phosphoric acid is eliminated in relation to a stable quantity of nitrogen, i.e., what percentage the phosphoric acid forms in relation to nitrogen.

A few examples will illustrate this approach.

The first question is how much the quantity of phosphoric acid rises in urine shortly after the ingestion of phosphoric acid and Natr. phosphor.

Test I

A spaniel weighing 6.8 kg eliminates from morning to noon (on 12 Apr. 1875): 2.17 g N. and 0.623 g P_2O_5. At noon a dose of 1.5 g Acid. phosphor. sol. is injected subcutaneously. Within six hours thereafter the dog eliminates 2.31 g N. and 0.532 g P_2O_5, hence an increase of 0.14 g N. and 0.269 g P_2O_5.

Test II

A young man (Schunemann), convalescent, eliminated from 7-10 a.m. on 28 April 1875, 2.23 g N. and 0.186 g P_2O_5. At 10 a.m. he received 1 g Natr. phosphor. and eliminated from then to 1 p.m. 1.16 g N. and 0.38 P_2O_5, i.e., a decrease of 1.07 g N. and an increase of 0.194 P_2O_5.

These tests show that in both cases the elimination of nitrogen is changed, in one instance insignificantly, in the other appreciably. Much more significant is the change in elimination of phosphoric acid. Simple subtraction would not suffice to produce an accurate result, because the +N. in one case and the -N in the other suggest disintegration of a certain amount of albuminates not in correspondence with the time factor. Here a quantity of phosphate is freed in one case but is missing from excreta in the other, this without relation to the ingested phosphoric acid.

When we assume that in both cases, representing normal conditions, the elimination of freed phosphates maintains correspondence with that of nitrogen-carrying substances, the increased quantity of phosphoric acid can be exactly expressed in that before and after each test the acid was brought into relation with the nitrogen.

Accordingly, one must set the following relationship: for each 100 parts of nitrogen, 12.1 parts phosphoric acid is eliminated before injection, 23 parts after.

In other tests 8.3 parts phosphoric acid correspond to 100 parts nitrogen before the injection and 30.1 parts phosphoric acid after.

Calculation now shows the increase of phosphoric acid in urine after injection over normal conditions.

If the relation of phosphoric acid to nitrogen is 12.1 : 100 in normal conditions before injection in the first experiment, the quantity of elimination after injection would stand in the same relation. Hence, the nitrogen amount later eliminated being set at 100, the increase in phosphoric acid corresponding to the introduction of substances will stand in a relation of 23.0 - 12.1 : 100 or 10.9% of the nitrogen quantity.

The absolute quantity of increased phosphoric acid eliminated would thus amount to 0.251 g.

In the second test, before injection the amount of nitrogen corresponded to 8.3% of its weight in phosphoric acid, 31% after injection.

Assuming a constant amount of elimination of phosphates before and after the test, the increase in phosphoric acid would be 30.1 - 8.3 = 21.8% of the weight of simultaneously eliminated nitrogen.

Measured absolutely on the basis of the demonstrated 1.16 g nitrogen, the increase in phosphoric acid amounts to 0.25 g.

The following tests show the degree to which the relation of nitrogen to phosphoric acid is changed by consumption of much water. In both cases the elimination of urine was checked shortly before and after the ingestion of water.

Test III

A young man (Kropp), convalescent, on 20 June 1875 eliminated from 7-9 a.m. 1.19 g. N and 0.200 g = 16.8% of weight of elimination N. at 9 a.m. He drank 2 liters of water and between 9 and 12 a.m., eliminated 1.12 g N., 0.245 g P_2O_5 = 21.8%.

Test IV

A young man (Luder), convalescent, on 14 June 1875 eliminated from 7-10 a.m. 1.08 g N. and 0.150 g P_2O_5 = 13.8%. At 10 a.m. he drank 1.2 liter water. From 10 to 1 p.m. the urine contained 2.03 g N. and 0.120 g P_2O_5 = 5.9%.

This shows that directly after drinking water the increase of the two substances does not proceed equally. In one case the nitrogen increased little, in the other appreciably; whereas phosphoric acid increased moderately in the first instance but was even diminished in the second. These changes in relationship can only be expressed accurately by proportional figures. They show how much, relatively, the phosphoric acid increased in one case and decreased in the other in relation to nitrogen.

I based the calculation, illustrated by these examples, on a series of tests the results of which show how the relation between substances in the urine changes and how it is affected by external causes.

The figures obtained by this method can be described as the relative values of phosphoric acid elimination. When all figures are available, one can also derive the absolute values if necessary.

I have used the nitrogen elimination and not urine as standard for the quantity of elimination and have reduced my own older observations and those of others to this standard because I no longer use the Rautenberg method of quicksilver titration but rather Knop's azotometer as modified by Wagner.

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The following tables provide a view of the quantities of eliminated nitrogen and phosphoric acid in a series of fever illnesses.

The first seven series are my observations, two from an earlier date. The cases of Variola, typh. exanthem. and pneumonia involve no rise in intestinal secretion. For comparison a case of typh. abdomin. is added, in which incidentally no serious diarrhea occurred.

I have also included observations by Pribram, Robitschek, Riesenfeld, and Rosenstein, partly because they complete the picture and partly for comparison.

A particularly sharp therapy is not involved in the reported cases.

All cases are pure instances of the respective afflictions, free of more intensive complications.

The total quantity of the substances under consideration is given in each table for the whole period of observation, for the period of fever and disappearance of fever, and for convalescence. Periods of fever are shown by spaced type.

I. Variola pustul., second grade[1]
(Relatively light case)
Carl Dohrmann (servant, 24 years old)
Admitted 27 May 1875, released 22 June 1875
Weight on 27 May: 53.08
" " 10 June: 49.50
" " 17 June: 53.33

Day of illness	Temperature a.m.	Temperature p.m.	Nitrogen	Phosph. acid	Relative value	Total
4.	—	39,1	—	—	—	
5	38,3	38,8	19,8	2,44	12,3	
6.	37,8	39,9	15,8	2,0	12,6	35,60—4,44 = 12,4 %
7.	37,7	38,9	13,7	2,07	15,1	
8.	38,1	38,5	14,3	2,001	13,9	
9.	37,6	38,0	11,9	2,03	17,0	
10.	37,4	37,2	8,0	1,17	14,6	
11.	37,1	37,0	19,0	2,80	14,7	
12.	37,1	37,3	14,6	1,97	13,4	
13.	37,0	37,2	13,3	2,18	16,3	
14.	36,8	37,0	14,5	1,90	13,1	
15.	36,5	36,9	13,3	2,00	15,0	
16.	37,1	37,3	14,5	1,92	13,2	
17.	37,2	37,3	10,6	1,43	13,4	147,7—21,47—14,5 %
	Total		183,3	25,91	14,1	

1) Fever periods are indicated by the spaced numerals.

II. Morbilli
(Catarrh. bronch. Pharyngitis. Laryngitis)
Heinrich Rausch (worker, 25 years old)
Admitted 5 August, released 16 August 1875

Day of illness	Time	Temperature	Nitrogen	Phos. acid	Rel. value	Total
4	6–8 o'clock evening Evening	39,8				
	Morning	39,9	3,68	0,546	14,8	
5	8–10 o'clock morning	40,1	3,21	0,231	7,1	
	10–12 " "	40,6	0,50	0,033	6,6	
	12–2 o'clock afternoon	40,0	1,05	0,091	8,6	
	2–4 " "	40,4	1,18	0,088	7,4	
	4–6 " "	40,2	0,70	0,042	6,0	
	6 o'clock eve. to 8 o'clock ev	40,0				
	Morning	39,2	4,70	0,414	8,8	11,34–0,899–7,9
6	8–10 o'clock morning	39,4	1,86	0,165	8,8	
	10–12 " "	39,6	1,25	0,103	8,2	
	12–2 o'clock afternoon	39,0	0,330	0,030	8,8	
	2–4 " "	39,3	2,08	0,165	7,9	
	4–6 " "	39,5	0,72	0,046	6,3	
	6 o'clock ev. to 8 o'clock ev.	39,6				
	Morning	38,3	4,03	0,276	6,8	10,27–0,787–7,6
7	8–10 o'clock morning	38,5	0,31	0,055	17,7	
	10–12 " "	38,7	0,94	0,...	18,5	
8/9	24 hours Evening	38,0				
	Morning	37,4	13,41	2,58	19,2	
9/10	24 hours Evening	37,6				
	Morning	37,2	15,90	2,67	16,7	
10/11	-	—	—	—	—	
11/12	24 hours	—	11,2	1,72	15,3	
12/13	24 "	—	9,83	1,184	12,0	
13/14	24 "	—	5,42	0,874	16,1	
14/15	24 "	—	7,82	0,883	11,2	64,83–10,140–16,6
		Total	86,44	11,891	13,6	

III. Variola pustul., third grade
(Angina variol. Secondary pyaemia. Transitory albumineria
Difficult convalescence)
August Haschke (servant, 29 years old)
Admitted 4 October, released 13 December 1871
Weight on 4th day of illness: 56.80 kg
" " 15th " " " : 56.80 "
" " 21st " " " : 51.5 "
" " 30th " " " : 43.50 "

Day of illness	Temperature a.m.	Temperature p.m.	Nitrogen	Phosph. acid	Relative value	Total
3.	—	41,3	—	—	-	
4.	39,5	40,5	17,87	2,23	12,5	
5.	38,5	38,8	13,30	1,78	13,3	
6.	38,1	39,4	10,54	2,07	19,6	
7.	38,5	39,4	12,27	1,30	10,5	
8.	38,4	39,8	20,09	2,54	12,6	
9.	39,2	40,5	33,83	3,40	10,0	
10.	39,5	40,5	33,86	3,21	9,6	Suppuration fever
11.	38,6	40,4	32,39	2,98	9,2	
12.	38,6	39,2	32,48	3,39	10,4	
13.	37,8	39,2	22,44	3,01	13,4	228,47 – 25,91 = 11,3%
14.	37,2	39,1	15,68	3,22	20,5	
15.	38,2	38,5	21,84	3,57	16,3	
16.	37,5	39,2	24,13	3,99	16,5	61,64 10,78 = 17,4%
17.	37,4	38,3	27,30	5,41	19,8	
18.	37,2	37,7	11,06	2,16	19,5	
19.	37,9	38,5	18,76	3,56	18,9	
20.	37,9	38,6	18,29	3,77	20,6	
21.	37,0	38,3	11,52	2,55	22,1	
22.	37,6	38,7	15,26	3,24	21,2	
23.	37,6	38,6	11,85	3,68	31,0	
24.	37,8	38,2	11,20	2,52	22,5	
26.	Normal		11,57	2,70	23,3	
27.	"		11,38	2,56	25,3	
28.	"		11,90	2,53	21,6	
29.	"		18,72	3,02	22,0	
	"		11,80	2,38	21,8	184,61 40,65 = 21,9%
	Total		476,78	77,34	16,2	

IV. Typhus exanthematicus
(Moderate case, Cat. bronch.)
Hermann Krause (worker, 18 years old)
Admitted 21 February, released 15 April 1873
Weight at release: 58.56 kg

Date	Day of illness	Temperature a.m.	Temperature p.m.	Nitrogen	Phos. acid	Relative value	Total
22. Febr.	7.	39,8	40,5	—	—	—	
23. "	8.	39,5	41,0	13,11	1,25	9,5	
24. "	9.	40,0	41,2	13,16	1,14	8,6	
25. "	10.	40,0	39,9	17,03	1,83	10,7	
26. "	11.	40,0	39,5	12,08	1,35	11,1	
27. "	12.	38,3	39,2	14,14	1,62	11,4	
28. "	13.	39,0	39,0	16,89	2,49	14,7	86,41—9,68—11,2
1. Mar.	14.	37,3	38,5	19,04	3,96	20,7	
2. "	15.	37,2	37,7	—	—	—	
3. "	16.	37,2	37,4	10,36	1,78	17,1	
4. "	17.	36,8	37,1	9,59	1,61	16,9	
5. "	18.	36,5	37,0	10,96	1,55	14,2	49,98—8,90—17,8
			Total	136,39	18,58	13,6	

V. Pneumonia lob. dext. inf.
Heinrich H. (salesman, 28 years old)
Afflicted 17 June 1875, released 3 July 1875

Day of illness	Temperature a.m.	Temperature p.m.	Nitrogen	Phos. acid	Rel. value	Total
3.	39,8	40,2	14,38	1,116	7,7	
4.	39,4	39,8	15,82	1,407	8,8	
5.	39,4	39,8	20,40	2,101	10,3	
6.	39,1	39,5	21,71	3,104	14,2	72,25—7,728=10,6
7.	38,4	36,8	23,87	5,132	21,4	
12.	Free of fever		15,35	2,578	16,7	
		Total	111,47	15,438	13,8	

VI. Typhus abdominalis
Emilie Zander (servant, 20 years old)
Admitted to St. Hedwig's Hospital 28 July, released 25 August 1875

Day of illness	Temperature a.m.	Temperature p.m.	Nitrogen	Phosph. acid	Relative value
8. . . .	40	40,8	13,54	1,22	9,0
9. . . .	40,1	40,6	12.24	0,95	7,8
10. . . .	39,8	40,4	21,5	1,28	5,9
11. . . .	38.2	40	22,42	2,47	11,0
12. (partly lost)	38,2	39,4	16,0	1,54	9,6
13. . . .	39,1	39,6	14,6	1,32	9,0
14. . . .	37,6	39,6	22,25	3,22	14,5
15. . . .	37,2	39,0	17,82	2,62	14,7
16. . . .	37,6	39,2	8,23	1.25	15,1
3 days later					
20. . . .	normal		19,82	3,05	15,4
		Total	168,42	18,92	11,2

VII. Pneumonia dextr. inf. post Variol.
Hermann Stein (blacksmith's helper, 22 years old)
Admitted 10 August, released 18 August 1875

Date	Temperature a.m.	Temperature p.m.	Nitrogen	Phosph. acid	Relative value
14–15. Aug.	39.6	40,1	16,48	1,492	9,0
16. "	39.5	39,7	18,46	1,582	8,5
17. "	39,1	39,5	17,24	1,140	6,6
18. "	39,8	—	1,72	0,088	5,1
		Total	53,90	4,302	7,9

VIII. Typhus exanthematicus[1]
Anna Fransen (26 years old, 65 kg)

Day of illness	Temperature a.m.	Temperature p.m.	Nitrogen	Phos. acid	Rel. value	Total
5— 6	40,5	40,1	12,99	1,13	8,7	
6— 7	41,0	39,2	12,96	1,20	9,3	
7— 8	40,4	40	12,73	1,22	9,6	
8— 9	40,3	40,0	15,69	1,52	9,7	
9—10	40,5	40,1	16,47	1,99	12,1	
10—11	40,0	39,6	13,75	1,77	12,8	
11—12	40,1	39,2	10,76	1,17	10,8	
12—13	39,6	38,8	11,63	1,68	14,4	106,98—11,68—10,9
13—14	39,2	38,1	7,43	1,17	15,7	
14—15	37,5	36,9	6,50	0,86	13,2	
15—16	37,6	—	10,48	1,44	13,7	24,41—3,47—14,2.
Patient begins to take soup. 3 weeks later normal. in 24 hours	—	—	13,06	1,42	10,7	
		Total	144,45	16,57	11,4	

[1]Rosenstein, "Mitteilungen uber Fleckfieber," Virchow's Archiv, Vol. 43, page 406.

IX. Typhus recurrens
Schultz (clothmaker, 25 years old)[1]

Date	Temperature		Nitrogen	Phos. acid	Rel. value	Total
	a.m.	p.m.				
15. Mar.	40,3	41,7	19,69	1,64	8,3	
16. "	40,8	42,3	10.64	0,83	7,8	30,33—2,47—8,1
17. "	38,6	36,5	20,48	3,69	18,0	
18. "	36,5	36,7	22,39	0,93	4,1	
19. "	36,5	36,8	19,64	3,20	16,3	
20. "	37,2	37,2	12,32	2,73	22,1	
21. "	37,1	37,3	12,64	2,08	16,4	
22. "	36,9	37,0	15,02	2,1	13,9	
23. "	37,2	36,9	13,72	2,52	18,3	
24. "	37,2	41,3	14,70	2,38	16,1	
25. "	37,2	37,9	14,74	2,7	18,3	145,65 22,33—15,3
26. "	36,9	36,9	17,87	2,24	12,5	
27. "	37,9	41,1	14,74	0,38	2,5	32,61—2,62 8,0
28. "	41,8	35,5	19,32	4,04	20,9	
29. "	35,1	36,3	15,12	1,75	11,5	
30. "	36,5	36,8	22,39	1,18	5,2	56,83—6,97—12,2
		Total	265,42	34,39	12,9	

[1]Riesenfeld, "Harnanalysen bei Febr. recurrens," Virchow's Archiv, Vol. 47, page 136.

X. Typhus recurrens
Simon Zoch (servant, 58 years old)[1]

Day of illness	Temperature a.m.	Temperature p.m.	Nitrogen	Phos. acid	Rel. value	Total
5.	39,8	40	15,72	1,74	11,0	
6.	39,8	40,5	13,39	1,39	10,3	
7.	39,6	40,5	10,78	1,09	10,1	
8.	39,6	40	10,78	1,21	11,2	
9.	39,	39,8	22,10	2,14	9,6	72,77—7,57—10,4 %
10.	38,5	38,4	9,98	1,27	12,7	
11.	36,8	36,6	18,43	2,88	15,6	
12.	36	36	10,68	1,36	12,7	
13.	36	35,8	14,09	2,05	14,5	
14.	35,8	35,8	10,31	1,72	16,6	
15.	36,8	36	16,60	3,12	18,7	
16.	36	36,6	13,39	2,18	16,2	
17.	36	36	14,93	1,86	12,4	
18.	36,4	36,6	10,37	1,88	18,1	118,78—18,32—15,4
		Total	191,55	25,89	13,5	

[1]Pribram and Robitschek, "Studien uber Febr. recurr." 1869, page 84.

XI. Febris intermittens quartana
H. Eggens (25 years old)[1]
Weight: 56 kg

Date	Hour	Temperature	Nitrogen	Phos. acid	Rel. value	Total
24 Feb.	12 o'clock noon	41.4	1.50	0.059	3.9	
	1 o'clock afternoon	40.8	0.93	0.024	2.5	
	2 " "	40.2	1.00	0.017	1.7	
	3 " "	39.8	0.82	0.010	1.2	
	4 " "	38.8	0.58	0.025	4.3	4.83-0.135-2.7%
	5 " "	38.8	0.44	0.048	10.9	
	6 " "	38.5	1.10	0.122	11.0	
	7 " "	37.8	0.51	0.100	19.6	
	8 " "	37.2	0.54	0.117	21.6	2.59-0.387-14.9%
25 Feb.	in 24 hours	free of fever	12.68	1.322	10.4	
26 Feb.	in 24 hours	free of fever	11.84	0.914	7.7	31.76-2.696-8.4%
26 Feb.	Evening 8 o'clock to morning 8 o'clock		7.24	0.46	6.3	
27 Feb.	Day of fever					
	8-10 morning	37.8 39.2	3.38	0.147	4.3	
	11-1½ noon	40.6 40.8	3.08	0.084	2.7	
	2-4½ afternoon	40.5 38.3	3.18	0.074	2.3	9.64-0.305-3.1%
	5-7 "	38 37.2	2.86	0.216	7.5	
		Total	51.68	3.739	7.2	

[1]Rosenstein, op. cit., page 413.

To gain a basis for evaluating the data in the tables, the total amounts of nitrogen and phosphoric acid have been calculated for all observations. The totals are 1868.7 g and 252.9 g respectively. That makes 13.5 parts of phosphoric acid to 100 parts of nitrogen. This figure can not be regarded simply as a median, for the periods of fever and free of fever are unequal.

But so far as one can take them as average values, the following comparisons appear: 1. during the fever period a smaller amount of phosphoric acid is eliminated in relation to nitrogen than the average suggests, and 2. the relative amount of phosphoric acid elimination during convalescence is significantly higher. The same result appears for each table in the comparison of average figures with individual periods.

The following conclusions apply to the relation of urine ingredients to each other:

1. An irregular relationship prevails between nitrogen and phosphoric acid.

2. During fever the relative value of phosphoric acid is much less than in the following period.

3. Relative diminution of phosphoric acid during fever is not regular. It varies between 5.1 (Table IV, shortly before death) 1.2% (Table XI) of the eliminated nitrogen.

4. Relatively the greatest amount of phosphoric acid is eliminated during the decline of fever.

5. During convalescence the amount of phosphoric acid in relation to nitrogen again diminishes.

6. The cases with short fever duration (Typh. recurrens, Intermitt.) show that reduction of phosphates is not caused by reduced nourishment.

7. Except for the fever period, higher temperature suggests decrease and the postfebrile suggests increase in the relative value of phosphoric acid.

8. During fever there is a retention of phosphoric acid in the organism.

As I intend to report further investigations soon, I have the duty to thank Herr Geheimrath Prof. Reichert, in whose institute I worked, and Herr Sanitatsrath Dr. Volmer, whose material I used extensively, for their friendly assistance.