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THE EXCRETION OF URINE COMPONENTS DURING FEVER ATTACKS

Virchow's Archiv,
Vol 155, 1899, pp 1-43

W. Von Morascewski

It is one of the most well-known facts that during fever the N-excretion is increased, whereas chlorine is retained by the body. Phosphates and potassium salts are to be added to nitrogen, and sodium salts are to be added to chlorine. The most beautiful and the best studies have led to these results; for instance, the research of Traube and Jochmann (1), Redtenbacher (2), Ringer (3), Brattler (4), Haxthausen (5), Rosenstein (6) Riesenfeld (7), Unruh (8), Huppert (9), Schleich (10), E. Hallervorden (11), Salkowsky (12), Naunyn (13, 14), Zulzer (15) Rohmann (16), v. Limbeck (17), Senator (18), v. Terray (19), Liebermeister (20), Leyden (21), S. Rem Pirei and v. Calcini (22), and many others. In the oldest works by Moos, Uhle, Ranke, Wasmuth, Bartels, and in the above-mentioned works which are not complete by far, rules are formulated, in most cases, on the basis of a longer observation period, an observation running for days and not for hours (with the exception of the work by Naunyn). The experimental material which included almost all urine components provided therefore a characteristic for the stage of the fever rather than for the beginning and the end of the fever.

Only the most recent observations made in the "shortened" fever -- malaria -- provided new and surprising facts. Also the present experiment has been stimulated by the work of my colleague and friend Dr. Theodor Hitzig. The abnormal behavior of the chlorides and of phosphorus in the case of malaria which is in great contrast to the findings of the fever metabolism (v. Limbeck, Terray) drew my attention to other types of fevers and stimulated me to repeat the old observations and to carry out independent experiments. To be sure, it had also been observed by the previous workers that there is an increase in N-elimination after the fever (Naunyn) or that there is a tremendous drop in the elimination of potassium salts after the fever (Salkowsky), or that ammonia is eliminated in increased amounts during the fever and is even more strongly eliminated after the fever (Hallervorden). There was also sometimes an increase in the retention of chlorides after a fever (Ringer), as well as an increase in phosphoric acid (v. Haxthausen) in the urine.

This all was known and our work cannot contribute many new data. In our work, the types of fevers are compared with respect to the behavior of the salts prior to, during, and after the fever, the results are summarized and interpreted from that point of view which, on the basis of the previous observations, appears to be most appropriate.

The material comes from the clinic of Professor Dr. Hermann Eichhorst and I am indebted to him for his cooperation and continuous support; I am also grateful to his assistant Dr. Th. Hitzig in whose department the patients were located and whose friendly cooperation has contributed much to the completion of this work.

The chemical methods which I have used have been frequently described in my earlier papers and I can limit myself to refer to these papers (Virchow's Archiv, Vols 146, 150, et cetera, Zeitschrift für klinische Medizin, Vols 34, 35).

The determination of potassium and sodium was carried out according to Fresenius' well-known method: fussion of 50 cc urine with ammonium sulfate to transform potassium and sodium into the non-volatile sulfates, treatment of the fusion residue with barium chloride and barium hydrate to obtain sodium and potassium chlorides, removal of the excess barium with ammonium carbonate, driving off of the excess ammonium salts, and weighing of the residue as sodium chloride and potassium chloride in a platinum crucible.

Potassium was subsequently precipitated with platinum chloride from the residue, washed with alcohol and ether, dissolved in boiling water, the solution evaporated, and the residue weighed as potassium platinum chloride.

The amount of sodium was calculated from the found amount of potassium by subtracting the potassium chloride from the sum of both chlorides.

Chlorine was determined according to the Volhard method, phosphorus and calcium according to Neubauer, urea according to Mörner, uric acid according to Ludwig-Salkowsky, ammonia according to Schlösing, the alloxuric bases according to the method which I have described in Virchow's Archiv, Vol 150*.

The same holds for the diet and the determination of the nutrition value of the food. The food analyses which Th. Hitzig carried out for his work confirmed our previous studies, and they provide sufficient assurance for uniform preparation of the food, as well as for reliability of the methods.

The patients were under reliable supervision and were, if necessary, instructed by us so that the examination which has to be done with extreme

* The new work of Salkowsky in Pflüger's Archiv 1898 was not yet known.

care was simplified. For instance, the separation of the urine from the feces was always very carefully observed; also, punctual emptying of the bladder was emphasized. The temperature was measured by experienced nurses.

We observed two cases of Febris continua with a gradual increase and a gradual decrease in temperature (typhus), one case of a fever involving a crisis (pneumonia), one case of malaria fever, and one case of hectic fever. We did not study other types of fevers during acute exanthemas, articular rheumatism, et cetera because it had been determined by earlier observations that such cases give less clear-cut results and are subject to individual fluctuations.

To obtain as clear a picture as possible, we have carried out urea determinations, the determination of the total nitrogen, of uric acid, of xanthine bases, [and] of ammonia. In addition, the chlorides, phosphates, potassium, sodium, and calcium were determined.

In the pneumonia case, the urine was collected until the crisis and after the crisis; in the case of the malaric fever, five portions were collected which corresponded 1) to the cold stage, 2) to the climax of the fever, 3) to the remission, 4) to the additional drop in the fever, [and] 5) to the apyrexia. In the case of Febris hectica, four portions corresponding to the stages 1) of the beginning fever, 2) of the climax of the fever, 3) of the remission, 4) of the apyrexia were collected. In the case of typhus I, the urine was collected as daytime urine and nighttime urine during three periods: 1) the climax of the fever, 2) the paracme, [and] 3) the afebrile period. In the case of typhus II, the entire amount of 24 hours was examined, without interruption of the entire course comprising the periods 1) of the increase, 2) of the continuous fever, [and] 3) of the apyrexia. Details will be discussed in each individual case.

The compilation of the tables differed, depending on the cases. The hourly amounts were emphasized in the cases of malaria and hectic fever; on the other hand, the daily balance was less emphasized because the feces could not be considered. In the typhus and pneumonia cases, the balance was also accurately determined in addition to the hourly amounts. In cases in which the determination of the hourly amounts appeared to be without value, it has been omitted from the Tables.

The cases cited here are to be regarded as average cases of repeated observations which we have collected in the clinic and a report [on all these cases] would needlessly expand this paper

Case I. B.O., 17 years. Typhus abdominalis.

Case history: patient comes from a healthy family. He suffered from measles as a child, but claims to have been always healthy since then. Ten days ago he became sick with headaches, loss of appetite, and diarrhea.

Present state: nothing abnormal discovered at the external and internal organs. Mild roseola, spleen moderately enlarged.

The patient has been put on a diet consisting of 1,200 cc milk, 800 cc broth with egg, 500-800 cc wine.

This diet contained	10,340	gram nitrogen per day
	6,246	gram chlorine per day
	1,260	gram phosphorus per day
	1,740	gram calcium per day
	2,748	gram potassium per day
	3,562	gram sodium per day

and has been maintained during the entire experimental series.

The feces were not considered because the examination days had been picked at random from the individual periods. The fact that the feces were not analysed introduces errors pertaining only to calcium. The amount of the other components is little affected by defecation.

The urine was collected in daytime and nighttime portions for three days. The first day was during the fever period.

Temperature during 24 hours	38.6	39.5	38.1	38.5
pulsation	106	108	104	100

The patient was bathed once a day; the temperature of the water was 30°.

The second day of urine examination was in the stage of decreasing temperature.

Temperature on the day of examination	37.2	36.8	38.2	38.1
pulsation	76	80	92	88

The third day belongs to the fever-free period.

Temperature	36.4	36.6	36.[illegible]	36.5
pulsation	76	68	68	76

This examination was supposed to indicate the typhus of urine during the fever period and of the urine from the afebrile periods. The numbers found were calculated for the hourly eliminations.

The balance was made without consideration of the feces. Table I. B.O., 17 years of age. Typhus abdominalis.

Temperature	38.6	39.5	38.1	38.5	climax of the fever
Pulsation	106	108	104	100	

From 6 AM to 6 PM

Amount of urine 1,300 cc, specific weight 1015.

N	1.001 %		per 12 hours	13.013	per hour	1.084
Cl	0.212 %		" " "	2.756	" "	0.229
P	0.077 %		" " "	1.141	" "	0.095
Ca	0.0082 %		" " "	0.106	" "	0.009
K	0.159 %		" " "	2.067	" "	0.172
Na	0.149 %		" " "	1.937	" "	0.161
urea	0.840 %	calculated as N	" " "	10.920	" "	0.910
uric acid	0.014 %		" " "	0.182	" "	0.015
allox. bases	0.018 %		" " "	0.234	" "	0.019
xanthine bases	0.004 %		" " "	0.054	" "	0.064
NH_3	0.057 %		" " "	0.742	" "	0.062

From 6 PM to 6 AM

Amount of urine 590 cc, specific weight 1016

N	1.218 %		per 12 hours	7.186	per hour	0.599 g
Cl	0.206 %		" " "	1.215	" "	1.101 g
P	0.1177 %		" " "	0.694	" "	0.058 g
Ca	0.0058 %		" " "	0.034	" "	0.003 g
K	0.183 %		" " "	0.079	" "	0.090 g
Na	0.116 %		" " "	0.684	" "	0.057 g
urea	0.984 %	calculated as N	" " "	5.806	" "	0.484 g
uric acid	0.012 %		" " "	0.0708	" "	0.006 g
allox bases	0.021 %		" " "	0.177	" "	0.015 g
xanthine bases	0.009 %		" " "	0.0531	" "	0.004 g
NH_3	0.079 %		" " "	0.466	" "	0.040 g

Result

	Food	Urine	Balance
N	10.340	20.199	− 9.859 g N
Cl	6.246	3.971	+ 2.275 g Cl
P	1.260	1.835	− 0.575 g P
Ca	1.740	0.140	+ 1.600 g Ca
K	2.748	3.146	− 0.398 g K
Na	3.562	2.621	+ 0.941 g Na

16.726 urea N
0.253 uric acid N
0.411 alloxuric bases N
0.158 xanthine bases N
1.208 ammonia N

Note: When possible losses in the feces are included, the result becomes more pronounced but it remains essentially unchanged. N, also P, may be excreted in still larger amounts, calcium may be retained to a lesser extent. Chlorine, potassium, and sodium remain essentially unchanged because the amount of feces is very small.

Remission

Temperature	37.2	36.8	38.2	38.1
Pulsation	76	80	92	88

From 6 AM to 6 PM

Amount of urine 510 cc, specific weight 1013

N	0.7945	%	per 12 hours	4.052	per hour	0.338
Cl	0.2548	%	" " "	1.299	" "	0.108
P	0.0594	%	" " "	0.3029	" "	0.025
Ca	0.0055	%	" " "	0.0281	" "	0.002
K	0.1170	%	" " "	0.5967	" "	0.049
Na	0.167	%	" " "	0.8517	" "	0.071
urea	0.672	%	" " "	3.427	" "	0.289
uric acid	0.0098	%	" " "	0.0499	" "	0.004
allox. bases	0.0126	%	" " "	0.0643	" "	0.005
xanthine bases	0.0023	%	" " "	0.0144	" "	0.001
NH_3	0.0434	%	" " "	0.2213	" "	0.0188

From 6 PM to 6 AM

Amount of urine 380 cc specific weight 1020

N	1.330	%	per 12 hours	5.504	per hour	0.421
Cl	0.309	%	" " "	1.295	" "	0.108
P	0.1566	%	" " "	0.710	" "	0.060
Ca	0.0075	%	" " "	0.0285	" "	0.002
K	0.1877	%	" " "	0.713	" "	0.060
Na	0.2126	%	" " "	0.806	" "	0.065
urea	1.176	%	" " "	4.474	" "	0.373
uric acid	0.017	%	" " "	0.0646	" "	0.005
allox bases	0.0224	%	" " "	0.851	" "	0.007
xanthine bases	0.0054	%	" " "	0.0205	" "	0.002
NH_3	0.0616	%	" " "	0.2341	" "	0.020

	Food	Urine	Result
N	10.349	9.106	+ 1.234 or
Cl	6.246	2.594	+ 3.652
P	1.260	1.013	+ 0.247 or
Ca	1.740	0.056	+ 1.684
K	2.748	1.319	+ 1.429
Na	3.562	1.657	+ 1.905

urea	7.901	calculated as N
uric acid	0.1145	
alloxuric bases	0.1494	
xanthine bases	0.0349	
ammonia	0.4554	

Note: The results may be substantially changed when the losses in the feces are included. Thus, a loss in N may occur after a loss in phosphorus; calcium may be retained less. The other quantities remain the same. The behavior of potassium must be pointed out; potassium is sparingly excreted — in agreement with the observation made by Salkowsky.

Afebrile Period

Temperature	36.4	36.6	36.0	36.5
Pulsation	76	68	68	76

From 6 AM to 6 PM

Amount of urine 1,200 cc, specific weight 1013.

N	0.7945	%	per 12 hours	9.534	per hour	0.794
Cl	0.3944	%	" " "	4.733	" "	0.394
P	0.0454	%	" " "	0.545	" "	0.045
Ca	0.0090	%	" " "	0.108	" "	0.009
K	0.1990	%	" " "	2.388	" "	0.1990
Na	0.2040	%	" " "	2.448	" "	0.2040
urea	0.680	%	" " "	8.160	" "	0.680
uric acid	0.0090	%	" " "	0.108	" "	0.009
allox. bases	9.0136	%	" " "	0.163	" "	0.0136
xanthine bases	0.0046	%	" " "	0.053	" "	0.0046
NH_3	0.0420	%	" " "	0.504	" "	0.042

From 6 PM to 6 AM

N	1.255	%	per 12 hours	6.468	per hour	0.539
Cl	0.4368	%	" " "	2.445	" "	0.204
P	0.0864	%	" " "	0.484	" "	0.401
Ca	0.0664	%	" " "	0.0358	" "	0.003

K	0.297 %	per 12 hours	1.663	per hour	0.139
Na	0.209 %	" " "	1.171	" "	0.099
urea	0.966 %	" " "	5.409	" "	0.451
uric acid	0.014 %	" " "	0.0784	" "	0.006
allox. bases	0.0189 %	" " "	0.1058	" "	0.009
xanthine bases	0.0049 %	" " "	0.0274	" "	0.003
NH_3	0.0616 %	" " "	0.3449	" "	0.029

	Food	Urine	Result
N	10.340	16.002	- 5.662
Cl	6.246	7.178	- 0.932
P	1.260	1.029	+ 0.231
Ca	1.740	0.144	+ 1.596
K	2.748	4.051	- 1.305
Na	3.562	3.619	- 0.057

urea	13.569	calculated as N
uric acid	0.186	
alloxuric bases	0.269	
xanthine bases	0.083	
ammonia	0.849	

Note: The result cannot be substantially changed when the components in the feces are considered. Nitrogen would be eliminated to an increased extent, phosphorus would perhaps remain in equilibrium, calcium would be less retained. The other components were all excreted to an increased extent. Again, the behavior of K is striking because its excretion is considerably increased.

This case was supposed to provide us with information about the behavior of the salts during a fever spell. When the results of the first day (climax of the fever) are compared to those of the last day, a rather typical picture is obtained. In the former case, chloride and sodium are retained, phosphorus is lost; in the latter case, chlorine and sodium are lost, phosphorus is retained — exactly the reverse [of the former case]. The behavior of the nitrogen and the potassium salts must not lead us astray. This behavior is subject to other laws, as is known, the nature of which we have to discuss. The period of the remission exhibits a real transition between both periods when the correction for the noninclusion of the feces components is made.

As far as the nitrogen-containing components of urine are concerned, they also behaved quite typically: during the fever, there was an increased amount of uric acid, xanthine bases and alloxuric bases, in general, (as calculated sum of the xanthine bases and uric acid) an increased excretion of ammonia.

	urea/N	uric acid/N	alloxuric bases/N	NH_3/N
fever	0.83;	0.012;	0.020;	0.060
Afebrile period	0.85	0.011	0.017	0.053

Also Zülzer's ratio P/N was typical

fever P/N 0.0917   fever-free stage P/N 0.064

Finally, when the ratio of N in the other components in the food and in the urine is formed, the following results for the fever stage:

N: Cl:	P:	Ca:	K:	Na:	
1:0.62	0.12	0.17	0.27	0.35	in the food
1:0.198	0.0917	(0.007*)	0.157	0.131	in the elimination

For the remission period

N:	Cl:	P:	Ca:	K:	Na:
1:	0.286	0.111	0.006	0.146	0.182

For the afebrile period

N: Cl:	P:	Ca:	K:	Na:	
1:0.62	0.12	0.17	0.27	0.35	in the food
1:0.448	0.064	(0.009)	0.253	0.226	in the elimination

N:	urea	uric acid	alloxuric bases	NH_3
climax of the fever	0.836	0.0126	0.0205	0.0604
remission	0.868	0.0125	0.0164	0.0500
afebrile period	0.878	0.0084	0.0168	0.0530

It is seen that: 1. none of the urine components are excreted to such an extent as the nitrogen components, 2. the fever-free period is characterized by an improvement in the ratio of the chlorides to the potassium salts.

This for the typical behavior during fever. In case II which is also a typhus case, we can study the changes with respect to the increase in body temperature.

Case II ZA., 32 years. Typhus abdominalis.

Case history does not disclose anything which would be of importance. Patient comes from a healthy family; he has been completely healthy until now. The present disease started 12 days ago. Patient lost sleep and appetite, did

* Only in urine

not feel well and had himself admitted to the hospital to obtain better food.

Present status: No essential changes of the internal and external organs. Nothing can be discovered except for a distinct swelling of the spleen.

The patient received the same diet as Case I: 1,200 cc milk, 800 [cc] broth with egg, and 1/2 liter of wine. This diet was kept unchanged until the end of the experiment. As in all other cases, the amount was measured. All foodstuffs were analyzed by us.

The patient was examined by us for the components under consideration and the amount of the components per day was calculated by calculating the total amount from the percentages, and this total amount was divided by the number of days.

The urine was measured daily and examined daily. The daily loss of N, Cl, P, Ca, K, Na and NH_3 and other nitrogen compounds was determined from the urine. All other figures were calculated as Cl, Na, K, P, Ca (not as P_2O_5, NaCl, et cetera). The nitrogen compounds were all recalculated in terms of nitrogen, obtaining, thus, the amount of nitrogen excreted as NH_3, uric acid, alloxuric bases (uric acid and xanthine), and xanthine.

At the beginning of the experiment, the temperature was ascending, reached its maximum, and then dropped to normal. The effect of the increase and of the drop was thereby observed.

13 July	38.9	38.7	39.5	39.2	Temperature
	88	90	100	96	Pulsation
14 July	39.0	39.5	39.0	38.6	Temperature
	92	100	96	92	Pulsation
15 July	37.8	38.4	38.5	39.0	Temperature
	100	96	100	92	Pulsation
16 July	38.5	39.5	39.9	39.6	Temperature
	92	92	96	96	Pulsation
17 July	38.6	39.6	38.8	37.5	Temperature
	89	92	96	84	Pulsation
18 July	37.5	38.1	39.5	39.0	Temperature
	84	96	100	92	Pulsation
19 July	37.6	39.4	40.1	39.0	Temperature
	92	96	100	101	Pulsation
20 July	37.6	37.2	37.2	38.2	Temperature
	100	100	96	100	Pulsation
21 July	36.5	37.2	39.3	38.9	Temperature
	96	96	96	112	Pulsation
22 July	38.9	37.5	37.8	38.5	Temperature
	104	101	101	88	Pulsation
23 July	37.0	37.1	38.3	38.5	Temperature
	92	88	100	96	Pulsation
24 July	36.2	37.3	38.2	38.3	Temperature
	84	98	100	92	Pulsation

Table II. Typhus abdominalis

14 July temperature 39.1, amount of urine 800 cc, specific weight 1026

N	2.289 %	18.312	per day	0.5267	in the feces	10.340	in the food	-8.499
Cl	0.2427 %	1.9416	" "	0.4669	" " "	6.246	" " "	+3.837
P	0.1450 %	1.1600	" "	0.2912	" " "	1.260	" " "	-0.191
Ca	0.0175 %	0.1400	" "	0.1901	" " "	1.740	" " "	+1.310
K	0.0985 %	0.7380	" "	0.3795	" " "	2.748	" " "	+1.581
Na	0.0905 %	0.7240	" "	0.1683	" " "	3.562	" " "	+2.670
urea	1.806 %	14.4480	" "					
uric acid	0.0224 %	0.1792	" "					
alloxuric bases	0.0289 %	0.2312	" "					
xanthine bases	0.0065 %	0.0520	" "					
NH_3	0.09035%	0.7224	" "					

15 July temperature 38.4, amount of urine 820 cc, specific weight 1027

N	1.757 %	14.507	per day	0.5267	in the feces	10.340	in the food	-4.694
Cl	0.4371 %	3.496	" "	0.4669	" " "	6.246	" " "	+2.283
P	0.1250 %	1.025	" "	0.2912	" " "	1.260	" " "	-0.036
Ca	0.0222 %	0.1800	" "	0.1901	" " "	1.740	" " "	+1.369
K	0.0802 %	0.6576	" "	0.3795	" " "	2.748	" " "	+1.711
Na	0.1495 %	1.2259	" "	0.1683	" " "	3.562	" " "	+2.168
urea	1.526 %	12.5132	" "					
uric acid	0.0217 %	0.1779	" "					
alloxuric bases	0.0289 %	0.2379	" "					
xanthine bases	0.0072 %	0.0600	" "					
NH_3	0.0861 %	0.7860	" "					

16 July temperature 39.4, amount of urine 1,220 cc, spec. weight 1026

N	1.6625 %	20.2775 per day	0.5267 in the feces	10.340 in the food	-10.465
Cl	0.4368 %	5.3289 " "	0.4669 " " "	6.246 " " "	+ 0.451
P	0.0860 %	1.0492 " "	0.2912 " " "	1.260 " " "	- 0.080
Ca	0.0076 %	0.0927 " "	0.1901 " " "	1.740 " " "	+ 1.457
K	0.0832 %	0.0150 " "	0.3795 " " "	2.748 " " "	+ 1.353
Na	0.1493 %	1.8215 " "	0.1683 " " "	3.562 " " "	+ 1.572
urea	1.518 %	19.519 " "			
uric acid	0.0210 %	0.2562 " "			
alloxuric bases	0.0298 %	0.3635 " "			
xanthine bases	0.0088 %	0.1073 " "			
NH_3	0.0875 %	1.0675 " "			

17 July temperature 38.6 amount of urine 700 cc, spec. weight 1030

N	1.967 %	13.769 per day	0.5267 in the feces	10.340 in the food	-3.956
Cl	0.2123 %	1.486 " "	0.4669 " " "	6.246 " " "	+4.292
P	0.1520 %	1.064 " "	0.2912 " " "	1.260 " " "	-0.095
Ca	0.0191 %	0.1337 " "	0.1901 " " "	1.740 " " "	+1.419
K	0.1134 %	0.7938 " "	0.3795 " " "	2.748 " " "	+1.575
Na	0.0664 %	0.4648 " "	0.1683 " " "	3.562 " " "	+2.929
urea	1.736 %	12.1520 " "			
uric acid	0.02345%	0.1641 " "			
alloxuric bases	0.03174%	0.2221 " "			
xanthine bases	0.00829%	0.0580 " "			
NH_3	0.0972 %	0.6804 " "			

18 July temperature 38.5, amount of urine 800 cc, spec. weight 1026

N	2.037 %	16.296	per day	0.5267 in the feces	10.340 in the food	-6.483
Cl	0.3034 %	2.427	" "	0.4669 " " "	6.246 " " "	+3.353
P	0.1890 %	1.513	" "	0.2912 " " "	1.260 " " "	-0.544
Ca	0.0288 %	0.2300	" "	0.1901 " " "	1.740 " " "	+1.320
K	0.0893 %	0.7144	" "	0.3795 " " "	2.748 " " "	+1.654
Na	0.0785 %	0.6280	" "	0.1683 " " "	3.562 " " "	+2.766
urea	1.708 %	13.6640	" "			
uric acid	0.0297 %	0.2380	" "			
alloxuric bases	0.0389 %	0.3115	" "			
xanthine bases	0.0092 %	0.0735	" "			
NH_3	0.1127 %	0.9016	" "			

19 July temperature 39.0, amount of urine 500 cc, spec. weight 1030

N	1.9915 %	9.9575	per day	0.5267 in the feces	10.340 in the food	-0.144
Cl	0.3034 %	1.517	" "	0.4669 " " "	6.246 " " "	+4.263
P	0.1425 %	0.713	" "	0.2912 " " "	1.260 " " "	+0.257
Ca	0.01793%	0.0897	" "	0.1901 " " "	1.740 " " "	+1.461
K	0.1125 %	0.5625	" "	0.3795 " " "	2.748 " " "	+1.806
Na	0.0459 %	0.2295	" "	0.1683 " " "	3.562 " " "	+3.165
urea	1.708 %	8.5400	" "			
uric acid	0.02625%	0.1313	" "			
alloxuric bases	0.03197%	0.1598	" "			
xanthine bases	0.00572%	0.0285	" "			
NH_3	0.1519 %	0.7595	" "			

20 July temperature 37.5, amount of urine 450 cc, spec. weight 1028

N	2.597 %	11.687	per	day	0.5267	in	the	feces	10.340	in	the	food	-1.884
Cl	0.2548 %	1.147	"	"	0.4669	"	"	"	6.246	"	"	"	+4.632
P	0.1640 %	0.738	"	"	0.2912	"	"	"	1.260	"	"	"	+0.231
Ca	0.0262 %	0.1180	"	"	0.1901	"	"	"	1.740	"	"	"	+1.432
K	0.0435 %	0.1958	"	"	0.3795	"	"	"	2.748	"	"	"	+2.173
Na	0.0458 %	0.2061	"	"	0.1683	"	"	"	3.562	"	"	"	+3.188
urea	1.736 %	7.812	"	"									
uric acid	0.0290 %	0.1305	"	"									
alloxuric bases	0.0364 %	0.1639	"	"									
xanthine bases	0.0074 %	0.0334	"	"									
NH_3	0.1820 %	0.8190	"	"									

21 July temperature 38.0, amount of urine 600 cc, spec. weight 1026

N	2.072 %	12.432	per	day	0.5267	in	the	feces	10.340	in	the	food	-2.618
Cl	0.3943 %	2.365	"	"	0.4669	"	"	"	6.246	"	"	"	+3.415
F	0.1250 %	0.750	"	"	0.2912	"	"	"	1.260	"	"	"	+0.229
Ca	0.0155 %	0.093	"	"	0.1901	"	"	"	1.740	"	"	"	+1.463
K	0.0825 %	0.4950	"	"	0.3795	"	"	"	2.748	"	"	"	+1.873
Na	0.0710 %	0.4260	"	"	0.1683	"	"	"	3.562	"	"	"	+2.868
urea	1.652 %	9.912	"	"									
uric acid	0.0329 %	0.1974	"	"									
alloxuric bases	0.0409 %	0.2457	"	"									
xanthine bases	0.0080 %	0.0483	"	"									
NH_3	0.1400 %	0.8400	"	"									

22 July temperature 38.1 amount of urine 600 cc. spec weight 1027

N	1.7500 %	10.500	per day	0.5267	in the feces	10.340	in the food	-0.686
Cl	0.3701 %	2.220	" "	0.4669	" " "	6.246	" " "	+3.560
P	0.1150 %	0.690	" "	0.2912	" " "	1.260	" " "	+0.279
Ca	0.0164 %	0.0984	" "	0.1901	" " "	1.740	" " "	+1.458
K	0.0810 %	0.486	" "	0.3795	" " "	2.748	" " "	+1.883
Na	0.0923 %	0.5538	" "	0.1683	" " "	3.562	" " "	+2.840
urea	1.680 %	9.080	" "					
uric acid	0.0294 %	0.1764	" "					
alloxuric bases	0.0373 %	0.2235	" "					
xanthine bases	0.0078 %	0.0471	" "					
NH_3	0.1232 %	0.7392	" "					

When considering the second table, it is noted, above all, that the body appears to react differently toward the increase in temperature in the initial stage than in the remission stage. The increase in temperature during the first days is connected with an increased elimination of nitrogen. However, once the temperature has dropped to normal, an increase in temperature is accompanied by a decrease in N-elimination. (This rule is by no means always true and we will specially emphasize those cases in which it is true. Most observations show a parallel behavior of fever height and nitrogen loss.)

The chlorine elimination should be opposite to the nitrogen [elemination], that is, it should increase with the drop in body temperature. This is mostly so in our case; but even here an increase in temperature after the fever spell is connected with an increase in chlorine separation -- an observation which has been made by many authors (Rosenstein, Brattler), but which has not been sufficiently emphasised.

The phosphorus elimination exhibits a certain sluggishness, it lasts longer than the temperature drop and decreases only when the fever is over for a long time. When the temperature drops, the elimination of phosphorus may increase; when the temperature increases the phosphorus elimination may drop. We find such behavior in our case in addition to the above-mentioned abnormalities of the nitrogen and chlorine elimination.

The elimination of calcium salts has been little observed until now; there are no data and we must limit ourselves to the mere mentioning of this observation. In this case, the calcium elimination was opposite to the temperature. Any drop [in temperature] brought about an increase in the calcium elimination; any increase [in temperature] brought about a drop in calcium elimination. It cannot be decided whether this is specific for typhus.

According to Salkowsky, the potassium salts are eliminated to an increased extent during the fever; after the fever, they decrease considerably and disappear gradually. We can completely agree to this rule. In fact, it appears that this situation is not affected by an accidental drop or increase in temperature. To be sure, a drop in potassium salt elimination has been observed during a rapid ascent of the temperature, but this does not narrow down the validity of the rule. The parallel behavior, which some believed to have observed between P and K, does <u>not exist</u> in this case; a divergent behavior is frequently noted.

The sodium salts behave in the same way as chlorine; thus in our case they undergo the same fluctuations and abnormalities, as have been discussed in the case of the chlorine elimination.

The elimination of ammonia need not be specially discussed. According to Hallervorden (see reference cited), its elimination is supposedly increased ruing the fever. It could therefore be set equal to phosphorus and nitrogen. In our cases, the elimination of ammonia is actually parallel to that of phosphorus and exhibits the fluctuations discussed for the case of phosphorus. Therefore, a similarity between P and ammonia is more justified than one between potassium salts and phosphorus*.

The other nitrogen-containing substances exhibit a complete dependence on the total elimination of nitrogen. I refer to the statements made in connection with the nitrogen elimination and to the Table given below.

The above-discussed case does not exhibit a continuous decrease in temperature; on the contrary, two recurrences are observed; these were welcome because we did not want to study the behavior during fever, but the behavior during changes in the course of the fever.

Table III

Temp.	Cl/N	P/N	Ca/N	K/N	Na/N	urea/N	uric acid/N	allox. bases/N	NH_3/N
39.1	0.107	0.065	0.0076	0.043	0.0402	0.800	0.0099	0.0128	0.0401
38.5	0.241	0.070	0.0125	0.045	0.0845	0.862	0.0122	0.0164	0.0542
39.4	0.266	0.052	0.0046	0.051	0.0911	0.975	0.0128	0.0182	0.0533
38.6	0.108	0.077	0.0090	0.057	0.0337	0.882	0.0119	0.0161	0.0473
38.5	0.148	0.093	0.0141	0.044	0.0385	0.838	0.0146	0.0191	0.0553
39.0	0.152	0.071	0.0089	0.056	0.0229	0.855	0.0131	0.0160	0.0760
37.5	0.098	0.063	0.0101	0.0167	0.0176	0.668	0.0111	0.0140	0.0700
38.0	0.190	0.060	0.0075	0.0400	0.0343	0.800	0.0159	0.0199	0.0677
38.1	0.211	0.065	0.0093	0.046	0.0526	0.864	0.0167	0.0217	0.07[illegible]

Table III has been constructed in such a way that the ratio of the daily elimination of urine components and of the nitrogen elimination was formed. Represented in this manner, the results show even more clearly the fluctuations occurring during an increase and during a drop in body temperature. The chlorides are always increased during an increase in temperature, and they are decreased during a drop in temperature. The phosphates behave exactly in a reverse way: they are increased during a temperature drop, and they are decreased during a raise in temperature. Calcium exhibits most clearly its antagonistic behavior with respect to the course of the temperature. Potassium behaves irregularly, even when these figures are considered, and it does not agree with phosphorus in its behavior. The ammonia is to be compared more likely with chlorine, however not as strictly as sodium. The nitrogen-containing compounds behave more or less in accordance with the temperature.

* This behavior of NH_3 indicates an acid elimination which we have often emphasized and which, in most cases, takes place in the form of phosphoric acid.

Case III. M. G. 20 years of age. Feverish pneumonia.

Case history: father of the patient died supposedly of tuberculosis, the brothers and sisters are reportedly healthy. The patient himself was well until now. Three days ago he became sick with twinges in the sides and the appearance of fever chills.

Present state: nothing abnormal is detectable at the organs, except for an extended damping in the left lung. Cultivation tests confirm the diagnosis of pneumonia. The expectoration is of a rusty color and sparse. The appetite is highly reduced.

The nitrition consisted of milk and broth with egg. The amount was accurately measured.

The investigation began directly after admission to the hospital. The fever was high: 38.8 to 39.7. The urine was collected during the fever period and quantitatively analyzed for N, Cl, P, Ca. The nurse had been instructed to collect separately all urine on the day of the crisis prior to onset of sweating; therefore, the second portion of urine collected on the day of the crisis belongs to the afebrile period. On the subsequent days, the entire urine was collected and examined. After onset of the crisis, the fever rose again to a maximum, which was desirable for our studies. This day can be immediately recognized on the Table. After this rise in the fever, the temperature dropped and remained normal until the end of the experiment. The urine was quantitatively analyzed for all components during the crisis and on the four subsequent days; it was then analyzed for N, Cl, P, and Ca on two additional days.

Nitrogen, chlorine, phosphorus, calcium, potassium, and sodium were determined in the feces, their total amounts ware calculated and then distributed over the individual days

The temperature ran as follows:

28 July	38.8 to 39.7	Pulsation	100 to 96
29 July	38.5 to 39.3 to 39.0	"	112 to 100 to 104
30 July	38.1 to 39.5 to 39.7	"	96 to 100 to 99
31 July	37.8 to 39.7 to 38.8	"	96 to 108 to 96
	37.1 to 36.7	"	92 to 96
1 August	37.5 to 39.3 to 38.0	"	96 to 104 to 108
2 August	37.7 to 36.2	"	86 to 84
3 August	36	"	72
4 August	36	"	70
5 August	36	"	70

Table IV

Date	Temp. and Pulsation	Percent	Amt of Urine	Spec. Wt.	Per Day Urine in gram	Per Day Feces	Diet	Balance
28.7	38.8 39.7 100 96	N 2.275 Cl 0.0607 P 0.0500						
29.7	38.5 112 39.3 100 39.0 104	N 2.121 Cl 0.0556 P 0.0500 Ca 0.0109	1000 cc	1.025	21.210 0.556 0.500 0.109	0.1514 g N per day 0.0018 g Cl 0.08374 g P	2.028 0.533 0.403 0.544	-19.333 - 0.025 - 0.181 + 0.223
30.7	38.1 96 39.5 100 39.7 104	N 2.1665 Cl 0.0182 P 0.0810 Ca 0.0016	1000 cc	1.026	21.665 0.082 0.810 0.016		4.056 1.066 0.806 1.088	-17.760 + 0.828 - 0.088 + 0.860
31.7 after the crisis	37.8 96 39.7 108 38.8 96 6 AM to 12 PM	N 2.170 Cl 0.0123 P 0.0560 Ca 0.0018 K 0.1506 Na 0.0652 urea 1.960 uric acid 0.0249 alloxuric bases 0.0371 xanthine bases 0.0122 NH_3 0.1057	460 cc	1.025	9.982 0.0566 0.2576 0.0083 0.6927 0.3001 9.016 0.11454 0.17066 0.05612 0.4862		4.056N	-18.885

Date	Temp. and Pulsation	Percent	Amt of Urine	Spec. Wt.	Per Day Urine in gram	Per Day Feces	Diet	Balance
after the crisis	37.1 92	N 2.247	570 cc	1.026	12.8079	0.21238 g Calcium	1.066 Cl	+ 0.949
	36.7 96	Cl 0.0124			0.0689		0.806 P	- 0.248
	12 mid-night to 6 AM	P 0.1250			0.7125		0.088 Ca	+ 0.858
		Ca 0.0017			0.0097		0.920 K	- 0.872
		K 0.1930			1.1004		0.657 Na	+ 0.256
		Na 0.0178			0.1014			
		urea 2.030			11.571			
		uric acid 0.0182			0.1037			
		alloxuric bases 0.0413			0.2314			
		xanthine bases 0.0231			0.1277			
		NH_3 0.1260			0.7182			
1.Aug.	37.5 96	N 2.3520	710 cc	1.025	16.7992		4.056	-12.894
	39.3 104	Cl 0.0061			0.0433		1.066	+ 1.022
	38.0 108	P 0.0500			0.355		0.806	+ 0.367
		Ca 0.0012			0.0085		1.088	+ 0.791
		K 0.2820			2.0020		0.920	- 1.082
		N 0.0138			0.0979		0.657	+ 0.560
		uric acid 0.0217			0.1542			
		alloxuric bases 0.0434			0.3078			
		xanthine bases 0.0217			0.1541			
		NH_3 0.0721			0.5419			
2.Aug	37.7 88	N 2.352	500 cc	1.028	12.760	0.15148 g N	4.056	- 8.955
	36.2 84	Cl 0.0010			0.050		1.066	+ 1.059
		P 0.0630			0.815		0.806	- 0.093
		Ca 0.0015			0.0075		1.088	+ 0.769

Date	Temp. and Pulsation	Percent	Amt of Urine	Spec. Wt.	Per Day Urine in gram	Per Day Feces	Diet	Balance
		K 0.2518	500 cc	1.028	1.259	0.15148 g N	0.920	- 0.339
		Na 0.0376			0.188		0.657	+ 0.469
		uric acid 0.0157			0.0785			
		alloxuric bases 0.0462			0.231			
		xanthine bases 0.0305			0.1525			
		NH_3 0.112			0.560			
3 Aug	36.1 72	N 2.562	1000 cc	1.025	25.620	0.00182 g Cl	4.056	-21.715
		Cl 0.0123			0.1230		1.066	+ 0.941
		P 0.1785			0.7850		0.806	- 1.063
		Ca 0.0016			0.0160		1.088	+ 0.861
		K 0.2106			2.1060		0.920	- 1.186
		Na 0.0188			0.1880		0.657	+ 0.469
		urea 2.384			23.840			
		uric acid 0.0280			0.280			
		alloxuric bases 0.0510			0.510			
		xanthine bases 0.0238			0.238			
		NH_3 0.1071			1.071			
4 Aug	36.2 70	N 1.8865	830 cc	1.028	15.654	0.08374 g P	2.028	-13.777
		Cl 0.001			0.0083		0.533	+ 0.523
		P 0.1470			1.3201		0.403	- 1.001
		Ca 0.0086			0.0714		0.544	+ 0.261
		K 0.2256			1.867		0.460	- 1.407
		Na 0.0468			0.387		0.325	+ 0.058
		urea 1.596			13.248			
		uric acid 0.01925			0.1577			

Date	Temp. and Pulsation	Percent	Amt of Urine	Spec. Wt.	Per Day Urine in gram	Feces	Diet	Balance
4 Aug	36.2 70	alloxuric bases 0.04450	830 cc	1.028	0.3652	0.21238 g Ca		
		xanthine bases 0.02530			0.2075			
		NH_3 0.0700			0.581			
5 Aug	36.1 70	N 1.995	830 cc	1.028	16.517		2.028	-14.644
		Cl 0.0364			0.155		0.533	+ 0.376
		P 0.1885			0.560		0.403	- 1.241
		Ca 0.0220			0.1830		0.544	+ 0.314
6 Aug	36.5 70	N 1.855	840 cc	1.025	15.582			
		Cl 0.6068			5.098			
		P 0.121			1.016			
		Ca 0.00436			0.361			
7 Aug	36.2 70	N —	870 cc	1.025	—			
		Cl 0.7595			6.595			
		P 0.0965			0.839			
		Ca —			—			

Table V

Table V represents the hourly elimination during eight days.

Date	Temp.	N	Cl	P	Ca	K	Na	Urea	Uric Acid	Allox Bases	NH_3
29 Jul	38.9	0.883	0.0230	0.021	0.0040	-	-	-	-	-	-
30 Jul	39.1	0.903	0.0080	0.034	0.0007	-	-	-	-	-	-
31 Jul	38.8	0.554	0.0032	0.0143	0.0005	0.0385	0.0168	0.5009	0.0063	0.0094	0.0270
31 Jul	36.8	2.1363	0.0115	0.1887	0.0016	0.1433	0.0169	1.9285	0.0173	0.0386	0.1164
1 Aug	38.3	0.6999	0.0018	0.0148	0.0004	0.0867	0.0041	-	0.0064	0.0128	0.0243
2 Aug	36.9	0.500	0.0002	0.0340	0.0003	0.0525	0.0078	-	0.0032	0.0096	0.0266
3 Aug	36.1	1.0675	0.0051	0.0741	0.0007	0.0875	0.0078	0.9917	0.0127	0.0216	0.0441
4 Aug	36.1	0.652	0.0003	0.0550	0.0029	0.0775	0.0161	0.552	0.0066	0.0153	0.0864
5 Aug	36.1	0.690	0.0068	0.0650	0.0076	-	-	-	-	-	-
6 Aug	36.1	0.649	0.2109	0.0431	0.0150	-	-	-	-	-	-

Table VI

Table VI shows the ratio of the excreted amount with respect to the amount of nitrogen.

Date	Temp	Cl / N	P / N	Ca / N	K / N	Na / N	Urea / N	Uric Acid / N	Allox Bases / N	NH_3 / N
29 Jul	38.9	0.0260	0.024	0.0040	-	-	-	-	-	-
30 Jul	39.1	0.0090	0.038	0.0008	-	-	-	-	-	-
31 Jul	38.8	0.0060	0.026	0.0009	0.069	0.0303	0.903	0.0110	0.0168	0.049
31 Jul	36.8	0.0050	0.084	0.0007	0.067	0.0079	0.865	0.0078	0.0173	0.054
1 Aug	38.3	0.0030	0.021	0.00055	0.124	0.0058	-	0.0091	0.0183	0.0304
2 Aug	36.9	0.0003	0.064	0.00056	0.098	0.004	-	0.0060	0.0180	0.042
3 Aug	36.1	0.0049	0.069	0.0006	0.082	0.0073	0.929	0.0118	0.0201	0.041
4 Aug	36.1	0.0004	0.084	0.0044	0.118	0.024	0.800	0.0101	0.023	0.132
5 Aug	36.1	0.0098	0.094	0.0111	-	-	-	-	-	-
6 Aug	36.1	0.322	0.063	0.0240	-	-	-	-	-	-

It is seen from Table IV that the loss in nitrogen may be larger after the crisis than during the fever. When the amount eliminated in the urine prior to and after the crisis is considered, the percentage content and also the absolute amounts of those components, whose elimination is characteristic for the fever, are found to be increased. This is observed even more distinctly when the hourly amounts are compared. It is found (Table V) that nitrogen and potassium are eliminated four times as much, chlorine and calcium three times as much, ammonia five times as much, and phosphorus eight times as much as prior to the crisis. The elimination of Na is peculiar because it is practically unchanged, whereas the nitrogen-containing components behave all similar to the other ones, that is, they are increased. It should be emphasized that the xanthine bases are eliminated twice as much [as prior to the crisis], whereas the former is eliminated four times as much. The eliminated amount surpasses by far the amount observed on fever days; also the loss in nitrogen and phosphorus, calculated from the balance, is at a maximum on the day of the crisis. When the ratio of the eliminated compounds with respect to N is calculated (Table VI), P is again at the top; in fact, the other urine components behave, at times differently. For instance, chlorine, potassium, sodium, calcium, et cetera are decreased with respect to nitrogen in spite of the fact that the hourly elimination increased significantly. As is seen from Table VI, sodium, chlorine, calcium, potassium, urea, and uric acid are decreased with respect to nitrogen (sodium the most), whereas phosphorus, xanthine bases, and ammonia are increased.

So much for the characterization of the crisis. As far as the postfebrile period is concerned, each increase in body temperature is accompanied by a decrease in nitrogen and phosphorus elimination, whereas the potassium and uric acid elimination increases. Chlorine, calcium, and socium behave like nitrogen; consequently, they decrease when the body temperature increases.

The reverse takes place when the body temperature drops. The nitrogen elimination is increased and so are the phosphorus and ammonia eliminations. The greatest losses in nitrogen and phosphorus occur during this period, as is seen from the balance. Chlorine behaves irregularly; often, it increases during the afebrile days. However, subsequently it drops to such values which have never been observed at the climax of the fever. It follows from the balance that retention in the body is greatest after the remission and that it gradually decreases. The sodium and calcium balances behave in the same manner. On the other hand, the loss in phosphorus increases after remission and this P-loss increases further after the fever, until it begins to recede after three to four days. The potassium salts are lost by the body, to the slightest extent immediately after the fever, subsequently more distinctly.

Approximately the same follows from an analysis of the Table of the hourly elimination; only in this case the dependence on the course of the fever is more distinct.

It is still more distinct in Table VI, where the hourly elimination is calculated with respect to nitrogen. The behavior of phosphorus exhibits the greatest regularity, chlorine is vague and so are the potassium and sodium salts.

It cannot be denied that chlorine, calcium, and potassium behave quite differently than in the typhus cases, and this may be the reason for the large difference in the results of the fever studies.

Case IV. H.K., 19 years of age. Febris intermittens quotidiana.

Case history: patient's father died of cholera, the mother is sickly. Three brothers and sisters died when they were young. The patient comes from Hamburg, spent some time in Italy where he got sick with fever and headaches. He left Italy and went to Switzerland. During the journey by foot, he suffered from fever chills which he had not had previously during the fever attacks in Italy.

Present state: nothing detectable at the organs, except for a slight enlargement of the spleen. Hemoglobin content 60 percent, [red] blood count 4,120,000.

The diet consisted of milk and broth and consisted per day of

10.340 g N	6.246 g Cl
1.260 g P	1.740 g Ca
2.748 g K	3.562 g Na

The urine was collected in five portions. The first portion comprised the time period prior to the fever 10 AM to 2:30 PM. Temperature 36.4°C, pulsation 92. Amount of urine 125 cc.

The second portion comprised the time of the fever chills 2:30 PM to 4 PM. Temperature 41.0°C, pulsation 106. Amount of urine 235 cc.

The third portion comprised the time period of the climax of the fever 4 PM to 7 PM. Temperature 40.2°C, pulsation 96. Amount of urine 295 cc.

The fourth portion comprised the time period after the fever attack 7 PM to 6 AM. Temperature 39.9, 38.6, 37.5°C, pulsation 108, 104, 96. Amount of urine 325 cc.

The fifth and last portion comprised the period of normal temperature from 6 AM to 10 AM. Temperature 36.3°C, pulsation 80. Amount of urine 185 [cc].

The patient eliminated 1165 cc urine in which:

N	15.792	balance N	- 5.452
Cl	4.934	Cl	+ 1.312
P	0.917	P	+ 0.343
Ca	0.263	Ca	+ 1.477
K	2.665	K	+ 0.083
Na	2.739	Na	+ 0.823

The food contained the above-mentioned amounts. Thus, the balance showed, as will be found on the subsequent Table, a loss for nitrogen. All other components were retained, a correction must be made for this because the feces were not considered. This concerns mainly P, Ca, K. If one remembers the known numbers, a slight loss in P and potassium may be assumed, whereas calcium, sodium, and chlorine remain probably unchanged.

In the food the ratio to the nitrogen is as follows:

N:	Cl:	P:	Ca:	K:	Na:	
1:	0.62	0.12	0.17	0.27	0.35	in the food
1:	0.312	0.058	0.016	0.161	0.165	in the feces

Compared to nitrogen, all components are eliminated to a lesser extent.

The hourly elimination is given in Table VII.

Table VII. Malaria Fever

Time	Temp. and Pulsation	Percent	Amt of Urine	Spec. Wt.	Total Elimination	Per hour Gram	Time
I.	36.4 92	1.6205	125 cc	1.022	N 2.025	0.455	10 A1 until 2:30 PM; 4.5 hours; amount of urine per hour 27.7 cc
		0.2912			Cl 0.364	0.081	
		0.0891			P 0.111	0.025	
		0.0484			Ca 0.061	0.014	
		0.1522			K 0.190	0.042	
		0.1377			Na 0.172	0.038	
II.	41.0 106	0.7875	235 cc	1.018	N 1.8485	1.2325	2:30 PM until 4 PM; 1.5 hours; amount of urine per hour 94 cc
		0.6371			Cl 1.4969	0.9969	
		0.0162			P 0.0376	0.0251	
		0.0171			Ca 0.0399	0.0266	
		0.2390			K 0.5497	0.3665	
		0.3676			Na 0.8454	0.5636	
		0.0259			NH_3 0.0596	0.0397	
III.	40.0 92	9.183	295 cc	1.019	N 3.481	1.160	4 PM until 7 PM; 3 hours; amount of urine per hour 95 cc
		0.4854			Cl 1.416	0.472	
		0.0043			P 0.0127	0.0042	
		0.0252			Ca 0.0737	0.0246	
		0.1884			K 0.5546	0.1849	
		0.2584			Na 0.7611	0.2534	
		0.0105			uric acid 0.0309	0.0103	
		0.0109			alloxuric bases 0.0321	0.0107	
		0.0004			xanthine bases 0.0018	0.0004	
		0.0266			NH_3 0.0784	0.0261	

Time	Temp. and Pulsation	Percent	Amt of Urine	Spec. Wt.	Total Elimination		Per hour Gram	Time
IV.	39.9	1.645	325 cc	1.024	N	5.3302	0.4845	7 PM until 6 AM; 11 hours; amount of urine per hour 29.5 cc
	38.6	0.3034			Cl	0.9847	0.0895	
	37.5	0.1458			P	0.4747	0.0432	
	108	0.0142			Ca	0.0455	0.0041	
	104	0.2916			K	0.9457	0.0859	
	97	0.1798			Na	0.5854	0.0532	
		1.120			urea	3.640	0.3310	
		0.0245			uric acid	0.0796	0.0072	
		0.0249			alloxuric bases	0.0809	0.0073	
		0.0004			xanthine bases	0.0013	0.0001	
		0.0560			NH_3	0.1810	0.0165	
V.	36.3	1.687	185 cc	1.025	N	3.1080	0.7770	6 AM until 10 AM; 4 hours; amount of urine per hour 46.2 cc
	80	0.3641			Cl	0.6734	0.1683	
		0.0512			F	0.2817	0.0704	
		0.9234			Ca	0.0433	0.0108	
		0.2208			K	0.4255	0.1064	
		0.2032			Na	0.3759	0.0940	
		0.624			urea	2.997	0.7490	

Temp.	Cl/N	P/N	Ca/N	K/N	Na/N	urea/N	NH_3/N	uric acid/N	allox bases/N
36.4	0.178	0.056	0.0307	0.092	0.083	-	-	-	-
41.0	0.809	0.020	0.0215	0.297	0.457	0.996	0.032	-	-
40.0	0.407	0.003	0.0212	0.159	0.218	-	0.0224	0.009	0.009
38.6	0.184	0.089	0.0084	0.117	0.109	0.660	0.034	0.014	0.005
36.3	0.215	0.091	0.0139	0.137	0.121	-	-	-	-

The results of this study do not present much new information so that it is hardly necessary to discuss them. What has been found by Limbeck, Terray, Hitzig, and others has been confirmed [here].

The elimination of nitrogen rose and declines with the temperature -- however, only when taken absolutely. Relative to the water elimination, the nitrogen elimination was decreased during the fever, as may be seen from the percentage of nitrogen.

The chlorine elimination increased during the fever quite significantly when taken relatively, as well as when taken absolutely; it decreased immediately after the remission of the fever and increased during apyrexia.

On the other hand, the phosphorus elimination dropped during the fever and reached its maximum in the post-febrile period. The elimination of P was normal in the post-febrile period.

The elimination of potassium salts was completely analogous to that of chlorine, even if relative to the water elimination, at the onset of the fever, a drop could be observed which lasted during the fever.

Potassium salts take up a special position, as usual. Relative to the water elimination, they attain their maximum in the post-febrile period. Taken absolutely, they follow chlorine and have their minimum in the post-febrile period. The sodium salts are to be compared to chlorine in all aspects.

The elimination of nitrogen-containing substances could not be determined in all cases because of lack of material. It is therefore difficult to state anything about its course. It seems as if the elimination of uric acid and xanthine bases increased relatively with respect to water and N elimination after the fever, even if the absolute amount per hour is lower in the post-febrile period.

In comparing the hourly amount eliminated with nitrogen, the above-stated facts become even more pronounced.

The daily elimination in comparison with the food consumption exhibits the course typical during the fever; a relatively diminished chlorine, calcium, and sodium elimination, and an increased nitrogen, phosphorus, and potassium elimination.

Case V. B.K., 49 years of age. Phtisis pulmonum Febris hectic..

Case history: father, brothers, and sisters are healthy, mother suffered supposedly from cough. The (female) patient had gonitis. She got married and had two children who died both in their childhood. The present suffering started a few months ago and resulted in a general weakness.

Present state: patient exhibits in both lungs the phenomena of a decomposing infiltration; she expectorates a lot. The other organs do not exhibit any abnormalities. Patient has hectic typhus. The difference in body temperature amounts to 2.5°C.

The patient was given the same diet for several days. This diet consisted of milk and broth. The urine was analyzed on two days; no differences were observed. The daily elimination was collected in four portions of which

the first portion was collected from 12 noon to 4 PM, corresponding to the prae-febrile period. The body temperature was 37.0, pulsation 100;

the second portion was collected in the febrile period from 4 PM to 10 PM. Temperature 38.0 to 39.0;

the third period corresponds to the remission from 10 PM to 6 AM. Temperature 37.0;

the fourth and final period lasted from 6 AM to 12 noon and corresponded to the apyrexia. Temperature 36.0, pulsation 90.

Also in this case, the feces were not examined; however, this does not affect the problem under consideration. The results were:

Elimination	Food	Balance		
5.6006 N	10.340	+4.7394	gram	N
3.7664 Cl	6.246	+2.4796	-	Cl
0.2749 P	1.260	+0.9851	-	P
0.0952 Ca	1.740	+1.6448	-	Ca
1.0642 K	2.748	+1.6840	-	
1.1028 Na	3.562	+2.4592	-	Na

The ratio of N to Cl, P, Ca, K, Na in the food was:

	N:	Cl:	P:	Ca:	K:	Na:
	1:	0.62	0.12	0.17	0.27	0.35
in the elimination:	1:	0.67	0.04	0.016	0.19	0.20

The difference concerns Ca and P; both are ample in the feces. We may assume that no special retention takes place, only a general apathy, an insufficient assimilation.

Table IX

Time	Temp. and Pulsation	Amt of Urine	Spec. Wt.	Percent	Total Elimination	Per hour Gram	Water Per hour
12 noon to 4 PM; 4 hours	37° 100	400 cc	1.006	N 0.217	0.9548	0.2387	I. 110 cc
				Cl 0.1214	0.5342	0.1335	
				P 0.0235	0.1034	0.0259	
				Ca 0.0049	0.0215	0.0054	
				K 0.0401	0.1764	0.0441	
				Na 0.0515	0.2860	0.0715	
				urea 0.196	0.8624	0.2156	
				alloxuric bases 0.0075	0.0430	0.0108	
				NH_3 0.0056	0.0246	0.0061	
4 PM to 10 PM; 6 hours	38-39 106	460 cc	1.010	N 0.378	0.7388	0.2898	II. 76.6 cc
				Cl 0.315	1.4490	0.2415	
				P 0.0290	0.1335	0.0223	
				Ca 0.0068	0.0312	0.0052	
				K 0.0629	0.2893	0.0482	
				Na 0.0852	0.3919	0.0653	
				urea 0.341	0.5686	0.2614	
				uric acid 0.0077	0.0354	0.0060	
				alloxuric bases 0.0109	0.0502	0.0084	
				xanthine bases 0.0032	0.0148	0.0024	
				NH_3 0.0119	0.0510	0.0085	
10 PM to 6 AM; 8 hours	37.1 100	450 cc	1.008	N 0.392	1.764	0.2205	III. 56 cc
				Cl 0.2669	1.201	0.1501	
				P 0.0160	0.072	0.0090	
				Ca 0.0078	0.0351	0.0043	
				K 0.0829	0.3731	0.0441	
				Na 0.0590	0.2655	0.0332	
				urea 0.322	1.449	0.1811	

Time	Temp. and Pulsation	Amt of Urine	Spec. Wt.	Percent	Total Elimination	Per hour Gram	Water Per hour
6 AM to 12 noon; 6 hours	36.0	240 cc	1.011	uric acid 0.0081	0.0365	0.0046	IV. 40 cc
				alloxuric bases 0.0116	0.0522	0.0063	
				xanthine bases 0.0035	0.0158	0.0019	
				NH_3 0.0097	0.0437	0.0055	
				N 0.476	1.1424	0.1904	
				Cl 0.2427	0.5822	0.0970	
				P 0.0275	0.0660	0.0110	
				Ca 0.0031	0.0074	0.0012	
				K 0.0939	0.2254	0.0376	
				Na 0.664	0.1594	0.0266	
				NH_3 0.0084	0.0202	0.0033	
				Second Day			
12 noon to 4 PM; 4 hours	370 90	280 cc	—	N 0.385	1.0780	0.269	I. 70 cc
				Cl 0.255	0.7140	0.179	
				P 0.038	0.1064	0.0266	
				uric acid 0.0081	0.0225	0.0056	
				alloxuric bases 0.0115	0.0329	0.00[illegible]2	
				xanthine bases 0.0037	0.0104	0.0026	
				NH_3 0.0105	0.0294	0.0074	
4 PM to 10 PM; 6 hours	39°	360 cc	—	N 0.518	1.8648	0.3108	
				Cl 0.2851	1.0260	0.1710	
				P 0.035	0.1260	6.021	
				uric acid 0.0103	0.0371	0.0062	
				alloxuric bases 0.0109	0.0392	0.0065	

Time	Temp. and Pulsation	Amt of Urine	Spec. Wt.	Percent		Total Elimination	Per hour Gram	Water Per hour
				xanthine bases	0.0006	0.0022	0.0003	
				NH_3	0.0133	0.0479	0.0080	
10 PM to 6 AM 8 hours	38°	250 cc	—	N	0.5145	1.286	0.161	III. 31 cc
				Cl	0.2548	0.637	0.079	
				P	0.0320	0.080	0.010	
				uric acid	0.0116	0.0290	0.0036	
				alloxuric bases	0.0126	0.0395	0.0039	
				xanthine bases	0.0010	0.0025	0.0003	
				NH_3	0.0168	0.0420	0.0052	
6 AM to 12 noon; 6 hours	36	50 cc	—	N		-	-	IV. 9 cc
				Cl	0.2366	0.1183	0.0197	
				uric acid	0.0131	0.0065	0.0011	
				alloxuric bases	0.0205	0.0102	0.0017	
				xanthine bases	0.0073	0.0036	0.0006	

Table X

Temp.	Cl/N	P/N	Ca/N	K/N	Na/N	urea/N	uric acid/N	allox. bases/N	NH_3/N
37°a	0.557	0.109	0.022	0.180	0.299	0.903	-	0.041	0.025
b	0.667	0.100	-	-	-	-	0.021	0.030	0.027
39°a	0.833	0.077	0.014	0.164	0.285	0.902	0.021	0.029	0.029
b	0.557	0.069	-	-	-	-	0.019	0.021	0.025
38°a	0.681	0.041	0.020	0.200	0.151	0.823	0.021	0.029	0.025
b	0.494	0.062	-	-	-	-	0.022	0.024	-
36°a	0.510	0.058	0.006	0.197	0.140	-	-	-	0.030

The results of the observation of elimination during hectic fever confirm the results observed in the malaria case. Also in this case, the chlorine elimination is lower during the febrile period than during the afebrile period. The minimum is found during the apyrexia. The phosphorus elimination drops with increasing body temperature, reaches a minimum during the post-febrile period, and subsequently increases during the period of the apyrexia up to the prae-febrile period during which it reaches its maximum.

Calcium drops with the onset of the fever, decreases somewhat more, and drops to its minimum in the prae-febrile period.

Strangely enough, sodium does not behave in parallel with chlorine. It drops at the climax of the fever, subsequently it drops still more, does not reach the minimum in the post-febrile period (in agreement with chlorine), and has its maximum in the prae-febrile period. Potassium increases with the fever, drops steadily up to the apyrexia during which it reaches its minimum, whereas the maximum occurs at the climax of the fever. Urea is eliminated to the largest degree at the climax of the fever; the alloxuric bases have their minimum in the prae-febrile period, whereas their maximum occurs during the apyrexia.

Ammonia, like chlorine, is eliminated to a larger extent at the climax of the fever; subsequently it drops, reaches its minimum during the apyrexia, and ascends in the prae-febrile period.

When the elimination is compared with nitrogen, it appears to be somewhat different, but no essential differences are noticed. Thus, chlorine has its maximum at the climax of the fever, its minimum during the apyrexia; phosphorus has its maximum during the prae-febrile period, its minimum during the post-febrile period. Calcium has its minimum during the apyrexia, its maximum during the prae-febrile period. Potassium has its minimum at the climax of the fever, its maximum during the post-febrile period. Sodium reaches its minimum during the apyrexia, its maximum during the prae-febrile period. The alloxuric bases are eliminated most during the prae-febrile period, least during the apyrexia. Ammonia behaves exactly in the reverse way.

The rise in body temperature is accompanied by an increase in chlorine and ammonia, and by a decrease in all other components. The drop in body temperature is accompanied by an increase in phosphorus and nitrogen, and by a decrease in all other components. Calcium, sodium, and potassium exhibited an increase only in the second fever period.

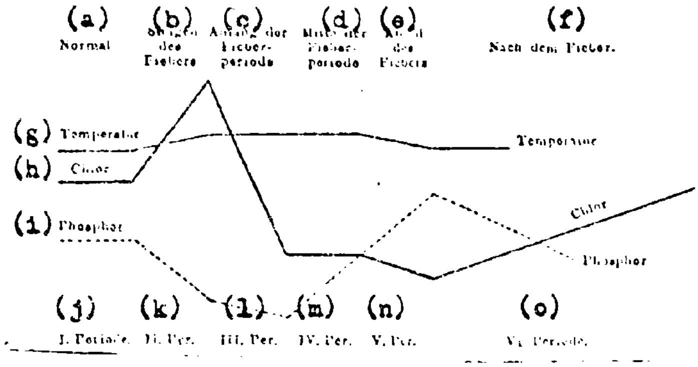
The study of the elimination in the various types of fevers has shown with certainty only one thing: elimination during remission may possess the characteristics of an elimination during a fever in a pronounced way. Elimination during rise of the fever can exhibit the same characteristics to a lesser extent.

When I am talking about elimination during the fever, I mean the known retention of chlorine and the increase in phosphorus and nitrogen. This can also occur during remission and can disappear when the fever increases.

In more detail, this means that after the drop in body temperature, chlorine is especially retained, and phosphorus and nitrogen are being especially [strongly] eliminated. If another increase in body temperature follows, chlorine is increased, although it should be retained; phosphorus is eliminated in smaller quantities instead of in increased quantities.

It appears that the body reacts differently at the onset and at the end of the fever than during the fever. In the long run, the fever causes the known changes; if, however, a temperature increase occurs also during the fever, then a situation arises which corresponds to the convalescence period (the afebrile period). If a decrease in body temperature takes place, increased fever phenomena occur. Rise and drop in body temperature shall be a measure for the fever. The question why this is justified, will not be discussed here.

Therefore, when we wish to devise a scheme according to what has been said, it will be of the following form: the first rise in temperature results in an increase in chlorine (I will omit sodium, potassium, calcium, and ammonia as not to complicate the discussion), in a decrease of nitrogen (or in an increase), and in a diminishing of phosphorus. When the fever persists unchanged, the second period exhibits a gradual decrease in chlorine elimination, an increase in nitrogen (or nitrogen stays at the previous height), a decrease in phosphorus. The third period -- still at the same temperature -- exhibits a decrease in chlorine, and an increase in phosphorus and nitrogen; to be sure, chlorine has dropped below normal, and phosphorus and nitrogen have risen above normal. At this point, we have the type of elimination which is known as fever urine. This situation may last when the body temperature remains unchanged. When the body temperature drops (perhaps due to dilution of the blood), the fourth stage sets in: chlorine is retained still more, phosphorus and nitrogen are eliminated still more strongly. When the drop in temperature lasts, chlorine attains its minimum, phosphorus and nitrogen attain their maximum, and the situation changes gradually. The fifth stage begins, the chlorine elimination rises up to normal, P and N recede to normal.



Key to Figure: a--Normal; b--rise of fever; c--onset of fever period; d--middle of fever period; e--remission; f--after the fever; g--temperature; h--chlorine; i--phosphorus; j-- I. period; k--II period; l--III period; m--IV period; n--V period; o--VI period.

This would be the situation of the fever as it occurs in malaria and as we have found it in other types of fever.

If an explanation is attempted, it must be presupposed that the blood vessels are the ones, or rather that it is the blood which undergoes the same changes as the urine. The blood contains more water and chlorine than the tissues, but it contains less phosphorus and nitrogen.

Thus, when we find the urine to be enriched in chlorine and poor in phosphorus at the onset of the fever (I period), then this implies that the flow from the tissues into the blood is interrupted; the blood supplies a small amount of water and a small amount of sodium chloride to the tissues, it takes up a small amount of phosphorus and a small amount of nitrogen. This corresponds to a circulation which makes the fiffusion flow little effective either by narrowing of the vessels or by slowing down the blood flow.

This type of circulation does not last long; it is followed by a stage of enlargement of the vessels and fast circulation. The II and III stage occur. The blood which is richer in water supplies its water and sodium chloride to the organs; it retains the externally added water and carries the nitrogen-containing substances along. The decomposition of the nitrogen-containing substances occurs within a short period of time, the phosphorus-containing substances are more stable. For this reason, the minimum of phosphorus occurs at this point and the N in the urine increases at a faster rate than the phosphorus. Thus, we are at the climax of the fever and the decomposing large albumin molecule yields increasingly more substances. The small molecule of the latter increases the osmotic pressure and water and salts* are increasingly retained. The albumin decomposition is, therefore, caused and maintained by the increase in water content of the body. When the fever starts to recede, that is, when the circulation is improved and the organs give off water, the fever phenomena are enhanced; the flow is reversed and the water with its salts is transferred from the organs into the blood instead of from the blood to the organs; the salts are poor in chlorine and rich in phosphorus. The elimination of water is increased, however the elimination of sodium chloride is not increased; phosphorus salts and nitrogen are eliminated with the water until the equilibrium is being reestablished and everything goes back to normal. If we imagine during the remission stage a sudden increase in the body temperature then the phosphorus elimination is inhibited due to the disturbance in the circulation, [and] the chlorine is increased; the reverse takes place when we think of a drop in temperature during the fever.

It is seen from the studies by Rosenthal (23), E. Aronsohn (24), Geigel (25), Maragliano (26) that a decrease in heat evolution (contraction of the vessels) takes place in acute fever cases when the body temperature increases (Rosenthal); [it is also found] that after the temperature remission and during the remission, the volume of the vessels increases (pletismograph -- experiments by Maragliano).

The increased nitrogen elimination in the stage of the latent fever period, which has been observed by Naunyn, does not contradict the above-stated facts; because firstly, we observed also an increase in N with temperature, and secondly, the experiments of Naunyn involve dogs who had been subcutaneously injected with sanies; thus, the fever started with the decomposition in the blood, as it is also the case with malaria.

Röhmann's explanation of the chlorine retention by the tissue albumin still holds. I have expressed a similar opinion when I studied the metabolism in anaemia cases; however, I believe that, even without this assumption, there are enough reasons for the chlorine retention.

Von Terray explained the increased chlorine elimination with the decomposition of the blood corpuscles. The blood corpuscles contain such a small amount of chlorine that they would all have to decompose to provide the necessary amount. When, however, a chronic decomposition of blood corpuscles takes place, the chlorine is by no means increased; on the contrary, it is decreased, as it is the case with all chronic anaemias.

There are also theories about the post-febrile nitrogen elimination. For instance, Naunyn and others believe that the increased N-elimination is due to an accumulation of nitrogen in the body. The kidneys are overloaded with decomposition products and give off the entire load at once. This opinion would be difficult to contradict, were it not for the fact that in

* Cf. E. Schulze, Zeitschrift fur physikalische Chemie Vol 23, page 18, "On the metabolism of albumens in the living plant"

the post-febrile period a decrease in chlorine elimination is observed in addition to the accumulation of nitrogen. This leads us to believe that a change in the circulation is the cause of all phenomena. After the fever, the exchange between the tissues and the blood corpuscles must become more vigorous; this way, an elimination occurs which represents a more acute picture of the fever elimination.

This post-febrile and prae-febrile change in the vessels has a special effect, particularly on soluble salts; only sodium and potassium salts -- probably the soluble chlorides -- exhibit the peculiarity of a swift rise, as well as that of a rapid drop. Calcium phosphate does not follow the fluctuations as rapidly, and its typical behavior remains: it decreases with a temperature increase and it increases with a temperature drop. Phosphorus and ammonium salts belong also to the sluggish substances. The phosphorus elimination must be preceded by a nucleic acid decomposition. For this reason, phosphorus reaches its maximum only in the second stage and lasts longer than the fever. The formation of the ammonium salts requires and "acidification"* of the fluids. Therefore, ammonia behaves similar to phosphorus.

Potassium exhibits, no doubt, the most peculiar behavior, and when we explain the increased elimination during the temperature rise with the fast diffusion, there remains no explanation whatsoever for the drop in the post-febrile period which, by the way, is not a rule, except that we would have to assume that potassium obeys here the same laws as those obeyed by sodium.

The explanation, whether elegant or not, is not the essential point of concern and it does not change anything in the observations. In the old studies of Langley and Huppert we have found figures which had been neglected or which had been considered useless by them, [and] which become even more significant in view of our explanation. We hope that we have been able to supply with our observations reliable data also for other theories.

* "Acidification", in the sense used previously, caused by a decrease in the alkalinity which decrease coincides with the increase in ammonia.

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