A Course of Lectures ON URINE, URINARY DEPOSITS, AND CALCULI.

DELIVERED AT THE PATHOLOGICAL LABORATORY,
DURING THE SESSION 1857-58.

BY

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LECTURE III.

Healthy Urine. III. INORGANIC CONSTITUENTS. *On the Salts generally; Changes effected in the Composition of the Salts by Incineration: Proportion of the Saline Matter in Urine: Phosphates; Common Phosphate of Soda; Alkaline Phosphate of Soda; Acid Phosphate of Soda; Phosphate of Soda and Ammonia; Phosphate of Magnesia; Phosphate of Ammonia and Magnesia; Phosphate of Lime; Estimation of the Alkaline and Earthy Phosphates; Quantity: Sulphates; Quantity; Estimation: Carbonates: Chloride of Sodium; Quantity; Detection; Circumstances affecting the Excretion of Chloride of Sodium: Bases in Urine: Soda and Potash: Lime: Magnesia: Iron: Silica: Alumina: Systematic Quantitative and Qualitative Examination of the Saline Matter of Healthy Urine.*

III.—INORGANIC CONSTITUENTS OF HEALTHY URINE.

[Concluded from page 503.]

Alumina. It has been stated by authorities that this substance does not pass off from the system in the urine at all; but from several observations which I made some years since, and which I have lately repeated, I have been led to conclude that it is very commonly present in the ash of urine. The alumina detected in the urine is in great part, if not entirely, derived from the alum taken in the bread. Some time since, while in the habit of eating pure home-made bread, I was unable to detect the presence of this substance in the manner presently to be described; but afterwards, when my diet consisted of baker's bread, I found very decided indications of its presence.

The test which has been employed is the ordinary blow-pipe test. A little of the fixed saline residue, which has been perfectly decarbonised, is moistened with a solution of nitrate of cobalt, and heated gradually in the blowpipe flame to a bright red heat. If alumina be present, the bead, upon cooling, is found to be of a beautiful *bright blue* colour. As is well known, there is great difficulty in separating phosphate of alumina from phosphate of lime; and the ordinary process of analysis is not sufficiently delicate to detect this substance in the small quantity in which it ordinarily occurs in the ash of urine. When the ash contains as much as one-fiftieth part, however, I have been able to detect it by the liquid tests. The blowpipe test above referred to is not without objection, inasmuch as any bead containing phosphates exhibits a blue colour when heated in the blowpipe with nitrate of cobalt. The blue colour produced is certainly very different to that developed when alumina is present. A bead consisting of phosphates of soda, lime, and magnesia, gave a very dull grayish blue colour with the cobalt; but, when the slightest trace of alumina was added, a very bright and decided colour resulted. I have applied this test, therefore, to the urine salts before and after alum was taken in the food. In the first case, the blue tint was very undecided, or not at all manifested; while in the last it was bright and distinct.

At a time when I was taking home-made bread perfectly free from alum, I examined the urine. The ash was tested for alumina with nitrate of cobalt in the usual manner, but only a faint blue colour was produced. Immediately after evacuating the bladder (12, noon), five grains of alum were taken, dissolved in an ounce and a half of distilled water. At 6 p.m., about fifteen ounces of urine were passed. A portion of this was evaporated to dryness, and the residue incinerated and decarbonised. A small quantity of the ash was treated with nitrate of cobalt, and heated in the blowpipe flame. The bead,

on cooling, was of a very bright blue colour. This experiment was repeated, with the same result. A similar reaction is met with in a great many specimens of ash obtained from the urine of hospital patients. Although this is not a perfectly accurate test, it indicates the presence of alumina in some specimens of urine in which one would expect a salt of this base to be present; while in urine which was perfectly free from alumina, no indication of its presence was afforded by the test. I think, therefore, if the cobalt test be employed carefully, it is worthy of more trust than most chemists seem disposed to place in it. A further series of researches is required to prove the proportion of alumina removed in the urine to that which escapes by the intestinal canal, when salts of this base are taken with the food. But I think there can be little doubt that a certain amount of this substance is really carried off in the urine. The urine-salts of most persons give a very decided reaction indicating the presence of this substance, a considerable quantity of which is taken with many kinds of bread. Although there are many objections to mixing alum with the bread, and the practice ought clearly to be put an end to, I am not aware that any deleterious effects have been produced by its introduction. Some have attributed habitual constipation to this cause.

It is desirable that the student should be acquainted with the principal characters of the most important inorganic salts of urine; and it has been considered desirable to give the following short course of systematic analysis. When it is required to estimate the constituents quantitatively, the volumetric process will be found the most accurate as well as the most convenient.

Systematic Qualitative or Quantitative Analysis of Healthy Urine: Inorganic Constituents.

The portion of urine B (p. 428) is also to be evaporated to dryness, and the dry residue incinerated in a large platinum capsule, and maintained at a dull red heat until it is perfectly decarbonised and nothing remains but an almost perfectly white ash. This, consisting of the fixed salts, is now to be examined as follows. Boiling distilled water is to be poured upon the saline residue, and the mixture thrown upon a filter.

The solution contains the *alkaline salts*.

The *insoluble matter*, consisting of *phosphate of lime, phosphate of magnesia, and silica*, remains behind on the filter.

1. The residue *insoluble in water* is to be treated with nitric acid, and boiled if necessary. *Silica* remains undissolved. If effervescence occur upon the addition of the acid, *carbonate of lime* was present in the ash. Filter; add excess of ammonia to the filtered solution, and redissolve the precipitated phosphates by adding excess of acetic acid. Next precipitate the lime as oxalate, by the addition of oxalate of ammonia. If the quantity of lime is required, the oxalate must be heated in a platinum capsule, and weighed as carbonate.

After the separation of the oxalate of lime by filtration, concentrate the clear solution by evaporation, and add a little ammonia and chloride of ammonium. Stir the mixture, and set it aside, that crystals of *triple or ammoniaco-magnesian phosphate* may form.

2. The *original solution*, containing the urinary salts, soluble in water, is divided into two portions, 2 a, 2 b.

2 a. The first portion is acidified with nitric acid, and treated with *nitrate of silver*. *Chloride of silver*, indicating the presence of chlorine, is precipitated. The chlorine originally existed in combination principally with sodium.

2 b. The second portion is also to be acidified with nitric acid, and an excess of solution of nitrate of barytes added; a precipitate of *sulphate of barytes*, proving the presence of sulphuric acid, occurs.

The mixture is boiled and filtered; and, upon the addition of ammonia to the solution, *phosphate of baryta*, showing the presence of phosphoric acid, is precipitated, care being taken to prevent the formation of carbonate of baryta by exposure to the air.

Next the phosphate of baryta is to be separated by filtration; and the solution, which contains nitrate of barytes, ammonia, and the fixed alkalies, is to be concentrated. Excess of carbonate of ammonia and ammonia is to be added, and the mixture thrown upon a filter. The solution is to be concentrated by evaporation, and the barytes separated by sulphuric acid, after which the solution is to be evaporated to dryness, and the residue heated to redness in a hard glass tube, in the mouth of which a fragment of carbonate of ammonia has been placed. The residue is to be treated with water, and filtered. The

solution contains the salts of the alkalies, *potash* and *soda*. The former is thrown down in the form of minute octohedral crystals of the *potassio-chloride of platinum*, upon the addition of a solution of bichloride of platinum. After stirring, these may be filtered off.

The solution contains the *sodio-chloride of platinum*. It is to be concentrated, in order that the beautiful acicular crystals of this substance may form.

Thus we have shown the presence of the following substances in the specimen of urine submitted to examination.

Fixed Salts	
Lime	
Magnesia	
Potash	
Soda	
Chlorine	
Phosphoric Acid	
Sulphuric Acid	

The constituents not included in the above list, and in that on page 429, require special processes for their demonstration; and, as many of them exist in very minute quantity, it is not desirable that the student should attempt to test for them in the small amount of urine usually operated upon. If the observer desire to carry on special researches on these constituents, I must refer him to works which treat fully upon the processes of analysis, especially to Dr. Thudichum's recent work. The substances alluded to are the following:—

Creatine.	Ammonia.
Creatinine	Hippuric Acid.
Sarkine	Iron.
Urematine.	Alumina.*
Uroxanthine.	Carbonic Acid.
Phenyllic Acid } ?	Leucine } †
Damaluric Acid }	Tyrosine }

The characters of several of these have already been discussed, and the methods for separating them from the urine described.

Average Composition of Healthy Urine, and the Quantity of the different Constituents excreted in twenty-four Hours.

It is clearly very important that we should form a general idea of the quantitative composition of healthy urine, and the amount of the various constituents which are excreted from the healthy organism in twenty-four hours. Those who are making observations on the urine in disease should be acquainted also with the relative proportion to each other of these different substances. It is true that the healthy variations are very great; but, in certain cases of disease, the difference in the quantity is so considerable that the observer cannot fail to be struck with the importance of the fact. Thus, in health, from 400 to 500 grains of urea are excreted in twenty-four hours. In certain cases of kidney-disease, when the cortical portion is impaired in structure, not more than 100 grains are eliminated; while, in some cases of fever, upwards of 1000 grains have been removed in the same time. Of the significance of such facts there can be no question; and the physician cannot fail to reflect upon the very different chemical conditions under which life is being carried on in these cases. Without considering all the circumstances likely to affect these abnormal processes, how can we hope ever to gain that insight into the nature of disease which in many instances can alone enable us to modify or counteract the morbid changes going on?

The composition of healthy urine is given in the analyses by Berzelius, Lehmann, and Dr. Miller. With a view of giving a rough idea of the general amount of the different urinary constituents excreted, and the proportion which these bear to each other, in twenty-four hours, I propose to arrange the results of numerous observations in a tabular form. The proportion of some of these substances is so variable, that it is impossible to give an average. In most cases, I have purposely given a round number, and avoided fractional parts; but in other instances, in which I have not been able to institute examinations for myself, and when the question has only been examined by one or two observers, I have given the exact figures published by the authority who has made the matter an object of special study. In constructing this table, I have not attempted to follow any single observer, but, with the exceptions alluded to, have put down num-

bers which appear to me to be tolerably correct. They have been obtained by consulting numerous authorities, and from my own analyses. This table, therefore, is only to be looked upon as a rough approximation to the truth. In the second column, the composition of 1000 grains of urine is given; in the third, the quantity of constituents in 100 grains of solid matter; and in the fourth, the percentage composition of the salts.

From what I have said before, it is obviously quite impossible to give what may be regarded as an *average* of the quantity of constituents removed in the urine in the course of twenty-four hours; since it will vary with the weight and power of the individual, the amount of exercise, quantity of food, etc. The figures in the table may be regarded as the proportion excreted by a strong healthy man in good nutrition, on full diet. Healthy women would excrete about one-third less than the quantities given in the first column.

The same exception may be taken to the numbers expressing the *relative* amount of the different ingredients. For instance, the proportion of urea to extractive matters undergoes the greatest variation. Sometimes the urea is double the weight of the extractives, while in other cases the numbers would be reversed. Many of the saline constituents also exhibit the greatest variations, not only in different individuals, but in the same person, on different days. Thus the quantity of chlorides is twice as great on some days as on others; depending, as before remarked, partly on the amount taken in the food, partly upon the quantity of fluid and other saline matters. As yet, these extraordinary fluctuations have not fully been accounted for; but, doubtless, in time the circumstances which determine them will be accurately made out.

A. An analysis of 1,000 parts of healthy urine by Berzelius;

B. One by C. G. Lehmann.

	A		B	
Water	933.00		932.019	
Solid matter	67.00	100.0	67.981	100.0
Urea	30.10	44.9	32.909	48.4
Uric acid	1.00	1.4	1.098	1.5
Lactic acid			1.513	2.3
Lactates			1.732	2.6
Water extract	17.14	25.5	.632	1.0
Spirit & alcohol extract }			10.872	16.0
Chloride of sodium	4.45	6.6		
Chloride of ammonium	1.50	2.2	3.712	5.5
Alkaline sulphates	0.87	10.2	7.321	10.8
Phosphate of soda	2.04	4.3	3.989	5.9
Biphosphate of ammonia	1.65	2.4		
Phosphates of lime and }	1.00	1.4	1.108	1.7
magnesia				
Mucus	.32	.4	.110	.3
Silica	.03	.04		

The following is an analysis of healthy urine by my friend Dr. W. A. Miller, of King's College:—

Specific gravity	1020
Water	956.80
Solid matter	43.2
Organic { Urea	14.23
29.79 { Uric acid	.37
{ Alcohol extract	12.53
{ Water extract	2.50
{ Mucus	.16
{ Chloride of sodium	7.22
{ Phosphoric acid	2.12
Fixed { Sulphuric acid	1.70
salts, { Lime	.21
13.35 { Magnesia	.12
{ Potash	1.93
{ Soda	.05

Vogel gives the following estimate of the quantity of urine and its most important constituents excreted in twenty-four hours in a state of health:—

Average quantity in twenty-four hours	52½ to 56 oz.
Average specific gravity	1.020
Average quantity of urea	556 grains.
Average quantity of chlorine	154 „
Average quantity of free acid	33 „
Average quantity of phosphoric acid	66.7 „
Average quantity of sulphuric acid	30.88 „

* Not necessarily present in healthy urine.

† In urine in certain diseases. Probably not in healthy urine.

Table showing the amount of Urinary Constituents excreted in twenty-four hours, and in 1000 parts of Healthy Urine, with the percentage composition of the Solid Matter and Fixed Salts.

	Excreted in twenty-four hours.	In one thousand parts of urine.	In one hundred grains of solid matter.	In one hundred grains of salts.
Specific gravity	1015 to 1025			
Quantity	40 oz. to 60 oz. 17500 grs. to 26250 grs.			
Water	16700—25050	968.0 — 940.0		
Solid matter	800 — 1200	32.0 — 60.0	100.0	
Organic matter	600.0—900.0	24.0 — 45.0	75.0	
Saline matter	200.0—300.0	8.0 — 15.0	25.0	100.00
Urea	400.0 — 600.0	12.0 — 30.0	45.0	
Kreatine	3.45*— 6.32*			
Kreatinine	5.50*— 10.00*			
Uric acid	5.00— 8.00	.3 — 1.0	1.5	
Hippuric acid	7.50*— 30.00+			
Extractives and colouring matter	140.0 — 200.0	9.0 — 20.0	20.0	
Free acid	20.0 — 30.0	.32— .64	1.0	
Ammoniacal salts	6.0 — 15.0	1.50— 3.00	5.0	
Mucus	10.0 — 30.0	.1 — .4	1.0	
Sulphates	50.0 — 85.0	1.5 — 6.0	8.0	30.0
Alkaline phosphates	60.0 — 100.0 or 160	2.0 — 9.0	9.0	38.0
Earthy phosphates	6.0 — 20.0	.5 — 1.2	1.5	6.0
Chlorides	100.0 — 300.0	4.0 — 8.0 or more	7.0 or more	25.0 or more
Chlorine	60.0 — 180.0	2.4 — 4.8	about { 4.2	15.1
Sulphuric acid	25.0 — 42.0	.75— 3.0	4.0	15.0
Phosphoric acid	30.0 — 50.0 or 80	1.0 — 4.5	4.5	19.0

* Thudichum.

+ Hallwachs.

This table may perhaps assist you in some measure in remembering the general composition of healthy urine, and the proportion of the different constituents eliminated from the body in twenty-four hours. It is quite impossible to use this or any other table as a standard of reference, because the proportion of the urinary constituents secreted in health is very different in different individuals. Before we can judge if a man is passing too much or too little of any substance, we must ascertain his weight, and form some general idea of the activity of his vital actions when he is in a state of health. For instance, the statement that a patient is passing daily about 150 grains of urea indicates nothing; for a small woman in good health weighing much less than 100 lbs. secretes daily even less than this; but if this amount only were excreted by a tall, strong, active, healthy man, weighing 170 lbs. or more, it would indicate a very serious condition, and we should at once know from this fact alone that he was in the greatest danger. The secreting structure of his kidneys must be temporarily or permanently affected, and, unless relief be afforded very soon, death must result from the accumulation of excrementitious substances in the blood.* Some observers calculate the quantity of solids of the urine, etc., which should be excreted for every pound of the individual's weight; but it is perhaps simpler to state the total weight of the person only, as just mentioned. If, therefore, you propose to conduct any series of researches upon the proportion of substances excreted in the urine, in health or disease, you must weigh the individual; and you must carefully ascertain the amount of ingesta; and the quantity of excrementitious substances generally, including the sweat, if possible, must be estimated. Again, you will see how very little information you can gain from learning the composition of a given quantity of urine, without knowing the proportion excreted in the twenty-four hours. There is very much to be made out by carefully conducting series of researches of this kind in the cases of patients suffering from various acute affections; and, since the introduction of the volumetric process of

* In many cases, the most valuable information bearing upon the progress of the case may be gained by the simple process of weighing the patient, which is too seldom adopted. All our hospitals and public institutions ought to be furnished with weighing machines. How often in the course of many diseases one desires to know simply if the patient has gained or lost in weight? The weighing machines which I have seen at present in use are very expensive, and not accurate. A good simple apparatus, which can be made for a moderate sum, is much required. I have just heard that Messrs. Weiss are constructing an improved apparatus suitable for the practitioner.

analysis, which I shall describe in a future lecture, we have had great facilities for conducting such inquiries.

In the next lecture I propose to commence the consideration of the second part of my subject—*morbid urine*. It is not an easy task to define in few words exactly what is comprised in the term *morbid urine*; and I shall, therefore, not offer an exact definition, but merely draw a general distinction between *healthy urine*, in which the proper amount of all the constituents, relatively and absolutely, exists, and *morbid urine*, in which there is too much or too little of one or more of the substances occurring in health, or certain constituents are present which do not exist in the healthy secretion at all.

Transactions of Branches.

CORNWALL MEDICAL SOCIETY.

PRESIDENT'S ADDRESS.

By CHARLES BARHAM, M.B., Truro.

[Delivered July 19th, 1859.]

[DR. BARHAM, for himself and other professional gentlemen of Truro, expressed a hearty welcome to their visitors from other parts of the county; and then he spoke of objects of professional and general interest in Truro, which might possibly engage the visitors' attention, if they could sufficiently prolong their stay. In the first place, he mentioned the County Infirmary, the oldest institution of the kind in Cornwall, and which, formed about the end of the last century, had gradually been extended until now it contained about sixty beds, all which were generally occupied. If any of their professional friends from other parts of the county should remain in Truro till the following (Wednesday) morning, that being the day for receiving patients, the Infirmary staff would be glad to show them what he believed they would admit was a very comfortable and well arranged hospital. There was also in the town a very good and effective Dispensary. And in the building wherein they had now assembled there was a Museum, which was perhaps unsurpassed by that of any provincial town of equal size with Truro, for the value of the collections themselves, and for their favourable arrangement either for study or for casual inspection. This institution was largely indebted