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 IV.

URINE IN DISEASE. *Arrangement of the Subject. Diathesis.*

EXCESS OR DEFICIENCY OF WATER AND THE ORGANIC CONSTITUENTS PRESENT IN HEALTH. *Excess of Water: Diabetes Insipidus; Deficiency of Water: Increased Acidity of Urine; Principles of Treatment: Nitric Acid in the Urine: Ammonia: on Detecting Urea in the Blood or Serum: on Detecting Ammonia in the Breath: Urea; Excess of Urea; Deficiency of Urea: Colouring Matter: Excess of Uric Acid and Urates: Principles of Treatment: Extractive Matters: General Remarks on the Increase of the Organic Constituents, with Analyses: Analyses of Urine in Chorea: Analyses of Urine in Skin-Disease.* EXCESS OR DEFICIENCY OF THE INORGANIC CONSTITUENTS PRESENT IN HEALTH. *Chloride of Sodium; its Diminution in Acute Inflammations: Sulphates; Increase in Cases of Chorea, Rheumatic Fever, etc.: Influence of Remedies: Alkaline Phosphates; Increased Secretion of Alkaline Phosphates in Inflammation of the Brain; Analyses; Earthy Phosphates; Increase in the Urine of Cases of Mollities Ossium; Analyses.*

EXCESS OR DEFICIENCY OF THE INORGANIC CONSTITUENTS.

[Concluded from page 942.]

Alkaline Phosphates. Much has already been said upon the quantity and origin of the alkaline phosphate in the urine; and I have brought forward evidence to show that the greater part of the phosphoric acid eliminated is carried into the organism in the food. A certain proportion, however, there can be little doubt, is formed in the body by the oxidation of the phosphorus of albuminous textures (nervous tissue). In diseases generally, the alterations which have been observed in the quantity of phosphate removed in the urine is to be attributed, to some extent, to the altered diet of the patient. It is reasonable to suppose that, in some conditions of the system in which a more than usual disintegration of tissues rich in phosphorus takes place, more phosphoric acid is formed in the organism than in health. This excess should be found in the urine in the form of alkaline phosphate, and the amount ought to correspond to the activity of the changes taking place. By ascertaining the proportion, we should be able to form an estimate of the quantity of phosphorus oxidised, and therefore of the nerve-tissue disintegrated, of which it was a component part. The really difficult part of the inquiry is to ascertain how much of the total proportion of phosphate present is derived from the food, and how much is actually formed in the organism. The sulphuric acid is almost entirely produced in the body; and there is not, therefore, the same difficulty in estimating the amount of sulphur oxidised, as there is in the case of the phosphorus.

Of late, the importance of this subject has been much increased by attempts to advance the experimental results already obtained in favour of the hypothesis, that the amount of phosphate excreted in the urine is to be regarded as an index of the activity of the nervous system. Those who labour to prove that all the changes in the body are the direct result of certain chemical decompositions, have not hesitated to bring forward these results in favour of their theory. It seems by some to have been regarded as a settled point, that the quantity of phosphate in the urine varies according to the amount of nervous tissue disintegrated; and it has been assumed that the quantity of work done by the brain is in direct proportion to the activity of the chemical changes going on in the nervous tissue. This question is obviously a most important one, and much more is involved in it than at first appears. I propose, therefore, to lay before you a few of the facts which have been ascertained; and I think we shall find

that, in this matter, speculation has taken the place of reasoning founded upon facts and experimental observations.

Dr. Bence Jones, as is well known, has written several important papers upon this subject. The general conclusions to which he has arrived are the following:—

"In delirium tremens, and in other delirium, a remarkable increase in the amount of sulphates in the urine was frequently observed; and the total phosphates were in the same cases occasionally remarkably diminished.

"In acute inflammatory diseases of the nervous structures, during the most febrile symptoms, an increase was observed in the amount of sulphates in the urine; and the total amount of earthy and alkaline phosphates in these diseases appeared to be increased in the same proportion as the sulphates were increased." (*Phil. Trans.*, 1850, p. 66.)

"In fractures of the skull, the phosphatic salts increase only when any inflammatory action occurs in the brain; and in acute phrenitis, an excessive increase takes place. In delirium tremens, there is a marked deficiency of phosphates, unless they are introduced with the ingesta; an excess is, however, met with in some functional affections of the brain."

These conclusions are founded upon analyses of 1000 grains of urine, in eleven cases of delirium tremens and eight cases of acute inflammatory affections of the nervous centres. From these I select a few of the extremes.

Delirium Tremens and other forms of Delirium.

Case.	Sulphate of baryta per 1000 grains of urine.	Specific gravity.	Total phosphates.
8. Delirium tremens—thirteenth day	13.10	1037.4	9.83
10. Poisoned by laudanum; delirium and excitement—second day	7.83	1026.8	7.53
4. Delirium tremens—tenth day	17.31	1024.74	0.87
11. Delirium with phthisis—fourth night	6.97	1024.2	0.72

Inflammatory diseases of Nervous Structures, with Head Symptoms.

2. Inflammation of the brain—twelfth day	3.96	1018.7	5.14
Ditto—thirteenth day	11.23	1027.26	11.13
6. Inflammation of lungs, with tubercles and violent head symptoms—fourth day	8.55	1027.85	7.19
Ditto—sixth day	7.81	1026.1	6.43

The quantity of urine passed by the patients in twenty-four hours is not stated, nor is the amount of solid matter in 1000 grains of urine given. It is therefore very difficult from the above data to form an estimate of the total quantity of phosphate removed from the organism in twenty-four hours. Although many of the results, as far as they go, favour the above view, and especially when the numbers are considered with reference to the amount of solid matter estimated from the specific gravity, the increase of the phosphates, in cases of inflammation of nervous structures, cannot, I think, be regarded as an established truth.

I have estimated the quantity of phosphate in urine in various cases of disease. Some time since, I examined the urine of many patients in St. Luke's Hospital, for Dr. Sutherland, with the view of ascertaining the proportion of alkaline phosphate excreted in different cases of mania, dementia, paralysis of the insane, etc. (*Med.-Chir. Trans.*, vol. xxxviii, p. 261.) Forty-two analyses were made, and the following formula was filled up in each case.

Water
Solid matter
Organic matter
Saline matter
Phosphate precipitated by chloride of calcium and ammonia

Some interesting facts were made out, and the quantity of phosphates relatively to other constituents of the ash differed much from the healthy standard. Some of the results confirmed, as far as they went, Dr. Bence Jones's conclusions; but I do not think we can form a very positive conclusion from these data, seeing that, in some of the cases, the solid matter contained 10 or 12 per cent. of mixed phosphate; while in others only 3 or 4 per cent. was found; and this variation did

not always correspond to a difference in the symptoms. I subjoin a few of the most interesting results from two of the series of cases.

Paralysis of the Insane.

21. From a man, aged 36. First attack. It lasted two months. Complete recovery.

22. From a man, aged 45. First attack, of one month's duration. Not relieved.

23. From a man, aged 42. The specimen was taken on a day when he was very violent and noisy.

24. From the same, about three weeks afterwards, when the excitement had passed off.

Analyses.

	21		22	
Reaction	Acid.		Feebly alkaline.	
Specific gravity	1030		1015	
Water	912.6		959.4	
Solid matter	87.4	100.00	40.6	100.00
Fixed salts	21.42	24.50	13.31	32.7
Phosphate of lime precipitated by chloride of calcium and ammonia	5.18	5.92	1.57	3.86

	23		24	
Reaction	Neutral.		Acid.	
Specific gravity	1008		1016	
Water	988.6		958.2	
Solid matter	11.4	100.00	41.8	100.00
Fixed salts	4.74	41.57	8.45	20.21
Phosphate of lime precipitated by chloride of calcium and ammonia	2.90	25.44	2.86	6.84

It is important to observe that, in 23 and 24, 1000 grains of urine contained almost exactly the same quantity of phosphates, but that the proportion to the other constituents was very different; the solid matter in the first case containing the very large proportion of 25.44 per cent.; in the second, only 6.84 per cent.

Acute Mania, with Paroxysms.

25. From a man, aged 18, with meningitis. The present is the first attack, and has lasted three months. He recovered.

26. From a woman, aged 55. First attack, which has lasted about three months. She recovered.

27. From a man, aged 26. First attack, which has lasted six days. There was much exhaustion and emaciation. Weighs 7 st. 12 lb. Discharged uncured.

28. From a girl, aged 18. Second attack. Weighs only 6 st. 6 lb.

Analyses.

	25		26	
Reaction	Acid.		Feebly acid.	
Specific gravity	1020		1023	
Water	945.8		943.00	
Solid matter	54.2	100.00	57.60	
Fixed salts	12.91	23.81	15.10	26.40
Phosphate of lime precipitated by chloride of calcium and ammonia	6.05	11.16	7.14	12.52

	27		28	
Reaction	Acid.		Acid.	
Specific gravity	1033		1028	
Water	908.00		931.6	
Solid matter	92.00		68.4	
Fixed salts	13.18	14.32	20.33	29.72
Phosphate of lime precipitated by chloride of calcium and ammonia	9.73	10.57	4.49	6.56

It is much to be hoped that such observations will be further carried out by those who have the opportunity. Most valuable results would certainly be obtained, if the urine could be carefully collected for the twenty-four hours.

The conclusions at which Dr. Sutherland arrives, in his paper above referred to, are the following:—

1. A plus quantity of phosphates exists in the urine in the paroxysms of acute mania.

2. A minus quantity exists in the stage of exhaustion in mania, in acute dementia, and in the third stage of paralysis of the insane.

3. The plus and minus quantities of phosphates in the urine correspond with the quantitative analysis of the brain and of the blood; for a plus quantity of phosphorus is found in the brain, and a slight excess of albumen in the blood of maniacal patients; and a minus quantity of phosphorus and albumen are found in the brains of idiots, and a minus quantity of albumen in paralysis of the insane.

4. The plus quantity of phosphates in the urine of cases of acute mania denotes the expenditure of nervous force, and is not a proof of the existence of acute inflammation in this disease.

I have selected the following analyses from my note-book:—

Chronic Inflammation of the Brain.

Analysis 29 shows the proportion of phosphates in the urine of a man, aged 34, who had been suffering from a tumour pressing on the veins of Galen, causing dropsy of the ventricles of the brain. There were many symptoms of chronic inflammation. Specific gravity 1018, acid.

30. Three weeks after the first analysis, acid, clear, pale; specific gravity 1015.

31. After another interval of three weeks, clear, natural colour; specific gravity 1016.

Analyses.

	29		30	31	
Water	962.10		1000.00	956.3	
Solid matter	37.90	100.00		43.70	100.00
Organic matter	27.09	74.12		33.72	77.17
Fixed salts	9.81	25.88		9.98	22.83
Phosphate of lime precipitated by chloride of calcium and ammonia	2.74	7.22	3.53	3.92	8.97

Urine in Epilepsy.

32. From a man suffering from epileptic fits, occurring every five or ten minutes, for seventeen hours. He breathed stertorously the whole time, and no urine could be obtained during this period. Urine was obtained on the next day (June 10th), acid, specific gravity 1024. Contained an abundant deposit of urates.

33. From the same patient, on the 12th; acid, 1024. Contains a good deal of pus.

34. From the same patient, on the 19th; alkaline, 1017.

35. From a very intemperate patient, aged 59, who had epileptic fits every few minutes for thirty hours, followed by exhaustion (twelve hours) and death. There was complete loss of consciousness.

36. From a man, aged 53, suffering from slight general paralysis, with impaired speech (slight), intellect, and memory. Duration of illness, three years. Urine pale, clear; no albumen; feebly acid; specific gravity 1009.

Analyses.

	32		33	
Water	931.2		927.2	
Solid matter	68.80	100.00	72.80	100.00
Organic matter	58.35	86.27	51.01	85.18
Fixed salts	9.45	13.73	10.79	14.82
Phosphate precipitated by chloride of calcium and ammonia	6.96	10.11	3.92	5.38

	34		35	36	
Water	958.8		1000	976.7	
Solid matter	41.20	100.00		23.30	100.00
Organic matter	34.68	84.18		17.46	75.94
Fixed salts	6.52	15.82		5.84	25.06
Phosphate precipitated by chloride of calcium and ammonia	2.15	5.21	8.86	1.79	7.68

The quantity of phosphate in the first analysis is very great, especially when the small proportion of saline matter in the urine is taken into consideration. In Analysis 32, the ash consists of as much as 73.63 per cent. of phosphate; in 33, 36.30 per cent.; and in 34, the proportion is further diminished to 32.93 per cent.

Urine in Delirium Tremens and Puerperal Mania.

37. From a man, aged 36, on the fifth day of a slight attack of delirium tremens. He had had three severe attacks previously. Clear, high coloured; specific gravity 1015. The saline matter contained much sulphate, but not a trace of chloride.

38. From a man, aged 31, with delirium tremens of a fortnight's duration. Acid; specific gravity 1020.

39. From a woman with puerperal mania. Acid; specific gravity 1012.

Analyses.				
	37	38	39	
Water	959.32	1000.00	1000.00	
Solid matter	40.68	100.00		
Organic matter				
Fixed salts	6.30	15.48		
Phosphate precipitated by chloride of calcium and ammonia	2.93	7.20	7.66	3.40

Urine in Health.

The following analyses show the varying quantity of the phosphates in the urine of a healthy man, twenty-three years of age. The large proportion of fixed salts depended upon the presence of much chloride of sodium.

40. Passed at 2½ P.M., immediately after dinner. Clear, natural colour; acid; specific gravity 1015.

41. Passed at 6 P.M. on the same day, after three hours reading. Acid; specific gravity 1011.

42. Passed at 2 P.M., immediately before dinner, on another day. Feebly acid; specific gravity 1022.

43. Passed at 6½ P.M., four hours after dinner. Acid; specific gravity 1026.

Analyses.					
	40	41	42	43	
Water	963.60	972.4	943.80	936.80	
Solid matter	36.40	100.00	56.20	63.20	100.00
Organic matter	14.75	68.00	37.80	30.38	63.84
Fixed salts	11.65	32.00	18.40	22.82	36.16
Phosphate of lime precipitated by chloride of calcium and ammonia	2.62	7.19	2.40	4.27	6.22 9.84

In the above analyses, can any relation be shown to exist between the symptoms of the patient and the proportion of phosphoric acid? In some, there is undoubtedly an indication of such a relation; but in others the proportion of phosphate is as great, although there was no evidence whatever of increased cerebral action or of inflammation. Without discussing the abstract question, I cannot think that the evidence at present obtained is sufficient to enable us to form a general conclusion. The inquiry is more difficult than it at first sight appears to be. Practically, we must determine how much phosphate is derived from the food, and how much from the oxidation of phosphorus. We have then to ascertain the proportion formed in the muscular system, as well as in the nervous structures. Dr. Hammond, who has carried on very many valuable researches upon subjects of this nature, has found that the phosphates in the urine are greatly increased after active exercise.

In any case of disease in which the excretion of an increased quantity of phosphates in the urine is suspected, we should ascertain—

1. The total quantity of phosphoric acid, in combination with alkalis, in the urine passed in the twenty-four hours.
2. The amount taken in the food within the same period of time.

To be more exact, the earthy phosphate in the urine should also be estimated, as well as that which passes off in the feces.

I have not been able to ascertain that the quantity of phosphate excreted in the urine has ever been compared with the amount taken in the food, in diseases in which we should expect an increased disintegration of nervous tissue. Until experiments have been conducted so as to furnish us with

positive data on this point, I do not think we are in a position to determine the question at issue. The results which have as yet been obtained are not sufficiently conclusive, as they fail to show even the total absolute amount of mixed phosphate eliminated from the body in twenty-four hours. One can hardly suppose that, in cases in which the greatest possible amount of disintegration of nervous tissue was occurring, a very great increase in the phosphate would be observed, considering how very much of the total quantity is derived from the food; and of the comparatively small amount formed in the organism, a considerable proportion originates in the muscular tissue. Very exact observations upon the in and out-going phosphates have therefore to be made before we can hope to have the fact established conclusively.

I have ventured to occupy much time in the discussion of this question, and have gone more into detail than perhaps its importance, in the opinion of many practical men, demands. Still, when a long train of theories is constructed, the truth of which entirely depends upon the accuracy and correct interpretation of the experimental results from which it starts, it behoves us to examine rigorously into the nature of this foundation; for until the fundamental facts have been firmly established, we cannot allow ourselves to be led by the reasoning, however logical it may be; or receive the conclusions, however closely they may follow on the premises. While, therefore, I do not deny that increased nervous action may be associated with the formation of an increased quantity of phosphoric acid, which is eliminated in the urine, I think that the facts hitherto advanced in favour of this view are by no means conclusive; and I therefore hold that we are not yet in a position to form any theory upon the nature of the changes occurring in health or disease, in cerebral action, regarded from this point of view.

Earthy Phosphates. The proportion of earthy phosphates does not seem to vary much in disease. Dr. Bence Jones has shown that, in cases in which the alkaline phosphates are increased, there is no corresponding increase in the proportion of earthy phosphates. Much of the earthy phosphate eliminated in the urine in health is doubtless derived from the food, but a certain proportion is set free in the disintegration of the tissues, especially the osseous tissues. An increase of earthy phosphate is observed in the urine in some very rare cases of disease, in which the earthy matter of the bones is absorbed (*mollities ossium*). In one acute case of this disease, Dr. Bence Jones (*Phil. Trans.*, 1848) obtained indistinct evidence of the presence of chlorine, and suggests that in future this substance should be searched for, as it may possibly be directly concerned in the removal of the earthy material from bones. This specimen of urine contained a peculiar substance of an albuminous nature. In 1000 grains, there were 1.20 gr. of earthy phosphate; and the solid matter contained 1.18 per cent. The analysis will be given in Lecture v, under *Albumen*. I have had opportunities of making analyses of the urine in two cases of *mollities ossium*. They were both well marked and fatal cases of the disease, and the specimens of urine were obtained shortly before death. The patients were quite bedridden, and the bones were so soft as to be readily indented by the finger.

44. This specimen of urine, from a woman suffering from *mollities ossium*, was sent to me by Dr. Chambers. The deposit contained oxalate of lime, with numerous stellate masses and separate crystals of triple phosphate. Reaction, acid; specific gravity, 1014.

45. From a case sent by Dr. Greenhalgh. Morning specimen.

Analyses.					
	44	45	46		
Water	971.9	965.2	960.88		
Solid matter	28.1	34.8	39.12	100.00	100.00
Urea	5.0	17.7			
Extractives	10.22	36.3			
Fixed salts	12.88	45.81	14.44	41.49	5.25 13.42
Earthy phosphs. precipitated by ammonia	1.185	4.21	.79	2.27	.4 1.02
Alkaline phosphs. precipitated by sulph. magnesia and ammonia	1.13	4.21	.86	2.47	1.3 3.32
Triple phosphs. filtered from the urine			.058	.16	

The large proportion of earthy phosphate in these analyses is a very interesting fact. In the first, the earthy actually exceeds the alkaline phosphate; and in the second, it is nearly equal to it. In healthy urine, the alkaline phosphate usually amounts to from ten to fifteen times as much as the earthy phosphate. The inorganic salts generally, are in considerable excess.

Excess of Earthy Phosphate, which has been shown so rarely to exist, must be carefully distinguished from the mere deposit of a certain amount in an insoluble form. The earthy phosphates very often form an insoluble deposit in urine. The characters of these salts will be described under *Urinary Deposits*. It is hardly necessary to observe, that the deposit does not depend necessarily upon the excretion of an excessive quantity, but is often due to a change having occurred in some of the constituents which normally hold these salts in solution. A small quantity of deposit of earthy phosphates makes a great show in urine; and it is obvious that a very large proportion might be held in solution in the urine, and thus escape detection, unless an analysis were made. In the case just cited, the greater part of the earthy phosphate was in solution in the urine. It is common enough to find the deposit in cases of dyspepsia and overwork, and it is often spoken of as indicating the destruction of nervous matter. In these conditions, the urine often becomes neutral or slightly alkaline, and this causes the precipitation of the phosphate. As before remarked, the quantity of the earthy phosphates is not perceptibly affected by those circumstances which influence the quantity of the alkaline phosphate; and, although an excess of earthy phosphate is of considerable importance, its existence depends upon morbid actions of a different nature. A diet composed of much sugar diminished the earthy phosphate in the urine (Böcker).

Of the principal Points to be ascertained from a Quantitative Analysis of Urine in Disease.

In clinical investigation, the principal points which it is important to ascertain with regard to the characters of the urine are the following:—

Quantity passed in twenty-four hours.

Specific gravity of specimens passed in the morning and evening.

Reaction of specimens in the morning, and about three hours after meals.

Colour; smell; consistence.

Presence or absence of a deposit. If present, its microscopical characters. (Lectures VIII, IX, X.)

Presence of any of the substances to be described in Lecture V—albumen, colouring matter of bile, sugar, etc.

Estimation of the quantity of constituents in 1000 grains of the mixed urine of twenty-four hours. From these data, the quantities passed in twenty-four hours are to be calculated.

In 1000 grs. In 24 hrs.

Water	—	—
Solid matter	—	—
Organic matter	—	—
Saline matter	—	—
Urea	—	—
Uric acid	—	—
Free acid	—	—
Extractives, etc.	—	—
Alkaline phosphates, or phosphoric acid	—	—
Earthy phosphates	—	—
Sulphates, or sulphuric acid	—	—
Chloride of sodium, or chlorine	—	—

In particular diseases, it is very desirable to ascertain the quantity of one or two constituents removed in the twenty-four hours; and very much valuable information with regard to the nature of many diseases might be obtained by a number of careful and exact analyses of this kind. It is not necessary to fill up the above scheme in every case. In some, it would be desirable to know the amount of urea and uric acid with precision; in others, the amount of urea and sulphates. In diseases of the nervous system, the exact amount of alkaline phosphates passed in the twenty-four hours should be noted, etc. Before the investigation is commenced, the observer should determine exactly the points he wishes to ascertain, construct a table, and fill up the several columns daily from his analysis-book. Every analysis should be made in precisely the same manner, and careful notes of the case should be recorded daily. If possible, analyses of the urine should be made after the patient is restored to health; so that the quantities of the various constituents eliminated from the body in a

state of health and disease may be accurately compared, and the patient should be weighed at intervals while under observation.

LETTERS AND COMMUNICATIONS.

Letters or communications for the JOURNAL should be addressed to Dr. WYNTER, Coleherne Court, Old Brompton, S.W.

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British Medical Journal.

SATURDAY, NOVEMBER 26TH, 1859.

THE PUBLIC HEALTH.

THERE is something grand, almost epic, in the employment of the Registrar-General of deaths. Throughout the year, he has ever open before him the great book of death, which at stated times he casts up, and tells the nation what progress the great reaper has made among us. Unperplexed with the conflicting reports which paralyse the judgments of those who watch the fatal shears of Atropos from lower heights, he is enabled at every quarterly period to show where the hand of the destroyer has lain heavy upon city or county, where he has passed lightly by, and where the science and attention of man have loosened his hold over all but those who legitimately succumb to his final power. Without such an officer, we should never know how we were fighting the great fight with disease. Public Rumour, with her hundred tongues, would exaggerate our epidemics as she did in the olden time; and the minor causes of death would be passed by, which strike so many, but which leave such slight traces upon the public mind.

Pondering over the great volume of the mortality, the Registrar-General puts his finger on one corner of the map, and shows that, in Bradford, man, using his reason and his philanthropy, has within the last few years driven away the too frequent visits of the destroyer. During the ten years 1841-50, death struck down no less than twenty-six in the thousand. Then man came to the rescue of his fellow; a limit was put to the long hours of toil; some of the processes which tended to enervate the inhabitants were replaced by machine-work which cannot feel; the water and the sewerage were attended to; and, to use the poetical words of the Registrar-General, "through the incessant noises of machinery are often heard, as the day declines, pleasant voices singing the concerted songs of the Bradford minstrels." These influences, moral and physical, now tell their tale in the great book of life and death he reads out to the nation; and, instead of a mortality of twenty-six in the thousand, we are informed that, for the last three years, the death-rate in the town has been only twenty-one in the thousand. Here we see the King of Terrors almost as visibly driven away by the hand of man, as in some of those quaint old woodcuts of Albert Durer.

By the aid of the unerring tests furnished by the mortuary pages, the Registrar-General tells us of changes and fluctuations of the death-rate which even more astonish us. This year the grim visitant has left many of his