Thesis

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Observations

on the

Phosphatic Diathesis

The Practitioner who makes a regular habit of examining the urine of his patients must be very familiar with what is usually and briefly styled 'Phosphates'. The deposit of 'Phosphates' is by no means infrequent.

All urines contain Phosphoric acid (H_3PO_4), not existing as such, but in combination with the alkalies Sodium and Ammonia; and with the alkaline Earths, Calcium and Magnesium. A minute quantity of free or uncombined Phosphorus may also be present, but the quantity is so small that it is not usually included in an analysis.

The entire absence from the urine of 'Phosphates' may occur, as in anaemia,(a) but very rarely does. Nor is this to be wondered at. Phosphorus enters largely into the constitution of all organized bodies and is an almost invariable ingredient of food. On account of this second fact alone, we would be certain to find it in an excretion like urine.

Assuming the Specific gravity to be 1025 and Temperature 32 Fah. Dr Christo

(a.) Dr Thudicum on Pathology of the Urine

Dr Bristow[a] reckons an average normal urine to contain .250 per cent. Phosphoric acid. The same authority states the daily aggregate in grains of the following constituents thus:—

Phosphoric Acid	50 grains
Sodium	120 "
Calcium	3·5 "
Magnesium	3 "

Referring to the Phosphatic Diatheses Sir Thomas Watson[b] remarks, that we must be careful to understand what the term means, and what it does not mean. The mere appearance – the visible presence – of phosphates, does not necessarily imply increased amount of them. The close relationship existing between increased elimination of phosphates and certain diseases, diabetes insipidus for example, has been frequently noted, but here we are not considering increased ejection, but only their presence in a visible form.

In normal urine the phosphates are in solution and invisible, but owing to the earthy phosphates being (very) insoluble in fluids other than acid, should the urine become alkaline, their precipitation at once proclaims their presence. Dr Golding Bird[c] believed that the phosphates might come down in neutral

a. Dr Bristows Practice of medicine
b. Lectures on the Principles and Practice of Physic.
c. Urinary Deposits (1844)

or even faintly acid urine and with this opinion Dr Frederick Roberts[a] agrees. Dr Thudicum, on the other hand, says that the presentation of an acid reaction excludes the possibility of the phosphates precipitating, and he explains how fallacious views might come to be held. "There is only one (questionable) case in which a deposit of an earthy phosphate is compatible with an acid reaction from the presence of chloride of Ammonium. In this case a deposit of phosphate of magnesium may perhaps exist, for this salt is little or not soluble in Chloride of Ammonium." In explanation of the statement that phosphate of calcium might come down in acid urine he describes the following experiment. "Clear acid urine was allowed to stand for three hours, when a pellicle of phosphates was observed on the surface. Blue test paper, immersed an inch deep into the fluid, on being withdrawn had become red. Another piece of the blue test paper was now laid flat upon the surface of the fluid, when no reaction took place. The upper stratum of the fluid had evidently become alkaline under the influence of the air, while the lower strata had retained their acidity."[b] When such high authorities, as those just quoted, disagree, we would not be very dogmatic. The very last urine we examined, however, that of a child afflicted

a Practice of Medicine
b. Dr Thudicums' Path. of the Urine

afflicted with Threadworms – turned the blue litmus paper red, and it contained a considerable Cloud of what proved to be phosphates. We must confess however that we omitted to test the Surface of the urine by allowing a piece of litmus to float upon it.

There are occasions when what one chiefly wants to know, or at least satisfy themselves of, is the nature of the deposit – its Exact Chemical composition being for the moment a secondary consideration. For instance there are several abnormal conditions of the urine which closely resemble one another. Urine loaded and opaque from pale urates, urine containing deposited Earthy phosphates, Chylous urine and urine containing a considerable quantity of pus, might Each be mistaken for the other. In all these cases an observant Patient would tell us, that the whole or part of the issuing Stream looked milky. Chyluria is certainly not common but a Case of it might come under our notice when least Expected. Between the first two – deposited pale urates and deposited Earthy phosphates – there is the closest possible resemblance – a resemblance however soon dispelled on the application of heat or addition of a weak acid.

Phosphatic deposits are met with in three different forms: –

1st. Amorphous phosphate of Lime or Bone earth ($Ca_3 2 PO_4$)

2nd Crystallized phosphate of Lime or Stellar phosphate ($Ca H PO_4$)

3rd. Phosphate of Ammonia and Magnesia or Triple phosphate ($NH_4 Mg PO_4$)

It was to urine containing the third form of these deposits – the phosphate of Ammonia and Magnesia – that Dr Prout[a] more particularly applied the term Phosphatic Diathesis Its pathology does not admit of so much conjecture as the first or second. Owing to an altered state of the mucus of the whole or part of the urinary tract, the urea which is identical in composition to Ammonium Cyanate ($CH NO, H_3 N$) becomes decomposed, Ammonia is set free and combines with the phosphate of Magnesium to form the triple salt. The urine being rendered alkaline by the ammonia, the triple salt is usually associated with some amorphous phosphate of Calcium.

It may be interesting here to remark that in perusing the Literature on urinary deposits we find two cases described by Dr Graves[b] where Carbonate of ammonia was not the result of decomposition. In both cases Dr Graves was of opinion that Carbonate of ammonia had been secreted as such by the kidneys – indeed the urine in the second case contained no urea to decompose

a. On Stomach and Renal diseases (1848)
b. Clinical Lectures on the Practice of medicine (1848) Vol II. Page 292

In such cases he looked upon the Carbonate as a vehicle for excreting those elements which usually form urea.
When we said that the decomposition of urea gave rise to free ammonia we should also have added "or" Carbonate of ammonia.
The pathogeny of the first or second form of deposit we remarked was not so clear or easily traced as the third. We shall now consider urine which permits of the deposit of the first form and it is to this one of the three that we have given most of our thoughts.

The urine is how secreted alkaline or if acid, very slightly so. The alkalinity not being due to the volatile alkali ammonia there an absence of that pungent smell that urine containing the triple phosphates possesses. A characteristic but not easely described smell is given off nevertheless. Sir Thomas Watson likens it to 'weak broth,'[a] Dr William Roberts describes it as a 'sweet aromatic odour'[b] and Dr Bristow as simply 'sweetish.'[c] The urine is pale, copious and of low specific gravity. Dr Prout has, in a few instances, seen it deep coloured, accescent and of a specific gravity above 1030.[d] After standing in the chamber for a variable, but usually very short time, an iridescent pellicle of Phosphate of Calcium forms on the surface. Most often we

a. Lectures on the Principles &c
b. On Urinary and Renal Diseases (1872)
c. Practice of Medicine
d. Stomach & Renal Diseases - page 282.

have found the phosphate deposit in the manner described, that is as the urine cooled or had become cold. At other times a cloud of Phosphates makes its appearance for the first time, when the urine is being heated - as in a test tube. To distinguish this cloud from one of albumen a drop or two of acetic acid must be added. A cloud or haziness due to the latter would be unaffected but if to the former would instantly clear up. In a third class of cases the phosphate is deposited while the urine is still in the bladder. When this happens the last portion of the stream appears milky. Scattered here and there amongst this amorphous powder, made up chiefly of phosphate of Lime and to a very slight extent phosphate of magnesium, the Microscope may reveals a few crystals of Oxalate of Lime.

We have said that the amorphous phosphate of Calcium often takes the form of an iridescent film on the surface of certain urines. Before we had began our Medical Studies - more than ten years ago, our attention was drawn to this scum on our own urine. We likened it to the effect of tar on the surface of water - both having a refracting action on light. Throughout these ten years we have often noted this condition and on our own urine particularly.

Although far from robust our general health during all these years has in -

invariably been good. Beyond Scarlet Fever in Childhood we have had no illness. Dyspepsia in the form of very slight Pyrosis we can remember showing itself as far back as twelve years and ever since it has appeared at irregular intervals to remind us to be careful about the 'Ingesta'. On account of this Pyrosis we could usually tell when the phosphates would be likely to put in an appearance as a scum. But we could also foretell, and very correctly too, when they would be precipitated while the urine was still in the bladder. If for instance we had much walking to do between breakfast and dinner (dinner we usually had about 3 o'clock) and we were conscious at breakfast-time that our digestive organs were not quite right, then we knew for a certainty almost that the last half ounce of urine voided on our return, would be milky from deposited Earthy phosphates. Without having had active Exercise, like walking, immediately previous, we have never known our urine permit of the precipitation of phosphates while still in the bladder. From having noted this so often we have concluded that Bodily Exercise between 10 a.m. and 3 p.m. diminishes the urines acidity, if indeed it does not on some occasions convert what would be an acid urine into an alkaline one. Urine depositing phosphate of Calcium

as an iridescent film on standing is acid when passed. So also is urine throwing down a cloud of phosphates on heating; but urine allowing the deposition to occur in the bladder is alkaline. This has been our experience.

Dr Thudicum explains in a very plausible manner how an acid reaction might be given to test paper in spite of the milky appearance of a portion of the stream. There might, he thinks, be strata, so to speak, of urine in the bladder — an acid and an alkaline stratum. We would add an intermediate or neutral stratum. The effect on litmus would of course entirely depend on which of the strata the urine tested belonged. Strata however are only consistent with the body being kept at rest.

Now the question we have asked ourselves over and over again is — Why should our urine allow of this deposition — this visible presence of the amorphous phosphates? The proportion of calcium phosphate to magnesium phosphate being as two to one, we shall speak only of the former.

Phosphate of Lime is (highly) insoluble in alkaline and proportionally soluble in acid liquids. Now although all urines contain phosphate of lime, its visible presence is a departure from the normal. To be in solution as when the urine is normal it is, that urine must be acid. Upon

upon what constituents does the acidity of the renal secretion depend?

According to Kirkes Physiology the acidity of the urine is due in great measure to the presence in it of acid phosphates. If Liebig be right the acidity is entirely due to them. Dr Bristow thinks that the acidity depends mainly not only on the acid phosphates but the urates as well, and in some degree also on traces of Lactic, oxalic and other acids. If the acidity be due to all these, the question becomes rather complex. Let us consider however only the first two — the urates and phosphates. — Even Dr Bristow says they are the main factors.

The Urates:—

The urates met with in the urine are chiefly the urates of Soda and Ammonia. The hypothesis at present accepted as to their formation is that the uric acid, which is bibasic, in the act of secretion in the Kidney, seizes upon the Soda and Ammonia of the alkaline phosphates of the blood and forms an acid urate of both bases.

A reasonable inference to draw from this hypothesis would therefore be, that the more uric acid secreted, the more Soda and Ammonia would be required for Combination and consequently the more alkaline phosphates converted into acid. Now uric acid like urea and indeed

every other constituent, varies considerably as to amount, but is increased when the food is highly Nitrogenous. The urine of herbivorous animals is habitually alkaline and this alkalinity may be due to two causes — the large amount of alkali and small amount of Nitrogen in their food. By feeding such animals on Nitrogenous food, their urine becomes acid. In the urine of Granivorous animals uric acid is largely present and this fact again may be explained by the large amount of Nitrogen in grain. But as is well known, afflicts those who live luxuriously or in other words, partake largely of Nitrogen. In them uric acid is formed in excess and is deposited as urate of soda in the tissues around the joints.

The Acid Phosphates.

In explaining the formation of the urates we incidentally explained the origin of part of the acid phosphates. In addition to uric acid there are Hippuric and Sulphuric acids. Hippuric is present in human urine in quantity equal to uric acid. Each of these acids by combining with Soda and Ammonia will convert a proportionate quantity of alkaline into acid phosphate.

A diet then which contained little Nitrogen, Caeteris Paribus, would be a diet which might indirectly cause the deposition of the Earthy phosphates.

Experiments go to prove that this is actually the case. If dogs for instance be fed exclusively on vegetables, their urine will become pale, turbid, and alkaline — the turbidity being doubtless due to the precipitation of the Earthy phosphates. When allowed to return to animal food their urine once more becomes acid and also clear.
"The alkaline urine of the octogenarian is the consequence of his not being able to afford meat once a week. Hence in these cases, the acidity of the urine is restored by a proper allowance of meat."[a] The faintly acid, neutral or even alkaline urine of the confirmed dyspeptic comes practically to the same thing. He does not take butcher-meat because he cannot digest it.

Although urine may be alkaline from the presence of alkaline instead of acid phosphates yet in the urines we have examined there was present a Carbonate of Potash or Soda, most commonly, if the reaction to Litmus was alkaline or slightly acid. That is to say that when we added a strong acid like Nitric to urine which allowed the Earthy phosphates to fall, effervescence usually took place. Urine then may be alkaline from two causes over and above decomposition. It may be alkaline from alkaline phosphates or fixed alkali. Vegetables and fruits Eaten in Considerable quantity

a. Dr Studleum's Pathology of the Urine - page 211

may cause a urine to be alkaline by the alkali they contain appearing in it as carbonate.

When considering the clinical significance of a deposition of earthy phosphate in urine, the time of day and relation to ingestion of food, should be taken into account. According to Dr Bence Jones' diagrams the urine is most acid at 9 a.m. and 6 p.m.; and least acid at 12 noon and 9 p.m.[a] He was the first to point out that the intensity of the urine's acidity varied considerably in twenty four hours. Urine passed after meals he found to be always less acid than that passed before, and the inference he drew was, that the intensity of the acidity was in inverse proportion to the amount of gastric juice secreted. "You will perceive" he says, (referring to two diagrams showing - one the relative acidity of the gastric juice and the other the relative acidity of the urine, each hour of the day) "that when the gastric juice is most acid the urine of that time is least acid or most alkaline, and when all the gastric juice is absorbed then the acidity of the urine is at its highest point."

Various experimenters have since found this ebb and flow (Dr William Roberts styles it 'alkaline tide') to exist in normal urine, but advance different reasons in explanation. Dr William Roberts for instance says that if Bence Jones was right no sooner would food

[a] Lectures on Pathology and Therapeutics page 77

food enter the stomach than the acidity of the urine would be diminished -- gastric juice being poured out at once, whereas the acidity of urine is unaffected for about an hour after eating. He (Roberts) ascribes the decline of the acidity after meals to the alkali contained in the food. "A meal is pro tanto a dose of alkali and must necessarily for a time add to the alkalescence of the blood and as the kidneys have delegated to them the function of regulating the reaction of the blood, the urine immediately reflects any undue addition to or subtraction from the blood's proper alkalescence."[a]

Neither the explanation of Bence Jones nor Roberts can be considered complete because Dr Hermann Weber[b] found by experimenting on himself that although breakfast lessened the acidity of his urine, the acidity ebbed so to speak even if he went without that meal, although not quite to the same extent.

Another explanation advanced to account for the 'alkaline tide' seems to us a very likely one. It is based on the researches of Dr Edward Smith ~~[illegible]~~ "On Elimination of Carbonic acid." Dr Smith finds that food increases and fasting decreases the exhalation of carbonic dioxide. More also is exhaled in the waking state than in sleep. The acidity of the urine then may depend on the quantity of Carbonic dioxide

a On urinary & Renal diseases page 30
b. Professor Parkes on the Composition of urine in Health and Disease page 55.

given off by the lungs. Throughout the night there is a gradual rise in the urines acidity and it is during the night that least Carbonic acid is exhaled. Then again there is a fall in the acidity after food, and food we have just said increases the exhalation.

The 'alkaline tide' may not be due to any one cause but several — the amount of gastric juice in the stomach, the alkali in the food and the quantity of Carbonic acid exhaled being perhaps the principal factors. The last factor may explain why Phosphates should come down in our urine before being voided after active Exercise. The active Exercise by increasing the Exhalation of carbonic acid may have turned what was doubtless a weakly acid urine into an alkaline.

To account for the presence of alkaline carbonates in urine, there must be an excess of both Carbonic acid and alkali in the blood.

Deficient Elimination from any cause, feeble respiration or breathing a vitiated atmosphere, would lead to excess of the carbonic acid. Excess of Potash and Soda might follow too much vegetable food or deficient secretion of bile. Bile carries away a large amount of Soda from the system.

The acidity of urine being such a variable quantity, depending on so many conditions —

– such as food, exercise, time of day, atmosphere and so on, that when amorphous phosphates appear in it, it would not be safe to give other than a general explanation. Dr Finlayson[a] concludes his remarks on the subject in these terms:– "Persistent deposits of the amorphous Earthy phosphates, being associated with habitual alkalinity of the urine are not infrequently the index of a depressed state of health." for depressed state of health we would prefer "faulty digestion." The digestive organs we believe are originally at fault in this form of Phosphatic Diathesis The depressed health is a result of digestive derangement – they will of course act and react upon each other – but the order is as we have stated. Our opinion is strengthened by the favourable results obtained by purely dietetic treatment.

The liver in mostly all these cases requires attention to begin with. A smart saline purge will go a long way in ~~tak~~ cleaning the tongue and improving the complexion – usually sallow. – Beyond this no other medicinal treatment is necessary if the bowels will keep regular. We used to give dilute phosphoric acid with some bitter infusion with the idea of raising the acidity of the urine, but now think this unnecessary. The patient may drink aerated water if he pleases – but should avoid alcohol and heavy ales. The diet must receive chief

[a] Clinical Manual for the Study of Medical Cases.

attention. All vegetables except the potato should be avoided and even the potato as well if the digestion be very weak. If a patient can only be persuaded to begin the day by taking oatmeal porridge, the improvement in his condition will be very rapid. We look upon oatmeal porridge as a specific for the more or less dyspepsia accompanying alkaline urine. A patient who takes oatmeal porridge of a morning will be able to digest a meat dinner with surprisingly little discomfort, even although he has scarcely eaten meat for months. One patient we had under our care some years ago failed to derive any but the most temporary benefit from any mode of treatment whatever until she commenced to take oatmeal. The oatmeal paved the way, as it were, for animal food, and once able to partake of animal food, the urine became quite normal.