CLINICAL URINARY ANALYSIS: A CRITICAL STUDY.

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The importance of the subject supplies me with the best reason I can urge for introducing this somewhat technical paper into the Journal.

The urine, in whose nitrogenous constituents are contained nine-tenths of the nitrogen excreted by the body, and in which the final chapter of the story of nitrogenous body metabolism may be read, does not appear to have received that attention in England which its importance demands. How often one hears the expression used "the urine was normal" or "the urine showed nothing," when only a simple qualitative test for sugar or albumen in the urine had been made. How hasty and misleading such conclusions may sometimes be is evident when we remember that both sugar and albumen may be absent and yet the urine be gravely abnormal, reflecting perhaps profound disturbance of the body metabolism.

A normal urine is one which not only contains no abnormal products, but one in which the normal constituents are proportionately represented, and excreted in quantities proportional to the individual who excretes them. It is because such is the case that quantitative urinary analysis has value in clinical work, and a knowledge of the quality of the urine becomes an asset in diagnosis and prognosis neither negligible nor unimportant.

So long as our conceptions of quantitative urinary analysis were limited to either the long and laborious processes of the laboratory, when an endeavour was made to obtain extreme accuracy for research purposes, or to the simple but generally inaccurate or misleading "clinical methods," the difficulty of making a urinary analysis practical and of real utility was very great. Experience and research, however, have suggested accurate yet rapid processes, and we appear to have reached a point where quantitative urinary analysis may become a practical help in the diagnosis and prognosis of disease.

As illustrative of the unsuitability of the pure laboratory
method and the inaccurate so-called clinical method of quantitative estimation, I will give two examples, one of each, taking urea as the urinary constituent estimated.

A clinical method of urea estimation one often sees employed, is as follows: 2 or 5 cc. from a sample of urine (generally morning urine) are mixed with some hypobromite of soda solution in a small Doremus ureometer, graduated in percentage of urea, the nitrogen evolved in the process being read off in these percentages. The sources of error in such a process are many: (1) If the urine has been taken from an isolated micturition, its urea percentage gives us no idea of the urea percentage in the cyclical urine, for the richness of the urine in urea may be three or four times as great after a meal, or when the urine is concentrated, as it is in the morning urine; (2) the hypobromite solution, if not carefully and freshly prepared, may not evolve all the nitrogen of the urea, or may itself evolve oxygen and so vitiate results: the hypobromite solutions used in routine clinical work are not always above reproach; (3) the nitrogen of other bodies besides urea is liberated by the hypobromite solution, approximately one-third of that of the uric acid and kreatinine, and all the nitrogen of the ammonia present. The hypobromite solution also only liberates 92 per cent. of the nitrogen of urea, unless sugar be present. These two sources of error are not allowed for, because one is supposed to balance the other. This rule is approximately true for normal urine, but quite un­true and misleading when applied to some abnormal urines, in which the nitrogen of the extractives and ammonia may rise to 20 or even 30 per cent. of the total nitrogen, as in diabetes; (4) no allowance is made for the influence of temperature or pressure on the volume of the gas; the effect of the former is sometimes considerable. This then is the so-called clinical method of estimating urea—a method so inaccurate as to be not only useless but misleading.

Perhaps the best known and one of the most accurate of laboratory research methods of estimating urea is that of Moerner and Sjöeqvist; but this process takes all one night and half of the next morning to complete, and consequently could only be used when time was no object. I hope to show, later on, that it is possible to estimate the urea in a reasonable time and, too, with a reasonable degree of accuracy.

I have used the expression “laboratory process” when speak-
of Moerner's method of urea estimation, in the sense that it is essentially a method used in research work only; for all quantitative processes must necessarily be laboratory ones though the laboratory be but a modest affair.

For general convenience this paper on urinary analysis has been divided into two parts. The first part is devoted to a description of the schemata employed, with notes upon the methods of analysis adopted; while in the second part, which I hope will appear in a future number of the Journal, it is proposed to consider some work which has been carried out by myself and others in France on similar lines and by methods analogous to the ones described.

On p. 195 is shown a draft form of an analysis report, which I have prepared, and which is based on analogous forms in current use in France. In this form of report are two schemata or graphics; some explanation of these graphics will be found on the form itself, but in order to elucidate matters some further explanation of them may be desirable. Such a form as this might be used with advantage in obscure or interesting cases, especially when nutritional disturbance has been a marked feature, particularly as it could be attached to an invaliding report or case book. The form is not so complicated as it may appear at first sight, for every effort has been made by the free use of graphical methods to render results which would otherwise be merely a collection of figures, striking and easy to understand.

Roughly speaking, this form may be divided into two halves. The schema or chart on the left hand side of the paper is intended to be used mainly for chronic cases, and the information noted about height, weight and chest measurements is of special value in such cases. This chart deals with both the quality and the quantity of the urine excreted. The schema on the right hand side of the report form is intended to be used when the analysis is made in a case of acute disease. It may be also employed, to any desired extent, for chronic cases. It illustrates only the quality of the urine.

The specimen report form given has been completely filled in for purposes of illustration. So complete an analysis would only rarely be required. The time spent on this analysis was four and a half hours. Two hours is generally sufficient for an analysis as usually carried out for ordinary cases.
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The chart on the left hand side is intended for chronic or convalescent cases; it is so restricted because an endeavour is here made to estimate the amount of the urinary output for the twenty-four hours, as well as its quality, and to furnish a normal standard for each individual case based on body-weight and other factors; these are data not to be obtained generally in cases of acute illness, and would be of doubtful value if they could.

The chart just referred to is adopted from Gautrelet, of Vichy, who introduced it. Gautrelet argued that if the cyclical urine of a certain number of young, healthy and well-proportioned people, living under ideal hygienic conditions, were collected and examined over a period sufficiently long to exclude accidental error, a normal standard of urinary excretion per kilogramme of body-weight could be formed, and that, by calculating the number of active or functional kilogrammes in every individual case, the one amount multiplied by the other would give the normal or ideal urinary cyclical output for the individual concerned. Experiments had been carried out some time previous to this by the French army surgeon, Peyraud, of Lebourne, on the correct proportion of weight to height, &c. Great numbers of healthy young soldiers were examined and the average worked out. Gautrelet adopted Peyraud's figures for his schema, which practically worked out that the weight in kilogrammes would be four-tenths of the height in centimetres, and one and three-fifths the interacromial measurement. The cyclical urine of twelve healthy French peasants of Burgoyne, of both sexes, ageing from 30 to 35 years, fulfilling the necessary requirements of weight to height, and living under almost ideal hygienic conditions as to food, temperature and exercise, was examined for eight days, and the average urinary output for the twenty-four hours per kilogramme of body-weight estimated. This amount, which worked out to 24 cc. of water, 1 gramme of extract, 0·5 gramme of urea, 0·1 gramme of chlorine, 0·005 gramme of phosphoric acid (in terms of P₂O₅) 0·001 gramme of uric acid and 0·001 gramme of urobilin was adopted as the standard or urological unit. The acidity equalled 0·84 cc. normal alkali solution or 0·03 gramme P₂O₅ per kilogramme. One factor in determining the normal standard for the individual had now been acquired, and if quantitative analysis had only to deal with healthy well-proportioned people of from 30 to 35 years of age, living...
REPORT OF URINARY ANALYSIS.

NAME.—J. S.

DISEASE.—Chronic Dyspepsia.

AGE.—20. WEIGHT.—65 Kilos. HEIGHT.—1 Metre 70.

INTERACROMIAL MEASUREMENT.—29 Metres.

ANTERO-POSTERIOR DIAMETER OF CHEST.—21 Metres.

DIABETIC COEFFICIENT.—67.

NAME.—J. S.

TREATMENT.—Diet.—Mixed, Full.

DIET.—Mixed, Full.

INTERACROMIAL MEASUREMENT.—29 Metre.

DISEASE.—Chronic Dyspepsia.

ANTERO-POSTERIOR DIAMETER OF CHEST.—21 Metre.

AGE.—20.

NOTE.—1. Metric weights and measurements are used in this report. 2. The chart on the left hand side of this report is intended to show the quantity as well as the quality of the urine, and is only filled in in chronic or convalescent cases, the information concerning height, weight, &c., being necessary only in such cases. The normal used in this chart varies with the individual; it is found by multiplying the output which each healthy kilogramme of body weight is known to excrete by the biological coefficient. 3. The biological coefficient is found by taking the mean between the actual weight and the theoretical weights for height, and chest measurement, age, diet, are also allowed for.
under healthy conditions, there would have remained only the
determination of the other factor or weight. But it was at
once seen that weight alone could not be adopted as the other
factor in estimating the normal standard for the average patient
who came to Vichy, for he might be very fat and short, and,
as fat does not play so active a part as muscle in nitrogenous
metabolism, any normal found by multiplying the kilogramme
output by the weight would in this case be too high and mis-
leading; or the patient might be thin and muscular, when the
opposite would be the case. Again age had to be allowed for,
a youth, say, of 15, would not be expected to weigh four-tenths
of his height, although this deficiency is somewhat counterbalanced
by the greater intensity of metabolism in the young, causing a
proportionately high urinary output.

Food, too, which plays so important a part in any calculation
of urinary output, had to be taken into consideration. It was
with a view to reducing the amount of error from these many
sources that the following principles were adopted in estimating
the second factor of the two necessary to ascertain the individual
normal. A mean is taken, between the actual weight and the
theoretical weights for height and chest measurement, with a
view to correcting the influence of ill proportion or excessive fat;
the influence of age is calculated on the mean or average thus
found. Thirty is adopted as the age at which growth has ceased
and metabolism become stable, and no allowance made if the
patient is of this age; half the difference between the actual age
of the individual and 30 is deducted from or added to the height-
weight mean which has been found for patients below or above
this age. This rule is only followed between the ages of 18 and
45; other rules govern the cases of very young and old persons.
The figure resulting from the calculations of height and weight,
influenced by age, is the second factor in the attempt to form
a normal individual standard; this factor has been called the
"biological co-efficient" and represents in an approximate way
the number of active kilogrammes of body-weight.

The "individual normal" is then deduced by multiplying the
urinary output, per kilogramme, by the biological co-efficient.
The amount so found is not affected if the patient is on an
ordinary mixed diet, but the result is multiplied by 1:75 if a purely
nitrogenous diet is being taken, and by 0:66 if no diet is being
taken at all.
I have described this method of Gautrelet’s at some length, as it is an ingenious attempt to solve an extremely difficult problem, and because it is the system on which the normals have been found in the schemata, to be given later on, and which are identical with the one on the left hand side of the suggested form of report. The method lends itself to criticism and has obvious defects; but as the same system has been applied to all the cases, the results have probably not been materially affected. To obtain an absolutely accurate standard for each individual is, I am convinced, quite impossible, even if the greatest care were taken in estimating the food intake, body weight, &c., of the individual. We have always to deal with the difference between man and man, that is, the difference of individual metabolic intensity. It is for this reason that I have described the simplest of the two methods given by Gautrelet, for estimating the normal standard. Gautrelet, in a further endeavour to achieve the impossible—an accurate and absolute individual standard—fills the paper with calculations, including a great many body measurements. The method has but to be seen to be condemned as impracticable; while it is doubtful if it is more accurate than the simpler method. Yet it is on a normal so obtained Gautrelet endeavours to dogmatise and draw conclusions from deviations, however slight, from the normal. Bouchard has gone to even further lengths in an endeavour to find an absolutely accurate normal standard, arguing that it is only the fixed albumen of the tissues which is the active agent in nitrogenous metabolism; he seeks to estimate the amount of this in each individual case. Pages and pages of one of the volumes of the last great work on pathology in France are filled with abstruse calculations, allowance being made for, among other things, the bony framework and the skin surface.

The question then arises, Is such a graphic system of illustrating the urinary output, and having for its unit of comparison a normal so open to error, of any value at all? The answer must be decidedly in the affirmative, if the system be applied to the right class of cases, and it be clearly recognised that the results must always be relative rather than absolute, with more attention paid to the relation of the curve of the output to itself than to its position with respect to the normal line. In Gautrelet’s system no difficulty exists in finding the urinary output per kilogramme
of weight. The difficulties of the system and its weak points are made evident when the second factor of the normal standard—the biological co-efficient—is estimated. They are as follows: (1) Insufficient allowance made for differences in the urinary output at different ages. In children and very young people the output of urinary constituents per kilogramme is much higher than in the adult, and for these young people it is almost impossible to obtain even an approximate normal standard. (2) The difficulty in estimating and allowing for the influence of excessive fat in the individual; for it is doubtful if such an arbitrary remedy as taking the mean between the actual and theoretical weights really overcomes this difficulty. (3) The insufficient and rather arbitrary allowance made for the influence of food, and the doubt which arises as to whether in private practice, where the system was used, sufficient allowance could be or was made for the food taken by the patients.

It may be opined that few of these difficulties would exist in any application of the system to the soldier, for here all the cases examined would be drawn from young men between the ages of 20 and 30. No special body measurements would be necessary, such as those which have been devised to meet the case of patients who go to Vichy or similar watering places, and who are often very corpulent, and whose weight is not a good index of their active tissue. In other words, for routine army work, physical details other than body weight might be ignored.

In the case of the soldier, the influence of the diet taken could easily be calculated in terms of carbon and nitrogen, as the dietaries are more or less fixed and their nutritive value known. In short, if the urinary output per kilogramme of body-weight were calculated by taking the cyclical urine of a number of healthy men for a period of days, the nutritive value of their diet being known, and the output per kilogramme for twenty-four hours adopted as the standard unit, the normal of any case could approximately be found by multiplying this amount by the number of kilogrammes which the patient weighed. The influence of the food taken by the patient on the result, being allowed for, such a method as this would be a simple one with strictly limited applicability, it could only be used for the soldier whose normal has been determined. The reason it can be used at all is because the men are mainly of an age (20 to 30) when metabolic intensity
does not vary very greatly. I do not think it is possible to devise a satisfactory system for use with children, owing to the great difficulty in fixing a normal. The urinary output per kilogramme varies so greatly at different ages up to 20 that a normal would have to be found for each year of life.

With the modifications above described we could have a simple and approximately accurate method for working out urinary analysis in the army, the graphical method employed rendering the results more striking and interesting, and, above all, we would have some organised system on which to work and compare results, a most important point. The results found would be relative, and greater attention would need to be paid to the shape of the curve of the constituents than to the position of that curve to the normal line. That such a system as has been described is sufficiently accurate will be readily seen when it is shown how the influences of disease on metabolism and on the urinary output are so marked as to overshadow small errors.

The schema on the right side of the report form is easy of explanation. The dark columns denote the normals, while the light double columns show the amounts actually found. It will be noticed that the "normal columns" are broken towards their upper ends; this is intended to show the limits between which the constituent concerned may vary and yet remain in normal proportion, for it is impossible to draw hard and fast lines. This graphic representation would generally be the only one filled in in acute cases, while being filled in to any desired extent in chronic cases.

The rest of the report-form presents no difficulty; a description of the physical characters of the urine occupies one corner and the results of the qualitative analysis for abnormal products another, while the microscopical or bacteriological results are suitably represented. Finally, a short space is left for remarks which might be filled in by the person analysing the urine, and be of use to the doctor in charge of the case.

Having, so far, considered general principles, I propose now to give a brief account of the methods employed for the analysis of each constituent of the urine, taking them in the order in which they come in the suggested scheme. Before doing so, however, I would like to draw attention to certain burettes with which most of the work can be conveniently done, and which are shown
in the accompanying photograph. These burettes are self regulating, and are the invention of Dr. Huguet, Professor of Chemistry in the University of Claremont Ferrand in France.

The bottle of the burette is filled with the reagent to be used. The burette bottles in the photograph are filled with (1) deci-

![Image of burettes](http://militaryhealth.bmj.com/)

Fig. 1.

normal alkali solution to test acidity; (2) decinormal nitrate of silver solution for chlorides; (3) decinormal acid solution for alkalinity; (4) nitrate of uranium solution for phosphates; (5) a solution of copper for the estimation of the urates.
By blowing down the small tubes seen jutting out horizontally just above the cork, the fluid in the bottle of the burette is forced up through the feeder-tube into the graduated burette tube; by a simple arrangement, syphon action is brought to bear as soon as the fluid reaches the zero mark of the burette, so that the fluid must always remain at this point. The burettes are sufficiently accurately graduated and clearly marked that an amount up to one-hundredth of a cubic centimetre can be read off, if desired. A great deal of time and labour is saved by the use of these burettes, for with them a quantitative analysis of the acidity or alkalinity of the urine, together with the chlorides, phosphates and uric acid, can be carried out in half an hour.

The apparatus shown on the right hand side of the photograph is one improvised by means of a bottle and ordinary burette; this gives as rapid results as the Huguet burettes, and can be easily put together.

Notes upon Methods Employed.

It would be quite impossible to describe all the methods used by different workers for obtaining details for the suggested form of report. But, as a rule, the methods employed have been on similar lines to those about to be described here; and when this is not the case the fact will be mentioned. It will be convenient to consider the methods under the following heads.

Volume.—The urine analysed has always been that of the twenty-four hours—analytical results based on isolated samples are misleading, as the quality of the urine varies greatly at different periods of the day. To prevent decomposition of the urine, a little cyanide of mercury, chloroform or ether is placed in the collecting vessel.

Extract.—In all the schemas this has been estimated by evaporation and drying at 100° C. This method is not absolutely accurate, owing to the volatilisation of certain substances in the extract at this temperature. Latterly I have used the densimetry method for estimating the extract, the specific gravity being calculated with great care to four places of decimals and the last two numbers multiplied by 2.33. This gives rapid and sufficiently accurate results.

Acidity.—The acidity of the urine is estimated by means of a decinormal alkaline solution, the process being continued until
an alkaline reaction is given with neutral litmus paper, the results being given in terms of anhydrous phosphoric acid ($P_2O_5$); this method is the one adopted by Gautrelet. By giving the amount of acidity in terms of phosphoric acid some comparison may be made with the total phosphates. I have latterly also estimated the acidity by Folins' method, which estimates the mineral and organic acidities separately; but this method was not used for all of the charts to be given in the second and further part of my paper. Acidity being the normal condition of the urine, it alone is allowed for in the graphic representation of percentages. Should the urine be alkaline, the alkalinity is estimated by a decinormal acid solution, and the cause of the alkalinity determined.

**Total Nitrogen.**—This is determined by the well known Kjeldahl method, the oxidiser used being peroxalate of potassium. Very simple and cheap apparatus can be bought or may be constructed from laboratory apparatus for this method.

If rapid results are required, a Kjeldahl-Henniger-process is employed. This consists in neutralising the acid ammonium sulphate formed during the first part of the Kjeldahl process and decomposing the neutral ammonium sulphate in a ureometer, instead of distilling it over into a decinormal acid solution as is usually done. The Kjeldahl-Henniger-process gives accurate results only if great care has been taken not to render the ammonium sulphate alkaline, or to prevent the great heat evolved during the process by keeping the vessel used in the process in cold water.

**Urea.**—A considerable amount of time has been devoted to endeavours to find a rapid and accurate process for the estimation of urea. Nearly all the better known methods have been tried and rejected either because they were inaccurate (Liebig's method and its modifications and the unmodified hypobromite process), or because they were long and complicated (Moerner, Braunstein, Folins, and Bohland's methods) and had no clinical value. The hypobromite method is by far the simplest of all urea processes, and eminently suited for clinical work; but owing to the manner in which it is almost invariably carried out in England it is so inaccurate as to be worthless. Earlier in this paper I expressed several reasons why this process was inaccurate, but as the method I have adopted, and am about to describe, is based on the hypobromite process, I may recapitulate them.

(1) The nitrogen of other bodies beside the urea is liberated
by the hypobromite solution. In a number of experiments carried out by reacting on solutions of some of these bodies with hypobromite, the following results were obtained: Uric acid evolved from 25 to 45 per cent. of its nitrogen, creatin 50 to 70 per cent., creatinin 30 to 40 per cent., and ammonia salts gave up all their nitrogen in contact with the hypobromite, while no gas could ever be obtained from hippuric acid. The smaller percentages quoted in each case were obtained when no glucose had been added to the solution under examination, while the higher percentages were obtained by the addition of glucose, and by violent agitation of the hypobromite and experimental solutions. These results are not dissimilar to those obtained by Falck and other observers.

(2) No allowance is generally made for temperature, which so greatly affects the bulk of gases.

(3) The use of bad ureometers and the want of care in the preparation of the hypobromite solution. The method adopted, which retains the use of hypobromite and at the same time overcomes the objections just mentioned, is as follows: All the nitrogenous bodies of the urine, except the urea, are precipitated by a solution of phosphotungstic acid (in excess), acting on a urine acidulated with hydrochloric acid. To 20 cc. of urine are added 2 cc. of a 10 per cent. solution of hydrochloric acid, and the mixture made up to 60 cc., with a 9 per cent. solution of phosphotungstic acid. The mixture is allowed to stand for half an hour and is then filtered; 15 cc. of the filtrate, which represents 5 cc. of urine, is reserved for use with the ureometer.

Sallerin Donzé and Lambling have shown that uric acid, creatin, creatinin, the xanthin bodies, and ammonia salts are precipitated from the urine by phosphotungstic acid, and though I have been able to recover minute traces of ammonia from a phosphotungstic filtrate by Shaffer's method, this does not militate against the fact that for practical purposes the ammonia is completely precipitated. As phosphotungstic acid in greater strength than 11 or 12 per cent. precipitates small quantities of the urea, 9 per cent. has been fixed upon as a convenient strength, and by using two volumes of the acid to one of urine one can always be sure of having an excess present.

Fifteen cc. of the filtrate are placed in one of the legs of the \( \wedge \) shaped tube attached to the ureometer in fig. 2, and a solution
of hypobromite of soda placed in the other. The gas evolved when the two solutions are mixed is read off and noted when contraction has ceased. This result, when compared with the amount of gas given off by 5 cc. of a 2 per cent. solution of pure dried urea—under exactly similar conditions of temperature—gives the amount of urea per litre in the urine.

In the accompanying fig. 2 will be found illustrations of the
two urometers used in the urea estimations. The one on the right-hand side of the figure has been constructed by joining two burettes together with a \( Y \) shaped tube and connecting the lower arm of the same tube to a movable reservoir of mercury by means of a piece of rubber tubing. The \( A \) shaped vessel in which the reaction between the hypobromite and urine solutions takes place is attached to the upper end of one of the burettes by a \( T \) shaped tube and a piece of rubber. Both the \( A \) shaped reaction tube and the burettes are placed in water boxes containing thermometers. The urometer just described has been placed on the stand of a Mercier’s instrument; but a simpler stand can be easily made.

The urometer on the left of fig. 2 is of simple construction, and has been made up out of laboratory apparatus. It needs no explanation.

The advantage of urometers such as these is that all the gas-holding apparatus is surrounded by water which can be brought to the same temperature before the gas, evolved by (1) the urea solution or (2) the urine, is read off. The temperature of the gas being the same in both cases, no allowance need be made for it, thereby avoiding troublesome calculation.

I have given up using glucose—which increases the amount of nitrogen evolved by the urea—and although only 92 per cent. of urea nitrogen is evolved by hypobromite alone, this does not influence the result, which is a comparative one between a pure urea solution and the urine examined. Glucose by evolving heat complicates matters.

The hypobromite solution is prepared by adding equal parts of a 40 per cent. solution of caustic soda and a mixture containing 10 cc. of bromine dissolved in 100 cc. of a 15 per cent. solution of bromide of sodium. This is used only when freshly prepared.

The urea process just described takes twenty minutes to complete (excluding the time taken for precipitation), it is simple of execution, rapid and accurate. In my hands it has given very satisfactory results in a long series of estimations.

Chlorine.—This is estimated by Mohr’s process as modified by Pribram. The modification consists in the destruction of urinary organic matter, which otherwise combines with the silver nitrate solution and vitiates the results. The organic matter is got rid of by heating with sulphuric acid and permanganate of potassium.
**Uric Acid.**—This is estimated by Gautrelet’s modification of Arthand and Butte’s method, the re-agent used being a hypo-sulphite of copper, and the indicator ferrocyanide of potassium with hydrochloric acid. The process is simple, very rapid, and gives fairly accurate results. It is the method used in most of the charts to be described.

When it is necessary to estimate the uric acid with great care, Denigès’s method, which has been adopted as the standard method in France, and for which very accurate results are claimed, is used in this process also. Copper hyposulphite is the re-agent used, and the amount of uric acid in the urate of copper which is formed being estimated by means of a cyanide.

**Phosphates.**—These are estimated by the nitrate of uranium method, the indicator used, however, being that recommended by Mercier, viz., tincture of cochineal, which appears to give better results than the ferrocyanide of potassium drop method.
Urobilin.—This pigment is estimated spectroscopically, the instrument used being Gautrelet’s uropigmentometer. This instrument is illustrated in the accompanying photograph (fig. 3), and consists of a spectroscope held vertically into a glass vessel filled with the urine to be examined and placed on a stand. By turning a screw on the instrument, this vessel can be raised or lowered at will, thus decreasing or increasing the depth of the layer of urine examined; the movement which raises or lowers the glass vessel also turns a disc at the bottom of the stand, which automatically registers the depth of the liquid thus produced. As soon as the spectrum of urobilin—a dark absorption band near F—is seen, the depth of the layer of urine is noted. A calculation table accompanies the instrument, from which one can estimate the amount of urobilin per litre.

A good deal of the urobilin of the urine when freshly emitted exists as a colourless chromogen, and it is sometimes almost impossible to detect the characteristic spectrum in such a case. On exposure to the air, however, this chromogen becomes converted into urobilin, completely according to some, partially so according to others. In the urine of twenty-four hours a band can always be seen by anyone used to spectroscopic work. To intensify the absorption band, Denigès of Bordeaux employs a solution of iodine in iodide of potassium, which is supposed to act by oxidising the chromogen to urobilin. I have adopted this method latterly, using 1 cc. to 100 cc. of urine. In the charts, however, to be given, the urobilin has been estimated directly.

Ammonia.—This is estimated by Shaffer’s method. This method consists in driving off the gas by boiling it with an alkali in vacuo, the boiling point, considerably lowered by the condition of vacuum, being further reduced by the addition of methyl alcohol to the urine. The mixture thus formed boils at from 40° to 45° C., and as urea is not broken up till a temperature of 60° C. is reached, the results are not liable to be vitiated by ammonia so derived. The accompanying photograph illustrates the apparatus (fig. 4).

The boiling is carried out in a water-bath, and the small bulbs are used to prevent the alkali being carried over to the small flasks which contain the decinormal solution of sulphuric acid, into which the ammonia is received. The amount of ammonia present is estimated by the loss in acidity of this decinormal acid; each cc. of acidity being equal to 0·0017 gramme
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of ammonia. The vacuum is produced by the use of an inexpensive water-suction tube, the degree of vacuum produced being shown by the large U-shaped pressure-tube placed on the white millimetre card (the process should be carried out at a pressure of 10 millimetres of mercury). The apparatus thus set up is simpler than it may appear at first sight; it is inexpensive and gives very accurate results; it can be fitted up anywhere
if a sufficient pressure of water can be assured. The apparatus
shown in Shaffer's description does not give very satisfactory
results—the one in the figure has been modelled on one set up by
Dr. Beddard in the Guy's Hospital laboratories, and I owe it to
his advice that I have escaped the inevitable trouble inseparable
from work with new processes.

Sulphates.—These are estimated by Salkowski's gravimetric
method.

Some of the methods employed for the qualitative and quanti­
tative analysis of abnormal products in urine which occupy a
place in the report form may be briefly referred to. Albumin
is estimated quantitatively by the gravimetric method, though,
if a Purdy's centrifugaliser be present, the centrifugal method
is greatly to be preferred. Qualitatively, Borreau's reagent—
sulphophenic and sulphosalicylic acids—has been used in addition
to the ordinary tests, as it is so delicate. Sugar is estimated by
Gerard's cyano-cupric method. B-Oxybutyric acid by the polari­
scope, i.e., by reading the polarimetric deviation caused by the
substance in solution plus the sugar; the quantity of the latter
being known and also its effect on polarimetric deviation, the
amount of B-oxybutyric acid can be readily calculated by difference.

The methods adopted for the albumoses, peptones and acetone,
and the qualitative tests for albumin, sugar, bile acids and pig­
mments are those usually adopted and described in all text books
on urine. It will be noticed that with two exceptions the pro­
cesses noted as being used are rapid processes. These exceptions
are the gravimetric methods of estimating the sulphates and albu­
min. Purdy has shown conclusively, however, that with care­
fully arranged centrifugal methods both the sulphates and the
albumin can be estimated with great rapidity, and with an
accuracy quite sufficient for all clinical purposes. I hope in
future work to be in a position to employ these methods. The
ratio of the constituents to each other, as shown in the schema
of columns and the percentage amounts of the constituents of
the urine to the calculated normal, are easily found, once the
amounts actually present have been estimated.

For further information about the procedures mentioned,
notably the methods of estimating the acidity and alkalinity of
the urine, and the amount of chlorides, phosphates, sulphates,
sugar and albumin, any standard work on urinary chemistry
Clinical Urinary Analysis

may be consulted; but for the information of those interested in this subject, I submit a short bibliography. The practical application of these methods in actual cases of disease, with comments upon their values, will be given in a subsequent communication.

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