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SOME NOTES UPON URINALYSIS.

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IN the course of examining urines I have found that certain data, of which the analyst stands much in need, are not to be met with in any of the works upon urinalysis with which I am conversant, and I have examined, I think, all the manuals in general use. For instance, the average daily amount of total solids in the urine of healthy persons is given by all authors; but a statement as to what range of total solids is compatible with health is made by few, and then not in a satisfactory form. The average amount of solids is usually stated to be 70 gm. a day, but I am of the opinion that this is slightly too high for the average men and women in this country, and think 63 gm. would fall nearer the true average. The specific gravity in health may range from 1.015 to 1.025, the average being 1.020. The quantity of urine passed daily by healthy persons is said to vary from 1300 to 1500 c.c. The Haeser and Neubauer formula for estimating total solids from the specific gravity is sufficiently accurate for clinical purposes. This is executed by multiplying the last two figures of the specific gravity by the factor 2.33, the product of which represents the number of grams of solids in 1000 c.c. of the urine, and must be multiplied by the number of cubic centimeters of the



urine under examination, and divided by 1000 in order to obtain the correct amount of solids. Taking this factor and the averages of specific gravity and quantity, we readily arrive at the following results for the health-range of total solids. Employing first the minimum specific gravity and maximum quantity, we have:

$$\frac{2.33 \times 15 \times 1500}{1000} = 52.43 \text{ gm. for the minimum solids.}$$

Using next the maximum specific gravity and minimum quantity, we have:

$$\frac{2.33 \times 25 \times 1200}{1000} = 69.90 \text{ gm. for the maximum solids.}$$

In calculating the maximum and minimum of total solids, I took as a basis the most usual conditions of healthy urine, *i. e.*, maximum quantity associated with minimum specific gravity and *vice versa*. But as there might be cases in which, along with apparent health, the maximum specific gravity is maintained simultaneously with maximum quantity, and *vice versa*, it seemed advisable to determine these widest possible limits of the health-range of total solids, as follows:

$$\frac{2.33 \times 15 \times 1200}{1000} = 41.94 \text{ gm.}$$

$$\frac{2.33 \times 25 \times 1500}{1000} = 87.38 \text{ gm.}^1$$

¹ Note the concordance between the average amounts of solids as determined from each of these limits:

$$52.43 + 69.90 \div 2 = 61.17 \text{ gm.}$$

$$41.94 + 87.38 \div 2 = 64.66 \text{ gm.}$$

An average of these two amounts is 63.42 gm.

In actual examination of urines it will be found that those whose total daily solids persistently approximate to either of these extreme figures represent some deviation from the normal standard of health. Whether a given case is pathologic or not must be determined by noting carefully all the conditions of the patient's environment; whether his diet is liberal or scanty; whether his habits are active or sedentary; the climate and season of the year, and, in addition, sex and weight are important factors in the problem. From my own experience I should say that the first determined limits, viz, from 52.43 to 69.90 grm., are much the safer ones to use in practice.

The ratio which the amount of urea in a sample of urine bears to the amount of total solids has seemed to me to be of some interest and value. Little is said concerning it in the manuals; but I have observed it in an extended series of experiments. It should first be remarked that all my figures are upon the basis of the whole twenty-four hours' urine, and all my examinations, with a few unavoidable exceptions, are made upon the total daily quantity. In estimating urea I use the hypobromite method exclusively, as being, upon the whole, the most satisfactory, and I make a fresh solution of hypobromite of sodium for each and every determination. I use the ureometer devised by Dr. Charles Doremus as the cheapest (for they will get broken), simplest, most readily cleaned, and, in general, the instrument best adapted for use in the physician's office; while at the same time I am confident that the ureometer of Dr. John Marshall is more scientific, more

accurate, and better fitted for the use of the chemist. The daily amount of urea excreted in health may range from 20 to 40 grm., according to diet, the average of these figures being 30 grm. I am, however, very much inclined to think that 27 grm. daily is as high an average as the analyst will make in this country. Using our previously-calculated average limits for total solids, we find the limits of the ratio between urea and solids to be as follows :

$$\frac{52.43}{20} = 2.6, \text{ or a ratio of urea to solids as } 1 : 2.6.$$

$$\frac{69.90}{40} = 1.7, \text{ or a ratio of urea to solids as } 1 : 1.7.$$

Here I have employed minimum figures of solids and urea, and *vice versa*, as, of course, we almost invariably find them associated in nature. Taking minimum urea with maximum solids, and *vice versa*, as rarely occurs in health, and never persistently, the ratios will be as follows :¹

$$\frac{69.90}{20} = 3.5, \text{ or a ratio of urea to solids as } 1 : 3.5.$$

$$\frac{52.43}{40} = 1.3, \text{ or a ratio of urea to solids as } 1 : 1.3.$$

From these two groups the average ratios will be calculated, as follows :

¹ Upon the basis of extreme limits of variation of solids the ratios might be figured as follows :

$$\frac{41.94}{20} = 2.1, \text{ or a ratio of urea to solids as } 1 : 2.1.$$

$$\frac{87.38}{40} = 2.2, \text{ or a ratio of urea to solids, as } 1 : 2.2.$$

The converse $\left(\frac{41.94}{40} = 1.05 \text{ and } \frac{87.38}{20} = 4.4 \right)$ is impossible.

$$2.6 + 1.7 = 4.3 \div 2 = 2.2 \text{ or a ratio as } 1 : 2.2$$

$$3.5 + 1.3 = 4.8 \div 2 = 2.4 \text{ or a ratio as } 1 : 2.4$$

Hence we may conclude that the average ratio of urea to solids in healthy urine is as 1 : 2.3, but that there may be a range, dependent wholly upon diet, of from 1 : 1.5 to 1 : 3.0. And I should say from somewhat extended observation upon this point, both in normal and pathologic urines, that a urine in which the ratio of urea to solids remains persistently at either the maximum or minimum figure is not excreted by a person in thoroughly good health. As far as my experiments have gone, the most notable fact to be observed concerning this ratio in the urine of persons suffering from various diseased conditions is its extreme variability from day to day, in this respect differing markedly from the ratios in healthy urines. I should not at present attribute great diagnostic value to this ratio, but in every case I meet it furnishes valuable collateral evidence.¹

The ordinary volumetric methods of estimating

¹ For normal urine the following averages are those given in the books for the twenty-four hours' quantity :

Average specific gravity	1.020
" quantity	1350 c.c.
" total solids	70 gm.
" urea	30 "

From this we find an average ratio of urea to solids of 1 : 2.33 $\left(= \frac{70}{30} \right)$. As 63 gm. seems a better figure for average solids, and 27 gm. a more correct average for urea, the corrected ratio will be 1 : 2.3 $\left(= \frac{63}{27} \right)$.

And note that the average amount of total solids calculated

phosphates and chlorids, while they are accurate and not difficult of execution for one who has plenty of time at his disposal, are yet out of reach of the average practitioner of medicine. Yet he would many times profit by the knowledge of the approximate amount of these substances in his patient's urine; so that I have endeavored to improve upon the rough methods of estimation given by most authors. I have not yet proceeded far enough in my experiments to be certain of the value of the method I propose, but, every time that I have checked it by the volumetric methods, it has furnished results sufficiently accurate for the physician's purpose. It is to be borne in mind that the knowledge of the exact amount of chlorids and phosphates in a urine is of no practical value to the physician. If he knows whether these substances are present in increased or decreased quantity, he possesses all the knowledge that he can apply in the present state of our science. The method I use is not new, but I am not aware of its application to the estimation of these salts in urine, though I doubt not it may have been so employed. I venture a hope that some physicians may find the method serviceable.

The necessary reagents are: The same solution of silver nitrate that is used in the volumetric estimation of chlorids (though any dilute solution will answer); a solution of a chlorid (preferably NaCl) of such strength as to represent the average proportion of chlorids in normal urine; and a simi-

from these very figures (quantity 1350 c.c. and specific gravity 1.020) differs from that stated in the table, as follows:

$$\frac{2.33 \times 20 \times 1350}{1000} = 63 \text{ gram.}$$

lar solution of a phosphate (preferably Na_2HPO_4).¹ One-half dozen ordinary stand test-tubes and a graduated pipette constitute the necessary apparatus. The principle of the method is the comparison of the relative bulk of the precipitates formed by adding the silver solution to the normal solutions, with similar precipitates formed by adding the silver solution to the urine. In estimating the chlorids I at present employ 1 c.c. of the sodium chlorid solution diluted to 5 c.c. in a stand-tube with distilled water, and 1 c.c. of the urine to be examined similarly diluted, to which is added one drop of nitric acid to prevent precipitation of the phosphates. Then 1 c.c. of the silver nitrate solution will completely precipitate the chlorid in the standard solution. Add silver solution to the diluted urine until the precipitate no longer forms, and shake both tubes thoroughly. In two or three minutes the comparison of the relative bulk of the precipitates may be made, and will give a fair estimation of the deviation from normal, if there is any, of the chlorids in the urine. This method is very easy of execution, the required solutions keep well, and it furnishes, so far as tested, fairly approximate results.

In roughly determining the phosphates I add 1 c.c. of the sodium phosphate solution to 1 c.c. of the

¹ Formulas :

1. <i>Silver nitrate solution.</i>	2. <i>Chlorid solution.</i>	3. <i>Phosphate solution.</i>
AgNO_3 7.265 grm. Water 250 c.c.	NaCl 3.25 grm. Water 337.5 c.c.	Na_2HPO_4 0.95 grm. Water 337.5 c.c.

sodium chlorid solution (as the chlorids and phosphates in the urine are necessarily precipitated together) and dilute to 5 c.c. with distilled water. As before, dilute 1 c.c. of urine to 5 c.c., and then add excess of silver solution to each tube, and shake. A mixed precipitate of silver chlorid and silver phosphate falls in each tube, and, as we already know the relative amount of chlorids in the urine, any change from that relation will denote the deviation in amount of phosphates from the normal. I am free to confess that the application of this method to the phosphates is not yet nearly so satisfactory as it is in the case of the chlorids.

Sometimes the analyst receives a sample of urine which is twenty-four hours old, or more, and it would be of great value to know approximately what changes, if any, had taken place in the urine since it was voided, either in specific gravity or amounts of urea and phosphates. The manuals furnish no information upon the point. I have only been able so far to try the effects of time upon the specific gravity and amount of urea, and then not in a sufficiently extended series of experiments to give authoritative results. Taking them for what they are worth, I note the following, and I select one case of each, rather than make an average. On a Sunday the specific gravity of a sample of fresh, warm urine (50 c.c.) was taken and found to be 1.018. When cold it read 1.022, and four days later it was 1.023. The evaporating surface was only three-fourths of an inch in diameter.

In a beaker, three inches in diameter, were placed 200 c.c. of fresh urine. An estimation of urea was

made at once, and upon every succeeding day, for seven days. When fresh, the urea amounted to 0.020 gm. in 1 c.c., or 24 gm. in 1200 c.c. On the fourth day it was 0.022 gm. urea to 1 c.c., or 26.40 gm. in 1200 c.c.; and upon the seventh day, 0.0234 gm. in 1 c.c., or 28.08 in the 1200. On the last day the urine was brought to the original bulk by adding distilled water, and then the urea read 0.018 gm. in 1 c.c., or 21.6 gm. in 1200 c.c. The result shows an apparent gain due to evaporation of 4.08 gm. of urea, but a real loss of 2.4 gm. due to decomposition of the urea. It is worthy of note that I find little actual change, except by evaporation, if that is not prevented, in most urines during the first forty-eight hours.

These facts are not sufficiently borne in mind, for I have seen an insurance examiner many times take the specific gravity of a warm, freshly-voided sample of urine and report the result as representative, which it certainly was not.

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