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Influence of Rate of Urine Formation on Potassium Excretion.*

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From an accurate description of the relations existing between the rate of renal excretion of any substance and the rate of urine formation, it is possible to make certain deductions concerning the manner in which the kidney excretes that substance. In spite of the active current interest in potassium metabolism, this relation as it exists in man has not been satisfactorily studied. We have attempted to fill this gap.

Repeated simultaneous determinations of plasma and urinary potassium concentrations were made upon 3 normal adult male subjects maintained on diets of approximately constant potassium content. The water content was varied within wide limits. With extreme water deprivation, urine flow rates as low as 0.5 cc per min. were obtained; while with ingestion of excess water, the flow reached 6 or more cc per min. Urine was collected for one 2-hour period, in the middle of which blood was drawn for analysis. The blood was oxalated and centrifuged immediately at 3000 rpm for 20 minutes. Potassium was determined on ashed urine and plasma by the method of Kramer and Tisdall.[1, 2] Special precautions were taken to prevent loss of precipitate in washing. The subjects carried on regular laboratory work during the experimental periods.

The excretion rates have been expressed as clearances (C), calculated by the conventional formula:

$$C = \frac{U\ V}{P}$$

in which U is the concentration of potassium in the urine (mg per cc), V the volume of urine (cc per min.), and P the plasma potassium concentration (mg per cc). The plasma potassium concentrations (means with standard errors of means) were: Subject L, 16.4 ± 0.2; Subject C, 16.5 ± 0.6; and Subject H, 17.9 ± 0.4 mg per 100 cc.

From Fig. 1, in which the clearances are plotted against the rates of urine flow, it may be seen that, over a wide range of flow rates,

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1 Kramer, B., and Tisdall, F. F., *J. Biol. Chem.*, 1921, **46**, 339.

2 Tisdall, F. F., and Kramer, B., *J. Biol. Chem.*, 1921, **48**, 1.

the clearance remains constant. Below about 0.6 cc per sq m per min ("the augmentation limit"), the clearance falls sharply in all 3 subjects. Since, according to Chesley,[3] the glomerular filtration rate begins to fall off as the urine flow reaches approximately this value, it is probable that the decrease in potassium clearance at urine flow rates below the observed augmentation limit is due to a reduction in glomerular filtration.

The observations of Griffon[4] apparently showed that the rate of potassium excretion in man was proportional to the rate of urine flow. However, he confined his observations to the range of 0.35 to 1 cc per min., and was thus working largely below the augmentation limit. On the other hand, the data of Cutler, Power and Kendall[5] suggested that in normal human subjects potassium excre-

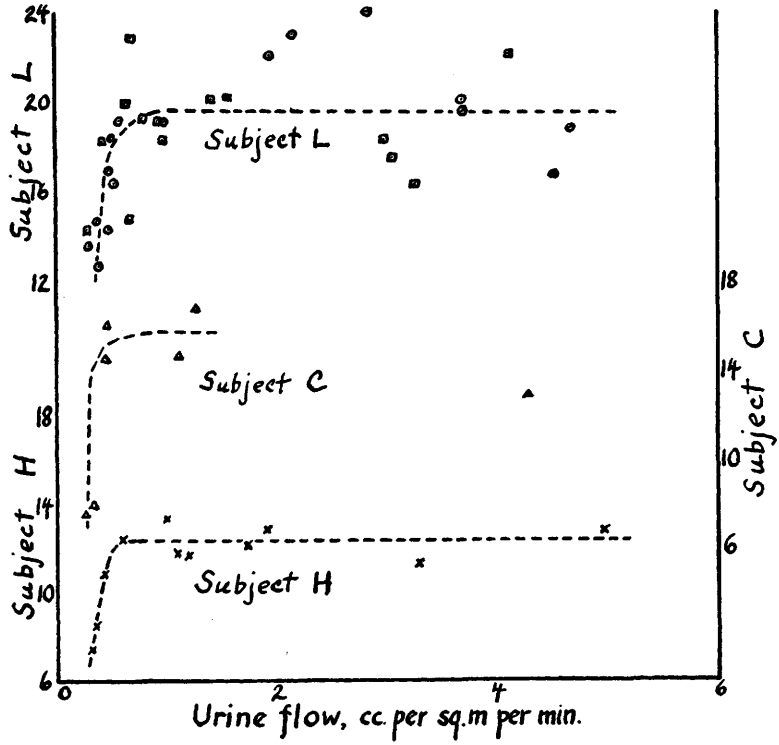

FIG. 1.

Effect of urine flow rate on potassium clearance in normal male subjects. Clearances (ordinates, with separate scales for each subject) are stated as cc plasma cleared per min.

3 Chesley, L. C., *J. Clin. Invest.*, 1938, **17**, 591.

4 Griffon, H., *Comp. rend. Soc. de Biol.*, 1936, **121**, 47.

5 Cutler, H. H., Power, M. H., and Wilder, R. M., *J. Am. Med. Assn.*, 1938, **111**, 117.

tion was independent of urine flow. All the flow rates of these investigators now appear to have been above the augmentation limit. Our observations confirm and reconcile the findings of both these groups of workers.

The clearance ("maximal") of our 3 subjects averaged about 16 cc per sq m per min. Since the glomerular filtration rate of normal subjects is about 69 cc per sq m per min, potassium must be reabsorbed by the kidney tubules. Since both the rate of glomerular filtration and the rate of potassium excretion remain constant over a wide range of urine flow rates, the rate of tubular reabsorption must also remain constant. Accordingly, the concentration of potassium in the tubular urine may vary widely without causing changes in the rate of tubular reabsorption. Such reabsorption cannot therefore be entirely a passive process resulting from the gradient established by the reabsorption of water.

The factors controlling such reabsorption are now under investigation in this laboratory.

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Hemolytic Action of Fluorides on Certain Nucleated Erythrocytes.

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In a study of CO_2 dissociation curves of dogfish blood (Ferguson, Horvath and Pappenheimer[1] it was observed that sodium fluoride added to prevent glycolysis caused a slowly progressive swelling, usually ending after 3 to 10 hours in hemolysis. Hemolysis of fish blood by oxalate has been observed by Black and Irving.[2] The effects of several fluorides, oxalates and other salts have been tested on the blood of various species with nucleated erythrocytes. One tenth molar and molar solutions of the salts were added to 9 times their volume of the blood to be tested, which had previously been defibrinated. The final concentration of the salts was, in one series, one-hundredth molar and, in the other, one-tenth molar. In the first series the final solution bathing the cells would be slightly

[1] Ferguson, J. K. W., Horvath, S. M., and Pappenheimer, J. R., *Biol. Bull.*, 1938, **75**, 381.

[2] Black, E. C., and Irving, Laurence, *J. Cell. Comp. Physiol.*, 1938, **12**, 255.