Magnesium and Calcium Content of Hedgehog Serum during Hibernation

OUR knowledge of the mineral metabolism of hibernation is still very meagre. I have therefore investigated, among other questions, the magnesium and calcium content of hedgehog serum. Part of the animals were analysed in early October, about four to five weeks before the final onset of hibernation, and others in early January when the hibernation was at its deepest. Calcium was determined by Kramer and Tisdall's method; magnesium was precipitated as magnesium ammonium phosphate according to Rappaport[1], and the phosphorus was determined colorimetrically with a Zeiss Pulfrich-photometer according to the amidole method of Müller[2].

In autumn, before the onset of hibernation, the magnesium content of the hedgehog serum averaged 3·20 mgm. per cent. The series comprised seven animals, the magnesium content varying from 2·90 to 3·55 mgm. per cent. The calcium content of the serum of these animals averaged 10·0 mgm. per cent, with variations ranging from 9·2 to 10·6 mgm. per cent. The average ratio calcium to magnesium was 3·15.

In the beginning of January the hedgehogs were in deep hibernation. The magnesium content of the serum then averaged 5·43 mgm. per cent. The series consisted of six animals, the variations in the magnesium content being 4·90–6·05 mgm. per cent. The calcium content in the serum of these animals averaged 10·2 mgm. per cent, varying from 9·6 to 10·7 mgm. per cent. The average ratio calcium to magnesium was 1·88. It is seen that the magnesium content of the hedgehog serum has increased considerably during hibernation. In the above experiments, the magnesium value during the deepest hibernation in mid-winter was 170 per cent of the corresponding value in autumn, before the onset of sleep. On the other hand, the calcium content remains constant. This causes a decrease in the ratio.

It seems that the increase of the magnesium content of the serum during hibernation is an important phenomenon in general biology. Lustig, Ernst and Reuss[3] have recently shown that there is a considerable increase also in the magnesium content of the blood of Kursiv during winter torpor. It is known that the most striking effect of the magnesium ion is its power to produce anæsthesia. It has an anæsthetic effect on several invertebrates of sea and fresh water and, as shown already by Meltzer and Auer[4], also on vertebrates. The anæsthesia disappears if some calcium is injected into an animal previously treated with magnesium. In view of these results, it is interesting to note that, according to my determinations, there is not only an increase in the magnesium content of the serum of the hibernating hedgehog, but also a considerable change in the ratio calcium to magnesium.

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A Contradiction in the Present Clearance-Reabsorption Views of Urea Excretion

BEYOND a certain rate of urine flow, for man, dog, rabbit, etc., and provided the blood concentration does not exceed a concentration of about 200 mgm./100 ml., the following equation holds approximately:

$$\frac{\text{Output of urea}}{\text{Blood conc.}} = \text{constant},$$

and has been chiefly demonstrated by the work of Addis and Drury[1]. The constant of this equation has been interpreted as a volume of blood per minute by Van Slyke and Peters[2] and called a 'clearance', since it has also the dimensions of a volume. The interpretation is here particularly unsafe since a much better equation applying over the whole range of urine volume gives a constant with no such dimensions (a diffusion pressure equation).

The explanation given of the constancy is that there is a constant filtration rate at the glomerulus and that variations in the urine volume excreted are almost altogether due to different volumes of water reabsorbed. Since, however, the inulin clearance is about twice that of the urea[3] and inulin is not regarded as actively excreted by tubular action, it must necessarily follow that about half the glomerular output of urea is reabsorbed in the passage through the tubules. It is this view that contains an inherent contradiction.

To demonstrate this, we may suppose that the subject (human) is excreting at a rate of 200 ml. urine per hour and at a blood urea concentration of 20 mgm./100 ml., this being achieved by water drinking. After the water diuresis has passed, urea is administered so that the blood concentration reaches 80 mgm./100 ml. and the urine rate again reaches 200 ml. per hour. There is now a general agreement that—at least within 10 per cent—the average clearance value will be the same as before. This can only mean on the above view that four times the amount of urea is being reabsorbed back across the tubule, and hence the conclusion that urea is reabsorbed back in proportion to its lumen concentration is inevitable.

It may then be supposed that the subject drinks water so that his urine rate reaches 800 ml. per hour. The clearance will remain unchanged, so that the amount of urea reabsorbed is the same as before, but at the same time the lumen concentration has fallen to upwards of one fourth its previous value, from which we may conclude in turn that the back absorption of urea is independent of its lumen concentration. This contradicts our previous conclusion.

Put in another way, it may be said that from the present clearance-reabsorption views, the excretion of urea or urea clearance should rapidly and asymptotically approach that of inulin beyond a urine rate for the human subject of about 120 ml. per hour. Of this it may be said with certainty there is no sign; since even if recent work[4] has shown a rise in the urea clearance with increasing rate, it goes parallel to the inulin clearance, which has been regarded as a standard for measuring the glomerular filtrate.

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