EFFECT OF CHANGES IN THE INTRAVASCULAR AND INTERSTITIAL FLUID VOLUMES ON SODIUM EXCRETION BY THE RAT KIDNEY

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After intravenous injection of plasma, isotonic and hypotonic (0.45%) NaCl solutions, and isotonic urea solution into rats the volume of the total extracellular space and its intravascular and interstitial components was increased to a varied degree. Analysis showed direct correlation between the change in volume of the intravascular space and sodium excretion. A similar relationship was found between the change in the intravascular volume and the sodium-excretory activity of blood plasma. Consequently, changes in the sodium-excretory function of the kidneys take place in response to an increase in volume of the intravascular, but not of the interstitial space.

Besides regulation of the constancy of the osmotic pressure of the body fluids, regulation aimed at maintaining the constancy of the fluid volume plays an important role in the maintenance of water and mineral homeostasis. With a decrease in the extracellular volume sodium retention usually develops, while an increase in its volume is associated with increased excretion of this cation [5, 9]. A hypothetical sodium-excretory factor, whose concentration in the blood rises considerably during these conditions, is attributed an important role in the mechanism of the increased sodium excretion in response to expansion of the extracellular space [7]. An increase in sodium excretion has been observed by some workers in response to an increase in the volume of interstitial fluid [4, 10], and by others [11] in response to an increase in the volume of the intravascular fluid. In the latter case, however, a hyperoncotic solution of albumin was injected intravenously and this not only increased the volume of intravascular fluid but also reduced the volume of the interstitial compartment.

Considering the contradictory nature of the existing evidence, it was decided to carry out experiments on rats to determine the increase in excretion of sodium by the kidneys in response to an increase in the volume of each compartment of the extracellular space.

EXPERIMENTAL METHOD

Experiments were carried out on 20 rats weighing 80-150 g and lightly anesthetized with pentobarbital (20-25 mg/kg). The total extracellular and the intravascular spaces were measured in each rat and the interstitial space calculated; the excretion of sodium in the urine was determined and the sodium-excretory activity (SEA) of the blood plasma estimated (in %). These indices were determined in the same rats after expansion of the water compartment, when each rat received only one of the solutions used. To increase the total extracellular space and the volume of intravascular fluid to different degrees, the rat was injected with plasma obtained from another animal in a dose of 2% of the body weight, isotonic and hypotonic (0.45%) sodium chloride solution, and isotonic urea solution in a dose of 3% of the body weight. Injection of the fluid usually continued for 15-20 min.

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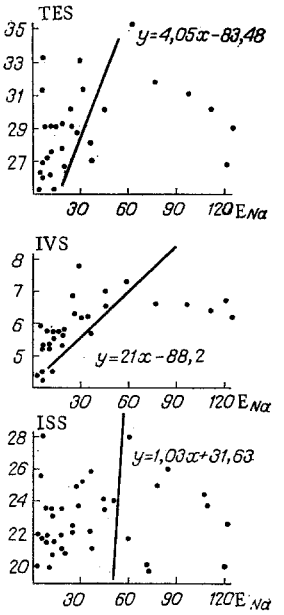

Fig. 1

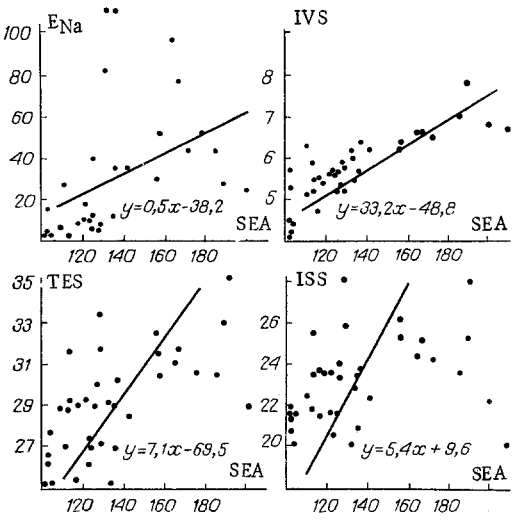

Fig. 2

Fig. 1. Correlation between change in water spaces in rats and sodium excretion. TES) total extracellular space; IVS) intravascular space; ISS) interstitial space (in % of body weight); E_{Na}) sodium excretion (in eq/h).

Fig. 2. Correlation between change in water spaces in rats and sodium-excretory activity of blood plasma. Legend as in Fig. 1.

The extracellular space was determined by intravenous injection of sodium thiocyanate into the animals in a volume of 0.3 ml of a 5% solution [1]. To determine the plasma volume, the dye Evans' blue was injected intravenously in a dose of 0.3 ml of a 0.15% solution [8]. The interstitial space was calculated, in addition to the difference between the total extracellular space and the intravascular fluid volume. The water compartments of the body were expressed as percentages of the body weight.

The SEA of the blood plasma was determined by a biological method [6] and expressed as a percentage of increase of sodium excretion after injection of 0.3 ml plasma into hydrated rats anesthetized with ethanol. The SEA of the plasma is an indirect index of activity of the sodium-excretory factor [6].

Sodium in the urine was determined by flame photometry. One week before the experiment an operation was performed on the rats to form a "microbladder" so that the urine could be collected at short time intervals.

The results were subjected to statistical analysis with determination of the general correlation coefficient (r) and a special coefficient of correlation (ρ) and the criterion of significance (P) [2, 3].

EXPERIMENTAL RESULTS AND DISCUSSION

After intravenous injection of plasma, isotonic and hypotonic (0.45%) sodium chloride solutions, and isotonic urea solution the total extracellular space was expanded to a different degree, and varied increases also took place in its intravascular and interstitial compartments. The results given in Fig. 1 show that correlation between the change in the total extracellular space and the sodium excretion is not significant ($r = +0.279$; $P > 0.05$). Positive correlation was found between the change in the intravascular space and sodium excretion ($r = +0.545$; $P < 0.001$). No correlation was found between the change in volume of the interstitial fluid and sodium excretion ($r = +0.063$; $P > 0.05$). These results indicate that an increase only in the volume of intravascular fluid causes changes in the sodium excretion following injection of the various fluids.

The results in Fig. 2 show a positive correlation between the SEA of blood plasma and sodium excretion ($r = +0.514$; $P < 0.001$).

Determination of the coefficient of correlation between the change in extracellular fluid volume and SEA showed that it is positive ($r = +0.547$; $P < 0.001$). The coefficients of correlation also were calculated between changes in the plasma volume and volume of the interstitial fluid, on the one hand, and SEA on the other hand. A sufficiently high positive correlation was found between the change in intravascular fluid volume and SEA ($r = +0.823$; $P < 0.001$). A direct connection also was found between the changes in the interstitial fluid volume and SEA ($r = +0.345$). However, the index of significance of this coefficient ($P < 0.05$) was much lower.

In the analysis of the results by the partial correlation method (assuming that the plasma volume is constant) revealed no correlation between the interstitial fluid volume and SEA of the blood plasma ($\rho = -0.027$; $P > 0.05$). Consequently, an isolated change in the interstitial fluid volume has no effect on the SEA of the blood plasma; this index is entirely dependent on changes in the volume of intravascular fluid.

The results described above thus indicate that changes in the sodium-excretory function of the kidneys take place in response to an increase in the volume only of the intravascular space and not of the interstitial space.

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