EFFECT OF WATER DEPRIVATION AND PROLONGED OVERHEATING ON DISTRIBUTION OF ACID MUCOPOLYSACCHARIDES IN THE RENAL MEDULLA OF ALBINO RATS

T. L. Dubynin

UDC 616.61-008.939.951-02:[616.395+614.873.24

If rats are deprived of water, depolymerization of acid mucopolysaccharides takes place only in the distal region of their accumulation at the apex of the papilla in the renal medulla. In a dry, hot climate, and if the rats are allowed free access to water, morphological signs of intensive diuresis are observed in the renal papilla.

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Comparative studies show that in mammals a direct connection exists between availability of water in the habitat of a given species and the character of the reflux system of the renal medulla, including the loop of Henle of the various types of nephrons, the collecting tubules, the specialized capillary network, and the interstitial tissues of this part of the kidney, containing large quantities of acid mucopolysaccharides [1-8].

The distribution of acid mucopolysaccharides in the interstitial tissues of the renal papilla of albino rats was studied in the present investigation in animals exposed for a long period to a high external air temperature and deprivation of water.

EXPERIMENTAL METHOD

Experiments were carried out on albino rats weighing 220-270 g, of which 5 were controls, 5 were subjected to hyperhydration by subcutaneous injection of physiological saline at 37° at the rate of 10% of the body weight, 24 rats were kept without water for 4-12 days, 6 rats were deprived of water for 6-12 days and were given water to drink until their thirst was completely quenched 30-40 min before sacrifice, 2 rats were sacrificed 30 min after receiving a subcutaneous injection of 0.2 unit pituitrin P, and 10 animals were kept in a vivarium in the city of Ashkhabad during the summer of 1967.

The kidneys were removed and fixed at 4° in 10% formalin. Blocks of tissue were then cut from them to contain a complete pyramid, embedded in paraffin wax, and cut into serial sections in three mutually perpendicular planes: horizontal, vertical, and a plane perpendicular to the long axis of the pyramid. The sections were stained with hematoxylin-eosin, picrofuchsin-fuchselin, and by the Ritter-Oleson method, with salivary amylase and testicular hyaluronidase controls.

EXPERIMENTAL RESULTS

In the normal animal acid mucopolysaccharides are concentrated in the interstitial tissue of the apex of the papilla and at the base of the papilla (at the border between the outer and inner zones of the pyramid); a small amount of Hale-positive substances is found in the interstitial tissue between these portions. Parts of the interstitial tissues forming nonhomogeneous sleeves around the collecting tubules and ducts of Bellini are of considerable thickness, comparable to the thickness of the wall of the corresponding structures. Inside the interstitial sleeves a few capillaries can be seen, and columns of erythrocytes are sometimes visible in the capillaries of the apex of the papilla.

In the hyperhydrated animals no appreciable differences were found in the distribution of acid mucopolysaccharides. The Hale-positive substance of the apex of the papilla was more homogeneous in character.

Institute of Human Morphology, Academy of Medical Sciences of the USSR, Moscow (Presented by Active Member of the Academy of Medical Sciences of the USSR A. P. Avtsyn). Translated from Byulleten' Éksperimental'noi Biologii i Meditsiny, Vol. 67, No. 1, pp. 91-94, January, 1969. Original article submitted December 29, 1967.

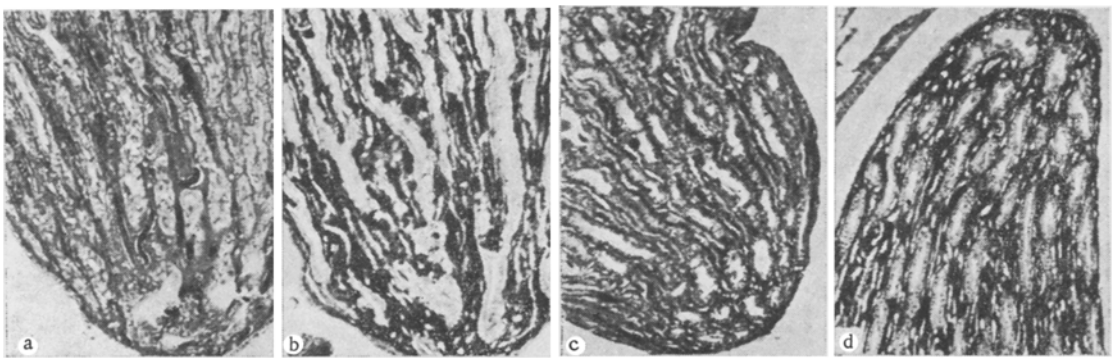

Fig. 1. Acid mucopolysaccharides in interstitial tissue of apex of papilla in the renal medulla. a) Water deprivation for 6 days; b) ditto after restoration of diuresis; c) after injection of pituitrin; d) rats kept in a dry, hot climate with excess of water. Stained by Ritter-Oleson method, 75 ×.

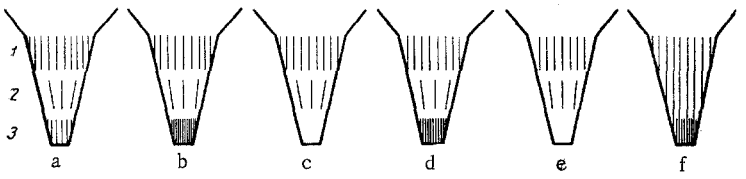

Fig. 2. Scheme of distribution of acid mucopolysaccharides in the papilla of the renal medulla of rats kept under different conditions. 1) Proximal accumulation of acid mucopolysaccharides; 2) intermediate part; 3) distal collection; a) usual distribution; b) 1 h after subcutaneous injection of physiological saline; c) water deprivation for more than 6 days; d) 30 min after end of drinking by rats previously deprived by water for 6 days; e) 1 h after subcutaneous injection of pituitrin; f) kept in a dry, hot climate with free access to water.

In rats kept without water diuresis stopped on the 2nd-4th day, and on the 5th-6th day the rats stopped eating. Changes in the distribution of acid mucopolysaccharides affected mainly the apical accumulation, and the intermediate part to a lesser degree. Starting from the 2nd day, the content of acid mucopolysaccharides was reduced. By the 4th-5th day of water deprivation, Hale-positive material had disappeared completely from the apical region. Its place was occupied by PAS-positive material, which did not disappear if the sections were treated with hyaluronidase or amylase. The PAS-positive basement membranes of the tubules, collecting tubules, ducts, and capillaries showed no appreciable changes. The lumen of the ducts of Bellini was comparatively narrow. The capillaries of this region were widely open and contained homogeneous plasma. Hale-positive material had disappeared almost completely from the intermediate part of the papilla.

In animals receiving dry food and sacrificed 30-40 min after free access to water a higher content of acid mucopolysaccharides and dilated capillaries filled with plasma were observed in the interstitial tissue of the apex of the papilla.

The interstitial tissue of the apex of the papilla in rats receiving pituitrin P had lost its acid mucopolysaccharides, and this part of the papilla appeared shrunken. In the middle part of the papilla the Hale-positive substance also had almost completely disappeared. The vasa recta, distended with plasma, were now visible.

In the rats spending summer in Ashkhabad the interstitial tissue of the papilla contained large quantities of Hale-positive material, and the content of acid mucopolysaccharides in the interstitial tissues of the middle part of the papilla was almost identical with that in the apical and proximal parts (Fig. 1).

Hence, the renal papilla of rats contains areas of accumulation of acid mucopolysaccharides which respond in different ways to various factors: the accumulation of acid mucopolysaccharides at the apex of the papilla can modify its staining properties rapidly, whereas the proximal accumulation does not behave in this way (Fig. 2). These differences can be explained by the complex topographic relationships developing between the structures of the loop of Henle, the collecting tubules, the ducts of Bellini, and the capillary system during adaptation of the species to the external environment.

These results suggest the presence of a morphological syndrome characterizing the state of antidiuresis associated with water deprivation: depolymerization of acid mucopolysaccharides in the distal region of their accumulation in the renal pyramid, accompanied by opening of capillary loops and their overfilling with plasma [2].

Changes in the distribution of acid mucopolysaccharides in the renal papilla in rats kept in a dry, hot climate and allowed free access to water are evidently an adaptation to maximal diuresis. In a hot, dry climate the loss of water rises sharply. In the existing view this takes place in rodents purely through the respiratory tract and the surface of the mucous membrane of the mouth [3]. Consumption of an excess of water under these conditions (as a result of the constant thirst associated with inadequacy of the mechanism of heat output) can cause a simultaneous increase in diuresis, and this must evidently be reflected in the morphological changes observed in the kidneys.

Bearing in mind the comparative inertia of the proximal portions of the papilla, the accumulation of acid mucopolysaccharides in the proximal and intermediate part must probably be interpreted as an adaptive change connected with disturbance of the hormonal regulation of urine excretion.

Hyperhydration, produced by subcutaneous injection of physiological saline, is evidently not characteristic of the mode of existence of the species, and for that reason the reaction to it was therefore marked only by slight quantitative changes, reflected in homogenization of the accumulations of acid mucopolysaccharides.

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