CONTENT AND FUNCTIONAL HISTOTOPOGRAPHY OF ZINC IN THE KIDNEYS

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In experiments on albino rats the content of zinc in the kidneys was studied polarographically and its histotopography was studied histochemically by the silver sulfide method. The content of zinc in the renal cortex was 4-5 times higher than in the medulla. The histochemical method showed that zinc is distributed irregularly in the kidney and is concentrated in structures with the highest functional activity. The highest concentration of zinc is found in the cytoplasm of cells of the juxtaglomerular apparatus, in the brush border of cells in the proximal portion of the nephron, in the ascending part of the loop of Henle, and in the cytoplasm of cells in the distal portion of the nephron. After unilateral nephrectomy the zinc content in the renal cortex rose considerably during the first days after the operation, but after completion of hypertrophy of the residual kidney it fell to its initial level.

Zinc is a trace element with an important role in cell metabolism [2]. It is an essential metallic component of certain enzymes [8, 9] and an activator of hormones and of certain enzymes of which it is not a component [4]. A study of zinc metabolism in various organs has shown that its content is higher in the endocrine glands than in other organs [2]. The degree of accumulation of zinc in the cytoplasm of the endocrine cells is directly proportional to their functional activity [5].

An increase in the zinc concentration is also observed in some cell structures whose function requires the active participation of enzymes [6].

In the accessible literature no results of investigations to study the histotopography of zinc in the kidneys could be found. Information was given only on the total zinc content in the kidneys of certain animals [2, 4]. This information is inadequate, if only for the reason that the cortex and medulla of the kidney differ from each other both functionally and morphologically.

Since the juxtaglomerular apparatus possesses an endocrine function and since enzymes participate in reabsorption in the tubules of the nephron [10], the study of the histotopography of zinc in the kidney is of considerable interest.

The object of the investigation described below was to study the content and distribution of zinc in the kidneys under normal conditions and during increased functional activity of the nephrons and juxtaglomerular apparatus.

EXPERIMENTAL METHOD

Experiments were carried out on 30 male albino rats weighing 100-120 g. To increase the intensity of function of all parts of the nephron, unilateral nephrectomy was performed on the experimental animals (the right kidney was removed from 15 and the left from another 15 rats). The kidneys which were re-

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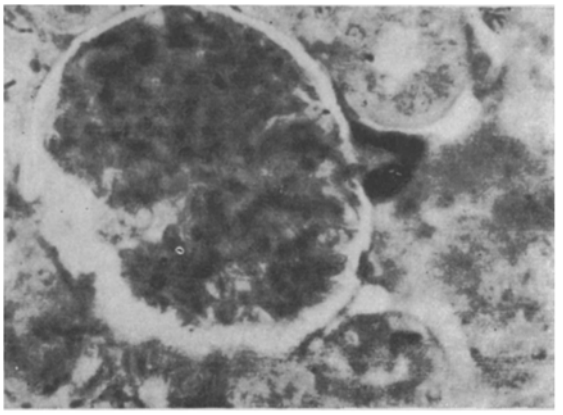

Fig. 1

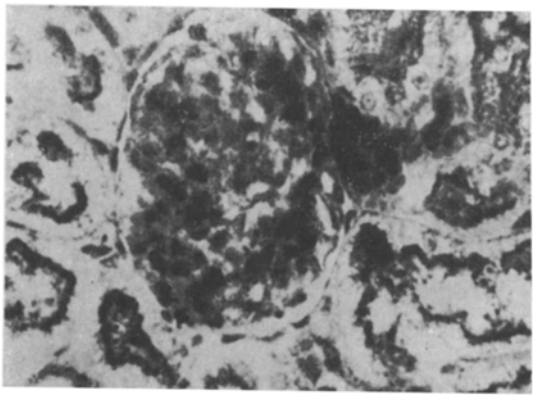

Fig. 2

Fig. 1. Reaction for zinc in the renal cortex of an albino rat. Photomicrograph 400×. Silver sulfide method. Counterstained with hematoxylin.

Fig. 2. Reaction for zinc in renal cortex of albino rat 5 days after unilateral nephrectomy. High concentration of zinc in cells of juxtaglomerular apparatus and in brush border of cells in proximal portion of nephron. Photomicrograph, 400×. Silver sulfide method, counterstained with hematoxylin.

moved were used as the controls. The rats were sacrificed 5, 10, and 50 days after the operation. The kidneys investigated (including the controls) were subjected to histological and histochemical tests for the detection of zinc. The total zinc content in the kidneys was determined polarographically [1]. For this purpose small pieces were taken separately from the cortex and medulla of each kidney, incinerated, and the zinc in the ash was then estimated. Zinc was demonstrated histochemically in other pieces of kidney by the silver sulfide method [7]. The essence of this method is that by fixation in 70° alcohol saturated with hydrogen sulfide the zinc in the tissues is converted into zinc sulfide, an active catalyst. If material fixed in this way is treated with a reagent consisting of a solution of hydroquinone, gum-arabic, and silver nitrate, the silver salt is reduced and deposited as brown granules in regions richest in zinc.

EXPERIMENTAL RESULTS

The mean relative weight of the removed (control) kidneys was 400 ± 9 mg.

Determination of the zinc content by the polarographic method showed that it is considerably higher in the cortex than in the medulla. The content of zinc in the cortical tissue was 2.27 ± 0.5 mg%, but in the medulla it was only 0.57 ± 0.5 mg%.

In sections treated by the silver sulfide method and stained with hematoxylin all the histological structures of the kidney were clearly defined. Brown granules of reduced silver, indicating the localization of zinc, were distributed mainly in the histological structures of the cortex, clearly distinguishable by its darker staining.

The section illustrated in Fig. 1 shows that the zinc concentration was highest in the cytoplasm of the granular cells of the afferent arteriole of the renal glomerulus and the dense spot of the nephron. Later an increased zinc content was also found in the region of the brush border of the principal part of the nephron. In the cell cytoplasm in the accessory part of the nephron and in the ascending part of the loop of Henle there was also an increased content of zinc, although its distribution here was diffuse. Only a small quantity of zinc was found in the descending parts of the loop of Henle and in the collecting tubules, so that the renal medulla appeared much paler than the cortex.

The assumption that the zinc content was increased in the juxtaglomerular apparatus was accordingly confirmed. This increased accumulation of zinc in the juxtaglomerular complex is further evidence of the endocrine nature of this structure.

The next part of the investigation was to study zinc metabolism in the kidneys when their functional load is increased (after unilateral nephrectomy). In these experiments the mean weight of the kidney 5 days after the operation was 450 ± 5 mg, 10 days after it was 550 ± 8 mg, and 20 days after the operation 600 ± 7 mg. Twenty days after the operation the weight of the kidney thus showed a compensatory increase of 50%.

The zinc content in the cortex of the residual kidney 5 days after the operation averaged 3 ± 0.3 mg%, 10 days after the operation 2.5 ± 0.8 mg%, and 20 days after the operation 2 ± 0.8 mg%.

Clearly, therefore, during the first days after unilateral nephrectomy the zinc content in the cortex rose sharply, after which it fell gradually, returning to its initial level after 20 days.

It is interesting to note that the increase in the zinc content in the kidney after unilateral nephrectomy was confined entirely to the cortex. Its content in the medulla remained approximately the same as in the control (0.5-0.6 mg%).

The distribution of zinc in sections from the residual kidney stained by the silver sulfide method 5 days after unilateral nephrectomy was the same as in the control kidneys. However, its concentration in the cell cytoplasm of the juxtaglomerular apparatus and in the region of the brush border of the cells in the principal part of the nephron was considerably higher, and the brush border itself was wider (Fig. 2).

The zinc content in the histological structures of the kidney 20 days after unilateral nephrectomy was about the same as in the control kidneys.

The results of this investigation show that zinc is localized in the kidney mainly in the cytoplasm of cells belonging to the juxtaglomerular apparatus, with an endocrine function, and in those parts of the nephron which are responsible for reabsorption. The concentration of zinc in these structures is increased to correspond to the increased functional activity of those portions of the nephron.

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