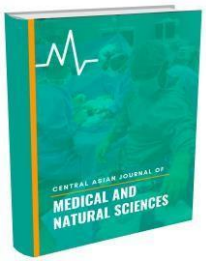

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Article

Morphometric Characteristics of Normal Rat Kidneys at 3 Months of Age

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Abstract: This study presents a detailed morphological and morphometric evaluation of the kidneys in 3-month-old white rats. The analysis included measurements of afferent and efferent arteriolar diameters, glomerular and renal corpuscle dimensions, as well as morphometric parameters of proximal and distal tubules and the thickness of cortical and medullary layers. Histological examination revealed a fully completed nephrogenesis, structurally mature glomerular filtration apparatus, high nephron density, and pronounced reabsorptive activity of the tubular system. These findings confirm the morphological maturity and high functional capacity of the kidneys at this age.

Keywords: Kidney Morphology, Morphometry, Nephron, Glomerulus, Proximal Tubule, Experimental Rats, Renal Histology

1. Introduction

The kidneys are one of the most necessary organs in the human body that are considered essential for survival [1]. Their function will have a much wider scope than the role of a simple "cleaning filter", they are a multifunctional biological system that provides homeostasis, detoxification, hormonal regulation and maintaining internal environmental constancy [2]. The kidneys retain proteins, carbohydrates and useful electrolytes in the body and at the same time filter out unnecessary and harmful substances from plasma [3]. This is a very complex selective filtration system, which cannot be directly influenced by any external factors. The kidneys control the amount of water in the body, the concentration of sodium, potassium, calcium, magnesium, chlorine, and phosphates, and the pH of the blood [4]. This helps maintain a stable internal environment, which is essential for the functioning of all organs, from the heart to the nervous system [5].

Objective of the study: to study the structural features of the kidneys at 3 months of age.

2. Methodology

The animals used in the experimental study were male albino rats weighing from 220 ± 20 grams aged 12 weeks (3 months), n = 15.

After macroscopic assessment of the removed organ, histological preparations of the kidneys were prepared [6]. Deparaffinized sections were stained with hematoxylin and eosin (HE) [7]. After staining, the sections were dehydrated in ethanol series, cleared in xylene and covered with a coverslip [8].

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The following kidney parameters were studied: - Diameters of afferent and efferent arterioles, μm; - Glomerular diameter, μm; - Total number of glomeruli (in the cortex, in the entire kidney per 1 mm^3); - Diameter of convoluted tubules of the proximal and distal sections; - Diameter of renal corpuscles; - renal corpuscle capsule volume; - capsule thickness; - epithelial cell height; - cortex width; - medulla width [9].

The study materials were statistically processed using parametric and nonparametric analysis [10]. The accumulation, adjustment, systematization of initial data, and visualization of the obtained results were performed in Microsoft Office Excel 2010 spreadsheets. Statistical analysis was performed using IBM SPSS Statistics v.23 (developed by IBM Corporation) [11].

3. Results and Discussion

The kidneys of 3-month-old intact albino rats exhibit a complex of features consistent with the stage of complete nephrogenesis and active functional activity [12]. When examining the general appearance of the organ, it was found that the cortex and medulla are clearly separated from each other, there is a vascular network sufficient to supply the organ with blood, and densely located nephrons. This indicates that the organ is at a stage of full functional capacity [13].

In white outbred rats of this age category, the cortex occupies a relatively large part of the total volume of the kidney, the main reason for this is the large number of renal corpuscles in the renal nephrons and the dense dilation of the proximal tubules of the nephron [14]. The medulla is fully developed, the loops of Henle in the nephron are mainly located in an upright position, which is of particular functional importance in the process of urine formation [15].

In 90-day-old rats, the lumen size of the afferent arterioles is 14-16 μm. These dimensions ensure sufficient blood flow to the renal corpuscle, as well as low intravascular resistance. The diameter of the efferent arteriole is 11-14 μm, which is smaller than the afferent, but still corresponds to normal dimensions and maintains the same pressure in the corpuscle. In some narrowed areas, this size has been observed to decrease to 4.3–5.7 μm. This reflects precise control of vascular tone and the ability of the filtration apparatus to quickly adapt to fluctuations in systemic hemodynamics.

Thus, the glomerular vascular bed in 3-month-old animals is morphologically and functionally intact, confirming an active level of glomerular filtration.

Analysis of the glomerular apparatus size demonstrates significant filtration activity at this age.

The diameter of the vascular glomerulus was 100–105 μm, and the diameter of the renal corpuscle was 113–118 μm, which corresponds to physiological norms and reflects the preservation of the glomerular size to Bowman's capsule ratio. The capsule area was found to be 150 to 165 units. This indicates the absence of various pathological processes, in particular, hypofiltration, inflammation, sclerosis, and the area was not pathologically enlarged or narrowed.

The number of glomeruli in each kidney was recorded as 29,000 to 33,000. This is also an average normal indicator and is a clear indication that they are not damaged due to congenital or acquired defects.

The cross-sectional area of the proximal convoluted tubules averaged 240–250 $μm^2$, and their lumen was within 9–10 μm. The ratio of diameter to cross-sectional area indicates that the reabsorption process is intensive. Through this, active absorption of various electrolytes, including sodium, water, amino acids, and glucose, occurs.

The cross-sectional area of the distal convoluted tubules was approximately 155–165 $μm^2$, and the lumen was 12–13 μm. This indicator corresponds to the data in the literature and is considered normal. Processes related to the transport of electrolytes are actively

carried out in these tubules. The indicators confirm that the processes are proceeding normally. The thickness of the medullary part is 3.34–3.54 mm, which indicates the absence of pathology in the formation of the loop of Henle and collecting ducts (Fig. 1).

The ratio of the cortical and medullary layers of 0.78–0.85:1 demonstrates the level of complete morpho-functional functioning of the organism without any problems.

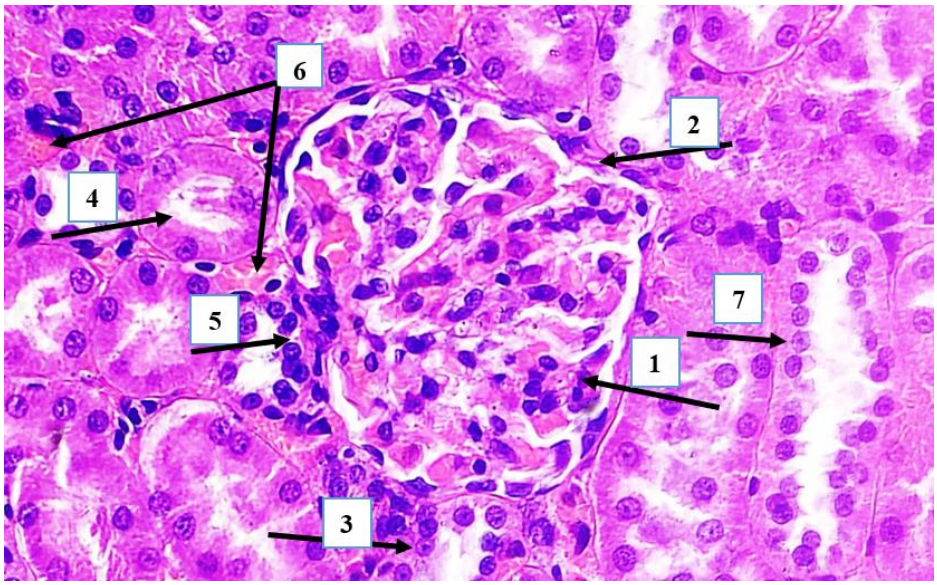

Figure 1. Histological appearance of a 3-month-old white outbred rat kidney. Stained with hematoxylin and eosin. Magnified 400 times. 1 - renal corpuscle; 2 - glomerular capsule; 3 - distal convoluted tubules; 4 - proximal tubules; 5 - macula densa of the distal tubule; 6 - peritubular rete capillaries; 7 - collecting duct.

Thus, during the histomorphometric examination, the following results were obtained:

1. The normal size of the afferent and efferent arterioles provides a sufficient volume of blood flow, which creates optimal conditions for the filtration process.
2. The position of the renal corpuscle, the size of the capsule cavity around it also contribute to the normal filtration process.
3. The diameter of the tubules in the nephrons, the thickness of the epithelial layer stimulate the reabsorption process.
4. The almost ideal ratio in the corticomedullary structure indicates the stable functioning of the organ.

4. Conclusion

The kidneys of 90-day-old white outbred rats are well-formed from a morphofunctional point of view, indicating a completed stage of nephrogenesis. The dimensions of the renal corpuscles, capsules, and tubules indicate that the organ is functioning at a highly active level.

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