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# Functional Morphology of the Kidney

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**Abstract:** The article presents an overview of the functional morphology of the human and rat kidneys in a comparative aspect. The significance of the kidneys for the infant in the dynamics of early postnatal ontogenesis is also indicated.
**Key words:** nephron, cortical, juxtamedullary, kidney function.

**Relevance**. The excretory system of humans and animals is characterized by both the complexity of organization and the highest level of integration with other functional systems. With the blood supply system, the kidney structurally and functionally regulates blood pressure, acid-base balance; ion exchange, carries out remodeling of the heart and blood flow in the systemic and pulmonary circulation. As one of the important organs for ensuring and regulating homeostasis, it selectively removes end products of metabolism, osmotically active substances, cations and anions from the body. In addition, the kidneys are involved in the synthesis of a number of biologically active substances (erythropoietin, erythropoiesis inhibitor, dopamine, renin, Ca2+, PO4-3 metabolism regulators, prostaglandins, etc.) [4, 5, 24, 43].

The main functions of the kidneys:
1. Osmoregulation
2. Volume regulation
3. Ionic regulation (K+, Na+, Ca2+, Po4 -3, C1-, etc.)
4. Excretion of end products of metabolism
5. Regulation of the acid-base state of the blood
6. Metabolism of proteins, fats and carbohydrates
7. Synthesis and secretion of biologically active substances (renin, erythropoietin, kinins, Vi + D3, etc.)

These functions are provided by the following physiological processes: 1. Ultrafiltration; 2. Reabsorption; 3. Secretion; 4. Integration within and between systems [26, 44, 48].

The structural and functional unit of the kidney is the nephron. This is a system of tubules connected in series with each other, integrated in function - filtration, secretion and reabsorption to maintain a number of parameters of blood homeostasis [1, 3, 48].

The kidneys are a paired bean-shaped organ weighing from 125 to 180 g and measuring 12x4x4cm. They are located retroperitoneally - at the level of 12 thoracic 2 lumbar vertebrae. In females, the kidneys are slightly lower than in males. The kidney is covered with a thin dense fibrous capsule and surrounded by a rather thick layer of adipose tissue. On the section of the kidney, two zones are clearly distinguished: the cortex is dark in color and the medulla is pale gray in color. The medulla consists of 8-12 renal pyramids, the bases facing the cortical substance. The tops of the pyramids are directed towards the renal calyces and pelvis and form the renal papillae. At the top of each papilla, from 10 to 25 small holes are found, which are the open ends of the collecting ducts [5]. In this regard, the top of each papilla is called a cribriform plate (lamina cribroza). Thin layers of cortical substance (Bertini columns), penetrating from the cortex, separate each cerebral pyramid from adjacent ones and form the renal lobe. The cortical substance of the kidney is adjacent to the base of all pyramids (lobes) from the side of the base. Along the cortico-medullary border, thin layers of the medulla (Ferrein's rays) are sent like rays from the medulla to the cortex. As part of the rays, collecting ducts are detected that collect urine from the distal segments of nephrons located from adjacent parts of the cortical substance. On this basis, the concept of a renal lobule was introduced, which is understood as a part of the cortical substance, limited by two interlobular (radial according to the modern classification) arteries, the central axis of which is the cerebral (Ferrein) ray [6, 8, 25].

In the parenchyma of the kidney, the connective tissue is poorly developed, and in the cortical substance it is almost absent. The stroma of the kidney is formed by thin papillae. The papillae of the renal pyramids are covered by the renal pelvis, which is the beginning of the urinary tract. In humans, 2-3 outgrowths extend from the pelvis - large cups. In mammals (for example, the rat) with one lobe, the papilla is covered directly by the pelvis, and the calyces are absent [3, 9].

In two human kidneys, about 2,400,000 nephrons are determined. In rats, each kidney contains 30,000–34,000 nephrons [8].

Each nephron is composed of the following parts: the capsule of the renal corpuscle, the proximal convoluted and straight, the distal straight and convoluted sections that connect them, the descending thin and ascending thick tubule (the loop of Henle). The direct sections of the proximal and distal tubules of the nephron, respectively, take part in the formation of the descending and ascending loops of Henley [46, 48].

The capsule of the nephron with an anastomosing network of blood capillaries (vascular glomerulus) in it is called the renal corpuscle. Due to this close structural interaction, the nephron is structurally and functionally connected with the circulatory system and other body systems, quickly adapts and regulates homeostasis [3, 43, 44].

The structures of the nephron in the parenchyma of the kidney have a certain topography. The renal corpuscles and convoluted tubules of the proximal and distal nephrons are located in the cortex. Part of the direct tubule of the proximal part of the cortex descends into the medulla and is located in the medulla at different depths in the thin, thick parts of the loop of Henle. The direct tubule of the distal medulla rises into the cortex as a direct continuation of the thick loop of Henle. This causes the nephron tube to rotate 180°. In the cortical substance, the distal straight tubule goes to its renal corpuscle and lies between the afferent and efferent arterioles, which form the vascular glomerulus [10, 11]. Topographically, the convoluted distal tubule begins from this level, which, through a connecting area, is connected to the initial collecting ducts. The latter flow into the cortical collecting ducts, which are located in the brain rays of Ferrein. At the border of the cortex and medulla, several collecting ducts merge with each other. In the outer medulla, they do not merge, while in the inner medulla, after repeated fusion, they open with the formation of 1-2 holes at the top of the cerebral pyramid, on the surface of the papilla [8, 9, 12, 13].

On a section of the kidney drawn from the convex surface through the middle to the hilum, the renal corpuscles and corresponding nephrons can be subdivided into populations: superficial (superfecial; 85%), and supracerebral (juxtamedullary; 15%). Their structural and functional differences are as follows:

- from the superficial supracerebral cross-sectional area of the renal corpuscles increases almost 2 times. This indicates the greatest value of glomerular filtration by juxtamedullary vascular capillaries;
- the diameters of the afferent (afferent) and efferent (efferent) arterioles that form the vascular glomeruli of the renal corpuscles of the respective nephrons differ. In superficial nephrons, the diameter of the lumen of the afferent arteriole is on average 2 times larger than that of the efferent arteriole. This contributes to an increase in hydrostatic pressure in the glomerular capillaries up to 80-85 mm Hg [12, 14, 15].

In the supracerebral renal corpuscles, the diameter of the afferent and efferent arterioles that form the vascular glomerulus is equal, and in a number of renal corpuscles, the lumen of the efferent arteriole is even larger. As a result, the hydrostatic pressure in the capillaries of their vascular glomeruli is much less - 35-45 mm Hg. and urination can be carried out even at low blood pressure values; blood circulation through the vascular glomeruli of juxtamedullary nephrons is faster due to the lack of obstruction in them; goes to its renal corpuscle and lies between the afferent and efferent arterioles, which form the vascular glomerulus [12, 13]. Topographically, the convoluted distal tubule begins from this level, which, through a connecting area, is connected to the initial collecting ducts. The latter flow into the cortical collecting ducts, which are located in the brain rays of Ferrein. At the border of the cortex and medulla, several collecting ducts merge with each other [8, 9, 14]. In the outer medulla, they do not merge, while in the inner medulla, after repeated fusion, they open with the formation of 1-2 holes at the top of the cerebral pyramid, on the surface of the papilla [6].

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- from superficial to juxtamedullary nephrons, the length of the thin descending and thick ascending tubules of the loop of Henle gradually increases mainly due to its thin section. In the juxtamedullary nephrons, the loop of Henle of the external and intermediate nephrons is located at different levels of the outer medulla. In the human kidney, long-loop juxtamedullary nephrons account for an average of 12-14%, in rats - 28-30% of their total number [8, 9, 15, 16, 30, 35].

It should be pointed out that the mammary gland during lactation plays an exceptional role in maintaining the immune homeostasis of the newborn [20, 21, 22]. They not only concentrate antibodies from the blood serum, but they themselves can serve as a site for the synthesis and isolation of various classes of immunoglobulins [1, 38, 39, 40]. Milk, along with biologically active substances, also contains cellular components, which, together with antibodies, are actively involved in providing a protective barrier function of the mucous membranes of the newborn [18, 19]. It has been established that the role of the mammary gland is not limited to the creation of passive or active immunity of the newborn. Cellular and humoral components of milk play a leading role in the formation of the newborn's own immune system [2, 17, 20, 39, 40]. In children not fed breast milk, the frequency of viral and bacterial infections of the intestine and respiratory tract is more than 2 times higher than those fed breast milk [41, 42, 44, 45, 46].

The exceptionally important role of milk in maintaining the immune homeostasis of the newborn was proved by the research of the employees of our laboratory, then called PNIKEBL I of the Tashkent State Medical Institute, which were registered as a discovery by K.A. Zufarov, V.M. Gontmakher, A.Yu., Yuldashev, 1987 [7] . It has been proven that in early postnatal ontogenesis, immunoglobulins supplied with mother's milk are not cleaved in the gastrointestinal tract and enter the blood in the whole state, thereby providing adoptive immunity of the newborn. This discovery served as an impetus for further in-depth research on the role of the mammary gland in providing the immune defense of the newborn and the development of his own immune system. At the same time, with extragenital pathology of the mother, in particular with hepatitis, there is a negative effect on the development of the organs of the immune, digestive, and excretory systems [23, 24, 29, 31, 32, 34, 35, 36, 37], therefore, in a newborn, from a mother with a aggravated diagnosis in the future, problems may also arise from the excretory system.

Thus, it can be concluded that the functional morphology of the kidneys is designed not only for the excretory function, but also performs a hormone-producing function, involved in hematopoietic, as well as in the regulation of blood pressure and maintaining homeostasis in the body. Along with this, in the early postnatal period of development of the newborn, they also contribute to the transfer of immunoglobulins to the newborn, participating in its immune defense.

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