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# MORPHOLOGY AND PHYSIOLOGY OF THE KIDNEYS

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**Abstract:**
This article will talk about the morphology and physiology of the kidneys, as well as the tendency of chronic kidney disease to damage all parts of the kidney.

**Keywords:** kidney, kidney failure, membrane, cell, physiology

Normal kidneys are a paired, continuously functioning organ. Constantly forming urine, they remove metabolic waste, regulate water-salt metabolism between the blood and other tissues, participate in the regulation of blood pressure and acid-base balance of the blood, and perform endocrine functions. A cross-section of the kidney clearly shows how immediately under the thin connective tissue capsule there is a moderately dense cortex (0.7-0.8 cm thick), and below it the medulla, represented by pyramids. The parenchyma of the cortex and medulla in one kidney consists of 1-1.5 million structural and functional units of the organ - nephrons. Each nephron has several sections: renal corpuscle (glomerulus surrounded by Bowman's capsule ); proximal convoluted and proximal straight tubules; loop of Henle (this loop descends from the cortex into the pyramid, the thin and distal straight tubules form the descending and ascending (back into the cortex) parts of the loop of Henle ); distal convoluted tubule; collecting duct extending into the pyramid (Fig.1)

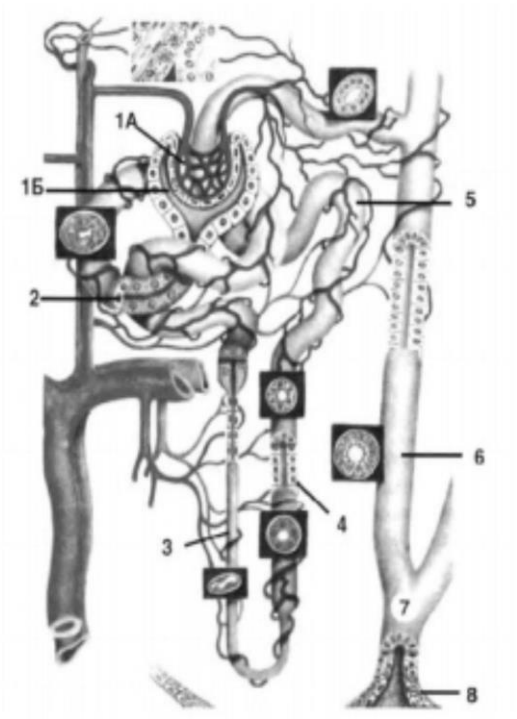


**Fig.1**. The structure of the nephron:

1A – glomerulus;
1B – Shumlyansky Bowman capsule;
2 – proximal convoluted tubule;
3 – the descending part of the loop Henle;
4 – the ascending part of the loop Henle;
5 – distal convoluted tubule;
6 – collecting tube;
7 – papillary canal;
8 – renal calyx

Each nephron begins with a renal glomerulus, which has a vascular-epithelial structure. It consists of a bundle of capillaries forming several lobules and surrounded by a network of extracellular matrix and cells located in the central zone of the glomerulus. Because of its centro -lobular location, this zone is called mesangium (capillaries are attached to this zone). A layer of visceral epithelial cells surrounds the outer surface of the capillaries. The layer of parietal epithelial cells forms a sac-like structure, Bowman's capsule, surrounding a network of capillary loops. Parietal and visceral epithelial cells embryonically and anatomically represent a single structure that forms Bowman's space. The capsule cavity opens into the proximal convoluted tubule. Primary urine is filtered into it from blood plasma.

Blood is delivered to the glomerulus through the afferent arteriole, which, piercing Bowman's capsule , breaks up into approximately 50 capillary loops that gather into the efferent arteriole. The glomerular capsule is a sphere consisting of a basement membrane and an outer (parietal) layer of flattened epithelial cells containing bundles of actin filaments The basement membrane of the capsule is multilayered and consists of separate layers separated by light spaces. When moving to the vascular bundle, the basement membrane of the capsule is transformed into the glomerular basement membrane, and when moving to the urinary part - into the basement membrane of the proximal tubule. The inner layer of the capsule is formed by visceral epithelial cells - podocytes , highly specialized lineage cells. Differentiated podocytes are not capable of dividing and, if they die, cannot be replaced. Podocytes have numerous long primary processes that entwine all capillary loops and give rise to secondary short processes - “legs”, immersed in the glomerular basement membrane. The feet of all podocytes are closely intertwined with each other, forming filtration slits, which are closed by the structures of the extracellular matrix - slit diaphragms. The slit diaphragms and luminal surface of podocytes are covered with a thick superficial layer rich in sialoproteins , creating a high negative charge on the podocytes . In addition to generating a negative charge, podocytes synthesize most, if not all, of the components of the glomerular basement membrane. The glomerular basement membrane is the main skeleton for the glomerular bundle. It is a continuous plate with a thickness of 240 to 340 nm . The basement membrane has three layers. The thickest middle layer, lamina densa , has electron density. The outer and inner layers have a more rarefied matrix ( lamina rara externa and interna ). The endothelial cells of the capillaries of the renal glomerulus structurally consist of a central part containing the nucleus and a peripheral part, represented by a thin fenestrated leaf. Unlike the fenestrated endothelium of other localizations, the pores of the glomerular endothelium (diameter 50-100 nm ) do not have a diaphragm, i.e. they are always open. Closed pores were found only on the terminal fragment of the efferent arteriole. The luminal surface of endothelial cells, like

podocytes , is covered with polyanionic glycoproteins that provide a negative charge. Thus, the capillary wall of the renal glomerulus, represented by endothelial pores, glomerular basement membrane and slit diaphragms between the podocyte stalks , represents a filtration barrier. The barrier function of a capillary wall for macromolecules is based on their size, shape and charge. The filtration barrier is easily permeable to water and small molecules. Polyanionic molecules, such as plasma proteins, are repelled by the electronegative shield of the glomerular filter. In addition to endothelium and podocytes , there is a third type of cell that is in close contact with the glomerular basement membrane - mesangial cells. Together with the mesangial matrix, they form the mesangium . Mesangial cells have a branched structure. Their processes attach to the glomerular basement membrane and contact the endothelium. Mesangial cells have close contacts with each other and with other cells of the extraglomerular mesangium - Gurmagtig cells and granular cells of the juxta-glomerular apparatus. Mesangial cells have receptors for angiotensin on the plasmalemma II , atriopeptin (atrial natriuretic protein) and vasopressin, are capable of producing various vasoactive agents, including prostanoids . Vasoactive agents stimulate the contractile activity of mesangial cells, thereby reducing the surface area of capillary loops and reducing the volume of filtration. The mesangium ensures uniform distribution of hydraulic pressure on the capillary wall and successful functioning of the filtration barrier. Mesangial cells are one of the main targets in many glomerular diseases of an immune and non-immune nature. In response to damage, they are capable of synthesizing numerous mediators, including cytokines and growth factors, which determine further proliferative and reparative processes in the glomerulus. Kidney disease is very complex. Conventionally, they can be divided into four groups depending on which morphological structure is affected to a greater extent - glomeruli, tubules, stroma ( interstitium ) or blood vessels. Certain kidney structures appear to be more vulnerable to specific forms of injury. For example, glomerular diseases are most often immunologically caused, while tubular (tubular) and interstitial lesions are more often caused by toxic or infectious agents. The interdependence of the kidney structures leads to the fact that damage to one of them almost always causes secondary damage to the others. Primary vascular disease, for example, leads to damage to all structures dependent on renal blood flow. Severe glomerular damage switches blood flow to the peritubular vascular system. On the contrary, the destruction of the tubules causes an increase in pressure inside the glomeruli, which may be the cause of their atrophy. Thus, regardless of origin, chronic kidney disease tends to damage all major structural components of the kidney, leading to chronic renal failure. The widespread use of kidney biopsy has changed the understanding of kidney diseases, especially the various types of glomerulonephritis .

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