

КАЗАНСКИЙ (ПРИВОЛЖСКИЙ) ФЕДЕРАЛЬНЫЙ УНИВЕРСИТЕТ

The Urinary System



Functions of the urinary system

• Excretion of metabolic wastes

• Regulation of ion, salt and water concentration of body fluid

• Synthesis



Kidney Structure





Nephron = functional unit of the kidney

1. Renal Corpuscle (Glomerulus + Bowman's Capsule)

- 2. Proximal Convoluted Tubule (PCT)
- 3. Loop of Henle (LOH)
- 4. Distal Convoluted Tubule (DCT)



Production of urine

Glomerular filtration



Tubular Secretion



The **glomerulus** - a tuft of capillaries composed of 10 to 20 capillary loops

The renal or **Bowman's capsule** - a double-layered epithelial cup

The glomerular capillaries are supplied by an afferent arteriole and are drained by an efferent arteriole

Renal Corpuscle

- Endothelial cells have fenestrations (blood cells can't go through)
- Vascular pole a part of glomerulus where aff. arteriole enters and eff. arteriole exits



Renal Corpuscle



A-arteriole; b-parietal layer of BC; c-PCT; d-podocyte (visceral layer of BC)

Renal Capsule

✓ Two layers – external (parietal) and internal (visceral)

- ✓ Space between the two layers urinary (Bowmen's space)
- ✓ From urinary space the filtrate enters PST



Internal layer of capsule - podocytes

Podocytes — a type of epithelial cells:

have long primary processes
 and interdigitating foot
 processes (**pedicles**) which grasp
 capillaries like fingers
 Filtration slits – spaces

between the pedicles





Glomerulus and Bowman's Capsule



Filtration barrier

- 1. Fenestrated Capillary Endothelium
- 2. Basement membrane
- **3.** Filtration Slits between pedicles of **podocytes** in the visceral layer of Bowman's capsule
- 4. The volume of ultrafiltrate is about 180 L/day





Albuminuria (presence of significant amounts of albumin in the urine) or hematuria (presence of significant amounts of red blood cells in the urine) indicate physical or functional damage to the GBM. The renal corpuscle contains an additional group of cells called **mesangial cells**. **Functions:**

• **Phagocytosis** - remove trapped residues and aggregated proteins from the GBM and filtration slit diaphragm, thus keeping the glomerular filter free of debris.

• Structural support.

• Modulation of glomerular distension - Mesangial cells have contractile properties.



Tubular Reabsorption

- Absorption of water, ions, glucose, amino acids and proteins back to the blood
- Image: Construction of the construc
- 85% in the proximal convoluted tubules

Tubular Secretion

 Some substances (K, H, ammonium, creatinine, some medicine and etc.) exit from surrounding capillaries into the lumen of tubules



Proximal Convoluted Tubule

Reabsorbtion:

- 65% ions of Na, Cl and water,
 80% ions of P and bicarbonate,
 80% of Ca,
- 100% glucose
- 100% protein
- 50% urea

• Secretion:

- H+ и NH4+, creatinine, acetylcholine, dopamine, adrenalin, histamine
- Fatty acids, bile acids, penicillin



Tubular Epithelium





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Loop of Henle

- Concentration of urine due to reabsorption of water and NaCl
- ✓ <u>Countercurrent multiplication:</u> <u>Descending part is permeable to</u> <u>water and impermeable to</u> Na+:
 - ✓ Water leaves the tubule into the interstitium
- ✓ <u>Ascending part is impermeable to</u> water and permeable to Na+:
 - ✓ Na+, Cl-, K+ leave the tubule into the interstitium
- ✓ The medullary interstitium around the tubules is "salty". The osmolarity is higher then in the lumen



Distal Convoluted Tubule

• **Reabsorption**: 10% ions of Na, Cl, Ca and bicarbonate





Kidney Cortex – PCT (P) & DCT (D)



Collecting ducts

- Are mainly in the medulla
- Reabsorption of water (5-25%)
- Aquaporins special canals for water.
- ADH regulates the number of aquaporins and reabsorption of water





Cross section of Kidney Medulla



Kidney Medulla (Collect tubules and loops)







Blood Supply

The kidneys are highly vascular organs; They receive approximately 25% of the cardiac output



Two Types of Nephrons

- Cortical nephrons (85%) located mostly in the cortex of kidney, produce "standard" urine
- Juxtamedullary nephrons (15%), located close to the medulla responsive to ADH, can produce concentrated urine due to longer Loops of Henle



Cortex

Medulla



Kidney Medulla – Vasa Recta (VR)



Endocrine functions of the kidney

- Secretion:
 - Renin
 - Erythropoietin

- Activation:
 - Vit D



Juxtaglomerular Apparatus

- Regulates blood pressure by activating the renin-angiotensinaldosterone system
- Located near the vascular pole of each renal corpuscie
- Includes:
 - macula densa

extraglomerular - mesangial cells

- juxtaglomerular cells -

Kidney Juxtaglomerular Complex

MD = macula densa

JGC = juxtaglomerular cells



Renal Corpuscle and Macula Densa



JG Cells



Renin – Angiotensin – Aldosterone System



Erythropoietin (EPO)

- Synthesized by endothelial cells of the peritubular capillaries in the renal cortex.
- Regulates red blood cell formation in the bone marrow in response to decreased blood oxygen concentration.



Excretion of urine

Collecting ducts within each renal papilla release urine into minor calyx \rightarrow major calyx \rightarrow renal pelvis \rightarrow ureter \rightarrow urinary bladder \rightarrow urethra



Urinary tract

- Mucosa, submucosa, muscularis externa, adventitia
- Mucosa transitional epithelium + lamina propria
- Transitional epithelium lines minor and major calices, renal pelvis, urether, bladder and proximal part of urethra

Transitional epithelium









Urethers



Urethers

- Inner longitudinal muscular fiber
- Outer circular muscular fibers
- Contraction of Longitudinal fibers in the proximal part of ureter keeps the lumen open for the passage of urine from the bladder
- Peristalsis of muscular fibers propels the urine down the ureter



Ureter – folded mucus membrane



Transitional Epithelium

Nephrolithiasis (kidney stones)

Occurs when urine becomes too concentrated and substances crystallize. Symptoms arise when stones begin to move down ureter causing intense pain.

Kidney stones may form in the pelvis, calyces, or in the ureter. (Rarely in the bladder.)



*ADAM

Urinary Bladder

3 layers in the wall:

- Mucosa transitional epithelium organ is expandable mucous prevents cells from contact with urine
- ✓ Muscularis (detrusor muscle)
 - 3 layers of smooth muscle (outer longitudinal, circular, inner
 - longitudinal) circular fibers form internal urethral
 - sphincter
- Adventitia/ serosa on the superior surface



Lamina propria_ Submucosa

Detrusor muscle

Adventitia

Ureter

Peritoneum

Detrusor muscle-Ureteral openings

Internal urethral sphincter

Neck of urinary bladde

External urethral sphincte

(in urogenital diaphragm)

Trigone

Bladder – Transitional Epithelium



Thank you for attention



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