POLTAVA STATE MEDICAL UNIVERSITY

Anatomical and physiological features of the urinary system in children. Methodology of examination. Semiotics of the most common diseases of the urinary system.

- Assoc. Professor Soloviova Halyna

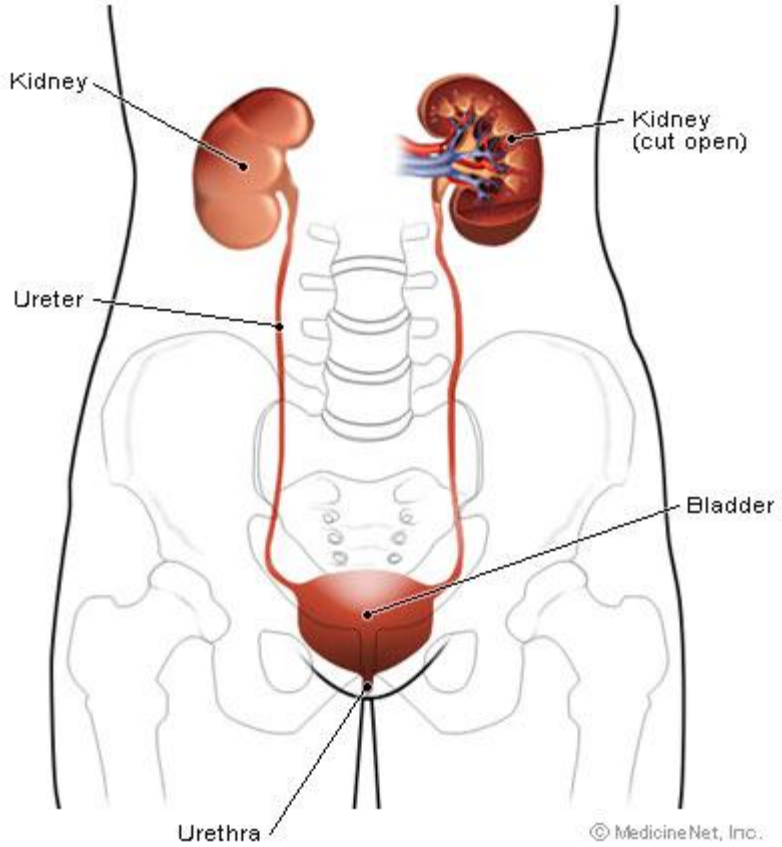
Plan of the lecture

- 1. Definition of the urinary system in children.
- 2. Normal kidneys and their function.
- 3. Kidney function in a fetus.
- 4. Renal structure and physiology.
- 5. Anatomical and physiological characteristics of the urinary system in children.
- 6. Methods of investigation of the urinary system.
- 7. Urinal disorders in children.

Urinary system in children

- The system of organs that form, accumulate and excrete urine in humans.
- Consists of a pair of kidneys, two ureters, urinary bladder and urethra.

Normal Kidneys and Their Function



The kidneys perform two main functions:

- 1) regulate the composition of extracellular fluid and acid-base state of the body;
- 2) ensure the removal from the body of toxic substances or metabolic products to be removed.

The kidneys also produce certain hormones:

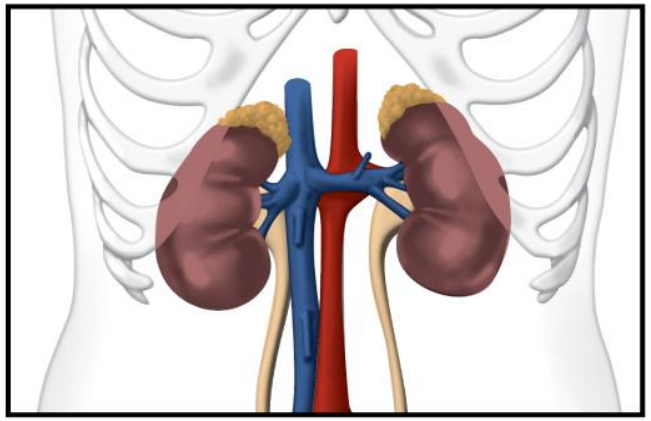
- Activate form of vitamin D (calcitriol or 1,25 dihydroxy-vitamin D), which regulates absorption of calcium and phosphorus from foods, promoting formation of strong bone.
- Erythropoietin (EPO), which stimulates the bone marrow to produce red blood cells.
- Renin, which regulates blood volume and blood pressure.

EMBRIOLOGY

- At 7-9 weeks, the kidneys move from the caudal part to the area above the aortic bifurcation and the kidney is rotated, the bladder is formed.
- *At 9-11 weeks - the beginning of the formation of urine.*
- At week 20-22, the distinction between the cortical and cerebral layer.
- *At 32-36 weeks, the end of the formation of nephrons (1 million in each kidney).*

Kidney function in a fetus

- The blood flow and glomerular filtration rate in the fetal kidneys are low.
- *The fetal kidneys are able to dilute and acidify urine, absorb phosphates and transport organic matter.*
- However, the main excretory organ in utero is the placenta.



Cortical blood vessels

Interlobar blood vessels

Renal hilum

Renal vein

Renal nerve

Renal artery

Medulla

Ureter

Capsule

Arcuate blood vessels

Minor calyx

Major calyx

Renal pelvis

Pyramid

Papilla

Renal column

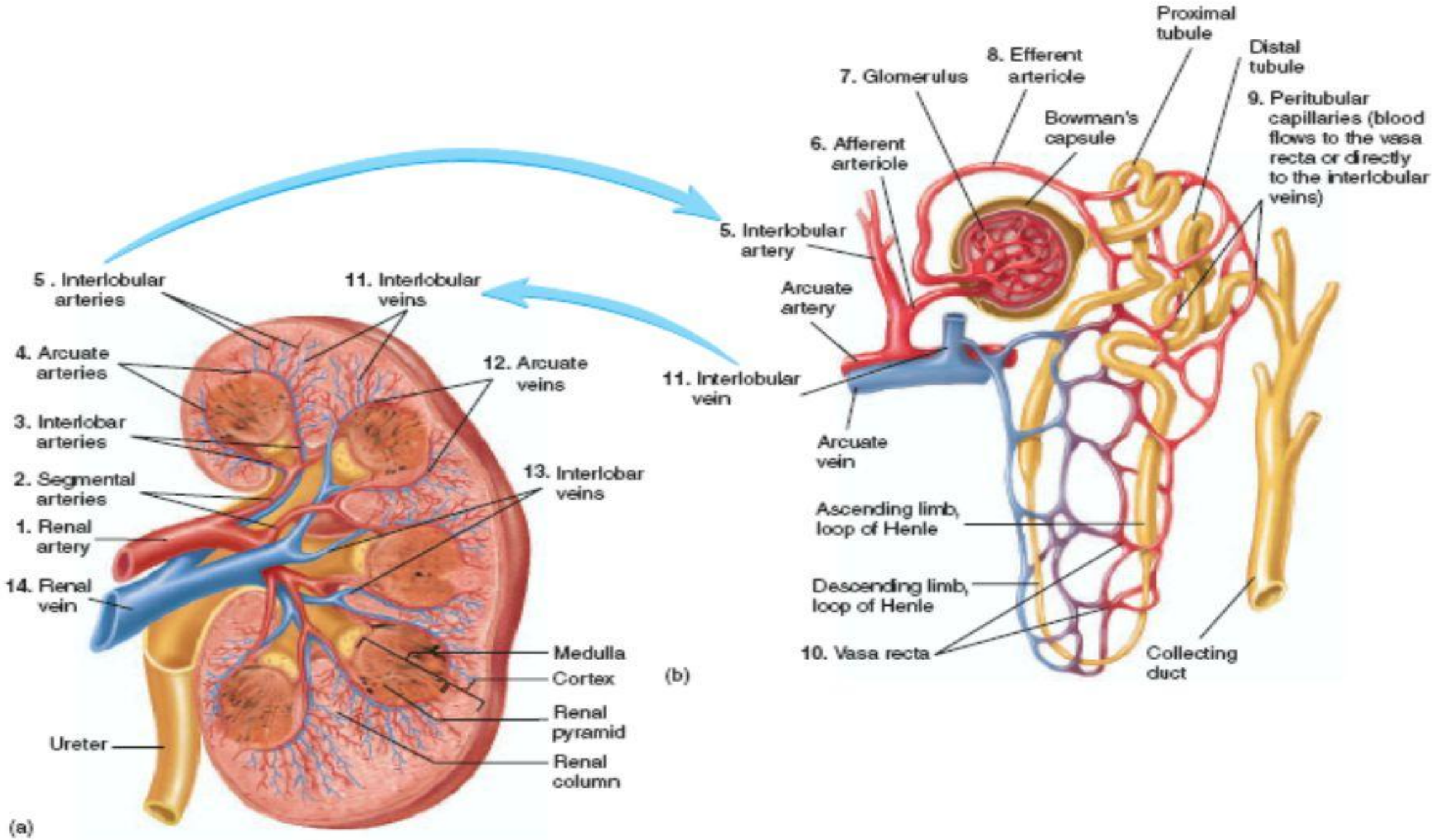
Cortex

Renal structure and physiology

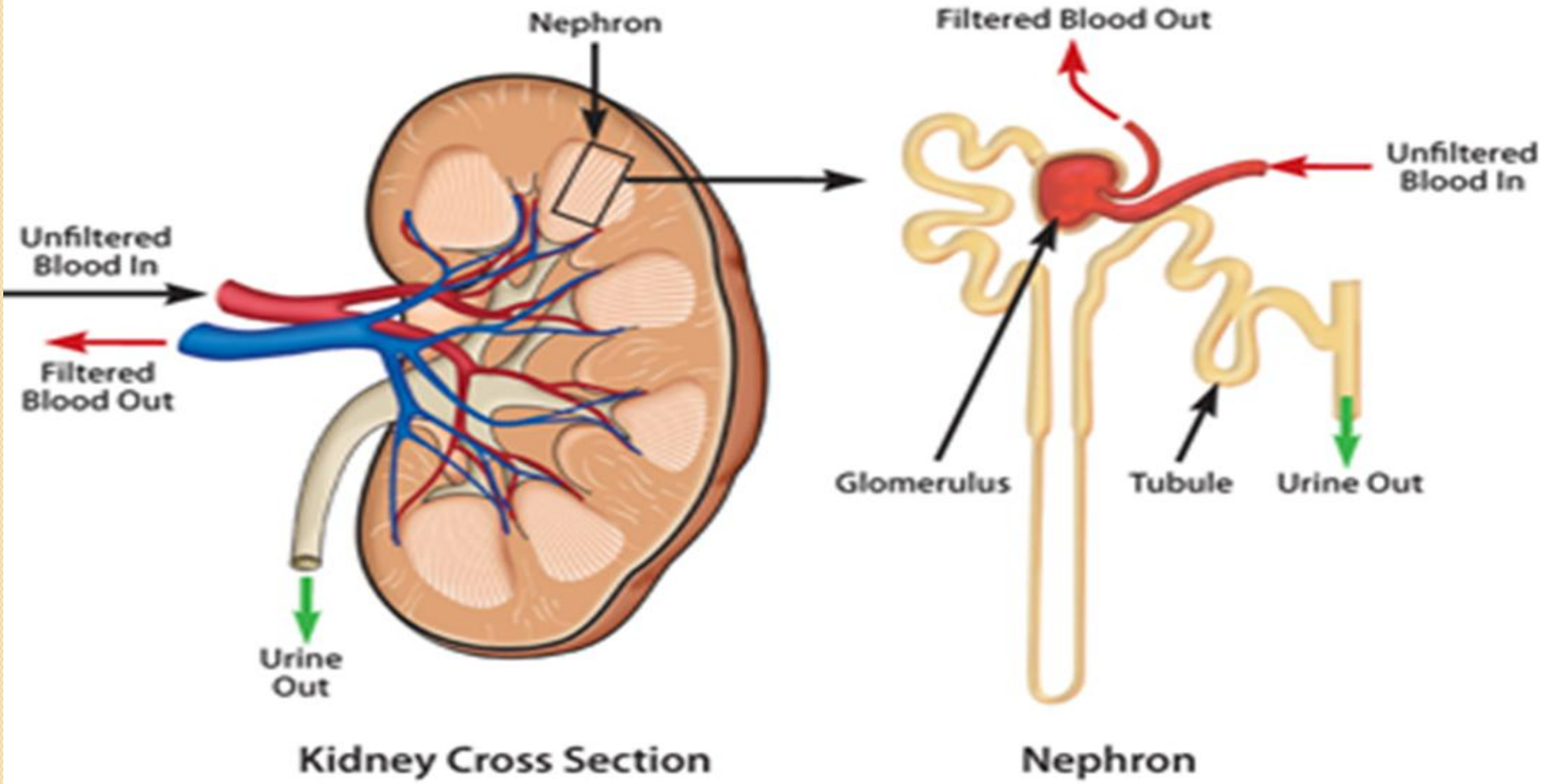
The structural and functional unit of the kidney is the nephron, which is composed of a complex system of tubules, arterioles, venules, and capillaries.

The nephron consists of:

- Bowman's capsule, enclosing the capillary tuft of the glomerulus, which is joined successively to the proximal convoluted tubule,
- Henle's loop,
- the distal convoluted tubule,
- the straight or collecting- duct.

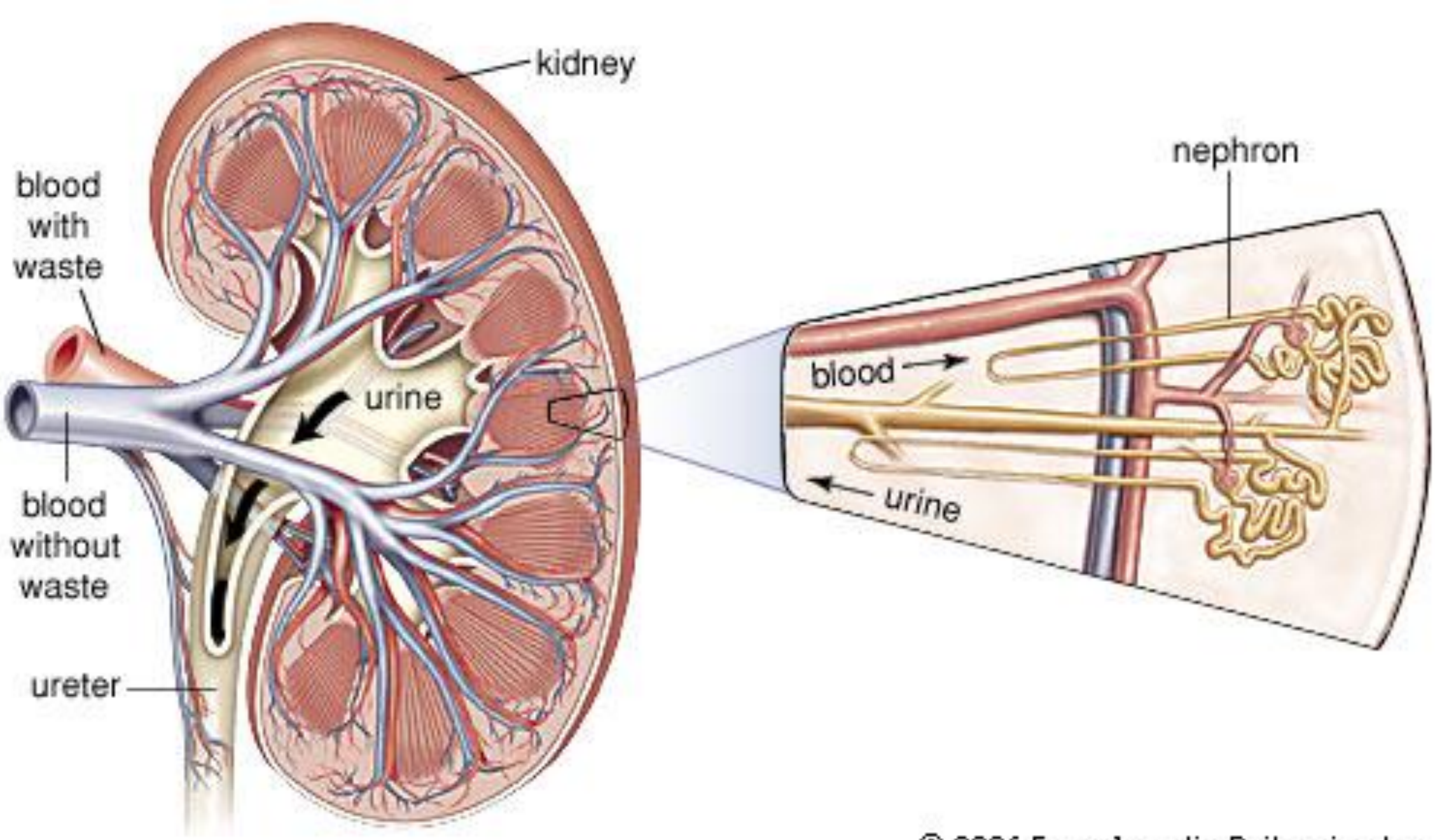

5 . Interlobular arteries
11. Interlobular veins
4. Arcuate arteries
12. Arcuate veins
3. Interlobar arteries
2. Segmental arteries
13. Interlobar veins
1. Renal artery
14. Renal vein
Medulla
Cortex
Renal pyramid
Renal column
Ureter
(a)
Proximal tubule
8. Efferent arteriole
Distal tubule
7. Glomerulus
9. Peritubular capillaries (blood flows to the vasa recta or directly to the interlobular veins)
Bowman's capsule
6. Afferent arteriole
5. Interlobular artery
Arcuate artery
11. Interlobular vein
Arcuate vein
Ascending limb, loop of Henle
Descending limb, loop of Henle
10. Vasa recta
Collecting duct
(b)

How The Kidney Works



Kidney Cross Section

Nephron


kidney
blood with waste
urine
blood without waste
ureter
nephron
blood
urine
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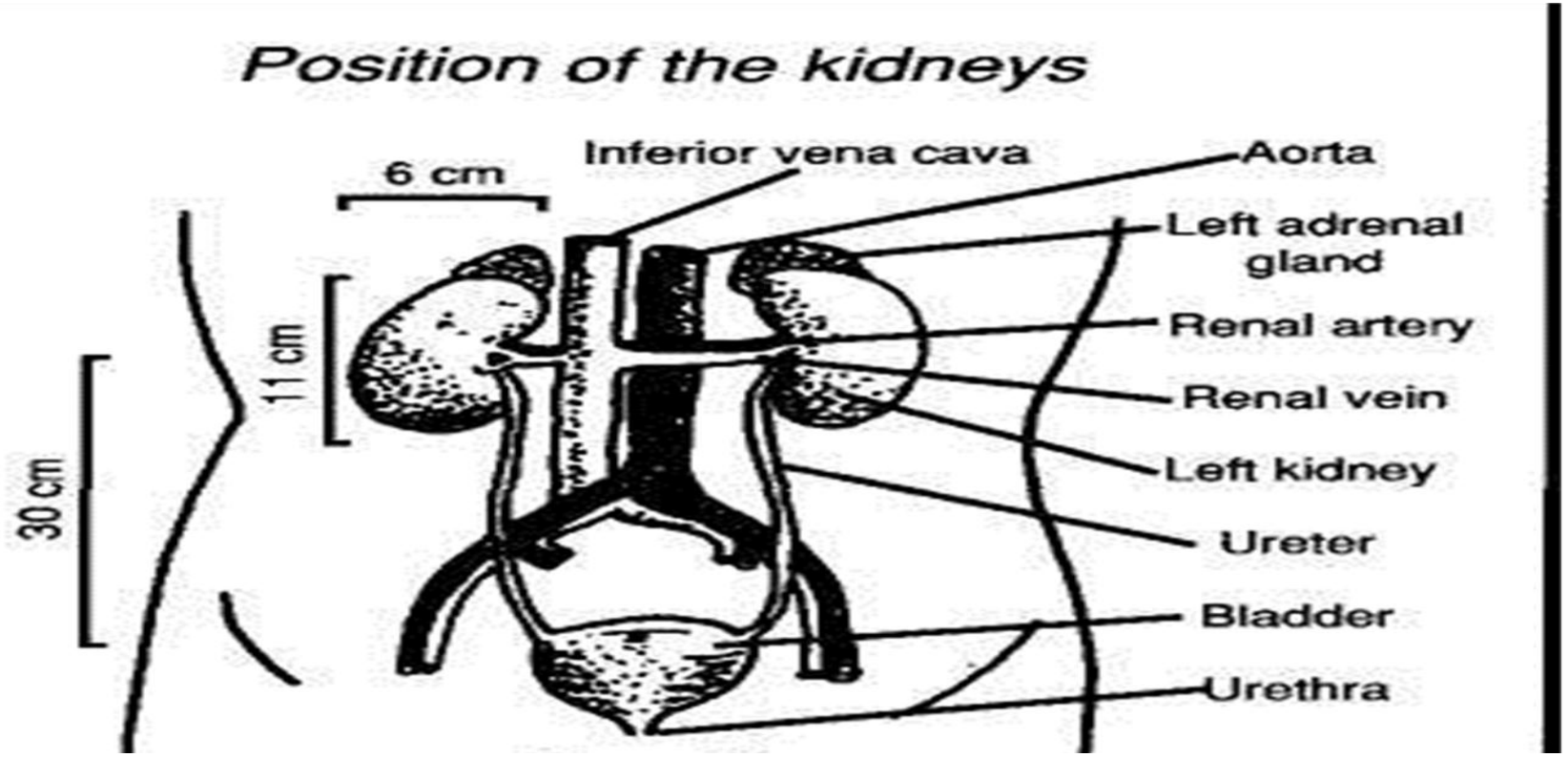
Anatomical and physiological characteristics of the urinary system

- Kidneys in young children are larger in size than in adults.
- In children, the kidneys make up 1/100 of body weight, while in adults, 1/200.
- By birth, the weight of the kidney is 10-12 g, and by the end of the first year it triplets, by the age of 15 the mass of the kidneys increases 10 times.

Localization of kidney.

- Newborn – in the level I - V thoracic vertebras.
- Older children - X thoracic and IV lumbal vertebras.



Anatomical and physiological characteristics of the urinary system

- In children under 1 year old, the upper and lower poles of each kidney are close, and it resembles a rounded organ, and in the future acquires a bean-like shape.
- The fat capsule of the kidneys is poorly expressed, so the kidneys are quite mobile and can be easily felt, especially the right one.

Anatomical and physiological characteristics of the urinary system

- In children under 2 years of age, the structure of the kidneys is lobed (disappearing by 2-5 years), the thickness of the brain layer prevails over the thickness of the cortical (1: 4, while in adults 1: 2).
- The cortical layer of the kidneys is not yet sufficiently developed.
- Morphological maturation of the cortical substance ends by 3-5 years, and the kidneys as a whole - by school age.

Anatomical and physiological characteristics of the urinary system

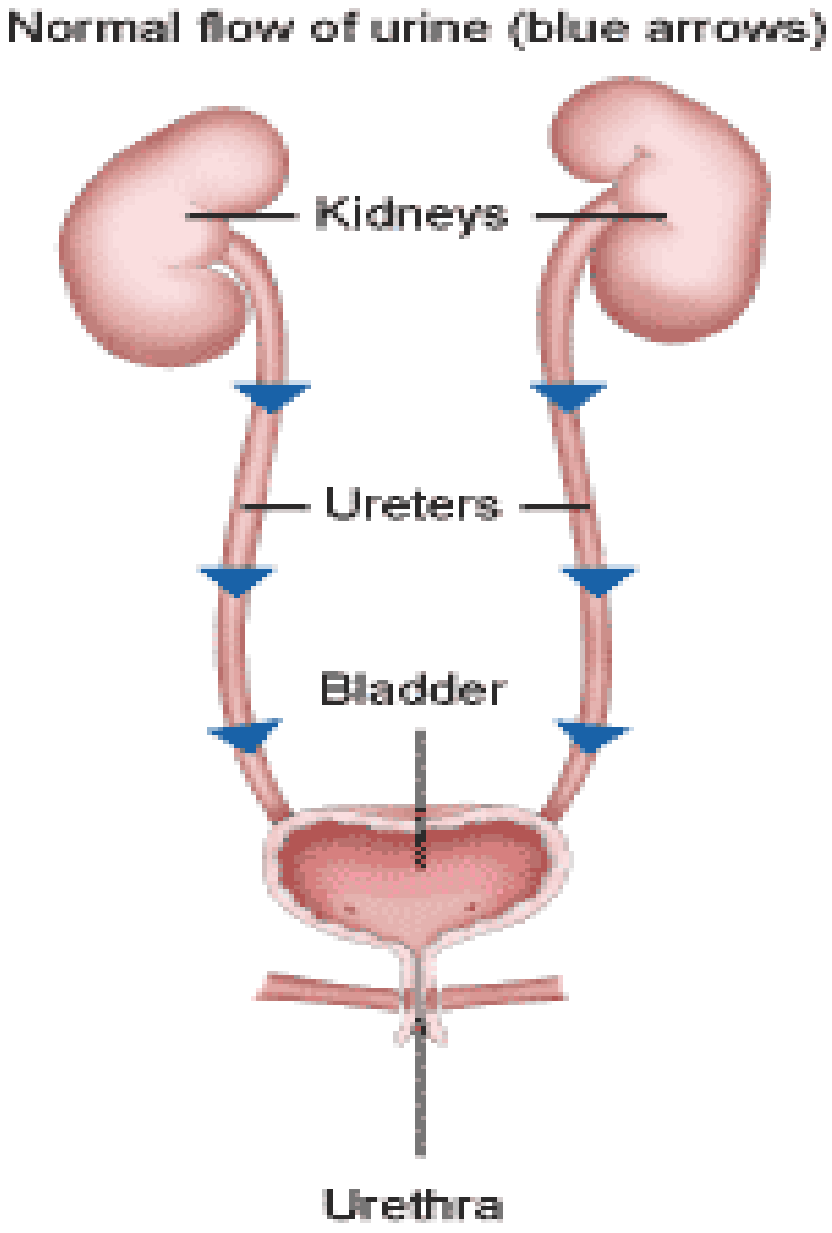
- The number of nephrons is the same as in adults, i.e., 1 million in each kidney, but their size is smaller and the degree of development is not the same.
- *The surface of the glomerulus is not sufficiently formed, which leads to a decrease in filtration and high resistance in this case.*
- The tubules are narrow, short, and their lumen is almost 2 times narrower than that of an adult.
- The Henle loop is also shorter, and the distance between its descending and ascending knees is greater than that of adults.

Anatomical and physiological characteristics of the urinary system

- The development of tubules, the loop of Henle and collecting tubes is not complete, juxtaglomerular apparatus is not formed.
- The maturation of the kidney as a whole ends by 3 to 6 years of life. However, there is still a difference between the kidneys of children and the kidneys of adults - this is a close connection of the lymphatic vessels of the kidneys with similar vessels of the intestine. This often leads to an easy transition of the infection from the intestines to the kidneys and the development of pyelonephritis.

Ureters

- In young children, the ureters are wider than in adults, they have many bends.
- They are hypotonic due to the weak development of muscle and elastic fibers.
- This leads to stagnation of urine and the development of a microbial inflammatory process in the kidneys.



Urinary bladder

Situated more upper (in children under 3 years can be find in public redion of the abdomen) can be palpate)

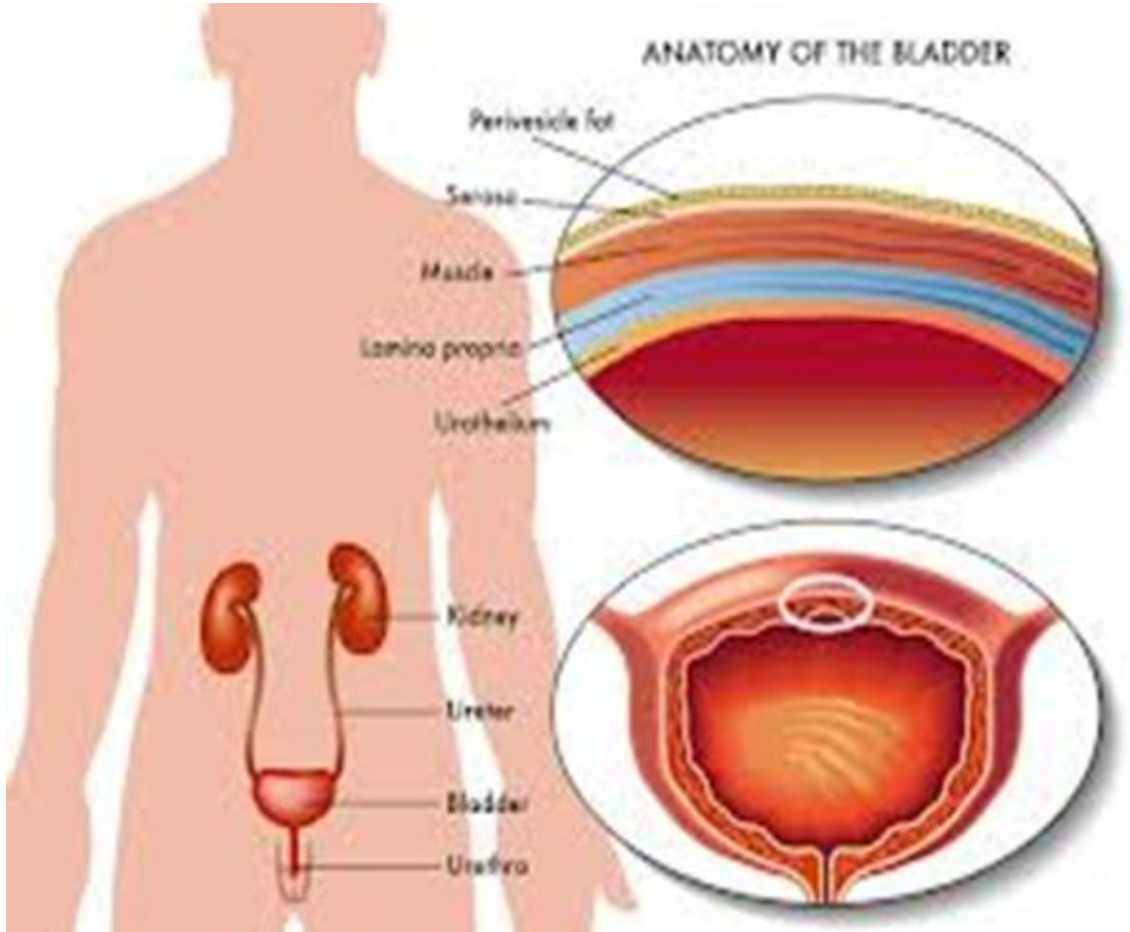
- poor development of vascules elastic tissue under 6 years
- Ureteric mouth (orifice) are commonly opened.

That's why in very often developed vesicoureteric reflux, ureteric torsion.

Very good developments vascularisation of bladder mucose, leads to development inflammation process of the ureter.

Capacity of the urinary bladder

Newborn	30ml
1 year	35-50 ml
1-3year	50-90 ml
3-5 year	100-150ml
5-9 year	200ml
9-12 year	200-300 ml
till	400 ml



Urethral canal, urethra

- In newborn boys, it has a length of 5-6 cm. Its growth is uneven: it slows down at an early age, accelerates during puberty (up to 14-18 cm).
- *In newborn girls, the length of the urethra is 1 - 1.5 cm, by the age of 16 it is 3-3.3 cm. Its diameter is wider than that of boys.*
- The mucous membrane of the urethra in children is thin, easily injured, its folding is poorly expressed.

Urine formation

- As the first step in filtration, blood is delivered into the glomeruli by microscopic leaky blood vessels called capillaries. Here, blood is filtered of waste products and fluid while red blood cells, proteins, and large molecules are retained in the capillaries. In addition to wastes, some useful substances are also filtered out. The filtrate collects in a sac called Bowman's capsule and drains into the tubule.

- The amount of urine excreted per day in children older than a year is calculated by the formula:

600+ 100 (x - 1), where x is the number of years

- In the first months of life, urination is a reflex act, which is carried out by congenital reflexes.

- Number of urinations:

  - in newborns 20-25,
  - in infants - 15-16 per day,
  - in 2-3 years - 7-8,
  - schoolchildren - 5-6 times.

- The formation of a conditioned reflex and neatness skills usually starts at 5-6 months of age, and by the year a child should ask for a pot.

- However, even up to 3 years, you can observe involuntary urination during sleep, exciting games, excitement.

Methods of investigation of the urinary system

- conversation with a child and his parents
- inspection
- palpation
- percussion
- laboratory and
- instrumental research methods

Symptoms of Kidney Disease

- **Changes in Urination**

Kidneys make urine, so when the kidneys are failing, the urine may change. How?

- to get up at night to urinate.
- Urine may be foamy or bubbly. Urinate more often, or in greater amounts than usual, with pale urine.
- Urinate less often, or in smaller amounts than usual with dark colored urine.
- Urine contain blood.
- Feel pressure or have difficulty urinating.

Symptoms of Kidney Disease

- Swelling

Failing kidneys don't remove extra fluid, which builds up in body causing swelling in the legs, ankles, feet, face, and/or hands.

- Fatigue

Healthy kidneys make a hormone called erythropoietin that tells body to make oxygen-carrying red blood cells. As the kidneys fail, they make less erythropoietin. With fewer red blood cells to carry oxygen, muscles and brain become tired very quickly.

Symptoms of Kidney Disease

- Skin Rash/Itching

Kidneys remove wastes from the bloodstream. When the kidneys fail, the buildup of wastes in blood can cause severe itching.

- Metallic Taste in Mouth/Ammonia Breath

A buildup of wastes in the blood (called *uremia*) can make food taste different and cause bad breath. Stop liking to eat meat, or Losing weight.

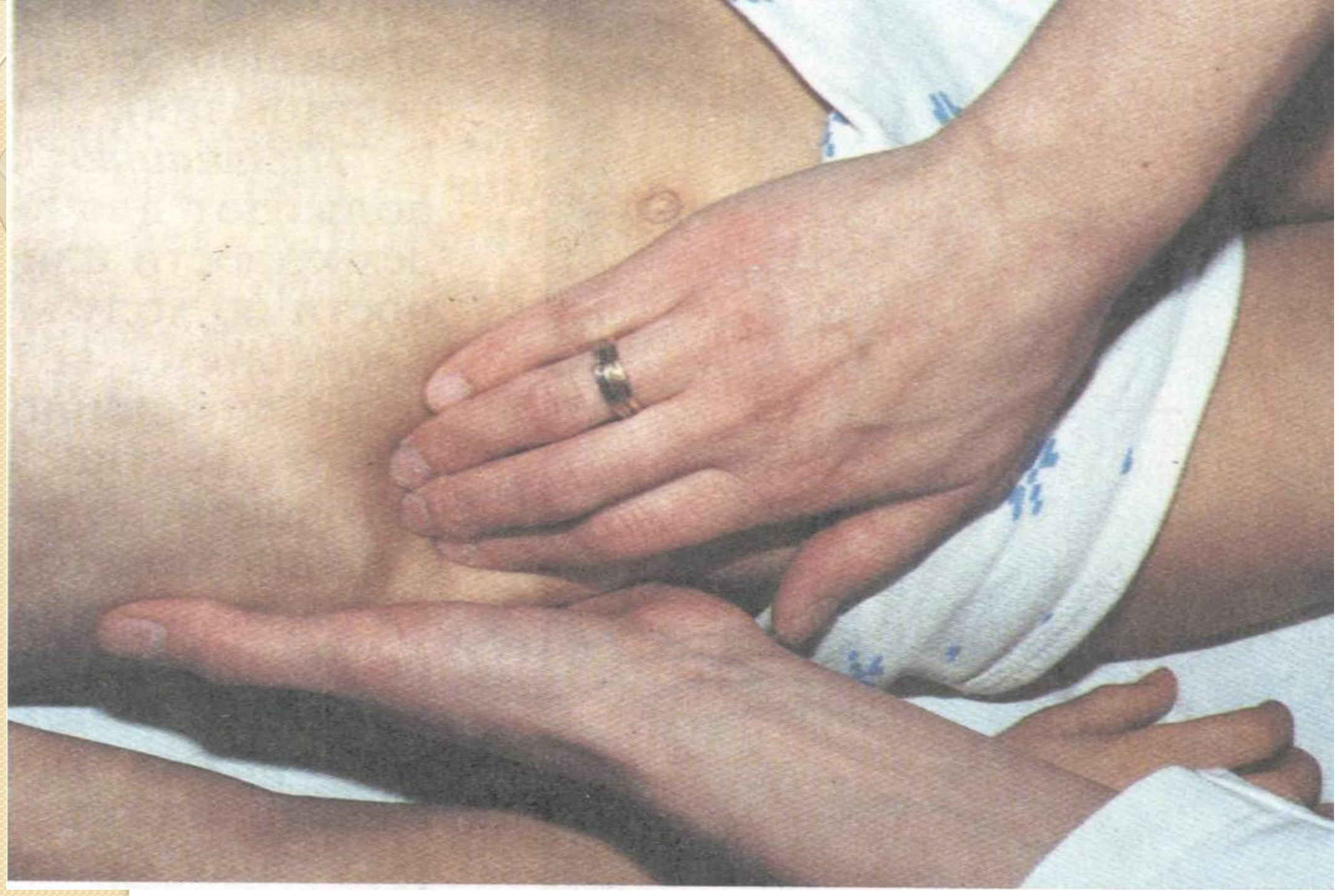
Symptoms of Kidney Disease

- Nausea and Vomiting
- Loss of appetite can lead to weight loss.
- Feeling Cold
- Anemia can make feel cold all the time, even in a warm room.
- Dizziness and Trouble Concentrating
- Anemia related to kidney failure means that brain is not getting enough oxygen. This can lead to memory problems, trouble with concentration.

KIDNEY PALPATION

- Palpation of the kidneys is an uninformative method, since they are located retroperitoneally, access to them is covered by a costal arch.

- You can feel the kidneys in children of the first 2 years of life (especially with low nutrition) due to the relatively large size and low location.



KIDNEY PALPATION

- You can palpate the kidneys in the position of the patient:

- lying
- standing
- in the knee-elbow position

- Normally, the kidneys are not palpable, the area their painless.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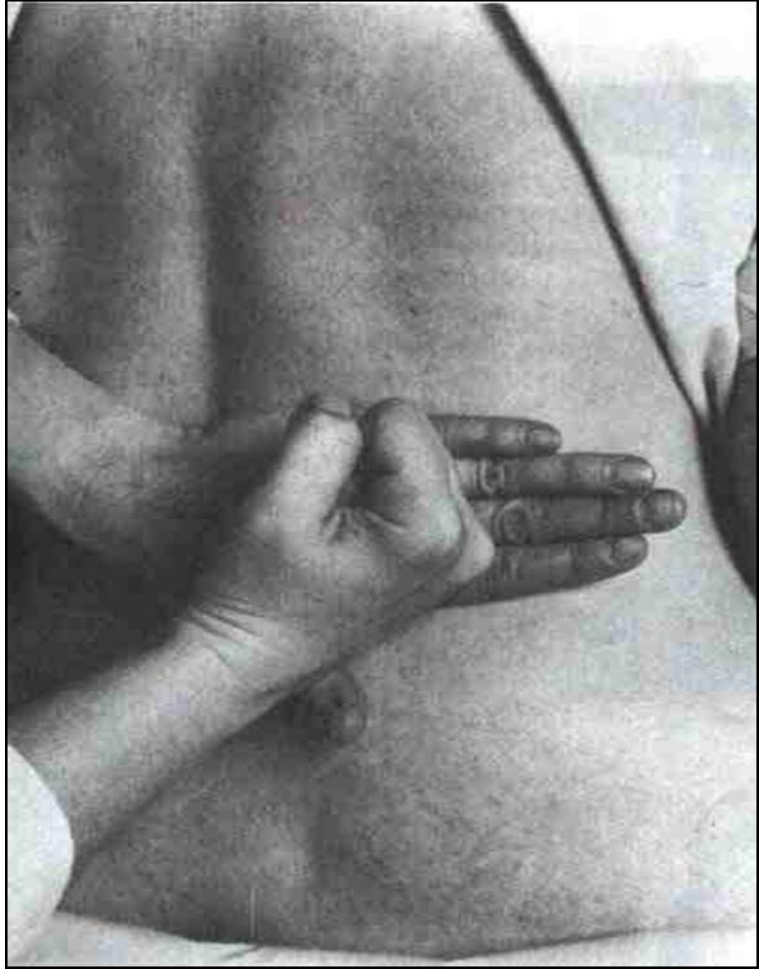
- Palpation of the bladder in the suprapubic region is carried out with two hands at the same time.
- With a significant accumulation of urine in it, especially with a thin abdominal wall, the bladder is felt in the suprapubic region in the form of an elastic fluctuating formation.
- With a sharp overflow of the bladder, its upper border is determined almost at the navel.

PERCUSSION

- Rumbling of the lumbar region (a modified Pasternatsky's symptom) is used to detect soreness or discomfort, sometimes radiating to the leg or lower abdomen, which may occur during this study (in this case, the symptom is assessed as positive).
- A positive symptom of thrashing is determined in inflammatory processes in the kidneys and perinephric fiber (pyelonephritis, paranephritis), urolithiasis.



- Percussion can determine the height of the upper pole of the filled bladder above the pubis. To this end, the finger pessimeter of the left hand is placed parallel to the pubis and percussed along the midline of the abdomen from the navel down to dullness of the sound.
- This method is used for suspected acute urinary retention.
- Percussion also reveals the presence of free fluid in the abdominal cavity.

Laboratory instrumental diagnostics

Laboratory tests

- Urinalysis: Analysis of the urine affords enormous insight into the function of the kidneys. The first step in urinalysis is doing a dipstick test. The dipstick has reagents that check the urine for the presence of various normal and abnormal constituents including protein. Then, the urine is examined under a microscope to look for red and white blood cells, and the presence of casts and crystals (solids).

In small infants, urine may by collected using a special bag that is applied after cleaning of the perineum with soap and water. The bag is removed as soon as baby has voided.

CLINICAL ANALYSIS OF URINE

Physical properties

- Amount - 100-200 ml; Daily diuresis - 1000-1500 ml
- Color - straw yellow
- Reaction - slightly acidic
- Transparency - Transparent
- Specific Gravity - 1018-1028
- Protein - not found
- Sugar - not found
- Bile pigments - absent
- Sediment - absent

Microscopy

- Epithelial cells - moderate amount
- White blood cells - 1-2 copies. in sight
- Red blood cells -
- Cylinders -
- Renal Epithelial Cells -
- Salts -
- Slime -
- Bacteria -

METHOD NECHIPORENKO

- The method allows you to determine the number of shaped elements in 1 mcl of urine. For research, one-time urine is used, and the average portion is needed.
- Normal indicators of the content of shaped elements in 1 ml of urine:
- White blood cells up to 2000
- Red blood cells up to 1000
- Cylinders up to 20
- Urinalysis according to Nechiporenko - is carried out in order to identify the inflammatory process in the urinary system.

Urine analysis according to ZIMNITSKY

- It characterizes the state of the concentration and excretory function of the kidneys.
- Urine is collected during the day 8 times every 3 hours, the amount and relative density are examined.

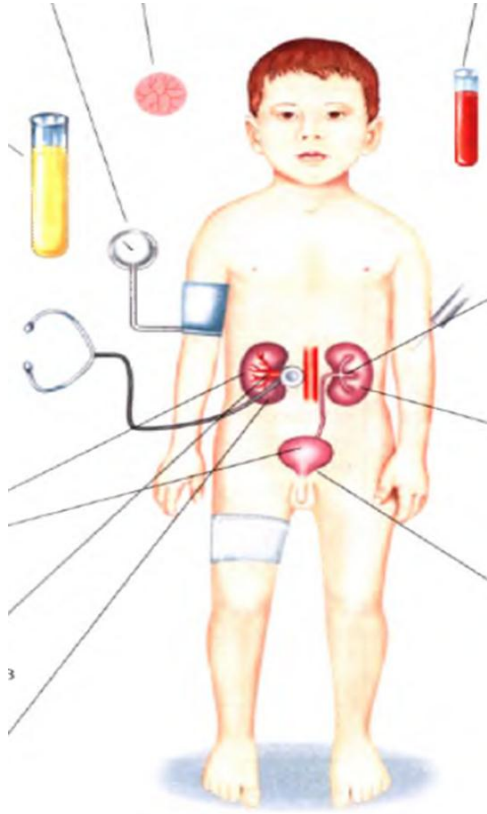
- The daily diuresis is normally 1000-1500 ml,
- the ratio of day and night diuresis 3: 1,
- relative density during the day from 1010 to 1025,
- the range of numerical values is 10-20 units.

- ***Bacteriological urine culture***

is a method for identifying and identifying microorganisms (bacteria) in the urine, determining their concentration and determining its sensitivity to antibacterial drugs.

- Pathological bacteriuria is considered when determining more than 104 microbial bodies in 1 ml of urine in newborns and young children and more than 0.5-1.0 * 105 in older children.

CLINICAL BLOOD TEST, BIOCHEMICAL BLOOD TEST



- In acute and exacerbation of chronic inflammatory diseases, in acute and chronic renal failure, leukocytosis is noted, often with a shift to the left.

ESR increased.

- *To assess kidney function, the blood content of nitrogen-containing substances (urea, creatinine, uric acid), total protein and its fractions, electrolytes is also determined.*

ULTRASOUND KIDNEY EXAM

- Ultrasound of the kidneys in children is an affordable, safe and informative research method.
- *Ultrasound allows you to evaluate the size, shape, contours of the kidneys, the state of the parenchyma and pyelocaliceal system, ureters, bladder, prostate gland.*
- Ultrasound can identify anatomical defects,

abnormalities in the development of a particular organ, but information on how the kidneys work cannot be obtained on ultrasound.

X-ray

- In the overview pictures you can see the shadows of the kidneys.

- ***Intravenous (excretory) urography is used for:***
- assessment of renal function (by speed and degree of excretion of contrast medium),
- assessment of the structure of the cavity system of the kidney, patency and function of the ureter,
- as well as for the diagnosis of certain diseases of the urinary system (developmental abnormalities, pathological renal mobility, etc.).
- The amount of contrast is calculated on the weight of the child.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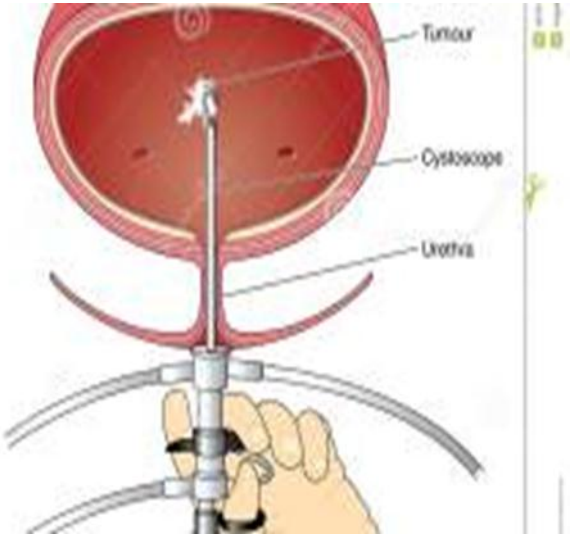
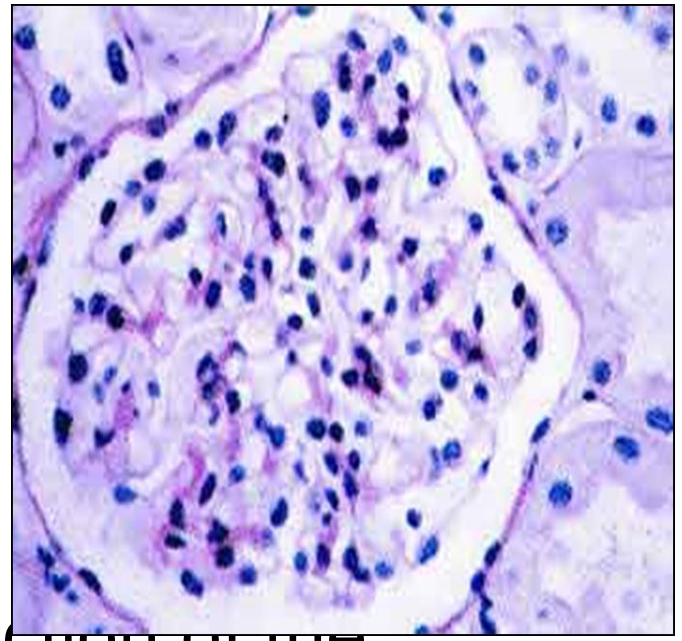
Bladder instrumental exam

- Cystography is an x-ray method of research, obtaining an image of the bladder on an x-ray by filling it with an x-ray contrast medium that enters the bladder downstream (from the kidneys with excretory urography) or ascending (when it is introduced through the urethra).
- Cystoscopy -this is an optical examination of the bladder using a special cystoscope instrument (endoscopic device), which is inserted into the bladder through the urethra.
- With the introduction of a cystoscope through the urethra, it can be examined and some medical procedures performed.



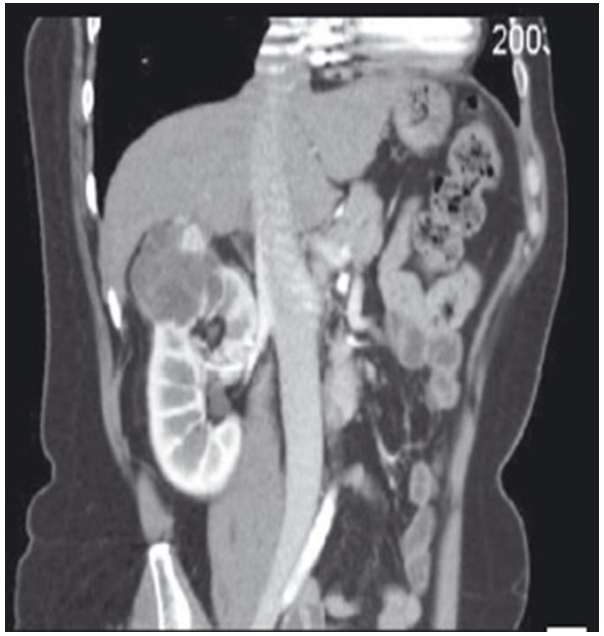
Kidney biopsy



- A kidney biopsy is the most reliable method for diagnosing diffuse kidney disease.

- From the lower back, in the area of the projection of the kidneys, a special needle with a mandrel is punctured, with a suction syringe, a piece of kidney tissue is taken for examination.

Tomography



- Computed tomography is a modern and highly informative x-ray method for diagnosing structural changes in human organs.
- Computed tomography allows you to get the most clear x-ray anatomical image.
- Magnetic resonance imaging is used to detect cancer pathology.
- Magnetonuclear angiography allows you to judge the structure of the renal arteries and the state of renal blood flow.

URINAL DISORDERS

- Pollakiuria - frequent urination
- Allakiuria - rare urination
- Polyuria - daily diuresis over than age norma
- Oliguria - daily diuresis of less than age norma
- Dysuria - painful urination
- Nocturia - the prevalence of nocturnal diuresis over daytime
- Anuria - lack of urine
- Ishuria - lack of urination. urinary retention in the bladder
- Stranguria - urination in small portions (drop by drop)

Epithelial cells in urine

- Individual cells of the transitional epithelium are found in the urine normally.
- Renal epithelial cells are detected only with pathology:

jade, intoxication, infectious diseases

- Enhanced desquamation of the epithelium of the pelvis, ureter, bladder is found in inflammatory processes.
- The squamous epithelium enters the urethra.

Leukocyturia (piuria) and Erythrocyturia (hematuria)

- Leukocyturia indicates inflammatory processes in the kidneys (pyelitis, pyelonephritis) and urinary tract - true leukocyturia.
- *When leukocytes enter urine from abscesses from adjacent organs, false leukocyturia is observed.*
- The detection of red blood cells in each field of view is treated as microhematuria, while the color of urine does not change.
- *If more than 2500 red blood cells are excreted in 1 mcl, the urine turns red, which indicates macrohematuria.*

Leukocyturia (piuria) and Erythrocyturia (hematuria)

- Hematuria is true (from the kidneys and urinary tract) and false.
- *In acute glomerulonephritis, hematuria occurs due to a violation of the permeability of the glomerular capillaries.*
- In trauma, damage to the vessels of the urinary tract occurs.
- *With tuberculosis, papilla necrosis is noted.*
- With tumors, vascular destruction occurs.

CYLINDURIA

- Urinary cylinders are protein or cellular formations of tubular origin.
- True cylinders are hyaline, granular, waxy, epithelial, erythrocyte, leukocyte.
- False - formations of a cylindrical shape of organic or inorganic origin.

SEDIMENT OF URINE (salt)

- Urine sediment can be represented by salts precipitated in the form of crystals or amorphous masses.
- It can be uric acid, urates, phosphates, oxalates and others.
- Salts in the urine and their composition can appear with metabolic disorders and dietary features.

Thank you for your attention!

Literature, was used in the lecture

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