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Educational and methodological manual

«THE VALUE OF URINALYSIS FOR CLINICAL MEDICINE»

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Methodological recommendations describe the methodology for conducting basic clinical and laboratory research in patients; criteria for normal indicators of the urinalysis; clinical interpretation of the results of laboratory studies in various diseases of internal organs is provided; clinical and laboratory tasks for self-control and a list of recommended literature are given.

Additional studies contribute to a deeper understanding of disorders of various organs and systems. Without additional research, it is impossible to establish the correct diagnosis of the disease, the degree of its activity, the stages of development.

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CONTENTS

URINALYSIS

It is a laboratory testing, which can help detect and identify diseases involving many parts of the body; more specifically, diseases of the urinary tract (kidneys, ureters, bladder), liver and Diabetes Mellitus.

Urine analysis includes:

- measuring the amount of urine,
- determining the physical properties of urine,
- determining the chemical composition of urine,
- examining the microscopic sediment of urine.

Scope and sequence of research

1. Obtaining urine sediment.

2. Determination of physical properties of urine (quantity, color, transparency, sediment, smell, relative density of urine).

3. Chemical research (urine reaction, qualitative and quantitative determination of protein and sugar, determination of acetone bodies, bilirubin, urobilinogen, indican).

4. Microscopy of sediment:

a) preparation of smears;

b) demonstration of unorganized and organized urine deposits;

c) study and description of the microscopic sediment of a urine sample.

Procedure and method of urine collection

A small amount of urine (about 20ml) should be collected in a sterile (completely clean) urine collecting container. It is preferable to collect the first morning urine. The urine sample should be as fresh as possible when tested. You should be aware that some drugs and nutritional supplements may influence the test results (vitamin C, antibiotics and drugs for Parkinson’s disease).

Study of the physical properties of urine

1. **Quantity.** It is determined using a measuring cylinder or other measuring container. It is of practical importance to determine the total amount of urine (diuresis) released by the body during a certain period of time (per day, during the

night or during the day). An adult in normal conditions secretes 1000-1700 ml of urine per day. The amount of urine excreted is 75-85% of the fluid taken. Fluctuations in daily diuresis in the direction of its increase or decrease can be observed under various physiological and pathological conditions.

An increase in the daily amount of urine (more than 2000 ml) - **polyuria** - normally can be caused by a significant consumption of liquid, a decrease in sweating, the consumption with food of products containing a large amount of water and potassium salts (watermelon, melon) or that cause a diuretic effect (beer , coffee, tea), with emotional excitement, with a decrease in ambient temperature. In pathological conditions, polyuria appears when swelling decreases, resorption of exudates, transudates, in chronic nephritis (compensatory polyuria). Pronounced polyuria is also observed in diabetes mellitus and diabetes insipidus - pollakiuria.

A decrease in the daily amount of urine (below 1000 ml) - **oliguria** - in physiological conditions can be caused by fluid restriction, increased loss of it by the body (for example, in hot weather or during physical exertion, when working in hot workshops). A pathological decrease in the daily amount of urine occurs with diarrhea, with diseases accompanied by fever, acute glomerulonephritis, with blood loss, burns, uncontrollable vomiting, severe forms of heart and acute kidney failure, with the formation of large transudates and exudates.

Oliguria is sometimes accompanied by liquid urination - **olakisuria**. Complete cessation of urine output - **anuria** - can be due to the cessation of the urinary function of the kidneys, for example, in severe forms of acute glomerulonephritis, in the terminal stage of heart failure, in shock, during surgical interventions in the abdominal cavity and pelvis.

Anuria can appear with acute toxic damage to the kidneys, as well as with mechanical obstruction of the urinary tract (stone, tumor, hypertrophy of the prostate gland).

Ischuria - retention of urine, when the patient is unable to empty the bladder on his own. This is observed, for example, with damage to the spinal cord, in an unconscious state.

A healthy person secretes 2/3-3/4 of the daily amount of urine during the day. An increase in the amount of urine at night - **nocturia** - is a symptom of some kidney diseases (chronic glomerulonephritis, nephroangiosclerosis), diabetes insipidus, cardiovascular failure.

2. **Color:** normal urine has a light yellow to dark amber color. It is caused mainly by the presence of the pigment urochrome in the urine. The color of urine depends on the presence of other substances in it (uroerythrin, urobilinogen). The intensity of the color of urine under normal conditions varies significantly depending on the quality of food, drinking regime, time of day. The saturated color of urine is observed when consuming dry food, when limiting fluid intake, in the first morning portion of urine. Less intensively colored urine may appear when consuming a large amount of liquid, in later portions of urine. A significant range of fluctuations in the color saturation of urine during the day indicates the preserved concentration capacity of the kidneys.

The color of urine can change significantly with various pathological processes. Urine acquires the color of "meat slops" in acute nephritis, beer color - in parenchymal jaundice, red - in renal infarction and renal colic, greenish-yellow - in mechanical jaundice, dark brown - in hemolytic anemia, pale, watery - in diabetes, milk - with lymphostasis of the kidneys, white - with fatty degeneration and disintegration of kidney tissue.

Sometimes the color of urine changes when eating certain food products and taking various medicines. The blue-green color of urine is observed when taking methylene blue, greenish-yellow - rhubarb, orange - carrots, red - beets and amidopyrine, pink - acetylsalicylic acid.

3. Transparency. It is determined visually. There are the following gradations when determining the transparency of urine: completely transparent, incomplete transparency, cloudy urine. Normal urine is clear and only slightly fluorescent. The turbidity of urine can be caused by salts, cellular elements, bacteria, mucus, drops of fat in it.

Turbidity of urine, depending on the presence of salts, disappears when heated. It is possible to get rid of turbidity caused by the presence of mucus, bacteria or cellular elements in the urine, using its centrifugation and filtration.

4. Sediment. It is formed when urine stagnates. Sediment of urine is due to settling to the bottom of its dense components, salts, pus, formed elements of blood, mucus, cystine. Depending on the predominance of certain elements, urine sediment can have a different color: red (uric acid), pink (urates), white (phosphates), gray (ammonium uric acid), purulent (leukocytes), blood (erythrocytes), grayish- white (cystine).

5. Smell. Urine normally does not have a very strong smell. Freshly released urine of a healthy person has the smell of "mowed grass". In the presence of blood or pus, the urine acquires the smell of "rotten meat". In the presence of acetone, urine has a "fruity smell". With purulent processes in the urinary tract (purulent cystitis, disintegrating cancerous tumor), urine may have an ammonia smell.

6. Relative density. In physiological conditions, it depends on the concentration of dense substances dissolved in it (urea, uric acid, creatine, salts). Other substances (sugar, a large amount of protein) that appear in urine during pathological processes can affect the value of urine density. Thus, every 3.3 g/l of protein increases the density of urine by 0.001, that is, by one division of the urometer, and 10 g/l of sugar increases by 0.004.

The density of urine is measured using a urometer. Urine is poured into a cylinder into which the urometer is lowered so that it floats freely in it. The readings of the scale are removed at the level of the lower edge of the meniscus (if foam is formed, it is removed using filter paper).

In a healthy person, during the day, the density of urine fluctuates within fairly significant limits (1010-1030 based on 1 g per 1 liter of urine), and in morning portions it is normally 1015-1025.

The density of urine depends on the amount of liquid taken, the content of dense substances in food, and the temperature of the environment. Normal density is closely related to diuresis: it decreases with polyuria and increases with oliguria.

It is believed that in healthy people, the sum of the first two digits of the daily diuresis and the last digits of the density is 30. For example, with a diuresis of 1500 ml, the density of urine should be equal to 1015, with a diuresis of 1000 ml – 1020.

A decrease in density - **hyposthenuria** - occurs in chronic renal failure (chronic glomerulonephritis, nephroangiosclerosis, chronic pyelonephritis, amyloidosis, polycystic kidney). Urine with a very low density (1001 – 1002) is released in patients with diabetes insipidus.

A decrease in the density of urine simultaneously with a decrease in the range of its fluctuations during the day - **hypoisosthenuria** - indicates a significant violation of the concentration function of the kidneys (chronic renal failure of various origins: chronic glomerulonephritis, diabetic kidney, nephroangiosclerosis).

An increase in the density of urine - **hypersthenuria** - indicates the tension of the preserved concentration ability of the kidneys. Hypersthenuria can be observed in various physiological states of the body (restriction of drinking regime, increased sweating with limited drinking regime, for example, in hot weather), as well as in cardiovascular insufficiency, diarrhea, vomiting, fever, acute glomerulonephritis.

Chemical examination of urine

1. **Urine pH test**. The urine is usually slightly acidic, the normal urine Ph value is around 6.0, but can range from 4.5-8. The kidneys play an important role in maintaining the acid-base balance of the body. Therefore, any condition that produces acids or bases in the body, such as acidosis or alkalosis can directly affect urine pH.

Determined with a universal indicator paper, as well as with the help of blue or red litmus paper. With an acidic reaction, a blue piece of paper turns red, with an alkaline reaction, red turns blue. Normally, with a mixed diet, the reaction of urine is weakly acidic. A change in the reaction of urine to the acidic or alkaline side can be determined in physiological and pathological conditions of the body.

Under normal conditions, urine excretion of an acidic reaction occurs when a large amount of meat is consumed; with a vegetable diet, urine acquires an alkaline reaction. A change in the reaction of urine to acid is observed in diabetes, acute nephritis, severe renal failure; alkaline - with inflammatory processes in the urinary tract (cystitis, pyelitis), with vomiting, during the period of reduction of edema. A shift in the reaction of urine to the acidic or alkaline side is an unfavorable factor. With a weakly acidic reaction, urates, uric acid, are precipitated, which can lead to the formation of urate or uric acid stones. With a constant alkaline reaction of urine, phosphate stones can form.

2. Detection of protein in urine. Normally, urine contains almost no protein. The small amount of protein that has passed through the intact kidney filter is not captured by existing qualitative tests. Excretion of protein in the urine - **proteinuria** - can be determined qualitatively and quantitatively.

<u>Methodology of the method</u>. A mandatory condition for testing urine for protein content is its transparency. To eliminate turbidity, urine is filtered or other means of turbidity elimination are used (centrifugation, heating, addition of acid or alkali, depending on the nature of the salts). If the urine is alkaline, add a few drops of 10% acetic acid to it.

- Qualitative determination of the sample with sulfosalicylic acid. Add 8-10 drops of 20% sulfosalicylic acid solution to 4-5 ml of urine. With a positive reaction, turbidity appears, the degree of expression of which is directly proportional to the quantitative content of protein in the urine.

Test with nitric acid. Filtered urine is poured into the tube along the wall, holding the tube at an angle. In the presence of protein, a white ring appears at the boundary between the two liquids.

- Quantitative definition. The principle of the method is based on the qualitative reaction of protein determination using nitric acid. If the appearance of a thin white ring occurs between 2 and 3 minutes, this indicates the presence of 0.033% protein in the urine (33 mg of protein in 1 liter of urine). If the ring appeared earlier than after 2 minutes, then the urine is diluted with distilled water, choosing the dilution at which the ring appears between 2 and 3 minutes. Protein concentration is calculated by multiplying 0.033 by the degree of dilution of urine.

Protein can appear in urine under some physiological and pathological conditions. Protein in the urine may be a sign of kidney disease. Namely, about the defeat of the glomeruli of the kidneys. Because normally, protein does not penetrate the renal filter. The appearance of protein in the urine in the norm (functional proteinuria) can be associated with an increase in the size of the pores of the renal filter, which can occur with postural abnormalities after intense physical exertion. Transient functional proteinuria can appear in an orthostatic position (orthostatic proteinuria), as well as after sharp and prolonged cooling of the body.

Pathological proteinuria can be of renal or extrarenal origin.

Renal proteinuria occurs as a result of organic kidney damage (nephrotic syndrome in glomerulonephritis, amyloidosis, nephropathy of pregnant women, diabetic nephroangiosclerosis, kidney damage in collagenosis).

Small proteinuria can be caused by various extrarenal causes (increased body temperature, cardiovascular insufficiency). Extrarenal proteinuria can also appear in diseases of the genitourinary tract and genitals. Extrarenal proteinuria usually does not exceed 1 g/l.

If a large amount of protein is detected on a urinalysis or if the protein persists in repeated tests, a 24-hour urine protein test may be used as a follow-up test.

3. Determination of glucose in urine. After filtration, through the membrane of the kidney glomeruli, glucose is completely reabsorbed in the proximal tubules of the kidneys into the blood.

Glucosuria (the appearance of glucose in the urine) occurs if the concentration of glucose in the blood exceeds 8.8 - 9.9 mmol/l, which exceeds the renal threshold for glucose.

Normal urine contains a small amount of glucose, which cannot be detected by ordinary qualitative reactions. Excretion of glucose in the urine (glucosuria) can be detected by qualitative and quantitative tests.

- Qualitative reaction. The glucose test is a paper or plastic strip with a yellow indicator (sensor) on it, which, when immersed in urine, changes color as a result of an enzymatic reaction. The test strip for glucose in urine should be immersed without bending, so that the indicators are completely covered with liquid. The test strip is lowered into the urine for 2-3 seconds, carefully remove, place on a flat, dry surface, wait 45-90 seconds (no more than 2 minutes). Next, compare the color of the indicator with the color scale on the tube or pencil case and evaluate the result. The sensor reacts to glucose in the urine, the color varies from yellow (in the absence of glucose) to blue-green, depending on the amount of the specified substance in the liquid.

- Quantitative reaction. Althausen's colorimetric method is used. It is based on the formation of a color reaction followed by a comparison of the resulting solution with a standard scale.

Clinical significance. Glycosuria in physiological conditions can appear when a large amount of carbohydrates is consumed with food, when the concentration of glucose in the blood exceeds the renal threshold for glucose. Such glycosuria is called alimentary. Temporary glycosuria can occur with strong excitement, after the introduction of adrenaline.

Pathological glucosuria, as a rule, is accompanied by an increased concentration of glucose in the blood (hyperglycemia) and occurs in diabetes, with long-term use of glucocorticoids, adrenaline, and impaired secretion of certain hormones (thyroxine, ACTH). Permanent glucosuria can appear without hyperglycemia, for example, in so-called renal diabetes, when the ability of the tubular epithelium to reabsorb glucose decreases.

Some other conditions that can cause glucosuria include hormonal disorders, liver disease, medications, and pregnancy. When glucosuria occurs, other tests such as a fasting blood glucose are usually performed to identify the specific cause.

4. Determination of ketone bodies. Ketone bodies are acetone, acetoacetic and β-oxybutyric acids, which are intermediate products of fat metabolism. Normally, a minimum amount of ketone bodies is excreted in the urine, which are not detected by ordinary quality tests. Excretion of ketone bodies in the urine indicates their accumulation in large quantities in the blood, which can occur with cachexia, uncontrollable vomiting, and prolonged starvation. However, ketonuria is most important in diabetes because it indicates deep changes in metabolic processes in the body (fat and carbohydrate metabolism).

Ketones are not normally found in the urine. They are intermediate products of fat metabolism. They are produced when glucose is not available to the body's cells as an energy source. They can form when a person does not eat enough carbohydrates (for example, in cases of fasting, starvation, or high-protein diets) or when a person's body cannot use carbohydrates properly. When carbohydrates are not available, the body metabolizes fat instead to get the energy it needs to keep functioning. Hard exercise, frequent, prolonged vomiting, and several digestive system diseases can also increase fat metabolism, resulting in ketonuria. In a person who has diabetes, ketones in urine may also be an early indication of insufficient insulin. With insufficient insulin, a diabetic cannot process glucose and instead metabolizes fat. This can cause ketones to build up in the blood, resulting first in ketosis and then progressing to ketoacidosis, a form of metabolic acidosis. Excess ketones and glucose are goes into the urine by the kidneys. This condition, called diabetic ketoacidosis (DKA), is most frequently seen with uncontrolled type 1 diabetes and can be a medical emergency.

5. Determination of bile pigments. Bilirubin and urobilin are determined from bile pigments in urine.

Bilirubin is not present in the urine of normal, healthy individuals. It is a waste product that is produced by the liver from the hemoglobin. It becomes a component of bile. The appearance of bilirubin in the urine (bilirubinuria) is a pathological phenomenon. Only direct bilirubin is excreted in the urine, since indirect bilirubin cannot pass through an intact renal filter. Bilirubinuria appears as a result of difficulty in the entry of bile pigments into the duodenum, for example, with parenchymal and obstructive jaundice. With hemolytic jaundice, bilirubinuria does not occur, since indirect bilirubin does not pass through the renal filter. In certain liver diseases, such as biliary obstruction or hepatitis, excess bilirubin can build up in the blood and is eliminated in urine. The presence of bilirubin in urine is an early indicator of liver disease and can occur before clinical symptoms such as jaundice develop.

Urobilin (urobilinogen) bodies are derivatives of bilirubin. Urobilinogen is formed from bilirubin in the intestines under the action of intestinal bacteria. Part of the urobilinogen is absorbed by the intestinal wall and enters the liver through the portal vein, where it is completely broken down. Unabsorbed urobilinogen is transformed into stercobilinogen, the main part of which is excreted in the form of stercobilin with feces. A small part of stercobilin enters the general bloodstream through the system of hemorrhoidal veins and is excreted by the kidneys.

The urine of a healthy person always contains a small amount of urobilinogen (urobilin), which is not detected by ordinary quality tests (0-4 mg/day).

Increased excretion of urobilin bodies in the urine - urobilinuria occurs in various pathological conditions of the body:

1) parenchymatous damage of the liver parenchyma (viral hepatitis, acute and chronic hepatitis of other etiologies), in which stercobilin bodies that have entered the portal system are not captured due to functional insufficiency of the liver and are excreted in the urine in the form of urobilinogen;

2) hemolytic anemia, in which increased formation of urobilinogen and stercobilin bodies occurs in the intestine. that entered through the system of hemorrhoidal veins into the general blood stream, and then are excreted in the urine.

5. Determination of nitrites. This test detects nitrite and is based upon the fact that many bacteria can convert nitrate (a normal substance in urine) to nitrite. Normally, the urinary tract and urine are free of bacteria and nitrite. A positive nitrite test result can indicate a urinary tract infection.

Microscopic examination of urine

Microscopic examination of urine is carried out using urine sediment analysis. Morning urine is usually examined. 10 ml of urine, taken with a pipette from the bottom of the dish, is placed in a test tube and centrifuged for 10-15 minutes at 1000 revolutions/minute. The liquid is poured over the sediment, and a drop of the sediment is placed on a microscope slide, covered with a cover glass and examined under a microscope (first under low, and then under high magnification). The result is expressed as the number of formed blood elements found in the field of vision.

Clinical significance. The elements of urinary sediment are divided into unorganized (salts, mucus) and organized (cellular elements and cylinders).

Organized elements

1.White blood cells (WBCs). The number of WBCs in urine sediment is normally low (0-5 WBCs per high power field, HPF). WBCs can be a contaminant, such as those from vaginal secretions. Increased excretion of leukocytes in the urine - **leukocyturia and pyuria** - occurs in inflammatory and purulent processes in the kidneys and urinary tract (pyelonephritis, cystitis, urethritis), fig. 1.

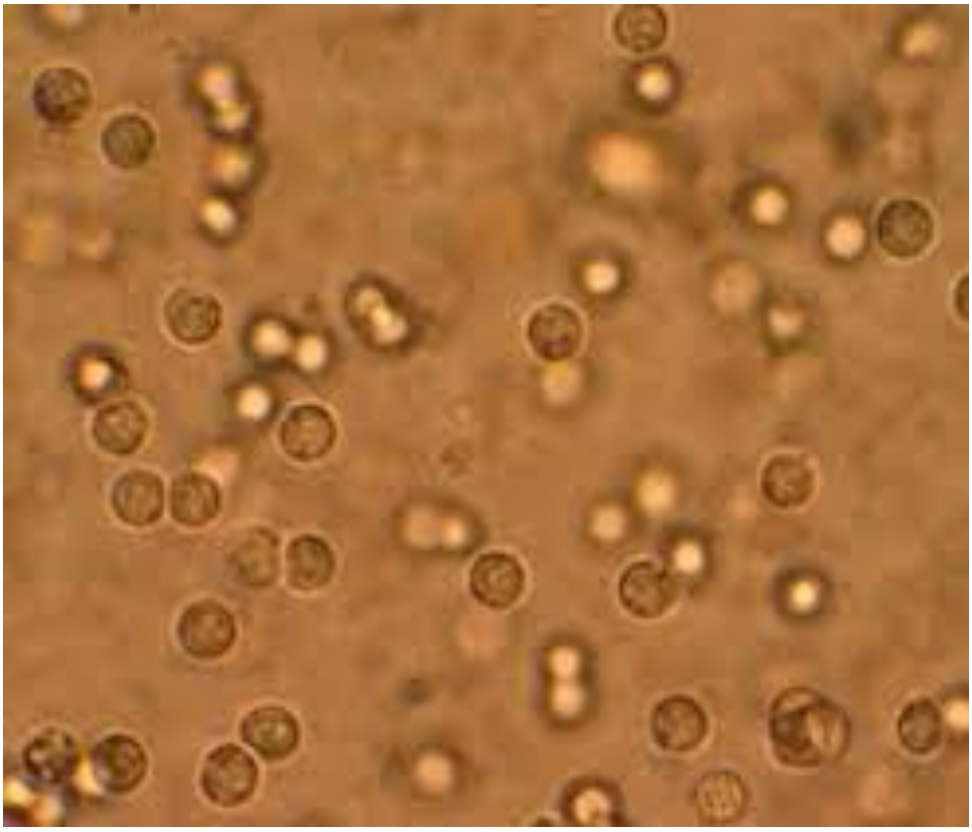

Figure 1. WBCs in urine

2. Erythrocytes. Normally, a few Red blood cells (RBCs) are present in urine sediment (0-5 RBCs per high power field, HPF). The appearance of erythrocytes in the urine is called hematuria (erythrocyturia). If there is visible blood in the urine, it is called macrohematuria, and only when examined microscopically, it is called microhematuria.

There are 2 types of hematuria:

- renal hematuria (with acute glomerulonephritis, pyelonephritis, amyloidosis, urinary diathesis, kidney stone disease);

- extrarenal hematuria (traumas of the urinary system, disintegrating cancer, prostate hypertrophy).

Depending on the features of the pathological process, unchanged and changed erythrocytes may appear in the urine. Hematuria with a predominance of changed erythrocytes, characteristic of the following diseases: acute and chronic glomerulonephritis, renal infarction, hypernephroma, renal tuberculosis, congestive kidney. Unchanged erythrocytes in the urine appear most often in case of damage to the endothelium of the urinary tract and kidneys (kidney stone disease, acute cystitis, malignant neoplasms, polycystic disease, tuberculosis of the urinary bladder, traumatic damage to the genitourinary organs), fig. 2.

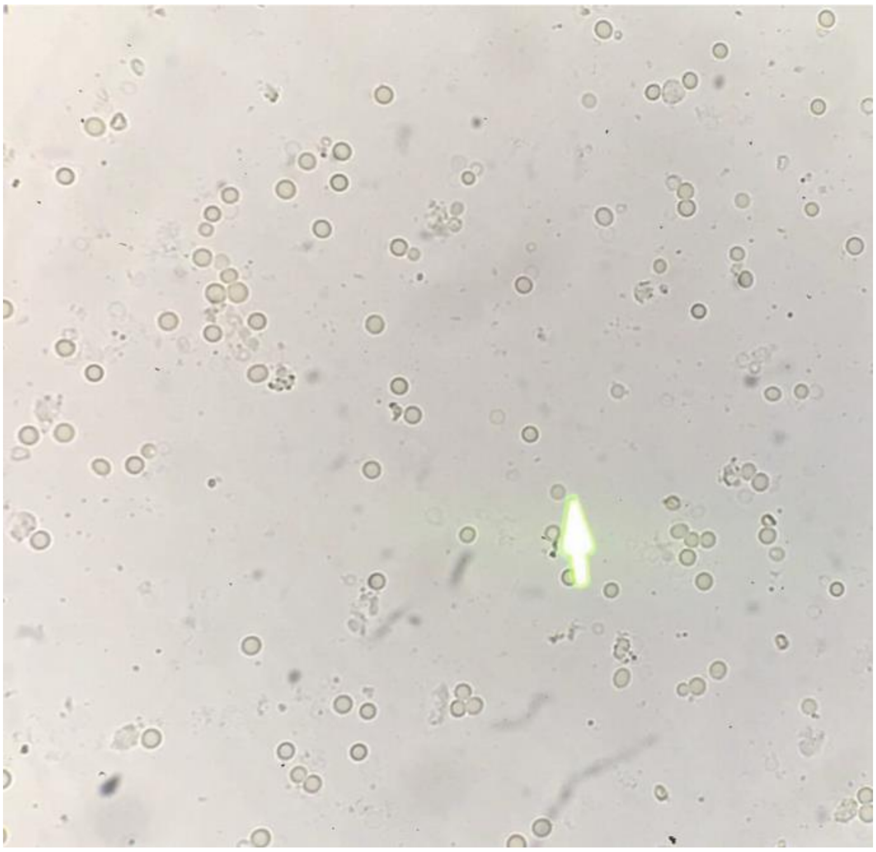

Figure 2. RBCs in urine.

3. Epithelial cells. Epithelial cells are usually reported as “few,” “moderate,” or “many” present per low power field (LPF). Normally, in men and women, a few epithelial cells can be found in the urine sediment. In urinary tract conditions such as infections, inflammation, and malignancies, an increased number of epithelial cells are present, fig. 3.

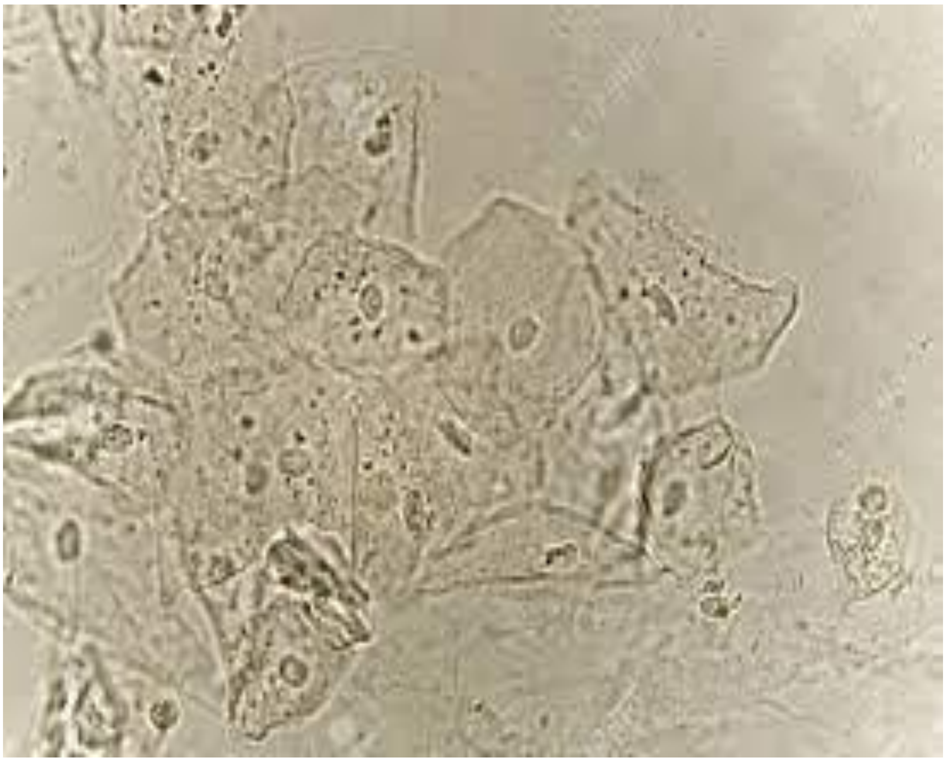

Figure 3. Epithelial cells in urine.

4. Casts. Casts are cylindrical particles sometimes found in urine that are formed from coagulated protein released by kidney cells. They are formed in the long, thin, hollow tubes of the kidneys known as tubules and usually take the shape of the tubule (hence there name). There are granular, waxy and hyaline casts. If the surface of the cast is covered with formed elements of blood, then such casts, depending on the appearance, are called erythrocyte, leukocyte, epithelial, respectively. If the cells stuck to the cast have disintegrated, then such casts are called granular.

Under the microscope, they often look like the shape of a “hot dog”. This type of cast is called a “hyaline” cast. Normally, healthy people may have a few (0–5) hyaline casts per low power field (LPF). A significant number of hyaline cylinders are found in almost all kidney diseases accompanied by proteinuria (nephritis, pyelonephritis, nephrotic syndrome), fig 4.

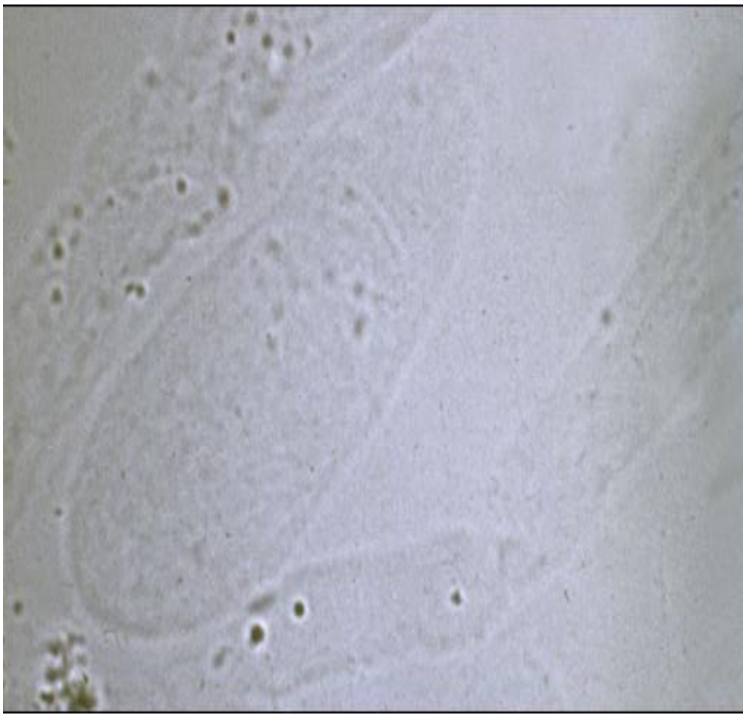

Figure 4. Hyaline casts in urine.

Other types of casts are associated with different kidney diseases, and the type of casts found in the urine may give clues as to which disorder is affecting the kidney. The presence of cell casts always indicates kidney disease. The appearance of erythrocyte casts indicates an acute lesion of the renal structures (acute glomerulonephritis, lupus nephritis), fig 5.

Figure 5. Erythrocyte casts in urine.

The main cells that make up the leukocyte casts are neutrophils. As a rule, their appearance is associated with tubulointerstitial disease, such as acute pyelonephritis, fig 6.

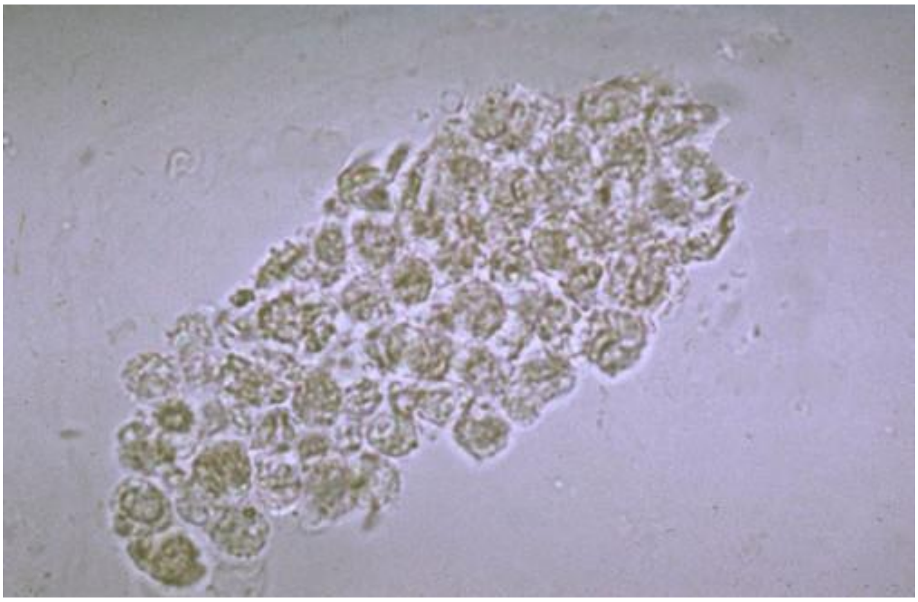

Figure 5. Leukocyte casts in urine.

Epithelial casts are composed of renal epithelial cells held together by a protein base. Their identification is a serious pathology, since the appearance of epithelial casts is associated with acute tubular necrosis, viral kidney damage, such as cytomegalovirus, and poisoning with nephrotoxic substances, fig. 6.

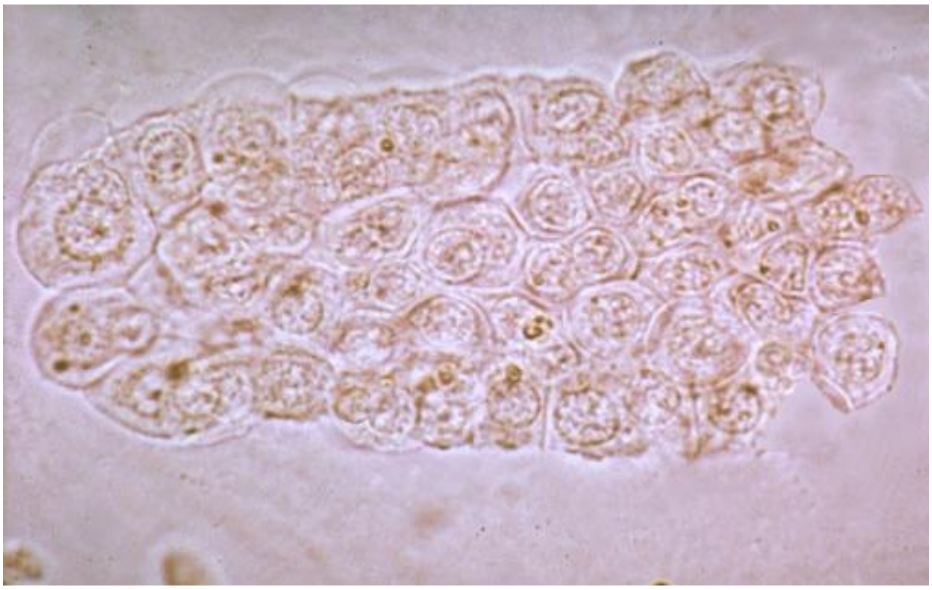

Figure 6. Epithelial casts in urine.

Bacterial casts are bacterial cells stuck together with a protein matrix. Their appearance indicates the development of acute pyelonephritis or renal infections of a bacterial nature, fig. 7.

Figure 7. Bacterial casts in urine.

The presence of granular casts indicates stagnation in the nephron. They are associated with tubulointerstitial diseases (nephritis), fig. 8.

Figure 8. Granular casts in urine.

Wax casts represent the final stage of cell degeneration. Their presence suggests congestion in the kidney or obstruction (blockage) of the nephron. They are also called casts of renal failure, fig 9.

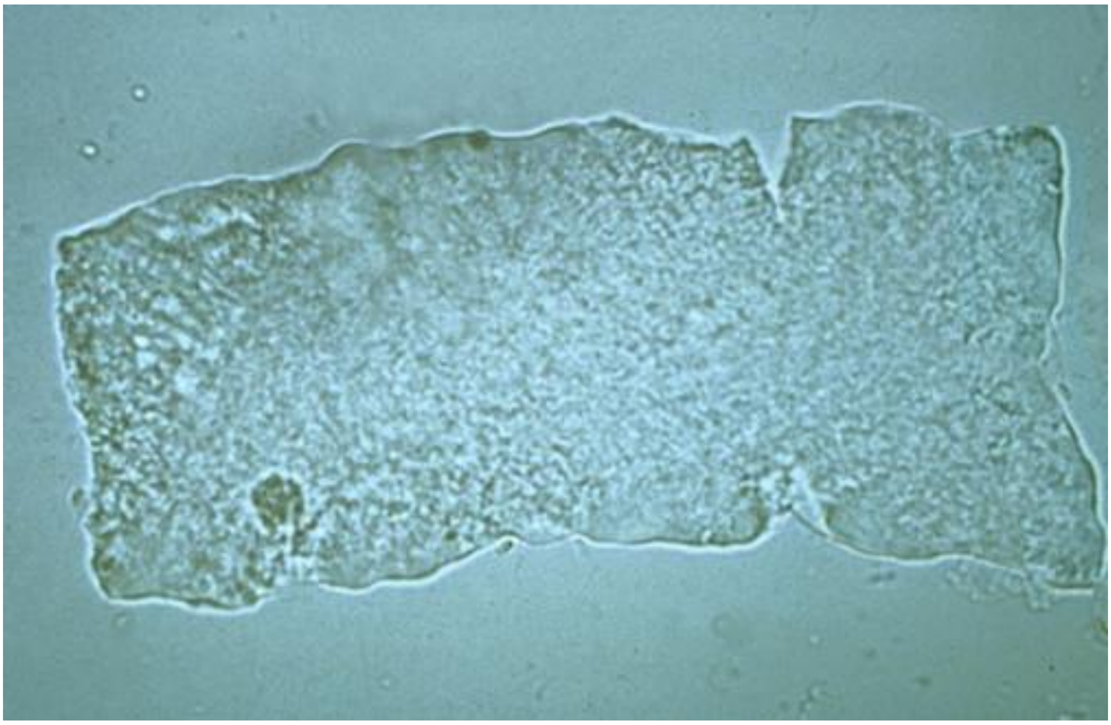

Figure 9. Wax casts in urine.

Fatty casts appear due to nephrotic syndrome, diabetic nephropathy, or the influence of nephrotoxins (poisoning), fig. 10.

Figure 10. Fatty casts in urine.

Quantitative study of urine sediment. Recently, the methods of quantitative research of the elements of urinary sediment - leukocytes, erythrocytes, cylinders - are increasingly being used. These methods have a significant advantage over the usual ones, as they allow more accurate determination of the initial manifestations of damage to the kidneys and urinary tract.

The methods of quantitative research of urinary sediment elements are based on the quantitative assessment and determination of the ratio between individual elements (erythrocytes, leukocytes, cylinders) in the daily amount of urine (Kakovsky-Addis test), in 1 ml of urine (Nechyporenko test), or in the amount of urine isolated kidney in 1 minute (Amburger's test).

In a healthy person, $2x10^6$ leukocytes, $1x10^6$ erythrocytes and up to $2x10^4$ cylinders can be excreted in the urine per day. According to J. Amburghe, under normal conditions, the kidney of a healthy person secretes up to 1,000 erythrocytes, 2,000 leukocytes and up to 1-3 hyaline casts in 1 minute. 1 ml of urine of a healthy person contains up to 4000 leukocytes, up to 1000 erythrocytes, casts, as a rule, are not detected.

Unorganized elements

Mucus. Under normal conditions, urine does not contain mucus. Mucus appears in diseases of the urinary tract and kidneys (urethritis, prostatitis, cystitis, kidney stone disease).

Crystals. These are chemicals that are formed in the urine and that may form stones in the urinary tract. Urine contains many dissolved substances that can form crystals, solid forms of a particular substance. Crystals are identified by their shape, color, and by the urine pH.

In "acidic urine" there are urates (under a microscope they look like grains), uric acid (like prisms), oxalates (the shape of a postal envelope) in the sediment, fig.11,12. During the alkaline reaction of urine, amorphous urates (under a microscope have the appearance of small amorphous grains with a white or grayish-white color), triple phosphates (the form of "burial lids"), ammonium uric acid (in the form of individual or double brown balls) precipitate. unorganized salt sediment does not have a great diagnostic value, although the nature of the sediment in some cases can determine the peculiarity of salt diathesis, fig. 13,14.

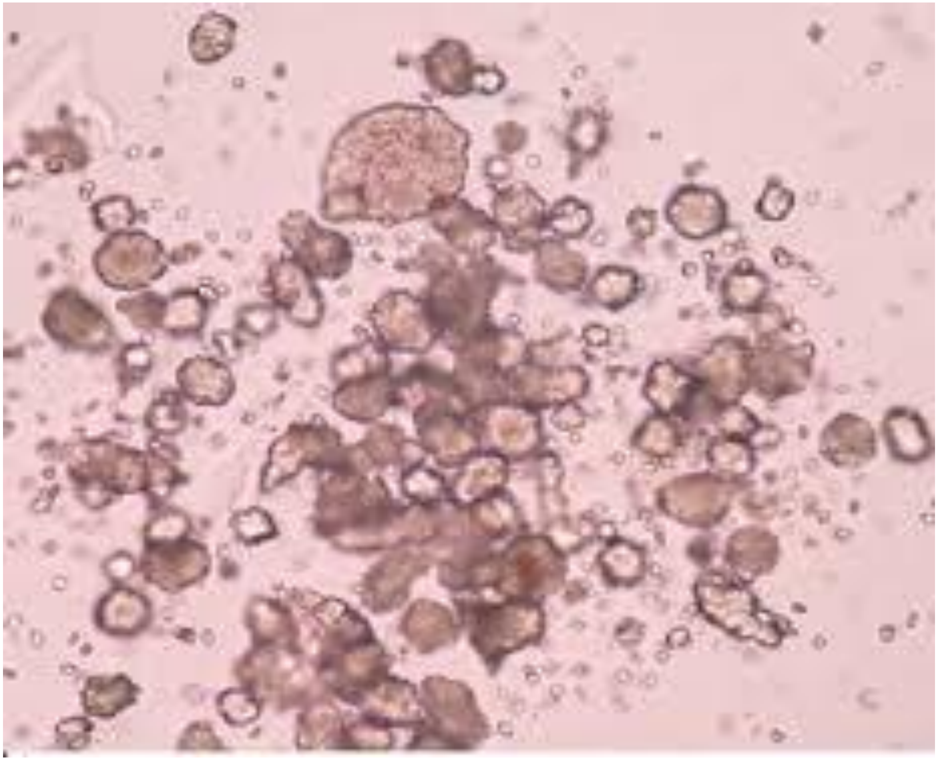

Figure 11. Crystalline uric acid

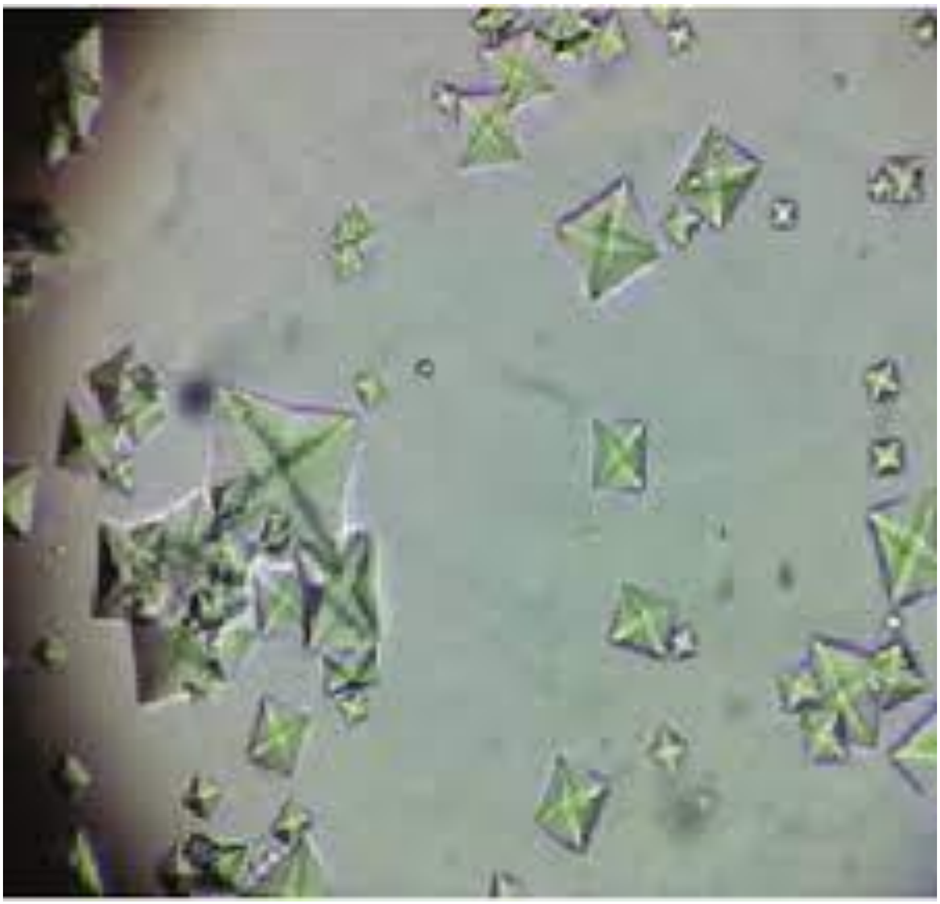

Figure 12. Calcium oxalates

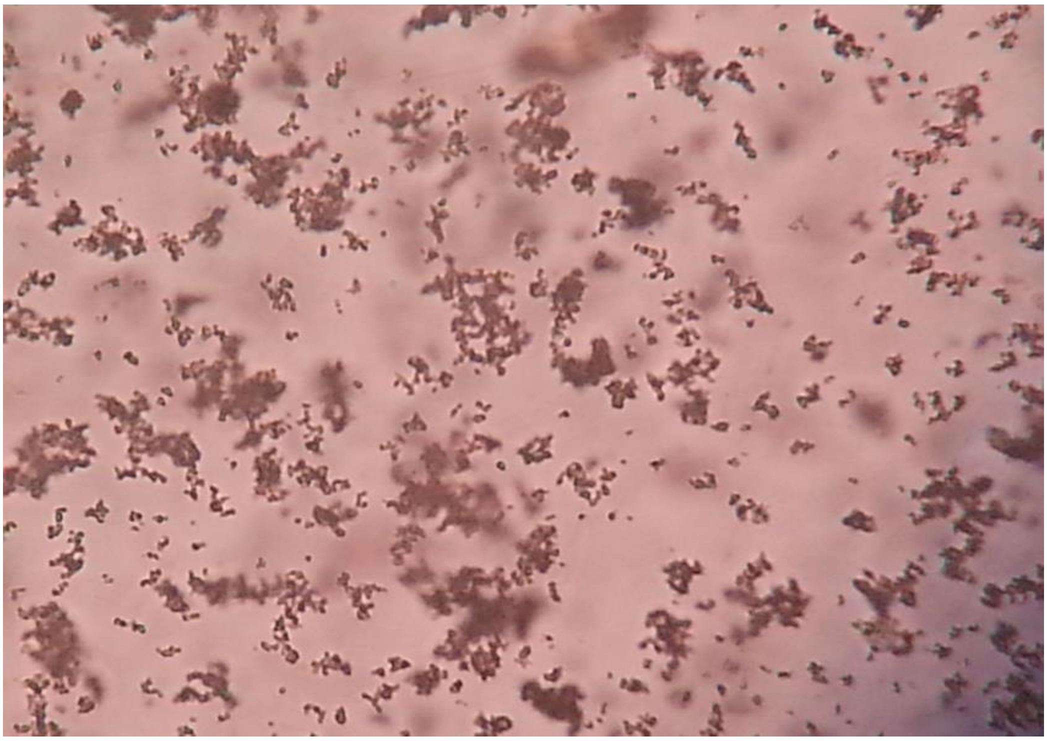

Figure 13. Amorphous urates.

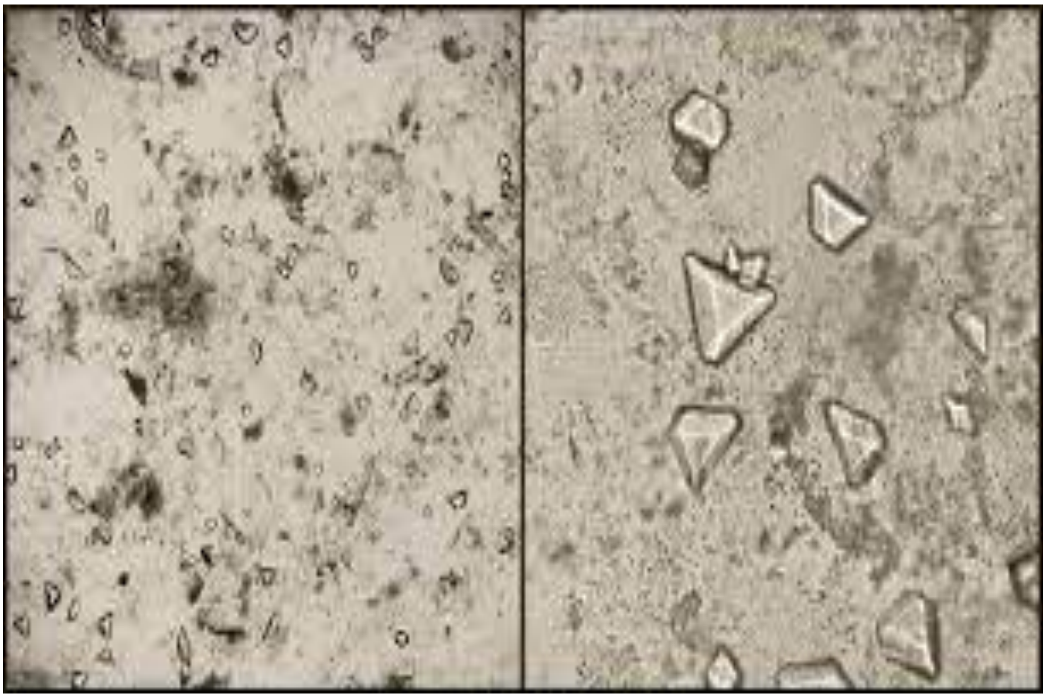

Figure 14. Amorphous phosphates.

Indicators of urine of a healthy person

Amount per day	1000 - 1800 ml
Relative density	1014-1026 (varies during the day within wide limits)
Color	Straw yellow
Transparency	Transparent
Chemical composition	
Reaction	Neutral or weakly acidic (in physiological conditions an alkaline reaction appears with a vegetable diet, alkaline drinking)
Protein	Absent
Glucose	Absent (traces)
Acetone	Absent
Ketone bodies	Absent
Urobilin	Absent (0-4 mg/day)
Bilirubin	Absent
Ammonia	0.6-1.3 g/day
Uric acid	270-600 mg/day
Urea	20-35 g/day
Creatinine	0.5-2 g/day
Creatine	Absent
Sodium	3-6 g/day
Potassium	1.5-3 g/day
Chlorine	170-120 meq/l
Urine sediment	
Epithelial cells	(flat) 0-3 in the field of vision
Leukocytes	0-2 in the field of vision
Erythrocytes	Single
Cylinders	Absent
Mucus	Absent
Inorganic sediment	- with an acidic reaction - uric acid, urates, oxalates - with an alkaline reaction - amorphous phosphates, ammonium uric acid, triple phosphates

CONTROL QUESTIONS

1. Rules for urine collection.

2. What does a urinalysis include and in what sequence is it performed?

3. What is the amount of daily diuresis and what does it depend on?

4. What is meant by polyuria, oliguria, anuria, nocturia and when do they occur?

5. What is the normal color of urine? What color of urine can be found in pathology? Dependence between diuresis and urine color?

6. How is the density of urine measured? What is the normal density of urine?

7. In what cases is there a high (low) density of urine? What kidney function does the density reflect?

8 What is called isosthenuria, hyposthenuria, hypersthenuria, hypoisosthenuria.

9. What are the methods for determining protein in urine? Their clinical significance.

10. Under what physiological conditions does protein appear in the urine?

11. What is meant by renal and extrarenal proteinuria? In what diseases do they occur?

12. What methods exist for determining glucose in urine?

13. Is glucose present in the urine of a healthy person? What is meant by glycosuria?

14. Methods of determining ketone bodies, bile pigments in urine, their clinical significance.

15. What color is urine in the presence of bile pigments? What bilirubin can appear in the urine?

16. What is hematuria and in what diseases does it occur?

17. The clinical value of determining "disorganized sediment" in urine.

TESTS FOR SELF-CONTROL

1. An 8-year-old girl complains of frequent painful urination in small amounts and urinary incontinence. Tie signs have heen present for 2 days already. She explains her disease by overexposure to cold. Costovertebral angle tenderness is absent. Complete blood count is without pathologies. Urine test: leukocytes - 20-30 in the vision field, erythrocytes -40-50 in the vision field, unchanged, bacteriuria. What is the most likely diagnosis?

A. Pyelonephritis

B. Glomerulonephritis

C. Urolithiasis

D. Cystitis

2. A 32-year-old woman complains of general fatigue, low-grade fever persisting for 4 months, lumbar pain, and dysuria. Anamnesis includes frequent acute respi-ratory diseases, overexposure to cold, low-calorie diet, a case of pulmonary tuberculosis in childhood. Clinical urine analysis: pH-4.8, leukocyturia, hematuria. Complete blood count: leukocytosis, lymphocytosis, increased ESR. Urography concludes: dilatation of renal pelvis and calyceal system of both kidneys, foci of calcification in the projection of right kidney parenchyma. What is the most likely diagnosis?

A. Nephrotuberculosis

B. Right renal carcinoma

C. Acute glomerulonephritis

D. Chronic pyelonephritis

3. A 7-year-old boy has been an inpatient for 1.5 months. He had been brought to the hospital with complaints of edemas all over his body, low urine output, and headache. Clinical urinalysis: proteins - 7.1 g/L, leukocytes - 1-2 in the vision field, erythrocytes - 3-4 in the vision field. During the course of treatment the edemas gradually dissipated, headache abated, diuresis normalized. Daily urine proteins - 3 g/L. Biochemical blood lest: total protein - 43.2 g/L, urea mmul/L. cholesterol - 0.2 mmol/L. glomerulonephritis syndrome is the likely to be present in the patient.

A. Nephritic

B. Hematuric

C. Nephrotic

D. Isolated urinary

4. After overexposure to cold a 45-year- old woman developed acute pain in her suprapubic and lumbar areas during urination, sharp pains at the end of urination, false urges to urinate. Urine is turbid with blood streaks. His doctor suspects urinary tract infection. What results of laboratory analysis would be the most indicative of such infection?

A. Leukocyturia, gross hematuria

B. Increased blood creatinine and blood urea

C. Daily proteinuria under 3.0

D. Daily proteinuria over 3.0

5. A 9-year-old girl complains of fever up to 37,5°C, headache, inertness, weakness, loss of appetite, stomachache, and frequent painful urination. Provisional diagnosis of acute pyelonephritis is mad- Clinical urine analysis: specific gravity - 1018, no protein, leukocytes - 10-15 in the vision fiel- What investigation method can verify the diagnosis of urinary system infection?

A. Bacteriological inoculation of urine

B. Rehberg test (creatinine clearance test)

C. Complete blood count

D. Clinical urine analyses, dynamic testing

6. A 46-year-old man notes swollen legs, weakness, sensation of fullness and heaviness in the right subcostal area; it is the first occurrence of these signs in the patient. The patient has 20-year-long history of rheumatoid arthritis. The liver and spleen are enlarged and dens- Blood creatinine -0,23 mmol/l, proteinemia - 68 g/l, cholesterol - 4,2 mmol/l, urine specific gravity - 1012, proteinuria - 3,3 g/l, isolated wax-like cylinders, leached erythrocytes in the vision field, leukocytes - 5-6 in the vision fiel- What is the most likely complication?

A. Renal amyloidosis

B. Acute glomerulonephritis

C. Heart failure

D. Chronic pyelonephritis

7. A 35-year-old man complains of intense lumbar pain irradiating to the inguinal area, external genitalia, thigh; frequent urination, chill, nausea, vomiting. Objectively: positive Pasternatsky's symptom (costovertebral angle tenderness). Urine analysis revealed that RBCs and WBCs covered the total field of microscope; the urine exhibited high protein concentration. These clinical presentations were most likely caused by the following pathology:

A. Urolithiasis, renal colic

B. Renal infarction

C. Intestinal obstruction

D. Osteochondrosis, acute radicular syndrome

8. A 42-year-old woman has been hospitalized with complaints of intense pain attacks in the lumbar and right iliac areas, which irradiate to the vulvar lips, frequent urination, nause= The pain onset was acute. Objectively: the abdomen is soft, moderately painful in the right subcostal area, costovertebral angle tenderness on the right. Common urine analysis: specific gravity - 1016, traces of protein, leukocytes - 6-8 in the vision field, erythrocytes - 12-16 in the vision field, fresh. What diagnosis can be made?

A. Right-sided renal colic

B. Acute right-sided pyelonephritis

C. Acute right-sided adnexitis

D. Acute appendicitis

9. 2 weeks after recovering from tonsillitis an 8-year-old boy developed edemas of face and lower limbs .Objectively: the patient is in grave condition, BP-120/80 mmHg. Urine is of dark brown color. Oliguria is present. On urine analysis: specifc gravity - 1,015, protein - 1,2 g/l, RBCs are leached and cover the whole vision field, granular casts- 1-2 in the vision field, salts are represented by urates (large quantity). What is the most likely diagnosis?

A. Acute glomerulonephritis with nephrotic syndrome

B. Acute glomerulonephritis with nephritic syndrome

C. Acute glomerulonephritis with nephrotic syndrome, hematuria and hypertension

D. Acute glomerulonephritis with isolated urinary syndrome

10. A 48-year-old patient complains of weakness, subfebrile temperature, aching pain in the kidney region. These presentations turned up three months ago after hypothermia. Objectively: kidneys are painful on palpation, there is bilaterally positive Pasternatsky’s symptom. Urine test res: acid reaction, pronounced leukocyturia, microhematuria, minor proteinuria - 0,165-0,33 g/l. After the urine sample had been inoculated on conventional media, bacteriuria were not found. What research is most required in this case?

A. Isotope renography

B. Nechiporenko urine test

C. Daily proteinuria

D. Urine test for Mycobacterium tuberculosis

LITERATURE

1. Zalubovska, O., Zlenko, V., Litvinova, O., Bereznyakova, M., Karabut, L., Fomina, H., ... & Kovalevska, O. (2014). Drug influence on laboratory indices.
2. Lepowsky, E., Ghaderinezhad, F., Knowlton, S., & Tasoglu, S. (2017). based assays for urine analysis. *Biomicrofluidics*, *11*(5), 051501.
3. Wiley, T. (1993). A Manual of Laboratory Diagnostic Tests. *Gastroenterology Nursing*, *16*(1), 39.
4. Simerville, J. A., Maxted, W. C., & Pahira, J. J. (2005). Urinalysis: a comprehensive review. *American family physician*, *71*(6), 1153-1162.
5. Materials for IFOM exam (license computer program).