SAINT PETERSBURG STATE PEDIATRIC MEDICAL UNIVERSITY
DEPARTMENT OF PROPAEDEUTICS OF INTERNAL DISEASES

INSTRUMENTAL METHODS OF INVESTIGATION OF THE DIGESTIVE, URINARY EXCRETORY AND ENDOCRINE SYSTEMS IN INTERNAL DISEASE CLINICAL PRESENTATION

(tutorial for the students)

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DIGESTIVE SYSTEM INVESTIGATION METHODS

Endoscopic investigation techniques

FIBROESOPHAGOGASTRODUODENOSCOPY (FEGDS) is a method of imaging the esophagus, stomach and the initial part of the duodenum by means of a special endoscope introduced through the mouth. During the procedure one can inspect the esophagus, stomach and duodenum mucus membrane condition, as well as take some biopsy samples and perform therapeutic manipulations such as remove a benign growth, stop bleeding, take out a foreign body and so on. The investigation is performed in each case when it is necessary to identify a pathology of the upper digestive tract, or define it more precisely (in case of esophagitis, gastritis, ulcer, tumor, burns and their consequences, etc.). The technique can help determine the character of changes caused by a disease of a neighbouring organ (like the liver, pancreas, gallbladder), or find out a foreign body, and so on.

FEGDS is indicated to reveal the extension of a malignant neoplasm, or for a differential diagnosis of a malignant or a benign growth, an organic stenosis of the esophagus, of pylorus, duodenum etc. During the investigation one can take a piece of the mucous membrane for a histologic investigation (endobiopsy) with the following histologic study. Apart from that, the method allows to define the state of the major duodenal papilla, to carry out a radiographic contrast study of bile and pancreatic ducts (retrograde cholangiopancreatography). During FEGDS it is possible to perform an endoscopic near-wall pH-metry (assessing the gastric juice acidity), as well as an express diagnosis of Helicobacter pylori by the urease test.

FEGDS is performed either for diagnosis or for treatment.

Indications for diagnostic FEGDS are:

- making the localization of a pathologic process more precise;
- an imaging study of the revealed pathologic changes, making their extension more precise;
- checking the therapy effect;
- differential diagnosis between diseases of the stomach and duodenum;
- determining the character of pyloroduodenal stenosis (whether it is organic or functional);
- biopsy of the areas involved (in a stomach ulcer, filling defects, neoplasms);
- identification of the stomach changes that can affect the choice of a rational surgical treatment method (before a surgical intervention on the heart).

Contraindications for performing a diagnostic FEGDS are:

- shock;
- acute cerebral or coronary circulatory disturbance;
- epileptic seizures;
- bronchial asthma attacks;
- acute myocardial infarction (while the endoscope is moving along the esophagus the heart may get irritated, which, in the presence of acute myocardial ischemia, may result in a life threatening disturbed cardiac rhythm);
- the consciousness depressed up to the coma;
- coagulopathy.

However, there can be no contraindications when one tries to cope with a situation threatening a patient's life (e.g. to control a gastro-intestinal bleeding), that is for a curative purpose.

FIBROCOLONOSCOPY (FCS) is one of the most informative methods of early diagnosing benign and malignant growths of the colon, ulcer colitis, Crohn disease etc. It allows to examine the whole length of the colon in 80-90% of cases. During the procedure one can inspect and assess the colon mucus membrane condition, as well as perform therapeutic manipulations, take some biopsy samples, remove a benign growth, stop bleeding, take out a foreign body and so on. A planned diagnostic FCS is aimed at determining the character, location, extent of a pathologic change and the degree to which it is marked in the colon. When necessary, biopsy is performed, some tissue may be taken for a histologic or cytological investigation.

Indications for FCS are:

- Final diagnosing and making the diagnosis more precise if a patient has clinical or radiographic signs of a colon malignant neoplasm;
- determining the morphological structure and the extension of malignant process in the colon in cases when the diagnosis of colon cancer has already been made;
- assessing the character, extent and the degree to which the pathologic change is marked in case of an acute or chronic inflammatory disease in the colon;
- checking the effect of a colon condition treatment, evaluating its quality, including that of a surgical treatment.

Contraindications to FCS include:

- marked pulmonary and cardiac failure; arterial blood hypertension of the 3d degree, and a number of other severe somatic disorders in which FCS may trigger a breakdown in the patient's condition dangerous for his life;
- severe forms of non-specific ulcer colitis, Crohn disease, diverticulitis and others, in which there is a real danger of grave complications like bleeding and perforation;
- general suppurative peritonitis.

Complete intestinal purgation is essential before performing FCS. For this purpose special medicine is applied.

Functional Diagnosis Methods (gastric and duodenal intubation)

INTRALUMINAL PH-METRY (gastric intubation) is a technique of investigating the secretory and motor functioning of the gastro-intestinal tract. At present intragastric and intraesophageal PH-metry is widely used. This technique allows us to assess gastric juice at different stages of the food digestion process. First, the gastric contents is taken out of the stomach fasting, then the gastric juice being secreted in response to the stimulating intubation is collected. In order to collect the gastric juice secreted in digesting food the work of the stomach is stimulated by special medication. Histamine, pentagastrin and insulin are most frequently used.

Intragastric PH-metry

To investigate the stomach secretory function one can employ several kinds of intragastric PH-metry.

Kinds of intragastric PH-metry:

• a short-term one;

• a prolonged one (for 24 hours);

• an endoscopic one;

• the one using radiocapsules.

pH (hydrogen index) is the vulgar\decimal algorithm of hydrogen ions concentration taken with an inverse sign which reflects the solution acidity.

The main advantages of the gastric pH-metry are its possibility to investigate the stomach secretory function accuvelocityly under the conditions close to the physiological ones, as well as to assess the individual effectiveness of the medication administered in the online environment (real time operation mode).

Indications for the intragastric pH-metry has been significantly reduced lately due to reevaluation of the acid-p3p5ic factor role in the gastric and duodenal ulcer

pathogenesis, as well as some other acid-dependent gastro-intestinal disorders pathogenesis. Indications for the intragastric pH-metry include the necessity to assess the acid- and alkali-producing function of the stomach and duodenum precisely (in particular, when diagnosing with gastrin), and also, the individual assessment of the effect of anti-secretory drugs administered.

Contraindications are:

Absolute contraindications are absent.

Relative contraindications are:

- decompensated ischemic heart disease, heart defects, severe arterial hypertension;
- respiratory and cardiac failure;
- aortic arch or thoracic aorta aneurism;
- marked systemic atherosclerosis;
- kidney failure;
- diabetic ketoacidosis;
- severe allergic reactions in the past history;
- esophageal diverticules;
- recent gastro-intestinal bleeding;
- diseases accompanied by disturbed swallowing;
- impaired consciousness.

Preparing the patient

12 hours before the procedure the patient should not take any medicine or food (for proton pump inhibitors this period is prolonged to 2-3 days). The patient must not smoke 3-4 hours before the investigation.

Method and the Care Following

The intragastric pH-metry is performed on the empty stomach in the morning. The catheter is usually introduced actively during the patient's swallowing motions, so any anesthesia of the pharynx is not recommended. During the catheter introduction the patient should be standing and breathe deeply to suppress a reflex to vomit. After introducing the catheter 55 - 60 cm deep its location should be checked by X-ray.

Having got into the stomach one records the basic pH level, then gastric secretion is stimulated by histamine or pentagastrin. pH is continued to be recorded for 1.5 – 3 hours. At the period of stimulation the patient is given antacid drugs (by mouth or through the catheter). Or antisecretory drugs are given, with their effect being assessed by several indicators.

Assessment of the acid-producing stomach function (in pH units)

Assessment	Basic conditions	After stimulation
Hyperacidity	1.5 and lower	1.2 and lower
Normacidity	1.6–2.0	1.21–2.0
Hypoacidity	2.1–5.9	2.1–3.0
Decreased reaction	-	3.1–5.0
Weak reaction	-	Decrease of pH by 1 within 3–5 units
Anacidity	Higher than 6.0	6.0 and higher

DUODENAL INTUBATION is very much like gastric intubation in its method. It is employed in cases when a liver or bile ducts disorder is suspected. Aspiration is performed out of the duodenum. As a stimulation, the patient is given 30-50 ml of warm 25% Magnesium sulfate solution by mouth, as well as 20 ml of olive oil, 10% pepsound solution, 10% solution of Natrium chloride, 40% solution of xylite, 40% solution of glucose and others. Parenterally patients may be given 2 ml of pituitrine, 0.5-1 ml histamine intramuscularly, atropine and others.

Classic fractional duodenal intubation consists of 5 phases or stages.

At the first stage the first portion of bile is obtained from the common bile duct, it is clear light yellow bile. The phase lasts 20 minutes. Usually 15-40 ml of bile is secreted during this period. If over 45 ml has been received, this demonstrates hypersecretion or widening of the common bile duct. A smaller amount of bile means hyposecretion or lessened capacity of the common bile duct. 20 min after beginning to obtain bile an irritator\stimulant is introduced: 25% solution of Magnesium sulfate warmed up to + 40-42 degrees C. At the end of the 1st phase the catheter is clamped.

At the start of the second phase of the fractional duodenal intubation the clamp is taken off, the free end of the catheter is put into the collector and a few minutes later flow of bile starts anew. Normally the phase (the interval before the

flow beginning) lasts 2-6 min. The phase prolonging shows hypertonus of the common bile duct or some obstacle present in it.

The third phase is the period before the gallbladder bile appears. Normally it continues 2-4 min. It takes this time for 3-5 ml of light-yellow bile to be secreted, this is the rest of the common bile duct bile. The prolonged time shows increased sphincter sound. The bile obtained during the first and third stages makes up portion A of the classic duodenal intubation.

The forth phase consists in fixing the length of the gallbladder emptying and of the bladder bile volume. Normally it takes 30 min. for 30-70 ml of bile to be secreted, with the bile being dark-olive in colour. This is he classic portion B. The speed of the gallbladder bile secretion is 2-4 ml per minute. When during 10 min. the speed is less than this, it is characteristic of hypomotor function of the gallbladder, and when the speed is higher it means hypermotor function of it.

The fifth phase of the duodenal intubation consists in receiving the hepatic bile (portion C). Normally it takes 20 min. for 15-30 ml of golden-yellow bile to be secreted (it is hepatic bile).

Phases of Duodenal Intubation

Phase	Origin	Colour	Time period	Volume	Speed
A1 (phase I)	Common bile duct	Yellow	10-15 min	10-20 ml	1-1.25 ml/min
Phase II	Closure of Oddi sphincter	-	2-5 min	-	-
A2 (phase III)	Common bile duct	Yellow	3-5 min	3-5 ml	1 ml/min
B (phase IV)	Cystic (gallbladder) bile	Olive	20-30 min	30-15 ml	1.5-2 ml/min
C (phase V)	Intrahepatic portion	Pale-yellow	10-15 min	10-15 ml	1 ml/min

ULTRASOUND INVESTIGATING METHODS (US) OF DIGESTIVE ORGANS are the most available non-invasive methods of investigation of

abdominal organs. The method is employed in the first place, to examine the liver, the gallbladder, as well as the pancreas.

The investigation **is indicated** when complaints of, or clinical signs, or laboratory tests findings showing a possibility of the liver or bile ducts disorder seem to be present. They may be:

- the jaundice syndrome (yellow tint of the skin and mucous membranes, increased bilirubin level in the blood, darkened urine);
- the pain syndrome in the right subcostal space;
- gastric dyspepsia signs (nausea, vomiting etc);
- checking and refining other diagnostic methods findings;
- suspecting a neoplasm;
- abdominal injuries and assessing their severity;

Besides these, liver biopsy is performed under US scanning check. There are no contraindications to this investigation.

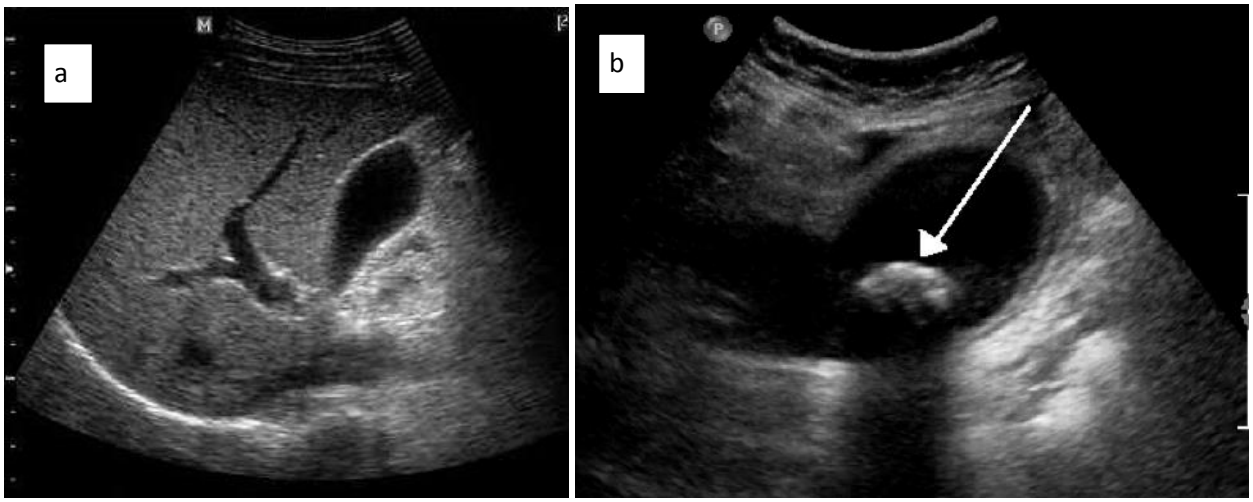
The standard protocol of the investigation allows to carry out:

1. Investigation of the parenchymatous organs of the digestive system (the liver, the pancreas):

- diagnosis of focal and diffuse diseases (a tumour, a cyst, an inflammation);
- diagnosis of the damage in cases of a mechanical trauma of the abdomen;
- identification of metastatic involvement of the liver by malignant tumours of any localization;
- diagnosis of the portal hypertension (including spleen investigation).

2. Investigation of the bile ducts and the gallbladder:

- diagnosis of gallstone disease with assessment of the bile ducts condition and determining concrements in them;
- making the character and the degree of the morphologic changes more precise in acute and chronic cholecystitis;
- defining the nature of the postcholecystectomy syndrome.



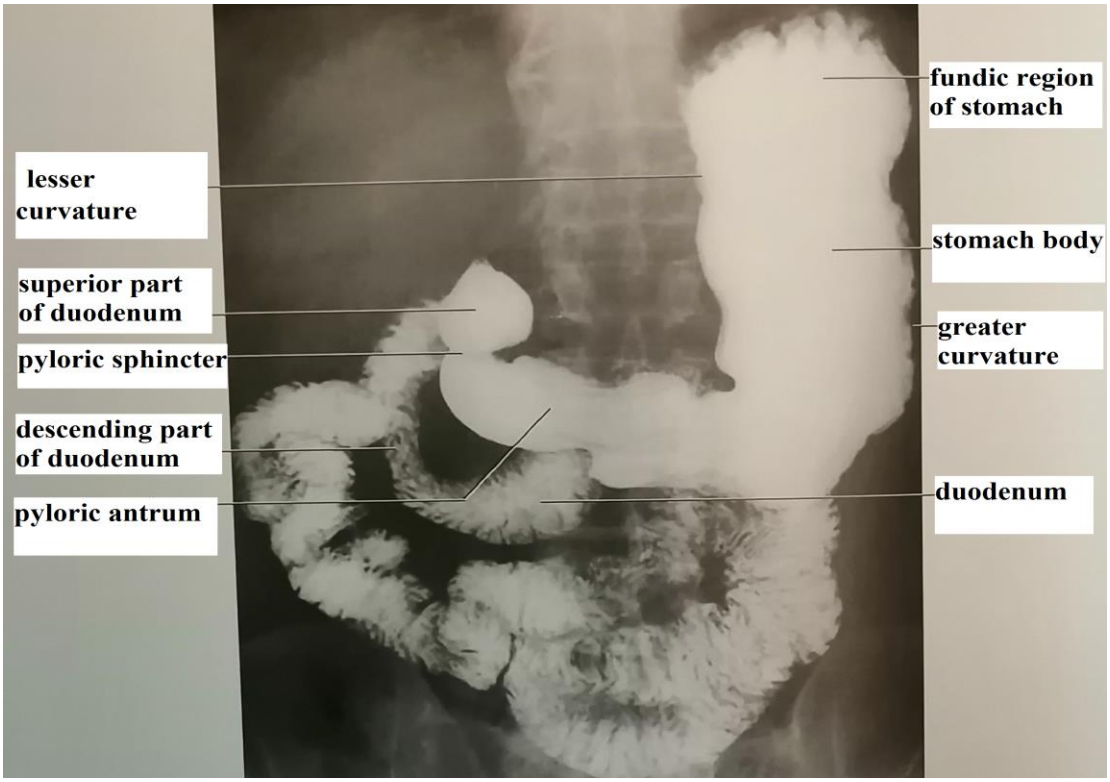
US of the liver and the gallbladder: a) the norm b) a gallstone in the gallbladder (see the white arrow)

Modern methods of assessing the condition of liver tissues include elastometry (elastography) of the liver using the FibroScan apparatus. This method, which is based on ultrasound, is more informative and allows us to determine the degree of fibrosis and fatty liver dystrophy even in the early stages. Indications for its implementation are chronic viral hepatitis, alcoholic disease and non-alcoholic fatty liver disease.

X-RAY METHODS

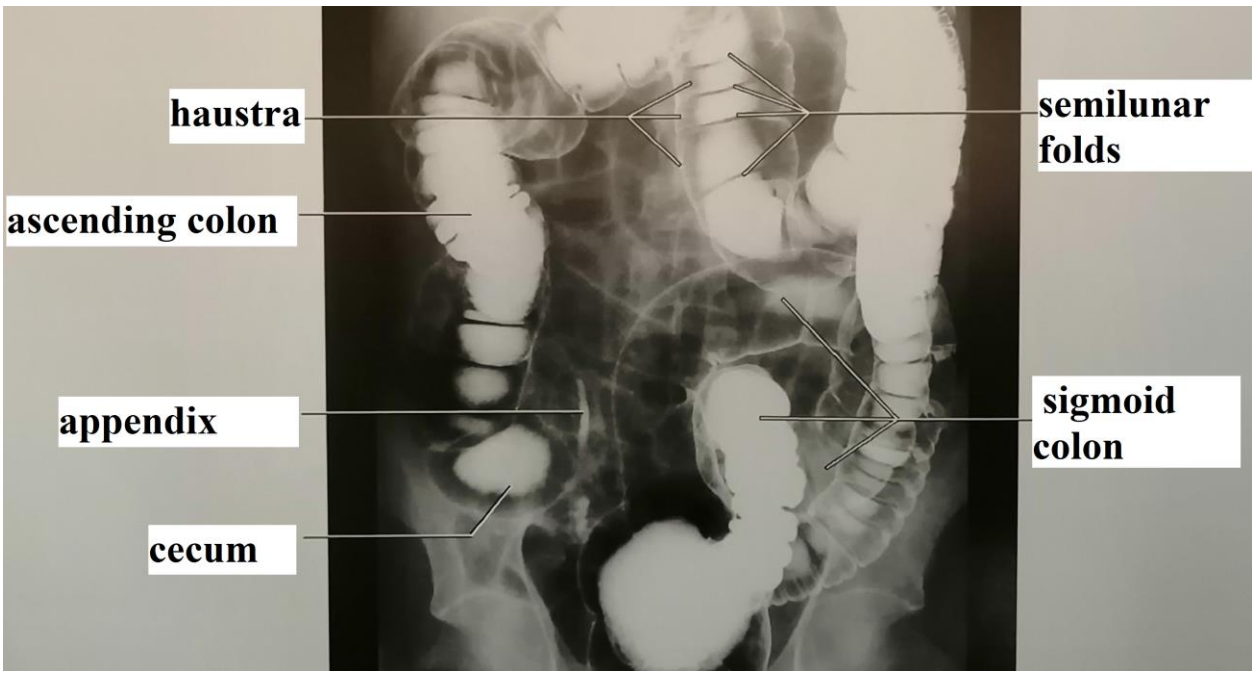
Since the esophagus and stomach absorb X-rays with approximately the same intensity as neighboring organs, the main way to study them is an artificial contrast with an aqueous suspension of barium sulfate.

The upper parts of the gastrointestinal tract are examined when a solution of barium suspension is taken orally, necessarily on an empty stomach (before meals and liquids).



Normal X-ray of the stomach and duodenum

X-ray examination of the colon (irrigoscopy) involves the injection of a contrast substance into the rectum by means of an enema and requires careful preparation: setting cleansing enemas or taking an isoosmolar solution of polyethylene glycol with electrolytes the day before.



Normal X-ray of the colon (irrigogram)

X-ray examination allows us to assess the position, shape, size, contours and structure of the organ as well as its elasticity of the wall, the relief of the mucous membrane, peristalsis and patency.

Indications for X-ray methods are the diagnosis of the following conditions:

• Congenital and development anomalies of the gastrointestinal tract,

• Inflammatory diseases of the esophagus, small and large intestine,

• Peptic ulcer of the stomach and duodenum (especially in cases of contraindications to fibro-esophagogastroduodenoscopy (FEGDS),

- Tumors,

• Foreign bodies of the digestive tract,

• Inhibition of the GIT evacuation activity,

• Assessment of the functional state after surgical interventions.

In cases of differential diagnosis and impossibility of visualization of the pathological process in the abdominal cavity during other research methods, computed tomography of the abdominal organs is used.

METHODS OF THE URINARY EXCRETORY SYSTEM INVESTIGATION

Imaging (radio-diagnosing) investigation methods are a most important component of identifying and differentiating diseases of the kidneys and urinary excretory tract. The part these techniques play has grown lately, especially when techniques of high precision, with the possibility to process the findings by computer, were introduced into clinical practice followed by construction of a 3-dimensional image. At the same time the use of various contrasting drugs and radio isotopes gives an opportunity not only to evaluate the size and structure of the organ, but also to get a notion of the kidney's functional, filtering, concentrating and secreting ability.

According to the physical basis of every method, imaging techniques may be divided into the following groups:

ultrasound ones (ultrasound scanning of the kidneys and urinary excretory tract, ultrasound Doppler sonography of the kidney vessels, energetic (tissue) Doppler sonography);

X-ray (reviewing radiography of the kidneys and urinary excretory tract, excretory urography, computer tomography);

magnetic resonance ones;

radioisotope ones (statistic and dynamic renal scintigraphy (renal scan), positron emission tomography).

ULTRASOUND METHODS (US) OF INVESTIGATING KIDNEYS AND URINARY EXCRETORY TRACT are employed most often, being also suitable for screening. To be scanned by US, patients don't need any special preparation, as a rule. There are no contraindications. The given investigation kind is applicable to each category of patients.

It is preferable to carry out kidney US on an empty stomach (absence of any active bowel movement or any content in the bowels improves image). The kidneys must be examined in several projections: frontal, sagittal and transverse ones).

Performing US the doctor evaluates the following parameters in sequence. The description starts with the assessment of the position, shape, borders (contour) and size of the kidneys. The kidneys are located behind the peritoneum, the left one is at the level of the vertebrae Th11 – L3, the right one is a bit lower, at the level of the vertebrae Th12-L4. The kidneys are surrounded by a layer of paranephral fat and they are enclosed into a special renal fascia, (Gerot's fascia). Medially the left kidney borders on the aorta, the right one borders on the lower vena cava. At the kidney's upper pole there is the adrenal gland. Describing a kidney's position one makes use of bones as guidepoints (12 ribs) and their relations to the organs surrounding them, as well as the degree of the kidney's displacement downwards while the patient is changing his body position to the vertical one.

Sonogram shows the kidney as an oval or bean-shaped structure, most commonly having an even and by all means clear-cut contour borders. Along the kidney's edge one can see a light stripe 1-1.5 mm thick, of high echogenicity, which is a connective tissue capsule. The kidney's average size is: it is 10-12 cm long, 5-7 cm broad, 3-3.5 cm thick. At this stage a number of pathological conditions can be diagnosed, in particular, some developmental abnormalities of the urinary excretory system, such as its changed position (pelvic dystopia, nephroptosis), changed number (agonesia, or doubled kidney), or its changed size (hypoplasia). Highly changed size of the kidney is typical of the inherited polycystic disease.

Further on, one should evaluate the kidney parenchyma and sinus structure. The renal parenchyma layer consisting of the cortex and medullary substance is located directly under the capsule. Normally the parenchyma is 15-18 mm thick. Its structure is non-homogeneous, containing areas of decreased echogenicity, renal pyramids. The safety of the renal parenchyma blood flow is determined by Doppler tissue

technique. Thinning of the renal parenchyma in association with its increased echogenicity and\or decreased parenchyma blood flow, is a sign of nephrosclerosis resulting from a lot of kidney disorders. It is an outcome of chronic (taking a long course) glomerulonephritis, tubulointerstitial nephritis, nephron-angiosclerosis (in hypertension disease).

The central echo-complex, pelvicalyceal system, is projected into the central part of the kidney. Anatomically it consists of the kidney's hilum calycis, pelvises, vessels and fat cellular tissue surrounding them. Normally individual structures of the pelvicalyceal system are not visible on the image. Widened calyces, pelvises can be seen under the conditions of the forced urine outflow (due to diuretic therapy or water loading). Or it may happen in case of urinary excretory tract obstruction, e.g. by kidney stone disease.

Special attention should be paid to revealing additional voluminous growths. They can include single or multiple cysts (these are seen as un-echogenic round patches), as tumors (of various echogenicity, with an intense blood flow), and as concrements.

Assessing the urinary excretory tract condition one should keep it in mind that normal ureters are not seen on the US scan. Widened ureter is an evidence of its obstruction and of the impaired urine outflow. The commonest cause of this condition is the kidney stone disease. Rarer obstruction may be due to a ureter tumour, or blood clots in case of bleeding upper urinary tract. Bilaterally widened ureters are caused by a pelvic obstruction, e.g. due to a large tumour, or to impaired emptying of the bladder. The bladder is examined by a transabdominal sensor\receptor, with the bladder being full up to the first urge to micturate. The bladder is visible as a non-echogenic formation with even walls. Normally no formations can be defined in the bladder cavities. Determining the residual urine volume is a stage of the bladder investigation. It is the volume that stays in the bladder directly after urination. The normal residual urine amount does not exceed 50 ml. Increased amount of it in men results from an impaired urine outflow caused by hyperplasia or a tumour of the prostate gland. In an acute or chronic retention of urine the bladder is distended, its size is enlarged, with its volume amounting to 3 liters in some cases.

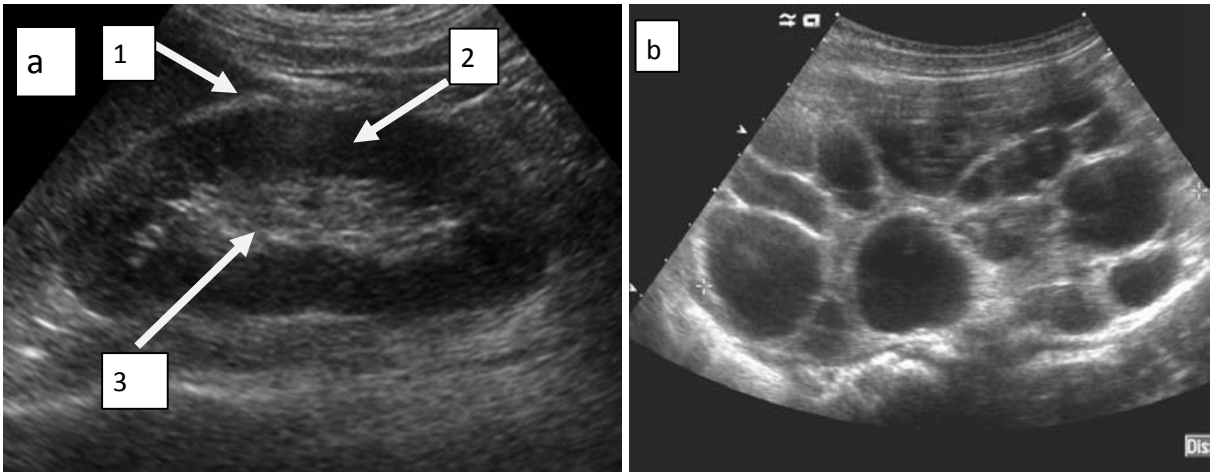
In a number of cases investigation of renal vessels by the Doppler ultrasonic technique is required. This method allows to assess the kidney's arteries along all their length from the aorta to the point they enter the kidney's hilum. Narrowed arteries in children or young people may be a sign of the fibromuscular dysplasia,

while in the older age groups it is more often associated with the atherosclerotic damage. Occasionally the Doppler technique can help get an image of additional and aberrant renal vessels resulting in symptomatic arterial hypertension.

Ultrasound scanning is a routine first stage investigation of every patient with a suspected nephrologic or urologic condition. The range of diseases that are included into indications for US is wide enough. They are:

- arterial hypertension of non-confirmed genesis and hypertension disease to evaluate the target organs condition;
- changed laboratory data showing kidney or urinary tract disorders (as azotemia, anemia, proteinuria, changed urine sediment, microhematuria, leukocyturia, cylinderuria);
- acute or chronic pain in the abdomen or small of back;
- fever of unclear genesis;
- changed urine volume, anuria, dysuric phenomena;
- swelling syndrome;
- macrohematuria;
- abdominal and pelvic injuries.

Besides these, nephrobiopsy is performed under the US control. It is the most important verifying investigation in the nephrology practice.

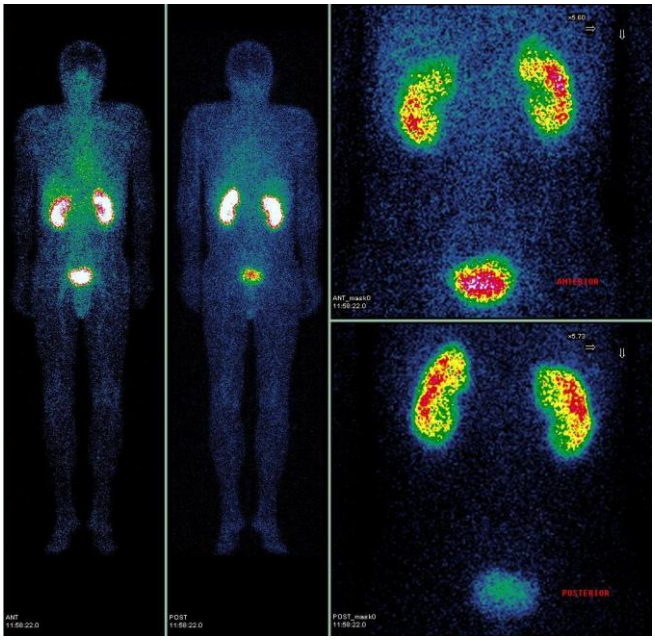


The kidney sonography: a) a normal view (1 – the capsule, 2 – parenchyma, 3 – the central echocomplex); b) polycystosis (the kidney is significantly enlarged in size, multiple anechogenic formations – cysts can be seen).

X-RAY METHODS

Renal scintigraphy (renal scan, isotope scanning). One of the imaging techniques applied to make kidneys and urinary tract visible is radionuclide diagnosing. The method relies on introducing various labelled radioisotopes into the body, with their excretion by the kidneys being assessed by a gamma-camera. Pharmaceutic radio-drugs (tracers) with iodine and technetium isotopes have become widely employed in the nephrologic and urologic practice.

An important feature of the isotope scanning is the opportunity it provides not only to evaluate the urinary tract anatomy, but also to perform a detailed study of its functional state. Thus, with the help of radionuclides one can get an idea of the glomerular filtration velocity, the kidney parenchyma condition, the kidney blood supply, as well as to assess the urodynamics. Radioisotope investigation gives a possibility to study both the summed up excretory capacity of the kidneys and that of each individual kidney separately. In contrast to the contrasting substances used in X-ray investigation, pharmaceutic radio-drugs can be administered to patients with a decreased kidney function who are at high risk of developing a contrasting substance induced kidney damage. As to the kinds of radionuclide investigation techniques used in the clinical practice, they are: renography, angio-reno-scintigraphy, static and dynamic isotope scanning of the kidneys.



Static kidney scintigraphy

Dynamic isotope scanning of the kidneys is most commonly administered at present. The method relies on recording radioactivity from the kidney area after the

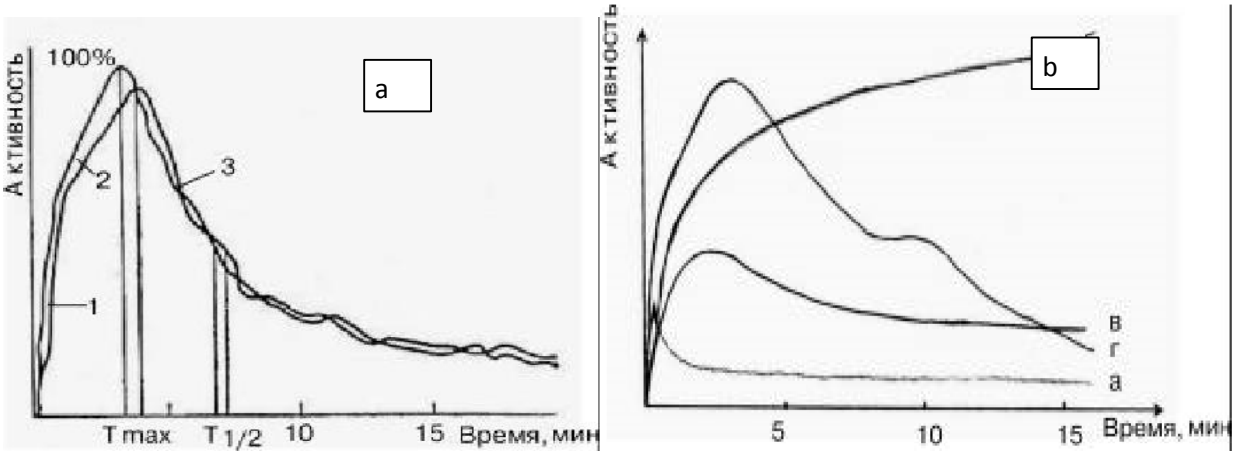
introduction of a nephrotropic pharmaceutic radio-drug into the blood, followed by computer processing of the images obtained. No special preparation of the patient to the procedure is required. The tracer is introduced intravenously by bolus, then a series of scintigrams (pictures) are performed during 15-30 minutes. As a result, we get a number of images and a graph – a radiograph. It is a curve reflecting the indicators "activity-time". According to this picture series a description of anatomo-topographic interrelationships in the kidney is produced. Presence of the radio-drug remained in the kidneys pelvicalyceal system is assessed. A provisional conclusion of the kidney excretory function is made. Then one analyses the radiograms. Normally such a curve has several segments (Figure 12):

1) The vascular one: a sharp rise of the activity curve on the graph, which reflects the radio-drug injected entering the blood and the starting storage of the drug in the kidney parenchyma.

2) The secretory one: a flat rise of the activity curve up to the maximum due to the drug collecting in the kidney tubules.

3) The excretory one: a gradual decline of the drug activity due to its excretion out of the kidney.

Normally the right and left renograms are symmetrical and contain all the three segments.



A dynamic scintigraph in the norm (a) and in various disorders (b). Horizontally: time in minutes, vertically: activity. The explanations can be found in the text.

There are four main types of the pathological curves reflecting kidney disorders:

a) The afunctional one: it is a lowered vascular segment in the absence of secretory and excretory ones. This indicates failure of the kidney to function, it is observed in the congenital kidney aplasia when the kidney is contracted (creased).

b) The obstructive one: it is characterized by the absent excretion phase due to an obstruction of the urinary excretory tract (by a kidney stone, a tumour or an external compression.

c) The iso-hyposthenuric one: it is a lowered peak of the renogram and a retarded (slowed down) secretory-excretory phase. This shows a significantly decreased excretory kidney function (a chronic renal failure).

d) A second curve rise is observed on the renogram when there is a back reflow (reflux) of urine during urination (a bladder-ureteral reflux.

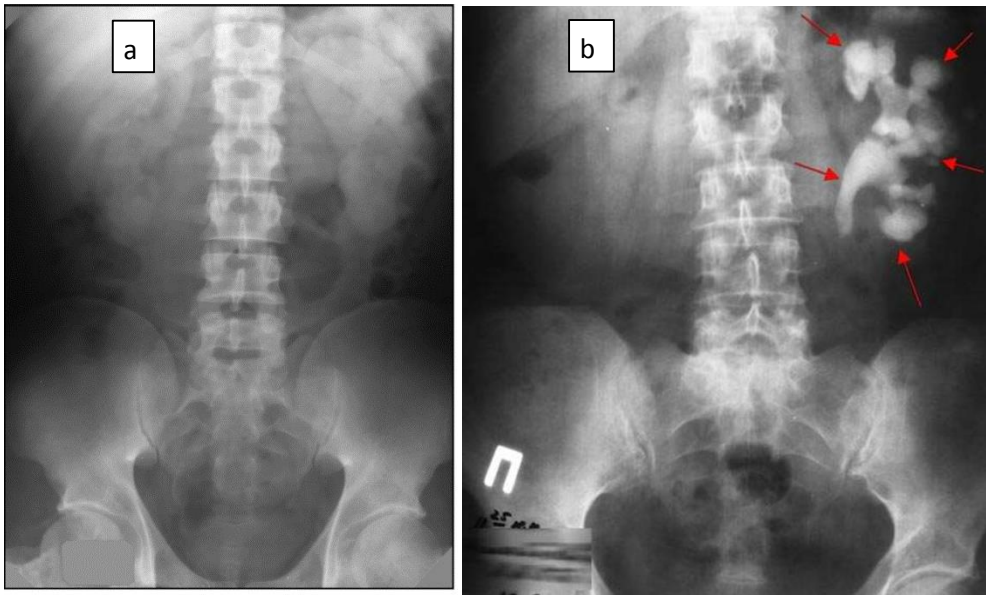
Apart from that, angioscintigraphy can be conducted by means of radionuclides, i.e. radionuclide investigation of the renal arteries. This technique is most commonly used in differential diagnosis of renovascular hypertension. Angioscintigraphy is an obligatory algorithm element in managing patients with a kidney transplanted. It is employed in order to evaluate the blood flow in the transplanted organ.

Radionuclide imaging is applied in diagnosing congenital abnormalities of the urinary excretory system, of the bladder-ureter reflux, reflux-nephropathy, obstructive disorders. Scintimaging (scintigraphy)of the kidneys is carried out to every patient going to be operated on for the kidneys or urinary tract (including a kidney donation), it is done to assess the individual renal functioning.

Overview radiography of the kidneys and urinary tract

Any X-ray examination of a patient with a urological disease begins with an overview urogram. The picture is taken in the position of the patient lying on his back. With this method, a number of pathological conditions can be diagnosed, including anatomical defects and functional disorders. On an overview urogram, the size and contour of the kidneys, their location are determined; the contour of the lumbar muscle; the presence of concretion shadows at the kidney level, in the projection of the ureters, bladder, along the urethra; bone changes in metastatic lesions (prostate cancer, kidney cancer, etc.).

On the radiograph, additional formations of high intensity can be determined in the projection of the renal pelvis, ureters, and bladder, which, as a rule, are caused by concretions. An increase in the size of the kidneys and a change in their contour is observed in neoplasms.



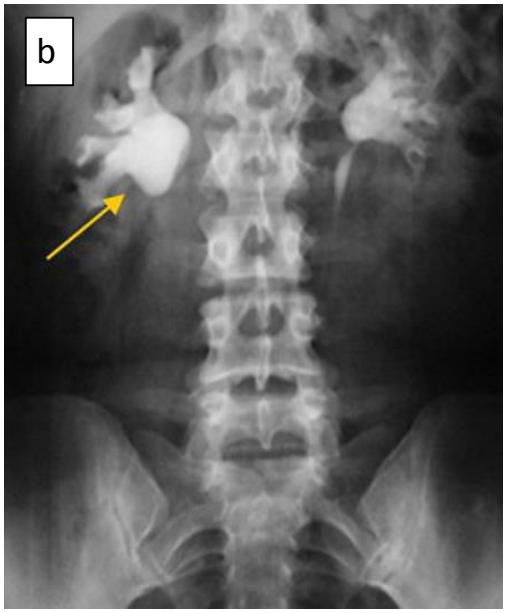
Urography: a – normal view, b – a coral stone in the left kidney

Intravenous (excretory) urography (IVU)

This method is more informative compared to conventional X-ray screening. It is based on the ability of the kidneys to capture a contrast substance from the blood and remove it with urine. We usually use iodine-containing contrast substances such as Verografin, Urografin, etc. for the study. Urography allows us to examine the collecting urine system (minor and major calyces, renal pelvis) of the kidneys, the ureters, to assess the function of the organ.

Methodology of the standard procedure: at the first stage, an X-ray shot of the kidney area is obtained, then 20-60 ml of contrast substance is injected into the vein of the elbow bend and a series of nephrographic images is obtained. As a standard, the first image is taken within the first minute after intravenous injection, which displays the nephrographic phase of the drug excretion. The next image is performed in 5-7 minutes (a clear image of the renal pelvis and ureters is obtained), the third in 10-15 minutes, the fourth in 20-25 minutes. In the case of the absence of a stone shadow in the urinary tract, we usually take delayed shots in 30, 60, 90 minutes

Minor and major calyces are visualized on radiographs. There are usually three major calyces which merge into a tub. The size and the shape of the tub and calyces are variable. Evaluation of the function of the kidneys according to excretory urography is based on the degree and the time of contrast of the collecting duct system.

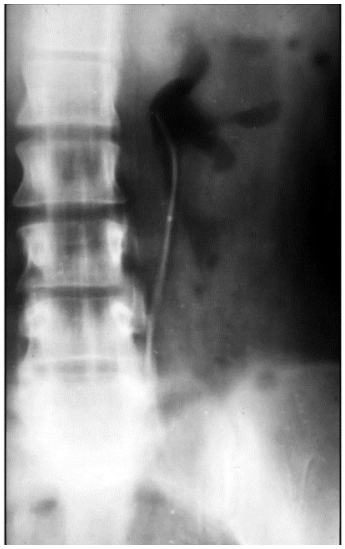


Excretory urography: a – normal view, b – hydronephrosis of the right kidney

Retrograde (ascending) pyelography

It is an invasive technique in which a contrast substance is directly injected into the pelvis through a ureteral catheter. As a rule, the method is used in individual patients with delayed removal of the contrast agent or if a detailed study of the collecting duct system is necessary (for example, with small tumors).

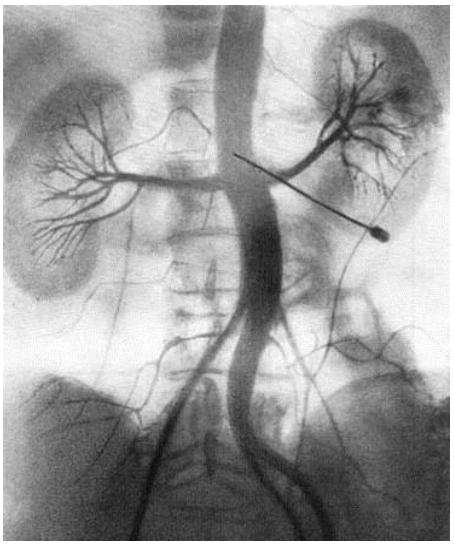
With the help of a cystoscope, the urologist inserts a catheter through the ureter into the renal pelvis. After removing the contents of the pelvis, a sterile contrast substance is injected into it (in some cases, the introduction of gas is possible – pneumopyelography) and a number of radiographs are obtained. However, due to the invasiveness of this technique, the risk of urinary tract infection increases significantly. The widespread applying of more modern non-invasive methods of X-ray diagnostics has led to the fact that retrograde pyelography is rarely used in modern clinical practice.



Retrograde pneumopyelography

Renal angiography

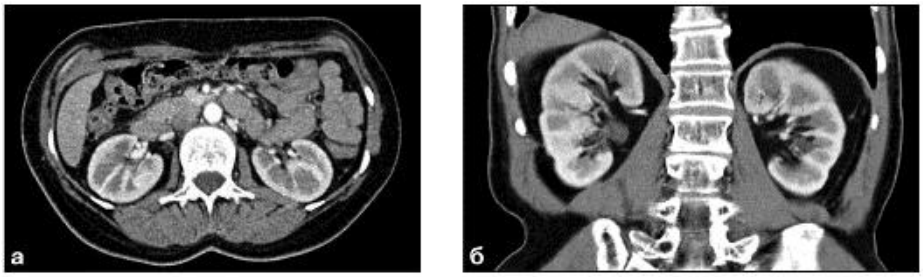
It is a modern radiopaque method for diagnosing kidney vascular diseases. An arterial catheter is carried out from the femoral artery into the abdominal aorta and its end is positioned over the place of the renal arteries, then 40-60 ml of a water–soluble contrast agent is injected into the aortic lumen under pressure using a special injector and a series of radiographs is produced (Fig. 17). First, we obtain an image of the aorta and large branches extending from it, including the renal arteries (early arterial phase), then the shadow of small intra-organ arteries (late arterial phase), after that, a general increase in the intensity of the kidney shadow is visualized (nephrographic phase), a weak shadow of the renal veins (venogram) and, finally, the image of calyces and pelvis, since the contrast agent is excreted in the urine (urographic phase).



Renal angiography

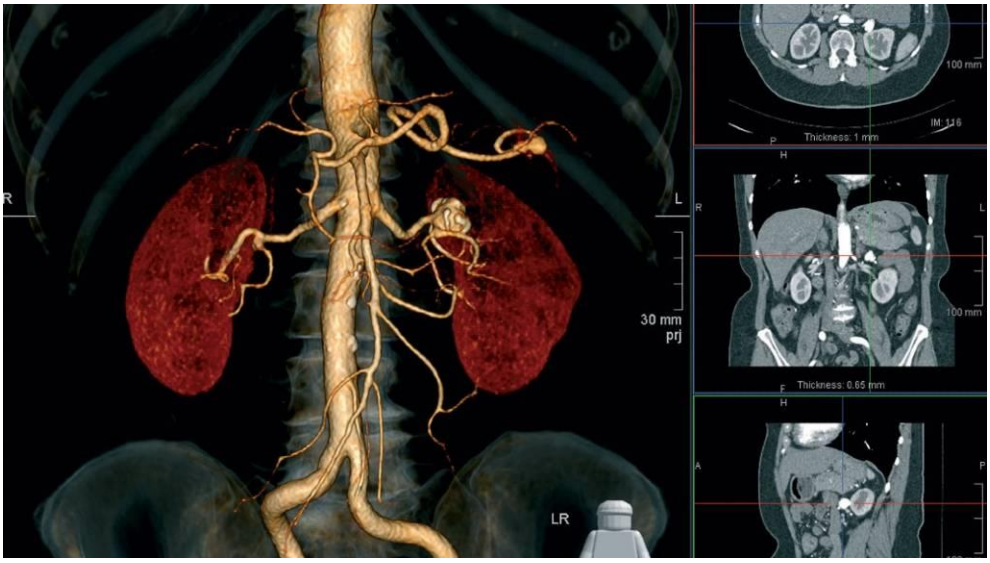
Computer tomography

Currently, computer tomography (CT) is the most informative method of detecting and differential diagnosis of kidney pathology.



Kidney CT with contrast enhancement in the axial (a) and frontal (b) planes

The method is high accuracy in the diagnosis of tumors, parenchymal calcifications, traumatic kidney injuries, in the recognition of ureteral and pelvic pathologic processes. Three-dimensional reconstruction on a spiral computed tomograph allows us to create a 3D demonstrative picture of the renal vessels.



Three-dimensional reconstruction of kidney vessels

THE ENDOCRINE SYSTEM INVESTIGATION METHODS

Most of the endocrine glands are not approachable enough by imaging technologies. This is firstly due to their small size, and secondly, explained by the fact that only few of them are located close to the skin. Besides that, instrumental investigations allow us to evaluate only structural peculiarities of the organs, which

often does not correspond to their functional changes. Here we are going to describe some techniques applied to thyroid investigation.

SONOGRAPHY INVESTIGATION OF THE THYROID GLAND (US) is a screening method giving a sufficiently complete information of the structural features of an organ. US **is indicated** when any signs of the increased thyroid hormone activity (hyperthyroidism) or the decreased one (hypothyroidism) appear:

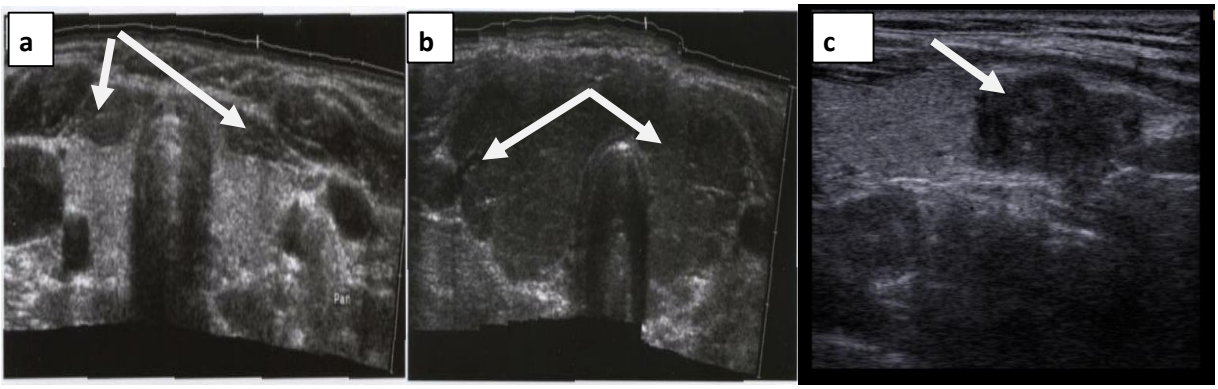
- apathy, listlessness (lack of vigor), fatigue, weakness, extra sleepiness;
- increased nervousness, extra irritability, frequent mood changes, aggressiveness, tremor;
- change of body weight without any reason;
- long-lasting sub-febrile temperature of the body;
- hacking cough, feeling of a foreign body in the throat;
- disturbed heart rhythm;
- disturbed menses periods and planning pregnancy;
- as well as deformed neck, enlarged thyroid revealed by palpation.

Apart from that, diagnostic puncture of the thyroid is conducted under the US control. This investigation has no contraindications.

The mandatory **protocol** of the investigation includes:

- a reviewing stage when the gland location, its tissue echogenicity, as well as presence of any nodular formations in it are determined;
- assessing the gland size and its volume;
- assessment of any additional formations, if there are any;
- exploring areas of possible localization of extra-thyroid voluminous formations, i.e. regional lymph nodes, lower parathyroid glands, middle and lateral cervical cysts. Investigation of regional lymph nodes should be carried out in any case, never mind, whether there is or there is no nodular formation in the gland.

Basing on the US picture one may suspect some disorders presence to be highly likely. Thus, lowered echo-structure of the thyroid associated with its increased volume is characteristic of the diffuse toxic goiter. In contrast, thyroid cancer is manifested by the presence of complex hypoechogenic nodes with unchanged size of the organ itself at the background.



Thyroid sonography: a - normal view, b - a diffuse thyroid enlargement (the thyroid tissue is designated by arrows), c- thyroid cancer (the hypoechogenic formation is marked by an arrow).

Thyroid scintigraphy / Radio-isotope scanning is based on the ability of the thyroid gland to capture and collect in itself molecules of radioactive iodine or technecium. Scintigraphy of the thyroid is a radionuclide technique of thyroid lobes functional activity assessment relying on the gland tissue capability to absorb iodine and use it for production hormones. Scintigraphy can assess the intensity of the absorption of the radio-drug by the node tissue. The findings obtained give an opportunity to suggest the source of the increased hormone production, as well as to determine the hormone activity of the adenomatous tissue. This tissue can either fully perform the function of a hormone producing organ, or it can be absolutely inactive.

Indications for scintigraphy of the thyroid gland are the following conditions:

- presence of one or more nodes over 5 mm in its diameter in association with an increased hormone level at the same time, due to the increased thyroid function;
- presence of a large node occupying not less than half of a thyroid lobe (adenoma);
- possibility of some thyroid tissue formations in untypical places.

Unusual situation of the thyroid is rather rare, much more frequently thyroid tissue emerges in various areas, which is characteristic of metastases spread in case of thyroid cancer. Scintigraphy helps to reveal location of pathological foci highly accurately, when they are located near the tongue (lingually), behind the breastbone and in other areas.

Before carrying out the procedure it is necessary to prepare the patient:

- a month before the investigation the patient should stop having food containing iodine (e.g. sea kale\laminaria);

- 2-3 months before the investigation medication containing iodine should be cancelled;
- 2-3 weeks before the investigation medicine administered as a therapy replacing hormones should be cancelled (L-tyroxin, Thyreodin, Euthyrox),thyreostatics (Thyrosol, Mercasolil, Propipil) should be stopped as well.

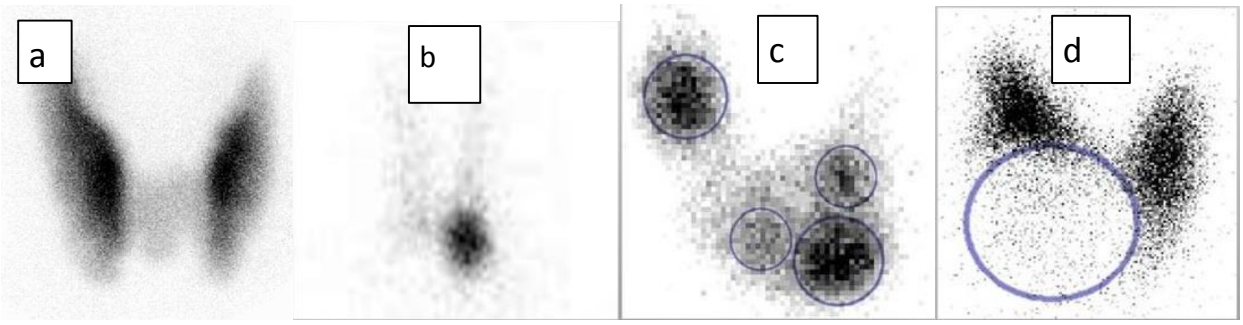
However, administration of technecium 99mTc as a pharmaceutic radio-drug does not require any long preparation for the investigation as the radionuclide does not participate in the iodine or hormone metabolism, but instead, it reflects real processes taking place in the body.

An absolute **contraindication** for the investigation is pregnancy at any term of the fetus development. The scintigraphy may be performed in the breast feeding period, however, breast feeding must be interrupted and replaced by a formula bottle feeding from the moment of the radio-active drug injection or taking in - up to its complete disintegration. Mother's own milk coming during this period should be expressed of the breast and thrown away. In some cases when rough iodine medication is used, mother should minimize any close contact with the baby.

Among unfavourable effects to taking in pharmaceutic iodine containing drugs are the following:

- allergy;
- increased body temperature;
- hyperemia (flushing) of the face, neck and hands;
- dizziness;
- nausea;
- change of arterial blood pressure.

However, when technecium is used as a radio-drug no allergy appears.



Scintigraphy of the thyroid gland: a - normal view, b - a"hot" node, c - multinodular toxic goiter (four nodes are shown), d - a "cold" node

By means of radioactive iodine (J131) one can analyze individual stages of the iodine metabolism. Iodine taken per os (by mouth) normally starts collecting fast in a healthy person thyroid. Its collection reaches 75% 12 hours after its introduction into the body, it gets almost completed 24 hours after. A normal thyroid gland absorbs about 30% of the dose taken out of blood during 24 hours. 60% are excreted with the urine, the other 10% are distributed throughout the body. In the diffuse toxic goiter collection of the radioactive iodine in the gland takes place faster and becomes completed earlier. It reaches about 70%, whereas its excretion with the urine decreases up to approximately 10%. In contrast to this, in hypothyroidism the thyroid gland absorbs less of the dose taken than normally, and at a slower speed. The rest of the radioactive iodine is mainly excreted with the urine within the first 24 hours, the remainder little part is removed during a few of following days.

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