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

INSTRUMENTAL METHODS OF INVESTIGATION OF CARDIOVASCULAR AND RESPIRATORY SYSTEMS IN INTERNAL DISEASE CLINICAL PRESENTATION

(tutorial for the students)

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INTRODUCTION

Instrumental methods of investigation rank especially high in the diagnostic algorithm. Fast development of technologies at the turn of the 20th-21st centuries led to the development of a great number of hardware-controlled diagnostic methods of high information value, able to reveal internal diseases. Interpretation of the findings of different instrumental methods is quite difficult and frequently requires specific skills and knowledge. Curricula of medical and pediatric faculties include information about diagnostic possibilities of the basic methods of instrumental investigation, however the majority of tutorials often have an out-of-date information and do not reflect modern potential of diagnostic departments of multi-profile hospitals.

Brief information on the basic methods of instrumental investigation nowadays applied for internal disease clinical presentation has become the aim of the tutorial. The tutorial includes such basic imaging methods as ultrasound scanning, endoscopic investigation of the upper and lower parts of gastrointestinal tract, and coronarography, as well as functional investigation methods like scintimaging, duodenal and gastric intubation. Besides those, the tutorial describes the main principles of phonocardiography which is not applied at present, but is very important to understand cardiovascular system auscultation. At the same time, a limited size does not allow to refer to all modern methods. So, the parts devoted to electrocardiography diagnosis or X-ray investigation methods are not included into this tutorial because these aspects are sufficiently covered in other corresponding textbooks.

METHODS OF CARDIOVASCULAR SYSTEM INVESTIGATION

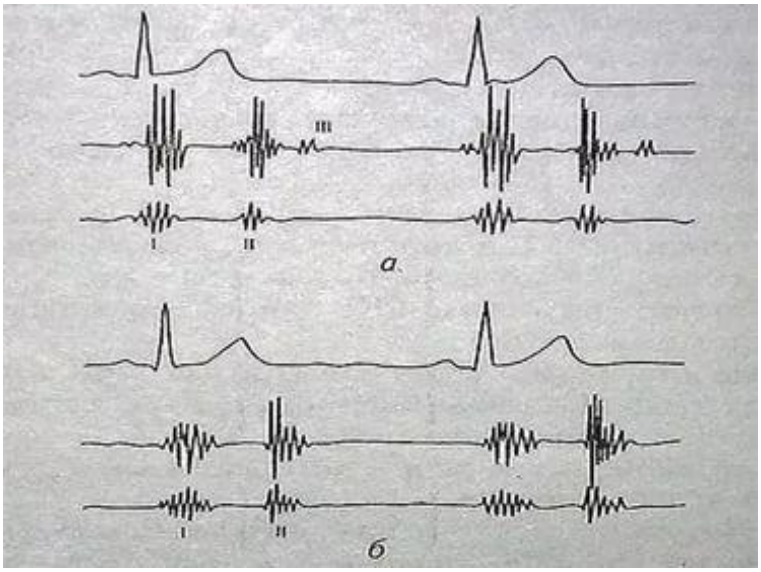
PHONOCARDIOGRAPHY (Greek phōnē sound + kardia heart + graphō to write, to represent) is a method of graphic registration and analysis of sounds heard during heart contraction and relaxation. Phonocardiography provides objective analysis of heart auscultation findings, it specifies them due to the possibility of amplitude and frequency analysis of sounds, and measurements of their duration and intervals between them. Special devices are used for phonocardiography

registration, like phonocardiographs consisting of a sound detector (microphone) transforming sound vibrations into electric ones; frequency filters combined with amplifiers of signals received from the microphone; registering device providing recording process. Recording of phonocardiography is made at the same points where the heart auscultation is performed (see the Figure), simultaneously at different in frequency channels in low-, modevelocity-, and high-frequency ranges and it must be done synchronously with electrocardiogram recording. Electrocardiogram registration is necessary to differentiate the heart sounds, - the first one coincides with the termination of S wave in time, and the second one - with the termination of T wave.

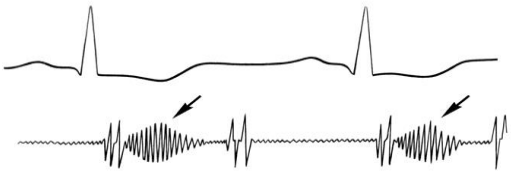
Phonocardiography, as well as auscultation, can reveal amplification and reduction, splitting and bifurcation of the basic heart sounds, appearance of additional sounds (gallop rhythm), sound of mitral valve opening (mitral snap), different murmurs. In case of a murmur detection its form, duration, and frequency features are described. The following forms of murmurs can be identified - increasing, decreasing, constant, diamond-shaped, fusiform. Murmurs can adjoin the sounds, be sepavelocityd from them by some interval, occupy only the middle part of systole or the whole systole (pure systolic murmur), be determined only at the beginning of diastole (protodiastolic murmur), in its middle part (mesodiastolic murmur) or at the end – before the systole beginning (presystolic murmur).

In the vast majority of cases phonocardiography of an adult person in its normal state is presented only by two basic heart sounds - systolic sound I and diastolic sound II. Changeable diastolic sounds III and IV (i.e. during the period of diastole - between sounds I and II) are recorded less often, and other additional sounds are extremely rare. In normal state heart murmurs in adult people are not usually heard or registered by phonocardiogram. However, sometimes in connection with some features of hemodynamics in case of the absence of heart valve involvement so-called functional murmurs can appear, they are usually systolic ones, of low- and modevelocity-frequency.

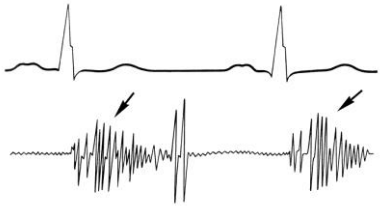
Phonocardiography examples:



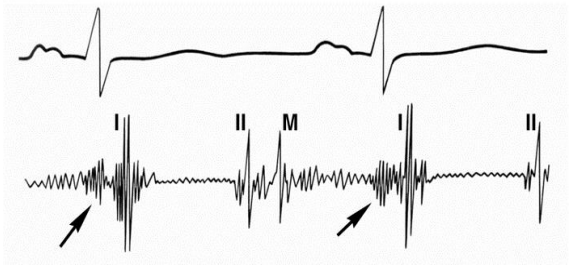
Normal phonocardiography: a) registration on the heart apex, b) registration on the heart base



Phonocardiography in case of aortic stenosis: systolic murmur of a diamond-shape (indicated by arrows)



Phonocardiography in case of organic mitral failure: sound I is weakened and adjoins the decreasing systolic murmur (indicated by arrows)



Phonocardiography in case of mitral stenosis: increased amplitude and frequency of heart sound I (“clapping” sound I), sound of mitral valve opening (M), and presystolic murmur preceding sound I (indicated by arrows)

Basic features of normal heart sounds

Signs	Sound I	Sound II	Sound III	Sound IV
Place of the best auscultation	Apex	Base	Apex or closer to the breastbone	Apex
Relation to the stages of heart cycle	Appears at the beginning of systole after a long pause (diastole)	Appears at the beginning of diastole after a short pause (systole)	Appears at the beginning of diastole soon after sound II	Appears at the end of diastole before sound I
Duration	0.09 – 0.12 sec	0.05 – 0.06 sec	0.03 – 0.06 sec	0.03 – 0.10 sec
Frequency features	30 – 120 Hz	70 – 150 Hz	10 – 70 Hz	70 – 100 Hz
Auscultation features	Loud, low, long	Loud, high, short, louder on the base	faint, dull, low, short	faint, dull, low, short
Coincidence with apex beat	Coincides	Does not coincide	Does not coincide	Does not coincide

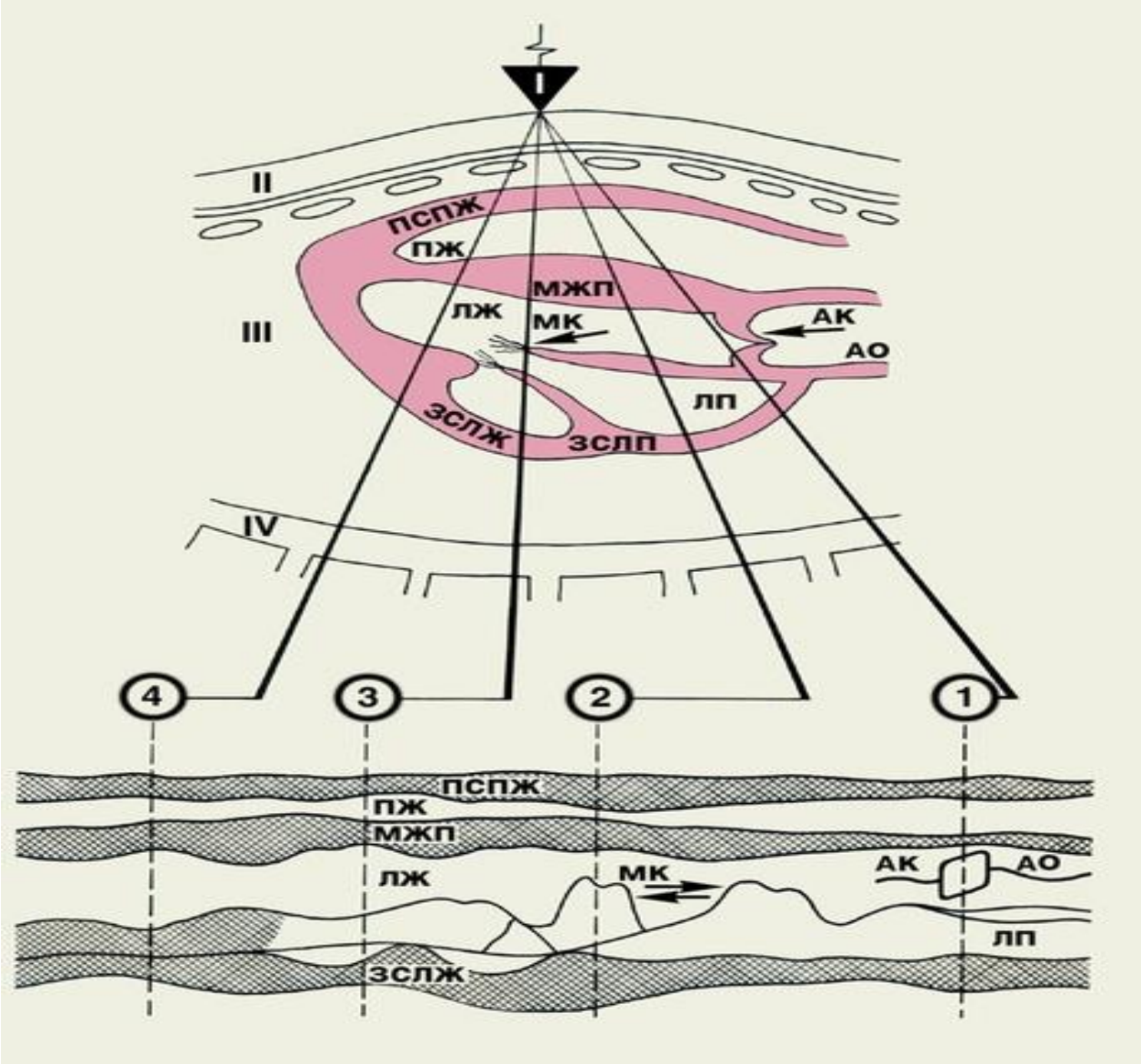
At present due to the absence of direct association between auscultation presentation and real changes of intracardiac hemodynamics in some cases, in clinical practice phonocardiography has been completely replaced by more informative methods of imaging, first of all by echocardiography.

ECHOCARDIOGRAPHY (Greek ēchō echo + kardia heart + graphō to write, to represent) is a method of examination and diagnosis of morphological disorders and heart mechanical activity, based on registration of ultrasound signals reflected from the heart moving structures. Special devices are applied to perform echocardiography – echocardiographs consisting of generator of ultrasound waves; detector receiving the reflected ultrasound signals; converter of ultrasound waves into electromagnetic ones; registration device. Echocardiography is also registered synchronously with electrocardiogram. The method principle is based on the ability of ultrasound waves to be reflected at the border of two environments with unequal acoustic density. The larger this difference is, the more intensive the level of

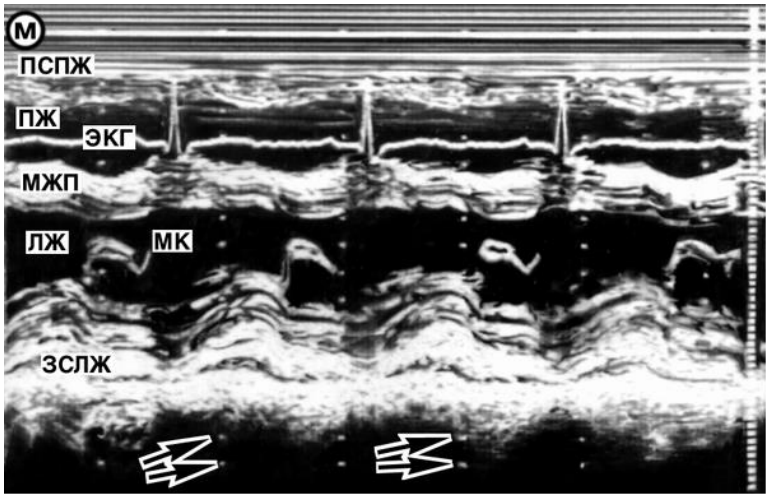
reflection is. The resolution depends on the frequency of ultrasound waves - the shorter the wave length is (the frequency is higher), the higher the resolution of the used device is. In modern echocardiographs the resolution is about 1 mm.

The following modes of echo signal reproduction are used nowadays: M-mode – one-dimensional image (English *motion, movement*) and B-mode (English *brightness*). Besides that, two-dimensional echocardiography gives the possibility to get a sliced image of the heart moving structures in real time. Today there are devices capable to form a three-dimensional image, but they are rarely used for heart investigation. Ultrasound method of identification of blood stream velocity and direction in relation to the detector, based on Doppler's effect, - doppler-echocardiography, is often used simultaneously with echocardiography.

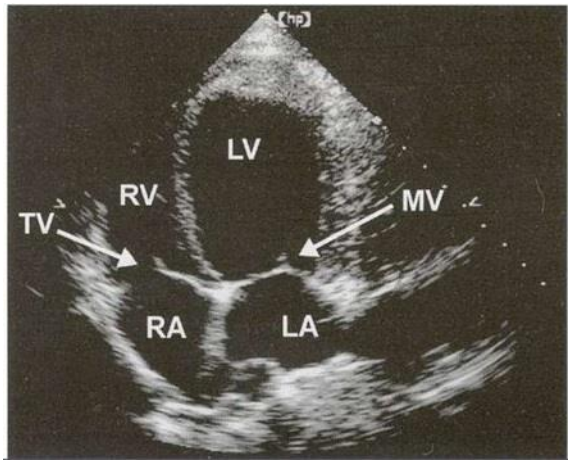
During the investigation a patient is lying on his/her back or left side. The detector is placed above the heart in various positions providing a proper investigation access to different parts of the heart along its long and short axes. A standard protocol of investigation includes assessment of the left ventricle size at the end of diastole and to systole, thickness of myocardium of the back wall and interventricular septum at the end of diastole; diameter of aorta opening and its ascending part; volume of the left and right auricles; size of the right ventricle at the end of diastole. Besides, it is necessary to describe the level of opening of mitral, tricuspid, aortic, and pulmonary valves, the velocity of blood stream through the valves; myocardium contraction ability and to assess the pericardium condition.



Scheme of the basic positions of one-dimensional echocardiography: near the base (position 1), in the middle of the third part of the length (positions 2 and 3) and in the apex area (position 4). All positions demonstrate the anterior wall of the right ventricle and its cavity, and positions 3 and 4 – the interventricular septum, the cavity of the left ventricle and its back wall, position 1 shows the aorta, the aortic valve, the cavity of the left auricle and its back wall, and position 2 - the left auricle and the mitral valve. Additional indications include the following ones: I - ultrasound generator and detector receiving the reflected signals; II - anterior chest wall; III - heart; IV - posterior chest wall.



Echocardiography of a healthy person in M-mode (notes: ЛЖ - cavity of the left ventricle, ПЖ - cavity of the right ventricle, ПСПЖ - anterior wall of the right ventricle (light lines), МЖП – interventricular septum (light lines), МК – echo signal from the anterior leaflet of the mitral valve, ЗСЛЖ - posterior wall of the left ventricle). In echocardiography at M-mode dark lines correspond to the cavities of the right and left ventricles, and light lines - to their walls. The waviness of the image of the heart walls is connected with its contractions to systole. The interventricular septum and the back wall of the left ventricle are moving towards each other.



Two-dimensional echocardiography from the apex access: the cavities of all four heart chambers (dark lines) are visible in the cross section, they are divided by septa and leaflers of atrioventricular valves (light lines).

Echocardiography makes it possible to reveal the signs of hypertrophy of myocardium of separate heart chambers, to assess the presence of dilatation; signs of myocardium ischemia (zones of hypo-, a-, dyskinesia, decreased contraction

ability); signs of the heart valvular mechanism involvement (heart diseases); disorders of endocardium and pericardium; cardiomyopathy.

Echocardiography is a noninvasive, safe, available and at the same time rather informative method, contraindications to which include only extensive involvement of the chest skin.

Routine percutaneous echocardiography has some limitations of resolution because there is quite a big layer of tissue between the detector and the heart (skin with subcutaneous cellular tissue, ribs and intercostal muscles). Pulmonary tissue makes ultrasound investigation almost impossible. Therefore information value of the method is significantly decreased in people with diagnosed obesity and pulmonary emphysema. Besides these drawbacks, parietal thrombi and vegetations on cusps are poorly seen during transcutaneous echocardiography. Transesophageal echocardiography is used to identify them. Imaging is improved on the whole by introducing the detector into the esophagus, and the back wall of the left ventricle becomes particularly well visible. Transesophageal echocardiography is usually performed under local anesthesia, and in emergency cases under general one.

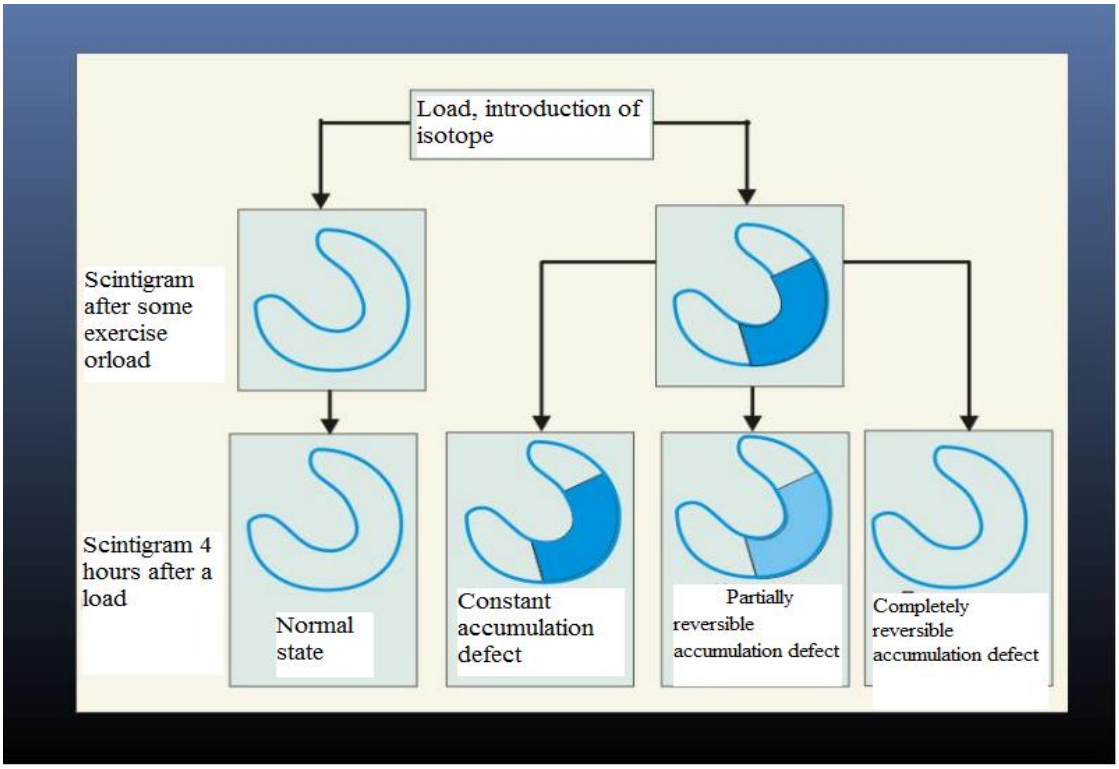
MYOCARDIUM SCINTIMAGING / SCINTILLATION SCANNING is regarded as a radionuclide investigation and is a modern method of myocardium perfusion assessment. Radiopharmaceutical tracer with tropism to myocardium (usually 99mTc) is used to perform scintimaging. The character of perfusion can be assessed according to its accumulation in the tissue - the better the myocardium blood supply is, the higher accumulation level of radiopharmaceutical tracer is. Scintimaging has high sensitivity to identify the sites of ischemia and, particularly, postinfarction cicatricial changes.

Myocardium scintimaging **is used** to diagnose presence, localization, prevalence and load of ischemic involvement of myocardium or cicatricial changes, to assess myocardium viability, efficiency of medical treatment and results of myocardial revascularization.

Contraindications to myocardium scintimaging are pregnancy, breastfeeding, patient's body mass over 120 kg.

The investigation is performed on an empty stomach. Administration of antianginal, antihypertensive and antiarrhythmic medicines should be stopped the day before it whenever possible. The investigation carried out with their uncancelled administration can lead to underestimation of severity and prevalence of perfusion and contraction disorders.

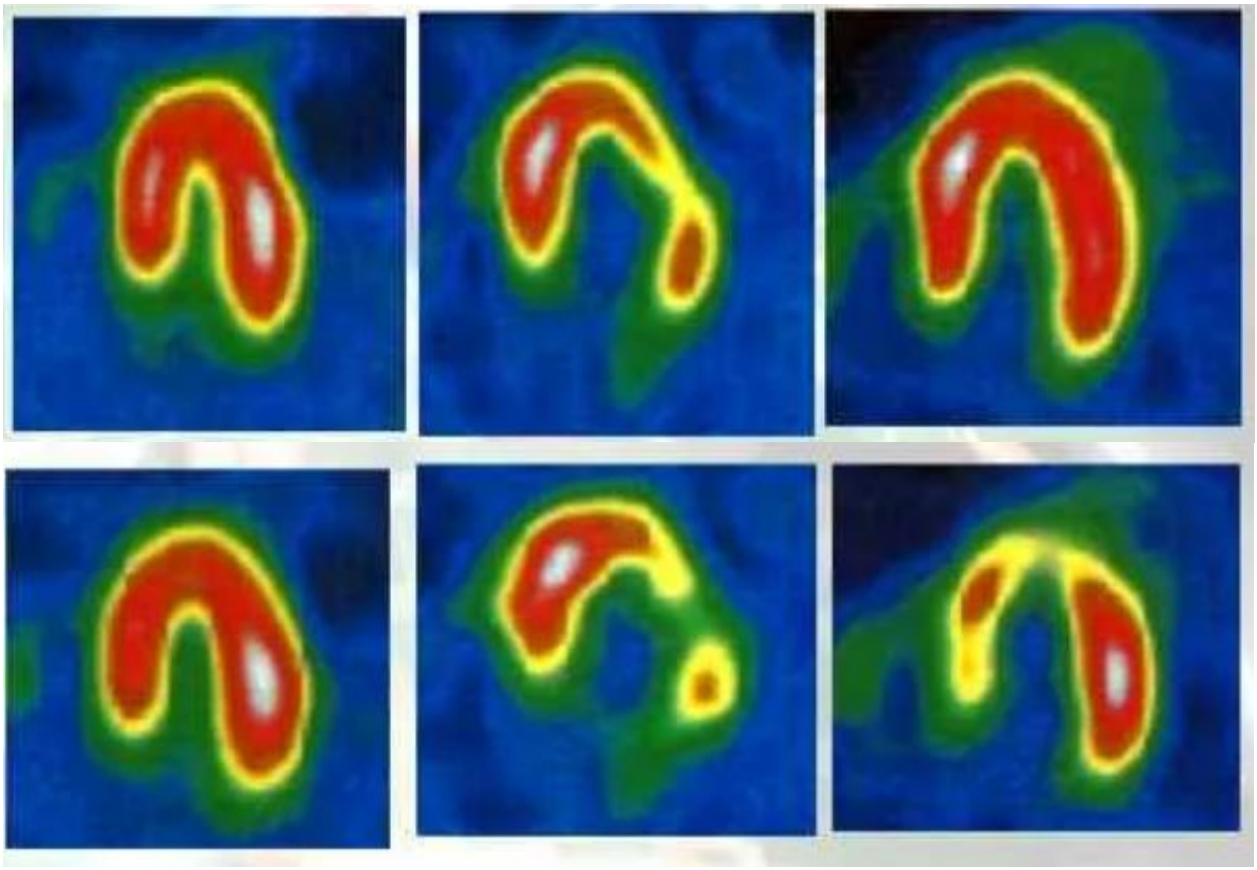
At first myocardium scintimaging is performed at rest, and then, with physical exercise or medication load in the majority of patients with ischemic heart disease. The necessity to perform the investigation during loading is connected with the fact that even significant involvement of coronal arteries (stenosis up to 75%) does not usually lead to considerable disorders of the left ventricle myocardium perfusion at rest. Myocardium scintimaging assesses the zones of myocardium hypoperfusion which look like defects of radiopharmaceutical tracer accumulation (zone of myocardium with lowered radiopharmaceutical tracer absorption). The defects differ in their intensity (from moderately lowered accumulation to its total absence). Constant and temporary defects of accumulation are distinguished. Constant defect does not change depending on the body condition (rest, stress) and indicates myocardial infarction or postinfarction cicatricial tissue. Temporary defect is diagnosed when a zone of myocardial hypoperfusion is seen on the images at stress state and is absent at rest or on delayed images. Radiopharmaceutical tracer accumulation is assessed by 4-point scale: 0 points indicate normal perfusion (level of radiopharmaceutical tracer accumulation is above 75% from the maximum accumulation level); 1 point - moderate perfusion decrease (51-74%); 2 points - considerable perfusion decrease (30-50%); 3 points - significant perfusion decrease (less than 30%).



Variants of myocardium scintimaging in normal and pathological state

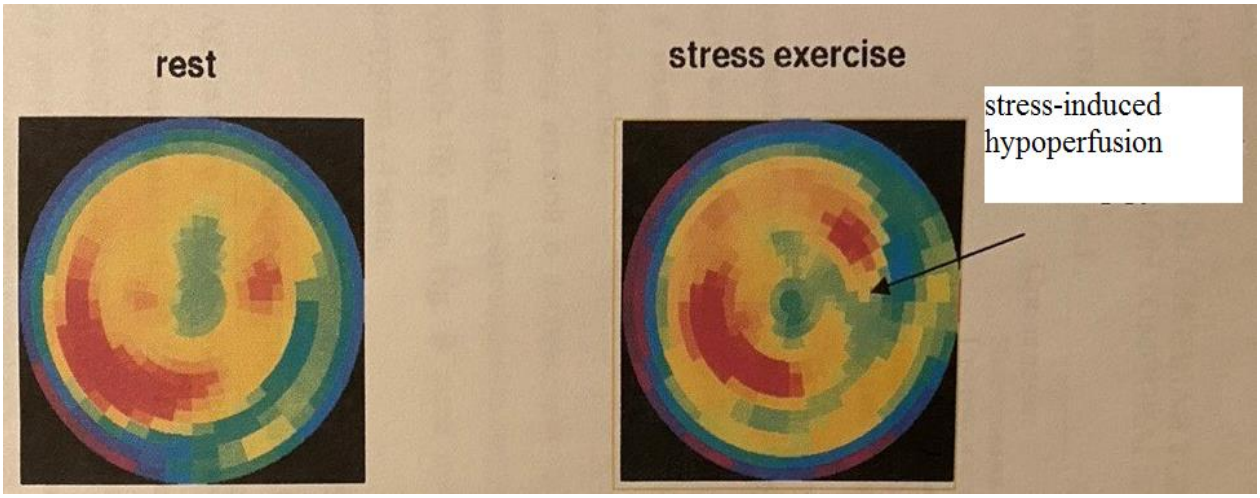
Myocardium scintimaging assesses the localization of perfusion defect in relation to corresponding walls of the left ventricle: bottom, lateral, anterior ones and septum, and also in relation to the zones of blood supply of corresponding coronal artery. Quantitatively perfusion defects are described as mild (5-10% of the left ventricle myocardium), moderate (15-20% of the left ventricle myocardium), and severe (more than 20% of the left ventricle myocardium).

The assessment of quantity of a viable myocardium is also important. Viable areas are the areas of the left ventricle myocardium with the level of radiopharmaceutical tracer fixation of 45-50% and above. It is especially important in patients with ischemic cardiomyopathy (the left ventricle ejection fraction <35% with multivascular involvement of coronal channel), and patients after acute myocardial infarction with extensive area of dysfunction and severe involvement of supplying coronal artery.



From top – at rest, at the bottom – stress test.
Normal state (left), myocardial infarction (center), ischemia (right)

Another study based on the same principle of drug accumulation is positron emission tomography scan, now combined with computed tomography scan (PET CT). The study allows us to assess the functional state of the myocardium, impaired accumulation of the drug due to ischemia, which manifests itself after patients' exercise.



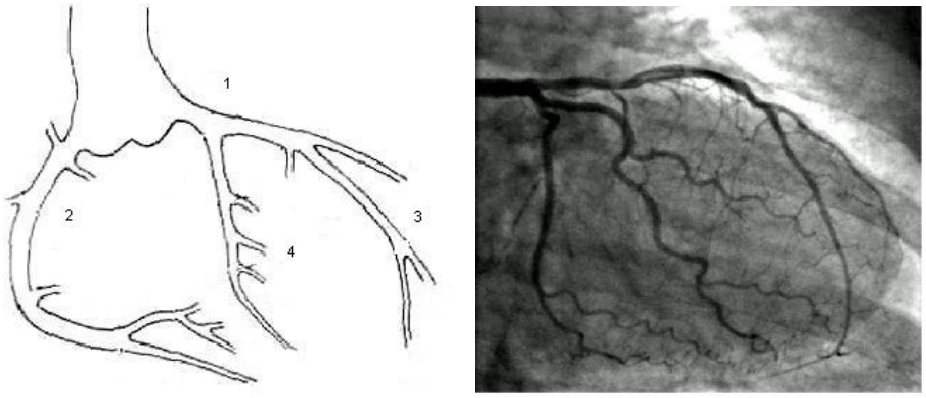
CORONAROGRAPHY is a radiopaque investigation method which helps to assess the heart arteries condition. The essence and principle of coronarography is that a catheter is inserted through a femoral or radial artery and installed into the openings of coronary arteries, then iodine-containing contrast substance is injected into the catheter. X-ray radiation tube is used to register the image of coronary arteries, and the internal vessel lumen is registered. The level and size of atherosclerotic involvement of coronary arteries is recorded during coronarography procedure that allows to develop the further treatment management. The investigation is performed under local anaesthesia.

Indications for coronarography investigation are the following: high risk of complications according to clinical and noninvasive investigations, including asymptomatic course of ischemic heart disease; inefficiency of medical treatment for stenocardia\angina pectoris; unstable stenocardia which can not be relieved by medication; postinfarction stenocardia; impossibility to determine the risk of complications by noninvasive methods; forthcoming surgery intervention on valvular mechanism of the heart in patients over 35 years old.

Contra-indications include the following: disorders of blood coagulability, severe anemia, renal failure, allergic reactions to iodine-containing drugs in the past

history, active infectious diseases, heart failure at decompensation stage, severe forms of involvement of peripheral arteries (risk of thrombosis development is increasing).

Possible rare **complications** of coronarography include bleeding in the puncture site, disorders of the heart rhythm, allergic reaction to contrast substance (containing iodine), thrombosis of coronary artery, and radio-opaque nephropathy.



a **b**

Structure of coronary channel: a) scheme, b) example of coronarography: 1 – left coronary artery, 2 – right coronary artery, 3 – circumflex artery; 4 – descending artery.

METHODS OF RESPIRATORY SYSTEM INVESTIGATION

SPIROGRAPHY (Latin spiro to breathe + Greek graphō to write, to represent) - a method of investigation of the lungs function by graphic registration of time changes of their volume during breathing. Spirography is used to reveal early stages of bronchopulmonary system diseases, and to assess functional disorders in clinically obvious diseases, it is very important to make a correct choice of therapy management and to assess the treatment efficiency. Spirography practically has no specific contra-indications. It is impossible to perform the investigation of external breath function in case of bloody expectoration or other pathological conditions complicating and excluding forced breathing.

Spirography is performed by devices of open or closed type. The first type applies spirograph – a hermetically sealed container with a mobile part in the form of a lung balanced by a counterbalance and connected with the register bell or bellows. After an examined patient exhales a portion of air into the spirograph the

volume of air in the device is increased, so the bell or bellows moves. During inhalation the volume of air in the spirograph is decreased, so the bell or bellows is displaced in the opposite direction. The bell or bellows movement is transferred to the register stylus drawing a curve reflecting the change of the lungs air volume. Devices of open type apply pneumotachograph. It registers volume and velocity parameters of inhaled and exhaled air, as well as measures oxygen consumption and carbon dioxide discharge (due to additional supplementation by physical gas analyzers).

Spirography is usually performed on an empty stomach or over 1 hour after breakfast. It does not require any special preparation of the patient. The investigation is performed in the sitting position, a clamp is placed on the patient's nose to avoid air leak, and a mouthpiece connected with the device is placed into the oral cavity.

The **basic indicators** fully reflecting the respiratory system functional condition include the following:

maximum volume of the air exhaled from the lungs in case of quiet exhalation after maximally deep inhalation (the lungs vital capacity),

maximum volume of the gas exhaled from the lungs per 1 sec. in case of forced exhalation after maximally deep inhalation (forced exhalation volume per 1 sec.),

correlation of forced exhalation volume per 1 sec. and vital capacity of the lungs in percentage (Tiffno index).

In addition one can assess:

respiratory rate,

volume of air received by the lungs during one inhalation (respiration volume),

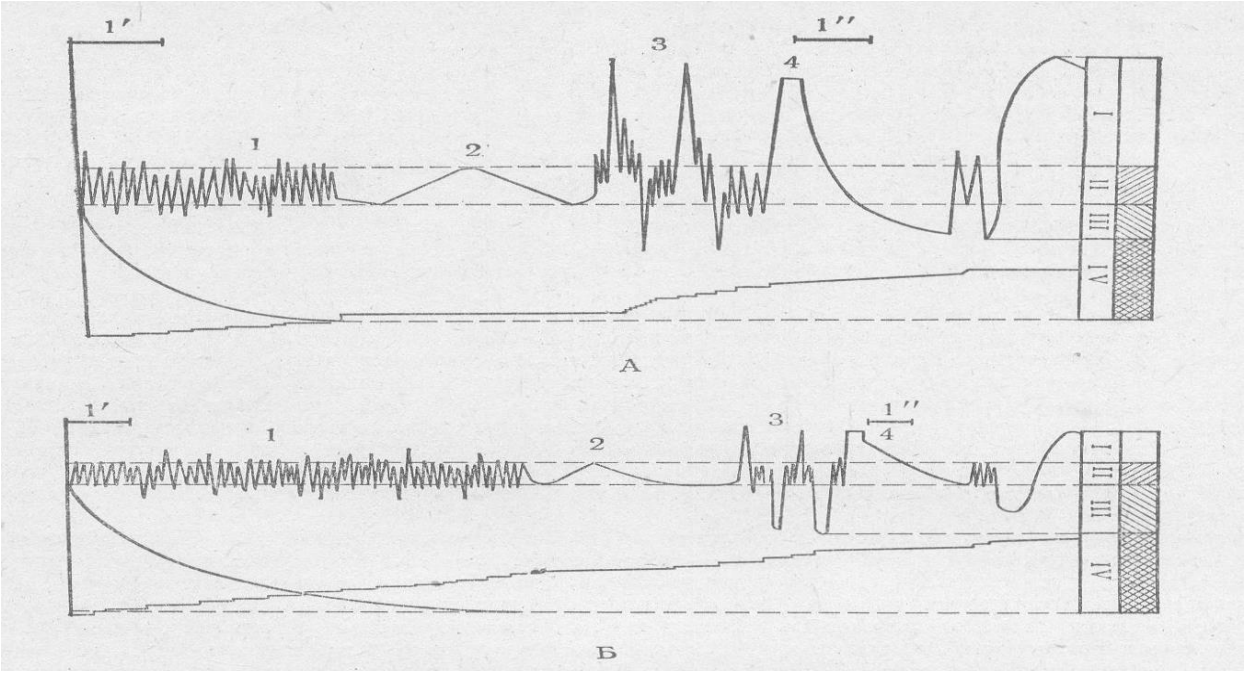
volume of air received by the lungs per 1 minute (minute breath volume),

volume of oxygen used by the body during 1 minute,

volume of oxygen used by the body from 1 liter of air received by the lungs (oxygen-utilization coefficient),

maximum volume of air exhaled from the lungs in case of forced exhalation after maximally deep inhalation (forced vital capacity of the lungs),

maximum volume of air received by the lungs in case of quiet inhalation after maximally deep exhalation (exhalation vital capacity of the lungs).



Spirogram of a healthy person (A) and of a patient with bronchial asthma (B):

1 – minute breathing volume, 2 – correlation of inhalation and exhalation stages at accelerated registration, 3 – the lungs vital capacity, 4 – forced vital capacity of the lungs,

I – exhalation reserve volume, II – respiration volume, III – inhalation reserve volume, IV – residual volume.

Assessment of spirography investigation results is made by comparison of actual values of functional indicators and so-called proper values indicated by investigation of practically healthy people. The proper values are counted according to the formulas reflecting the dependence of functional indicators on gender, age and height. Normal bottom border for the lungs vital capacity, forced vital capacity of the lungs, forced exhalation volume per 1 sec. and Tiffno index is considered 80% of proper value, normal top border for minute breath volume is120%, normal bottom border for oxygen-utilization coefficient is 33,3 *ml*. Decrease of the lungs vital capacity, forced vital capacity of the lungs, forced exhalation volume per 1 sec. and Tiffno index to 79-60% of proper values is considered a mild one, and to 59-40% - a significant one, under 40% - an acute one.

In case of obstructive type of ventilation disorders (bronchial asthma) the decrease of forced exhalation volume per 1 sec. and Tiffno index exceeds the level of the lung vital capacity reduction. In contrast to it, in case of restriction type of ventilation disorders the decrease of the lung vital capacity prevails, and Tiffno

index is at optimum level or even higher. Nowadays spirography investigation results are processed automatically.

FIBER-OPTIC BRONCHOSCOPY (greek bronchos – bronchial tube + scopia – to look, to observe) is a method to make diagnosis of air-passages diseases by flexible endoscope. Fiber-optic bronchoscopy is used to assess the condition of mucous membrane of trachea and large bronchial tubes. Fiber-optic bronchoscopy is performed under local anaesthesia with lidocaine solution. Fiber-optic bronchoscopy can be performed for diagnostic and medical purposes. Tissue biopsy and lavage for bacteriological and cytologic investigation are possible during the investigation.

The investigation method. The investigation is performed on an empty stomach, mainly in the position when a patient is lying, it consists of three stages: local anaesthesia, introduction of fiber-optic bronchoscope, and investigation of the tracheobronchial tree. Anaesthesia of nasal and oral mucous membrane, nasopharynx and larynx is made by 2% solution of lidocaine by spraying and application. Trans-nasal way of fiber-optic bronchoscope introduction is commonly employed, sometimes – trans-oral one. In case of unilaterally localized pathology bronchial tubes of a healthy lung are examined first, and after them - bronchial tubes involved in the pathological process are investigated. In case of a laterally localized pathology one should start from the bronchial tubes of the right lung. One investigates the trachea and bronchial tubes mucous membranes relief and their condition, identifies trachea and greater bronchial tubes membranous part sound. One can examine the tracheobronchial tree topography and bronchial tube opening and spur shape to the level of subsegmental bronchial tubes. They also investigate submucous vascular pattern, identify foreign particles and bronchial tube tumours. Draining of pathological bronchial secretion is made simultaneously with the investigation, a proper medicine is introduced endobronchially, and biopsy of the mostly affected areas of bronchial tube mucous membrane is performed.

Indications for diagnostic fiber-optic bronchoscopy are:

unmotivated persistent cough being the only symptom of the disease;

breathlessness which is not characteristic of the involvement,

bloody expectoration and pulmonary bleeding,

suspicion of trachea and bronchial tube neoplasm,

radiological signs of bronchial tube patency include: volume reduction of the lung or its part, atelectasis, swelling of the lung or its parts,

prolonged pneumonia,

stains of unknown etiology in low and middle parts, as well as at the lung root and in the mediastinum,

quick change of intrapulmonary cavity size (in case of cavernous tuberculosis or abscess),

disseminated pulmonary diseases,

pulmonary tuberculosis,

pleuritis of unknown etiology.

Contra-indications for fiber-optic bronchoscopy are the following:

acute myocardial infarction less than 6 months before,

acute disorder of cerebral blood circulation,

heart arrhythmia with severe hemodynamic disorders,

hypertension with increased diastolic pressure over 100 mm Hg,

severe respiratory and/or heart failure,

acute stage of bronchial asthma,

profuse pulmonary bleeding,

neuropsychic diseases (epilepsy, condition after craniocereberal trauma, schizophrenia),

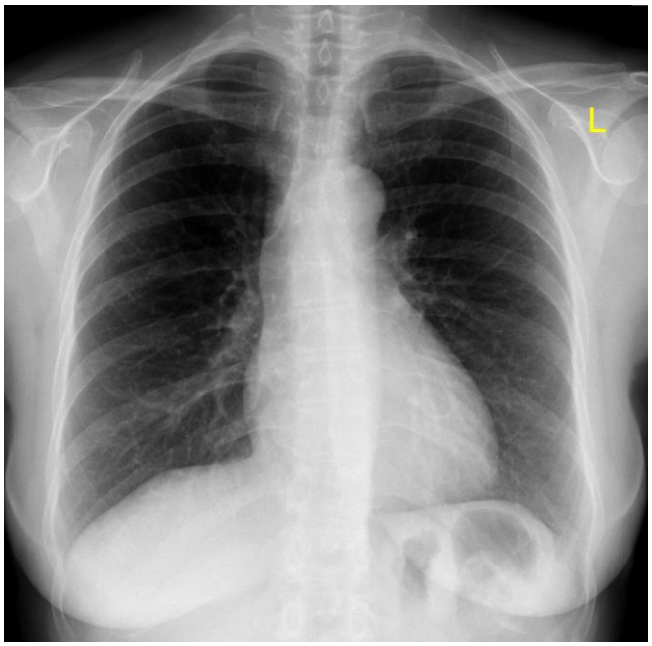
abdominal pains.

X-RAY EXAMINATION OF THE LUNGS

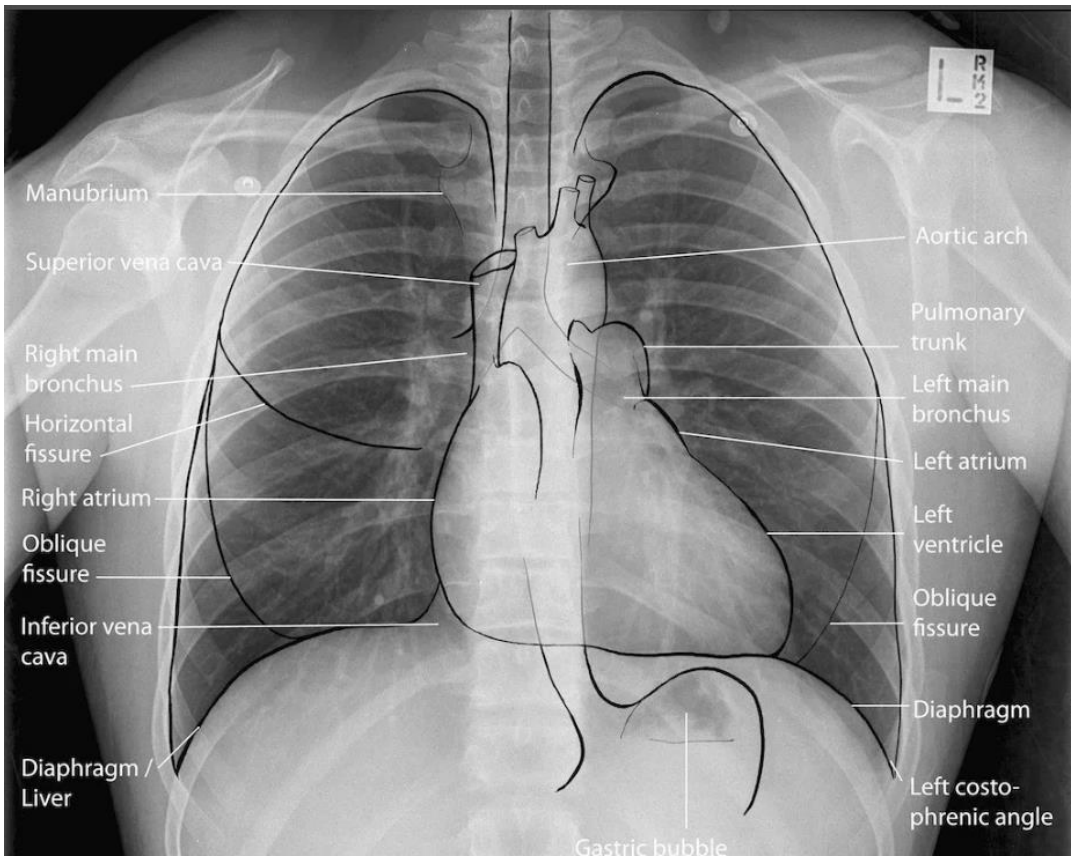
X–ray examination is one of the most informative methods of additional research, which allows to obtain fairly accurate data and to assess changes in the state of the chest organs in dynamics. This group of methods for diagnosing lung diseases includes overview radiography (X-ray), computed tomography, magnetic resonance imaging, bronchography and angiography.

Fluorography is a variant of radiography that is widely used for the chest X-ray screening of the population. The feature of this method is X-ray small-size films. Projectional radiography allows us to assess the size and structure of the fields and the roots of the lungs as well as to identify inflammatory foci of lung tissue consolidation, neoplasms, fluid or gas in the pleural cavities. The study is carried out in two projections – erect postero-anterior (front view) and latero-lateral (side view, right and left). The main advantage of fluoroscopy is the option to study the lungs during breathing. During the study, you can thoroughly examine the movements of the diaphragm, assess the condition of the sinuses and the position of

the esophagus. However, the main disadvantage of fluoroscopy is the greater radiation dose to both the patient and the medical staff.



Projectional radiography of the chest organs (heart and lungs), erect postero-anterior projection (front view)



Projectional radiography of the chest organs (heart and lungs), erect postero-anterior projection (front view), with notations

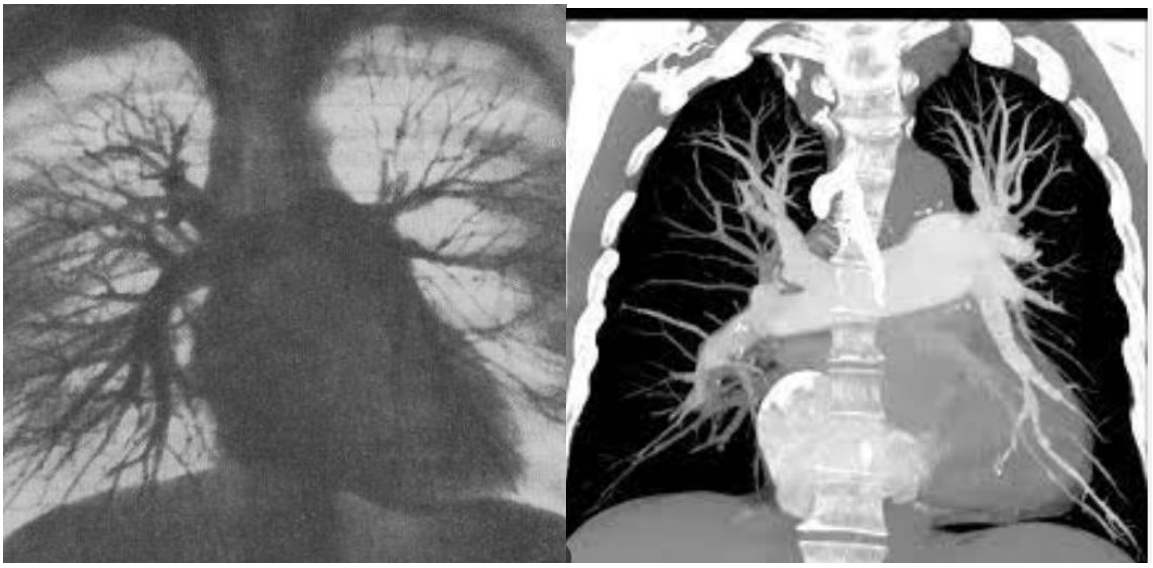
COMPUTED TOMOGRAPHY SCAN (CT scan) is a much superior imaging technique to radiography in its diagnostic capabilities. This method is based on performing a series of axial (along the longitudinal axis of the body) layered slices at 2-5 mm thickness, which are then reconstructed in the form of a layered image with high definition (acuity). Tomography images make it possible to examine in detail the structure and, if necessary, the function (ventilation, perfusion) of the lungs. The widespread application of computed tomography scan in practical medicine allows us to detect different type of cancers and interstitial lung lesions, bronchiectasis at an early stage. The disadvantage of the method is a significant radiation dose to the patient.

Computed tomography imagine of the lungs

BRONCHOGRAPHY is a method of X-ray scanning based on coating of the trachea and bronchial tree with sterile radiopaque liquid. Filling the airways up to the distal bronchi, contrast agent displays the structure of the organ. Bronchography is mainly used for the diagnosis of bronchiectasis and bronchial tumors. The drawback of the method includes its invasiveness that can lead to the diffuse bronchospasm and the limitation of obtaining a biopsy to verify the diagnosis.

Bronchogram of the right lung

ANGIOGRAPHY (X-ray contrast examination of blood vessels) is a medical imaging technique performed by injecting a radiopaque contrast agent into the blood vessel and imaging using X-ray based techniques. Angiography of the lungs is now used to diagnose embolisms, developmental abnormalities and acquired lesions of the pulmonary vessels.



Angiopulmonography (left) and CT angiopulmonography (frontal reconstruction) (right)

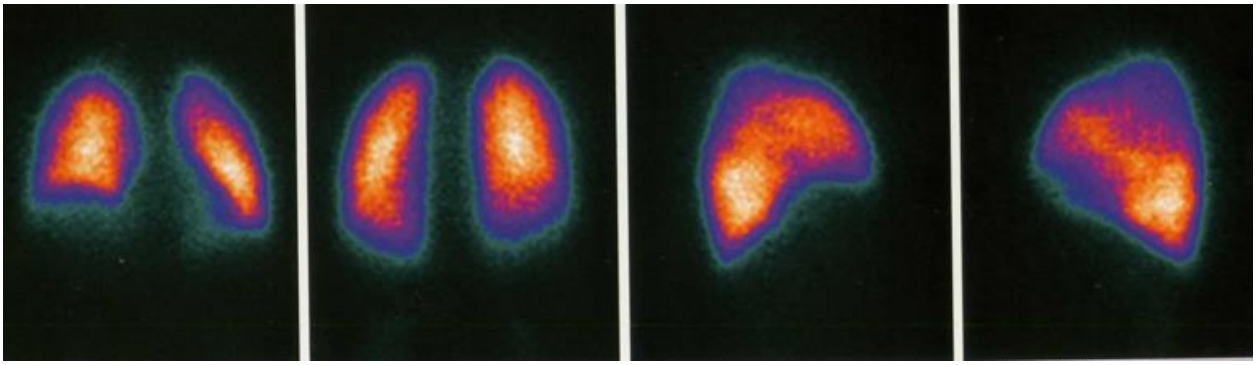
PULMONARY PERFUSION SCINTIMAGING is a radiological investigation that allows to assess the condition of ventilation and pulmonary blood circulation. The technique principle is based on "sticking" of intravenously

introduced radioactive particles to precapillary arterioles or pulmonary capillaries with a temporal capillary channel embolization. Their distribution is proportional to regional pulmonary blood circulation. During embolization of 0.1-0.3% precapillary arterioles and pulmonary capillaries the particles of radiopharmaceutical tracer provide the information about regional capillary blood circulation in the lung areas. Pulmonary perfusion scintimaging is performed in the standing position because it allows to get the lungs image in unchanged anatomic-topographical position. Scintigrams are registered in the static mode and in a polypositional way: in anterior-posterior, posterior-anterior, and two lateral views, and also, if necessary, in oblique view at 45º angle (left and right anterior and posterior ones). Indications **for pulmonary scintimaging include:**

pulmonary embolism,
pulmonary infarction,
regional disorders of the lungs ventilation,
chronic obstructive pulmonary diseases,
emphysema of the lungs,
diagnosis of oncological neoplasm in the lungs,
assessment of administered treatment quality,
assessment of the lungs condition before surgery.

The analysis of pulmonary scintigrams includes qualitative (visual) and quantitative assessment of the investigation results. Visual investigation of scintigrams allows to estimate sharpness of the pulmonary field borders, uniformity of radiopharmaceutical tracer distribution, localization and size of radiopharmaceutical tracer accumulation defects. Quantitative analysis is made automatically. Pulmonary fields of the right and left lungs are divided into three equal symmetric zones (Vesta zones). The score of all six zones of both lungs is 100%, and the percentage distribution of the score for each zone is calculated. One should take it into account that pathology foci in the lung parenchyma cause perfusion and ventilation disorders. Moreover, any process causing the increase of pulmonary venous pressure (hypertension of the lesser blood circulation) can lead to redistribution of pulmonary blood circulation, so that, instead of normal spread of radioactivity in basal parts of the lungs (lower zones), basal perfusion gets deficient and increased in upper zones. It is also known that disorder of pulmonary hemodynamics in healthy people is often indicated only for cases of significant (60-70%) decrease of pulmonary blood circulation. In normal state uniform distribution of radiopharmaceutical tracer in both lungs in anterior-posterior and

posterior-anterior views is detected during visual investigation of perfusion scintigrams (Figure 11). The received images do not differ from radiological picture of the lungs in their shape or position.



Normal distribution of radiopharmaceutical tracer during pulmonary perfusion scintimaging. Views: Anterior-straight line, Posterior-straight line, Right lateral one and Left lateral one

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