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Vice-rector for scientific and pedagogical work

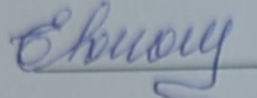_____ Eduard BURIACHKIVSKYI

«____» September 2024

PRACTICAL SKILLS IN INTERNAL MEDICINE

International Faculty, IV-th course

Educational discipline: **Practical Inpatient Medical Training «Internal Medicine»**

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Approved

At the meeting of the Department of Internal Medicine #2 with postgraduate training

Protocol № 1 dated «02» September 2024

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CONTENT

INTRODUCTION

Description of the discipline

Name of indicators	Characteristics of the discipline	
	Full-time education	
The total number of:	*Required / optional*	
Credits – 2,0	Year of preparation	4
Hours - 60	Semester	VII - VIII
Content sections - 2	Lectures	-
	Practical classes	36
	Self-study	24
	incl. individual tasks	0
	Form of final control	CSE

The purpose is to consolidate practical skills within the goals defined in the educational and professional training program for the specialty "Medicine » (222):
Objective:

1. Formation of skills and abilities for clinical examination of patients with major diseases of the cardiovascular and endocrine systems and analyze their results;
2. Formation of skills and abilities to substantiate the clinical diagnosis, drawing up a plan of laboratory and instrumental studies of patients with the most common diseases of the cardiovascular and endocrine systems.
3. Mastering the ability to determine the tactics of treatment and prevention of the most common diseases of the cardiovascular and endocrine systems.

The process of studying the discipline is aimed at forming elements of the following competencies:

IC: Ability to solve complex problems and problems in a certain field of professional activity or in the learning process, which involves research and / or innovation and is characterized by complexity and uncertainty of conditions and requirements;

A) general (GC)

- GC1. Ability to abstract thinking, analysis and synthesis;
- GC 2. Ability to know and understand the subject area and understanding of professional activity.
- GC 4. Ability to learn and master modern knowledge, use information and communication technologies; ability to search, process and analyze information from various sources.
- GC 5. Ability to adapt and make an informed decision in a new situation.
- GC 6. Ability to work in a team.
- GC 7. Ability to work in an international context, to communicate in foreign languages.
- GC 8. Ability to evaluate and ensure the quality of work performed.
- GC 9. Ability to act on the basis of ethical considerations, socially responsible and consciously.

б) special professional (SC):

- SC1. Communication and clinical examination skills of the patient with the most common diseases of the cardiovascular and endocrine system.
- SC2. Ability to determine the necessary list of clinical, laboratory and instrumental studies, evaluate their results in diseases of the cardiovascular and endocrine systems.
- SC3. Ability to establish a preliminary and final diagnosis of diseases of the cardiovascular and endocrine systems.
- SC4. Ability to determine the principles of treatment of diseases, the required regime of work and rest and the nature of nutrition in the management of patients with diseases of the cardiovascular and endocrine systems.
- SC5. Ability to diagnose emergencies in internal medicine.
- SC6. Ability to determine tactics and provide emergency medical care to patients with diseases of the cardiovascular and endocrine systems.

- SC8. Ability to perform medical manipulations, use modern medical equipment.
- SC13. Ability to conduct an examination of the ability to work in patients with diseases of the cardiovascular and endocrine systems.
- SC14. Ability to keep medical records.

Expected learning outcomes.

As a result of studying the discipline "Medical practice in the therapeutic department of the hospital" the student must:

To know:

1. Etiology, risk factors for the development and progression of diseases of the cardiovascular and endocrine systems.
2. Basic principles of treatment of diseases of the cardiovascular and endocrine systems, based on the principles of evidence-based medicine.
3. Fundamentals of primary and secondary prevention of diseases of the cardiovascular and endocrine systems.
4. Fundamentals of clinical pharmacology of drugs used in the treatment of diseases of the cardiovascular and endocrine systems, primarily prognosis-modifying drugs.

Be able to**:**

- Collect data on patient complaints, medical history, life history of patients with diseases of the cardiovascular and endocrine systems;
- Evaluate information about the diagnosis, using a standard procedure, based on the results of laboratory and instrumental studies. Determine the list of required clinical, laboratory and instrumental studies and evaluate their results (according to list 4).
- Identify the leading clinical symptom or syndrome (according to list 1). Establish a preliminary diagnosis, make a differential diagnosis and determine the final diagnosis of the disease (according to list 3).
- To determine the principles of treatment of diseases, the necessary mode of work and rest, the nature of nutrition (according to list 2).
- Diagnose emergencies (according to list 3).
- Define tactics and provide emergency medical care (according to list 3).

Master the skills:

- Communication and clinical examination of the patient.
- Perform medical manipulations (according to list 5) in diseases of the cardiovascular and endocrine systems.

Keep medical records.

PULMONARY PERCUSSION

Percussion of the lungs — is applied to the chest percussion beats leading subject authorities in oscillatory motion whose physical characteristics (duration of sound vibrations, their frequency, amplitude and timbre coloration) depend on the density of the body, elasticity its structure and moisture content of the air. There are the following methods of percussion:

a) direct percussion;

b) indirect percussion using pleximeter and mallet percussion finger by finger.

The palm of the left hand is placed on the surface of the body, fingers spaced slightly apart, the middle finger plays the role of plessimeter (the site of applicationof percussion blow to the finger-plessimeter — in the middle of an average or first phalanx). Right wrist bent for applying a percussion blow is placed parallel the left hand at a distance of 1-2 cm between the finger-plessimeter and finger-hammer.

The stroke should be delivered from the wrist and finger joints to give you controlover the force of the blow and over the precision of the site where it lands.

You should pay attention to the fact that the blow should be abrupt, perpendicular to the finger-plessimeter, finger-the -hammer should not be committed at the finger-plessimeter. For percussion at one point cause two of the same percussion of impact in a short time interval, after which the finger-plessimeter move to a new location.

One of the main advantages of this method of percussion consists in the possibility to dose the force of percussion blow in a wide range, so this method canbe used for both comparative and topographic percussion.

Dull percussion sound — small amplitude (volume), duration and relatively highfrequency. Tympanic sound — loud, long and relatively low frequency. Clear pulmonary sound — loud, long and also relatively low frequency.

Clear pulmonary sound, defined a healthy person, is characterized by a rich tonal colouring, which is caused by vibrations of elastic structures of the lung tissue. The propagation of sound vibrations with a quiet percussion (1) — about 3-4 cm,with the average percussion force (2) — 5-6 cm, while conducting a loud percussion (3) — 7-8 cm. In quiet (threshold) percussion sound waves penetrate deep into tissues 2-3 cm.

As the standard of the absolutely dull sound is the sound, which is determinedby percussion of the thigh muscles (femoral sound). The tympanic sound is a sound that can only be detected by percussion of the abdominal cavity and space of Traube. The standard of the clear pulmonary sound is the sound, which will be determined during percussion of the axillary and subscapular areas in a healthy person. The standard hyperresonant (tympanic) sound is the sound that appears when the percussion cushion.

General rules of percussion of the lungs:

1. Position of patient and physician should be comfortable to study.
2. Finger-plessimeter pressed tightly to the skin.
3. Finger-the hammer perpendicular to the finger-plessimeter.
4. Right-hand parallel the left (wrist joints placed one above the other).
5. 2 applied percussion blows are delivered through short time intervals.
6. Hand movements are carried out only in the wrist joint.
7. The doctor's hands should be warm.

Distinguish between comparative and topographic percussion of lungs. Comparative percussion of the lungs is used to determine the nature of pathological changes in the lungs and pleural cavity and used for the diagnosis of bronchopulmonary syndromes.

Technique of comparative percussion is:

1. Conduct a comparison of the nature of percussion sounds obtained oversymmetrical areas of the chest.

2. Cause "rebounding" of percussion blows of medium strength. The volume of the percussion sound can change depending on the thickness of the subcutaneous tissue,the degree of development of muscles, the depth of location of the pathological process and other reasons.

3. Percussion is carried out on the intercostal spaces.

To percuss the front of the chest, you should start by percussing over theclavicle on one side, then

on the other side, and then percuss on each ribspace and compare the note elicited over the corresponding note on the other side. Percussion is carried out 1 finger phalanx of plessimeter, because anatomically this is the most convenient. Then put the direct percussion blows to the collarbone, using it as plessimeter.

Further percuss in the first, second and third right and left intercostal spaces at the level of the midclavicular line. Below level III intercostal space on the left cardiacdullness, so further research is carried out in the pits of Maran ham. The patient standsor sits, arms lowered along the torso, muscles tense, breathing smooth and shallow. The doctor performs the percussion, usually standing to the right of the patient. Finger-plessimeter is parallel to the ribs, but it is tightly pressed against the patient's body.

For percussion axillary region finger-plessimeter put vertically in the upper part of the right, and then left arm. The doctor is beside the patient, opposite the axillary region. Then comparative percussion is carried out by comparing the percussion blows in the third intercostal space of the axillary region on the right and left, andthen the percussion continue in the fourth intercostal space of the axillary region on the right and left. The doctor is in front of the patient.

When performing comparative percussion on the posterior surface of the chest atthe beginning percuss suprascapular region, the finger-plessimeter set slightly above the spine of the scapula and parallel to it, percussion is applied consistently blows right and left with the patient standing with his hands at his sides, muscles tense.Then percuss "alarm" zones and interscapular region. Finger-plessimeter is parallel tothe spine at the edge of the blades, sequentially from right to left. Hands patient is asked to cross on his chest, putting hands on shoulders, with the blades of the supplies are provided, expanding the interscapular space. Further percuss subscapular area. Finger-plessimeter is placed horizontally below the angle of the scapula, alternately right and left. The arms of the patient are lowered along the body, the muscles are relaxed.

The clinical significance of comparative percussion of lungs: Percussion the clear pulmonary sound is heard in a healthy person over the lungs withunchanged pulmonary tissue. Characteristic sound: loud, long and of low frequency caused by fluctuations in the unmodified elastic structures of the lung tissue. The standard is sound, as determined by percussion in the axillary and subscapular areasin a healthy person.

Dull percussion sound – quiet, vague and high-frequency sound. Is formed over the area of the lung containing less air than in norm or above the liquid. Causes and anatomical localization of physiological shortening of percussion sound: increase the thickness of the pulmonary layer over the right top of the shorter right bronchus; in patient with muscled, in 2-3 intercostal space to the left due to the proximity of the heart, over the upper lobes of both lungs, in the right axillary region due to the proximity of the liver.

Lung comparative percussion abnormalities

Into dull or flat	Into tympanic
Infiltration of the lung parenchyma	Emphysema
Exudative pleuritis and hydrothorax	Empty pulmonary cavity (lung abscess)
Pleura thickening (adhesions)	Large bronchiectasis
Obturative atelectasis	Pneumothorax

Topographic percussion

In order to determine the exact size of the various organs or to differentiate the borders of two organs that lie adjacent to one another, they must be of different densities. Thus, by percussion it is

easy to determine where the lung ends and the heart begins because of the different densities of these organs. However, it is extremely difficult to differentiate between heart and liver dullness, or between the dullness of pleural effusion and liver dullness since the densities so closely approximate one another.

The normal limits of pulmonary resonance correspond accurately to the anatomic boundaries of the lung. With light percussion the inferior limits of the lung are found at the level of the sixth rib in the mediclavicular line, the eighth rib in the midaxillary line and the tenth rib in the scapular line. **Lungs topographic percussion abnormalities (lower lung borders).**

Elevation	Depression
Shrinking of the lung	Emphysema
Thickening of pleura	Asthma
Pneumothorax (false depression)	Chronic pulmonary congestion
Exudative pleuritis and hydrothorax	High diaphragm
	Flatulence(meteorism)

The lower limit of pulmonary resonance should in all instances be examined by percussion during both forced inspiration and expiration; normally the difference in space between these two extremes measures 3 to 4 cm. This space represents the complemental pleural space, and by this means the degree of respiratory mobility is attained. This respiratory mobility is diminished or absent in diseases of the lung suchas emphysema, pleural diaphragmatic adhesions and conditions that interfere with movement of the diaphragm.

Measuring the respiratory mobility of the right lung at midclavicular line Measuring the

respiratory mobility of the right lungat

posterior axillary line

On the left side near the lower costal margin, a tympanitic area, called Traube's semilunar space, is encountered. This area is bounded above by the lower border of the left lung, below by the spleen, internally by the left lobe of the liver and externally by the costal margins. It contains the fundus of the stomach, and the tympanitic note obtained by percussion is occasioned by the air content of the stomach. When the stomach is filled with food, the tympanitic note is decreased or disappears, as it also does in cases of pericardial effusion and left pleural effusions.

PULMONARY AUSCULTATION

Auscultation of the lungs is the most importing examining technique for assessing airflow through thetracheobronchial tree.
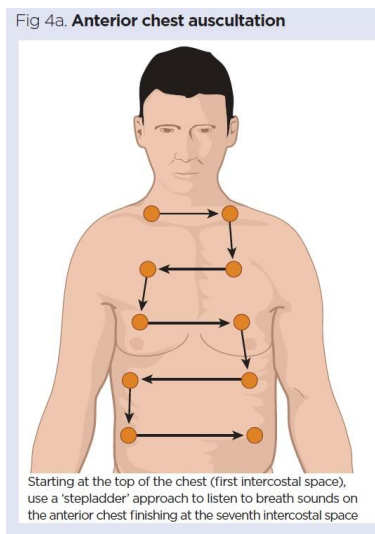
Auscultation involves:

1. listening the sounds generated by breathing – breath sounds (respiratory sounds);

2. listening for any adventitious (added) sounds.

Auscultation technique. Listen to the respiratory sounds with the diaphragm of a stethoscope after instructing the patient to breathe deeply through a nose with close mouth. Be alert for patient discomfort due to hyperventilation (light headedness, faintness), and allow the patient to rest as need.

As auscultation is also comparative method, use the pattern suggested for comparative percussion, moving stethoscope from one side to the other and comparing symmetrical areas of the lungs. Listen to at least one full breath ineach location.

Listen to the breath sounds in supra-, infraclavicular regions, and them move stethoscope downward. In the left 2nd and3rd interspaces place stethoscope more laterally, as compared with percussion, in order to round the heart.

Fig 4a. **Anterior chest auscultation**

Starting at the top of the chest (first intercostal space), use a 'stepladder' approach to listen to breath sounds on the anterior chest finishing at the seventh intercostal space
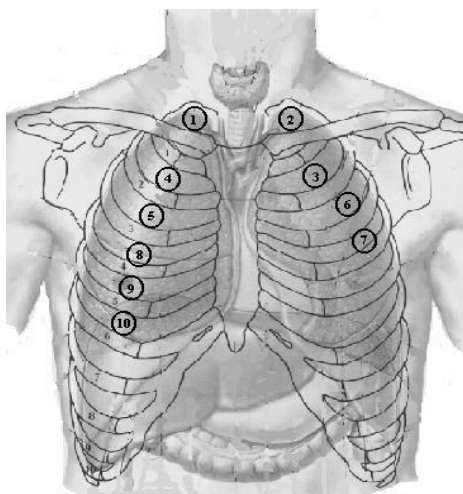
Auscultation of the lungs. Anterior view.

The lungs are then auscultated in the axillary regions with the patient's hands on the back of the head.

Fig 4c. **Right lateral chest auscultation**

Move from the peak of the axilla to between the seventh or eight rib on the right and left.
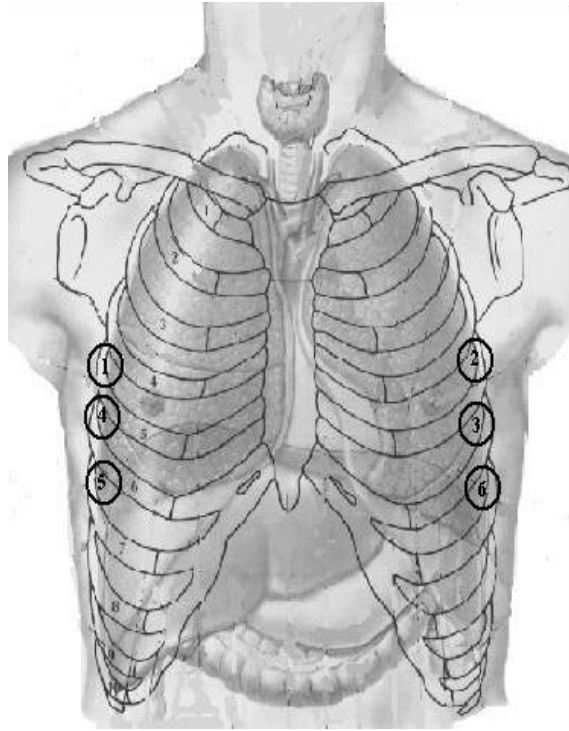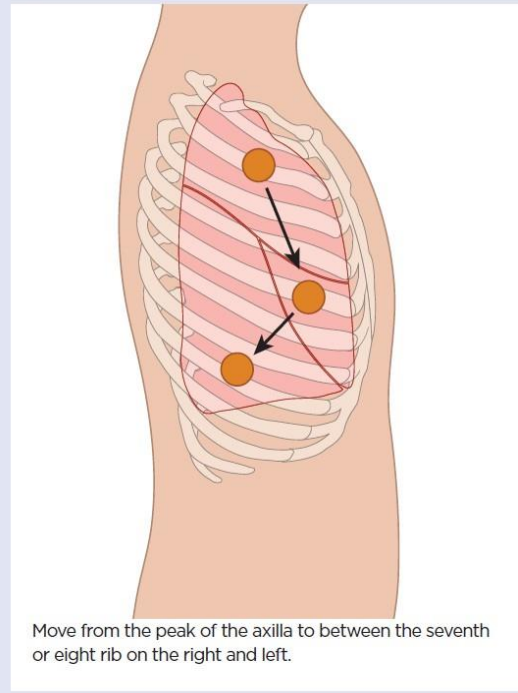
Auscultation of the lungs in axillary regions.

Listen to the breath sounds posteriorly in supra-, inter-, and infrascapular regions. Ask the patient to crosshis arms on the chest to move scapular from the spine.

Fig 4b. **Posterior chest auscultation**

Start at the first intercostal space of the posterior chest moving downwards, avoiding the scapula, to the seventh intercostal space
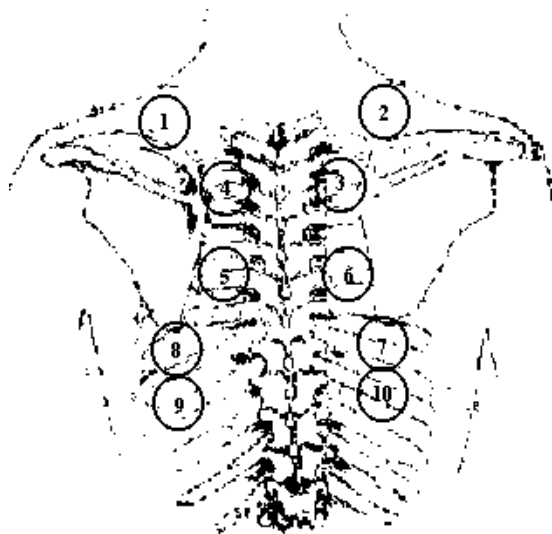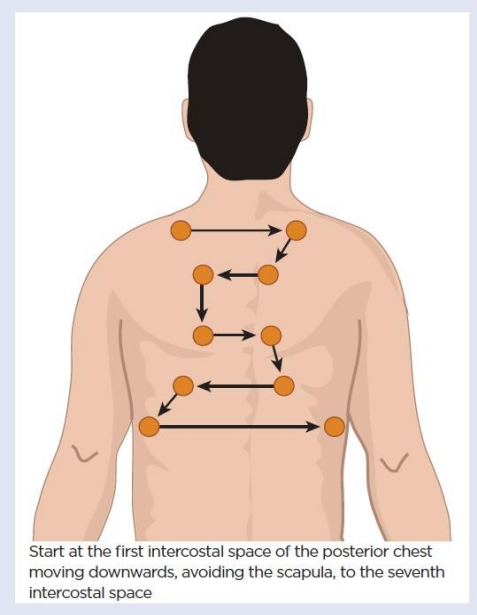
Auscultations of the lungs. Posterior view.

Two types of sound can be heard coming from the lungs: the main respiratory sounds (breath sounds) and adventitious (added) sounds. Breath sounds may be normal or abnormal, added sounds are always abnormal.

Lung sounds

Main respiratory (breath) sounds	**Adventitious** (added) sounds
-vesicular (alveolar) breath sounds ▪bronchial (laryngotracheal) breath sounds	- rales - crepitation - pleural friction sounds

The main respiratory sounds (breath sounds) Normal breath sounds have been classified into two categories: *vesicular* and *bronchial*, according to their intensity, their pitch, and the relative duration of their inspiratory and expiratory phases.

Vesicular breath sounds are soft, low pitched, and are heard through inspiration continue about one third of way through expiration.
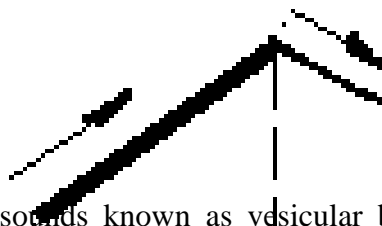
Vesicular breath sound. Breath sounds known as vesicular breathing are generated by vibration of the alveolar walls due to airflow in inspiration. A long soft (blowing) noise gradually increases and is heard through inspiration. Alveolar walls still vibrate during initial stage of expiration to give shorter expiratory sound during about one third of the expiration phase. Vesicular breathing is also therefore called – alveolar breathing.

Vesicular breath sounds are heard normally over most of both lungs. It should be remembered however that intensity of vesicular breathing is differ over healthy lungs.
Physiological difference of the vesicular breath sounds.

Intensity	Location	Cause
More loud	below the 2nd rib, laterally of the parasternal line; axillary regions; below scapular angle	Largest of the massespulmonary tissue
Longer and louder	over the right lung as compared with left one	Better conduction by the right main bronchus, which is shorter and wider
Less loud	lung apices; lowermost parts of the lungs	Smallest masses of the pulmonary tissue

Vesicular breath sounds can vary for both physiological and pathological causes.
Physiological changes of the vesicular breathing always involve both part of the chest, and breath sounds areequally changes at the symmetrical points of the chest

Physiological changes of the vesicular breath sounds.

Decreased vesicular breathing	**Increased** vesicular breathing
Thick chest wall: ▪ excessively developed muscles ▪ orsubcutaneous fat	Thin chest wall: - underdeveloped muscles or - subcutaneous fat - in children (good elasticity of the alveoli). This type of breathing is called *puerile* (1 puer – child)

Pathologic changes of the vesicular breathing can be a result of following causes:
1. abnormal generation of breath sounds, which depend on amount of intact alveoli, properties of their walls, andamount of air contained in them;
2. abnormal transmission of the breath sounds from the vibrating elastic elements of the pulmonary tissue to thesurface of the chest.

Abnormalities in vesicular breath sounds may be unilateral, bilateral, or only over a limited area of the lung. Vesicular breathing can be decreased or inaudible, and increased.
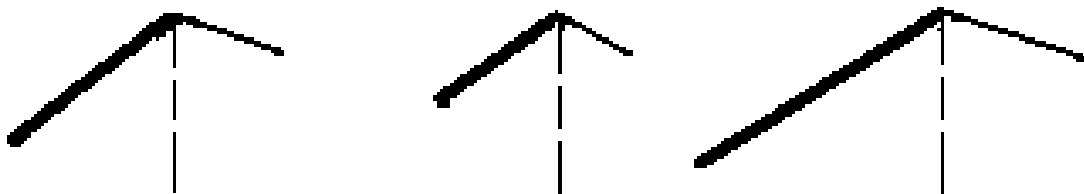
Vesicular   Decreased vesicular   Increased vesicular
Vesicular breath sounds and their changes.

Pathologically decreased vesicular breathing observes in:
I. abnormal generation of breath sounds occurs in:
o pulmonary emphysema, when the number of the alveoli significantly diminished. The remaining alveoli are no longer elastic, their walls become incapable of quick distension, and do not give sufficiently strong vibration;
o initial stage of acute lobar pneumonia due to inflammation and swelling of alveolar walls and decreased their vibrations. Vesicular breath sounds becomes inaudible during the second stage of acute pneumonia, when alveoli of affected lobe are filled with effusion;
o obstructive atelectasis, when airflow is decreased (over atelectasis zone). In complete obstruction breath sounds are inaudible;
o compressive atelectasis, when alveoli are compressed, and airflow in them is decreased;
o inflammation of the respiratory muscles, intercostals nerves, rib fracture, muscular weakness as a result of markedweak inspiration.
II. abnormal transmission of breath sounds results from:
o thickening of the pleural layers;
o pleural effusion;
o pneumothorax.

Pathologically increased vesicular breathing occurs when air flows at increased speed through narrowedairways (inflammatory edema of the mucosa, bronchospasm) in bronchitis and bronchial asthma. This increase in speed increases turbulence, the amount of noise made, and expiration become louder and longer.

Deeper vesicular breathing when inspiration and expiration are intensified is called **harsh**. This type of increasedvesicular breathing can observe in bronchitis as a result of marked and nonuniform narrowing of small bronchi and bronchioles due to inflammatory edema of their mucosa.

Interrupted or cogwheel respiration is characterized by short jerky inspiratory efforts interrupted by short pauses between them.

Interrupted or cogwheel respiration.

Such type of respiration can be observed in non-uniform contraction of the respiratory muscles, when you listen patient in cold room, in nervous trembling, and sometimes in children during crying. Cogwheel respiration over limited area indicates difficult airflow from small bronchi to the alveoli, and also uneven unfolding of the alveoli. Interrupted breathing indicates pathology in fine bronchi and is more frequently heard over lungs apices during their tubercular infiltration.

Bronchial breath sounds are loud, harsh, high in pitch, and expiratory sound last longer than inspiratory one.
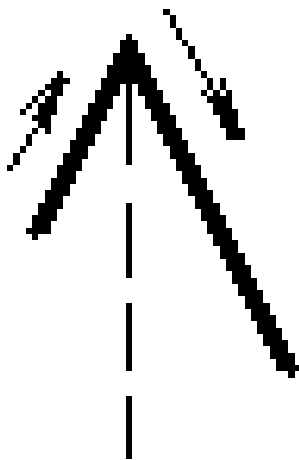
Bronchial breath sound.

Bronchial breath sounds are generated by turbulent airflow in the larynx and the trachea when air passes through the vocal slit. Since the vocal slit is narrower during expiration, expiratory sounds are louder, harsher, and longer. This type of breath sounds is also called laryngotracheal.

Bronchial breathing is heard normally over the larynx, the trachea in the neck, and at the site of projection of the tracheal bifurcation (anteriorly over manubrium, and posteriorly in the interscapular region at the level of T3 and T4 spinous processes)
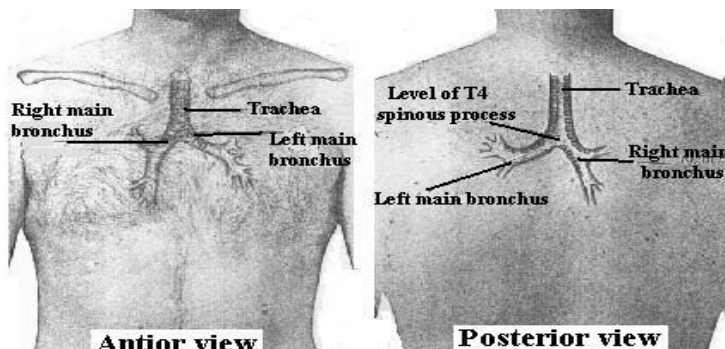
Trachea and main bronchi projection on the chest.

Bronchial breath sounds are inaudible over the lungs because bronchi are covered by air-containing 'pillow' ofthe pulmonary tissue.

If bronchial breathing is heard over the lungs, suspect that air-filled lung has been replaced by fluid-filled orsolid lung tissue, which conducts sounds better. This is so-called pathological bronchial breathing.

Pathological bronchial breathing is observedin *consolidation of the pulmonary tissue*

in:

- acute lobar pneumonia, tuberculosis (when alveoli are filled with effusion);
- lung infarction (when the alveoli are filled with blood);
- lung tumor (airiness tissue);
- compressive atelectasis (when alveoli are compressed completely by pleural air or fluid);
- pneumosclerosis, carnification of the lung lobe (airless connective tissue replace airiness lung tissue);in formation of an **empty cavity** in the lung communicated with a large bronchus:
- pulmonary abscess;
- cavernous tuberculosis;

- disintegrated tumor;
- disintegrated lung infarction;
- seldom opened echinococous.

Solid pulmonary tissue round the cavity transmits the breath sounds better, and the sounds are intensified in the resonant cavity.

Amphoric respiration is heard in the presence of a large smooth-wall cavity (not less than 5-6 cm in diameter) communicated with a large bronchus. A strong resonance causes additional high overtones, which alter the main tone of the bronchial breath sounds. Blowing over the mouth of an empty glass or clay jar can produce such sounds. This altered bronchial breathing is therefore called amphoric (GK amphoreus jar).
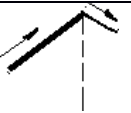
Bronchovesicular or mixed breathing is intermediate in intensity and pitch, inspiratory and expiratory sounds are about equal (inspiratory sounds is characteristic of vesicular breathing, expiratory of bronchial breathing).
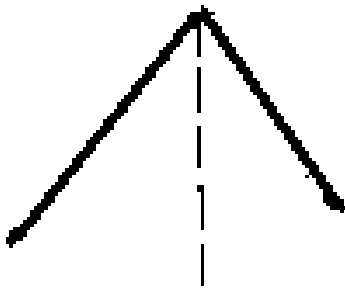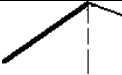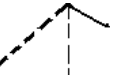
Bronchovesicular breathing.

Such type of breath sounds are heard when solid lung tissue locates deep or far from one another.

The characteristics of the main respiratory sounds

Sound	Duration	Intensity of the expiratory sound	Pitch of the expiratory sound	Example location	Pathologic example
Vesicular	Inspiratory sounds last longer than expiratory one	Soft	Low	Over most of both lungs	---
Decreased vesicular	Inspiratory and expiratory sounds last shorter	Softer	Low	None normally	Emphysema,acute pneumonia, obstructive atelectasis, muscular weakness, hydrothorax, pneumothorax

Increased vesicular	Inspiratory and expiratory sounds last longer	Louder	Low	None normally	Bronchialasthma, bronchitis
Cogwheel	Interrupted inspiration	Relatively soft	Relatively low	Cold room, nervous trembling	Diseases of the respiratory muscles, pathology in fine bronchi (tuberculosis)
Bronchial	Expiratory soundslast longer than inspiratory one	Loud	Relatively high	Over the larynx, the trachea, manubrium, interscapular region (at the level of T3, T4)	Over the lungs in consolidation of the pulmonary tissue (acute lobar pneumonia, tuberculosis, lung infarction, compressive atelectasis), cavity in the lungs (abscess, caverna)
Broncho-vesicular	Inspiratory soundsand Expiratory sounds are about equal	Inter mediate	Intermediate		Deep location of the solid lungtissue

INTERPRETATION OF X-RAY EXAMINATION OF THE CHEST ORGANS
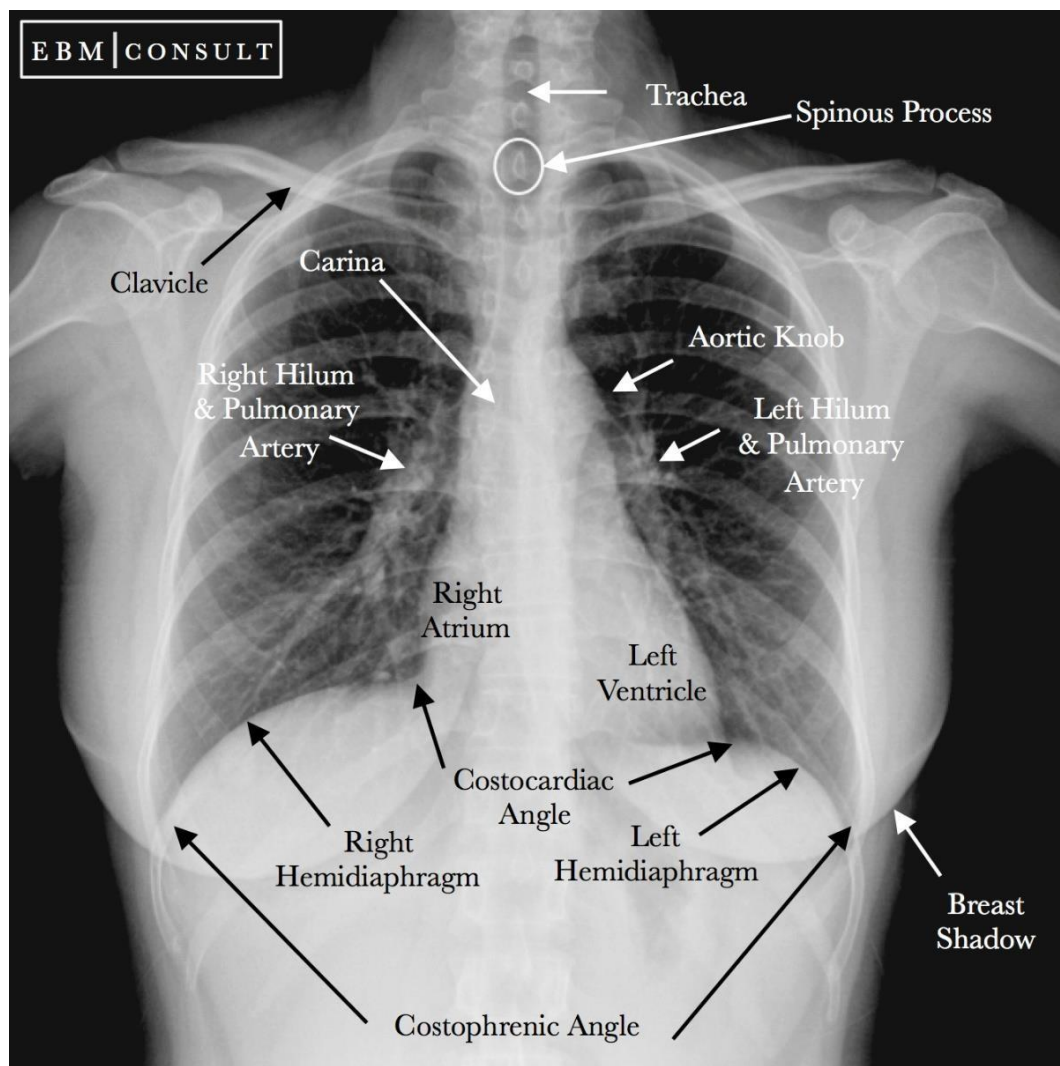
On all Xrays check the following:
- Check patient details
  - First name, surname, date of birth.
- Check orientation, position and side description
  - Left, right, erect, ap, pa, supine, prone
- Check additional information
  - inspiration, expiration
- Check for rotation
  - measure the distance from the medial end of each clavicle to the spinous process of the vertebra at the same level, which should be equal
- Check adequacy of inspiration
  - Nine pairs of ribs should be seen posteriorly in order to consider a chest x-ray adequate in terms of inspiration
- Check penetration
  - one should barely see the thoracic vertebrae behind the heart
- Check exposure
  - One needs to be able to identify both costophrenic angles and lung apices

Specific Radiological Check List:

A - Airway
- Ensure trachea is visible and in midline
  - Trachea gets pushed away from abnormality, eg pleural effusion or tension

    pneumothorax
- o Trachea gets pulled towards abnormality, eg atelectasis
- o Trachea normally narrows at the vocal cords
- o View the carina, angle should be between 60 –100 degrees
- o Beware of things that may increase this angle, eg left atrial enlargement, lymph node enlargement and left upper lobe atelectasis
- o Follow out both main stem bronchi
- o Check for tubes, pacemaker, wires, lines foreign bodies etc
- o If an endotracheal tube is in place, check the positioning, the distal tip of the tube should be 3-4cm above the carina
- Check for a widened mediastinum
  - o Mass lesions (eg tumour, lymph nodes)
  - o Inflammation (eg mediastinitis, granulomatous inflammation)
  - o Trauma and dissection (eg haematoma, aneurysm of the major mediastinal vessels)

B – Bones
- Check for fractures, dislocation, subluxation, osteoblastic or osteolytic lesions in clavicles, ribs, thoracic
- Spine and humerus including osteoarthritic changes
- At this time also check the soft tissues for subcutaneous air, foreign bodies and surgical clips
- Caution with nipple shadows, which may mimic intrapulmonary nodules
  - o compare side to side, if on both sides the "nodules" in question are in the same position, then they are likely to be due to nipple shadows

C - Cardiac
- Check heart size and heart borders
  - o Appropriate or blunted
  - o Thin rim of air around the heart, think of pneumomediastinum
- Check aorta
  - o Widening, tortuosity, calcification
- Check heart valves
  - o Calcification, valve replacements
- Check SVC, IVC, azygos vein
  - o Widening, tortuosity

D – Diaphragm
- Right hemidiaphragm
  - o Should be higher than the left
  - o If much higher, think of effusion, lobar collapse, diaphragmatic paralysis
  - o If you cannot see parts of the diaphragm, consider infiltrate or effusion
- If film is taken in erect or upright position you may see free air under the diaphragm if intra-abdominal perforation is present

E – Effusion
- Effusions
  - o Look for blunting of the costophrenic angle
  - o Identify the major fissures, if you can see them more obvious than usual, then this could mean that fluid is tracking along the fissure
- Check out the pleura
  - o Thickening, loculations, calcifications and pneumothorax

F – Fields (Lungfields)
- Check for infiltrates
  - o Identify the location of infiltrates by use of known radiological phenomena, eg loss of heart borders or of the contour of the diaphragm
  - o Remember that right middle lobe abuts the heart, but the right lower lobe does not
  - o The lingula abuts the left side of the heart
- Identify the pattern of infiltration
  - o Interstitial pattern (reticular) versus alveolar (patchy or nodular) pattern

- o Lobar collapse
- o Look for air bronchograms, tram tracking, nodules, Kerley B lines
- o Pay attention to the apices
- Check for granulomas, tumor and pneumothorax

G – Gastric Air Bubble

- Check correct position
- Beware of hiatus hernia
- Look for fee air
- Look for bowel loops between diaphragm and liver

H – Hilum

- Check the position and size bilaterally
- Enlarged lymph nodes
- Calcified nodules
- Mass lesions
- Pulmonary arteries, if greater than 1.5cm think about possible causes of enlargement

Extended Radiological Check List – Lateral Film:

A - Airway

- Ensure trachea is visible and in midline
    - o Trachea gets pushed away from abnormality, eg pleural effusion or tension pneumothorax
    - o Trachea gets pulled towards abnormality, eg atelectasis
    - o Trachea normally narrows at the vocal cords
    - o View the carina, angle should be between 60 –100 degrees
    - o Beware of things that may increase this angle, eg left atrial enlargement, lymph node enlargement and left upper lobe atelectasis
    - o Follow out both main stem bronchi
    - o Check for tubes, pacemaker, wires, lines foreign bodies etc
    - o If an endotracheal tube is in place, check the positioning, the distal tip of the tube should be 3-4cm above the carina
- Check for a widened mediastinum
    - o Mass lesions (eg tumour, lymph nodes)
    - o Inflammation (eg mediastinitis, granulomatous inflammation)
    - o Trauma and dissection (eg haematoma, aneurysm of the major mediastinal vessels)

B – Bones

- Check the vertebral bodies and the sternum for fractures or other osteolytic changes

C – Cardiac

- Check for enlargement of the right ventricle and right atrium (retrosternal and retrocardiac spaces)
- Trace the aorta

D – Diaphragm

- Check for fluid tracking up, costophrenic blunting and the associated hemidiaphragm

E – Effusions

- Check to see the fissures here as well – both major fissures and the horizontal may be found in the lateral view

F – Fields

- Check the translucency of the thoracic vertebrae in the lateral view, when there is a sudden change in transparency, then this is likely to be caused by infiltrate
- Also try to find the infiltrate that you think you saw on the pa-film to verify existence and anatomical location
- Pay special attention to the lower lung lobes

I would like to close with a clarification of two important radiological findings, whose understanding is very useful for a correct interpretation of chest x-ray findings.

The first is **the silhouette sign**, which can localise abnormalities on a pa-film without need for a lateral view. The loss of clarity of a structure, such as the hemidiaphragm or heart border, suggests that there is adjacent soft tissue shadowing, such as consolidated lung, even when the abnormality itself is not clearly visualised. The reason is, that borders, outlines and edges seen on plain radiographs depend on the presence of two adjacent areas of different density, Roughly speaking, only four different densities are detectable on plain films; air, fat, soft tissue and calcium (five if you include contrast such as barium). If two soft tissue densities lie adjacent, then they will not be visible separately (eg the left and right ventricles). If, however, they are separated by air, the boundaries of both will be seen.

The second important x-ray finding is the **lung collapse**. A collapse usually occurs due to proximal occlusion of a bronchus, causing subsequently a loss of aeration. The remaining air is gradually absorbed, and the lung loses volume. Proximal stenosing bronchogenic carcinoma, mucous plugging, fluid retention in major airways, inhaled foreign body or malposition of an endotracheal tube are the most common reasons for a lung collapse. Tracheal displacement or mediastinal shift towards the side of the collapse is often seen. Further findings are elevation of the hemidiaphragm, reduced vessel count on the side of the collapse or herniation of the opposite lung across the midline.
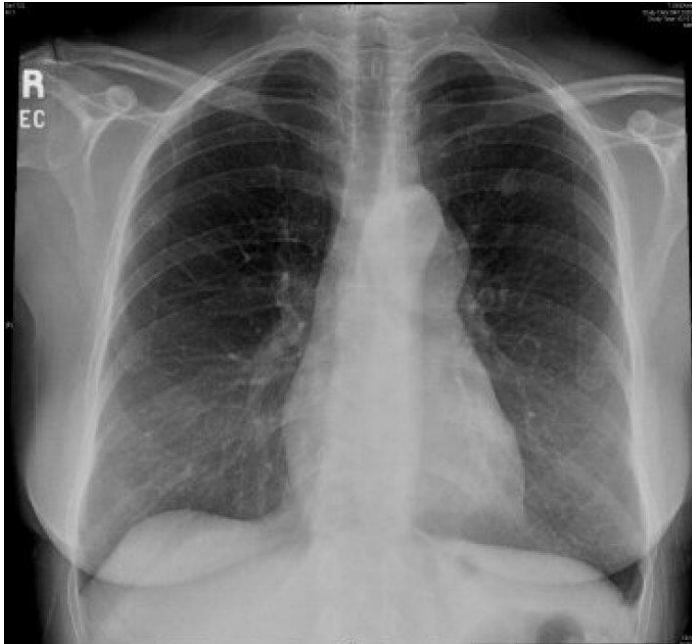
Left mid mediastinal / paraaortic tumor and left upper lobe satellite lesion

Left basal pleural effusion and consolidation

Left upper lobe tuor
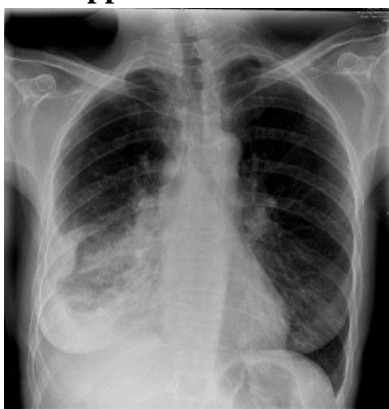
Right pleural metastases and pleural effusion due to carcinoma of the ovary
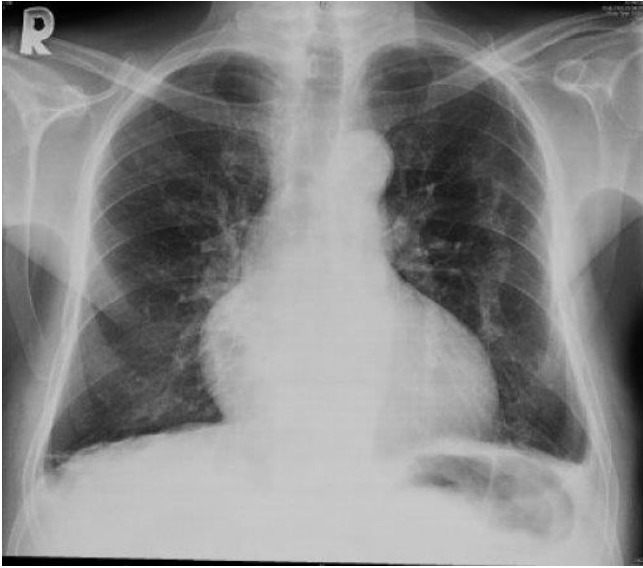
Pleural calcifications and adhesions due to asbestos exposure

Pulmonary fibrosis and superimposed infection

Right middle lobe pneumonia

PULSE CHARACTERISTICS

Pulse – it is fluctuations of arterial walls associated with cardiac cycles. Under the pulse understand any changes in the vascular system associated with the activity of the heart. Distinguish arterial, venous and capillary pulse.

Method of palpation and radiation of pulse

The most frequent place to study the pulse is the radial artery as it is located superficially under the skin between the styloid process and the tendon of the inner radial muscle. The topography of the radial artery allows to press the vessel to the bone, which facilitates the study of the pulse. The hand of the patient is held with the physician's right hand in the area of the radioulnar joint, the thumb of the physician should be on the elbow side, the fingers on the radial side. After the artery is felt it is pressed with the point and middle fingers.

When the wave passes the artery, the physician feels dilation of the artery, that is the pulse. First, it is necessary to study the properties of the radial artery. The fingers of the physician should glide along the artery in transverse and longitudinal direction. The normal sensation is that of thin, soft, even, elastic, pulsating tube. The artery is soft but elastic. If it is soft but not elastic, this suggests decreased vascular tone, which is present in fever, shock, collapse. If it is hard and elastic, this suggests increased tone of the arterial muscles observed in increased blood pressure. If the artery is hard and not elastic (rigid), this suggests development of connective tissue or calcification of the vessel, a sign of atherosclerosis.

This vessel looks curly. In significant atherosclerosis, separate hard regions with calcific deposits can be felt (atherosclerotic beads). In addition to the radial arteries, the properties of the wall and pulsation can be studies on the temporal, carotid, brachial, femur, popliteal, tibial arteries and the sole of the foot. In narrowed isthmus (coarctation), the volume of the pulse waves decreases considerably on the lower extremities, while on the carotid arteries and those of upper extremities it remains normal or increased. In obliterating arteritis of the large vessels originating from the aorta arch (Takayasu disease, absence of the pulse) pulsation of the carotid, axillary, brachial, radial arteries disappears or decreases. Reduction or absence of pulsation on the plantar arteries is the sign of endoarteritis (in young patients), obliterating atherosclerosis (in the middle or elderly age), thrombosis of the vessels. Then it is necessary to determine whether the pulses are equal on the both hands.

Normally they are equal. If the pulses are unequal, this is called pulsus differens. Pulsus differens in observed in anomalies of the radial artery (it goes to the back side of the hand and the usual place is occupied by its branch), in pathological changes: aortic arch aneurysm, mediastinal tumors, narrowing of the left atrioventricular orifice when enlarged left atrium presses the subclavicular artery and the pulse of the left hand, especially in the left decubitus, decreases (Popov-Saveliev sign), when a tumor or enlarged lymph nodes compress the artery, when the lumina of the large vessels are compressed with scars.

After comparison of the pulse on the both hands, it is necessary to study the properties the pulse on one hand. If the pulse is different on the both hands, it is studied on the hand where it is more intensive.

Properties of arterial pulse:

Pulse rate, the number of pulse beats per minute. In healthy individuals pulse rate is 60-80 beats per minute .

Depending on the frequency, distinguish pulse:
• moderate frequency -60-90 UD. / min;
• Liquid (Pulsus rarus) -mere 60 UD. / min;
• frequent (Pulsus frequins) is more than 90 UD. / min..

Rhythm of the pulse, the beats follow with equal intervals and are equal, i.e. regular pulse (pulsus regularis). In disturbances of the heart function, this regularity changes, it becomes arrhythmical, irregular, an irregular pulse (pulsus irregularis). Three types of arrhythmias are observed: extrasystole (extraordinary heart contractions), the interval between this and the following contraction can be unusually long (compensatory pause), ciliary arrhythmia (disordered pulse waves are palpated), paroxysmal tachycardia (very frequent pulsation which is difficult to count, appearing and disappearing suddenly). If the pulse is arrhythmical, it is necessary to determine if the number of

the pulse waves corresponds to the number of the heart contractions. In frequent arrhythmical contractions of the heart, separate systoles of the left ventricle may be so weak that the blood is not ejected to the aorta, or the amount of the blood is so small that the pulse wave does not reach the periphery. The difference between the number of the heart contractions and pulse waves per one minute is termed pulse deficiency, the pulse is called a ***deficiency pulse (pulsus deficiens).***

The more is the deficiency, the more unfavorable is its effect on the blood supply of the organs and tissues.

Pulse rhythm disorders: a) extrasystole; b) bigeminal pulse; c) ciliary arrhythmia.

Pulse tension is the pressure of the blood exercised on the wall of the artery. It is determined by the force, which should be exercised to compress the artery completely in order to arrest the blood flow in it. This property of the pulse gives the information about the state of the vascular system and the arterial pressure. In healthy persons the pulse tension is satisfactory.

In a tense pulse, the force of compression to arrest the pulse wave should be great (***pulsus durus***), this is a sign of hypertension of various origin or arterial sclerosis. Reduction of tension, soft pulse (***pulsus mollis***) suggests decreased arterial pressure (reduction of the heart contractile function, shock, collapse, blood loss).

Pulse filling is the amount of blood in the vessel. This property is most difficult to determine, namely according to the maximum and minimum volume of the vessel (how the diameter of the vessel changes in the period of dilation and collapse). To do this, proximal fingers on the radial artery should press the vessel gradually, the distal finger determines its maximum filling.

In healthy persons the pulse is satisfactory. In reduction of the volume of circulating blood (blood loss, shock, collapse), disturbances of contractile function of the heart, the pulse filling decreases, ***pulsus vacuus***, in increased volume of the circulating blood, blood filling increases, full (strong) pulse (***pulsus plenus***). Pulse filling and tension give similar information. Pulse value is a collective concept, uniting such properties as filling and tension. It depends of the degree of the artery widening during systole and its collapse during diastole. In healthy persons the pulse is sufficient. With the increase of the stroke blood volume, great fluctuations of the arterial pressure as well as decreased tone of the arterial wall, the value increases, pulsus magnus; in insufficiency of the aortic valve, thyrotoxicosis, fever, the tone of the aorta wall decreases. Reduction of the stroke volume, increased tone of the arterial wall reduces the number of pulse waves, small pulse (***pulsus parvus***). This is observed in stenosis of the aorta opening, mitral stenosis, tachycardia, heart failure; in shock, massive blood loss the pulse is poorly felt, thready pulse (***pulsus filiformis***). The shape or rate of the pulse is the rate of dilation and the following contraction of the artery. This property depends of the rate of the pressure changes in the arterial system during systole and diastole. In aortic valve incompetence, an abrupt pulse (***pulsus celer***) or a bouncing pulse (***pulsus silens***) as well as ***pulsus altus***: the stroke blood volume and systolic blood pressure are increased, during diastole the pressure drops quickly as the blood returns from the aorta to the left ventricle can be present. Abrupt pulse is also observed in thyrotoxicosis, nervous excitement. Slow pulse (***pulsus tardus***) is opposite to an abrupt pulse. This is associated with slow increase of the blood pressure in the arterial system and its small fluctuations during a cardiac cycle. This is observed in stenosis of the aorta opening. Due to reduction of the pulse waves it is not only slow but also small (***pulsus parvus***). Pulse shape disorders: a) bouncing ***pulsus magnus***; c) slow small pulse.

Dicrotic pulse (***pulsus dicroticus***) is a second additional wave after reduction of a normal pulse wave. In healthy subjects it is not palpated but registered on sphygmogram. A dicrotic pulse is present in reduced tone of the peripheral arteries (fever, infections, severe pneumonia).

An alternating pulse (**pulsus alterans**) is alterations of large and small pulse waves when the pulse is rhythmical (severe affection of the myocardium, i.e. myocarditis, cardiomyopathy.

A paradoxical pulse (**pulsus paradoxus**) is reduction of the pulse waves during breathing in (in adhesion of the pericardium layers due to compression of the large veins and reduction of the heart filling during expiration

MEASUREMENT OF BLOOD PRESSURE

Arterial pressure can be measured with a direct and indirect methods. Direct measurement is performed with artery puncture. This is mainly used in cardiosurgery. Three methods are used for indirect measurement: auscultation, palpation, oscillographic. The most practical is an auscultation method proposed by N. S. Korotkoff in 1905. It allows measuring both systolic and diastolic pressure. The measurement is done using a sphygmomanometer (mercury, Riva-Rocci apparatus, spring, electronic).

The pressure is usually measured on the brachial artery. The cuff is wrapped and fastened around the bare upper arm of the patient. The cuff should be tightened to allow only one finger between it and the patient's skin. The edge of the cuff with the rubber tube should face downward. The zero level of the apparatus, the artery and the patient's heart should be at the same level. The patient's arm should rest comfortably with the palm upright and the muscles relaxed. Than the valve of the apparatus is turned off and the cuff is inflated with air until the pressure in it exceeds the 30 mm the level when pulsation of the brachial and radial artery is not felt. After that the valve is turned on and the air is allowed to escape slowly from the cuff. At the moment the pressure in the cuff becomes a little lower than systolic pressure, the first slight pulsations of the radial artery will appear (palpation method of measurement systolic blood pressure).

Diastolic pressure cannot be determined using this method.

The most frequently used is Korotkoffs method, which allows determining both minimal and maximal pressure. With this method, when the pressure in the cuff is a little lower than systolic pressure, sounds simultaneous with the heartbeat are heard with a phonendoscope over the brachial artery. When the sound appears, the values noticed correspond to systolic pressure. N. S. Korotkoff described four phases of sound phenomena, which are heard during blood pressure measurement over the vessel. Phase 1 is appearance of the sounds over the artery, that is first portions of the blood entering the vessel under the place of narrowing causing vibrations in the relaxed wall of the empty vessel. While the pressure in the cuff is dropping, more blood can pass the narrow area thus turbulent blood movement appears above the narrowing, the sound resembles murmurs (phase 2). Gradually, more blood enters the vessel increasing the vibration of its wall and the sound increases (phase 3, low sounds). When the pressure in the cuff equals diastolic pressure, the obstacle to the blood flow disappears, the vibrations decrease sharply. This moment is characterized by evident weakening and disappearing sounds (phase 4) and corresponds to diastolic pressure.

PERCUSSION AND AUSCULTATION OF THE HEART

Percussion is used to determine sizes, position and configuration (shape) of a heart and its vascular bundle.

The right contour of dullness of the heart and the vascular bundle is formed (from top to bottom) by the superior vena cava to the upper edge of the 3rd rib and by the right atrium at the bottom. *The left contour* is formed by the left part of the aortic arch at the top, then by the pulmonary trunk, by the auricle of the left atrium at the level of the 3rd rib and downward by a narrow strip of the left ventricle. *The anterior surface* of the heart is formed by the right ventricle. Being an airless organ, the heart gives a dull percussion sound. But since it is partly covered on its sides by the lungs, dullness is dual in its character, i.e. it is relative (deep) and absolute (superficial). The relative cardiac dullness is the projection of heart anterior surface onto the chest. It corresponds to the true borders of the heart. The relative cardiac dullness is covered by the lungs. The absolute dullness of heart corresponds to the anterior surface of the heart that is not covered by the lungs.

Rules of percussion of heart:

1. Percussion is performed in most cases in a vertical position of the patient, with the arms lowered downwards, at impossibility of keeping of this rule it is possible to confine percussion in a horizontal position. It should, however, be remembered that the area of cardiac dullness in the vertical position is smaller than in the horizontal. This is due to mobility of the heart and the displacement of the diaphragm as the patient changes his 65 posture.

2. The doctor can sit or stand to the right of the patient at the time of percussion.

3. Respiration of the patient should be superficial.

4. The finger-pleximeter (3-rd finger of the left arm) must be densely applied to intercostals spaces to avoid lateral distribution of vibrations along the ribs.

5. Percussion is conducted from a clear sound to dulled or dull depending on the purpose of percussion (that is from lungs to heart).

6. The revealed border of the heart dullness is marked on outside edge of the finger-pleximeter inverted to a louder percussion sound.

7. The strength of percussion stroke depends on the purpose of percussion: at delimitation of relative dullness of heart the medium (quiet, or light) percussion is used, at delimitation of absolute dullness of heart - the quietest percussion.

8. The sequence of percussion: - Delimitation of relative dullness of heart, - Definition of a configuration of heart - Definition of transverse length of relative cardiac dullness, - Definition of size of heart vascular bundle, - Delimitation of absolute dullness of heart.

Delimitation of relative dullness of heart

It is distinguished right, left and upper borders of relative dullness of the heart. Determining the borders of relative cardiac dullness, interspaces should be percussed in order to avoid lateral distribution of vibrations along the ribs. The percussion stroke should be of medium strength. The pleximeter-finger should be tightly pressed against the chest so that the percussion vibration might penetrate deeper regions. In the beginning the right border of relative dullness of the heart is determined. Since the border of cardiac dullness depends on the position of the diaphragm, the lower border of the right lung is first determined in the midclavicular line; its normal position is at the level of the 6-th rib. The position of the lower border of the lung indicates the level of the diaphragm. The various height of position of diaphragm can be reflected in the dimensions of heart and by that on a position of heart in thorax. For this purpose the finger- pleximeter is applied at the level of 2-d intercostals space on midclavicular line, and percussion is performed strictly on intercostals spaces downwards by quiet percussion before change of a clear pulmonary sound on a dull sound. The mark is made on the edge of the fingerpleximeter inverted to a side of a clear pulmonary sound. Further the right border of relative dullness of the heart can be defined immediately. The pleximeter-finger is moved on two interspace 66 above the lower border of the right lung and placed parallelly to the right border of the heart being determined (normally, in the 4-th costal interspace). Percussion is continued by moving the pleximeter-finger gradually along the interspace toward the heart until the percussion sound dulls. *The right border of the heart* is marked by the external edge of the finger directed toward a clear resonant sound. Its normal position is 1 cm laterally of the right edge of the sternum .

In case of a change of height of standing of a diaphragm the rules of percussion for definition of the right border of relative dullness are not variated. In order to definition of the right contour of the heart the finger - pleximeter is located in the 3-d and 2-d intercostals spaces at the level of midclavicular line parallel to a sternum (parallel to a finding border of heart in this intercostals space). Percussion with medium strength is continued by moving the pleximeter-finger gradually along the interspace toward the heart until the percussion sound dulls. Further the points received at a percussion in the 4-th, 3-d, 2-d intercostals space are connected among themselves to representation of a right contour of heart. *The right contour of heart* is formed at the 2-d to 3-d intercostals spaces by superior vena cava and ascending aortic arch, and at the 4-th intercostals space by right auricle.

Normal position of relative heart dullness

Border/ Countour	Position	Anatomical structure
Right - 4-th interspace	1 cm laterally of the right edge of the sternum	right atrium
Right – 2-d and 3-d interspaces	0.5 - 1cm laterally of the right edge of the sternum	superior vena cava and an ascending aortic arch
Left – 5-th interspace	1-1.5 cm medially of the left midclavicular line	left ventricle
Left – 4-th interspace	more medially than in 5-th interspace	left ventricle
Left – 3-th interspace	on the middle between midclavicular and parasternal lines	left auricle
Left – 2-th interspace	0.5 - 1cm laterally of the left edge of the sternum	left part of an aorta arch and a pulmonary trunk
Superior	on the upper edge of 3-d rib at the left parasternal line	cone of a pulmonary artery and left auricle

The left border of the relative cardiac dullness is determined in the interspace, where the apex beat is present Therefore the apex beat is 67 first determined by palpation, and the pleximeter-finger is then placed laterally of this point, parallel to the sought border, and the interspace is percussed toward the sternum. If the apex beat cannot be determined, the heart should be percussed in the 5-th interspace from the anterior axillary line toward the sternum. The normal left border of relative cardiac dullness is located 1-2 cm medially of left midclavicular line; it coincides with the apex beat.

Definition of the left contour of the heart begins with definition of localization of the apex beat. Further the left border of relative dullness of the heart is determined (in norm it settles down in the 5-th intercostal space on 1 sm medially from midclavicular line). Next the pleximeter-finger is raised on one intercostals space above, the pleximeter-finger position in the 4-th intercostals space is parallel to sternum at the level of anterior axillary line, and percussion is performed before change of a clear pulmonary sound on a dulled sound. The point is marked from the side of a clear note. Percussion in the 3-d intercostal space is performed by the same rules. Later the left border of heart vascular bundle in the 2-d intercostals is defined by percussion from midclavicular line to sternum before change of a clear pulmonary note on a dulled sound. The points received by means of percussion in the 5-th, 4-th, 3-d, 2-d intercostals spaces are connected and represents about the left contour of heart. The left contour of the heart is formed in the 2-d intercostals space by the left part of the aorta arch and the pulmonary trunk, at the 3-d intercostals space - the left auricle, and lower - left ventricle. The superior border of relative cardiac dullness is determined on a left parasternal line (1-2 cm to the left of left sternal line). To that end the pleximeter-finger is placed at the 1 -t intercostals space perpendicularly to the sternum, and then moved downward until dullness appears. The normal superior border of the relative cardiac dullness is located in the 3-d intercostals space. For more accurate determination of the superior border the immediate percussion (Obraztcov method) is performed on two overlying ribs above a dulled sound (first – the 2-d control rib, then – the 3-d test rib). If the percussion by ribs yields an identical note, the border is placed on the inferior edge of the

lower (the 3-d) rib. If the dull percussion sound is found above the lower rib, the superior border is defined on the upper edge of this rib. The normal superior border of relative cardiac dullness is located at the level of the upper edge of the 3-d rib and is formed by a cone of a pulmonary artery and the left auricle. The enlargement of relative dullness of the heart is observed under the following conditions:

- elevated position of diaphragm (in hypersthenic constitution, 68 meteorism ascites, pregnancy);

- in hypertrophy and dilatation of the right auricle and the right ventricle (in stenosis and incompetence of tricuspid valve, stenosis of ostium of the pulmonary artery, sclerosis of the pulmonary artery, development of the pulmonary heart, mitral stenosis) the borders of heart are displaced to the right;

- as a result of the hypertrophy and dilatation of the left ventricle (in arterial hypertension, stenosis of ostium of aorta, incompetence of the aortal valves, aneurysm of the left ventricle) the borders of heart are displaced to the left;

- as a result of the hypertrophy of the left auricle (mitral stenosis and incompetence of the mitral valve) the borders of heart are displaced upwards;

- as a result of combined heart valves diseases the enlarging of the dimensions of heart is observed in all directions.

The restriction of the relative dullness of heart is observed:

- as a result of phrenoptosis (descent position of a diaphragm in asthenic constitution, at the general enteroptosis);

- as a result of pulmonary pathology (pulmonary emphysema).

Determination of transverse length of relative cardiac dullness

Once the area of relative cardiac dullness of the heart has been established, its transverse length is measured by a measuring tape, from the extreme points of the relative dullness to the anterior median line. The normal distance from the right border of relative cardiac dullness (usually in the 4-th intercostals space) to the anterior median line is 3 or 4 cm, while the distance from the left border of relative cardiac dullness (usually in the 5-th intercostals space) to the same line is 8 or 9 cm. The sum of these lengths is the transverse length of relative cardiac dullness (normally 11-13 cm).

Determination of a configuration of heart

The shape of the heart can be determined by percussion of the borders of the vascular bundle in the 2-th intercostal space on the right and left, and of relative cardiac dullness in the 4-th or 3-rd interspace on the right, and in the 5-th, 4-th, or 3-rd interspaces on the left. The pleximeter-finger is moved parallel to the borders of expected dullness and the elicited points of dullness are marked on the patient's skin. The points are connected later by a line to mark the contours of the relative cardiac dullness. Normally, an obtuse angle is formed by the lines of the left heart contour between the vascular bundle and the left ventricle. The narrowing of contours of relative cardiac dullness is normally placed at the 3-d intercostal space and named «waist of heart». The heart is of normal configuration in such cases. In pathological conditions, when the chambers of the heart are dilated, mitral and aortal configurations are distinguished.

Delimination of absolute (superficial) cardiac dullness

The part of anterior wall of the right ventricle heart is not covered normally by the lungs. Percussion of the anterior wall of heart not covered by the lungs area produces the dull sound and reveals the absolute cardiac dullness of the heart. To determine absolute dullness of the heart, the quietest (lightest) percussion strokes are needed. The right border of absolute cardiac dullness is first elicited. The pleximeter-finger is placed on the right border of relative (deep) cardiac dullness, parallel to the sternum, and then moved medially, to the left, to dullness (change a dulled note on dull). The border is marked by the outer edge of the finger directed toward resonance. In normal subjects this border passes along the left edge of the sternum.

Normal position of absolute heart dullness

Border	Position	Anatomical structure
Right - 4-th interspace	at the left edge of the sternum	right ventricle
Left – 5-th interspace	1.5-2 cm medially of the left midclavicular line	right ventricle

Superior		on the lower edge of 4-d rib at the left parasternal line	right ventricle

The most common causes of changes in the boundaries and configuration of the heart are given in the table

		Causes	Diseases and syndromes
Changes borders Hearts. Displacement right border of relative dullness of heart	To the right	Dilatation of the right ventricle Dilatation of the right ventricle and right auricle Dilatation of the right auricle Displacement of the mediastinum to the right	1. Pulmonary artery stenosis 2. Pulmonary heart Tricuspid insufficiency Atioventricular defect Left side hydrothorax Left side pneumothorax Right obstructive atelectasis
	To the left	Drip" configuration of the heart Displacement of the mediastinum to the left	Asthenic body type 1. Left obstructive atelectasis 2. Right-sided hydro- or pneumothorax (at this border is often not detected)
Displacement left border of relative dullness of heart	To the right	Dilatation of the left ventricle	1. Aortic insufficiency. 2. Mitral insufficiency. 3. Aortic stenosis (stage of decompensation). 4. Arterial hypertension. 5. Acute myocardial damage. 6. Chronic left ventricular failure
	To the left	Displacement of the mediastinum to the left	Right side hydrothorax Right side pneumothorax Left obstructive atelectasis
Displacement left border of relative dullness of heart	To the right	"Lying" heart / horizontal position of the heart	High standing of the diaphragm (ascites, flatulence, obesity.)
	To the left	Displacement of the mediastinum to the right	1. Right obstructive atelectasis 2. Left-sided hydro- or pneumothorax (at

			this border is often not detected)
Displacement superior border of relative dullness of heart	Superior	Dilatation of the left auricle	1. Mitral insufficiency 2. Mitral stenosis
Configuration Of heart	Mitral	Dilatation of the left Auricle and waist smoothing hearts	1. Mitral insufficiency 2. Mitral stenosis
	Aortic	Dilatation of the left Ventricle and emphasized waist hearts	1. Aortic insufficiency 2. Aortic stenosis emphasized waist hearts
Wided size of a vascular bundle	To the right	1).Extension or ascending aortic aneurysm	1. Arterial hypertension 2. Atherosclerosis of the aorta
	To the left	1)Expansion descending part aorta 2).Expansion pulmonary artery	1. Arterial hypertension 2. Atherosclerosis of the aorta High pressure in the pulmonary artery
	Right and to the left	Expansion, elongation and reversal of the aortic arch	1. Arterial hypertension 2. Atherosclerosis of the aorta
Expansion of absolute (superficial) cardiac dullness		Dilatation of the right ventricle	1. Mitral stenosis 2. Pulmonary heart 3. Insufficiency of the three-leaf valve
		Extracardiac reasons	1. High position of the diaphragm 2. Shrinking lung syndrome 3. Tumor of the posterior mediastinum that brings the heart closer to the anterior chest wall
Reduction of absolute (superficial) cardiac dullness		Extracardiac reasons	1. Emphysema of the lungs

			2. Left or right pneumothorax 3. Low position of the diaphragm

Rules of heart auscultation:

- The heart is usually auscultated by a stethoscope or a phonendoscope, but direct (immediate) auscultation is also used.

- The condition of the patient permitting the heart sounds should be heard in various postures of the patient: erect, recumbent, after exercise (e.g. after repeated squatting).

- Sounds associated with the mitral valve pathology are well heard when the patient lies on his left side, since the heart apex is at its nearest position to the chest wall; aortic valve defects are best heard when the patient is in the upright posture or when he lies on his right side.

- The heart sounds are better heard if the patient is asked to inhale deeply and then exhale deeply and keep breath for short periods of time so that the respiratory sounds should not interfere with auscultation of the heart.

- The valve sounds should be heard in decreasing order of their affection frequency. The mitral valve should be heard first (at the heart apex); next follows the aortic valve (in the second intercostal space to the right of the sternum), the pulmonary valve (in the second intercostal space, to the left of the sternum), tricuspid valve (at the base of the xiphoid process), and finally the aortic and mitral valve again at the Botkin-Erb point. If any deviations from normal sounds have been revealed at these points, the entire heart area should be auscultated thoroughly.

Heart valve	Topographic projection	Points of auscultation
Mitral (bicuspid)	to the left of the sternum at the 3-rd costosternal joint;	**Apex of the heart**
Tricuspid	on the sternum midway between the 3-rd left and 5-th right costosternal joints;	lower part of the sternum near its junction with the xiphoid process (the right-ventricular area)
Aortic	in the middle of the sternum at the level of the 3-rd costosternal joint.	in the second intercostal space, to the right of the sternum where the aorta is the nearest to the anterior chest wall;
Valves of the pulmonary trunk	in the 2-nd intercostal space, to the left of the sternum;	its anatomical projection onto the chest, i.e. in the second intercostal space, to the left of the sternum;

TRANSMISSION OF SOUNDS AND MURMURS

AORTIC AREA

PULMONARY AREA

TRICUSPID AREA

MITRAL AREA
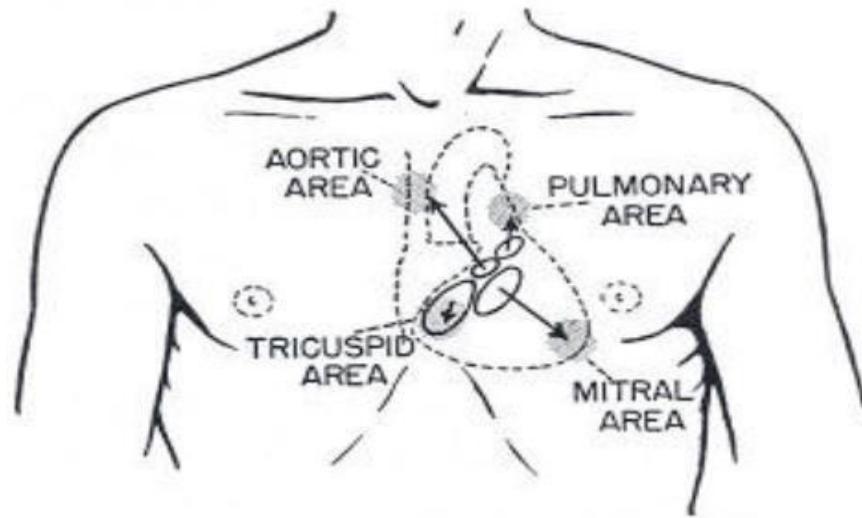
Auscultator sequence & alternate auscultation areas

Auscultator sequence & alternate auscultation areas

Aortic area

Pulmonic area

LV area

RV area
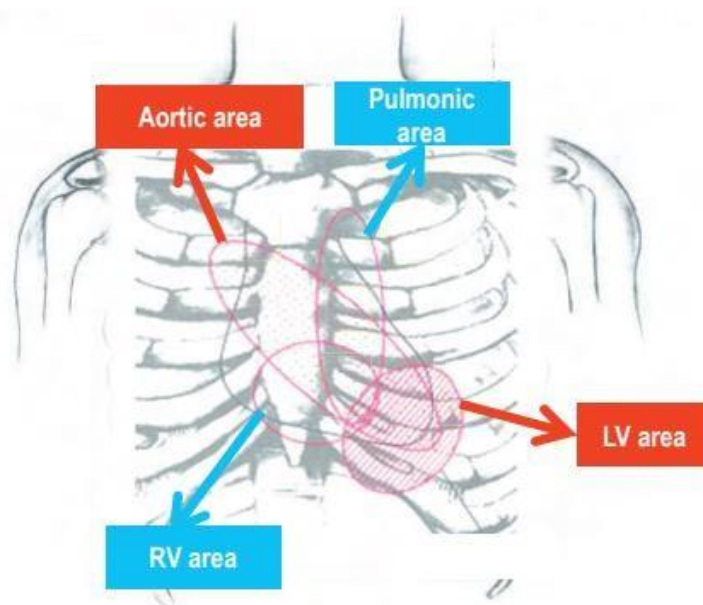
Algorithm of heart auscultation (2)

Locating the assessment points
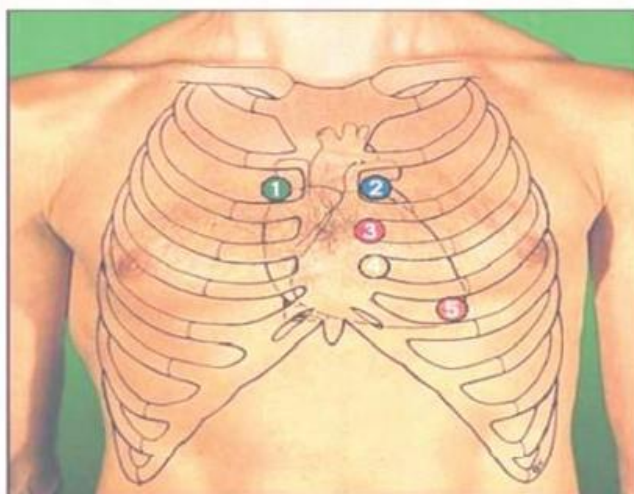
1 Aortic area—second intercostal space, right sternal border
2 Pulmonic area—second intercostal space, left sternal border
3 Erb's point—third intercostal space, left sternal border
○ Tricuspid area—fourth (or fifth) intercostal space, left sternal border
5 Mitral area or apex—fifth intercostal space, left midclavicular line

Auscultator sequence.
The rule of «8»
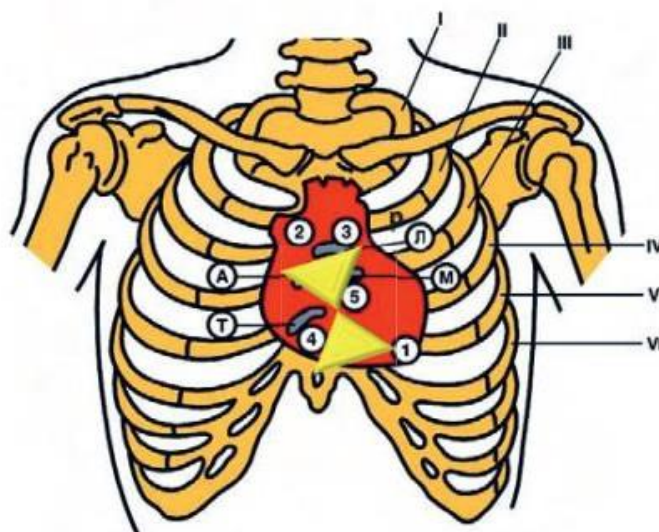
Algorithm of heart auscultation (1)
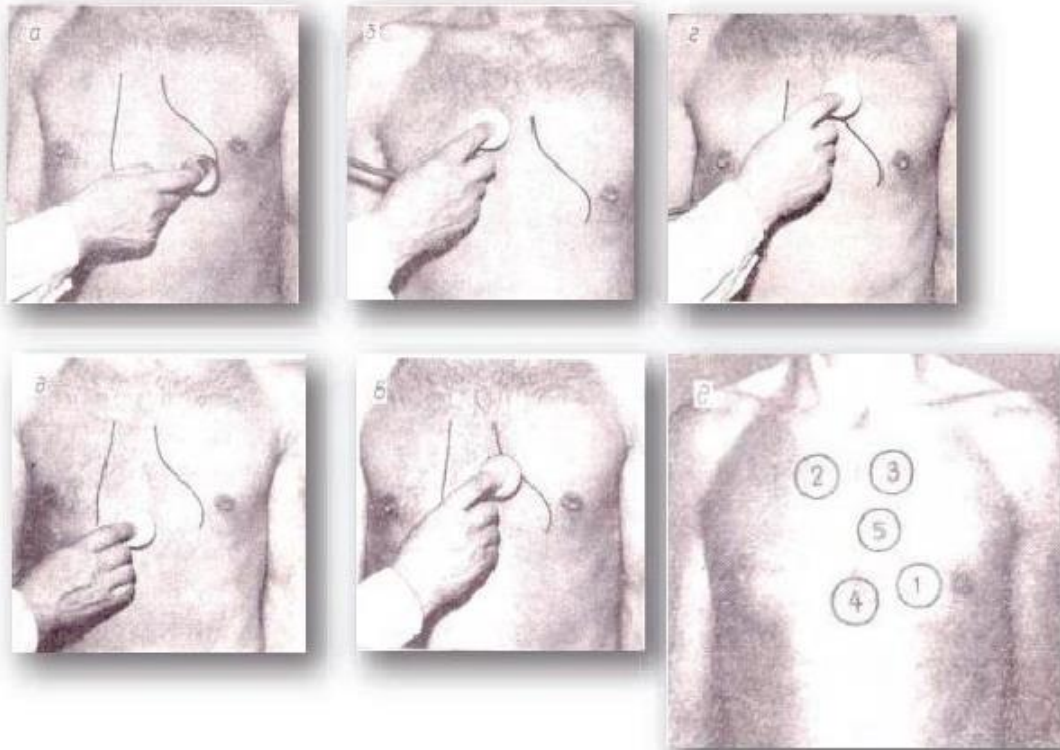
Positions for auscultation
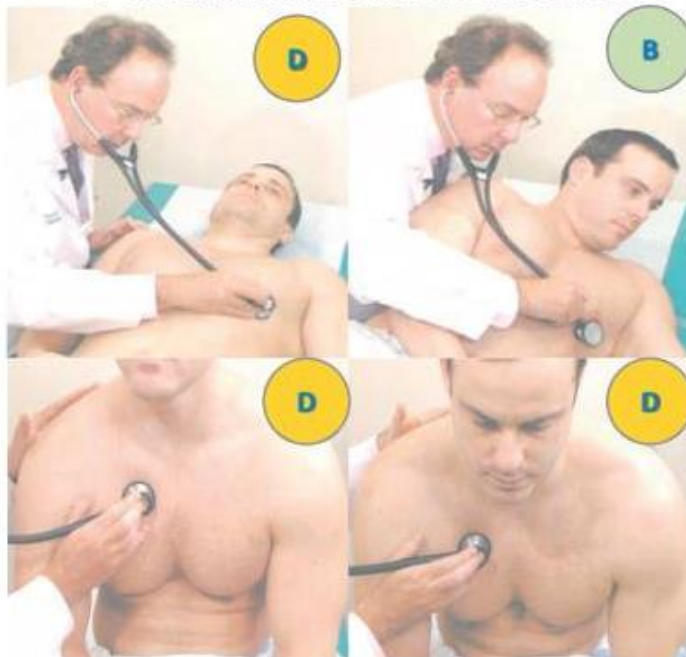
A, The supine position, used for listening to all areas.
B, The left lateral decubitus position, used for listening with the bell in the mitral area.
C, The upright position, used for listening to all areas.
D, The upright, leaning-forward position, used for listening with the diaphragm at the base positions.
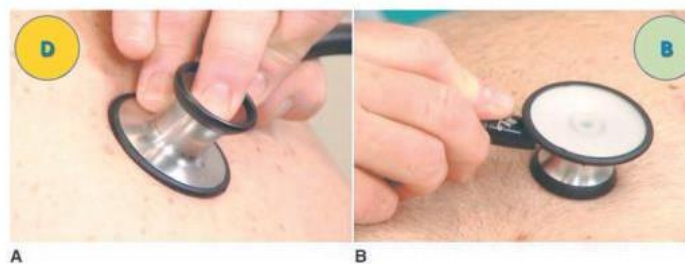
Placement of stethoscope heads.
A, Correct placement of the diaphragm. Notice that the head is applied tightly to the skin.
B, Placement of the bell. Notice that the bell is applied lightly to the skin

Changes in the heart sounds

The heart sounds may increase or decrease their intensity, the tone, or length; they may be split or reduplicated, or adventitious sound may appear.

Intensity of the heart sounds may depend on conditions of the sound wave transmission, i.e. on the extracardiac causes. If subcutaneous fat or muscles of the chest are overdeveloped, or there are lung emphysema, liquid in the left pleural cavity, and some other affections that separate the heart from the anterior chest wall, the intensity of the heart sounds decreases. If conditions for sound transmission are improved (thin chest wall, the lung edges are sclerosed, the heart is pressed against the anterior chest wall by a growing tumour in the posterior mediastinum, etc.), the intensity of the heart sounds increases. The sounds can also be increased by the resonance in large empty cavities filled with air (a large cavern in the lung, large gastric airbubble). The intensity of the heart sounds also depends on the composition of the blood flowing through the heart: if the blood viscosity decreases (in anemia) the intensity increases.

Intensity of the heart sounds can decrease in decreased myocardial contractility in patients with myocarditis, myocardial dystrophy, cardiosclerosis, collapse, and accumulation of fluid in the pericardial cavity.

Both heart sounds can be increased due to the effect of the sympathetic nervous system on the heart. It occurs in physical and emotional strain, during exercise, and in patients with exophthalmic goiter. Changes of only one of heart sounds are very important diagnostically.

Intensity of the first heart sound diminishes in the mitral and aortic valve insufficiency. The cusps of the affected mitral valve fail to close completely the left atrioventricular orifice during systole. Part of the blood is thus regurgitated to the left atrium. The pressure of the blood is below norm against the ventricular walls and the cusps of the mitral valve, and the valvular and muscular components of the first heart sound markedly diminish. The period of closed valves is absent also during systole in the aortic valve insufficiency. It means that the valves and muscle components of the first heart sound will also diminish significantly. In tricuspid and pulmonary valve failure, the diminution of the first heart sound will be better heard at the base of the xiphoid process due to the diminution of the muscular and valves components of the right ventricle.

The first sound can be diminished at the heart apex in stenotic aortal orifice because systolic tension of the myocardium grows slowly when the blood flow from the left ventricle is obstructed and it is overfilled with blood; the amplitude of the sound vibrations decreases. In diffuse affections of the myocardium (due to dystrophy, cardiosclerosis or myocarditis), the first heart sound only may be diminished because its muscular component also diminishes in these cases.

The first sound increases at the heart apex if the left ventricle is not adequately filled with blood during diastole. The first sound often becomes louder in stenosis of the left atrioventricular orifice, when less than normal amount of blood is discharged from atrium to the ventricle during diastole. The muscle of the left ventricle is therefore less distended by the blood by the start of systole; it is more relaxed and therefore contracts more rapidly and energetically to intensify the

first sound. The first sound increases in stenosed right atrioventricular orifice at the base of the xiphoid process. This sound is also intensified during extrasystole (premature contraction of the heart) due to inadequate diastolic filling of the ventricles.

The variation of the first sound at the heart base is not important because this sound is transmitted here from its best auscultative area, i.e. from the cardiac apex area.

The second heart sound is heard over the base. In normal cases the intensity of this sound over the aorta is the same as over the pulmonary trunk. Although the blood pressure in the aorta is higher and the cusps of its valve are closed with a greater force than those of the pulmonary valve, the sound produced by the closing aortic valve is perceived by the examiner as being of the same intensity as the sound of the pulmonary valve, because of the deeper location of the aortic valve.

The second sound over the aorta *is diminished* in aortic valve affections because either the cusps of the valve are destroyed or their vibrating power decreases due to developing cicatrices. Moreover, the thrust of the blood discharged at early diastole from the aorta to the cusps of the aortic valve is weaker than in normal persons because part of the blood is regurgitated to the ventricle through an incompletely closed aortic orifice. The second sound can be inaudible over the aorta if the aortic valve is much destroyed. The second sound diminishes over the aorta in cases of marked hypotension; the second sound diminishes over the pulmonary trunk in cases of aortic valve incompetence (in very rare cases) and in decreased pressure in the lesser circulation.

The *second sound may increase (accent)* either over the aorta or over the pulmonary trunk. If the sound is more intense over the aorta, it is said to be accentuated over the aorta, and if it is stronger over the pulmonary trunk, accentuation of the second sound over pulmonary artery is meant. The aortic second sound is accentuated when the blood pressure in aorta increases (in essential hypertension, during heavy exercise, in psychic excitation), because during early diastole, the aortic valve cusps are closed with a greater force due to increased blood pressure in the aorta. The tone of the second heart sound over the aorta often varies. For example, in patients with sclerotic aortic valve, the second sound over the aorta acquires a metallic character which, however, can be heard in normal arterial pressure as well.

The accentuated second sound over the pulmonary artery occurs when pressure in the lesser circulation is elevated or when the vessels of the lesser circulation are overfilled with blood (e.g. in mitral heart diseases), deranged circulation in the lungs and stenosed pulmonary artery (in lung emphysema or pneumosclerosis).

Reduplication of the heart sounds may be revealed by auscultation. Two short sounds which quickly follow one another are heard instead of one. Reduplication of the sounds occurs in asynchronous work of the left and right chambers of the heart. Asynchronous closure of the atrioventricular valves splits the first sound while asynchronous closure of the semilunar valves causes reduplication of the second heart sound. If the two short sounds follow one another at a short interval, they are not perceived as two separate sounds, the sound is said to be split. Both physiological and pathological splitting of the heart sounds is possible.

Physiological *reduplication* or *splitting of the first sound* is due to asynchronous closure of the atrioventricular valves, e.g. during very deep expiration, when the blood is ejected into the left atrium with a greater force to prevent the closure of the mitral valves; the valvular component of the left ventricle is therefore split and is perceived as a separate sound.

Pathological reduplication of the first sound can occur in impaired intraventricular conduction (through the His bundle) as a result of delayed systole of one of the ventricles.

The *second sound is reduplicated* more frequently than the first heart sound. Reduplication occurs due to asynchronous closure of the valve of the aorta and pulmonary trunk because of the different length of contractions of the left and the right ventricles. The length of the ventricular systole depends on the volume of the ejected blood and the pressure in that vessel (aorta or the pulmonary artery) into which the blood is expelled. When the amount of blood in the left ventricle decreases and the pressure in the aorta is low, systole of the left ventricle ends sooner and the aortic valve cusps will close earlier than the cusps of the valve of the pulmonary trunk. The second heart sound can therefore be duplicated in cases with diminished or increased filling of one of the ventricles or when pressure in the aorta or the pulmonary artery changes. Physiological reduplication of the second sound is mostly connected with various respiratory phases: the filling of

the right and left ventricles differs during inspiration and expiration and the length of their systole changes accordingly, as well as the time of closure of the valve of the aorta and pulmonary trunk. The amount of blood flowing to the left ventricle decreases during inspiration because part of blood is retained in the distended vessels of the lungs. The left-ventricular systolic blood volume decreases during inspiration, its systole ends earlier, and the aortic valve therefore closes earlier as well. At the same time, the stroke volume of the right ventricle increases, its systole prolongs, the pulmonary valve closure is delayed and the second sound is thus doubled.

Pathological reduplication of the second sound can be due to delayed closure of the aortic valve in persons suffering from essential hypertension, or if the closure of the pulmonary valve is delayed at increased pressure in the lesser circulation (e.g. in mitral stenosis or emphysema of the lungs), delayed contraction of one of the ventricles in patients with bundle-branch block.

True reduplication of the heart sounds should be differentiated from apparent doubling which is connected with the appearance of adventitious sounds. The *mitral valve opening sound* is an example. This sound is heard at the heart apex of patients with mitral stenosis. The sound is heard 0.07-0.13 s following the second sound, during diastole. In normal conditions, the cusps of the atrioventricular valves open noiselessly; they are freely forced back by the blood flow ejected from the atria to the ventricles. In mitral stenosis, the cusps of the sclerosed valve adhere to each other by their edges and cannot freely move to the walls of the ventricle. Therefore, blood thrusts against the valve as it passes from the atrium to generate sound vibrations that are responsible for the appearance of adventitious sounds. The mitral valve opening sound follows soon after the second heart sound to give it the character of reduplication. This sound is best heard at the heart apex rather than at the heart base; it is characterized by stability and is combined with other auscultative signs of mitral stenosis. The mitral valve opening sound is heard together with a loud (snapping) first sound characteristic of mitral stenosis, and the second sound, to form a specific triple rhythm - *"rhythm of quail"*.

An *extrapericardial sound* can occur in pericardial adhesion. It originates during diastole, 0.08-0.14s after the second sound, and is generated by the vibrating pericardium during the rapid dilatation of the ventricles at the beginning of diastole. The extra sound in adhesions in the pericardium can also arise during systole, between the first and the second heart sounds. This short and loud sound is also known as the systolic click. Changes in heart sounds in heart diseases can be due to intensified physiological third or fourth sound. In normal subjects these sounds are better revealed in graphic recording (phonocardiography). But if the ventricular myocardium is much weakened, these sounds can be revealed by auscultation. Intensification of one of these sounds gives a three-sound rhythm, known as *the gallop rhythm* (because it resembles the galloping of a horse). The sounds of the gallop rhythm are usually soft and low, always attended by a thrust, for which reason they are best heard on direct auscultation; the gallop rhythm can also be heard in auscultation with a phonendoscope, but the patient should lie on the left side after a mild exercise.

Protodiastolic (at the beginning of diastole), mesodiastolic (in the middle of diastole), and presystolic (at the end of diastole) gallop rhythms are distinguished by the time of appearance of the extra sound in diastole. Gallop rhythm is also classified as ventricular or atrial, according to its origin.

Protodiastolic gallop rhythm arises in considerably diminished tone of the ventricular myocardium. The ventricles distend quickly during their filling with blood at the beginning of diastole and the vibrations thus generated are audible as an extra sound. The sound appears 0.12 - 0.2 s after the second heart sound and is an increased physiological third sound.

Presystolic gallop rhythm arises in intensification of the physiological fourth sound, which is due to the diminished tone of the ventricular myocardium and a stronger atrial contraction. Intensified contraction of the overfilled atrium increases blood ejection into the ventricle, while a diminished tone of the ventricular myocardium causes quicker distention of its walls. The presystolic gallop rhythm is better detected in delayed atrioventricular conduction, when atrial systole is separated from the ventricular systole by a longer than normal period.

Both the third and the fourth heart sounds can intensify significantly in grave myocardial affection, but in tachycardia they sum up to give a *mesodiastolic or summation gallop rhythm.* Gallop rhythm is an important sign of myocardial weakness, and it has a great diagnostic and

prognostic value. It develops in severe heart affections in patients with myocardial infarction, essential hypertension, myocarditis, chronic nephritis, decompensated heart diseases.

A. pronounced acceleration of the cardiac rhythm makes the diastolic pause shorter so that it becomes almost as short as the systolic one. If the heart sounds heard at the cardiac apex are similar in intensity, a peculiar auscultative picture resembles the tic-tac or fetal rhythm, known also as *embryocardial* or *pendulum rhythm.* It occurs in severe cardiac failure, attacks of paroxysmal tachycardia, high fever, etc.

Cardiac murmurs

Physical and hemodynamic bases of originating of cardiac murmurs In addition to the normal heart sounds, abnormal sounds known as murmurs may be heard. Cardiac murmurs may be both endo- and exocardiac.

Endocardiac murmurs occur most frequently. These may occur in anatomical changes of the structure of the heart (organic murmurs) or in dysfunction of the intact valves (functional murmurs). Functional murmurs may be heard with increased rate of blood flow or decreased blood viscosity. The mechanism of endocardiac murmurs can be easier understood if one remembers the laws of physics concerning the flow of liquids in tubes. If a tube has a point where its otherwise even lumen is narrowed, the passing liquid produces noise. This noise is associated with turbulent flow of liquid above the narrowed portion of the tube, which causes vibration of the tube. The intensity of noise depends on two factors, viz., the liquid velocity and the extent of narrowing.

The higher the velocity of the liquid, the more intense is the noise; when the liquid velocity decreases, the noise lessens or disappears. As to the extent of tube narrowing, its influence on noise intensity is directly proportional only within a certain range. If the lumen is narrowed to a very high degree, noise may weaken or even disappear. Liquid is also set in vortex movement when it passes a narrow portion of the tube and enters its wider part again. The same reasons account for the murmurs that arise in the heart. If the passage is narrowed or on the contrary widened, blood is set in turbulent flow which generates murmurs. If the vascular lumen remains unchanged, murmurs may be produced by the changes in the blood flow rate, as is the case with thyrotoxicosis, fever, or nervous excitation. Decreased blood viscosity (e.g. in anemia) increases the flow rate of blood and can also be the cause of murmurs. The most frequent cause of endocardiac murmur is various heart defects.

According to the time of appearance, murmurs are classified as systolic and diastolic (Table 6). Systolic murmur occurs in cases when, during systole, blood moves from one chamber of the heart to another or from the heart to the main vessels and meets an obstacle. Systolic murmur is heard in the stenotic orifice of the aorta or the pulmonary trunk because blood ejected from the ventricles meets a narrowed vessel (ejection murmur). Systolic murmur is also heard in cases with mitral and tricuspid incompetence (regurgitation murmur). Generation of systolic murmur is explained by regurgitation of blood which is not completely expelled into the aorta and pulmonary trunk during the ventricular systole, but is partly returned to the atrium through an incompletely closed mitral or tricuspid orifice. Since this partly closed orifice is actually a narrow slit, murmur is generated as blood passes through it.

Diastolic murmur occurs if blood meets a narrowed passage during diastole (ejection murmur). This murmur is heard in a stenosed left or right atrioventricular orifice, since blood meets a narrow passage in its flow from the atria into the ventricles. Diastolic murmur also occurs in aortic or pulmonary valve incompetence. Murmur is generated when blood flows back from the vessels into the ventricles through a slit formed by incomplete closure of the cusps of the affected valve (regurgitation murmur).

Classification of cardiac murmurs

Criterion of classification	Classification groups
Cause	Endocardiac and exocardiac murmurs (pleuropericardial/ cardiopulmonary and pericardial friction murmurs)
Changes of the structure of the heart	Organic and functional murmurs

Time of appearance	- Systolic murmurs - Diastolic murmurs (protodiastolic mesodiastolic, presystolic murmurs)
Relation to course of blood flow	Ejection and regurgitation (regurgitant) murmurs
Amplitude of the murmur	High and low amplitude murmurs
Oscillation frequency of the murmur noise	High-pitched and low-pitched murmurs
Character of the murmur noise	Faint (weak), soft, blowing, coarse, rough, grating or grazing sounds; musical murmurs
Changes of the intensity of the noise with the phase of the heart activity.	Decrescendo (decreasing), crescendo (increasing, growing), and crescendo decrescendo (diamond-shaped) murmurs

Properties of murmurs

The following characteristics of murmurs should be determined during auscultation:
(1) the relation of the murmur to the phase of the heart activity (to systole or diastole);
(2) the features, character, strength, and length of murmur;
(3) localization of the murmur, i.e. the area where this murmur is heard best;
(4) direction of transmission (radiation).

The relation of murmurs to systole or diastole is determined by the same signs that are used to differentiate between the first and the second heart sounds. Systolic murmur appears with the first heart sound, during a short pause of the heart; it is synchronous with the apex beat and the carotid pulse. Diastolic murmur follows the second sound, during the long pause of the heart. Three types of diastolic murmurs are distinguished:

1) protodiastolic murmur which arises at the very beginning of diastole, immediately after the second heart sound;

(2) mesodiastolic murmur which is heard soon after the second heart sound;

(3) presystolic murmur which appears at the end of diastole.

Murmurs may be pansystolic and pandiastolic murmurs which arise at the very beginning of systole (or diastole) and longs to the end of systole (or diastole).

Character of murmur. By their character, murmurs may be soft, blowing, or on the contrary rough, grating or grazing sounds; musical murmurs can also be heard. By duration, heart murmurs are classified as short and long, and by their intensity as soft and loud.

The intensity of the noise may change with the phase of the heart activity. Murmurs may become weaker (decrescendo) or louder (crescendo), and crescendo-decrescendo (diamond-shaped). Decrescendo murmurs occur more frequently. This can be explained as follows: as blood begins flowing from one heart chamber to another or from the heart to the main vessel, the difference in pressures in two chambers is high and the blood flow rate is therefore high as well. But as the blood is expelled, the pressure inside the chamber from which the blood is ejected gradually decreases, the blood flow rate slows down, and the noise intensity decreases. Presystolic murmur has an increasing character and occurs mostly in stenosis of the anterior left atrioventricular orifice, at the very end of ventricular diastole, when atrial systole begins to increase the blood outflow from the left atrium to the left ventricle. Systolic crescendo-decrescendo (diamond-shaped) murmur presents in aortic stenosis.

Location of the murmur corresponds to the best listening post of that particular valve where this murmur is generated. In certain cases, however, murmurs are better heard at a distance from the point where they are generated, provided their transmission is good. Murmurs are well transmitted in the direction of the blood flow. They are better heard in areas where the heart is close to the chest wall and where it is not covered by the lungs. Systolic murmur due to mitral valve incompetence is best heard at the heart apex. It can be transmitted by the firm muscle of the left ventricle to the

axillary area or by the course of the backward blood flow from the left ventricle to the left atrium, i.e. into the second and third interspace, to the left of the sternum.

Diastolic murmur generated in a narrowed left atrioventricular orifice is usually heard over a limited area at the heart apex. Systolic murmur due to stenosed aortic orifice is heard in the second interspace, to the right of the sternum. As a rule, it is well transmitted by the course of the blood flow onto the carotid arteries. Since this heart defect is characterized by a rough and loud sound, it can be determined in auscultation over the entire heart region and be transmitted to the interscapular space. Diastolic murmur due to aortic valve incompetence is better heard not over the aortic valve but rather at the Botkin-Erb point, where it is transmitted by the back flow of blood from the aorta to the left ventricle. Systolic murmur associated with tricuspid insufficiency is best heard at the base of the xiphoid process, since the right ventricle is the closest to the chest wall at this point, from which the sound can be transmitted upwards and to the right, in the direction of the right atrium. In the rare heart disease associated with stenosis of the right atrioventricular orifice, the diastolic murmur is heard over a limited area at the base of the xiphoid process.

It should be remembered that murmurs are best heard in certain postures of the patient. Systolic murmurs associated with incompetence of atrioventricular valves or with stenosis of the aortic or pulmonic orifice, are best heard with the patient in the recumbent posture because the blood flow from the ventricles is facilitated and the blood-flow rate increases. Diastolic murmurs arising due to stenosis of the atrioventricular orifice or incompetence of the aortic valve and the valve of pulmonary trunk are better heard in the upright position, since the blood flow to the ventricles from the atria or from the vessels (in insufficiency of the corresponding valves) is thus facilitated and the blood-flow rate increases.

Differentiation of murmurs

If several murmurs are heard simultaneously over different valves, it is necessary to determine the affected valves and the character of their affections. Systolic and diastolic murmurs over one valve indicate its composite affection, i.e. incompetence of the valve and stenosis of the orifice. If systolic murmur is heard over one valve and diastolic murmur over the other, a combined affection of two valves can be diagnosed. It is more difficult to decide whether one or two valves are affected if murmurs can be heard at various listening points during one and the same phase of heart activity. The character of the murmur should then be analyzed. If a soft and blowing murmur is heard over one valve and rough and grating over the other, the murmurs are generated by two different affected valves. By moving the stethoscope bell along the line connecting the two valves, the changes in the murmur intensity should be followed. If at some point of the line the murmur disappears or weakens markedly, and then again becomes louder, it will in most cases indicate affection of two valves. If the murmur decreases or increases as the stethoscope bell moves in the direction of the second valve, it usually indicates affection of only one valve. But this is not an indisputable sign because the degree of valve affection may differ too, and an independent, though less loud, murmur will then be heard over milder stenotic affection. The character of murmur transmission helps differentiation. For example, systolic murmur occurring in mitral valve incompetence is transmitted into the axillary region. It may be heard also over the aortic valve but it will not be transmitted onto the carotid arteries (as distinct from systolic murmur associated with stenosis of the aortic orifice). During auscultation of the heart, it is necessary to differentiate between functional and organic, and between endocardial and exocardial murmurs.

The following properties of functional murmurs help differentiate them from organic murmurs:
(1) in most cases of functional murmurs are systolic;
(2) functional murmurs are not permanent and may arise and disappear when the person changes his posture, after exercise and during various respiratory phases;
(3) they are mostly heard over the pulmonary trunk and less frequently over the heart apex;
(4) functional murmurs are transient and are rarely heard during the entire systole; these are soft and blowing sounds;
(5) the murmurs are normally heard over a limited area and are not transmitted to long distances from their source;

(6) functional murmurs are not accompanied by other signs of valve affections (e.g. enlargement of the heart chambers or changes in the heart sounds).

Systolic apex murmur

Systolic murmur can be heard at the point of apex beat, which is the main sign of mitral incompetence. It arises during systole when the stream of blood passes a narrow slit leading from the left ventricle to the left atrium. The systolic murmur is synchronous with the first sound. It can be transmitted by the firm muscle of the left ventricle to the axillary area or by the course of the backward blood flow from the left ventricle to the left atrium, i.e. into the second and third interspace, to the left of the sternum. Auscultation findings are confirmed and verified by phonocardiography. The amplitude of the first sound is decreased on a PCG taken at the heart apex; systolic murmur occupies the entire pause between the first and second heart sounds.

Diastolic apex murmur

Diastolic murmur is characteristic of mitral stenosis because the passage from the left atrium to the ventricle during diastole is narrowed. This murmur can be heard to follow the mitral valve opening sound (protodiastolic murmur) because the velocity of the blood flow in early diastole is higher due to the pressure difference in the atrium and the ventricle. The murmur disappears when the pressures equalize. If stenosis is not pronounced, the murmur can be heard only at the end of diastole, immediately before systole proper (presystolic murmur); it arises during acceleration of the blood flow at the end of ventricular diastole because of the early atria systole. Diastolic murmur can be heard in mitral stenosis during the entire diastole. It increases before systole and joins the first snapping sound. Murmurs of functional etiology can also be heard in aortic incompetence at the heart apex. If the left ventricle is markedly dilated, relative mitral incompetence develops and systolic murmur can be heard at the heart apex. Diastolic murmur (presystolic, or Austin Flint, murmur) can sometimes be heard. It arises due to an intense regurgitation of the blood that moves aside the mitral valve cusp to account for functional mitral stenosis. Systolic murmur at the second intercostal space by the right edge of a sternum.

Rough systolic murmur over the aorta is characteristic of aorta stenosis. This murmur is generated by the blood flow through the narrowed orifice. It is conducted by the blood onto the carotids and can sometimes be heard in the interscapular space. The phonocardiogram shows the specific changes in the heart sounds: diminished amplitudes of the first sound at the heart apex and of the second sound over the aorta. Systolic murmur over the aorta is typical; its oscillations are recorded in the form of specific diamondshaped figures.

Diastolic murmur at the second intercostal space by the right edge of a sternum.

Diastolic murmur heard over the aorta and at the Botkin-Erb listening point is characteristic of aortic incompetence. This is a low blowing protodiastolic murmur which weakens by the end of diastole as the blood pressure in the aorta drops and the blood-flow rate decreases. The described changes in the sounds and murmurs are clearly visible on PCG in aortic incompetence. The amplitude of the heart sounds and diastolic murmur are decreased on the PCG taken over the aorta. Systolic murmur at the second intercostal space by the left edge of a breast bone is characteristic of pulmonary artery valves stenosis. The mechanism formation of this murmur is similar to systolic murmur in aortic stenosis.

Diastolic murmur at the second intercostal space by the right edge by the breast bone is characteristic of pulmonary artery valves incompetence. The mechanism formation of this murmur is similar to diastolic murmur in aortic incompetence.

Systolic murmur above the xiphoid process can be heard in tricuspid valve incompetence at the same listening point and also at the 3rd and 4th interspaces, to the right of the sternum; this murmur increases when the patient keeps his breath at the height of inspiration. Diastolic murmur above the xiphoid process is characteristic of tricuspid stenosis. The mechanism formation of this murmur is similar to diastolic murmur in mitral stenosis.

Extracardial murmurs

Although synchronous with the heart work, they arise outside the heart. These are pericardial and pleuropericardial friction sounds.

   Pericardial friction murmurs are connected with the changes in the visceral and parietal pericardial layers in which fibrin is deposited (in pericarditis), cancer nodes develop, etc. The mechanism by which pericardial friction sounds are generated is similar to that of the pleural friction sounds, except that they depend not on- the respiratory movements but on the movements of the heart during systole and diastole. Pericardial friction murmurs vary. Sometimes they resemble pleural friction or the crisping sounds of snow, and sometimes they are very soft, as if produced by rattling of paper or scratching.

        The following signs can be used for differentiation between pericardial friction sounds and intracardiac sounds:

(1) there is no complete synchronism of pericardial friction sounds with systole and diastole; friction sounds are often continuous, their intensity increasing during systole or diastole;

(2) friction sounds can be heard for short periods during various phases of the heart work, either during systole or during diastole;

(3) pericardial friction sounds are not permanent and can reappear at intervals;

(4) friction sounds are heard at sites other than the best auscultative points; they are best heard in the areas of absolute cardiac dullness, at the heart base, at the left edge of the sternum in the 3rd and 4th intercostal spaces; their localization is inconstant and migrates even during the course of ne day;

(5) friction sounds are very poorly transmitted from the site of their generation;

(6) the sounds are heard nearer the examiner's ear than endocardial murmurs;

(7) friction sounds are intensified if the stethoscope is pressed tighter to the chest and when the patient leans forward, because the pericardium layers come in closer contact with one another.

        Pleuropericardial friction murmurs arise in inflammation of the pleura adjacent to the heart and are the result of friction of the pleural layers (synchronous with the heart work). As distinct from pericardial friction sounds, pleuropericardial friction is always heard at the left side of relative cardiac dullness. It usually combines with pleural friction sound and changes its intensity during the respiratory phases: the sound increases during deep inspiration when the lung edge comes in a closer contact with the heart and decreases markedly during expiration, when the lung edge collapses.

Peripheral edema

General edema becomes noticeable in the body delay at least 2 liters of liquid.

Hidden edema is detected by daily body weight measurement and volume drunk and dedicated native. A careful examination of the patient is conducted.

In the study of edema, determine their presence, localization, consistency, degree severity, symmetry, skin color over them and density, and also accompanying diseases.

In the study of edema on the face, a review with an emphasis on the region is carried out the periorbital zone, the patient is asked to open and close his eyes. Estimate the presence of edema on the upper limbs, especially distal sites, placing a thumb to the inner . Part of the forearm and pressing 3 fingers to the bone base. Further in the patient's position lying on the back by examination and palpation is conducted to study the edema of the lower limbs. Big fingers with both hands soft tissues are pressed to the bone in symmetrical sites from bottom to top in the following order: rear stop, internal ankles, lower,

Average and upper third of the shin - on the anterior surface of the tibia by pressing, when pressed for at least 20 seconds and subsequent conduct in this the area with a finger to detect the fossa.

For patients, who have long been in a horizontal position, assessment of edema on the back of the legs and in the area of sacrum.

In generalized edema in the type of anasarca is determined an enlarged stomach at ascites.

PITTING

EDEMA   NORMAL

PITTING EDEMA

- INDENTATION in the AFFECTED AREAS

- EXCESS FLUID MAINLY COMPOSED of WATER

NON-PITTING EDEMA

- ASSOCIATED with CONDITIONS AFFECTING the THYROID or LYMPHATIC SYSTEM

- BUILD UP COMPOSED of PROTEINS, SALTS, & WATER

GRADING SCALE

GRADE +1
UP to 2mm of DEPRESSION, REBOUNDING IMMEDIATELY

GRADE +2
3-4mm of DEPRESSION, REBOUNDING in 15sec or LESS

GRADE +3
5-6mm of DEPRESSION, REBOUNDING in 60sec

GRADE +4
8mm of DEPRESSION, REBOUNDING in 2-3min

COMMON RISK FACTORS

MEDICATIONS

OBESITY

LOW PROTEIN LEVELS

SITTING/STANDING in SAME POSITION TOO LONG

PREGNANCY

TREATMENT
IMPORTANT to DIAGNOSE and TREAT UNDERLYING CAUSE

MILD CASES
- RESOLVE ON ITS OWN
- FACILITATED by ELEVATING AFFECTED LIMB

SEVERE CASES
- DIURETIC PRESCRIBED to HELP ELIMINATE EXCESS FLUID THROUGH URINE

CHRONIC CASES
- COMPRESSION SOCKS to PROMOTE CIRCULATION

METHODS OF REGISTRATION AND SKILLS OF ECG INTERPRETATION

ECG recording technique

To properly remove the ECG before that it is not recommended to eat or drink coffee or smoking, exercising.

The patient lies down on a couch, and electrodes are placed on his skin. Electrodes set so as to register the potentials from two points with different names charges. The skin under the electrodes is degreased before recording the ECG alcohol solution. Wet wipes are applied to the forearms of both hands and the left leg (pre-soaked in 9% NaCl solution) or treated with a special spray.

Floor napkins are superimposed electrodes, from which the wires go to the electrocardiograph. The wires have different colors: the electrode on the right hand is red, on the left - yellow, on the left leg is green, the electrode approaches the right leg, from which the black wire departs: this onethe electrode performs the function of grounding.

There are 12 classic leads:
1) standard (I, II, III);
2) enhanced leads from the extremities (aVR, aVL, aVF);
3) 6 chest leads.

I standard assignment - the charge between the forearms of the right and left hands is registered.
II standard assignment - the charge between the forearm of the right hand and the left leg is registered.
III standard lead - the potential between the left arm and the left leg is registered

Reinforced unipolar leads have the following designations:
1) AVR - from the right hand;
2) AVL - from the left hand;
3) AVF - from the left leg.

These leads are characterized by the presence of only one active electrode, and the second the electrode is inactive, it connects the electrodes from other limbs.

Chest leads are also unipolar. Chest leads are denoted in Latin letter V:
1) V1-active electrode is located in the IV intercostal space near the right edge of the sternum;
2) V2-active electrode is located in the IV intercostal space near the left edge of the sternum;
3) V3-active electrode is located between the IV and V intercostal spaces along the left thoracic line;
4) V4-active electrode is located in the V intercostal space along the left mid-clavicular line;
5) V5-active electrode is located in the V intercostal space along the anterior axillary line;
6) V6-active electrode is located in the V intercostal space along the middle axillary line.

Teeth in the ECG are denoted by Latin letters: P, Q, R, S, T, U, where each of them reflects the condition of different parts of the heart:
• P - atrial depolarization;
• QRS complex - ventricular depolarization;
• T - repolarization of the ventricles;
• underexposed U may indicate repolarization of the distal parts of the conductor ventricular systems.

RR interval (distance between R-waves)

PP interval (distance between P-waves)

PR segment

P-wave duration

ST-T segment

TP interval

ST segment

PR interval
0,12 - 0,22 s

J-60 point: measurement of ST-segment depression in exercise stress testing.

QRS duration
<0,12 s

J point: measurement of ST-segment elevation and ST segment depression in most instances.

QT duration
Corrected QT duration men: ≤ 0,45 s
Corrected QT duration women: ≤ 0,47 s

The reference level for measuring ST-segment deviation (depression or elevation) is not the TP interval. The correct reference level is the **PR segment**. This level is also called **baseline** level or **isoelectric level**.

General scheme of ECG decoding

- Analysis of heart rate and conduction:
   assessment of the regularity of heart contractions;
   heart rate calculation;
  determining the source of excitation;
  assessment of the conduction system of the heart.
- Determination of heart rotation around the anteroposterior, longitudinal and transverse axes:
  determining the position of the electrical axis of the heart in the frontal plane;

determining the rotation of the heart around the longitudinal axis; determining the rotation of the heart around the transverse axis.
- Analysis of the atrial tooth R.
- Analysis of the ventricular QRS-T complex:
    QRS complex analysis;
    RS-T segment analysis;
    analysis of the T wave;
    Q-T interval analysis.
- Electrocardiographic conclusion.

Prong \ interval	Duration (sec)	Characteristics
P	<0.1 s	1. Always "+" in I, II, aVF, V2-V6 2. Always "-" in aVR 3. «±» in III, aVL, V1 4. Amplitude of 1.5-2.5 mm
The PQ interval	0.12 - 0.20 s	
QRS complex	0.06 – 0.10 s	
Q	<0.03 s	1. All standard leads + V4-V6 2. Amplitude: <¼ from the tooth R (except aVR) 3. In aVR in norm Q> 0,03 with (QS)
R	0.02 - 0.04 s	1. All leads except aVR 2. Amplitude ↑ V1 → V4 and ↓ V5 → V6
S	0.01 - 0.02 s	1. In all leads, the amplitude varies (<20 mm) 2. Amplitude ↓ V1 → V4; ↓↓ V5-V6 (or missing)
Segment ST	0.27 - 0.33 s	1. Located on the isoelectric line (± 0.5 mm) 2. Possible elevation: V1 -V3 (<2 mm) and V5 -V6 (<0.5 mm)
T	↑↓	1. Always "+" in I, II, aVF, V2 -6 (TI> TIII; TV6> TV1) 2. Always « - »in aVR 3. «±» in III, aVL, V1
QT interval	0.30 -0.46 s	1. The duration is inversely proportional

		Heart rate 2. Adjusted QT interval: $QTc = QT / \sqrt{RR}$ 3. QTc: ≤ 0.47 s

ECHOCARDIOGRAPHIC EXAMINATION

The purpose of ultrasound diagnosis is to assess the work of the heart. Echocardiography allows to estimate volume, size of the heart cavities and the thickness of its walls, detect morphological changes in the valves and other structures of the heart, pressure in the cavities of the heart and valves, the presence of cavity thrombi.

The most common modes:
- **M-modal mode (single-chamber ECHO)** allows you to get an idea of the movement various structures of the heart that are crossed by an ultrasound beam that does not change its own direction. The disadvantage of the M-modal mode is its one-dimensionality, but the image quality and the accuracy of measuring intracardiac structures is higher than when using others modes of echocardiographic examinations.
- **B-mode (two-chamber ECHO, or sector scan)** allows you to get on the screen is a planar two-dimensional image of the heart, which clearly shows the mutual location individual heart structures, as well as the movement of heart structures in real time.
- **Doppler study mode (Doppler echocardiography)** is usually used for qualitative and quantitative characteristics of intracardiac and intravascular blood flows.

In clinical practice, usually use all 3 modes during echocardiography research.

The study can be performed in any position of the patient in which it is achieved the clearest image of the studied structures. Most often the patient is in horizontal position on the back with a raised headboard or on the left side. For the best visualization of the vascular bundle from the suprasternal access under the patient's shoulders is subjected roller, and the head is thrown back. For better contact of the sensor with the patient's body use a special gel.

Echocardiographic examination is performed using the following standard approaches:
- Parasternal access - area III-V of the intercostal space to the left of the sternum;
- Apical (apical) access - the area of apical shock;
- Subcostal access - the area under the xiphoid process;
- Suprasternal access - jugular fossa.
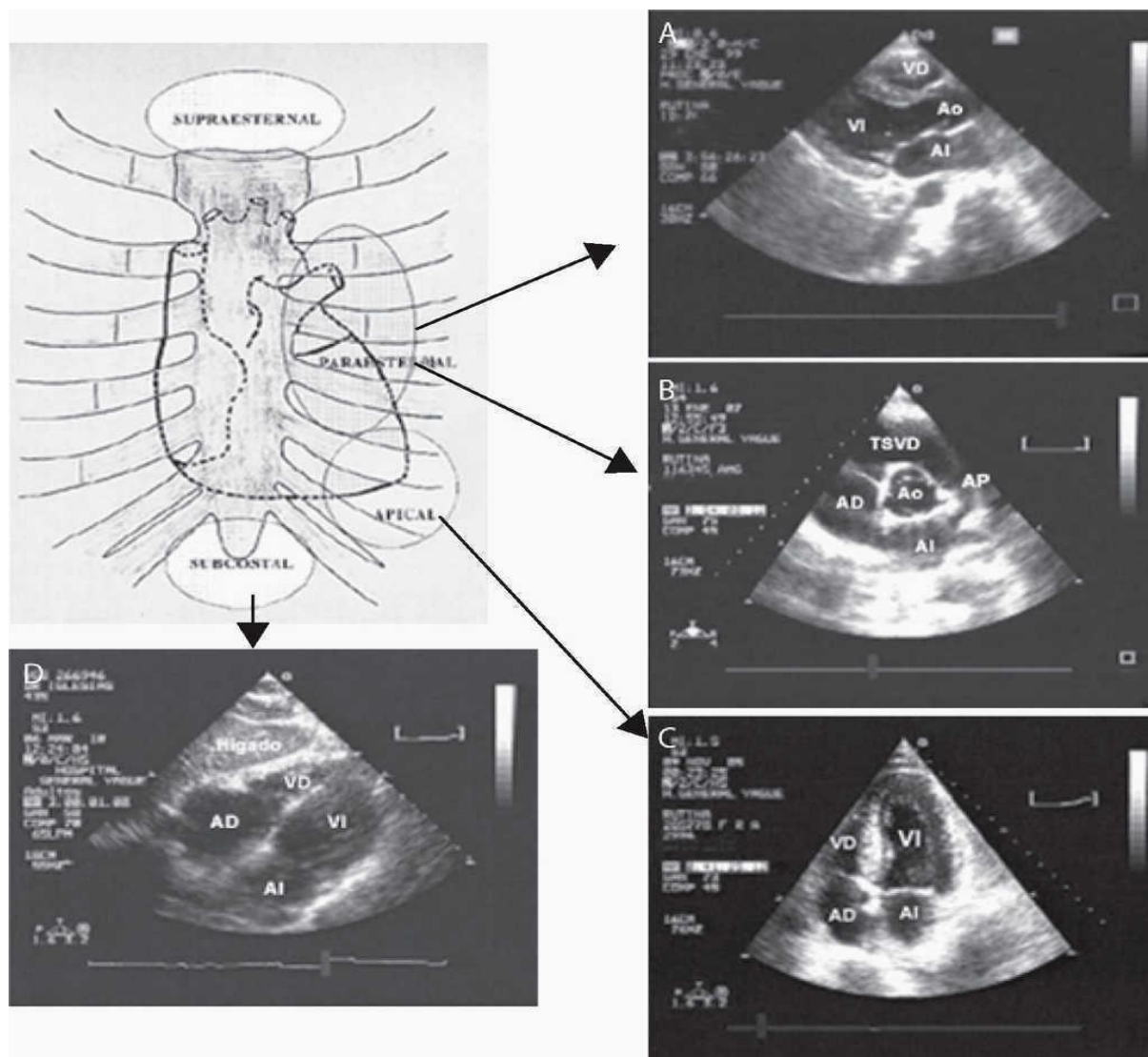
Scheme of ultrasound scanning from the left parasternal access along the long axis of the left ventricle

* RVOT - outflow tract of the right ventricle
* Septum - interventricular septum
* LV - left ventricle
* LVOT - external tract of the left ventricle
* MV - mitral valve
* AV - aortic valve
* LA - left atrium

PLAX

SAX

Apical 4CH

Subcostal
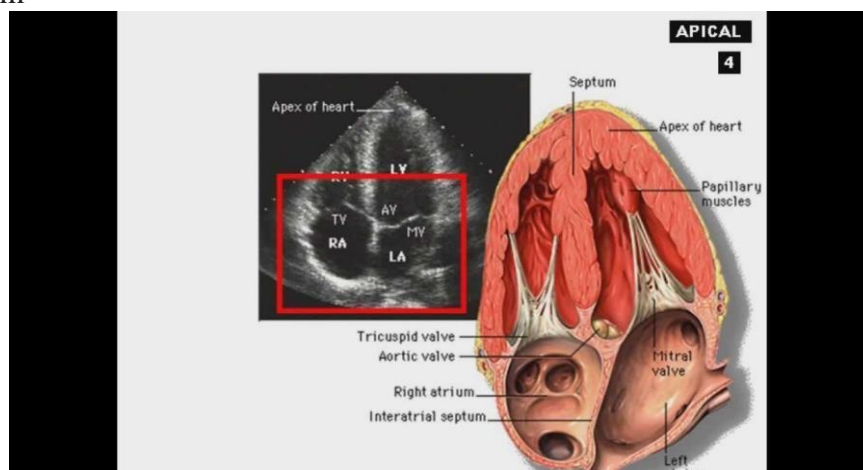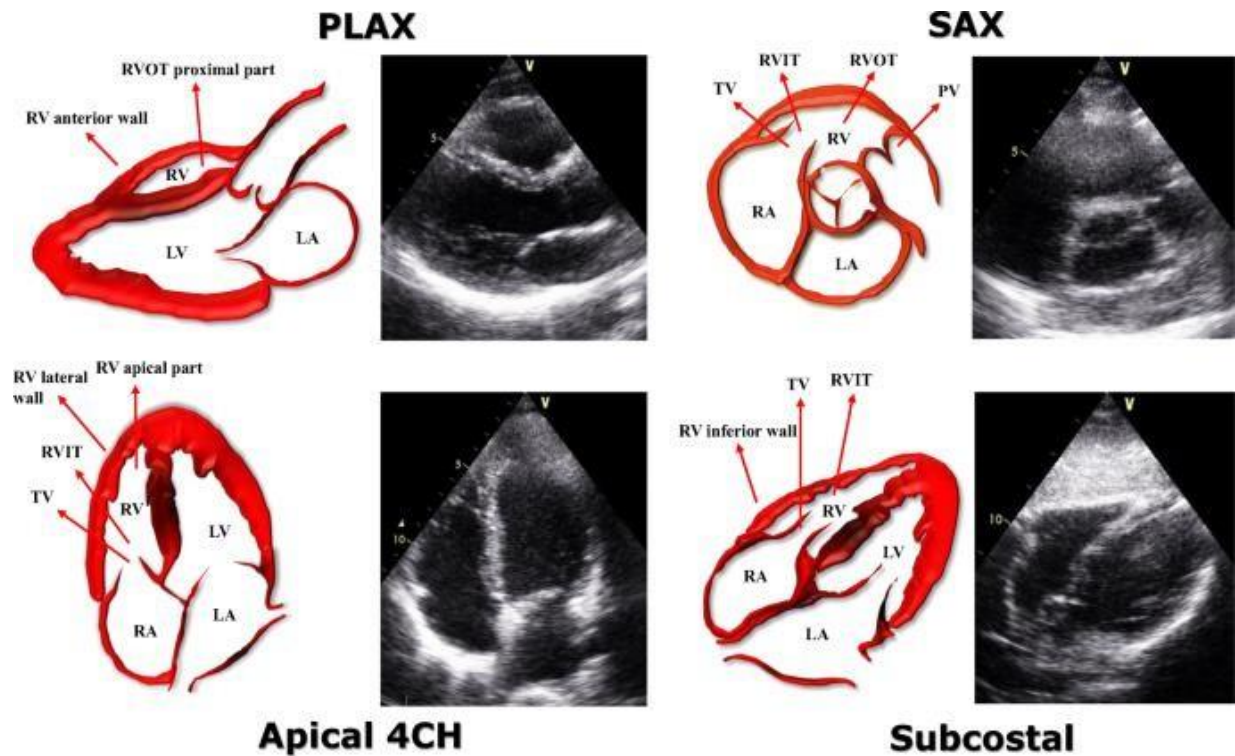
Left atrium	27-33 30-40	Peak P on mitral valve	≤ 4 mm Hg
Aortic diameter	20-38	Gradient on MV	
Aortic disclosure valve AV	15-26	Peak P on AV	≤ 8 mm Hg
Right ventricle, diameter, mm	20-35	Gradient on AV	
Pulmonary artery	up to 32	Gradient on PA	≤ 15 mm Hg
Ultimate diastolic LV size	39-53 , 42-59	Gradient on tricuspid valves	≤ 4 mm Hg
End systolic LV size	25-36	Final diastolic volume	56-104 , 67-155
Interventricular membrane in diastole	6-9 ,6-10	Final systolic volume	19-49 , 22-58
The posterior wall of the left ventricle diastole	6-9 , 6-10	Shock volume	60-100
Emission fraction (Teichholz)	≥ 55%	Minute volume	1 4.5 - 5.5

Emission fraction (Simpson)	≥ 55%		

The normal amount of fluid in the pericardium is 10-30 ml. An increase in fluid volume indicates pericarditis

Esophageal echocardiography is performed by inserting the sensor directly into the esophagus. With the help of esophageal echocardiography examine the mitral valve before surgery or after it to evaluate the results of the intervention. Also this species research is appointed at suspicion of existence of an abscess or a thrombus in the left auricle, aortic aneurysm, atrial septal pathology. The procedure is contraindicated in varicose veins of the esophagus, osteochondrosis, diaphragmatic hernia, relatively contraindicated in vomiting reflex.
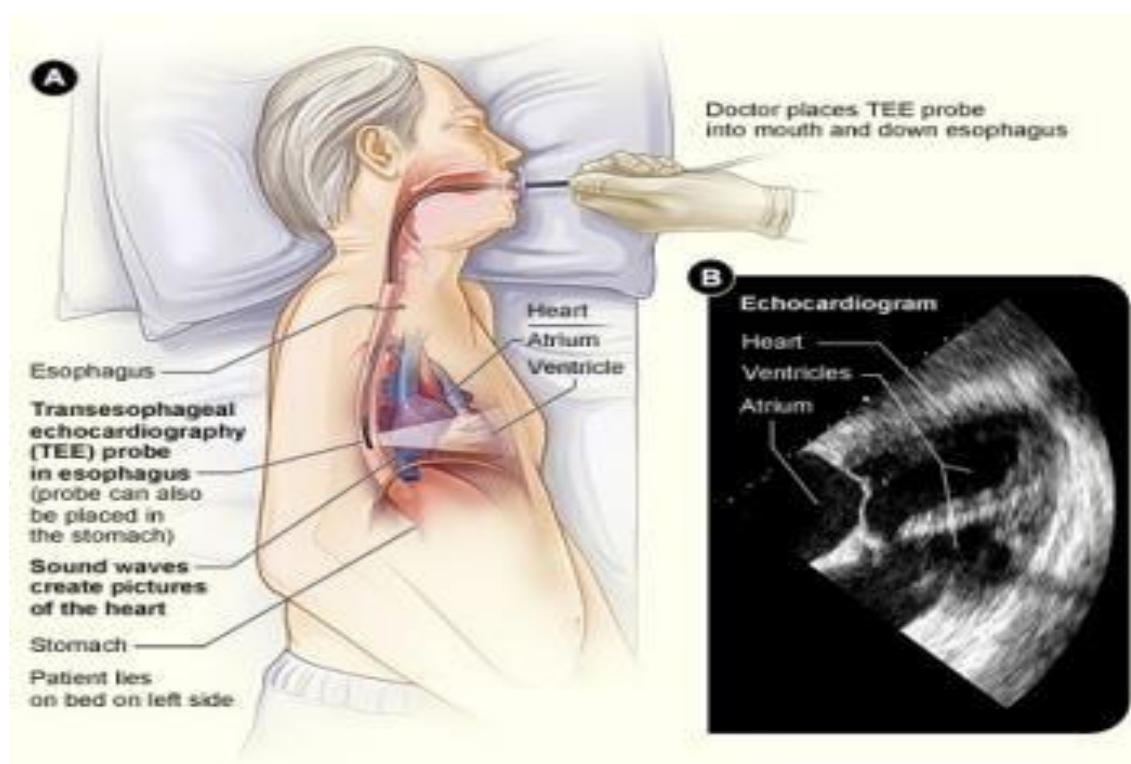
TYPES OF STRESS TESTS FOR PATIENTS WITH CARDIOVASCULAR PATHOLOGY. TECHNIQUE OF THEIR PERFORMANCE

Exercise tests are one of the most commonly used non-invasive cardiac tests used for a more complete diagnosis, determining the prognosis and functional assessment of the patient's cardiovascular system. Tests with exercise can be performed using a variety of protocols that differ in that some provide a gradual increase in load capacity, in other loads remain constant The purpose of tests with a continuous step - increasing load is to achieve maximum stress of the cardiovascular system.

During the test, the patient performs ascending load before the appearance of signs of load intolerance or reaching the limit values Heart rate, taking into account age and gender. These protocols have a number of benefits for both the patient (good tolerability) and the physician(ease of interpretation of testing).

Tests with constant power are usually performed with submaximal voltage and are used mainly for scientific purposes

The magnitude of the load is usually expressed in watts (W).

May be the maximum oxygen consumption in MET units (metabolic equivalent) is also indicated – in ml of oxygen used per 1 kg of body weight per minute During exercise, the ECG is recorded, blood pressure, ventilation parameters

There are physiological and pathological reactions to exercise. Pathological reaction, which has the greatest clinical and diagnostic value in ischemic heart disease, is the appearance angina and ECG changes in the form of a horizontal or oblique decrease in the ST segment by 1 mm or more. The pathological changes in blood pressure include its insufficient increase or decrease in load, indicating the development of severe left ventricular dysfunction, or excessive increase in blood pressure (with hypertension).

This study allows you to give an objective assessment of the condition of the coronary arteries of the heart patient and features of the cardiovascular response to exercise, which is impossible to receive at registration of the electrocardiogram at rest. Load test data allow the doctor to assess the patient's condition and then prescribe adequate treatment or necessary additional examination.

In cardiology, the most common of the functional tests are physical tests load (stair test, ergometer, treadmill).

Indications for exercise tests in cardiology

Diagnosis of coronary heart disease in patients without a "coronary history", especially in middle-aged people intermediate probability of coronary heart disease and with interpretable ECG

Recurrence of angina in patients with a history of coronary heart disease preceding myocardial revascularization have an interpretable ECG

Differential diagnosis of cardiac and pulmonary causes of shortness of breath in physical loads and / or reduced efficiency

Assessment of the prognosis in patients with:
- known coronary heart disease or suspicion of its presence;
- recent myocardial infarction;
- chronic heart failure

Assessment of the functional status of patients with:
- known coronary heart disease or suspicion of its presence;
- patients with symptoms during exercise (palpitations, dizziness, loss of consciousness);
- recent myocardial infarction;
- preliminary procedure of myocardial revascularization;
- pathology of the valvular apparatus of the heart;
- chronic heart failure;
- previous heart transplantation

When prescribing the expansion of physical activity and physical training to patients with:
- known coronary heart disease or suspicion of its presence;
- recent myocardial infarction;

- preliminary procedure of myocardial revascularization;
- pathology of the valvular apparatus of the heart;
- chronic heart failure;
- previous heart transplantation.

Evaluation of the effectiveness of treatment of patients with:
- known coronary heart disease or suspicion of its presence;
- recent myocardial infarction;
- previous direct myocardial revascularization;
- arrhythmias caused by exercise;
- chronic heart failure.

Evaluation of the response to heart rate load in patients with:
- frequency-adaptive pacemakers;
- arrhythmias caused by exercise or suspicion of their presence

Examination of healthy people:
- assessment of functional status;
- examination of asymptomatic men older than 40 years of special specialties (pilots, firefighters, police, drivers of public, freight, railway transport) or having 2 or more risk factors, or planning intense physical activity;
- examination;
- forecast assessment;
- recommendations for expanding physical activity and training.

Information on the frequency of complications

Despite the undeniable clinical value, stress tests with achievement maximum load have certain risks of adverse events. In general patient populations aimed at stress testing, cases of lethal outcome registered in <0.01% of patients, other pathological conditions - in <0.05% of patients.

When performing a stress test in the first 4 weeks after an acute heart attack myocardial death rate increases to 0.03%, and the risk of non-fatal myocardial infarction or the need for resuscitation reaches 0.09%. In patients with a stable course of compensated chronic heart failure additional (for patients without CHF) risk of testing with the maximum level no load.

There may be an absolute risk of severe complications during stress testing minimized with strict adherence to accepted patient selection criteria, careful history taking, detailed clinical examination, continuous monitoring 12-channel ECG, blood pressure and their recording during exercise and every minute (minimum - every 3 minutes)immediately after the test

Requirements for the conditions

Despite the small absolute number of serious complications in the process stress tests can be expected to occur from time to time due to a large number of studies.

In the room where the tests are performed, everything necessary for cardiopulmonary resuscitation should be available, including drugs for emergency care, defibrillator and intubation kit. The exercise test should be performed by a doctor who has special training, or specially trained nurses at providing the possibility of an emergency call to the doctor

An emergency telephone must always be available. To be needed emergency care was provided in a qualified and timely manner, with staff to be provided regular trainings on cardiopulmonary resuscitation.

Criteria for termination of the stress test

-Muscle weakness
-Severe shortness of breath, especially disproportionate to the intensity of the load
-Angina pectoris of moderate or severe intensity
-Horizontal or oblique depression of the ST segment> 3 mm in comparison with the initial ECG
-Rise of the ST segment> 1 mm from the isoline in leads without pathological tooth Q, except leads V1 and aVR

-Complex arrhythmias and conduction (AV-blockade of II and III degree, atrial fibrillation, paroxysmal supraventricular tachycardia and ventricular tachycardia)

-Load-induced complete blockade of the leg of the His bundle, especially if it is difficult differentiate from ventricular tachycardia

-Rise in systolic blood pressure over 240 mm Hg, diastolic - over 120 mmHg

-Reduction of systolic blood pressure> 10 mm Hg from the previous measurement, especially accompanied by other manifestations of myocardial ischemia

-Exacerbation of atypical pain in the chest

-Signs of peripheral hypoperfusion (pallor, cyanosis, cold sweat, etc.)

-Neurological signs / symptoms (incoordination, dizziness, sensation emptiness in the head, flashes of light before the eyes and others)

-Intermittent claudication

-Restrictions associated with pathology of the musculoskeletal system

-Technical impossibility of continuous ECG monitoring

-The patient's wishes

Contraindications to the test with exercise

Absolute	Relative
-The most acute period of myocardial infarction -Decompensation of CHF. -Unstable angina. -Acute myocarditis, pericarditis or endocarditis. -Acute pulmonary embolism or thrombosis deep veins. -Complex atrial or ventricular arrhythmias. -High degrees of sino-auricular or atrioventricular block -Severe aortic stenosis. -Severe systemic or pulmonary hypertension. -Simpressed aneurysmal dilation of the aorta Acute noncardiac disease. -Acute systemic disease -Acute thrombophlebitis -Acute cerebral circulatory disorders -Severe anemia. -Heavy limiting load of the musculoskeletal system	Moderate aortic stenosis. -Severe proximal stenosis left coronary artery. -Severe subaortic hypertrophic stenosis. AV-blockade of the II-III degree. -Electrolyte disturbances. -Mental disorders

The 6-minute walk test (6MWT) is a simple and effective assessment tool functional capabilities of the patient, especially in the presence of severe and moderate degrees severity of heart and lung pathology. The 6-minute walk test is another method diagnosis of heart failure, but is not used to confirm it, but for determination of functional class, assessment of tolerance to physical activity

The test allows you to assess the level of daily activity of patients, its performance is good correlate with quality of life indicators. They can be used as additional criteria evaluation of the effectiveness of treatment and rehabilitation of patients. The test is easy to perform, does not require complex equipment for both inpatient and outpatient settings.

The test should be performed in the morning. Before the test for 3 - 4 hours the patient receives light breakfast, does not take any cardiac drugs, does not smoke for at least 2 years before the test.

To conduct this study requires a corridor (at least 30 m long), countdown stopwatch, mechanical tape measure, pulse oximeter or sphygmomanometer. In the cardiology clinic also needs a defibrillator and an oxygen source.

The patient rests for 10 minutes sitting on a chair near the starting position. The doctor fixes pulse, blood pressure, preferably pulse oximetry. In the initial state the patient evaluates shortness of breath and fatigue on a 10-point Borg scale (no shortness of breath - 0 points, mild shortness of breath - 2 points, severe shortness of breath - 5 points, very severe shortness of breath - 10 points).

The doctor turns on the stopwatch, the patient gets to the beginning of the path, and as much as possible the pace moves for 6 minutes, with shortness of breath, fatigue and discomfort at any time the patient can sit on a chair and rest, the stopwatch thus does not stop. The patient does not is informed about the distance traveled and the time remaining. At all times the patient is under medical supervision. At the end of the test measure the distance traveled to the nearest 1 m (54 meters - minimal significant change in distance), the pulse tested re-evaluates shortness of breath and fatigue on the Borg scale, it is desirable to conduct pulse oximetry. When interpreting 6MWT data compare the relevant parameters before and after treatment (treatment, surgery, rehabilitation).The functional class of CH is determined.

Parameters of physical activity and oxygen consumption in patients with CHF:

Functional class (FC), NYHA	Distance traveled for 6 minutes	Consumption of O2 (VO2max), ml / (kg * min)
0	551 and more	More 22,1
IFC	426-550	18,1 – 22,0
IIF	301– 425	14,1 – 18,0
IIIF	151-300	10,1 – 14,0
IVFC	Less 150	Less 10

When assessing the effectiveness of treatment, the maximum significant improvement is an increase in distance at 70 m compared to the original result.

Criteria for termination of the sample:
 - chest pain,
 - intense shortness of breath,
 - leg cramps,
 - violation of stability,
 - dizziness,
 - sharp pallor,
 - reduction of blood oxygen saturation to 86%.

TREDMIL TEST

The treadmill, or treadmill, is the most modern and convenient to test with physical activity. Its advantages are that the intensity of the patient's effort when performing the test is regulated by the speed of the tape, the inclination of its plane and duration movement, while simulating the imitation of natural walking or running. Load test on a treadmill is performed to detect ECG signs of myocardial ischemia. In conducting this studythe physical endurance of the patient (tolerance to physical activity) is defined. The treadmill test is used for cardialgia to monitor the condition of patients after a heart attack myocardium or operations on the vessels of the heart (stenting, shunting), evaluation of effectiveness treatment. With this study, you can assess the relationship of heart rhythm disorders with physical activity, as well as the reaction to such blood pressure

All these data help in the diagnosis and treatment of coronary heart disease (especially stress angina and postinfarction cardiosclerosis).

The test is recommended once a year for men older than 45 years, women older 50 years regardless of the presence or absence of complaints. This examination is prescribed for the purpose professional expertise, for example, pilots or railway workers

Treadmill test - a safe examination, with careful selection of patients and compliance precautions the frequency of serious complications is 1-2 per 10,000. The essence of the test is to make the subject's heart accelerate to a certain level frequency of contractions and evaluate its

response to exercise and blood supply (determined by ECG or complaints). The ultimate goal of the study is to achieve a sub-maximum frequency heart rate, which is calculated by the formula: 220 - age (years) * 0.75 or, for greater reliability of the result, by 0.85).

According to the doctor's prescription, the following drugs are canceled:
• beta-blockers, cardiac glycosides and diuretics are discontinued 2-3 days before research;
• prolonged nitrates and sedatives (sedatives) are canceled 1 day before research.

When an angina attack, you can use nitroglycerin, nitrospray.
About this should alert the treadmill doctor.
For the test, it is desirable to have light sports pants and a towel.

Indications for research
• Diagnosis of coronary heart disease.
• Determining the severity of angina (functional class), assessing its effectiveness treatment.
• Assessment of prognosis in cardiac patients.
• Choice of training load for rehabilitation of cardiac patients.
• Determining the response of the cardiovascular system to stress, physical endurance patient

Contraindication:
Absolute contraindications (research cannot be conducted):
1. The first 2 weeks after myocardial infarction.
2. Unstable angina.
3. Some arrhythmias, including heart rate greater than 100 per minute.
4. Severe circulatory failure (CH IIB - III art.).
5. Acute endocarditis, myocarditis, pericarditis.
6. Pulmonary artery thromboembolism, thrombosis in the ventricles of the heart, severe respiratory failure.
7. Severe aortic stenosis.
8. Acute or severe diseases of other organs, including those accompanied by fever
9. Aortic aneurysm.
10. Suffered a stroke in the last 6 months.
Relative contraindications (the study may be canceled or postponed by a doctor):
1. Rhythm disorders (frequent extrasystole, paroxysmal atrial fibrillation or other paroxysmal arrhythmias).
2. Hypertension with systolic blood pressure above 170 mm Hg., diastolic blood pressure - above 130 mm Hg.; pulmonary hypertension.
3. Concomitant diseases of other organs of moderate severity.
4. Moderate heart defects.
5. Postinfarction left ventricular aneurysm.
6. Cardiomegaly
The test begins with a load in the form of a normal slow walk. Then every 3 minutes (degrees) of the load is complicated by changing the speed of the track and the angle of inclination(imitation of walking up).
After exercise, the ECG and blood pressure are monitored for at least 3 minutes.
The doctor usually prepares the result of the examination within 10 - 20 minutes after its completion

The criteria for termination of the test are such complaints as:
• dizziness,
• headache
• a sharp increase in shortness of breath,
• chest pain
• the appearance of weakness,
• leg fatigue and general fatigue.

Of the main objective criteria should be noted:
The appearance of ischemic changes on the ECG
• Emergence of new arrhythmias and heart block
• Achieving a certain heart rate, which is determined individually for each patient.

• Decreased blood pressure or heart rate with increasing load.

• Excessive, more than 240/120 mm Hg. increase in blood pressure

Interpretation of the treadmill test

The test is negative - no coronary heart disease.

The test is positive - means that problems with blood supply to the heart due to atherosclerosis of the coronary arteries.

Patients with positive test combined with poor exercise tolerance is almost always shown coronary angiography .

The test is positive, clinically - the postscript "clinically" means that the objective reasons cardiac ischemia was not detected, but the patient's complaints indirectly indicate this. Most often in this group patients also have atherosclerosis of the coronary arteries, however, erroneous cannot be ruled out test result

The test is questionable - there is little data in favor of reliable ischemia, but the prerequisites for it appeared, or there were any nonspecific pains in a thorax which cannot be unambiguously estimated as angina. This result greatly complicates the work of the doctor, as to determine the tactics management of such a patient is difficult. Figuratively, this test result can be called "50 to 50"

The test is incomplete or uninformative - if the patient refuses to continue increase in load (for various reasons) and when the required heart rate is reached interpretation of the test is complicated.

Bicycle ergometry (VEM)

Many researchers prefer a bicycle ergometer - a device that allows you to conduct research both in a vertical position, and in a lying position. In practice, most often use the technique of bicycle ergometry with the subject in vertical position. Conducting a physical test carried out an experienced doctor-functionalist and a nurse. In the process of performing a load test, visual ECG monitoring is mandatory for timely registration of ischemic changes and arrhythmias, measurement of heart rate and blood pressure.

The best time to study is in the morning, on an empty stomach or 2 hours later eating. The test should be performed in a well-ventilated room at a temperature air 18-22 C. The patient's clothing should be loose and comfortable for exercise. On the day of the test, the patient should not smoke or take drugs. Before the diagnostic breakdown cancel antianginal drugs (nitrates for 24 hours, calcium antagonists and β-blockers 48 hours before the study). To change the ST segment at rest and during exercise may affect cardiac glycosides (it is desirable to cancel them 7 days before the test), saluretics, tricyclic antidepressants, lithium salts. The latest drugs if possible cancel 3-4 days before the test. Antianginal drugs are not canceled when determining themeffects on exercise tolerance in patients with angina During the study, the patient may have some signs of the disease, in particular, an attack of chest pain, arrhythmias, and some latent manifestations of the disease that are notare felt at daily motor activity, however demand special treatment. If any signs of poor exercise tolerance appear, the patient should report this is the doctor who oversees the test. Complications were revealed during bicycle ergometry allow the doctor to prescribe treatment for their prevention in the future .The patient can stop the load at any time, but be aware that it is the test before the appearance of objective signs of stress intolerance, which are controlled by a doctor, and after the appearance which he terminates the study, is the real object of the ergometric test

STRESS ECHO

Stress echocardiography is prescribed to detect disorders of the left myocardial kinesis ventricles, which cannot be determined by routine examination. The peculiarity of stress echocardiography is that before the examination the patient is exposed to physical activity or pharmacological tests, because at rest not all diseases can be diagnosed. Dane research allows to reveal ischemia and to trace how it develops, is appointed by a doctor before heart surgery to prevent complications as well as for detection of hibernating myocardium

When performing stress echocardiography, several types of exercise tests are used: tests with exercise, with pharmacological drugs (dobutamine, dipyridamole, adenosine). Exercise tests have become the most common, as they allow to reproduce a real situation that leads to heart failure. However, many patients who turn to a cardiologist, unable to perform intense physical work. These

are elderly people, patients with concomitant pathology of the musculoskeletal system, diseases of the respiratory system, severe obesity, detrained people. In such a situation, they gain an undeniable advantage tests with pharmacological drugs.

The occurrence of ischemia is preceded by a violation of local contraction. Sensitivity and the specificity of the sample is similar to the load ECG sample. The preference of this method is given at initially changed ECG (action of medicinal drugs, left ventricular hypertrophy, electrolyte disturbances).

The main difficulty of the technical plan - the inability in some cases to get quality image of the left ventricle. The specificity of the sample decreases sharply in violations conductivity in patients who have suffered a myocardial infarction

Criteria for a sharply positive sample:

- Left ventricular ejection fraction is maximum.
- The emission fraction increases by less than 5% during exercise.
- There is a violation of contraction in some segments of the left ventricle.
- There is a violation of the contractility of the left ventricle with small physical loads.

TEST WITH DOBUTAMINE

The dobutamine test is used for diagnostic purposes in patients who cannot perform a test with dosed exercise or in case of lack of information samples.

Dobutamine is a short-acting synthetic catecholamine when administered intravenously introduced increases the strength of myocardial contractions, increases its need for oxygen, which contributes local contraction in the segments provided by the stenosed arteries, causes in patients with coronary heart disease ischemia in the areas of responsibility and the development of myocardial asynergia, heart rate increases. This method is very effective for diagnosing three-vessel lesions

The main indications for stress echocardiography with dobutamine:

- Assessment of the true severity of aortic valve stenosis in patients with low contractile ability of the heart.
- Diagnosis of myocardial ischemia, hemodynamically significant coronary stenosis arteries;
- monitoring the effectiveness of treatment;
- stratification of patients according to the degree of risk of perioperative complications;
- determination of the forecast and prospects of revascularization procedures;
- determination of viable myocardium.

Contraindications to this study:

- acute phase of myocardial infarction;
- acute myocarditis and pericarditis;
- pronounced arrhythmias of high gradations, including ventricular arrhythmias;
- severe aortic stenosis;
- severe anemia,
- acute infection;
- acute aortic dissection;
- hyperthyroidism

Sharply positive criteria for the test are the same as for stress - echocardiography with exercise.

Methods of stress echocardiography with dobutamine:

The patient lies on a couch, ECG electrodes are fixed on a thorax, on a shoulder the cuff for BP control is imposed. The electrodes are connected by wires to a computer. Then in one of superficial veins of a forearm or a hand the catheter connected with is established a dispenser that automatically controls the rate of administration and dose of dobutamine. Infusion dobutamine start with a small dose of 0.005 mg / kg / min with a slow increase to 0.020-0.04mg / kg / min

This drug is administered intravenously over 15 minutes, in parallel there is a continuous monitoring of ECHO and ECG, as well as regularly monitored blood pressure. The test is terminated when the

subject reaches the target heart rate or when it appears adverse symptoms (changes in heart rate on ECHO CS, fatigue, chest pain, shortness of breath, ECG changes, significant fluctuations in blood pressure).

This test can cause slight discomfort from finding a thin catheter in a vein, and also from the increase in heart rate imposed by dopamine. During input side effects may occur: headache, flushing, hypotension, ventricular arrhythmias, including tachycardia and fibrillation.

The results are entered into a computer, decoded, analyzed and published doctor's report in printed form (within 15 minutes) after the test; at subsequent visits of the patient, the results of the study and changes are analyzed in the dynamics. General duration of stress echocardiography with dobutamine - 1.5 hours

Perfusion myocardial scintigraphy

or **nuclear scanning,** is considered the most informative modern method of substitution diagnostics, which is used to assess the functioning of various organs and tissues, including numbers and hearts. This is a method of functional visualization, which consists in the introduction into the body intravenous radioactive isotopes and imaging by determination radiation emitted by these isotopes. Circulating with the bloodstream, the drug absorbed by the myocardium.

Healthy areas of the myocardium, which are well supplied with blood, are active accumulate the drug. Reduced absorption of the drug is observed in foci of ischemia, the localization of which can be established by the uneven distribution of the substance in the images, made by a gamma camera.

In this method of blood flow study used radiopharmaceuticals: small doses radioactive waist 201 or technetium-labeled 99m perfusion indicators with radiation. After 15-45 minutes after drug administration, myocardial imaging is performed using a gamma camera, which captures radioactive radiation.

There are 2 options for myocardial perfusion scintigraphy:
• Scintigraphy of the myocardium at rest - is performed for 1 day
• Myocardial scintigraphy at rest and with load (bicycle ergometry) - is performed for 2 days

During maximum exercise, the isotope is introduced into the body, in that the moment when the patient shows symptoms characteristic of myocardial ischemia. If used thallium, the images are obtained immediately or within minutes after exercise. In the future, the scan is repeated in a few hours or at the day after the next injection of the radioactive indicator.

99m TC is used as a label, which has a short half-life – total 6 years Gamma quanta leave the body and are detected by detectors of the device. For objectivity of an assessment of a condition of coronary vessels it is necessary to carry out also tests with physical activity (VEM, treadmill) and analyze the distribution of medical drug in the myocardium. Thus, it is possible to detect asymptomatic coronary heart disease occurs at rest, and is detected only under load, when the intensity increases myocardial contractions. In cases where the patient is unable to exercise, a special drug is used that stimulates heart contractions.

The second stage of the procedure involves the patient performing aerobic exercise for creating conditions for the load on the myocardium. For this purpose, used, as a rule, exercise bike or treadmill. The intensity of the load gradually increases. In this ECG, heart rate and blood pressure are monitored. At the peak of the load is repeated injection of radiopharmaceutical. Only after 15-45 minutes again take pictures of the heart in different projections. The procedure lasts from 2 to 4 hours.

Another way is to use vasodilators, which increase perfusion supply areas with "normal" coronary arteries. Pharmacological load used in cases where the patient himself is unable to exercise.

Adenosine and dipyridamole are used for this purpose, which dilate non-stenotic coronary arteries arteries and increase perfusion levels when supplying segments. This causes a pronounced effect inhomogeneous absorption of thallium.

After that, the thallium may be redistributed (temporary ischemia), or NOT redistributed (myocardial necrosis).

After vasodilation, an insufficiently blood-supplied area or myocardial ischemia is recognized as an area with less isotope accumulation at the time of exercise, in contrast to with accumulations at rest. To more easily interpret the test results, a tomographic image or semi-quantitative analysis is used. In the early phase, thallium in the myocardium accumulates in a directly proportional degree to the regional blood flow. The appearance of another accumulation defect indicates temporary ischemia. Permanent accumulation defects indicate scarring or myocardial infarction. The zone of myocardial hypoperfusion stands out as a defect in the accumulation of radiopharmaceuticals. Defects are permanent and transient. The permanent defect does not change at any condition of an organism and testifies to a necrosis of myocytes. The transient defect is manifested under stress, and at rest is absent. Scintigraphy is a non-invasive procedure, unlike coronary angiography.

Advantages:
• Determining the feasibility of coronary angiography and shunting based on individual risk assessment
• Detection of ischemia associated with small vessel damage, which may not be detected by angiographic studies
• The conclusion of the study in exercise contains not only tomographic examination of the myocardium, but also the results of ergometry

Each conclusion is prepared by two doctors of the department (the method of "double interpretation"). The conclusion is issued on the day of the study, usually within 40-60 minutes after the study.

General indications for perfusion scintigraphy of the myocardium:
• Detection and differential diagnosis of coronary heart disease:
     -Angina
     -Episodes of unstable angina
     -Evaluation of the significance of coronary artery disease in patients diagnosed with coronary heart disease
     -Assessment of the risk of cardiovascular complications
• Evaluation of the effectiveness of revascularization (coronary angioplasty, shunting and thrombolysis)
• Repeated scintigraphy in the resumption of angina after interventions on the coronary vessels
• Confirmation of the diagnosis of acute myocardial infarction (MI) myocarditis, early complications of diabetes mellitus)
• Determination of treatment strategy and quality control of treatment
• Identification of areas of muffled myocardium

According to experts, myocardial scintigraphy at rest, i.e. without a load test, is uninformative. However, in some cases, this method of diagnosis is indicated for:
• Chest pain of unclear etiology. At researches of perfusion of heart at rest it is actually possible to confirm existence of cicatricle changes (infarct zones) of a myocardium, and also to estimate blood supply whereas research of a myocardium at rest and with loading expands diagnostic possibilities of a technique.

Contraindications:
• for scintigraphy: -pregnancy, restrictions during breastfeeding (cancellation for 48 hours)
• for stress test:
-hypertensive crisis
-myocardial infarction in the last two days (48 hours)
-unstable angina with a high risk of cardiovascular complications
-resistant to treatment of arrhythmia, accompanied by hemodynamic disorders-severe aortic stenosis
-severe heart failure
-pulmonary embolism
-aortic aneurysm-acute myocarditis, pericarditis or infectiousendocarditis
-severe extracardiac diseases that may affect the performance of the test, or may be exacerbated by the test (including infections, renal failure, thyrotoxicosis)
-severe emotional disorders psychosis.

Preparation for the procedure

The day before the procedure it is necessary to exclude from the diet all foods and beverages that contain caffeine: coffee, tea, cocoa, cola, chocolate. Do not eat a few hours before the scintigraphy to avoid getting the drug into the duodenum from the stomach, and not earlier than 45-60 minutes after intravenous administration of the drug to ensure maximum clearance with the liver.

Young women are advised to exclude the possibility of pregnancy during scintigraphy. Breastfeeding women are advised to express breast milk in advance for the first two days after the procedure.

As the radiopharmaceutical is gradually eliminated from the body, breast milk may contain radionuclides for another 48 hours after scintigraphy.

Therefore, milk must be drained and poured for two days.

It is necessary to inform the doctor about taking drugs such as Viagra, Cialis, Levitra, the day before the procedure due to the fact that scintigraphy with exercise can provoke the onset of angina, which is stopped by nitrates, dilate coronary vessels. These drugs in interaction with nitrates can cause severe hypotension

Patients taking any medication should inform their doctor in advance. Some medications may be temporarily stopped. If you are supposed to do only research at rest, drugs are not canceled. At researches with loading after consultation with the doctor it is recommended to cancel β-adrenoblockers for 3 days before carrying out the loading test. Research is carried out in 30 -60 min.

After administration of a radiopharmaceutical. The procedure takes up to 30 minutes.

Patients must have an extract from the outpatient card / medical history with a cardiologist or therapist, electrocardiogram archive, heart test results if available (echocardiography, holter monitoring, VEM, treadmill test, etc.), which he must provide to the doctor For research with loading of the patient it is necessary to take with itself comfortable footwear and the free clothes which are not restraining movements, for carrying out VEM.

Causes of false positive results:

-Obesity (poor image).

-Large mammary glands.

-High location of the diaphragm.

-Accumulation defects can persist for several weeks, even despite the resumption of perfusion by balloon coronary angioplasty.

Criteria of sharply positive test:

- Manifestation of accumulation defects at low loads.

- Multiple accumulation disorders.

- Too high accumulation of waist by myocardium.

-Defects of accumulation not in a heart attack zone .

RADIONUCLIDE ANGIOGRAPHY DURING EXERCISE

Radionuclide angiography is performed using erythrocytes marked with technetium. It is used to assess the functioning of the left ventricle during exercise and at rest.

These studies are performed in the supine position of the patient with a gradual increase in workload with a duration of each increase of 3-5 minutes. At each stage of increasing the load, the image is obtained in one or two minutes. In healthy patients, the value of the ejection fraction at rest is marked as normal. Under load, the emission increases. Patients with coronary heart disease often do not have a decrease or increase in the ejection fraction, and there are regional disorders of left ventricular wall kinesis during exercise.

SPECKLE-TRACKING ECHOCARDIOGRAPHY-a new, effective, non-invasive ultrasound imaging method, using a standard two-dimensional image to quantify global and regional kinetics and myocardial deformation in all spatial planes. In contrast to traditional echocardiography, this technique is based on the assessment of LV contractile function based on vector analysis of myocardial deformity and avoids errors inherent in Doppler echocardiography.

The principle of echocardiography tracking technology is that the reflection, scattering and interference of ultrasonic waves in the myocardial tissue lead to the formation of spots (speckles),

and the two-dimensional image is divided into small segments (like a mosaic). Areas of the myocardium with a unique set of these spots in the gray scale mode of the two-dimensional image can be traced frame by frame throughout the cardiac cycle. This allows you to assess the rotational movements of the left ventricle, which are often a twist (torsion) or curvature (twist).

Speckle tracking echocardiography allows you to assess the rotational and torsional dynamics of the left ventricle -parameters of left ventricular function, which before the introduction of this technique, were analyzed exclusively using magnetic resonance imaging.

The spiral shape of the left ventricular myocardial fibers causes a complex three-dimensional rotating mechanism of systolic contraction and unwinding during diastole. The degree of twisting or curvature, apparently, is associated with age and diastolic function, as well as systolic contraction. The myocardium of the left ventricle consists of two layers:

subendocardial, which envelops the left ventricle helically clockwise, and subepicardial, which envelops the left ventricle helically counterclockwise. If you look from the top of the heart, it rotates counterclockwise during systole, and the base of the heart - clockwise. When the apex and base of the left ventricle rotate in opposite directions, the myocardium thickens and shortens in the longitudinal direction.

By tracking the movement of speckles during the cardiac cycle, speckle-tracking echocardiography allows semi-automatic processing of myocardial deformity data in three spatial directions: longitudinal, radial and circular. In addition, speckle-tracking echocardiography evaluates the occurrence, direction, and speed of rotation of the left ventricle. The semi-automatic nature of speckle-tracking echocardiography guarantees good intraspectral and interstitial reproducibility.

The system analyzes any points and segments of the myocardium selected by the operator (at the level of the endocardium, myocardium, epicardium). The data obtained after processing by the software are represented graphically: curves, color scale, tables and vectors. The technique of calculating the deformation of the two-dimensional image is much simpler than when using tissue Doppler echocardiography, because there are no restrictions associated with parallel movements of the object and the ultrasound beam. For calculations, one cardiac cycle is enough, because ultrasound images are processed offline

To analyze the image of speckle tracking EchoCG use parameters that can be divided into two groups: motion and deformation. These, at first glance, such processes have fundamental differences. If an object moves without changing its shape, it is called an offset. If the individual parts of the object move at different speeds, it changes its shape. This type of movement is called deformation. Derivatives of these indicators are the rate of shear and deformation.

Although this new method has been introduced solely to analyze left ventricular function, several studies have recently expanded its scope in other chambers of the heart, such as the left atrium.

LIVER PERCUSSION

The location of the liver below the edge of the costal arch indicates its enlargement or displacement. This issue can be solved only when determining the position of its boundaries, which are made percutory.

The size of the liver is determined by the Kurlov's method (see picture). To do this, measure the distance between the upper (percutoricly found) and lower (found percutoricly and palpatorly) boundaries of the liver along the right mamillary line (percussion begins from the 2nd inter-rib, The I-st point is normally located in the VIth inter-rib, the IInd point at percussion from the bottom - at the edge of the right costal arch) and on the front mamillary line (IIIrd point - perpendicular to the Ist point, IVth with percussion from navel up), as well as on the left costal arch (the distance between the set point on the left costal arch - Vth point - and the conditional upper limit liver along the front mamillary line - oblique size). Liver sizes normally along the middle-mamillary line on average are $9 \pm 1\text{-}2$ cm, on the front middle - $8 \pm 1\text{-}2$ cm, on the left rib arc - $7 \pm 1\text{-}2$ cm.
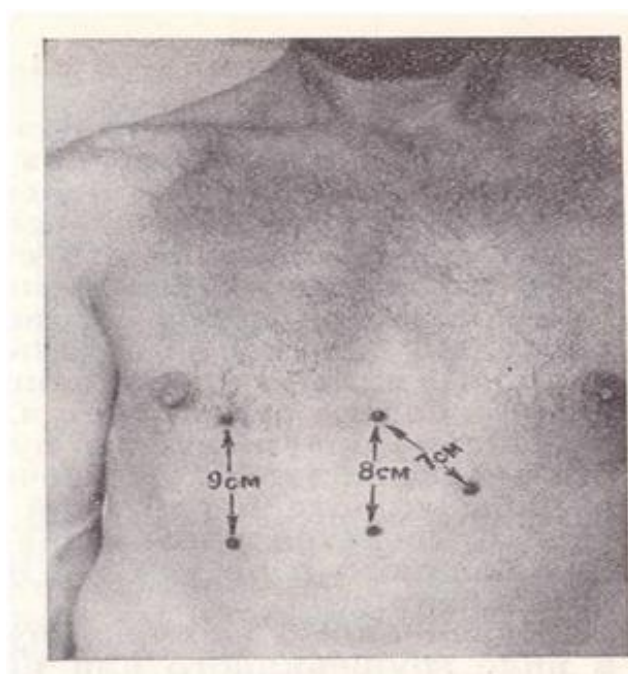
If the size of the liver is not changed, then the shift of the lower limit of the hepatic bluntness, which occurs simultaneously with the unidirectional displacement of its upper limit, indicates only the lowering of the liver. With an increase of the liver down, only its lower limit shifts. This is observed with congestive venous blood in the liver (congestive liver), inflammatory processes in the liver and biliary pathways, in some acute infectious diseases (dysentery, typhoid, cholera, malaria), in the initial stage of liver cirrhosis, etc.

Only the displacement of the lower boundary of the liver up can be caused by shrinking of the liver (for example, in the final stage of portal cirrhosis).

The displacement of the upper boundary of the liver (upward or downward) is relatively rarely due to the liver damage itself (because of cancer or liver ehinococosis, the upper limit may move upward). Most often this occurs for other reasons (high standing of the diaphragm in tympanites, ascites, pregnancy; low - with emphysema, pneumothorax, visceroptosis; liver prolapse in cases of gas accumulation under the diaphragm). With right-sided exudative pleurisy, pneumonia, lung infarction, wrinkle of the lower lobe of the right lung can simulate a displacement in the upper limit of the hepatic bluntness upwards.

LIVER PALPATION

Before palping the liver, it is recommended to percutorially determine its boundaries. This allows not only to judge the size of the liver, but also to determine where palpation should begin. The liver gives a blunt sound during percussion, but since the lower edge of the lung partially covers it, you can determine the two upper limits of the hepatic bluntness: relative (real) and absolute. In practice, as a rule, the determination the limits of absolute bluntness, upper and lower.

When doing the palpation of the liver, it is necessary to follow certain rules and technique of performance. The patient should lie on his back with his head slightly raised and straightened or slightly curved legs in the knee joints. Their hands should lie on their chest (to limit the mobility of the chest to inhale and relax the abdominal muscles). The researcher sits to the right of the patient so he could face them, the palm of his right hand with slightly curved fingers is being put flat on his stomach, in the right sub rib, 3-5 cm below the boundary of the liver which have been found percutoraly, and with his left hand covers the lower part of the right half of the chest, with 4 fingers located at the back, and the big thumb - on the rib arc (see picture). This limits the mobility (expansion) of the rib cage during inhale and enhances the movement of the diaphragm downwards. When a patient exhale, the researcher with superficial movement pulls the skin down, forming a skin fold, plunge the tips of the fingers of the right hand into the abdominal cavity and asks the patient to take a deep breath. In this case, while the lower edge of the liver goes down it enters the artificial pocket, bypasses the fingers and slips out from under them. The palpator arm remains motionless all the time. If the lower edge of the liver could not be palped, the manipulation is repeated, moving the fingertips 1-2 cm up. This is done until, rising higher, until the lower edge of the liver is palpable or the right hand reaches the rib arc.

Palpation of the lower edge of the liver is usually carried out along the right mamillary line or along the outer edge of the right straight abdominal muscle. However, if necessary, the edge of the liver can be palped along all 5 lines, starting with the right front axillary and ending with the left near brestbone.

When a significant amount of fluid accumulates in the abdominal cavity, liver palpation becomes complicated.

In this case, it can be palpatored by push-like palpation. With closed 2nd, 3rd, 4th fingers of the right hand apply push-like blows on the front abdominal wall from the bottom upwards to the rib arch, until a dense body is detected - the liver. When pushed, it first goes to the depths of the abdominal cavity, and then turns and hits the fingers, that is, it becomes tangible (a symptom of the "floating ice floe").

Liver palpation:

a - regular;

b - push-like palpation
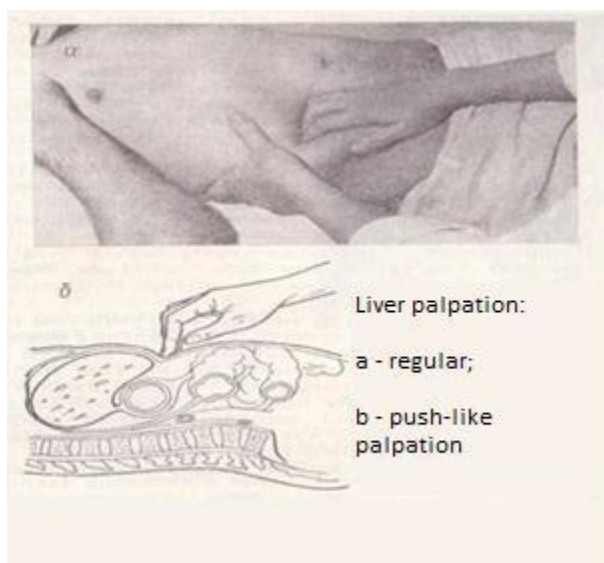
Normally, the liver is being palpated in 88% of cases. Its lower edge is located near the edge of the rib arch, on the right mamillary line. It is soft, sharp or slightly rounded, smooth, painless, easily turned up during palpation.

In some cases, you can palpate not only the lower edge of the liver, but also parts of it (fingers are placed immediately under the right rib arch and, easily pressing on the abdominal wall, gliding on the surface of the liver). At the same time, they find out the features of its surface (smooth, straight, hilly), consistency (soft, dense), show the presence of soreness, etc.

Smooth, straight, soft surface of the liver with a rounded edge, the liver pain during palpation are observed in inflammatory processes in the liver and biliary pathways, as well as in acute blood congestion against the background of heart failure

The hilly surface, inequality and compaction of the lower edge are noted for syphilitic damage to the liver - the echinococosis. Especially sharp density ("wooden density") is manifested in cancer damage to the liver.

Compaction of the edge of the liver may happen in case of hepatitis, cirrhosis (there is also an uneven surface)

The liver pain during palpation is observer during the inflammatory process or when the liver is stretched (for example, a stagnated liver).

PERCUSSION AND PALPATION OF THE SPLEEN

It is carried out in the horizontal position of the patient on the right side, the left arm of the patient is bent in the elbow joint, the right hand is under the head, the right leg is elongated, the left leg is bent in the knee and hip joint. The length of the spleen is determined along the lower edge of the 10th rib, percussioning from the gums to the blunt percutoric sound (Ist point), then from the line of the shoulder blade to the front (IInd point). Then, to the middle of the line, we move along the inter-ribs from the IVth inter-rib from the middle axillary line and from the bottom of the XIIth rib (IIIrd and IVth points, respectively). Percutorely the size of the spleen is 6-8cm × is 4-6cm.

Percussion of spleen
a - the position of finger plessimeter for designation of upper and lower boundaries;
b - front and back boundaries
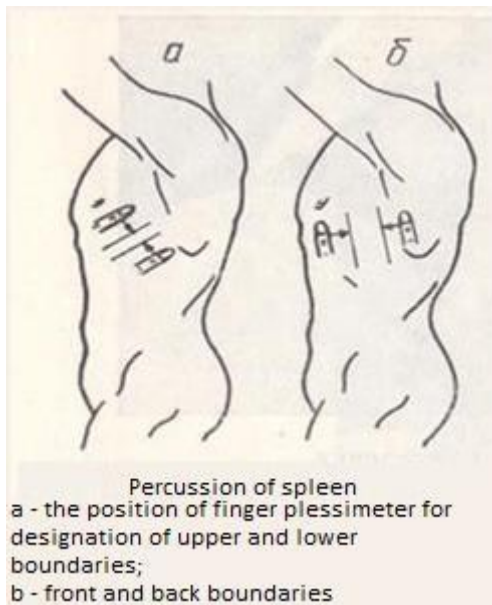
Normally, the spleen does not palpate, because it is located behind the bone-articular line. While palpation, the doctor's left hand is placed on the left rib arc to limit breathing excursions. After setting the right hand, a skin fold is forming, on the exhalation of the patient - dipping the hand into the abdominal cavity, inhaling the patient "pushes" the doctor's hand.

LABORATORY DIAGNOSIS OF DISEASES OF THE CARDIOVASCULAR SYSTEM

PROCALCITITONIN

Procalcitonin (PCT) interleukin-6. However, PKT has no hormonal activity and does not affect calcium metabolism. Normally, all PKT is converted into calcitonin in the C-cells of the thyroid gland in response to hormonal stimulants . The amount of PKT in a perfectly healthy person is less than 0.5 μg / liter. With severe bacterial infections and sepsis there is an increase in the concentration of PKT in the blood due to extrathyroid synthesis -in leukocytes, neuroendocrine cells of the lungs, intestines, liver under the influence of pro-inflammatory stimulants. All this leads to a rapid and sharp increase in PKT levels (6-12 hours after generalization of the process) on the background of maintaining the level of calcitonin. bacteria.

Procalcitonin is a marker for the diagnosis of sepsis, assessment of systemic inflammatory reactions and the degree of risk of septic shock in critically ill patients (along with other clinical and physical data). It should be borne in mind that the level of PKT increases only in the generalization of bacterial infection (sepsis) and reflects its degree, local foci do not lead to an increase in the level.

Therefore, diagnostic value is not only the presence of increase, but also the degree of increase and dynamics of PKT level.Rapid and accurate diagnosis in patients with sepsis is crucial when choosing a treatment strategy to reduce patient mortality.

Indications for use

1. In a set of studies for early diagnosis and differential diagnosis in patients with or at risk of sepsis and systemic inflammatory reactions (shock of unclear origin, major surgery, trauma, burns, fever in the postoperative and postpartum period, differential diagnosis - monitoring of the condition, treatment effectiveness, assessment of the prognosis in patients with severe sepsis, severe bacterial infections, etc.).
2. Diagnosis of infections in newborns (suspected neonatal sepsis);
3. Monitoring the effectiveness of treatment.
4. Assessment of the severity of the condition, the course of the disease and the prognosis of sepsis.

Interpretation of results

At primary diagnosis presence of increase and dynamics of growth is estimated, at control of efficiency of treatment - dynamics and terms of normalization of level PKT, stability of preservation of normal levels

• PKT levels above 10 ng / ml are observed almost exclusively in patients with severe sepsis or septic shock.

• In severe generalized bacterial, parasitic or fungal infection with systemic manifestations, PKT levels increase rapidly and strongly.

• In patients with sepsis, severe sepsis and septic shock, the concentration of PKT can increase up to 1000 ng / ml (1000 times!) And reach 1000 ng / ml. Clinical conditions in which the concentration of PKT is increased.

    A. Associated with infections: o sepsis with confirmed or unconfirmed bacterial infection, o sepsis-related conditions such as pancreatitis, o overt systemic infections that may occur with pneumonia or pyelonephritis, o overt systemic viremia , fungal infections, severe malaria

.B. Not related to infections: o burns; o injuries; o sunstroke (heat stroke).

C. Related to pulmonary diseases: o aspiration or inhalation pneumonitis, o adult respiratory disease syndrome (ARDS); o pulmonary neuroendocrine hyperplasia, which occurs in chronic obstructive pulmonary disease or chronic bronchitis associated with smoking.G.

Associated with malignant tumors: o medullary thyroid cancer, o small cell lung cancer, o non-small cell lung cancer, o carcinoid tumor, o other neuroendocrine tumors (pheochromocytoma, pancreatic islet cell tumor

At the raised values of PKT the patient needs to pass the analysis again in 6-24 hours. If the value of PKT does not increase, you can eliminate the risk of sepsis and look for other causes that provoked high values. Immediately after extensive injuries, burns, surgery, PKT is always high. They decrease within 2-7 days, which indicates the stabilization of the condition. If the concentration does not fall, it is necessary to evaluate the effectiveness of treatment.

The half-life of PKT is 25-30 hours, which allows you to use it as a marker of the effectiveness of antibiotic therapy (after successful surgery or antibiotic therapy, the level of PKT in the blood decreases rapidly by 30-50% per day). On the other hand, if the increase in PKT levels persists for more than 4 days, correction of treatment is required. If after treatment there is no rapid decrease in the level of PKT, the prognosis is doubtful

Constantly increasing indicators of PKT indicate a poor prognosis. In acute pancreatitis PKT - an indicator of severity and a marker of infectious complications

D-DIMERD

-dimer is a marker of thrombosis and fibrinolysis, is the end product of fibrin degradation under the action of plasmin. high (98%) negative prognostic significance -normal levels rule out thrombosis. Due to these diagnostic capabilities of the test, it is included in the algorithms for diagnosing such a fatal condition as pulmonary embolism (pulmonary embolism), allowing for negative results to exclude pulmonary embolism.

Elevated levels will indicate the processes of thrombosis and fibrinolysis, which from a diagnostic point of view is important to determine the tactics of management, treatment control and prognosis of acute thrombosis with a lethal outcome in a number of diseases and conditions: lower extremity venous thrombosis, DIC syndrome, prolonged immobilization , bed rest, cardiovascular pathology (including CHF, coronary heart disease, stroke, heart attack), pregnancy, postoperative period, taking oral contraceptives, etc

In any case, when interpreting the results, it is necessary to assess not only the level of
D-dimer, but also its dynamics. An important area of application of D-dimer level is monitoring the effectiveness and adequacy of discontinuation of thrombolytic and anticoagulant therapy (dynamics of reduction and achievement of normal D-dimer level will indicate the effectiveness of therapy, maintaining a normal level after discontinuation of drugs for 1 month). and therefore in this category of patients can be **observed positive results of D-dimer**.

Indications
1. Diagnosis of thrombotic conditions (deep vein thrombosis -exclusion test, pulmonary embolism, C-syndrome) .
2. Complicated pregnancy (preeclampsia, preeclampsia, diabetes, kidney disease) .
3. Monitoring of thrombolytic therapy

Elevated levels:
• DIC (secondary fibrinolysis)
 • Myocardial infarction, stroke
 • Arterial or venous thrombosis
 • Postoperative period
 • Oral contraceptives, glucocorticosteroids
 • Renal failure
 • Hepatic failure
• Acute or acute diseases
 • physiological and complicated pregnancy
 • tissue plasminogen activator therapy False negative results of D-dimer:
 • small thrombus size,
• decreased fibrinolytic activity due to deficiency of tissue plasminogen activator (tPA) or high level of inhibitor of plasminogen activator inhibitor diagnostics.

NATRIUURETIC PEPTIDE

Brain natriuretic peptide (BNP) is a marker of heart failure. due to the fact that it was first detected in the brain of animals. In humans, the main source of BNP is the ventricular myocardium. It is secreted by myocytes as a 108-amino acid precursor (pro-BNP) in response to increased ventricular wall tension, increased ventricular volume, and pressure (in response to volumetric overload). Pro-BNP is cleaved into 32-amino acid active hormone (BNP) and N-terminal 78-amino acid inactive peptide NT-proBNP. BNP levels are elevated in patients with impaired cardiac pump function. The content of BNP in blood plasma significantly correlates with the functional classes of chronic heart failure (according to the classification of the New York Association for the Study of Heart Disease).

Increased levels of BNP and NT-proBNP are positively correlated with the degree of heart failure (up to 25-fold increase in the concentration of NT-proBNP) and is detected even at minimaclinical symptoms. Increased concentrations of BNP and NT-proBNP can be observed in asymptomatic left ventricular dysfunction, arterial or pulmonary hypertension, cardiac hypertrophy, heart valve pathology, arrhythmias and acute coronary syndrome. Determining the level of BNP in blood plasma helps to assess the severity of chronic heart failure, to predict the further development of the disease, as well as to assess the effect of therapy. BNP is an antagonist of the angiotensin-aldosterone system

It increases renal blood circulation and filtration, increases the excretion of sodium in the urine and the volume of urine excreted, increases cardiac output (by reducing systemic and pulmonary vascular resistance), reduces blood renin, aldosterone, norepinephrine, endothelin-1

      diagnosis between heart and lung diseases;
      • Diagnosis of heart failure in the early preclinical stages, assessment of the severity of heart failure, assessment of the effectiveness of therapy;
      • Clinical examination of patients at high risk of adverse outcomes.

Interpretation of NT-proBNP results less than 125 pg / ml -development of heart failure is unlikely and such levels are conventionally accepted as "normal" in heart function and can be excluded with a high probability.

• NT-proBNP above 125 pg / ml -development of heart failure is likely.

• NT-proBNP levels above 125 pg / ml -can reflect the presence or development of cardiac dysfunction and be associated with an increased risk of cardiac complications

• Increased NT-proBNP levels above 250 pg / ml in patients with acute coronary syndrome without ST-segment elevation on ECG definition is a predictor of high mortality and myocardial infarction for 6 months

NT-proBNP can be used to select and monitor therapy in patients with heart failure. Serum or plasma NT-proBNP levels may be reduced with intensive drug therapy in patients with HF. Drug therapy, selected based on the results of NT-proBNP, reduces the total number of cardiovascular diseases and conditionally "postpones" the time of the patient's first visit to the doctor and the appointment of intensive care

Negative predicted value of the test is more than 95% -that is, a normal level of NT-proBNP with a high probability to exclude HF (for example, in cases of shortness of breath caused by a sharp exacerbation of chronic obstructive pulmonary disease or edema not associated with HF).

It should be noted that NT-proBNP should not be used as the sole criterion for evaluating the patient. Test results should be interpreted based on individual patient data (sex, age, body weight), although the introduction of differentiated diagnostic thresholds continues to be discussed.

A moderate increase in NT-proBNP is observed in old age. NT-proBNP levels are slightly higher in women than in men (false-positive test results are more common in women over 75 years). There is a tendency to lower levels of NT-proBNP in obese people, even approximately the same severity of heart failure (should take into account possible false-negative results)

• NT-proBNP, as a biochemical marker, has some advantages over BNP, because longer and in higher concentrations circulating in the blood (half-life for BNP -20 minutes, for NT-proBNP -from 60 to 100 minutes), shows less intraindividual variability (up to 130% for BNP and up to 90% for NT-proBNP), more stable as an in vitro assay

• Positive predictive value of the test (confirmation of the diagnosis in excess of the threshold value used) is slightly lower, due to the influence of other

causes of increased levels of NT-proBNP (eg, renal failure). In patients diagnosed with CHFNT-proBNP is proposed to use to assess the severity of the condition, for prognostic purposes and to monitor therapy (increase in the marker> 2 -3 times from its initial level in the patient indicates acute deterioration). pg / ml

COAGULOGRAM

The hemostasis system consists of many biological substances and biochemical mechanisms that ensure the preservation of the liquid state of the blood, prevent and stop bleeding. It maintains the balance between coagulation and anticoagulation factors in the blood. Significant violations of the compensatory mechanisms of hemostasis are manifested by the processes of hypercoagulation (excessive thrombosis) or hypocoagulation (bleeding), which can be life-threatening.

There are internal and external ways of blood coagulation, which differ in the mechanisms of coagulation. The internal way is realized at contact of components of blood with collagen of a subendothelium of a vessel wall. This process requires coagulation factors XII, XI, IX and VII. The external pathway is triggered by tissue thromboplastin (factor III), released from damaged tissues and the vascular wall. Both mechanisms are closely interrelated and since the formation of the active factor X have common pathways.

The study of such indicators as PTI (prothrombin index) and EOM (international normalized ratio) allows us to assess the state of the external coagulation pathway. PTI is calculated as the ratio of standard prothrombin time (clotting time of control plasma after tissue thromboplastin addition) to plasma clotting time, expressed as a percentage. EOM is a standardized prothrombin test in accordance with international guidelines. It is calculated by the formula

EOM = (patient prothrombin time / control prothrombin time) x MIC, where MIC (International Sensitivity Index) is the thromboplastin sensitivity factor relative to the international standard. MNV and PTI are inversely proportional, ie the increase in MNO corresponds to a decrease in PTI in the patient and vice versa. Reference values of PTI depend on the set and characteristics of the reagents and differ in the activity used in the test thromboplastin. The results of determining the EOM, thanks to standardization, allow us to compare the results of different laboratories.

Tests for PTI (or a similar indicator -prothrombin according to Quick) and EOM in the coagulogram help to identify disorders in the external and internal blood coagulation pathways associated with deficiency or defect of fibrinogen (factor I), prothrombin (factor II), factor V), VII (proconvertin), X (Stuart-Prauer factor). At decrease in concentration of these coagulation factors in blood prothrombin time increases in relation to control laboratory indicators.

Fibrinogen-coagulation factor I, which is produced in the liver. Due to the action of the coagulation cascade and active plasma enzymes, it is converted into fibrin, which takes

involved in the formation of blood clots and blood clots. Fibrinogen deficiency can be primary (due to genetic disorders) or secondary (due to excessive consumption in biochemical reactions), which is manifested by a violation of the formation of a stable blood clot and increased bleeding Fibrinogen is also an acute phase protein. Its concentration increases in the blood in diseases accompanied by tissue damage and inflammation.

Determination of fibrinogen levels is important in the diagnosis of diseases with increased bleeding or thrombosis, as well as to assess the synthetic function of the liver and the risk of cardiovascular disease with complications.

What is the study used for
 • For a general assessment of blood clotting.
 • To diagnose disorders of external and general blood clotting.
• To study the activity of coagulation factors I, II, V, VII, X.
• To monitor the patient's condition when prescribing anticoagulants.
• To assess the risk of cardiovascular complications
• To assess the protein-synthesizing function of the liver (synthesis of coagulation factors).
When is the test scheduled?
 • For a comprehensive examination
 • When planning surgery

• When examining patients with nosebleeds, bleeding gums, blood in the stool or urine, hemorrhages under the skin and in the large joints, with chronic anemia, heavy menstrual discharge, sudden loss of vision.

 • When examining a patient with a history of thrombosis.

• With hereditary predisposition to disorders of the hemostasis system.

 • With a high risk of cardiovascular complications and thromboembolism.

 • Before prescribing anticoagulants.

 • When monitoring the hemostasis system on the background of anticoagulants. according to Quick: 70 -120%

The reasons for the increase in IOP and decrease in the level of prothrombin according to Quick (indicates a possible deficiency of factors of external hemostasis and predisposition to increased bleeding):

 • DIC syndrome (disseminated intravascular coagulation) during hypocoagulation

 • hypofibrinogenemia (deficiency factor I; protein unable to participate in the cascade of biochemical reactions);

 • hereditary or acquired deficiency of factors II, V, VII;

• deficiency of factor X (eg, purpura in amyloidosis);

 • vitamin K deficiency;

 • neonatal hemorrhagic disease; fats (due to celiac disease, chronic diarrhea);

 • acute leukemia;

antiphospholipid syndrome;

 • congestive heart failure;

 • liver pathology (hepatitis, cirrhosis, alcoholic liver disease);

• biliary obstruction, mechanical jaundice;

 • pancreatic cancer;

 • Zollinger-Ellison syndrome (pancreatic adenoma;

• pancreatic adenoma;

 • nephrotic syndrome (excessive urinary excretion of factors V and VII),

• oral anticoagulants (warfarin).

Causes of increased fibrinogen levels (indicates an increased risk of thrombosis and cardiovascular complications):

• acute infection (eg, pneumonia, tuberculosis),

• autoimmune diseases (rheumatoid arthritis, reactive arthritis),

 • acute coronary syndrome, myocardial infarction;

• cancer (breast, kidney, stomach)

• multiple myeloma

 • Hodgkin's disease (lymphogranulomatosis)

 • glomerulonephritis, nephrotic syndrome, nephrosis

• pregnancy

• eclampsia

 • cerebrovascular disease, stroke

 • hepatitis

• postoperative

 • rheumatic fever

 • tissue damage

Causes of decreased MNV and increased prothrombin according to Quick (indicates a tendency to form blood clots):

 • DIC syndrome (hypercoagulation period),

 • deep vein thrombosis (initial stages),

 • polycythemia,

 • pregnancy (recent months),

 • increased factor VII activity.

Causes of decreased fibrinogen levels (may indicate an increased risk of bleeding):

 • dysfibrinogenemia,

• hereditary afibrinogenemia,

• DIC syndrome,

• fibrinolysis,

• hemophilia A and B

• liver pathology (hepatitis, cirrhosis)

• abortion

• premature placental abruption

• late stage of cancer

• embolism (amniotic fluid, meconium, fat, tissue)

• anemia

• eclampsia

• leukemia

• malabsorption

• shock;

• sepsis;

• post-transfusion reactions

. What can affect the result?

• Factors that distort the result of the analysis: o violation of the technique of taking and storing blood; o hemolysis of blood samples;

o the presence of lupus anticoagulant in the blood (directly inhibits coagulation factors), o transfusion of donor blood components in the last month (distorts fibrinogen)

• **Factors that increase EOM** and IF and reduce PTI (or prothrombin according to Quick), o food;

o drugs: antibiotics, anabolic steroids, aspirin (in high doses), acetaminophen, allopurinol, warfarin, vitamin A, heparin, glucagon, diuretics, MAO inhibitors, indomethacin, kanamycin, clofibrate, corticotropin, levothyroxine, mercaptopurine, metildofa,

mefenamic acid, mitramycin, nalidixic acid, neomycin, nortriptyline, propylthiouracil, reserpine, streptomycin, sulfonamides, tamoxifen, tetracycline, tolbutamide, phenylbutazone, phenytoin, quinidine, chlorinyl, quiniline, quinine, quinine and IF and increase PTI (or prothrombin according to Quick): o excessive intake of vitamin K with food (contained in the liver, green tea, broccoli, chickpeas, cabbage, turnips, soy, green leafy vegetables), o diarrhea and vomiting tongue with dehydration and increased blood viscosity)

o drugs: vikasol (vitamin K analogue), antacids, antihistamines, ascorbic acid, barbiturates, griseofulvin, digitalis, diuretics, colchicine, corticosteroids, caffeine, xanthines, meprobamate, theopharalphatic contraceptives. that increase the level of fibrinogen: estrogens, oral contraceptives.

Factors that reduce the level of fibrinogen: atenolol, valproic acid, hypolipidemic drugs, corticosteroids, progesterone, ticlodipine, thrombolytic drugs, urotokinazine (depletokinase)

APTT (activated partial thromboplastin time) is a screening test that simulates the process of blood clotting and aims to assess the content in the blood of inhibitors, plasma factors and anticoagulants. This is an indicator of the effectiveness of the internal mechanism of blood coagulation, which allows to detect and diagnose hemophilia, monitor patients undergoing heparin and gerudine treatment. also other necessary reagents.

Increased APTT (indicative of hypocoagulation) can be observed in the deficiency of factors XII, XI, X, IX, VIII, V, II or fibrinogen, liver disease, vitamin K deficiency, the presence of heparin, lupus anticoagulant, the presence of pathological inhibitors of fibrin polymerization. , myeloma proteins) or other coagulation inhibitors. APTT usually changes when the level of any of the factors is below 30 -40% of normal. If an elevated APTT level is detected when interpreting the results, this may indicate a tendency to bleed.

Decreased APTT indicates increased coagulation (hypercoagulation).

Determination of APTT, along with other tests, is used in the diagnosis of intravascular coagulation syndrome (ICE). Decreased values may indicate:

• the first phase of ICE syndrome;

• thrombosis and thromboembolism;

• venipuncture injury;

• increased levels of activated coagulation factors. Reference values are 25.9 -38.2 sec. (21.1 -36.5)
Indications:
• in the presence of problems with blood clotting,
• in the control of hemostasis,
• during the study of the blood coagulation system,
• for the diagnosis of lupus coagulant,
• for the diagnosis of profound hypofibrinogenemia, dysfibrinogenemia and polymerization disorders of fibrin monomers.
• for antiphospholipid syndrome and intravascular coagulation syndrome
• to diagnose hemophilia
• to establish the dosage for treatment with anticoagulants (heparin)
• to determine the patient's susceptibility to bleeding (in a set of preoperative procedures).
• if the patient is bleeding or bruising of unknown origin, thromboembolism or diffuse intravascular coagulation, which may cause both bleeding and thrombus formation
• during heparin therapy or when transferring a patient from heparin therapy to long-term treatment with warf.
• In the complex of preoperative examination to detect the body's tendency to bleed, especially if the proposed operation is associated with heavy blood loss or the patient's clinical history indicates earlier bleeding
• In the treatment of myocardial infarction.
What may affect the result
• Presence of impurities of direct anticoagulants (in particular, heparin) in the blood sample
• High concentration of lipids (fats) in the blood, for example, after eating fatty foods on the eve of the study
Important Notes
• At very high doses of heparin, such as open heart surgery, the APTT test loses its sensitivity - thrombosis is greatly reduced
• The APTT test is not prescribed as a routine screening test. It is needed if there is an indication in the patient's medical history of a hereditary predisposition to thrombosis or hemophilia. Asymptomatic patients are often screened for APTT before surgery, especially when their doctor thinks it will help determine the risk of excessive bleeding during surgery

International Normalized Ratio (INR)

The ratio of the patient's prothrombin time to the standard prothrombin time is reduced to the degree of the ISI (special index). is one of the studies on prothrombin. Assessment of the hemostasis system, a marker of the state of the coagulation system, disorders of the external coagulation pathway. Used to monitor oral anticoagulant therapy
Used to control indirect anticoagulant therapy. The optimal indicators of EOM, which should be achieved during treatment with indirect anticoagulants, depend on the therapeutic goals and are determined by the attending physician.
TTR (Time in Therapeutic Range) - the percentage of days in the therapeutic window 0 -3.0. Therapy at TTR more than 70% is considered effective.
Indications for appointment
1. Diagnosis of pathology of the blood coagulation system.
2. Control of therapy with indirect anticoagulants (coumarins, etc.).
3. Study of liver function (assessment of the function of synthesis of prothrombin complex factors).

Rules of preparation of the patient In the morning till 11-00, on an empty stomach, in 8-12 hours of the fasting period. Break not less than 6 hours after food (to exclude fatty food)
Interference:
• Acetohexamide, anabolic steroids, antibiotics, acetylsalicylic acid, laxatives, methotrexate, nico , quinidine, quinine, thiazide diuretics, tolbutamide.

• Mercaptopurine, oral contraceptives. Interpretation:
• Deficiency of factors: VII, V, X, II, lesions of the liver parenchyma, enteropathy and intestinal dysbacteriosis, DIC syndrome, hypofibrinogenemia, elevated levels of antithrombin or antithromboplastin
 • Initial stages of deep vein thrombosis of the lower extremities, late pregnancy, polycythemia

BLOOD CULTIVATION FOR STERILITY

 Blood culture should be performed in all critically ill patients with fever, chills, in case of suspicion of endocarditis, intravascular infection or immunosuppression. Blood backs for sterility is used in the diagnosis of sepsis, septic. Under normal conditions, the blood is sterile. Getting infectious agents into the bloodstream most often occurs during the generalization of any local infection
The primary septic focus can be any infection of soft tissues, bones, joints and internal organs: a large wound or burn surface, purulent skin diseases (carbuncle, boil, phlegmon), osteomyelitis, urogenital infections. Rarely, the cause of sepsis are infectious complications after surgery, childbirth, abortion. Most often, sepsis develops in people with weakened immune systems due to serious illness, major surgery, significant blood loss, HIV-infected people, drug addicts, people taking immunosuppressive drugs.
Microorganisms that are released: Aerobes: streptococci, staphylococci, enterobacteria, non-fermentable, enterococci, anaerobes Actinomyces, Bacteroides, Clostridium, Eubacterium, Fusobacterium, Gemella, Peptostreptococcus, Staphylococcus, Prophylaxis
• fever of unclear genesis
 • selection of adequate antibiotic therapy
 • treatment monitoring
Preparation for the study: Features: blood for culture is taken before the start of specific antibacterial chemotherapy or at least 12-24 hours after the last administration of the drug. It is recommended to conduct the study during a rise in temperature, at the beginning of the fever. Blood sampling with a volume of 10 ml or more is carried out from different veins with an interval of 30-60 minutes Significantly increases the detection of the pathogen by increasing the number of samples to three.
Interpretation of the results:
• normal growth of microorganisms is not detected -seeding is sterile
 • detection of microorganisms indicates an infectious process, in which case the sensitivity to antibiotics is determined

DIFFERENTIAL DIAGNOSIS OF EXUDATE AND TRANSUDATE

 The pleural fluid of inflammatory origin is an exudate. fluid, for which a pleural puncture is performed
The nature of the exudate is determined not only by a variety of causes, but also the ratio of accumulation and resorption of effusion, the duration of its existence:
a) moderate effusion and good resorption -fibrinous pleurisy; purulent microflora - purulent pleurisy (pleural empyema);
d) the rate of resorption exceeds the rate of exudation of adhesions during resorption;) -hemorrhagic effusion;
e) the predominance of allergic processes -eosinophilic exudate;
g) trauma to the thoracic duct in tumor or tuberculous lesions -chillous exudate;
c) chronic perennial exudative pleurisy, in particular, in tuberculosis -cholesterol exudate. **Causes of 1 transudate**:
Congestive heart failure
2. Nephrotic syndrome
3. Cirrhosis of the liver
4. Myxedema
5. Pulmonary artery embolism, with the formation of infarct pneumonia and effusion6. Sarcoidosis

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Causes of 1 transudate: Congestive heart failure

2. Nephrotic syndrome
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Cholesterol

-secondary monohydric cyclic alcohol.In the blood and tissues of the body is contained in free and esterified forms.Free cholesterol -a component of cellular plasma membranes, as well as membranes of mitochondria and endoplasmic reticulum in the endoplasmic reticulum. , corticosteroids, bile acids, vitamin D.

High risk of coronary heart disease in adults - blood cholesterol concentration above 5.22 mmol / l. It is advisable to examine cholesterol in combination with the determination of triglycerides, HDL and LDL. Reference values, mmol / l <5.2 - no risk, conversion factor38 66 = mg / dl
Indications for use

Determination of cholesterol characterizes lipid status and metabolic disorders, risk of atherosclerosis, coronary stenosis and myocardial infarction • Monitoring of high risk factors for coronary heart disease • Screening of primary and secondary dyslipidemia, monitoringtherapy and therapy
Interpretation of results

Elevated levels
 • Hyperlipoproteinemia type IIb, III, V
• Hereditary hypercholesterolemia type Iia
 • Biliary obstruction: cholestasis, biliary cirrhosis
 • Nephrosis
• Pancreatic disease
 • Hypothyroidism
• Diabetes
 • High fat diets and diets
 • obesity

Decrease in level
• Hypo-or α-betalipoproteinemia • severe hepatocellular lesions • hyperthyroidism • myeloproliferative diseases • steatorrhea with malabsorption • chronic anemias (megaloblastic, sideroblastic) • acute diseases, inflammation, infections • hunger

HIGH DENSITY LIPOPROTEINS (HDL) HDL

 - the smallest lipoprotein particles, are synthesized in the liver and at the time of entry into the bloodstream consist mainly of apoprotein (protein on the surface of lipoprotein), which is involved in the metabolism of lipoprotein. cholesterol from all extrahepatic cells back to the liver for further excretion in the bile.Together with LDL involved in maintaining cellular cholesterol levels.
Due to the ability to bind and remove HDL cholesterol is called antiatherogenic, as they prevent the development of atherosclerosis. Concentrations of HDL and apoliprotein A-1 are positive risk factors for atherosclerosis. Patients with high levels of HDL are protected. development of atherosclerosis.

Reference values, mmol / lFemale:> 1.68 -no risk; 1.15-1.68 -conditional risk; <1.15 -high risk.Men:> 1.45 -no risk; 0.90-1.45 - conditional risk; <0.90 -high riskRecalculation factormol / l x38.66 = mg / dl; mg / dl x0.0259 = mmol / l

TRIGLYCERIDES

 lipids that enter the body with food, are synthesized in the liver, intestines and adipose tissue and circulate as part of protein complexes -lipoproteins. essential components of cell membranes. Triglycerides accumulate in fat cells, as a result of hydrolysis are broken down into glycerin and fatty acids and released into the circulatory system.
In adipose tissue

are deposited as glycerol, fatty acids and monoglycerides, which are converted in the liver to triglycerides that are part of VLDL (80%) and LDL (15%). Hypertriglyceridemia together with hypercholesterolemia are independent risk factors in the development of atherosclerosis. lUp to 1.70 mmol / lRecalculation factormol / l x88.5 = mg / dL

VERY LOW DENSITY LIPOPROTEIDS (VLDL)

VLDL is synthesized in the liver. Circulating free fatty acids form triglycerides in the liver, which bind to apoproteins and cholesterol, then are exported to the blood in the form of VLDL. The main function is the transport of triglycerides synthesized in the liver into fat and muscle cells. Serve as precursors of LDL. LDL is the lipoprotein that contains the highest amount of cholesterol (60-70% of total serum cholesterol), formed as a result of the breakdown of LDL. The main LDL protein is apoprotein B (apo-B).
Although the half-life of LDL is higher (3-4 days) than its predecessor, they are more common in the bloodstream than LDL.
LDL-cholesterol is involved in the transport of cholesterol into tissues, primarily in the arterial system, which explains the high level of atherosclerosis and coronary heart disease in patients with elevated levels of this lipoprotein. diseases, and deciding on the definition of therapeutic procedures.
Coefficient of atherogenicity = total cholesterol -LDL / HDL. This indicator reflects the ratio of atherogenic lipoproteins (LDL) to the content of antiatherogenic lipoproteins (HDL) in blood plasma, ie more accurately reflects the favorable and unfavorable combination of lipoproteins in terms of the risk of coronary heart disease.
Indications • risk assessment of coronary heart disease • diagnosis of hyperlipoproteinemia • atherosclerosis and cardiovascular disease • liver disease

MARKERS OF MYOCARDIAL NECROSIS

Detection of elevated levels of markers of myocardial necrosis helps to identify a group of patients with the highest risk of adverse outcomes (MI or death) requiring the most aggressive antithrombotic treatment and myotcardial treatment, myocardial necrosis without ST segment elevation.
Early markers of myocardial necrosis-myoglobin, creatine phosphokinase MB fraction (CPK-MB)
Late markers Lactate dehydrogenase (LDH), cardiac troponins I and T, aspartate aminotransferase (AST)

MYOGLOBIN

 Myoglobin is a protein, a respiratory pigment found in skeletal muscle and myocardium. The use of stored O2 in muscle tissue begins with a marked decrease in the partial pressure of oxygen in the muscles. It is able to bind oxygen in muscle cells, giving them energy to contract. Myoglobin and hemoglobin are hemoproteins, they contain the porphyrin derivative -heme, which provides them with red color and the ability to interact with O2. Hemoglobin is responsible for the transport of oxygen, and myoglobin -for its deposition.
In the absence of inflammation or damage to muscle tissue, it is practically not fixed in the blood. This property is used to clarify the diagnosis of "myocardial infarction". The high content of

myoglobin in skeletal muscle and the dependence of its concentration on renal function make it nonspecific for myocardial necrosis and limit its use for the diagnosis of MI. The most appropriate use of myoglobin to judge the success of thrombolytic therapy. In patients with successful recanalization of the artery that feeds the area of MI, the concentration of myoglobin in the serum increases after 60-90 minutes after the start of fibrinolytic administration.

Preparation for the study:

 • Do not eat for 2-3 hours before the study (you can drink clean still water) • Eliminate physical and emotional stress for 30 minutes before the study

 • Do not smoke for 30 minutes before donating blood.Reference values: 0 - 70 mcg / l. If within 12 hours of chest pain there was no increase in myoglobin, the likelihood of myocardial infarction is extremely low.

Since myoglobin, in addition to the heart, is also contained in skeletal muscle, it may increase in other situations: 1. long-term compression syndrome (crash syndrome) occurs as a result of crushing or crushing of muscle tissue, as well as prolonged cessation of blood flow to the extremities;

 2. any injuries;

 3. after surgery;

4. convulsions of any origin;

5. any diseases that lead to muscle damage: dermatomyositis, polymyositis, muscular dystrophy, etc.

Important notes

• Elevated myoglobin is an insufficient basis for the diagnosis of MI. A comprehensive assessment of the patient's condition is required, which can only be performed by a physician. This takes into account the nature of the pain syndrome, the history of the disease, ECG, the results of other laboratory and instrumental examinations. on the likelihood of renal failure.

CREATINE PHOSPHOKINASE

 Creatine phosphokinase (CPK) is an enzyme that is responsible for stimulating the process of converting creatinine to creatine phosphate, which is needed to provide energy for muscle contraction, and is in high concentrations in the myocardium and skeletal muscle and in many lower concentrations in the brain. The enzyme enters the bloodstream in large doses in the case of damage to cells containing it. Isolated determination of total CPK levels in the blood is now considered by most experts to be inappropriate for the diagnosis of MI due to the high content of this enzyme in skeletal muscle and low specificity for myocardial necrosis.

Increased activity of the enzyme in the serum is observed due to the release of the enzyme from the cells when damaged. In acute myocardial infarction, the definition of CPK-MB gives more accurate information about myocardial damage than total

CPK. MV-CPK in MI appears in the serum 3-4 hours after the onset of symptoms and reaches a diagnostically significant level by 4-6 hours. Its elevated level persists for 48-72 hours.

Indications:

 • symptoms of coronary heart disease,

• suspected myocardial infarction, in particular in the blurred clinical picture,

• hypothyroidism,

• signs of myositis, myodystrophy, myopathy,

 • pregnancy planning by a woman whose family had Duchenne myopathy,

 • disease, provoking pathologies of the heart or muscular system

Preparation for research: For research on creatine phosphokinase take venous blood. It is necessary to hand over a biomaterial on an empty stomach, from the moment of the last meal should pass not less than 8 - 12 hours, to exclude reception of alcohol, medicines. Half an hour before the analysis it is recommended to refrain from smoking, to exclude emotional and physical overstrain (15 minutes of rest).

Children under 5 years, before donating blood, be sure to drink boiled water (portions, up to 150-200 ml, for 30 minutes) Reference values, U / lMen: 39.0-308.0 (up to 174). Women: 26.0-192.0 (up to 140) Conversion factorU / l x 0.0167 = mkat / l

Raising the level

• Acute myocardial infarction;
 • severe myocarditis;
• after open heart surgery, electrical defibrillation;
• Duchenne muscular dystrophy, polymyositis, dermatomyositis, muscle injuries; • myalgia syndrome;
 • malignant hyperthermia;
 • subarachnoid hemorrhage;
 • intramuscular injections
• Aminocaproic acid,
• amphotericin B,
• captopril,
 • clindamycin,
 • diclofenac,
 • digoxin,
 • 3-hydroxy-3-methylglutaryl-CoA reductase inhibitors,
 • insulin,
 • lidocaine,
• propranolo ,
• streptokinase.

Decrease in level

• With a decrease in muscle mass associated with tumor metastases,
 • alcohol intoxication of the liver,
 • collagenosis,
 • ascorbic acid,
 • amikacin,
 • aspirin
 • corticosteroids

TROPONINE

 A highly specific marker of myocardial damage, troponins are a family of proteins contained in skeletal muscle and myocardium that are involved in the regulation of muscle contraction. The troponin complex, which regulates muscle contraction in cardiomyocytes, consists of three subunits: T Troponin I and troponin T are found only in the heart muscle. Cardiac troponins and skeletal muscle troponins have different amino acid sequences, which allows to create highly specific diagnostics to determine the concentration of cardiac troponins I and T in the serum. These cardiospecific troponins (also referred to as ctnI and ctnT) are normally practically not contained in the blood.

When the myocardium is damaged, cardiac troponins I and T enter the bloodstream in large quantities. The amount of troponins in the blood directly depends on the extent of myocardial damage. The most sensitive and specific for damage to the heart muscle is troponin I. This test is useful in deciding the management of patients with acute coronary syndrome, including patients with unstable angina. In acute coronary syndrome, elevated levels of troponin-I are regarded as a sign of myocardial ischemia due to activation and aggregation of platelets, leading to necrosis. Elevated troponin-I levels in patients with unstable angina indicate an unfavorable prognosis and risk of myocardial infarction in the next 4-6 weeks.

 The concentration of cardiac troponins in the blood increases in 3-4 hours after the onset of the attack (reach a diagnostically significant level in the blood of patients 6 h after the onset of symptoms) and their elevated level persists for 7-14 days, making them convenient for late diagnosis IM. The peak concentration of troponin-I is observed at 14-20 hours after the onset of chest pain, 7 hours after the development of acute myocardial infarction

myocardial troponin-I concentration is increased in 95% of patients.

Troponins are also suitable for late diagnosis, when the concentration in the blood of other cardiac markers is already returning to normal. In addition, knowing the concentration of troponin, you can not only diagnose a heart attack, but also with a high probability to predict the risk of its occurrence, as well as to assess the chances of survival of a patient who suffered a heart attack. A single determination of troponin in the blood is not always sufficient for a reliable diagnosis.

Interpretation of resultsReference values, ng / ml - To0,16 In most cases, troponin-I in the blood is not detected. In healthy people with a positive reaction to troponin in 98% of cases, its level is below 1 μg / liter. The results of the determination of troponin-I should be used in combination with data from clinical observations and studies of other markers of myocardial damage. Recommended serial studies of troponin-I to identify characteristic of myocardial infarction growth and decline in its level

Increased levels: • myocardial infarction • heart trauma, heart surgery • myocardial damage after percutaneous transluminal coronary angiography, defibrillation and other cardiac manipulations • recent unstable angina (slight increase in concentration) • non-ischemic dilamathocytocytosis;); • myocarditis; • heart transplant rejection; • sepsis and other critical (shock) conditions; • end-stage renal disease; • Duchenne-Becker myodystrophy; • DIC syndrome

Moderate increase in troponin can also occur in lesions of non-ischemic etiology: • cardiac or renal decompensated failure (acute or chronic diseases), • hypotension, hypertension, cardiac arrhythmias, myocarditis, severe pericarditis, • pulmonary embolism, • acute stroke

Increase: cytostatics, cardiac glycosides

LACTATE DEHYDROGENASE

Lactate dehydrogenase (LDH) is a glycolytic intracellular enzyme that reversibly catalyzes the cleavage of hydrogen from a lactic acid molecule (oxidation of L-lactate to pyruvic acid), used in clinical practice for four decades. LDH has five iso-enzymes. The heart muscle contains mainly the isoenzyme LDH-1. LDH-1 has been found in the kidneys, myocardium, skeletal muscle, brain, liver, stomach and lungs, so an increase in LDH is not always associated with myocardial necrosis and limited role in diagnosis in the absence of correlation with clinical data and other laboratory studies.

Although LDH increase is not specific, this test is used to diagnose myocardial or pulmonary infarction. In MI, the duration of elevated LDH levels is longer than in other enzymes, which is especially valuable for late diagnosis. The increase in LDH activity is observed in 8-10-14 hours after the onset of the pathological process, after 48-72 hours the maximum activity is reached, and it remains increased for 10 days (returns to normal on the 7-14th day of illness). These terms may vary depending on the size of the damaged muscle.

Reference values,

Units / children. 4-20 days of life: 225.0-600.0; 20 days of life - 2 years: up to 430.0; 2-15 years: 120,0-300,0.Women: 135,0-214,0.Men: 135,0-225,0

Recalculation coefficient U / l x 0,0167 = mkat /

lIncrease • Exercise, skin diseases , neonatal period • Acebutolol, anesthetics, azlocillin, cephalosporins, dicoumarol, ethanol, filgrastim, fluorouracil, heparin, imipramine, interferon, isotretinoin, ketoconazole, labetalol, methotrexate, diproprolout, metoprolol, (low doses).

Raising the level

• Myocardial infarction • Pulmonary infarction, pulmonary embolism • Congestive heart failure • Liver pathology (cirrhosis, alcoholism, acute viral hepatitis) • Blood diseases (megaloblastic, hemolytic anemia, acute leukemia, lymphomas) • Malignant neoplasms; kidney (renal infarction) • muscle disease (dystrophy, trauma) • acute pancreatitis • hypothyroidism • convulsive syndrome • alcoholic delirium • shock (hypoxia, hypotension, hyperthermia) • fractures • infectious mononucleosis

ASPARTAMATINOTRANSFERASE

Aspartate aminotransferase (AST) is an enzyme representative of the class of transaminases. AST is involved in amino acid metabolism, which is carried out in all metabolically active cells. AST is present in the tissues of the myocardium, liver, skeletal muscle, kidneys, pancreas, brain, spleen. The sharpest changes in the activity of ACT are observed in heart muscle damage and liver disease. An important indicator is the ratio of ACT / ALT activity (de Ritis coefficient), its value should be calculated only with increased activity of one or both enzymes. An increase in the coefficient of more than 1.4 is observed in cirrhosis, severe alcoholic and toxic liver damage, which is evidence of deep necrosis of hepatocytes. In uncomplicated viral hepatitis or non-alcoholic liver disease, the value of the coefficient is less than 1.0. In myocardial infarction, ALT activity increases slightly, so the de Ritis coefficient increases sharply.

Indications for appointment-
Diagnosis and differential diagnosis of MI and other diseases of the heart muscle-liver pathology-muscle pathology-donor examination
Reference values, IU / l Men: up to 40.0. Women: up to 32.0
Raising the level
Myocardial infarction
-liver disease (acute viral, toxic hepatitis, liver injury, chronic liver disease) (chronic active hepatitis, cirrhosis)
-obstructive bile duct obstruction-septic conditions
-cardiac surgery
-rhabdomyolysis-alcohol abuse-infectious mononucleosis diseases of the biliary tract
Decrease in level
-Severe necrotic liver damage, liver rupture, in patients undergoing renal dialysis, chronic vitamin B6 deficiency (malnutrition, alcohol intake)
 - pregnancy

CHAPTER 5. PALPATION OF THE THYROID GLAND

Palpation: Anterior Approach

The patient is examined in the seated or standing position.

1. Attempt to locate the thyroid isthmus by palpating between the cricoid cartilage and the suprasternal notch.
2. Use one hand to slightly retract the sternocleidomastoid muscle while using the other to palpate the thyroid.
3. Have the patient swallow a sip of water as you palpate, feeling for the upward movement of the thyroid gland.

Palpation: Posterior Approach

1. The patient is examined in the seated or standing position.
2. Standing behind the patient, attempt to locate the thyroid isthmus by palpating between the cricoid cartilage and the suprasternal notch.
3. Move your hands laterally to try to feel under the sternocleidomstoids for the fullness of the thyroid.
4. Have the patient swallow a sip of water as you palpate, feeling for the upward movement of the thyroid gland.

Note: This traditional technique is based on physiological reasoning; data of effectiveness is lacking

Nodules: Examination of the thyroid for nodularity

1. The location of the thyroid is identified by inspection.
2. Using the anterior or posterior approach, palpate the thyroid to identify nodules
3. Note the size and number of nodules.
4. Note the consistency of the nodule.
5. Palpate regional lymph nodes for consistency and mobility.

Findings in Thyroid Disease

Thyroid Enlargement

1. **Diffuse Enlargement**: isthmus and lateral lobes, no nodules. Grave's disease, Hashimoto's thyroiditis, endemic goiter
2. **Single node**: Cyst, benign tumor, false positive (only one nodule of multinodular goiter detected). Elevates index of suspicion for malignancy.
    1. Assess for risk factors: radiation exposure, hardness, rapid growth, fixation to surrounding tissue, cervical LAD, male, others.
3. **Multinodular Goiter** (iodine deficiency)
    ### According to the World Health Organization (WHO) classification:
- **Grade 0**: no goiter is palpable or visible.
- **Grade 1**: palpable goiter, not visible when neck is held in normal position
- **Grade 2**: a clearly swollen neck (also visible in normal position of the neck) that is consistent with a goiter on palpation

* A thyroid gland will be considered goitrous when each lateral lobe has a volume greater than the terminal phalanx of the thumbs of the subject being examined

Structure of the gland:

> **Soft** in Graves Disease and may have bruit.
>
> **Firm** in Hashimoto's thyroiditis, malignancy, & benign and malignant nodules.
>
> **Tender** in thyroiditis.

Systolic or continuous bruit may be heard over lateral lobes in hyperthyroidism.

CHAPTER 6. PERIPHERAL ARTERIAL EXAMINATION

The popliteal artery passes vertically through the deep portion of the popliteal space just lateral to the midplane. It may be difficult or impossible to palpate in obese or very muscular individuals. Generally this pulse is felt most conveniently with the patient in the supine position and the examiner's hands encircling and supporting the knee from each side. The pulse is detected by pressing deeply into the popliteal space with the supporting fingertips. Since complete relaxation of the muscles is essential to this examination, the patient should be instructed to let the leg "go limp" and to allow the examiner to provide all the support needed.

The *posterior tibial artery* lies just posterior to the medial malleolus. It can be felt most readily by curling the fingers of the examining hand anteriorly around the ankle, indenting the soft tissues in the space between the medial malleolus and the Achilles tendon, above the calcaneus. The thumb is applied to the opposite side of the ankle in a grasping fashion to provide stability. Again, obesity or edema may prevent successful detection of the pulse at the location.

The *dorsalis pedis artery* is examined with the patient in the recumbent position and the ankle relaxed. The examiner stands at the foot of the examining table and places the fingertips transversely across the dorsum of the forefoot near the ankle. The artery usually lies near the center of the long axis of the foot, lateral to the extensor hallucis tendon but it may be aberrant in location and often requires some searching. This pulse is congenitally absent in approximately 10% of individuals.
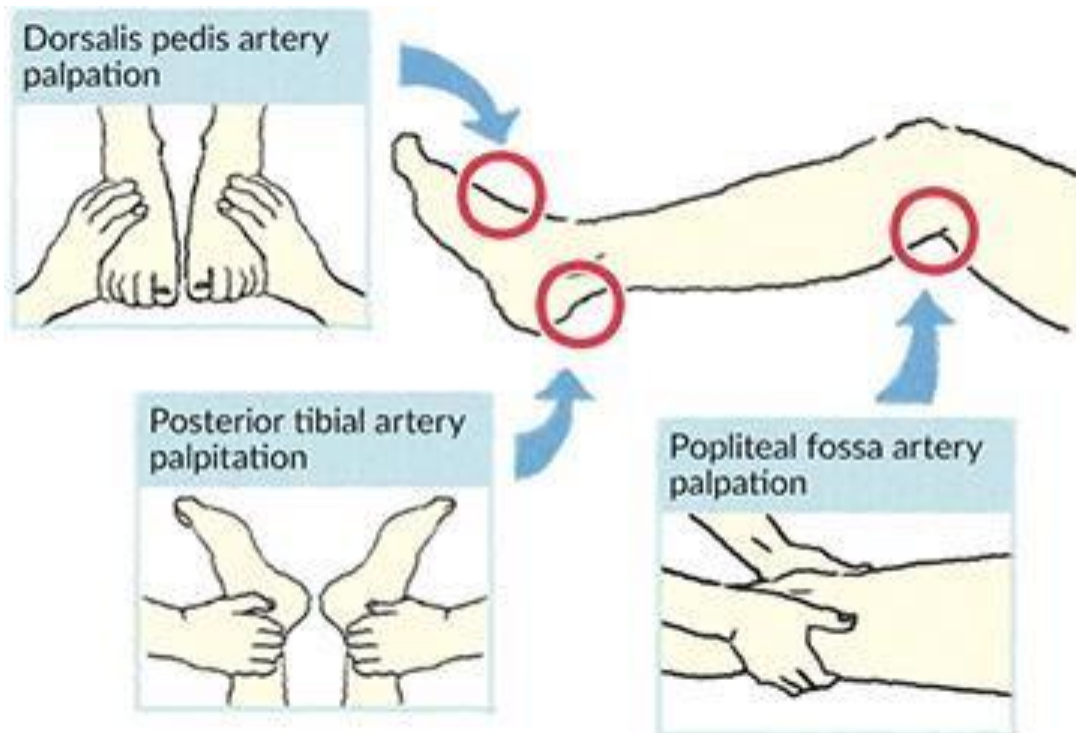
Supervisor: Shukichi Sakaguchi (Hamamatsu University school of medicine)

CHAPTER 7. DIABETIC PERIPHERAL NEUROPATHY (DPN) EXAMINATION

Ankle reflex test

While reflex tests are a conventional clinical examination in neurology, it is most common to test only ankle reflexes in the assessment of DPN. The test is performed at both ankles. With the patient sitting or lying, the examiner dorsiflexes the foot and gently strikes the Achilles tendon with the reflex hammer. In the absence of reflex, the test can be repeated with reinforcement. Reflexes are typically scored as zero (absent with reinforcement), one (present but decreased), two (normal), three (increased), or four (increased with clonus).

Touch sensation test

Semmes‐Weinstein monofilament test (SWMT)

The SWMT is a common screening tool for assessing the sensory function and the loss of pressure sensation (light touch perception). The size of the monofilament includes 0.5 g, 2 g, 10 g, 50 g, 200 g and other various types, which indicate the magnitude of the force on the monofilament when the monofilament is just bent. A 10 g monofilament test (also referred to the 5.07 monofilament) is the most common in practice.

During the monofilament examination, patients should close their eyes, and then the examiner will select the appropriate locations (1st, 3rd, and 5th metatarsal heads and plantar surface of distal hallux recommended; areas of callus avoided), use the required force, and ask patients to answer "yes" or "no" to indicate whether they feel the monofilament and to report the correct sites as well. The answer "no" suggests anaphia of the site in this strength. The examiner can also apply a rapid threshold test to grade the anaphia
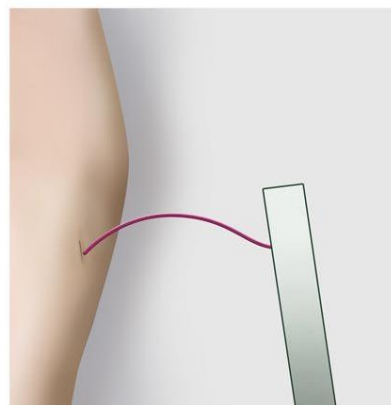
Neuropen

The Neuropen combines an interchangeable 10 g monofilament for cutaneous pressure assessment, and a calibrated sterile Neurotip for assessing pain sensation. The operation of the 10 g monofilament in the Neuropen is similar to that of SWMT.

To assess pressure perception, the Neuropen monofilament should be pressed against the skin surface until it is buckled. The monofilament can be performed twice in random order on the plantar surface of each hallux and also the 1st, 2nd, 3rd and 5th metatarsal heads which are areas that most frequently ulcerate in diabetic patients as a result of high pressure loading. The monofilament should be held in place for two seconds and then be removed. The patient is requested to affirm when a stimulus is felt.

Ipswich touch test (IpTT)

As a simple, quick, and easily taught procedure, IpTT has been developed recently to screen DPN with the initial purpose of simplifying touch sensation test from SWMT. The fact that IpTT necessitates little training may facilitate care assistants and nurses to obtain immediate feedback as to which patients require protection.

The IpTT involves lightly touching/resting the tip of the index finger for one to two seconds on the tips of the 1st, 3rd, and 5th toes and the dorsum of the hallux in both feet. Diabetic peripheral neuropathy (DPN) can be defined as ≥ 2 insensate of the eight sites. The other procedure is to test only the 1st, 3rd, and 5th toes and neuropathy can be defined as ≥ 2 insensate of the six sites. Examiners should not push, prod, tap, or poke because this may elicit a sensation other than light touch. With eyes closed, patients indicate whenever they feel the touch.
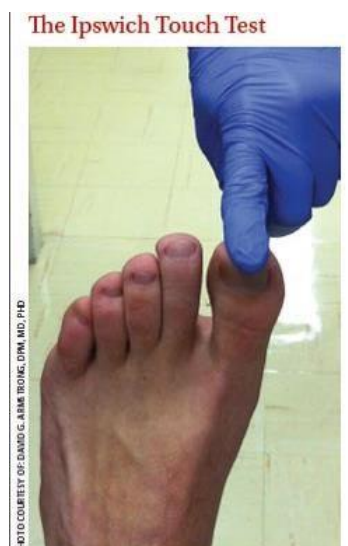
Vibratory sensation test

128‑Hz standard tuning fork

As an easy and traditional way to test vibratory sensation, the 128‑Hz standard (non‑graduated) tuning fork is a tool of screening for DPN. An abnormal response is identified when the tested patients fail to perceive the vibration sensation while the examiner can. There are two general methods: on‑off method and timing method.

In the on‑off method the 128‑Hz tuning fork is bilaterally applied to the bony prominence situated at the dorsum of the first toe proximal to the nail bed. The test is conducted twice on each toe and the patients are asked to report the perception of both the start and the cessation of the vibration. The vibration testing threshold is defined as the total number of times the application of the vibrating tuning fork and the dampening of vibration is not felt, with scores varying between zero and eight.

The operation of timing method is similar to that with the on‑off method, but patients examined are asked to report the time at which vibration diminished beyond perception. The tuning fork is also applied to the dorsal aspect of the distal phalanx of the examiner's thumb. The time (in seconds) at which vibration sensation diminished beyond both patients' and examiner's perception is then recorded. DPN could be defined according to the difference between the time indicated by the patient and the examiner.

Graduated tuning fork

Unlike the standard tuning fork with limited capability to determine only the presence or absence of vibration perception, the graduated 128‑Hz tuning fork (Rydel‑Seiffer tuning fork) is able to determine the ability of patients to discriminate different vibration intensities. It relies on a threshold of vibration extinction estimated by the intersect between two virtual triangles that move exponentially on a scale from 0 to 8. In general practice, most physicians would rate a tuning fork vibration perception threshold of lower than four as abnormal.

The difference of the graduated tuning fork from the standard one is that the vibration extinction threshold can be estimated as the intersection of two virtual triangles that moves on a scale from zero to eight which represents different vibration intensities from the strong to the weak. This intersection point moves from zero to eight in an exponential way. The graduated tuning fork is applied bilaterally to the test site (for example, the distal phalange of the big toes). Patients are requested to respond when they can no longer feel the vibration. At this time, the vibration threshold is determined on the nine‑point grading scale (0/8–8/8) of the tuning fork.

1. TAP THE TUNING FORK TO CREATE VIBRATION

2. APPLY BASE OF THE TUNING FORK TO A BONE ON THE TIP OF THE GREAT TOE

3. ASK THE PATIENT TO TELL YOU WHERE THE VIBRATION STOPS

4. CONFIRM

VibraTip

VibraTip is a pocket sized, wipe clean device to test vibration perception for routine screening of DPN. The product can overcome the limitations of using tuning forks by using a vibrating motor which provides consistent frequency and amplitude to allow a consistent intensity of vibration without pressure, coldness and sound. When activated, it provides a stimulus of 128 Hz.. VibraTip can be applied to the toe from any angle facilitating ease of testing, and can be magnetically attached to a specially designed neck lanyard facilitating ease of access.

The device should be held firmly to the hallux and placed very gently against the patient's skin twice, each time for half to a second, explaining that 'this is touch one' and 'this is touch two'. VibraTip is randomly activated on either the first or second touch and the patients with their eyes closed are asked to indicate which of the touches is associated with vibration.

Figure 2. VibraTip is a key fob sized device (a) which is used to assess sensitivity to vibration (b)

(a) VibraTip

Reproduced courtesy of Danny O'Connell, McCallan Medical

(b) Use of VibraTip to assess vibration sense

Reproduced courtesy of Professor Andy Levy, University of Bristol

Electromechanical instruments for testing vibration perception thresholds (VPT)

Electromechanical instruments for VPT include Biothesiometer, Neurothesiometer, Maxivibrometer, Vibrameter, Vibratron and the CASE IV system used on the basis of method of limits or method of levels (also called 'forced choice'). An average of three readings is recorded commonly from a test site (for example, at the end of the great toe). VPT cut‑off scores indicative of high or low risk for long‑term complications vary by the type of equipment utilised. Because of their ability to measure lower VPTs than a tuning fork, electromechanical devices have been

recommended for community screening and routine clinical use, but the their expense can be higher.

To test the sensory threshold, algorithms have been developed and generally can be described as methods of limits and methods of levels. As to the former, the patient should indicate when first feeling an increasing stimulus or no longer feeling a decreasing stimulus. With the latter method, also known as the 'forced choice' algorithm, the participants should report whether the stimulus with a specific level is perceived. For most tests, cut‑offs have been determined for the discrimination between normal and abnormal perception. VPT is usually performed with the Biothesiometer, Neurothesiometer, Maxivibrometer and Vibrameter using the method of limits, while the Vibratron and CASE IV System are used in 'forced choice' protocol.

As the Biothesiometer is quick, portable and relatively inexpensive, it is beneficial for clinical screening of DPN). The biothesiometer probe can vibrate at an amplitude proportional to the square of the applied voltage. After patients are initially familiarised with the sensation by holding the probe against the distal palmar surface of hand, the probe is applied perpendicular to the distal plantar surface of great toe of both the legs. The voltage slowly increases at the rate of 1 mV/sec and the VPT value can be defined as the voltage level when the patient indicates that he or she first feels the vibration sense. The mean of three records is taken and neuropathy can be diagnosed if the VPT is ≥ 25 mV
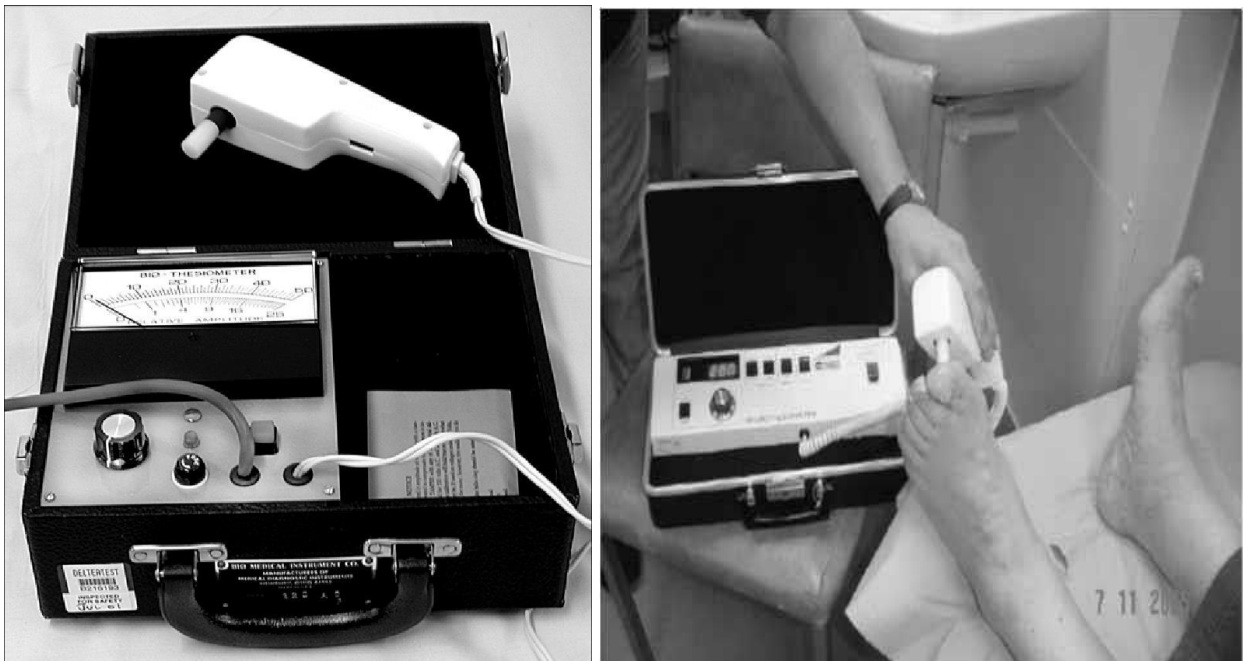
Tactile circumferential discriminator (TCD)

The TCD is a new, portable sensory testing device used for a two‑point discrimination test which can reflect large‑fibre nerve function (two‑point discrimination). The device consists of a handheld disc with eight protruding rods of increasing circumference (numbered zero through seven). Rod zero rod is 12.5 mm in diameter, and rod seven is 40 mm. Scores are denoted as the lowest number of rods a patient can discriminate from rod zero and this is the threshold value of the TCD test. A score of six or higher is significantly correlated with neuropathy

The tactile discrimination threshold is assessed with the TCD. The tested site can be the plantar aspect of the great toe. Stimuli with different circumference are presented and participants are asked to discriminate them. According to the standard procedure, first the smallest rod (0) is presented followed by the largest (7), with a standard contact time of two seconds. Then an ascending and descending method of stimulus presentation and a two‑alternative forced‑choice response procedure will be used to determine the ability to discern the smallest difference. Scores are denoted as the lowest number of rods a patient can discriminate from rod (0) and this is

the threshold value of the TCD test. For example, if the patient can only discern rods (5), (6), and (7) from (0), a score of five will be denoted. A score of six or higher is significantly correlated with neuropathy.
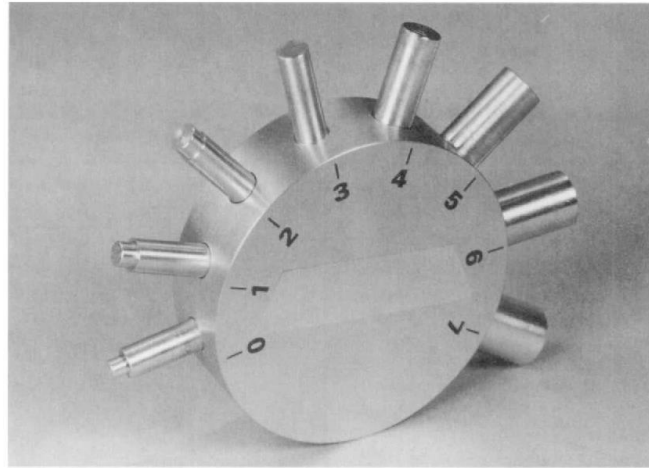
CHAPTER 8. LIFE STYLE MODIFICATION RECOMMENDATIONS IN ENDOCRINOLOGY

The recommended lifestyle interventions include:
- Taking two and a half hours each week of moderate intensity physical activity or one hour and 15 minutes of high intensity exercise.
- Losing weight gradually to achieve a healthy body mass index
- Replacing refined carbohydrates with wholegrain foods and increase intake of vegetables and other foods high in dietary fibre
- Reducing the amount of saturated fat in the diet

Goals of Nutrition Therapy for Adults With Diabetes

1. To promote and support healthful eating patterns, emphasizing a variety of nutrient-dense foods in appropriate portion sizes, in order to improve overall health and specifically to:
   ○ Achieve and maintain body weight goals
   ○ Attain individualized glycemic, blood pressure, and lipid goals
   ○ Delay or prevent the complications of diabetes
2. To address individual nutrition needs based on personal and cultural preferences, health literacy and numeracy, access to healthful foods, willingness and ability to make behavioral changes, and barriers to change
3. To maintain the pleasure of eating by providing nonjudgmental messages about food choices
4. To provide an individual with diabetes the practical tools for developing healthy eating patterns rather than focusing on individual macronutrients, micronutrients, or single foods

Weight Management

In overweight and obese patients with type 2 diabetes, modest weight loss, defined as sustained reduction of 5% of initial body weight, has been shown to improve glycemic control and to reduce the need for glucose-lowering medications. Weight loss can be attained with lifestyle programs that achieve a 500–750 kcal/day energy deficit or provide ∼1,200–1,500 kcal/day for women and 1,500–1,800 kcal/day for men, adjusted for the individual's baseline body weight. For many obese individuals with type 2 diabetes, weight loss >5% is needed to produce beneficial outcomes in glycemic control, lipids, and blood pressure, and sustained weight loss of ≥7% is optimal.

Physical activities

- Children and adolescents with type 1 or type 2 diabetes or prediabetes should engage in 60 min/day or more of moderate- or vigorous-intensity aerobic activity, with vigorous muscle-strengthening and bone-strengthening activities at least 3 days/week.
- Most adults with with type 1 and type 2 diabetes should engage in 150 min or more of moderate-to-vigorous intensity physical activity per week, spread over at least 3 days/week, with no more than 2 consecutive days without activity. Shorter durations (minimum 75 min/week) of vigorous-intensity or interval training may be sufficient for younger and more physically fit individuals.
- Adults with type 1 and type 2 diabetes should engage in 2–3 sessions/week of resistance exercise on nonconsecutive days.
- All adults, and particularly those with type 2 diabetes, should decrease the amount of time spent in daily sedentary behavior. Prolonged sitting should be interrupted every 30 min for blood glucose benefits, particularly in adults with type 2 diabetes.

- Flexibility training and balance training are recommended 2–3 times/week for older adults with diabetes. Yoga and tai chi may be included based on individual preferences to increase flexibility, muscular strength, and balance.

Smoking cessation

Recommendations
- Advise all patients not to use cigarettes and other tobacco products or e-cigarettes.
- Include smoking cessation counseling and other forms of treatment as a routine component of diabetes care.

Psychosocial issues

Recommendations
- Psychosocial care should be integrated with a collaborative, patient-centered approach and provided to all people with diabetes, with the goals of optimizing health outcomes and health-related quality of life.
- Psychosocial screening and follow-up may include, but are not limited to, attitudes about the illness, expectations for medical management and outcomes, affect or mood, general and diabetes-related quality of life, available resources (financial, social, and emotional), and psychiatric history.
- Providers should consider assessment for symptoms of diabetes distress, depression, anxiety, disordered eating, and cognitive capacities using patient-appropriate standardized and validated tools at the initial visit, at periodic intervals, and when there is a change in disease, treatment, or life circumstance. Including caregivers and family members in this assessment is recommended.
- Consider screening older adults (aged ≥65 years) with diabetes for cognitive impairment and depression.

Diabetes Distress

Recommendation
- Routinely monitor people with diabetes for diabetes distress, particularly when treatment targets are not met and/or at the onset of diabetes complications.

CHAPTER 9. BLOOD GLUCOSE MEASURING WITH GLUCOMETER

Key Characteristics of Different Types Glucose Meters

Size:

The average size of Glucose Meters is now approximately the size of the palm of the hand, although hospital meters can be the size of remote control. They are powered by the battery and hence called the battery-powered.

Test strips:

Test Strip is a consumable element that contains chemicals that react with glucose in the drop of blood is used for each measurement. For some models, it is a plastic test strip with a small spot impregnated with glucose oxidase and other components. Each strip can be used only once and then discarded. Instead of strips, some models use discs, drums, or cartridges that contain the consumable material for multiple tests.

Coding:

Since test strips may be different from batch to batch, some models require the user to manually enter a code found on the vial of test strips or on a chip that comes with the test strip. By entering the coding or chip into the glucose meter, the meter will be calibrated to that batch of test strips. However, if this process is carried out incorrectly, the meter reading can be up to 4 mmol/L (72 mg/dL) inaccurate.

The implications of an incorrectly coded meter can be serious for patients actively managing their diabetes. This may place patients at an increased risk of hypoglycemia. Alternatively, some test strips contain the code information in the strip; others have a microchip in the vial of strips that can be inserted into the meter. These last two methods reduce the possibility of user error. One-Touch has standardized their test strips around a single code number, so that, once set, there is no need to further change the code in their older meters, and in some of their newer meters, there is no way to change the code.

The volume of blood sample:

The blood drop size needed by different models varies from 0.3 to 1 μl. (Older models required larger blood samples, usually defined as a "hanging drop" from the fingertip.) Smaller volume requirements reduce the frequency of unproductive pricks.

Alternate site testing:

Smaller drop volumes have enabled "alternate site testing" – pricking the forearms or other less sensitive areas instead of the fingertips. This type of testing should only be used when blood glucose levels are stable, such as when before meals, when fasting, or just before going to sleep.

Testing times:

The times it takes to read a test strip may range from 3 to 60 seconds for different models.

Display:

The glucose value in mg/dl or mmol/l is displayed on a digital display. The preferred measurement unit varies by country: mg/dl are preferred in the US, France, Japan, Israel, and India. mmol/l is used in Canada, Australia, and China.

Germany is the only country where medical professionals routinely operate in both units of measure. (To convert mmol/l to mg/dl, multiply by 18. To convert mg/dl to mmol/l, divide by 18.)

Glucose vs. plasma glucose:

Glucose levels in plasma are higher than glucose measurements in whole blood; the difference is about 11% when the hematocrit is normal. This is important because home blood glucose meters measure the glucose in whole blood while most lab tests measure the glucose in plasma. Currently, there are many meters on the market that give results as "plasma equivalent," even

though they are measuring whole blood glucose. The plasma equivalent is calculated from the whole blood glucose reading using an equation built into the glucose meter. This allows patients to easily compare their glucose measurements in a lab test and at home. It is important for patients and their health care providers to know whether the meter gives its results as "whole blood equivalent" or "plasma equivalent." One model measures beta-hydroxybutyrate in the blood to detect ketosis for measuring both unhealthy ketoacidosis and healthy nutritional ketosis.

Clock/memory:

Most meters now include a clock that is set by the user for date and time and a memory for past test results. The memory is an important aspect of diabetes care, as it enables the person with diabetes to keep a record of management and look for trends and patterns in blood glucose levels over days and weeks. Most memory chips can display an average of recent glucose readings. A known deficiency of all current meters is that the clock is often not set to the correct time (i.e., due to time changes, static electricity, etc.) and therefore has the potential to misrepresent the time of the past test results making pattern management difficult.

Data transfer:

Many meters now have more sophisticated data handling capabilities. Many can be downloaded by a cable or infrared to a computer that has diabetes management software to display the test results. Some meters allow entry of additional data throughout the day, such as insulin dose, amounts of carbohydrates eaten, or exercise. A number of meters have been combined with other devices, such as insulin injection devices, PDAs, cellular transmitters, and Game Boys. A radio link to an insulin pump allows automatic transfer of glucose readings to a calculator that assists the wearer in deciding on an appropriate insulin dose.

<p align="center">Types of Glucose Meters</p>

Hospital glucose meters

One of the best types of Special glucose meters for multi-patient hospital use now come in trend and use. Hospital Glucose Meter provides more elaborate quality control records, The data handling capabilities of these Glucose Meter are designed to transfer glucose results into electronic medical records and the laboratory computer systems for billing purposes.

Point-of-Care Blood Glucose Meter

POC testing is a widely used tool to enable immediate determination of glucose levels in hospitalized patients and facilitate rapid treatment decisions in response to fluctuations in glycemia.

Noninvasive meters

Non-invasive glucose monitoring refers to the measurement of blood glucose levels (required by people with diabetes to prevent both chronic and acute complications from the disease) without drawing blood, puncturing the skin, or causing pain or trauma. The search for a successful technique began about 1975 and has continued to the present without a clinically or commercially viable product. As of 1999, only one such product had been approved for sale by the FDA, based on a technique for electrically pulling glucose through intact skin, and it was withdrawn after a short time owing to poor performance and occasional damage to the skin of users.

Continuous glucose monitors

A continuous glucose monitor (CGM) is a device used for monitoring blood glucose on a continual basis by people with either type I or type II diabetes. It takes a reading on set intervals with a small electrode placed under the skin and held in place by an adhesive. A transmitter attached to the electrode sends data to a separate receiver.

Fingerprick testing of blood glucose levels measures the level at a single point in time. CGM use allows trends in blood glucose to be displayed over time. Users must calibrate CGM devices with traditional blood glucose measurements.

A limitation of the CGM system is that glucose levels are taken from the interstitial fluid rather than the blood. As it takes time for glucose to travel from the bloodstream into the interstitial fluid, there is an inherent lag behind the current blood glucose level and the level measured by the CGM. This lag time varies based on the person and the device and is generally 5–20 minutes.

Checking glucose level with Point-of-Care Blood Glucose Meter

You will need:

- Blood glucose monitor
- Test strips (check that they are in date and have not been exposed to the air)
- Alcohol swab
- Single-use safety lancets or lancing device
- Gloves
- Cotton wool/gauze
- Sharps box
- Control solution for calibration

Method

Apply these general principles when using the different types of electronic blood glucose meters available.

- Ask the patient to sit down and explain what you are going to do.
- Wash your hands and put on gloves.
- Choose the site for the blood sample: usually the side of a finger, but the arm or thigh may be used (change the site used if frequent measurements are needed).
- Use an alcohol swab to clean the site and let the alcohol dry.
- Insert the test strip into the monitor, following the instructions.

- Use a single-use lancet or a lancing device to draw blood and dispose of it in a sharps container.

- Apply the blood to the testing strip in the correct way: some strips need the blood drop to be over the whole of the test pad and some suck up the blood directly from the site of the bleeding.

- Place the alcohol swab (note: it will sting) ora piece of gauze over the site and hold it there, or let the patient hold it there until the bleeding stops. Monitor for excess bleeding.
- Read and record the result, reporting and/or responding to abnormal readings.
- Tell the patient what the result is, explain it and discuss options.
- Dispose of all used equipment safely, in line with hospital or health care policies.

Calibrating the blood glucose monitor

- Calibrate the monitor and each new pack of test strips together.
- Calibrate the monitor each week.
- Place the control solution on a test strip and check that the value shown on the monitor matches the value on the bottle (or the pack of strips it accompanies). Record the calibration readings.
- If one is provided, use the check strip to make sure that the meter is working.

Preventing sore fingertips

Frequent and repeated testing can cause sore fingertips. Here are a few suggestions that may help prevent this:

- Don't reuse a lancet. They can become dull, which may make pricking your finger more painful.
- Be sure to prick the side of your finger, not the pad. Pricking the end of your finger can be more painful.
- Though it may be a tempting way to produce more blood quickly, don't squeeze your fingertip vigorously. Instead, hang your hand and arm down, allowing blood to pool in your fingertips. In addition:
  - You can help increase blood flow by washing your hands with warm water.
  - If you still have too little blood, you can squeeze your finger, but start at the part closest to your palm, and work your way down your finger until you have enough.
  - Don't test on the same finger each time. As part of your routine, establish which finger you'll use and when. This way, you'll never repeat testing on the same finger during the same day.
  - If a finger becomes sore anyway, avoid prolonging the pain by not using it for several days. Use a different finger if possible.

- o If you have chronic finger pain as a result of testing, see your doctor about changing glucose monitors. Some monitors can use blood drawn from other parts of your body.

CHAPTER 10. CALCULATION OF BODY MASS INDEX (BMI)

Body Mass Index is a simple calculation using a person's height and weight.

The formula is BMI = kg/m^2

where kg is a person's weight in kilograms and m^2 is their height in metres squared.

BMI is **NOT USED** for muscle builders, long distance athletes, pregnant women, the elderly or young children. This is because BMI does not take into account whether the weight is carried as muscle or fat, just the number. Those with a higher muscle mass, such as athletes, may have a high BMI but not be at greater health risk. Those with a lower muscle mass, such as children who have not completed their growth or the elderly who may be losing some muscle mass may have a lower BMI. During pregnancy and lactation, a woman's body composition changes, so using BMI is not appropriate.

Under weight	Normal weight	Over weight	Obese (Class I)	Obese (Class II)	Obese (Class III)
<18.5	18.5 – 24.9	25.0 – 29.9	30.0 – 34.9	35.0 – 39.9	>40.0

CHAPTER 11. LAB TESTS INTERPRETATION IN DIABETES MELLITUS

Fasting Blood Sugar Test

This measures patient`s blood sugar after an overnight fast (not eating). A fasting blood sugar level of 99 mg/dL or lower is normal, 100 to 125 mg/dL indicates a patient has prediabetes, and 126 mg/dL or higher indicates diabetes.

A1C Test

The A1C test measures patient`s average blood sugar level over the past 2 or 3 months. An A1C below 5.7% is normal, between 5.7 and 6.4% indicates is prediabetes, and 6.5% or higher means diabetes.

Oral Glucose Tolerance Test (OGTT)

This measures patient`s blood sugar before and after you drink a liquid that contains glucose. A patient is fast (not eat) overnight before the test and have blood drawn to determine fasting blood sugar level. Then a patient will drink the liquid and have blood sugar level checked 1 hour, 2 hours, and possibly 3 hours afterward. At 2 hours, a blood sugar level of 140 mg/dL or lower is considered normal, 140 to 199 mg/dL means prediabetes, and 200 mg/dL or higher means diabetes.

Indications for a OGTT:

- Considered overweight or obese (body mass index > 25)
- Who have one or more additional risk factors for diabetes
- Asian Americans with a body mass index > 23 who have one or more additional risk factors for diabetes.
- The ADA also recommends screening overweight and obese adults without additional risk factors beginning at age 45. On the other hand, the United States Preventive Services Task Force recommends screening all overweight and obese individuals ages 40-70 for abnormal blood glucose levels.

The OGTT is done in several steps. These steps differ depending on whether the test is being used to screen for type 2 diabetes or gestational diabetes.

Using the oral glucose tolerance test to screening for type 2 diabetes

Screening for type 2 diabetes takes a little over two hours.

1. In the days leading up to the test, you should continue to eat your typical diet. You should also discuss with your healthcare provider if there are any medications you are taking that may interfere with the results of the test (for example, corticosteroids).
2. At least eight hours before the test, you should begin fasting. Fasting means you do not eat or drink anything except for water. Because you are fasting, this test is typically done in the morning. If you do ingest something within 8 hours of the test, your healthcare provider will not know how to interpret the results.
3. When the test begins, a blood sample is drawn to check your fasting blood sugar level.
4. You are given an oral dose of glucose. This typically comes as a syrupy glucose solution that you drink (a dose of 75g of glucose is typically given).
5. After two hours have passed, a second blood sample is drawn to check your blood sugar level.
6. When the results are available, your healthcare provider interprets them.

Test results of the OGTT as a screen for type 2 diabetes can be interpreted as the following:

- 2-hour blood sugar level <140 mg/dL is considered normal

- 2-hour blood sugar level 140-199 mg/dL indicates you may have prediabetes (sometimes referred to as impaired fasting glucose)
- 2-hour blood sugar level ≥200 mg/dL indicates you may have diabetes

For a diagnosis to be made, the test needs to be repeated on another day shortly afterward, which yields similar results. Alternatively, a diagnosis can be confirmed using one of the other screening tests. A single abnormal OGTT is not sufficient for the diagnosis of diabetes or prediabetes.

Using the oral glucose tolerance test to screening for gestational diabetes

It is recommended that women who are 24–28 weeks pregnant get screened for gestational diabetes, which is diabetes that occurs during pregnancy. While some use the 2-hour OGTT, the American College of Obstetricians and Gynecologists recommends the following steps be done:

1. You do not need to fast before the test.
2. You are given a 50g dose of glucose orally.
3. After one hour has passed, a blood sample is drawn to check your blood sugar level.
4. When the results are available, your healthcare provider interprets them. Depending on your results, you may or may not need to progress to the next step. Different institutions have different cutoff levels. You may be told that your results are normal, that your results are sufficient for a diagnosis of gestational diabetes, or that you need to proceed to the three-hour OGTT.
5. If you proceed to this step, you undergo a three-hour OGTT during which a 100g dose of glucose is given, and additional blood samples are drawn.
6. When the results are available, your healthcare provider interprets them. Elevated levels can be diagnostic for gestational diabetes without needing to repeat the test on a different day.

What are the advantages and disadvantages of the oral glucose tolerance test?

One advantage of the OGTT is that in most populations, it is a more sensitive test than the fasting plasma glucose test and the hemoglobin A1C test (UpToDate, 2019). This means that the OGTT test is better at identifying some people who have diabetes that the other tests may miss. The test can also be adjusted depending on whether it is being used to screen for type 2 diabetes or for gestational diabetes. However, one limitation with screening for gestational diabetes is that different institutions use different cutoff values for diagnosis.

The main disadvantage of the OGTT is the inconvenience of the test. When you are being screened for type 2 diabetes, preparing for the test requires at least 8 hours of fasting. Additionally, the test is guaranteed to take at least two hours. Another issue is that a single test cannot confirm a diagnosis. To be diagnosed with diabetes or prediabetes, you need to return to your healthcare provider on a different day to repeat the test, or you have to have one of the other diabetes screening tests performed.

Random Blood Sugar Test

This measures your blood sugar at the time you're tested. You can take this test at any time and don't need to fast (not eat) first. A blood sugar level of 200 mg/dL or higher indicates you have diabetes.

Result*	A1C Test	Fasting Blood Sugar Test	Glucose Tolerance Test	Random Blood Sugar Test
Diabetes	6.5% or above	126 mg/dL or above 7.0 mmol/l or above	200 mg/dL or above 11.1 mmol/l or above	200 mg/dL or above

Result*	A1C Test	Fasting Blood Sugar Test	Glucose Tolerance Test	Random Blood Sugar Test
				11 mmol/l or above
Prediabetes	5.7 – 6.4%	100 – 125 mg/Dl 5.5 to 6.9 mmol/l	140 – 199 mg/Dl 7.8-11.1 mmol/l	N/A
Normal	Below 5.7%	99 mg/dL or below 3.9 to 5.4 mmols/l	140 mg/dL or below 7.8 mmol/l or below	N/A

*Results for gestational diabetes can differ.

CHAPTER 12. HORMONAL LABORATORY TESTS INTERPRETATION: THYROID HORMONES INTERPRETATION

- TSH (0.4 – 4 mU/L)
- Free T4 (9 – 25 pmol/L)
- Free T3 (3.5 – 7.8 nmol/L)

There are separate reference ranges for children and pregnant women.

TSH TESTS

The best way to initially test thyroid function is to measure the TSH level in a blood sample. Changes in TSH can serve as an "early warning system" – often occurring before the actual level of thyroid hormones in the body becomes too high or too low. A high TSH level indicates that the thyroid gland is not making enough thyroid hormone (primary hypothyroidism). The opposite situation, in which the TSH level is low, usually indicates that the thyroid is producing too much thyroid hormone (hyperthyroidism). Occasionally, a low TSH may result from an abnormality in the pituitary gland, which prevents it from making enough TSH to stimulate the thyroid (secondary hypothyroidism). In most healthy individuals, a normal TSH value means that the thyroid is functioning properly.

T4 TESTS

T4 is the main form of thyroid hormone circulating in the blood. A **Total T4** measures the bound and free hormone and can change when binding proteins differ (see above). A **Free T4** measures what is not bound and able to enter and affect the body tissues. Tests measuring free T4 – either a free T4 (FT4) or free T4 index (FTI) – more accurately reflect how the thyroid gland is functioning when checked with a TSH.

The finding of an elevated TSH and low FT4 or FTI indicates primary hypothyroidism due to disease in the thyroid gland. A low TSH and low FT4 or FTI indicates hypothyroidism due to a problem involving the pituitary gland. A low TSH with an elevated FT4 or FTI is found in individuals who have hyperthyroidism.

T3 TESTS

T3 tests are often useful to diagnosis hyperthyroidism or to determine the severity of the hyperthyroidism. Patients who are hyperthyroid will have an elevated T3 level. In some individuals with a low TSH, only the T3 is elevated and the FT4 or FTI is normal. T3 testing rarely is helpful in the hypothyroid patient, since it is the last test to become abnormal. Patients can be severely hypothyroid with a high TSH and low FT4 or FTI, but have a normal T3.

FREE T3

Measurement of free T3 is possible, but is often not reliable and therefore not typically helpful.

REVERSE T3

Reverse T3 is a biologically inactive protein that is structurally very similar to T3, but the iodine atoms are placed in different locations, which makes it inactive. Some reverse T3 is produced normally in the body, but is then rapidly degraded. In healthy, non-hospitalized people, measurement of reverse T3 does not help determine whether hypothyroidism exists or not, and is not clinically useful.

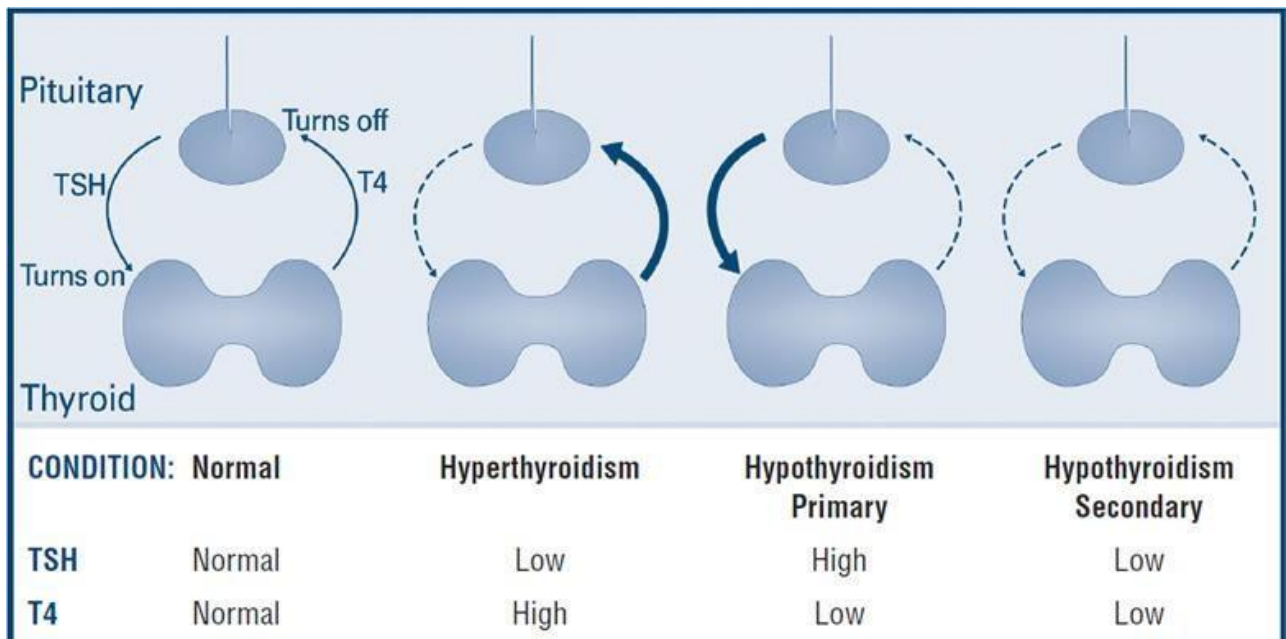THYROID ANTIBODY TESTS

The immune system of the body normally protects us from foreign invaders such as bacteria and viruses by destroying these invaders with substances called antibodies produced by blood cells known as lymphocytes. In many patients with hypothyroidism or hyperthyroidism, lymphocytes react against the thyroid (thyroid autoimmunity) and make antibodies against thyroid cell proteins.

Two common antibodies are thyroid peroxidase antibody and thyroglobulin antibody. Measuring levels of thyroid antibodies may help diagnose the cause of the thyroid problem. For example, positive anti-thyroid peroxidase and/or anti-thyroglobulin antibodies in a patient with hypothyroidism result in a diagnosis of Hashimoto's thyroiditis. While detecting antibodies is helpful in the initial diagnosis of hypothyroidism due to autoimmune thyroiditis, following their levels over time is not helpful in detecting the development of hypothyroidism or response to therapy. TSH and FT4 are what tell us about the actual thyroid function or levels.

A different antibody that may be positive in a patient with hyperthyroidism is the stimulatory TSH receptor antibody (TSI). This antibody causes the thyroid to be overactive in Graves' Disease. If you have Graves' disease, your doctor might also order a thyrotropin receptor antibody test (TSHR or TRAb), which detects both stimulating and blocking antibodies. Following antibody levels in Graves' patients may help to assess response to treatment of hyperthyroidism, to determine when it is appropriate to discontinue antithyroid medication, and to assess the risk of passing antibodies to the fetus during pregnancy.

THYROGLOBULIN

Thyroglobulin (Tg) is a protein produced by normal thyroid cells and thyroid cancer cells. It is not a measure of thyroid function and it does not diagnose thyroid cancer when the thyroid gland is still present. It is used most often in patients who have had surgery for thyroid cancer in order to monitor them after treatment. Tg is included in this brochure of thyroid function tests to communicate that, although measured frequently in certain scenarios and individuals, Tg is not a primary measure of thyroid hormone function

CONDITION:	Normal	Hyperthyroidism	Hypothyroidism Primary	Hypothyroidism Secondary
TSH	Normal	Low	High	Low
T4	Normal	High	Low	Low

Thyroid Binding Globulin

Most of the thyroid hormones in the blood are attached to a protein called thyroid binding globulin (TBG). If there is an excess or deficiency of this protein it alters the T4 or T3 *measurement* but does not affect the *action* of the hormone. If a patient appears to have normal thyroid function, but an unexplained high or low T4, or T3, it may be due to an increase or decrease of TBG. Direct measurement of TBG can be done and will explain the abnormal value. Excess TBG or low levels of TBG are found in some families as an hereditary trait. It causes no problem except falsely elevating or lowering the T4 level. These people are frequently misdiagnosed as being hyperthyroid or hypothyroid, but they have no thyroid problem and need no treatment.

TRH Test

In normal people TSH secretion from the pituitary can be increased by giving a shot containing TSH Releasing Hormone (TRH...the hormone released by the hypothalamus which tells the pituitary to produce TSH). A baseline TSH of 5 or less usually goes up to 10-20 after giving an injection of TRH. Patients with too much thyroid hormone (thyroxine or triiodothyronine) will not show a rise in TSH when given TRH. This "TRH test" is presently the most sensitive test in detecting early hyperthyroidism. Patients who show too much response to TRH (TSH rises greater than 40) may be hypothyroid. This test is also used in cancer patients who are taking thyroid replacement to see if they are on sufficient medication. It is sometimes used to measure if the pituitary gland is functioning.

Iodine Uptake Scan

A means of measuring thyroid function is to measure how much iodine is taken up by the thyroid gland (RAI uptake). Remember, cells of the thyroid normally absorb iodine from our blood stream (obtained from foods we eat) and use it to make thyroid hormone. Hypothyroid patients usually take up too little iodine and hyperthyroid patients take up too much iodine. The test is performed by giving a dose of radioactive iodine on an empty stomach. The iodine is concentrated in the thyroid gland or excreted in the urine over the next few hours. The amount of iodine that goes into the thyroid gland can be measured by a "Thyroid Uptake". Of course, patients who are taking thyroid medication will not take up as much iodine in their thyroid gland because their own thyroid gland is turned off and is not functioning. At other times the gland will concentrate iodine normally but will be unable to convert the iodine into thyroid hormone; therefore, interpretation of the iodine uptake is usually done in conjunction with blood tests.

Thyroid Scan

Taking a "picture" of how well the thyroid gland is functioning requires giving a radioisotope to the patient and letting the thyroid gland concentrate the isotope (just like the iodine uptake scan above). **Therefore, it is usually done at the same time that the iodine uptake test is performed.** Although other isotopes, such as technetium, will be concentrated by the thyroid gland; these isotopes will not measure iodine uptake which is what we really want to know because the production of thyroid hormone is dependent upon absorbing iodine. It has also been found that thyroid nodules that concentrate iodine are rarely cancerous; this is not true if the scan is done with technetium. Therefore, all scans are now done with radioactive iodine. Both of the scans above show normal sized thyroid glands, but the one on the left has a "HOT" nodule in the lower aspect of the right lobe, while the scan on the right has a "COLD" nodule in the lower aspect of the left lobe (outlined in red and yellow). Pregnant women should not have thyroid scans performed because the iodine can cause development troubles within the baby's thyroid gland.

Two types of thyroid scans are available. A camera scan is performed most commonly which uses a gamma camera operating in a fixed position viewing the entire thyroid gland at once. This type of scan takes only five to ten minutes. In the 1990's, a new scanner called a Computerized Rectilinear Thyroid (CRT) scanner was introduced. The CRT scanner utilizes computer technology to improve the clarity of thyroid scans and enhance thyroid nodules. It measures both thyroid function and thyroid size. A
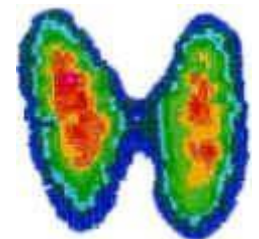
life-sized 1:1 color scan of the thyroid is obtained giving the size in square centimeters and the weight in grams. The precise size and activity of nodules in relation to the rest of the gland is also measured. CTS of the normal thyroid gland In addition to making thyroid diagnosis more accurate, the CRT scanner improves the results of thyroid biopsy. The accurate sizing of the thyroid gland aids in the follow-up of nodules to see if they are growing or getting smaller in size. Knowing the weight of the thyroid gland allows more accurate radioactive treatment in patients who have Graves' disease.

Thyroid Scans are used for the following reasons:

- Identifying nodules and determining if they are "hot" or "cold".
- Measuring the size of the goiter prior to treatment.
- Follow-up of thyroid cancer patients after surgery.
- Locating thyroid tissue outside the neck, i.e. base of the tongue or in the chest.

Thyroid Ultrasound

Thyroid ultrasound refers to the use of high frequency sound waves to obtain an image of the thyroid gland and identify nodules. It tells if a nodule is "solid" or a fluid-filled cyst, but it will not tell if a nodule is benign or malignant. Ultrasound allows accurate measurement of a nodule's size and can determine if a nodule is getting smaller or is growing larger during treatment. Ultrasound aids in performing thyroid needle biopsy by improving accuracy if the nodule cannot be felt easily on examination. Several more pages are dedicated to the use of ultrasound in evaluating thyroid nodules.

Thyroid Needle Biopsy

This has become the most reliable test to differentiate the "cold" nodule that is cancer from the "cold" nodule that is benign ("hot" nodules are rarely cancerous). It provides information that no other thyroid test will provide. While not perfect, it will provide definitive information in 75% of the nodules biopsied

- subclinical hyperthyroidism
- recent treatment for hyperthyroidism
- drugs (steroids, dopamine)
- assay interference
- NTI

- Graves' disease
- toxic multinodular goitre
- toxic adenoma
- thyroiditis (post-viral, post-partum)
- drugs (amiodarone); excess iodine intake
- excess thyroxine ingestion
- pregnancy-related (hyperemesis gravidarum; hydatidiform mole)
- congenital hyperthyroidism

- NTI
- central hypothyroidism
- isolated TSH deficiency
- assay interference

FT4/FT3 ↑
TSH ↓*

FT4/FT3 ↔
TSH ↓*

FT4/FT3 ↓
TSH ↔ or ↓*

FT4/FT3 ↔
TSH ↔

FT4/FT3 ↔
TSH ↑

FT4/FT3 ↑
TSH ↔ or ↑

FT4/FT3 ↓
TSH ↑

- subclinical hypothyroidism
- poor compliance with thyroxine
- malabsorption of thyroxine
- drugs (amiodarone)
- assay interference
- NTI recovery phase
- TSH resistance

- autoimmune thyroiditis (Hashimoto's; atrophic)
- post-radioiodine therapy/thyroidectomy
- hypothyoid phase of thyroiditis
- drugs (amiodarone, lithium, TKIs, ATDs)
- iodine deficiency or excess
- neck irradiation
- Riedel's thyroiditis
- thyroid infiltration (tumour, amyloid)
- congenital hypothyroidism

- assay interference; FDH
- thyroxine replacement therapy (including poor compliance)
- drugs (amiodarone, heparin)
- NTI (including acute psychiatric disorders)
- neonatal period
- TSH-secreting pituitary adenoma
- Resistance to thyroid hormone
- Disorders of thyroid hormone transport or metabolism

ADRENAL HORMONES INTERPRETATION

- **Testing for Pheochromocytoma (medulla-arising tumors)**
    - **Blood Test**
    - Catecholamines, fractionated
    - Epinephrine
    - Norepinephrine
    - Dopamine
    - **24h Urine Collection**
    - Metanephrine
    - Normetanephrine
    - Metanephrines, total
    - Dopamine
    - VMA
    - Catecholamines, total
- **Testing for Cushing's & Conn's syndromes, as well as Adrenal Cancer (cortex-arising tumors)**
    - **Tests for Cushing's syndrome**
    - A.M. Cortisol
    - ACTH (low)
    - Low dose dexamethasone test
    - Late-night salivary cortisol testing (saliva test)
    - 24h urine collection for UFC = Urinary Free Cortisol
    - **Tests for Conn's syndrome**
    - Potassium (K+; low)
    - Plasma aldosterone concentration (PAC)
    - Plasma renin activity (PRA; low)
    - PRA/PAC ratio
    - Adrenal vein sampling (Interventional radiology study)
    - 24h urine collection for Aldosterone
    - **Tests for Sex-Steroid Hormones and Adrenal Cancer**
    - Testing for Cushing's syndrome and Conn's syndrome as above
    - DHEAS
    - 17-OH-Progesterone
    - Androstenedione
    - Total Testosterone
    - Free Testosterone
    - 17-Beta-estradiol (serum, only in men and postmenopausal women)

A. Cortisol

1. Serum Cortisol (free and total)

Cortisol is present in peripheral circulation in three forms: bound to cortisol binding globulin, CBG (~80%), albumin (~10%) and in free form (~10%). Routinely laboratory measures total cortisol in serum including both free and protein-bound fractions. Random measurements of serum cortisol are usually not helpful in the diagnosis of intactness of the HPA axis. Nevertheless, in assessing adrenal insufficiency states, if the serum cortisol is > 20 µg/dL one can likely rule out the possibility of primary adrenal insufficiency while cortisol concentrations < 5µg/dL usually make one suspicious of primary adrenal insufficiency, especially if the patient is acutely ill or

stressed. When assessing states of cortisol excess, a random cortisol concentration of <5µg/dL can usually exclude CS, even if obtained during the nadir of its profile. On the other hand, serum cortisol >50µg/dL, although not diagnostic, is certainly suggestive of hypercortisolism.

In conditions where CBG concentrations are affected, such as pregnancy or critical illness for example, total serum cortisol may not always reflect the true pituitary-adrenal status. In these cases assessment of serum free cortisol is preferred. Free serum cortisol levels can either be measured directly or estimated by calculating the free serum cortisol index. Serum cortisol index is a ratio of serum cortisol and CBG. Alternative, but cumbersome procedures to directly measure the free serum cortisol involve extraction of cortisol by equilibrium dialysis or ultrafiltration. Although not affected by CBG levels, free cortisol is also secreted in episodic fashion and thus not much more useful than random total serum cortisol levels in assessment of HPA axis functionality.

2. Urinary Free Cortisol

Cortisol is excreted in urine in an unbound (free) form and, like free serum cortisol is unaffected by fluctuations in CBG levels. Properly collected 24 hour urine specimens can be used to eliminate fluctuations that would affect serum cortisol levels, due to the pulsatile nature of its release. Therefore, measurement of UFC from 24 hr urine collections has become a valuable diagnostic tool for evaluation of adrenal cortical function and it is one of the first line tests recommended for CS diagnostic testing. In the unstressed patient, with normal renal function, elevation of UFC in 24 hour urine specimen is usually sufficient to diagnose CS. A normal result is strong evidence against that diagnosis.

3. Salivary Cortisol

In recent years, late-night (23:00-24:00 h) salivary cortisol (LNSC) testing has been increasingly used as an initial test for evaluation of patients with clinical suspicion of CS. Most studies report high diagnostic sensitivity of this test (80-90%), but there are discrepancies in reported specificities (70-90%), resulting mostly from difference in methodologies and populations studied. Nevertheless, LNSC is a very useful screening test due to excellent sensitivity of available salivary cortisol methods, coupled with the fact that it is a less invasive test than serum cortisol and approximates the free fraction of cortisol in the blood. Salivary cortisol concentration is not dependent on CBG and could therefore be useful during an ACTH stimulation testing in patients with increased CBG concentrations due to increased estrogen or decreased plasma binding globulins due to critical illness.

B. ACTH

ACTH measurements, while subject to the same circadian variability as cortisol (actually it is the variability of the ACTH that is directly responsible for the variability of the cortisol), are not subject to the effects of CBG. Values of ACTH > 100 pg/ml in the setting of possible adrenal insufficiency are usually suggestive of primary adrenal insufficiency, while values >500 pg/ml are diagnostic. Low concentrations of plasma ACTH are not diagnostic, except for the undetectable levels observed in patients with cortisol producing adrenal adenomas. Plasma ACTH concentration is also low in patients taking exogenous steroids.

C. Miscellaneous Non-Stimulated Measurements: Cortisol Binding Globulin (CBG)

As mentioned earlier, majority of cortisol (~92%) is bound to CBG, a serum protein. CBG levels increase in pregnancy and patients on oral contraceptives or supplemental estrogen. CBG is decreased in hyperinsulinemic states, nephrotic syndrome, starvation and chronic liver disease. This

test is useful for the assessment of unexpected serum cortisol values. It is offered by large reference laboratories and uses a radioimmunoassay method.

11-deoxycortisol (Compound S)

This is the immediate precursor of cortisol and is typically increased when ACTH is elevated or in 11 beta-hydroxylase deficiency.

Anti-adrenal Antibodies

The use of anti-adrenal antibodies has been suggested as useful in detecting early evidence of adrenal insufficiency, before cortisol values are decreased even in response to stimuli. The only test currently clinically available is a test that detects 21-hydroxylase autoantibodies, which are present in the common autoimmune form of Addison's disease. This test is offered by major reference laboratories and is based on the radioimmunoassay format.

Corticotrophin Releasing Hormone (CRH)

Serum concentration of CRH is markedly elevated in pregnancy, presumably due to the production of CRH by the placenta. High levels are associated with high levels of CRH binding protein. Although mentioned as useful in the diagnosis of ectopic CRH syndromes, little data is available in this regard. CRH testing is not commonly done.

<div align="center">DYNAMIC TESTING</div>

<div align="center">A. Glucocorticoid Deficiency</div>

1. Primary Adrenal Insufficiency

a. High dose ACTH stimulation Test

WHEN TO USE THIS TEST: Patients acutely ill in the hospital or clinic who present with signs and symptoms suggestive of primary adrenal insufficiency. Patients who are thermodynamically unstable should be resuscitated with crystalloids and given dexamethasone prior to testing if the diagnosis of primary adrenal insufficiency is being considered.

PROCEDURE: An intravenous (IV) line is placed 30 minutes before the test for rapid phlebotomy and to eliminate a temporary rise in cortisol associated with a needle stick. The IV line is to be kept open with 0.9% sodium chloride (NaCl) at a rate of 50 ml/hr. Blood is drawn at 0' for ACTH (2 ml in a lavander top tube on ice) and cortisol (2 ml in a red top tube). Cotrosyn, 0.25 mg is administered as an IV bolus over 2 minutes. The Cotrosyn comes as a lyophilized powder which should be reconstituted with 1 ml of 0.9% NaCl. 30' after the injection, blood is obtained from the IV line (2 ml) for cortisol. The same is repeated at 60' (2 ml) for cortisol.

SPECIAL CONSIDERATIONS: The test can be performed at any time of the day. If the patient is receiving hydrocortisone or cortisone acetate, the medication should be held for at least 12 hours prior to testing (if possible). Although the test can be performed while the patient is receiving dexamethasone, there is some cross-reactivity in some assays and cortisol levels may not be accurate. Each laboratory should determine for itself, the effect of dexamethasone on their assay. Patients with known sensitivity to Cotrosyn or its preservatives should not have it administered.

CONTRAINDICATIONS: Hypersensitivity to cosyntropin or any component of the formulation.

WARNINGS / PRECAUTIONS: Use with caution in patients with pre-existing allergic disease or a history of allergic reactions to corticotropin. Class C in pregnancy.

ADVERSE REACTIONS 1% to 10%: Cardiovascular: Flushing. Central nervous system: Mild fever. Dermatologic: Pruritus. Gastrointestinal: Chronic pancreatitis.

<1%: Hypersensitivity reactions

DRUG INTERACTIONS: Decreased effect: May decrease the effect of anticholinesterases in patients with myasthenia gravis; nondepolarizing neuromuscular blockers, phenytoin and barbiturates may decrease effect of cosyntropin

INTERPRETATION OF RESULTS: Baseline cortisol values <5 µg/dl and ACTH concentrations >100 pg/ml are usually diagnostic of primary adrenal insufficiency. The normal peak cortisol value post stimulation should be an increment no less than 7µg/dl and a maximal level >20 µg/dl at 30'. Since 37% of subjects had a peak response to Cotrosyn at 30' and 63% had a peak response at 60', both time points are analyzed in all patients and if either the 30' or 60' sample reaches the criteria as noted above, the test is considered normal.

Serum aldosterone can be measured in 0', 30' and 60' blood samples as ACTH stimulation of the adrenal cortex will also stimulate aldosterone. It has been suggested that a normal aldosterone response to ACTH in the presence of a suboptimal cortisol response is diagnostic of secondary adrenal insufficiency.

b. Low dose ACTH stimulation Test

WHEN TO USE THIS TEST: Patients with subtle signs of adrenal insufficiency or patients who have been treated with glucocorticoids in whom determination of adrenal reserve is necessary. Patients who have autoimmune disease and may have early adrenocortical insufficiency may be best assessed with this test.

PROCEDURE: An intravenous line is placed 30 minutes before the test for rapid phlebotomy and to eliminate a temporary rise in cortisol associated with a needle stick. The IV line is to be kept open with 0.9% NaCl at a rate of 50 ml/hr. Blood is drawn at 0' for ACTH (2 ml in a lavander top tube on ice) and cortisol (2 ml in a red top tube).

Cotrosyn, 1 µg is administered as an IV bolus over 2 minutes. The injection material was prepared according to the method of Dickstein as follows: The Cotrosyn was diluted with 50 ml of sterile saline to a stock concentration of 5 µg/ml. Aliquots of 0.2 ml were aliquoted into sterile plastic tubes and kept at 4ºC for a maximum of 4 months [20]. Immediately prior to testing 0.8 ml of saline is added to the tube (final dilution 1 µg/ml) and 1 ml is injected into the patient. 30' after the injection blood is obtained from the IV line (2 ml) for cortisol. The same is repeated at 60' (2 ml) for cortisol.

SPECIAL CONSIDERATIONS: Same as for high dose ACTH stimulation test, see above.

INTERPRETATION OF RESULTS: This test was originally developed to be more sensitive for diagnosing secondary adrenal insufficiency because of it was more of a "physiologic" dose. It is much better at diagnosing secondary adrenal insufficiency than the high dose, although it is not at all recommended in acute or recent hypopituitarism when the intact adrenal glands can still respond normally to any dose of ACTH. Although probably not useful for the initial purpose of secondary adrenal insufficiency, it may be more sensitive at distinguishing more mild forms of primary adrenal insufficiency. Furthermore, this low dose test was helpful in identifying mild adrenal suppression in asthmatic children being treated with inhaled steroids. As noted above, each laboratory should establish their normal values, however in general, a stimulated value at 30' or 60' greater than 20 µg/dl would be considered normal.

2. Secondary Adrenal Insufficiency (Pituitary or Hypothalamic)

a. Insulin tolerance testing (ITT)

WHEN TO USE THIS TEST: Patients in whom pituitary or hypothalamic disease may result in impaired corticotroph (or somatotroph) activity. Patients following pituitary surgery or pituitary radiation can be tested at any time, unlike the ACTH stimulation tests described above which are not useful in the acute setting. A random serum cortisol should be drawn prior to scheduling the test, as if the value is > 20 µg/dl, the test may not be helpful. This test, can be performed in the outpatient clinic, however while relatively safe, requires a trained endocrine registered nurse to be present with the patient during the course of the test.

PROCEDURE: A 50 ml vial of 50% Dextrose should be at the patient's bedside in a syringe ready for injection before beginning the procedure.

An intravenous line is placed 30 minutes before the test for rapid phlebotomy, to eliminate a temporary rise in cortisol associated with a needle stick, and in order to have IV access for 50% Dextrose in the event of severe hypoglycemia. The IV line is to be kept open with 0.9% NaCl at a rate of 50 ml/hr. Blood is drawn at 0' for cortisol (2 ml in a red top tube) and glucose (1 ml in a gray top tube). Blood glucose is also checked at the bedside with a glucose monitor.

Regular (short acting) insulin is administered as an IV bolus at a dose of 0.1 units/kg. Blood is sampled for cortisol and glucose as noted above at 10', 15', 30', 45', 60', 90' and 120'. A bedside nurse should monitor the blood glucose more frequently if glucose drops below 60 mg/dl on the glucometer or if the patient complains of neuroglycopenic symptoms, such as fatigue, diaphoresis, hunger, lightheadedness or nausea. The test should continue until the blood sugar drops below 40 mg/dl.

In patients with diabetes on insulin, consideration should be given that they may be insulin resistant. In which case, larger doses of insulin may be given. We usually begin with a single bolus of 0.1 U/kg and then re-bolus with insulin depending on the response to the initial dose (either give the same dose again if there was some response but insufficient, or double the dose if there was only minimal response to blood glucose, or give half the dose if the hypoglycemic response was close to the desired goal). This can be repeated several times until adequate hypoglycemia is reached.

Once the goal response of a glucose < 40 mg/dl is reached, patients can be fed a meal such as crackers and orange juice. Blood glucose should be checked at 5', 10' and 15' minutes post feeding. If there is no increase in glucose or a clinical response within 5 minutes, intravenous glucose should be administered. If no response, then a repeat bolus of glucose is suggested. If no response or IV access is lost, glucagon 1 mg intramuscular can be given.

SPECIAL CONSIDERATIONS: The test can be performed at any time of the day, although due to the need for patients to be fasting it is most conveniently done in the morning. If the patient is receiving hydrocortisone or cortisone acetate, the medication should be held for at least 12 hours prior to testing (if possible). Unlike the ACTH stimulation tests, the ITT cannot be performed while the patient is receiving dexamethasone, due to suppression of the hypothalamic pathways necessary to respond to hypoglycemia.

In general ITT is not recommended in patients with uncontrolled seizure disorder or significant coronary artery disease.

In order to determine if the level of dysfunction is at the hypothalamus or at the pituitary this test is sometimes used in addition to the CRH stimulation test. When the ITT fails to stimulate cortisol, but the CRH test does stimulate it is likely that the patient is having hypothalamic dysfunction.

INTERPRETATION OF RESULTS: Serum cortisol should increase within 30 minutes of the hypoglycemic response to > 20 µg/dl. If the serum cortisol at baseline is 18 ug/dl the test may not be diagnostic. If the baseline serum cortisol is higher than 19 mcg, AI is unlikely. Although the response of cortisol is more reproducible than that of growth hormone in the ITT, intra-subject differences have been reported.

b. Metyrapone testing

WHEN TO USE THIS TEST: This test is perhaps the most sensitive to determine whether the HPA axis is intact. Although metyrapone is not generally available from your neighborhood pharmacy. Metyrapone blocks 11-beta hydroxylase and results in the inhibition of conversion of 11-deoxycortisol to cortisol. Serum levels of cortisol decrease and concentration of 11-deoxycortisol increases, however 11-deoxycortisol does not down regulate ACTH. Therefore in a normally functioning HPA axis there is an increase in 11-deoxycortisol. This metabolite can be directly

measured in the serum or measured in the urine as 17-OH corticosteroids. This test will be abnormal in either primary adrenal deficiency or ACTH deficiency.

PROCEDURE: For assessment of adrenal or pituitary insufficiency the test can be performed as an overnight test. Metyrapone is given orally (30 mg/kg body weight, or 2 grams for <70 kg, 2.5 grams for 70 to 90 kg, and 3 grams for >90 kg body weight) at midnight with a glass of milk or a small snack. Serum 11-deoxycortisol and cortisol are measured at 8 AM the next morning; plasma ACTH can also be measured.

SPECIAL CONSIDERATIONS: The concurrent use of glucocorticoids will interfere with the test. Any medications that the patient is taking which increase the P450 enzymes will increase the metabolism and clearance of metyrapone (such as rifampin, phenobarbital and phenytoin). Similarly, hypothyroidism or hyperthyroidism will affect clearance of metyrapone and the adrenal responsiveness. Therefore, thyroid function tests should be measured prior to performing this test. Measurement of 11-deoxycortisol, like cortisol itself is dependent on CBG and drugs such as estrogens and oral contraceptives will falsely increase the concentrations of 11-deoxycortisol.

PREGNANCY IMPLICATIONS - Use during pregnancy only if clearly needed. Subnormal response may occur in pregnant women and the fetal pituitary may be affected.

LACTATION - Excretion in breast milk unknown/use caution

ADVERSE REACTIONS - Frequency not defined. Central nervous system: Headache, dizziness, sedation. Dermatologic: Allergic rash. Gastrointestinal: Nausea, vomiting, abdominal discomfort or pain. Hematologic: Rarely, decreased white blood cell count or bone marrow suppression.

INTERPRETATION OF RESULTS: 8 AM serum 11-deoxycortisol concentrations should be >7 µg/dL with serum cortisol less than 5 µg/dL (138 nmol/L), confirming adequate metyrapone blockade. The plasma ACTH concentration at 8 AM should exceed 75 pg/mL (17 pmol/L), confirming that any increases in serum 11-deoxycortisol concentrations are ACTH-dependent, thereby separating primary from secondary adrenal insufficiency.

B. Glucocorticoid Excess

1. Dexamethasone Suppression Tests

At least five different tests have been described using dexamethasone, which differ in the dose and timing of dexamethasone treatment and differ in whether there is measurement of urine or serum cortisol or 17-OH-corticostseroids. Although the endocrine basis for the tests are in general the same, none are perfect. Confirming the diagnosis of patients with suspected hypercortisolism requires several tests for accurate diagnosis.

A popular screening test for confirming hypercortisolism is the overnight 1 mg dexamethasone. A single dose of 1 mg is administered (or 0.3 mg/Kg for children) at 11PM and blood is obtained by 8 AM the following morning. The dexamethasone dose is given prior to the diurnal rise in endogenous ACTH release and therefore suppresses the early AM cortisol. A normal response would be a serum cortisol concentration of <1.8 mcg/dl, alternatively a cut point of < 5 µg/dl can be used which will yield more specificity with less sensitivity. If cortisol is >10 µg/dl the likelihood of hypercortisolism is high. Patients with corticotroph macroadenomas or very active tumors, may have urine free cortisol in excess of 1000 µg/dl which will require higher doses of dexamethasone to confirm suppressiblity and/or rule out ectopic ACTH production.

2. CRH stimulation test

WHEN TO USE THIS TEST: This test is one of the most sensitive to determine if there is an abnormality in the HPA axis and for diagnosing the etiology of hypercortisolism in ACTH dependent Cushing's. Although CRH is expensive, when one considers the cost of multiple urine collections and analyses of cortisol as well as the cost of a single MRI of the pituitary. CRH is at least cost effective when one considers the overall expense in the evaluation of these patients.

PROCEDURE: An intravenous line is placed 30 minutes before the test for rapid phlebotomy and to eliminate a temporary rise in cortisol associated with a needle stick. Blood is drawn at -15' and 0' for cortisol and ACTH (2 ml in a lavender top tube on ice). CRH is then injected IV at a dose of 1 μg/Kg up to a maximum of 200 μg. Blood is obtained at 15, 30, 60, 90, 120, 180 and 210 minutes for cortisol and ACTH (2 ml in a lavender top tube on ice).

SPECIAL CONSIDERATIONS: The test can be performed at any time of the day, although the initial studies describing the test have been done in the morning.

Side effects: The patient may experience slight nausea, metallic taste, urgency to urinate, a change in blood pressure (either increase or decrease), a change in heart rate, headaches, abdominal discomfort, facial flushing, and lightheadedness. These side effects are mild and last for only few minutes. INTERPRETATION OF RESULTS: The mean ACTH concentrations at 15 and 30 minutes after CRH should increase by at least 35% above the mean basal value at -15 and 0 min in patients with Cushing's disease, but not in patients with ectopic ACTH secretion. This measure gave the best sensitivity (93%) and specificity (100%). The best cortisol criterion was a mean increase at 30 and 45 min of 20% or more above mean basal values, which gave a sensitivity of 91% and a specificity of 88%. It should be noted that the criterion for Cushing's disease is based on the presence of hypercortisolism. The CRH test will not adequately differentiate subjects with pseudoCushings and those with true pituitary dependent Cushing's disease.

3. CRH Test with Dexamethasone

WHEN TO USE THIS TEST: Several investigators have found that modifications of the CRH stimulation test can increase further the sensitivity and specificity in the diagnosis of the etiology of Cushing's disease. While the simultaneous use of vasopressin can augment the response to CRH, dexamethasone can be used to suppress all but pathologic responses to CRH stimulation. Without dexamethasone the sensitivity and specificity of the CRH test is 65 and 100%, respectively, while with dexamethasone the CRH test is 100% sensitive and specific. This test is also particularly useful to differentiate true Cushing's from pseudo-Cushing's state.

PROCEDURE: Dexamethasone, 0.5 mg is self-administered orally by the patient every 6 hours for 2 days, at 6 AM, 12 Noon, 6 PM and midnight. On the morning of the 3rd day an additional dose of dexamethasone is given at 6 AM. The patient arrives at the testing center by 8 AM and an intravenous line is placed 30 minutes before the test for rapid phlebotomy and to eliminate a temporary rise in cortisol associated with a needle stick. Blood is drawn at -15' and 0' for cortisol and ACTH (2 ml in a lavender top tube on ice). CRH is then injected IV at a dose of 1 μg/Kg up to a maximum of 200 μg. Blood is obtained at 15, 30 60, 90 120, 180 and 210 minutes for cortisol and ACTH (2 ml in a lavender top tube on ice).

SPECIAL CONSIDERATIONS: The test can be performed at any time of the day, although it is usually done in the morning.

Side effects that the patient may experience are: slight nausea, metallic taste, urgency to urinate, a change in blood pressure (either increase or decrease), a change in heart rate, headaches, abdominal discomfort, facial flushing, and lightheadedness. These side effects are mild and last for only few minutes.

INTERPRETATION OF RESULTS: A normal response would be a plasma cortisol concentration less than 1.3 μg/dl measured 15 minutes after the administration of CRH. Values of cortisol greater than 1.3 μg/dl correctly identified all cases of Cushing's syndrome and all cases of pseudo-Cushing's states (100% specificity, sensitivity, and diagnostic accuracy). While this is a general recommendation, each laboratory should confirm based on the sensitivity of the respective cortisol assay. Furthermore, it is important to confirm the serum level of dexamethasone at the time of the blood draw to assure patient compliance with the dexamethasone regimen. Patients with ectopic

ACTH production will have nonsuppressed cortisol and ACTH levels that are not stimulated by CRH.

<div align="center">Reference ranges</div>

Free serum cortisol reference range

8 AM: 0.121-1.065 mcg/dL

Total serum cortisol reference ranges

Adult/elderly :

- 8 AM: 5-23 mcg/dL or 138-635 nmol/L (SI units)
- 4 PM: 3-13 mcg/dL or 83-359 nmol/L (SI units)

Child 1-16 years:

- 8 AM: 3-21 mcg/dL
- 4 PM 3-10 mcg/dL

Newborn: 1-24 mcg/dL

Urine (24-hour)

Adult/elderly: < 100 mcg/24 hr or < 276 nmol/day (SI units)

Adolescent: 5-55 mcg/24 hr

Child: 2-27 mcg/24 hr

Saliva

7 AM-9 AM: 100-750 ng/dL

3 PM-5 PM: < 401 ng/dL

11 PM-midnight: < 100 ng/dL

Visualization methods

Characteristic	Adenoma	Carcinoma	Pheochromocytoma	Metastasis
Size	<4 cm	>4 cm	Variable	>4 cm
Shape	Round	Irregular	Round	Irregular
Border	Smooth	Irregular	Well delineated	Irregular
Laterality	Unilateral	Unilateral	May be bilateral or unilateral	May be bilateral
Appearance	Round, homogeneous	Inhomogeneous with central necrosis. May have calcifications	Cystic and hemorrhagic changes.	Inhomogeneous
Vascularity	Normal	Increased	Increased	Increased
Growth rate	Slow (1 cm/year)	Fast (>2 cm/year)	Slow (0.5-1 cm/year)	Variable/Fast
Lipid content	Lipid rich or poor	Lipid poor	Lipid poor	Lipid poor
CT attenuation	<10 HU unenhanced. >50% absolute washout.	>20 HU unenhanced. <50% absolute washout.	>20 HU unenhanced. <50% absolute washout.	>20 HU unenhanced. <50% absolute washout.
MRI	Isointense with liver in T1 and	Hypointense compared to liver on	High signal intensity on T2-w	Hypointense compared to liver

	T2-w. Chemical shift	T1-w High to intermediate signal on T2-w		on T1-w High to intermediate signal on T2-w
FDG-PET-CT	Low SUV	High SUV	Variable SUV	High SUV
Other		Evidence of invasion or metastasis		History of prior cancer

HYPOTHALAMUS AND PITUITARY HORMONES INTERPRETATION

Water deprivation test

The water deprivation test is also known by the terms 'indirect water deprivation test' and 'dehydration test'. The term 'indirect' is utilized as this test generally does not involve 'direct' measurements of plasma arginine vasopressin (AVP) to diagnose and differentiate the various forms of diabetes insipidus (DI). The water deprivation test is almost always followed with desmopressin administration to further characterize the type of polyuric polydipsic state. The basic principle behind the water deprivation test is that in individuals with normal posterior pituitary and renal function (or those with primary polydipsia), an increase in plasma osmolality from dehydration stimulates AVP release from the posterior pituitary which then leads to water reabsorption in the nephrons, thus resulting in concentration of urine and an increase in urine osmolality. In central or nephrogenic DI, the urine fails to optimally concentrate with water deprivation and there is persistent excretion of hypotonic urine. Once the diagnosis of DI is established, desmopressin administration can distinguish between central and nephrogenic DI. In central DI, once the deficient action of AVP is substituted with desmopressin administration, the urine osmolality should increase while in nephrogenic DI, as the desmopressin is ineffective due to lack of renal response to its actions, the low urine osmolality persists.

Growth hormone (GH) testing is usually provocative using either a GH stimulation test or a GH suppression test to track GH levels over time. GH testing may be used to test for abnormal pituitary function and to help diagnose the condition causing the abnormality, its severity, and the complications that have arisen because of it.

IGF-1 (Insulin-like growth factor–1) is often measured before or during GH provocation testing and can be used by itself or with GH as a monitoring tool. Produced in the liver, IGF-1 mirrors GH excesses and deficiencies, but its level is stable throughout the day, making it a useful indicator of average GH levels.

GH testing is usually ordered on those with symptoms of growth hormone abnormalities or as a follow-up to other abnormal hormone test results. It is not recommended for general screening. GH tests may be ordered to help evaluate pituitary function:

- GH stimulation tests help diagnose growth hormone deficiency (GHD) in children and adults.
- GH suppression tests help diagnose gigantism in children and acromegaly in adults. Along with other blood tests and imaging scans, they help identify and locate pituitary tumours

GH and IGF-1 levels are often monitored for extended periods of time following treatment for GH deficiency, gigantism and acromegaly, and are monitored following surgery, drug treatment, and/or radiation therapy for a pituitary tumour.

Follicle stimulating hormone (FSH)

Follicle stimulating hormone (FSH) is often used in conjunction with other tests (LH, testosterone, oestradiol and progesterone) in the investigation of infertility in both men and women. FSH levels are also useful in the investigation of menstrual irregularities (irregular periods) and to aid in the diagnosis of pituitary gland disorders. In children, FSH and LH are used to diagnose delayed or precocious (early) puberty.

In women, FSH and LH levels can help to tell the difference between primary ovarian failure (failure of the ovaries themselves) and secondary ovarian failure (failure of the ovaries due to disorders of either the pituitary gland or the hypothalamus in the brain). Increased levels of FSH

and LH are consistent with primary ovarian failure. Some causes of primary ovarian failure are listed below.

Developmental defects:

- Ovarian agenesis (failure to develop ovaries)
- Chromosomal abnormality, such as Turner's syndrome
- Ovarian steroidogenesis defect, such as 17 alpha hydroxylase deficiency

Premature ovarian failure due to:

- Radiation therapy
- Chemotherapy
- Autoimmune disease

Chronic anovulation (failure to ovulate) due to:

- Polycystic ovary syndrome (PCOS)
- Adrenal disease
- Thyroid disease
- Ovarian tumour

When a woman enters the menopause and her ovaries stop working, FSH levels will rise. Low levels of FSH and LH are consistent with secondary ovarian failure due to a pituitary or hypothalamic problem.

In men, high FSH levels are due to primary testicular failure. This can be due to developmental defects in testicular growth or to testicular injury, as indicated below.

Developmental defects:

- Gonadal agenesis (failure to develop testes)
- Chromosomal abnormality, such as Klinefelters syndrome

Testicular failure:

- Viral infection (mumps)
- Trauma
- Radiation therapy
- Chemotherapy
- Autoimmune disease
- Germ cell tumour

Low levels of FSH are consistent with pituitary or hypothalamic disorders.

In young children, high levels of FSH and LH and development of secondary sexual characteristics at an unusually young age are an indication of precocious (early) puberty. This is much more common in girls than in boys.

Luteinising hormone (LH)

In women, FSH and LH levels can help to tell the difference between primary ovarian failure (failure of the ovaries themselves) and secondary ovarian failure (failure of the ovaries due to disorders of either the pituitary gland or the hypothalamus in the brain). Increased levels of FSH and LH are consistent with primary ovarian failure. Some causes of primary ovarian failure are listed below.

Developmental defects:

- Ovarian agenesis (failure to develop ovaries)
- Chromosomal abnormality, such as Turner's syndrome
- Ovarian steroidogenesis defect, such as 17 alpha hydroxylase deficiency

Premature ovarian failure due to:

- Radiation therapy

- Chemotherapy
- Autoimmune disease

Chronic anovulation (failure to ovulate) due to:

- Polycystic ovary syndrome (PCOS)
- Adrenal disease
- Thyroid disease
- Ovarian tumour

When a woman enters the menopause and her ovaries stop working, FSH and LH levels will rise. Low levels of FSH and LH are consistent with secondary ovarian failure due to a pituitary or hypothalamic problem.

In men, high FSH levels are due to primary testicular failure. This can be due to developmental defects in testicular growth or to testicular injury, as indicated below.

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- Gonadal agenesis (failure to develop testes)
- Chromosomal abnormality, such as Klinefelter's syndrome

Testicular failure:

- Viral infection (mumps)
- Trauma
- Radiation therapy
- Chemotherapy
- Autoimmune disease
- germ cell tumour

Low levels of FSH are consistent with pituitary or hypothalamic disorders.

In young children, high levels of FSH and LH and development of secondary sexual characteristics at an unusually young age are an indication of precocious (early) puberty. This is much more common in girls than in boys.

Thyroid stimulating hormone (TSH)

A high TSH result often means an underactive thyroid gland caused by failure of the gland (hypothyroidism). Very rarely, a high TSH result can indicate a problem with the pituitary gland, such as a tumour, in what is known as secondary hyperthyroidism. A high TSH value can also occur in people with underactive thyroid glands who have been receiving too little thyroid hormone medication.

A low TSH result can indicate an overactive thyroid gland (hyperthyroidism) or damage to the pituitary gland that prevents it from producing TSH. A low TSH result can also occur in people with an underactive thyroid gland who are receiving too much thyroid hormone medication.

An abnormal TSH usually indicates a deficiency or an excess of thyroid hormones available to the body but it does not indicate the reason why. An abnormal TSH result is usually followed by additional testing of free thyroxine (FT4) and/or free tri-iodothyronine (FT3) to investigate the cause. The combination of a TSH test and tests for the thyroid hormones T3 and T4 is known as a thyroid function test (TFT).

The following table summarises patterns of thyroid function test results and their most common causes.

TSH	FT4	FT3	INTERPRETATION
High	Normal	Normal	Mild (subclinical) hypothyroidism
High	Low	Low or normal	Hypothyroidism

TSH	FT4	FT3	INTERPRETATION
Low	Normal	Normal	Mild (subclinical) <u>hyperthyroidism</u>
Low	High or normal	High or normal	Hyperthyroidism
Low	Low or normal	Low or normal	Nonthyroidal illness; rare pituitary (secondary) hypothyroidism

Adrenocorticotropic hormone

ACTH is usually requested if you are found to have low cortisol or have signs or symptoms that suggest adrenal or pituitary disease. Changes in ACTH and cortisol are usually evaluated together, as shown in the table above.

An increased ACTH result can mean that a patient has Cushing's disease, Addison's disease, or an ectopic ACTH-producing tumour. A decreased ACTH result can mean an adrenal tumour that is making cortisol or hypopituitarism.

In some cases, the test results are not clear enough to interpret. Testing the change in ACTH and/or cortisol when certain drugs are given often helps to clarify the picture and allows the doctor to make the right diagnosis. The most commonly used drugs are tetracosactide (trade name Synacthen, a drug form of ACTH) and dexamethasone.

• Tetracosactide, like ACTH, should normally tell the adrenal glands to make cortisol. If cortisol levels don't rise after tetracosactide is given, this indicates adrenal failure, as can occur in Addison's disease or hypopituitarism.

• Dexamethasone is a very potent drug that acts like cortisol. In normal people, it should stop ACTH production. By testing the ability of different doses of dexamethasone to stop ACTH production, it is often possible to tell if the patient has Cushing's syndrome and help determine its cause.

Prolactin

Men and non-pregnant women will normally have only small amounts of prolactin in their blood. The levels are ideally interpreted knowing when the sample was collected. The levels will vary over a 24 hour period - rising during sleep and peaking in the morning. Ideally, your blood sample should usually be taken a couple of hours after waking up, preferably after you have been resting quietly for 30 minutes (although your doctor may have reasons for doing them at other times).

High levels of prolactin (hyperprolactinaemia) are normal during pregnancy and after childbirth while the mother is breastfeeding. High levels can also be seen with:

• Drugs: Oestrogen, tricyclic antidepressants, and drugs that block the effect of dopamine (a brain chemical that controls the production of prolactin) such as tranquilizers, some hypertension drugs, and some drugs that are used to treat gastro-oesophageal reflux

• Hypothalamic diseases
• Hypothyroidism
• Kidney disease
• Nipple stimulation (small increase)
• Other pituitary tumours and diseases
• Polycystic ovary syndrome (PCOS)
• Prolactinomas
• Macroprolactinaemia

- Levels of prolactin that are below normal are not usually treated but may be indicative of a more general hypopituitarism (decreased pituitary function and decreased hormone production). Low levels may also be caused by some drugs.

CHAPTER 13. FIRST AID IN ENDOCRINOLOGY: FIRST AID FOR AN ACUTE ADRENAL FAILURE

- Stabilise the patient with normal saline (intravenously) and injected hydrocortisone *prior to transportation*
- Keep the patient lying down - they may become profoundly hypotensive when sitting upright
- Where the patient cannot be transported flat on a stretcher they must not be moved until full circulatory volume has been restored with IV fluids *and they have received injected hydrocortisone*
- Get them to an emergency medical facility urgently

* Note : Lower hydrocortisone doses/ saline infusion rates are appropriate for children

These guidelines are provided by Clinical Advisory Panel, as an aid for A&E emergency teams receiving Addisonian patients following an adrenal crisis :

- For Adults, administer parenteral hydrocortisone 100mg stat (IM preferable) and repeat 6 hourly until the patient is haemodynamically stable and clinical improvement (alternative 200mg/24hrs by continuous IV infusion).
- Infants and children should receive an initial parenteral injection of 50mg hydrodortisone/m2 (usually 25mg in infants and 50mg in children) followed by 50mg/24h in infants and 100mg/24h in children.
- Administer 1 litre IV 0.9% saline stat (adjust for infants and children), and continue saline resuscitation at an appropriate rate until haemodynamic stability and correction of any electrolyte disturbance and AKI
- Monitor U&E at least 12 hourly during initial resuscitation and continue regular monitoring until any hyponatraemia, hyperkalaemia or renal impairment are corrected
- Identify and treat any precipitating cause for Addisonian crisis:
    - vomiting/diarrhoeal illness
    - infection
    - myocardial infarction

* Note : Lower hydrocortisone doses/ saline infusion rates are appropriate for children

FIRST AID FOR A DIABETIC KETOACIDOTIC COMA (DKA)

Managing diabetic ketoacidosis (DKA) in an intensive care unit during the first 24-48 hours always is advisable. When treating patients with DKA, the following points must be considered and closely monitored:

- Correction of fluid loss with intravenous fluids
- Correction of hyperglycemia with insulin
- Correction of electrolyte disturbances, particularly potassium loss
- Correction of acid-base balance
- Treatment of concurrent infection, if present

Correction of Fluid Loss

- Administer 1-3 L during the first hour.
- Administer 1 L during the second hour.
- Administer 1 L during the following 2 hours
- Administer 1 L every 4 hours, depending on the degree of dehydration and central venous pressure readings

When the patient becomes euvolemic, the physician may switch to half the isotonic sodium chloride solution, particularly if hypernatremia exists.

When blood sugar decreases to less than 180 mg/dL, isotonic sodium chloride solution is replaced with 5-10% dextrose with half isotonic sodium chloride solution.

After initial stabilization with isotonic saline, switch to half-normal saline at 200-1000 mL/h (half-normal saline matches losses due to osmotic diuresis).

Insulin Therapy

Insulin should be started about an hour after IV fluid replacement is started to allow for checking potassium levels and because insulin may be more dangerous and less effective before some fluid replacement has been obtained.

Only short-acting insulin is used for correction of hyperglycemia. Subcutaneous absorption of insulin is reduced in DKA because of dehydration; therefore, using intravenous routes is preferable.

The initial insulin dose is a continuous IV insulin infusion using an infusion pump, if available, at a rate of 0.1 U/kg/h. A mix of 24 units of regular insulin in 60 mL of isotonic sodium chloride solution usually is infused at a rate of 15 mL/h (6 U/h) until the blood glucose level drops to less than 180 mg/dL; the rate of infusion then decreases to 5-7.5 mL/h (2-3 U/h) until the ketoacidotic state abates.

Larger volumes of an insulin and isotonic sodium chloride solution mixture can be used, providing that the infusion dose of insulin is similar. Larger volumes may be easier in the absence of an IV infusion pump (eg, 60 U of insulin in 500 mL of isotonic sodium chloride solution at a rate of 50 mL/h).

The optimal rate of glucose decline is 100 mg/dL/h. Do not allow the blood glucose level to fall below 200 mg/dL during the first 4-5 hours of treatment. Hypoglycemia may develop rapidly with correction of ketoacidosis due to improved insulin sensitivity.

Allowing blood glucose to drop to hypoglycemic levels is a common mistake that usually results in a rebound ketosis derived by counter-regulatory hormones. Rebound ketosis necessitates a longer duration of treatment. The other hazard is that rapid correction of hyperglycemia and

hyperosmolarity may shift water rapidly to the hyperosmolar intracellular space and may induce cerebral edema.

Electrolyte Correction

If the potassium level is greater than 6 mEq/L, do not administer potassium supplement. If the potassium level is 4.5-6 mEq/L, administer 10 mEq/h of potassium chloride. If the potassium level is 3-4.5 mEq/L, administer 20 mEq/h of potassium chloride.

Monitor serum potassium levels hourly, and the infusion must be stopped if the potassium level is greater than 5 mEq/L. The monitoring of serum potassium must continue even after potassium infusion is stopped in the case of (expected) recurrence of hypokalemia.

In severe hypokalemia, not starting insulin therapy is advisable unless potassium replacement is under way; this is to avert potentially serious cardiac dysrhythmia that may result from hypokalemia.

Potassium replacement should be started with initial fluid replacement if potassium levels are normal or low. Add 20-40 mEq/L of potassium chloride to each liter of fluid once the potassium level is less than 5.5 mEq/L. Potassium can be given as follows: two thirds as KCl, one third as KPO4.

Correction of Acid-Base Balance

Sodium bicarbonate only is infused if decompensated acidosis starts to threaten the patient's life, especially when associated with either sepsis or lactic acidosis. If sodium bicarbonate is indicated, 100-150 mL of 1.4% concentration is infused initially. This may be repeated every half hour if necessary. Rapid and early correction of acidosis with sodium bicarbonate may worsen hypokalemia and cause paradoxical cellular acidosis.

Bicarbonate typically is not replaced as acidosis will improve with the above treatments alone. Administration of bicarbonate has been correlated with cerebral edema in children.

Treatment of Concurrent Infection

In the presence of infection, the administration of proper antibiotics is guided by the results of culture and sensitivity studies. Starting empiric antibiotics on suspicion of infection until culture results are available may be advisable.

FIRST AID FOR A HYPERGLYCEMIC HYPEROSMOLAR COMA

The main goals in the treatment of hyperosmolar hyperglycemic state (HHS) are as follows:
- To vigorously rehydrate the patient while maintaining electrolyte homeostasis
- To correct hyperglycemia
- To treat underlying diseases
- To monitor and assist cardiovascular, pulmonary, renal, and central nervous system (CNS) function

Standard Care for Dehydration and Altered Mental Status

Standard care for dehydration and altered mental status is appropriate, including airway management, IV access, crystalloid fluid replacement, and administration of any medications routinely given to coma patients.

Airway management

Protection of the airway is mandatory in patients presenting with mental status changes, obtundation, or unconsciousness. Patients may present with respiratory failure and circulatory collapse and must be ventilated mechanically.

If patients are presenting with metabolic acidosis, take care to hyperventilate them when mechanical ventilation is instituted. Hyperventilation generates respiratory alkalosis, which compensates for the metabolic acidosis and also decreases the risk of cerebral edema.

Intravenous access

IV access, large bore if possible, or central venous access is useful, provided attempts to obtain it do not significantly delay transfer to the nearest emergency department (ED). A centrally placed catheter offers an avenue for vigorous rehydration, especially if means for intravenous (IV) access are difficult secondary to profound dehydration.

Fluid resuscitation

Aggressive fluid resuscitation is key in the treatment of HHS. This is to avoid cardiovascular collapse and to perfuse vital organs. Fluid deficits in adults are large in HHS, being about 9 L on average.

Fluid resuscitation with 0.9% saline at the rate of 15-20 mL/kg/h or greater is indicated to expand the extracellular volume quickly in the first hour. This amounts to about 1-1.5 L in an average-sized person. (In patients with contraindications to rapid fluid resuscitation [ie, cardiac or renal disease], slower rates are indicated.) A greater rate of fluid resuscitation is needed in patients with severe volume depletion but should not exceed 50 mL/kg in the first 4 hours. The choice of fluids after initial resuscitation depends on the patient's hydration status, serum electrolytes, and urinary output. If the patient's sodium level is normal or elevated, 0.45% normal saline may be used at a rate of 10 mL/kg/h. If the patient is hyponatremic, 0.9% normal saline may be used instead. In the first 18-24 hours, the first half of the patient's fluid deficit should be corrected. The plasma osmolality should not change over 3 mmol/kg/hr during fluid resuscitation.

When the blood glucose concentration, initially checked hourly, reaches 250 mg/dL, change the infusion to 5% dextrose in 0.45-0.7% normal saline. This helps to prevent a precipitous fall in glucose, which may be associated with cerebral edema. In pediatric patients with suspected HHS, correcting fluid deficits over a longer period (48 h) may help to reduce the risk of cerebral edema.

The IV fluids should also include 20-40 mEq/L of potassium chloride to treat hypokalemia, which is seen in patients with HHS.

Patients with persistent hypotension may require pressor support in the ICU while rehydration is being accomplished.

Medications for coma patients

Basic medications given to coma patients in the field may include dextrose (50 mL of 50% dextrose in water [D50]). This is of benefit to many comatose patients with few adverse effects. When possible, fingerstick glucose measurement is obtained before dextrose administration. Whenever fingerstick glucose measurement is unavailable or is likely to be delayed, D50 must be administered to comatose patients on an empiric basis without delay. Undiagnosed and untreated hypoglycemia, which may present with signs and symptoms very similar to those of HHS, is readily reversible but can be rapidly lethal if not treated promptly.

Insulin Therapy for Correction of Hyperglycemia

All patients with HHS require IV insulin therapy; however, immediate treatment with insulin is contraindicated in the initial management of patients with HHS. The osmotic pressure that glucose exerts within the vascular space contributes to the maintenance of circulating volume in these severely dehydrated patients. Institution of insulin therapy drives glucose, potassium, and water into cells. This results in circulatory collapse if fluid has not been replaced first.

IV insulin administration is accomplished most effectively in the ICU, where cardiovascular and respiratory support is available if needed. Infuse insulin separately from other fluids, and do not interrupt or suspend the infusion of insulin once therapy has been started.

The following steps may be used as a guideline for insulin infusion, as per American Diabetes Association recommendations :

- If hypokalemia (K < 3.3mEq/L) has been excluded, an IV bolus of regular insulin of 0.10 U/kg/h should be administered.
- Begin a continuous insulin infusion of 0.1 U/kg/h.
- Monitor blood glucose by means of bedside testing every hour; if glucose levels are stable for 3 hours, decrease the frequency of testing to every 2 hours.
- If plasma glucose levels do not achieve a reduction of 50 mg/dL in the first hour, check volume status. If volume status is normal, it is okay to double insulin infusion every hour until a drop in glucose of 50-75 mg/dL is obtained.
- Set the target blood glucose level at 300 mg/dL; this target level may be adjusted downward after the patient is stabilized.
- Once blood glucose concentration reaches 300 mg/dL, decrease the insulin infusion rate by 0.5-1.0 U/h. Add dextrose to the IV fluids.
- Do not discontinue the insulin drip. Continue IV insulin at a goal glucose level of 250-300 mg/dL until the patient becomes more alert and hyperosmolarity has resolved.

Once the patient is alert and able to eat, an insulin regimen consisting of short-/rapid-acting insulin and long-acting insulin is needed to wean the patient off of IV insulin therapy and to control glucose levels. If the patient already had an insulin regimen before the onset of HHS, it is okay to continue the current regimen and adjust to better glycemic control. If the patient is new to insulin or a newly diagnosed diabetic, total subcutaneous insulin dosages should not exceed 0.5-1 U/kg/day. The IV insulin infusion should be continued for about 1-2 hours after subcutaneous insulin administration to avoid hyperglycemia.

When the glucose level has been between 200 and 300 mg/dL for at least 1 day and the patient's level of consciousness has improved, glycemic control may be tightened. The recommended level of glycemia for most patients with type 2 diabetes mellitus (DM) is 80-120 mg/dL. This correlates to the hemoglobin A_{1c} value of 7% recommended by the American Diabetes Association.

Electrolyte Replacement

Profound potassium depletion necessitates careful replacement. Patients may initially present with normal or elevated potassium levels. With rehydration, the potassium concentration is diluted. With the institution of insulin therapy, potassium is driven into cells, exacerbating hypokalemia. A precipitous drop in the potassium concentration may lead to cardiac arrhythmia.

Potassium may be added to the infusion fluid and should be started at a level of 3.5 mEq/L or less and with adequate urine output. Usually, replenishing potassium with 20-30 mEq of potassium chloride in each liter of IV fluid is sufficient. The goal is to keep a potassium level of between 4 and 5 mEq. It is important to replenish potassium before starting insulin infusion, especially when levels are below 3.5 mEq, to avoid cardiovascular compromise. Check the potassium level at least every 4 hours until the blood glucose concentration is stabilized.

Phosphate, magnesium, and calcium are not replaced routinely, even though patients may have whole body deficits in these electrolytes. A patient who is symptomatic with tetany requires replacement therapy for calcium.

FIRST AID FOR A DIABETIC LACTIC ACIDOSIS COMA

1. **Prevention and treatment of shock**:
1) Use fluid resuscitation to increase intravascular volume as in DKA or HHS. Crystalloid and colloid solutions are both effective.
2) In patients with hypotension, IV administration of catecholamines may be ineffective (as in other instances of severe acidosis).
3) High doses of catecholamines can aggravate hyperlactatemia by reducing tissue perfusion or overstimulating beta2-adrenergic receptors; therefore, the dose should be adjusted carefully.

2. **Improvement of blood oxygenation and treatment of hypoxia**: Administer oxygen as needed. Invasive ventilation may also be required to prevent hypercapnia, particularly if acidemia persists or worsens (note that achieving levels of hyperventilation required to mimic spontaneous hyperventilation may be difficult or impossible).

3. **Reduction of hyperglycemia**:
1) Administer insulin infusion as in the treatment of HHS.
2) When blood glucose levels decrease <11.1 mmol/L (200 mg/dL), administer a 5% glucose (dextrose) infusion. Once blood glucose levels have normalized, administer a 10% glucose infusion and continue the insulin infusion.

4. **Treatment of acidosis**: Administer IV sodium bicarbonate (this remains a controversial intervention; it is usually done with a pH <7.2; associated with some benefits in other instances of lactic acidosis)

5. **Hemodialysis**: Renal replacement therapy may be needed.

6. **Treatment of the underlying condition**.

7. **Measurement of the blood lactate level** remains the cornerstone of monitoring for lactic acidosis. Lactate can be measured in arterial or venous blood. Although a single elevated blood lactate level often predicts an adverse outcome, sustained hyperlactatemia is associated with even worse prognoses. An interval of 2 to 6 hours has been suggested for repeat lactate measurements.

FIRST AID FOR A HYPOGLYCEMIC COMA

Prehospital care

Emergency medical services (EMS) care generally consists of drawing serum glucose or using Accu-Chek prior to administering dextrose 50% in water (D50) in the field. This procedure usually is performed in the case of an unconscious patient or a patient with altered mental status. When hypoglycemia is found and treated in the diabetic patient, the patient may awaken and not desire transport. In view of the multiple causes of a sudden episode of hypoglycemia in a patient with previously well-controlled diabetes, it is prudent to advise transport and emergency department (ED) evaluation.

Emergency department care

The initial approach in the ED should include the following:
- ABCs (airway, breathing, circulation)
- Intravenous (IV) access
- Oxygen
- Monitoring

A hyperglycemic patient with an altered mental status may receive a bolus of glucose. This procedure is unlikely to harm the patient with high glucose; however, the delay in giving glucose to the hypoglycemic patient may be detrimental.

If an Accu-Chek can be performed immediately, it is reasonable to await the results (which are typically available within 1 minute) before deciding whether to administer glucose.

Once the diagnosis of hypoglycemia is made, search carefully for the cause in the previously healthy patient. In the diabetic patient, potential causes of the hypoglycemic episode include medication changes, dietary changes, new metabolic changes, recent illness, and occult infection.

Admission criteria for patients with acute hypoglycemia include the following:
- No obvious cause
- Oral hypoglycemic agent
- Long-acting insulin
- Persistent neurologic deficits

Patients with no known cause or no previous episodes of hypoglycemia must be admitted for further evaluation.

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