МИНИСТЕРСТВО ЗДРАВООХРАНЕНИЯ РЕСПУБЛИКИ БЕЛАРУСЬ
БЕЛОРУССКИЙ ГОСУДАРСТВЕННЫЙ МЕДИЦИНСКИЙ УНИВЕРСИТЕТ
КАФЕДРА ПРОПЕДЕВТИКИ ВНУТРЕННИХ БОЛЕЗНЕЙ

КЛИНИЧЕСКИЕ МЕТОДЫ ИССЛЕДОВАНИЯ ПАЦИЕНТОВ С ЗАБОЛЕВАНИЯМИ ОРГАНОВ ДЫХАНИЯ

CLINICAL EXAMINATION METHODS IN CASE OF RESPIRATORY DISEASES

Учебно-методическое пособие

Минск БГМУ 2023

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Представлен материал для подготовки к занятиям, посвященным обследованию системы органов дыхания. Дан перечень основных клинических признаков пульмонологических заболеваний, позволяющих студенту распознать нозологическую группу. Описаны методики расспроса и осмотра, пальпации, перкуссии и аускультации пациентов с заболеваниями органов дыхания.

Предназначено для студентов 2–3-го курсов медицинского факультета иностранных учащихся, обучающихся на английском языке

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EXPLANATORY NOTE
(MOTIVATIONAL CHARACTERISTICS OF THE TOPIC)

Total class time: 6 academic hours for students of the Faculty of Foreign Students.

The study of propaedeutics of internal diseases begins with the assimilation by students of the basic methods of clinical examination. The main clinical examination methods include: Interrogation and IPPA (inspection, palpation, percussion, auscultation). The essential duties of teaching doctors of any speciality include ensuring that students acquire and successfully use the concepts, skills, and techniques of patient examination.

The purpose of the class: to teach students the basic methods of clinical examination of respiratory system.

Class objectives:

1. To demonstrate to students how to examine a patient for a respiratory condition, taking note of basic and additional complaints, the disease's history, and history of life (anamnesis).
2. To teach students the technique of general inspection and chest inspection (static and dynamic chest examination).
3. To teach students the technique of chest palpation (identification of pain points, determination of chest resistance and study of vocal fremitus).
4. To familiarize students with percussion as a method of lung examination. To reveal the clinical value of comparative and lung percussion.
5. To teach students the technique of comparative and topographic lung percussion. Results of percussion in case of pathological processes in the lungs (pneumonia, exudative pleurisy, pneumothorax, emphysema).
6. To familiarize students with auscultation as a method of lung examination.
7. To teach students the technique of lung auscultation. Normal and pathological breathing sounds.
8. To teach students the technique of bronchophony.

Requirements for the initial level of knowledge. To master the topic, students should review from the following courses:

1) human anatomy — the anatomy of the lungs and respiratory tract;
2) normal physiology — the physiology of the lungs and respiratory tract;
3) general patient care — features of general patient care in case of respiratory diseases.

Control questions from related disciplines:

1. The structure of the respiratory organs.
2. The main functions of the respiratory system.

Control questions:

1. List the main complaints of patients in case of respiratory diseases, give their characteristics, indicate their pathogenesis and diagnostic significance.
2. Describe the features of patient's history in case of respiratory diseases.
3. Describe the results of visual examination of pulmonary patient: position in bed, skin discoloration, changes of the nails, indicate the mechanism of these symptoms.
4. Describe the significance of static and dynamic chest examination.
5. List the normal chest shapes and give their characteristics.
6. Describe the pathological chest shape, the mechanism of their formation and diagnostic significance.
7. Describe the causes of one of the chest's halves swelling (bulging) or shrinking (sinking).
8. List the main reasons for the asymmetry or asynchrony of chest expansion (lagging) when breathing.
9. Describe the types of breathing pattern and their diagnostic value.
10. List and characterize changes of breathing frequency, depth and rhythm, indicate possible mechanisms of formation.
11. List the types and mechanism of periodic respiration.
12. List the general rules and sequence of chest palpation.
13. Describe the technique of chest resistance evaluation.
14. List the purposes of chest palpation.
15. Describe the process that leads to the formation of vocal fremitus. How can we examine it?
16. List the causes and mechanism of strengthening and weakening of vocal fremitus.
17. Describe percussion as an examination method. List the percussion types and general rules of percussion.
18. List the rules for comparative and topographic percussion of the lungs.
19. Describe the characteristics of main percussion sound (clear pulmonary, femoral and tympanic sounds).
20. Name the causes and indicate the mechanisms of development over the lungs: a) dull percussion sound; b) flattened percussion sound; c) tympanic sound; d) hyperresonant sound.
21. List the topographic lines of the chest.
22. Specify the location of the lower border of the lungs (right and left) in the norm for each topographic line.
23. List the reasons for changes in lung borders (left, right) and their potential causes.
24. Describe the technique for determining the excursion of the lower border of the lungs along topographic lines in the norm.

25. Indicate the projection of the lobes of the lungs on the surface of the chest.

26. Describe auscultation as an examination method.

27. Describe the rules and technique of lung auscultation.

28. Normal breathing sounds: types, mechanism of formation, characteristics.

29. List the reasons and mechanism of physiological and pathological weakening and enhancement of vesicular breathing.

30. Specify the difference between normal and pathological bronchial breathing.

31. List the pathological breathing sounds.

32. Give definition for the term «rales», specify their variants.

33. Specify the main cause of wet rales (crackles), mechanisms of formation, types and diagnostic value.

34. Specify the main causes of dry rales, possible mechanisms of formation, types (wheezing and rhonchi) and diagnostic value.

35. Give the definition of the term «crepitation» (crepitus), specify the mechanism of formation and diagnostic value.

36. What are the differences between crepitation and wet rales (by auscultation)?

37. Pleural friction rub sound: mechanism of formation, characteristics, diagnostic value.

38. Indicate the differences between pleural friction rub sound and crepitation, dry and wet rales (by auscultation).

39. Describe bronchophonia as an examination method, technique of bronchophonia and clinical value.

SUBJECTIVE EXAMINATION

Interrogation is a subjective method of examination, it includes finding out the patient's complaints, the history of the disease (present history, *anamnesis morbi*) and history of life (past history, *anamnesis vitae*).

The main complaints of patients in case of respiratory diseases are as follows:

1. Shortness of breath (dyspnea).
2. Cough.
3. Hemoptysis (cough with blood).
4. Chest pain.

Additional complaints can be the following: malaise, weakness, fever, sweating, decreased appetite, fatigue, etc.

Dyspnea is one of the most important and most frequent sign of respiratory diseases. It is characterized by the individual's feeling of breathing difficulty as

well as a change in the frequency, depth, and rhythm of his or her respiration. Due to hypoxemia, the patient may experience chest tightness, a feeling of lack of air, an inability to correctly inspire or expire, or a general unpleasant feeling during breathing.

Physiological dyspnea occurs in healthy individuals with significant physical and emotional stress, staying in high-altitude conditions, being in a hot and stuffy room, etc.

Pathological dyspnea is observed in case of respiratory diseases, cardiovascular diseases, hematologic diseases, neurological diseases, intoxication, etc. Shortness of breath in respiratory diseases is most often caused by a violation of the function of external respiration.

Various respiratory diseases can be causes of shortness of breath. Dyspnea is caused by pathological processes with airway obstruction (asthma, etc.), decrease in the respiratory surface (atelectasis, emphysema, inflammation, pulmonary edema, etc.). The mechanism of shortness of breath in these diseases and conditions is associated with the excitation of the respiratory center by excess carbon dioxide and various under-oxidized products that accumulate in the blood and brain matter with insufficient oxygen supply to the body through the lungs.

There are three types of dyspnea: inspiratory, expiratory and mixed. Inspiratory dyspnea is characterized by difficulty in inhalation, it is observed in case of upper airways narrowing (pharynx, larynx, trachea, large bronchi). With a significant narrowing (tumor, foreign body, laryngeal edema), the inhalation becomes loud, noisy, audible at a distance (stridor breathing).

Expiratory dyspnea means difficulty in exhaling, which is performed slowly, sometimes with a whistle, while inhaling remains relatively free. It is observed in case of narrowing of the small bronchi and bronchioles due to inflammatory edema and swelling of the mucous membrane or with spasm of their smooth muscles. These factors interfere with the normal movement of air from the alveoli and complicate the exhalation phase.

With mixed shortness of breath, both inhalation and exhalation are difficult. This type of shortness of breath is observed in many lung diseases that cause a decrease in the respiratory surface (pneumonia, compression of the lung with fluid or air, etc.), while shortness of breath may be temporary (pneumonia, pleurisy) or permanent (lung emphysema). Mixed dyspnea is the most common dyspnea type, it can be in case of chronic respiratory failure and chronic heart failure.

Depending on its manifestations, shortness of breath can be subjective, objective and mixed. Subjective shortness of breath can be when a patient's feeling of difficulty breathing without objective signs of dyspnea, i. e. there are no changes in the depth, frequency, rhythm of breathing. Subjective dyspnea occurs in case of psychological disorders, flatulence, thoracic radiculitis. Objective dyspnea, along with the subjective sensation of breathing difficulties by patients, is also character-

ized by its objective signs: changes in the frequency, depth or rhythm of breathing, duration of the phases of inhalation or exhalation, participation in the act of breathing of auxiliary respiratory muscles, cyanosis; observed on case of respiratory and cardiovascular diseases.

Cough is a voluntary or involuntary act that clears the throat and breathing passage of foreign particles, microbes, irritants, fluids, and mucus; it is a rapid expulsion of air from the lungs. Coughing can be done deliberately or as part of a reflex. The most common cause of cough is irritation of receptors located in the mucous membrane of various parts of the respiratory tract (larynx, trachea, bronchi, etc.). Irritation of cough receptors can be caused by various factors: 1) chemicals (acids, alkalis, toxic substances); 2) mechanical (dust, small particles into the respiratory tract, compression of airway by a tumor, enlarged lymph nodes); 3) temperature (inhalation of very cold or very hot air); 4) inflammation in the respiratory organs. The cough reflex is controlled by the cerebral cortex, so it can be triggered and suppressed arbitrarily.

There are two types of coughs: dry cough (without sputum or non productive) and wet cough (with sputum or productive). Dry cough is characteristic of the early stage of acute bronchitis, pneumonia, pleurisy, lung infarction, first period of asthma attack, bronchial tumor, compression of the trachea or bronchus from the outside (enlarged lymph nodes, thyroid gland, etc.), pulmonary fibrosis, pulmonary tuberculosis, interstitial pulmonary edema, congestive heart failure.

Sputum is the pathological fluid of the respiratory tract. In the case of a productive cough, it is necessary to find out the amount of sputum, color, consistency and smell. The amount of sputum can be from a few milliliters to 1–1.5 liters, and sometimes more. Color of sputum can be related with type of pathological process: white or gray sputum corresponds with non-bacterial inflammation (allergic, autoimmune, etc.). Yellow or green sputum usually means purulent process at the airways. Red or pink sputum color happens in case of respiratory bleeding. Sputum has brown color because of blood or the intense chronic inflammation that comes with the chronic disease state. Foul smell of sputum may be in case of lung abscess.

According to the time of day, there are three types of coughs: morning, evening and night. Morning cough is typical for smokers, patients with chronic bronchitis. In these diseases, sputum accumulated in the bronchi at night. In the morning after the patient rises from bed, the sputum moves to less affected areas, irritates preserved receptor and stimulates the cough and sputum discharge. Evening cough is observed with acute bronchitis, pneumonia (cough presents whole day, and significantly increases in the evening). Night cough is typical for tuberculosis, lymphogranulomatosis, lung cancer. In such a case the receptors at tracheal bifurcation are irritated by enlarged lymph nodes or tumor in supine patient's position.

Hemoptysis is a symptom characterized by the release of sputum with a mixture of blood during coughing. It has high clinical significance. Hemoptysis means coughing up sputum with tinted blood or containing streaks of blood. Pulmonary hemorrhage, also referred to as massive hemoptysis, is a potentially life-threatening condition involving bleeding from the pulmonary or bronchial vasculature which is usually due to high blood pressure in vessels. Pulmonary hemorrhage is considered to be the release of more than 50 ml of blood per day when coughing, and the release of blood in an amount of up to 50 ml is considered hemoptysis. With the release of more than 200 ml of blood per day, they talk about massive pulmonary bleeding.

When a patient has hemoptysis, it should not be forgotten that the latter can often be as a result of blood entering the sputum from bleeding gums or nose.

Chest pain can vary in its origin, localization, nature, intensity, duration and radiation, as well as in relation to breathing, coughing, movement and body position. There are following causes of chest pain:

1) chest wall disease (ribs, muscle, skin, soft tissue);
2) respiratory diseases;
3) heart or aorta;
4) radiation into the chest from abdomen organs.

The first group of pain (superficial pain, somatic pain) includes pain due to skin and/or subcutaneous tissue damage (trauma, inflammation, etc.), muscles (myositis), intercostal nerves (neuritis, neuralgia), bones (periostitis, osteomyelitis, bone fracture, etc.). Superficial pain is well localized, intermittent or constant; it is described as aching, gnawing, throbbing, or cramping. It increases with deep breathing and related with a patient's position (increases on the affected side position and with sudden movements of the trunk.

Pain in case of respiratory diseases (deep pain) caused by irritation of the pain receptors of the pleura located mainly in its parietal leaflet and especially the costal and diaphragmatic pleura. Such type of pain has the following causes:

1) pleura inflammation (pleurisy);
2) superficial pathological process in the lung, right under the pleura, when pleura linings are involved in the inflammatory process (pneumonia, lung infarction, abscess, etc.);
3) pleura tumor;
4) trauma.

Most often pleural pains are caused by fibrinous (dry) pleurisy. Localization of pain is anterior and inferior lateral chest part. Pleural pain is stabbing sharp pain, increases with a deep breath, coughing, laughing, sneezing, when the trunk is tilted to the healthy side. In this position, the respiratory movements of the «healthy» lung are limited, and the «sick» ones increase, which leads to increased friction of inflamed pleural lining. When a patient is in position on the affected side, the

pleural pain decreases or disappears, since the mobility of the lung on this side is limited. Pleural pain due to pneumothorax is sudden and sharp in a limited area. It goes together with severe shortness of breath due to acute lung collapse.

In addition to the above main complaints, patients with respiratory diseases can make a number of general complaints: malaise, weakness, sweating, fever, fatigue, weight loss, etc. These complaints do not allow to localize the pathological process, but significantly complement and characterize the clinical picture of the disease.

OBJECTIVE EXAMINATION

Physical examination includes the following four objective methods of examination:

1) inspection;
2) palpation;
3) percussion;
4) auscultation.

INSPECTION

Cyanosis is a bluish discoloration of the skin, mucous membranes due to an increased concentration of reduced hemoglobin (Hb) in the small vessels of certain parts of the body. Usually, cyanosis is more noticeable on the lips, gums, earlobes, nail beds (fig. 1).

Fig. 1. Cyanosis of the nail beds

There are two types of cyanosis: central and peripheral.

Central cyanosis (total) is a generalized bluish discoloration of the body and the visible mucous membranes, which occurs due to inadequate oxygenation, alveolar hypoventilation or disbalance between ventilation and perfusion of the lungs. It can be due to respiratory diseases and damaged oxygen diffusion at lungs.

Peripheral cyanosis is the bluish discoloration of the certain parts of the body: fingertips, nails, lips, tip of nose, ears. Usually, it is caused by cardiovascular diseases due to a slowdown in blood flow (table 1).

Table 1

Difference between central and peripheral cyanosis

Parameter	Central cyanosis	Peripheral cyanosis
Mechanism	Decrease of oxygen saturation	Decrease of blood flow
Localization	Total	Local
Skin temperature	Warm	Cold
Mucous membranes	Involved	Not involved
Nail clubbing	May be	Not present
Oxygen therapy	Improved (respiratory causes)	Not improved
Capillary refill time	< 2 sec	> 2 sec

Central cyanosis is usually «warm», because hypercapnia leads to dilatation of small vessels, and often compensatory erythrocytosis. Especially pronounced cyanosis of the face is noted in primary and secondary sclerosis of the pulmonary artery. In patients with lobar pneumonia, cyanosis of the face is often combined with hyperemia of the cheeks, more pronounced on the affected side.

Nail clubbing is a deformity of the finger nails resulted from chronic low blood-oxygen levels. It can be found in case of chronic lung diseases (chronic obstructive pulmonary disease, asthma, bronchiectasis, etc.).

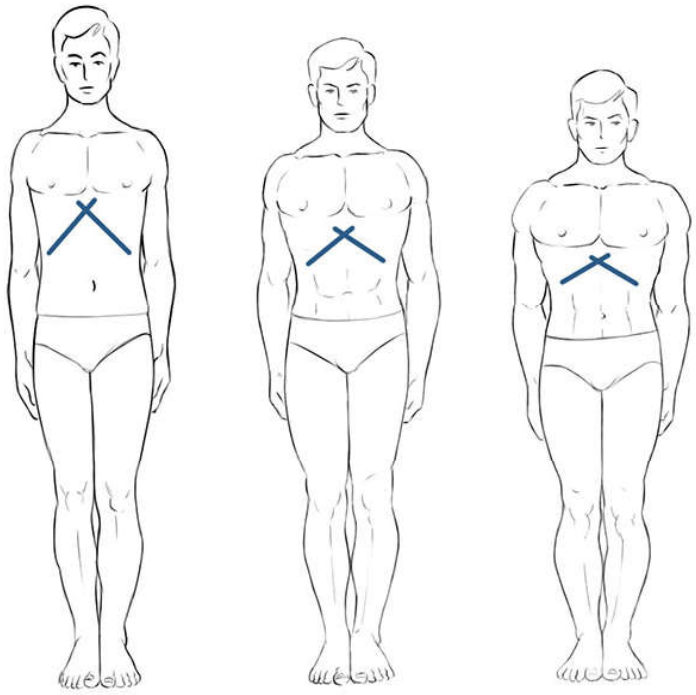
Edema accompanied by pulmonary hypertension, initially it appears on the lower extremities.

Chest inspection. The chest inspection is carried out in a certain order. The patient is in vertical (standing or sitting) position, and undressed.

Static chest inspection means evaluation of the chest shape and size. It is performed with the patient's normal breathing. Chest shape, the location of the clavicles, supraclavicular and subclavian pits, shoulder joints, ribs and sternum, as well as vertebra column is inspected.

Dynamic chest inspection means evaluation the chest movements in the act of breathing, doctor pays attention on the breathing pattern, respiration rate, depth and rhythm of breathing, the participation of auxiliary respiratory muscles in the act of breathing, symmetry of the both halves of the chest in breathing, Patient is asked to breathe deep several times.

Thorax shape can be normal or pathological. Normal thorax shapes are the following: normosthenic (mesomorph), hypersthenic (endomorph) and asthenic (ectomorph) (fig. 2). When examining the chest, it is necessary to pay attention to the position of the clavicles, supraclavicular and subclavian pits, ribs, shoulder joints, scapulas.



a ***b*** ***c***

Fig. 2. Normal chest shapes:
a — asthenic (ectomorph); *b* — normosthenic (mesomorph); c — hypersthenic (endomorph)

The normosthenic (mesomorph) chest shape is symmetrical and elliptical in cross section. The epigastric angle is approximately 90 degrees (fig. 3). The scapula with lowered arms are tightly attached to the back surface of the chest, its corners are slightly contoured, ribs have oblique direction.

Asthenic (ectomorph) chest shape is flat and long, the anteroposterior to transverse ratio is 1 : 2. The supraclavicular and subclavian pits are pronounced, the clavicles are clearly visible, ribs are more vertical, the epigastric angle is less than 90 degree.

Hypersthenic (endomorph) chest shape is short and wide with well defined muscles. The supraclavicular and subclavian pits are not pronounced, the clavicles are not very visible, ribs are more horizontal, the epigastric angle is more than 90 degree.

Fig. 3. Determination of the epigastric angle

Pathological thorax shapes are the following:

– barrel chest (emphysematous) is a symptom of chronic obstructive pulmonary disease (COPD), emphysema. The lungs fill with air and are unable to fully breathe out. The anteroposterior to transverse diameter ratio is 1 : 1;

– pigeon chest (Pectuscarinatum) has the forward protrusion of the sternum and adjacent costal cartilage;

– funnel chest (Pectus excavatum) is when the ribs and the breastbone (sternum) grow inward and form a dent in the chest.

Other pathological thorax deformities can be caused by vertebral column pathology (pathological lordosis, kyphosis, etc.). Doctor has to estimate symmetry of the thorax (chest volume increasing or reduction, shape of supra- and subclavicular areas), position of shoulder joints, clavicles, scapulas.

During a static examination of the chest, in addition to determining its shape, it is necessary to pay attention to its symmetry: the presence of an increase (bulging) or decrease (sinking) of one of the halves or some part of it.

An increase in the size or swelling of one of the halves of the chest is observed in the presence in the pleural cavity:

a) a significant amount of fluid (pleurisy, heart failure, liver cirrhosis, etc.);

b) a significant amount of air (pneumothorax).

A decrease in the size of one of chest halves is observed in case of (fig. 4):

a) adhesive process in the pleural cavity after inflammation;

b) extensive pneumosclerosis;

c) lung atelectasis (due to obstruction of main or lobar bronchi by a foreign body or a tumor);

d) after pneumonectomy (surgical removal of the lung).

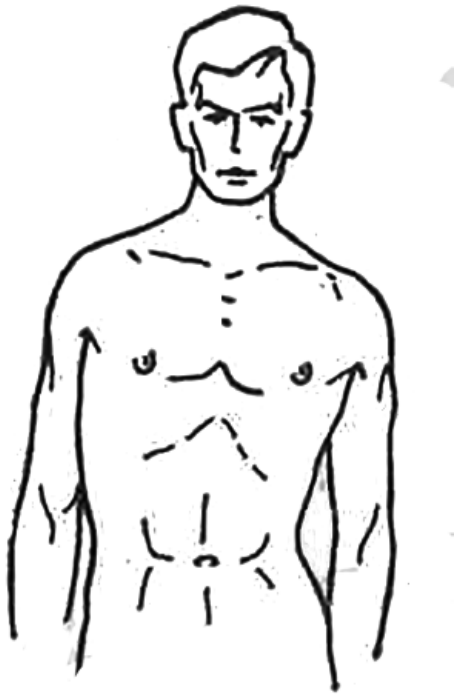


Fig. 4. Enlargement of the right half of the chest

The chest in the area of retraction becomes flatter, narrower and looks asymmetrical. Intercostal spaces on this side narrow, retract, and even disappear (the ribs touch or may find each other). The shoulder on the sunken half of the chest is lowered, the clavicle and scapula are located lower, the supraclavicular and subclavian pits sink, and the spine bends, protruding with its bulge in the healthy side.

Dynamic chest inspection. On inspection doctor evaluates the chest movement on respiration: synchronism of the thorax movement, indicate exactly sites where the thorax lagging is revealed while breathing. Normally additional respiratory muscles do not take part in breathing, in case of pathology their contraction can be visible. In healthy people, the chest is symmetrical and both halves of it are equally involved in the act of breathing.

Breathing type (pattern) may be the following (fig. 5):

– abdominal, when respiration is based on diaphragm movement (common for adult male);

– thoracic, when respiration is based predominantly on intercostal muscles movement (common for female);

– mixed (children, elderly persons).

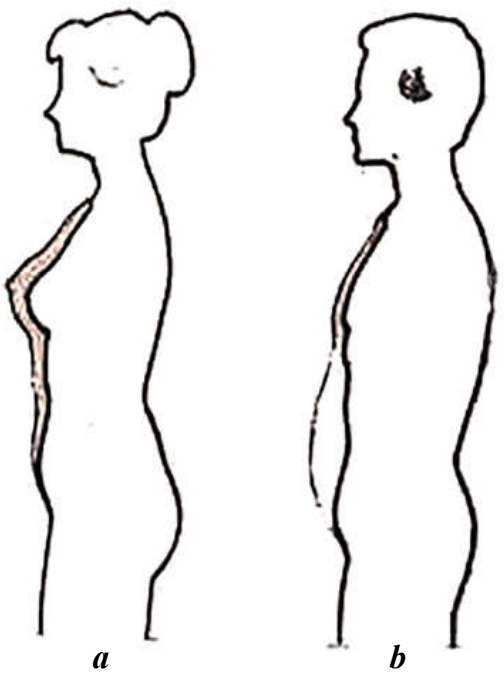


Fig. 5. Types of breathing:
a — thoracic; *b* — abdominal

Respiratory rate. When the doctor counts respiratory rate, it is necessary to avoid patient's influence on the respiratory rate. One hand the doctor places on the patient's wrist, and pretend to determine the pulse rate, at the same time doctor follows the movements of the patient's chest and abdomen movements, count the number of respiratory movements in one minute. One inspiration and one expiration are counted as one respiratory act. Respiratory rate per minute normally is 12–20 per minutes at rest. Increased respiratory rate is called *tachypnea*, decreased is called *bradypnea*.

A physiological tachypnea is observed after physical exertion or stress and it rapidly disappears when the underlying cause subsides.

Pathological tachypnea can be caused by:

1. Fever.

2. Respiratory diseases (decrease in respiratory surface in case of pneumonia, pneumothorax, lung infarction; block of airways in case of laryngedema, bronchospasm, etc.).

3. Cardiovascular disease (heart failure, myocardial ischemia, etc.).

4. Chest diseases (restriction of respiratory movements).

5. Abdomen organ diseases (increased intra-abdominal pressure and high level of diaphragm in case of ascites, flatulence).

6. Anemia.

7. Neurological diseases (disorders of breathing center, anxiety or panic attack, etc.).

Bradypnea occurs in case of respiratory center suppression (increased intracranial pressure due to brain tumor, brain edema, meningitis, intoxication, etc.).

The depth of breathing. In healthy adults, the volume of respiratory air is 300 to 900 ml (500 ml in average). Breathing may be deep or shallow due to changes in the depth of breathing. A change in the depth of breathing is usually accompanied by a change in its frequency and vice versa.

Breathing rhythm should be regular (rhythmic). In case of pathology respiration can be irregular. There are several types of abnormal breathing patterns (Kussmaul breathing, Cheyne–Stokes respiration, Grocco's respiration) (fig. 6).

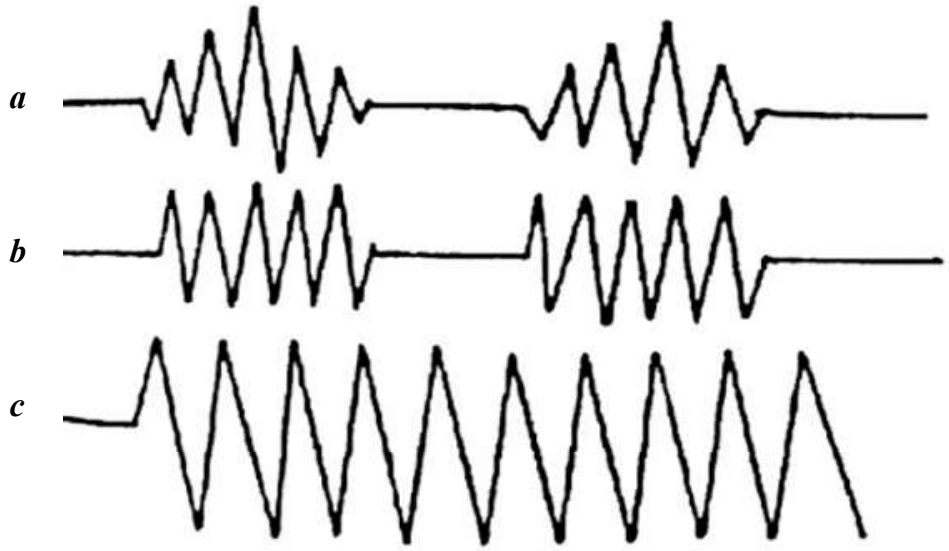


Fig. 6. Pathological respiration patterns:
a — Cheyne-Stokes respiration; *b* — Biot respiration; *c* — Kussmaul breathing

Kussmaul breathing is an abnormal breathing pattern characterized by rapid, deep breathing at a constant rate. It is most commonly associated with conditions that cause metabolic acidosis, particularly diabetes.

Cheyne–Stokes respiration is an abnormal pattern of breathing characterized by progressively deeper, and sometimes faster, breathing followed by a gradual decrease that results in a temporary stop in breathing (apnea). Biot respiration is characterized by regular deep respirations interspersed with periods of apnea. Biot and Cheyne Stokes breathing patterns occur when there is damage to the medullary respiratory center in the brain, which can be caused by brain injury (trauma), brain tumor or increased intracranial pressure

CHEST PALPATION

Palpation is a method of patient's physical examination with the fingers or hands. When palpating the chest, it is necessary to follow the general rules of palpation: it should be carried out in a warm room; the hands of the examiner should be warm and clean, and the nails should be cut short, gloves can be used; the patient's chest should be exposed. Chest palpation includes:

1. Chest resistance palpation.
2. Vocal fremitus palpation.
3. Palpation of pain points.

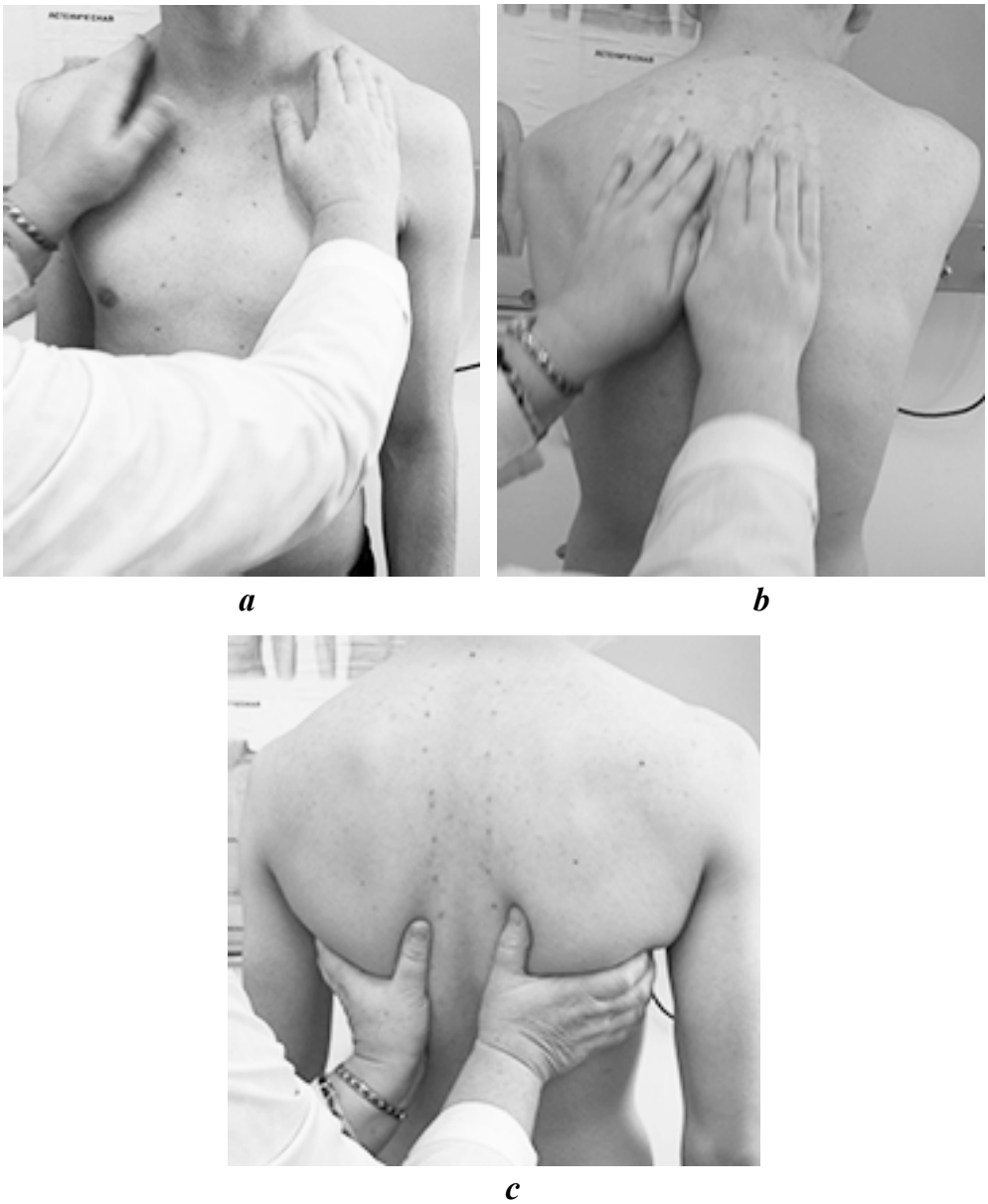
Chest resistance is checked as follows (fig. 7). Pressure is produced by vigorous, springy movements, mainly with the base of the palms. Then the palms are placed on symmetrical sections of the lateral sections of the chest, parallel to the course of the ribs, along the axillary lines, closer to the armpit and compression is carried out laterally. Palpation of the chest in healthy young people, and especially in children, creates a feeling of elasticity. With age, the chest loses its elasticity due to ossification of the rib cartilage, and in older people it becomes rigid.

a ***b***

Fig. 7. Determination of chest resistance in the antero-posterior direction:
a — frontal view; *b* — lateral view

Vocal fremitus, also known as tactile fremitus, refers to the vibration of the chest wall that results from sound vibrations created by speech or other vocal sounds.

When determining the vocal fremitus, the palms of the hands are placed on symmetrical areas of the patient's chest, necessarily tightly pressing the palm surfaces of the fingertips, and ask him to pronounce «ninety-nine». The definition of vocal fremitus begins with the supraclavicular pits (fig. 8, *a*), placing the palms vertically, then descend into subclavicular pits.



a ***b***

c

Fig. 8. Vocal fremitus examination:
a — on supraclavicular pits; *b* — on intercostal space; *c* — on subscapular areas

Next, the vocal fremitus is determined in the axillary areas on both sides. Then, vocal fremitus is determined at the back (fig. 8, *b*, *c*):

1) 1 on supraspinatus area;
2) on interscapular area;
3) below the inferior angle of scapula.

In healthy person, vocal fremitus should be the same in the symmetrical parts of the chest.

Pathological processes with consolidation of lung tissue lead to increased vocal fremitus, because dense tissue conducts the sounds and vibrations better.

Weakening or complete disappearance of voice fremitus is caused by pathological processes accompanied by the accumulation of fluid, air, fibrous tissue, etc. in the pleural cavity, which move the lung away from the chest wall and prevent the sounds conduction. Vocal fremitus weakens (amount of fluid or air is not very big) or disappears (amount of air or fluid is great).

Performing palpation of the chest can reveal pain points. Usually chest pain points are caused by a musculoskeletal disorder and associated with tenderness of the chest wall (superficial pain). Pain in case of respiratory diseases couldn't be revealed by palpation, because this pain is deep.

LUNG PERCUSSION

Percussion is an objective method of physical examination, it is an assessment technique which produces sounds by the examiner tapping on the patient's body. Chest contains a lot of different organs, that's why lung percussion is of great importance for the diagnosis of respiratory diseases.

For successful percussion and for obtaining proper percussion sounds, it is necessary to follow general rules:

1. Rules for room condition:
– quiet;
– warm temperature;
– good light.
2. Rules for the patient:
– undressed;
– proper position (sitting, standing).
3. Rules for the doctor:
– short nails;
– warm and clean hands;
– proper position (comfortable).

The pleximeter, the middle phalanx of the 3rd finger of the examiner's left hand must be firmly applied to the chest wall, so that no air pockets are interposed between the finger and chest wall (fig. 9). The pleximeter is kept flexed at a right angle and must hit the middle phalanx of the pleximeter finger perpendicularly, with the pad and not the tip of the finger. The percussion stroke must be sudden, the pleximeter finger being withdrawn immediately after the stroke, to prevent a damping of the note. The movement of percussion must originate at the wrist and

not at the elbow or finger. The force of the stroke must be varied according to the purpose of the percussion the tissue or organ being percussed, thickness of the chest wall or area of the chest wall.

Fig. 9. Percussion

Percussion produces different sounds depending on the density of the underlying tissue. Main percussion sounds are the following:

1. Resonance (clear resonant lung sound) is the normal sound over the lungs of a healthy person.

2. Dullness is heard over a solid organs (liver, heart, partially covered by lungs).

3. Flatness (absolute dullness, stony dull) is heard when percussing over solid tissue (muscles, bones).

4. Tympany is heard over the air-filled organs (bowel loops, stomach gas bubble).

5. Hyperresonant is a drum-like sound, it is heard above the lungs in case of emphysema (lungs hyperinflated with air).

There are two types of percussion: comparative and topographic. The purpose of *comparative percussion* is to compare percussion sounds over the lungs on the opposite parts of the chest, and also on neighboring areas on the one side.

Rules for comparative percussion are the following:

– place the pleximeter finger into intercostals space;
– move the pleximeter finger for one intercostals space;
– move the hands from right side to the left one each time;
– comparative percussion is loud or moderate.

Places of comparative lung percussion performing are presented at figures (fig. 10–13).

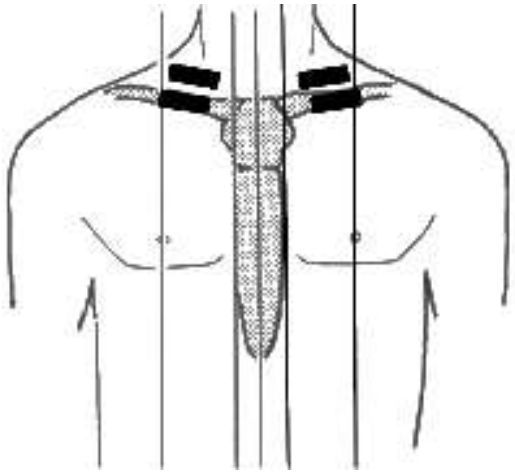


Fig. 10. Comparative percussion of lungs on supraclavicular regions and clavicles *(black lines indicate the places of finger-pleximeter)*

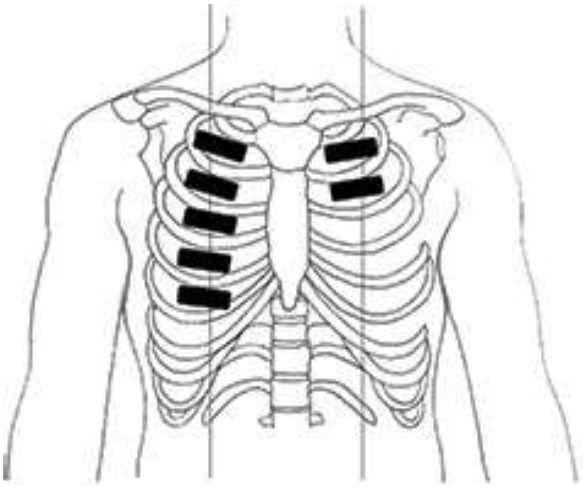


Fig. 11. Comparative percussion of lungs on anterior chest surface *(black lines indicate the places of finger-pleximeter)*

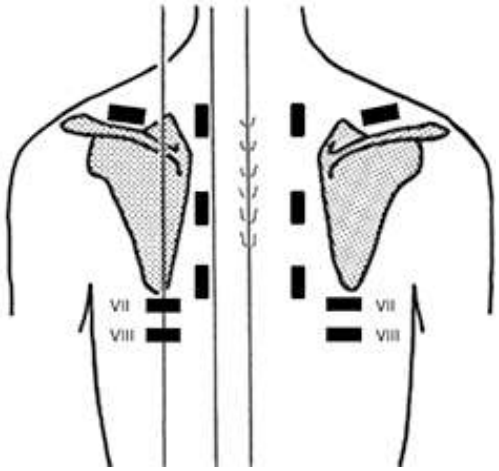


Fig. 12. Comparative percussion of lungs on lateral chest surface *(black lines indicate the places of finger-pleximeter)*

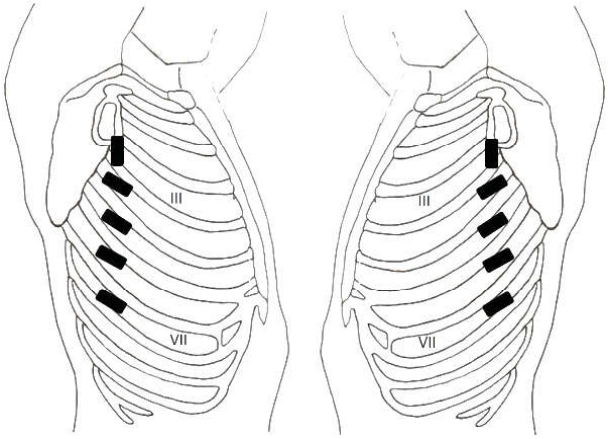


Fig. 13. Comparative percussion of lungs on posterior chest surface (black lines indicate the places of finger-pleximeter)

The purpose of *topographic percussion* is to determine the borders of the organ.

Rules for topographic percussion are the following:

– the pleximeter finger is placed on parallel position to the searched border;

– the pleximeter finger is moved on perpendicular direction to the searched border;

– the topographic percussion is always performed from a clear note in the direction of dull sound;

– the pleximeter finger is moved at 1–2 cm;

– topographic percussion is soft;

– the border of a lung is marked on that side of a finger-pleximeter from the side of more clear sound.

Inferior border of lungs is determined along vertical topographic lines. These are the following topographic chest lines (fig. 14, table 2).

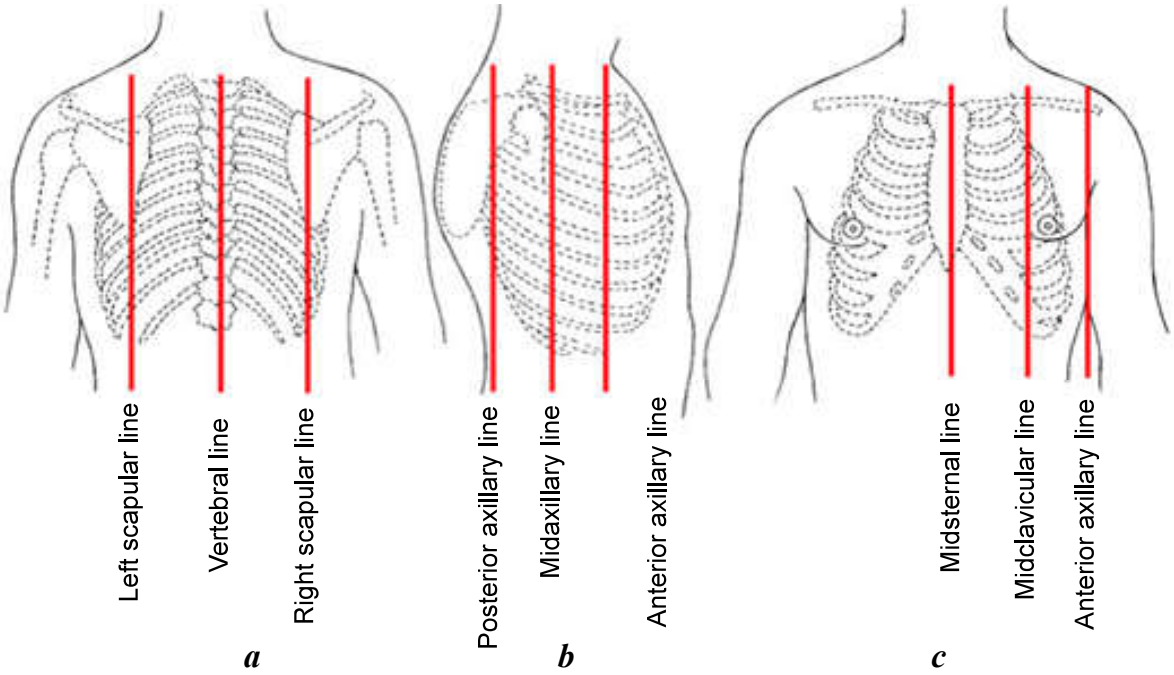


Fig. 14. Topographic chest lines:
a — posterior view; *b* — lateral view; *c* — anterior view (https://sites.google.com)

Table 2

Topographic chest lines and lung borders

Topographic line	Location of line (dropped vertically from)	Location of inferior lung border	
		right	left
Anterior midline	Middle of sternum	–	
Sternal line	Lateral edge of sternum	–	
Parasternal line	Between sternal and midclavicular line	5th intercostal space	–
Midclavicular line	Middle of clavicula	6th rib	–
Anterior axillary line	lateral edge of pectoralis major muscle	7th rib	7th rib
Middle axillary line	apex of axilla	8th rib	8th rib
Posterior axillary line	lateral edge of latissimus dorsi muscle	9th rib	9th rib
Scapular line	inferior angle of scapula	10th rib	10th rib
Paravertebral line	transverse processes of vertebrae	11th rib	11th rib
Posterior midline	spinal processes of vertebrae	–	

Inferior border of right lung usually is found by percussion along three lines: right midclavicular, midaxillary and scapular lines. Inferior border of left lung is determined along two lines only, left midaxillary and scapular lines (fig. 15–18). We do not use the left midclavicular line due to the presence of the heart (at the side) and gastric gas bubble (below) in close proximity to the inferior lung border. In people with asthenic (ectomorph) chest shapes, the normal position of the inferior lung boundary is lower, whereas in people with hypersthenic (endomorph) chest shapes, it is higher.

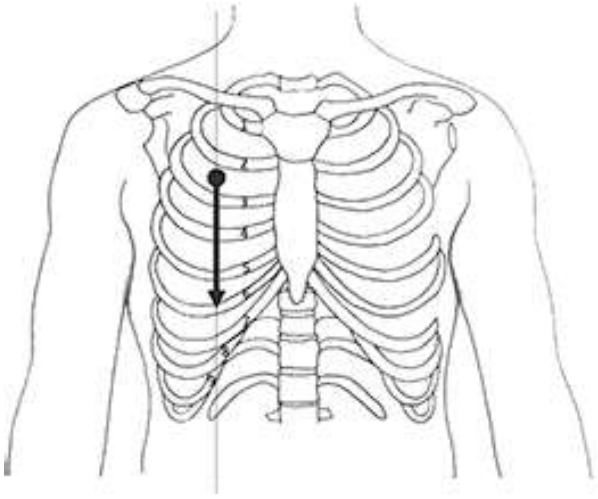


Fig. 15. Estimation of inferior border of right lung by right midclavicular line

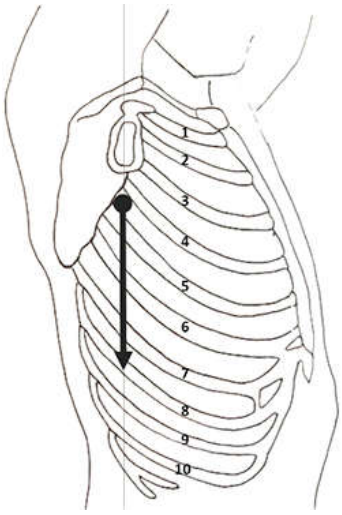


Fig. 16. Estimation of inferior border of right lung by right midaxillary line

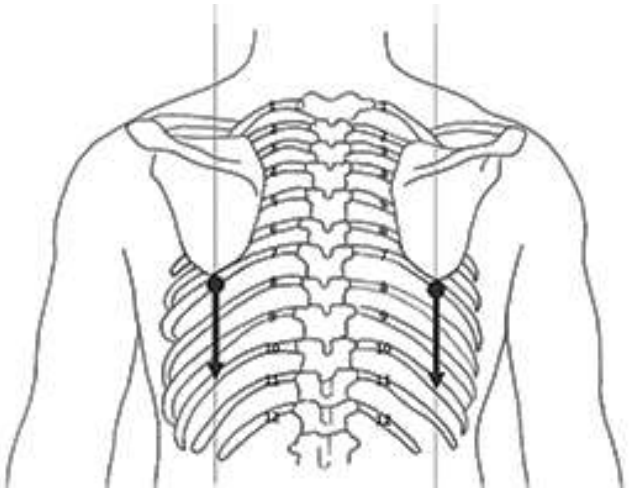


Fig. 17 Estimation of inferior border of right and left lung by scapular lines

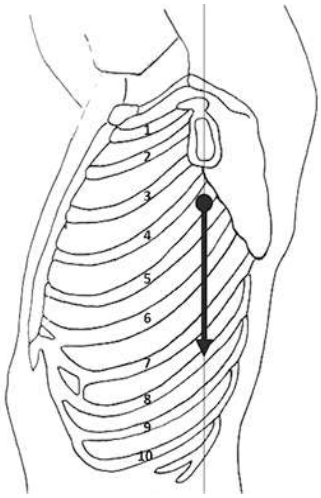


Fig. 18. Estimation of inferior border of left lung by left midaxillary line

LUNG AUSCULTATION

Lung auscultation is the main physical method of lung examination. General rules of lung auscultation are the following:

1. Room should be quiet and warm.

2. Patient is in proper position (standing or sitting, seriously ill patients can have supine position).

3. Patient's chest should be naked, because the rustle of clothes can be mixed with lung sound. Auscultation should never be done through the clothing. Areas with hair may be moistened with water, it prevents the friction of the hair and artificial sounds.

4. Stethoscope is held by its head with two fingers and is tightly applied to the patient's body without pressure.

5. Lung auscultation is performed with stethoscope diaphragm.

6. Lung auscultation is comparative, i. e. point of auscultation have to be moved from right to left and vice versa every time.

7. At each point whole respiratory act should be auscultated (inspiration and expiration).

Breathing sounds are heard over the lungs of a healthy person are (fig. 19):

1) vesicular breathing;

2) bronchial breathing.

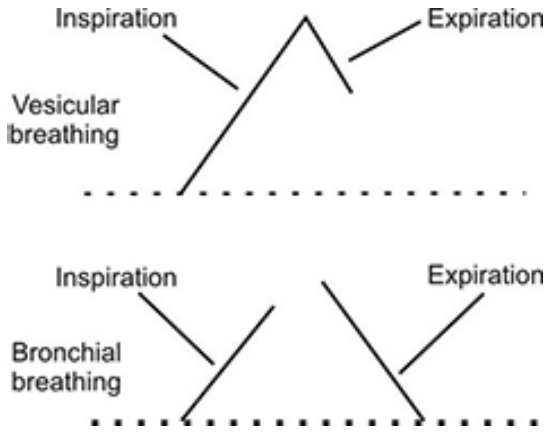


Fig. 19. Vesicular and bronchial breath sounds
https://www.jaypeedigital.com/book/9788180616150/chapter/ch5

Rene Lennac invented the term «*vesicular breathing*», because he believed that they are produced by air flowing through the alveoli. But in fact, vesicular breath sounds are produced by the air flowing through the bronchioles. Difference between vesicular and bronchial breathing presented at table 3.

Table 3

Normal breathing sounds

Characteristics	Vesicular breathing	Bronchial breathing
Location	over both lungs (all surface of chest)	over the larynx, trachea and tracheal bifurcation (manubrium, upper chest and upper interscapular area)
Pitch	low	high
Loudness	low	high
Timbre	soft	harsh
Part of respiratory act	inspiration and $^{1}/_{3}$ part of expiration	inspiration and expiration (expiration is louder)
Ratio inspiration/expiration	2 : 1 or 5 : 2	1 : 2
Pause between inspiration and expiration	No	Yes

Changes in vesicular breathing. In various conditions, both physiological and pathological, the character of vesicular breathing can change. Physiological weakening of vesicular breathing occurs in patient with excessively developed muscles or fat, in persons with hypersthenic (endomorph) body built.

Physiological high intensity of vesicular breath sounds is observed in asthenic individuals who have a thin chest wall due to weak muscle development and subcutaneous fat layer (like healthy children and teenagers). Increased vesicular breathing also occurs during physical exertion, which is due to an increase in the depth and frequency of respiration and, consequently, a greater tension of the walls of little airways in inspiration. Increased vesicular breathing (harsh vesicular breathing) occurs in marked narrowing of the lumen in small bronchi and bronchioles due to inflammatory edema of their wall (the inspiration and expiration phases are intensified).

Intensity of vesicular breath sounds (pathological weakening) can be reduced due to following factors:

1. Weak sound generation (airway obstruction, emphysema, pneumonia, pulmonectomy or lobectomy etc.).

2. Impaired sound transmission (pneumothorax, pleural effusion, etc.).

Bronchial breath sounds are generated by turbulent air flow in large airways (larynx, trachea). It is heard both in inhalation and exhalation, but expiratory phase is louder and longer. Normally, bronchial breathing is heard only over the large air passages e. g. the trachea and main bronchi. The appearance of bronchial breathing in any other place of the chest indicates pathological changes in the lungs. Such bronchial breathing is called pathological bronchial breathing. Possible cause is lung consolidation (pneumonia, atelectasis, lung fibrosis. etc.).

In various diseases of the respiratory system, along with the normal respiratory sounds, *adventitious sounds* may be heard. There are three types of adventitious sounds (table 4):

1) pleural friction rub;
2) crepitus (crepitation);
3) rales.

Pleural friction rub sound results from the movement of inflamed and roughened pleural surfaces against one another during movement of the chest wall. Normally, the parietal and visceral pleural leaves have a smooth surface and are separated by a very thin layer of fluid, so the visceral pleural leaf slides along the inner surface of the parietal leaf during breathing is completely silent. In case of some pathological process, surfaces of pleural leaves become uneven, rough, then their movements in breathing is accompanied by sounds. Pleural friction sounds are heard during both inspiration and expiration. The sounds are variable by intensity, length, and timbre.

Table 4

Adventitious lung sound characteristics

Parameter	Pleural friction rub	Crepitation	Rales	
			Wet (moist) rales = crackles	Dry rales
Place of formation	pleura	bronchioles, alveoli	bronchi	
Causes	dry pleuritis, lobar pneumonia with pleuritis, cancer	pneumonia (inflammation of lung parenchyma)	bronchitis, pneumonia, pulmonary edema	bronchitis, asthma, COPD, heart failure
Mechanism of formation	rubbing of pleura leaves	alveoli inflate and deflate with each breath	air bubbles go through fluid sputum	bronchial obstruction (narrow bronchi): a) spasms of smooth muscles of the bronchi (like asthma); b) swelling of the bronchial mucosa; c) viscous sputum in bronchi narrows its lumen; d) sclerosis of bronchial wall; e) vibration of viscous sputum in the bronchi (like strings)
Duration of sounds	various	short	short	long
Timbre	various	soft	soft	various
Phase of respiration	inhalation and exhalation	peak of inhalation	inhalation, sometimes exhalation	inhalation and exhalation

End of the table 4

Parameter	Pleural friction rub	Crepitation	Rales	
			Wet (moist) rales = crackles	Dry rales
False breathing	no changes	disappear	disappear	
Cough	no changes	no changes	can change area, timbre or disappear	
Features	heard better when the stethoscope is applied firmly to the chest wall; often accom-panied by chest pain; can be felt by palpation	similar like sound rubbing a lock of hair.	a) *fine crackles* are produced within the small bronchi; b) *medium crackles* are caused within medium bronchi; c) *coarse crackles* arise from the large bronchi	a) high-pitched rales (*wheezing*) are produced within small bronchi b) low-pitched rales (*rhonchi*) are produced within large bronchi
Duration	intermittent	intermittent	intermittent	continuous

Crepitation (crepitus) occurs when a bronchioles and alveoli open during inspiration after collapsing due to exudate inside. During expiration, the alveoli stick together, while during inspiration the alveolar walls are separated with difficulty and only at the end of the inspiratory movement. Crepitation is therefore only heard during the height of inspiration. Crepitation is the discontinuous sound produced by many alveoli during their simultaneous reinflation. Crepitation also is called «*late inspiratory crackles*».

Other meaning of crepitation (*subcutaneous crepitation*) is a sound and sensation associated with subcutaneous emphysema, a condition in which air is trapped under the skin in case of pneumothorax.

Moist rales (crackles) are generated in case of accumulation of watery fluid (sputum, edematous fluid, blood) in the bronchi. Air bubbles pass through this liquid and collapse to produce the specific cracking sound. Moist rales are heard during both the inspiration and expiration (better in inspiration). Depending on the caliber of bronchi, moist rales are classified as fine, medium and coarse.

Fine crackles are generated in fine bronchi; medium crackles are produced in bronchi of a medium size. Coarse crackles are produced in large bronchi, and in lung cavities (abscess) communicating with the large bronchus.

Dry rales are generated inside of bronchi when their lumen is narrowed. Dry rales are heard during inspiration and expiration and vary in their loudness, tone and pitch.

According to pitch of the sounds dry rales are divided according the pitch into:

– *wheezing* (sibilant(hissing), high-pitched) sounds are produced in the small bronchi;

– *rhonchi* (low-pitched sounds) are generated in medium and large bronchi.

Bronchophony is a method of examination, which is when voice transmission through lung structures is heard with stethoscope. Doctor asks the patient repeats in a whisper word containing hissing sounds, for example, “sixty-six”. Normally it is impossible to determine words by auscultation due to poor transmission of sounds (*negative bronchophony*). In case of lung tissue consolidation a doctor can hear whisper words clearly (*positive bronchophony*).

SELF-CONTROL QUIZ

1. A 70-year old patient L. suffers from a severe cardiac failure. His examination revealed irregular breathing patterns, with the amplitude of respiratory movements increasing to reach their maximum length by cycle 6 or 7, then decreasing to end with an interruption in breathing for 10–15 seconds with a similar «wave» following without the patient noticing it. Which of the following best describes a disordered breathing pattern?

a) Kussmaul breathing;
b) Biot breathing;
c) Cheyne-stokes breathing;
d) Grocco breathing;
e) Apnoea.

2. A 59-year old patient K. complains of the expiratory dyspnea. Explain this term «expiratory dyspnea»:

a) it is difficult to breathe in;
b) it is difficult to breathe out;
c) it is difficult to both breath in and out;
d) asthma attacks occur;
e) a periodic respiration takes place.

3. Which of these figures refer to the respirations-per-minute rate of breathing in a healthy adult when at rest?

a) 10–12; b) 16–20; c) 22–28; d) 30–32; e) 30–36.

4. What complaint is not typical for pathology of respiratory organs?

a) Cough;
b) Cough out sputum;
c) Dyspnea;
d) Vomiting;
e) High temperature.

5. During the inspection of a patient an accelerated respiratory rate of 24 per minute was observed. What does this mean?

a) Cheyne-Stokes breathing;
b) apnea;
c) bradypnea;
d) breathlessness;
e) tachypnoea.

6. It is impossible to define by percussion border between:

a) lung lobes;
b) lung and muscles;
c) lung and liver;
d) lung and heart;

7. First percussion tap is done at comparative percussion over:

a) right side of chest;
b) left side of chest;
c) increased side of chest;
d) decreased side of chest;
e) side of chest with good amplitude of breathing.

8. Choose a condition that is required for the occurrence of pleural rub:

a) collapse of pulmonary tissue;
b) infiltration of pulmonary tissue;
c) inflammation of pleural layers;
d) increased airiness of the lungs;
e) pulmonary edema.

9. A 48-year-old patient K, had a severe case of dyspnea («I can not exhale») during an attack. She is seated on the bed, her head resting on the pillow; her breathing rate is 24 breaths per minute; her exhalation is drawn out and there is a wheezing noise coming from her chest. Her emphysematous chest is symmetrical and produces a hyperresonant percussion tone. In this instance, the breakdown of the respiratory system is due to:

a) accumulation of air in a pleural cavity;
b) accumulation of fluid in a pleural cavity;
c) massive low-lobe right pneumonia;
d) attack of bronchial asthma
e) expressed pleurae adhesions.

10. During inspection of patients with syndrome of obstructive atelectasis of lung can be revealed the following:

a) decrease of the affected half of the chest;
b) increase of the intercostals spaces;
c) enlargement of the affected half of the chest;
d) emphysematous (barrel-like) chest;
e) protrusion of supraclavicular fossae.

Answer: **1** — c; **2** — b; **3** — b; **4** — d; **5** — e; **6** — a; **7** — a; **8** — c; **9** — d; **10** — a.

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CONTENT

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