Ministry of health Republic of Belarus
Establishment of education "Gomel state medical university"

Department of histology, cytology and embryology

MANUAL
for 1-st year students of faculty of foreign students on gynecology

Topic: 2:
HISTOPHYSIOLOGY OF THE RESPIRATORY SYSTEM

Duration 4 hours

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THE MOTIVATIONAL CHARACTERISTIC OF THE THEME

Organs of respiratory system, except for the basic function of gas exchange, except respiratory functions it also have non respiratory function. Knowledge of a structure and histophysiologies organs of breath very important for doctor to understanding of frustration of these functions and carrying out of purposeful therapy. Development and application of modern methods of research and diagnostics of diseases of bodies of breath, such as bronchoscopes? X-ray, laboratory researches separated of air ways.

THE PURPOSE

Studying of a microscopic and ultramicroscopic structure of organs of respiratory system and histophysiologies their structural components.

PROBLEMS

The student should know:

1. The general principle of the organization of respiratory system.
2. Sources of development of organs of respiratory system.
3. Features of a structure air ways organs.
4. A structure of structurally functional unit respiratory asinus.
5. A structure of air-blood barrier
6. Features of blood circulation and innervation of the lungs.

The student should be able:

1. To identify organs of respiratory system on microscopy level.
2. To explain a role of structural components of air ways and a respiratory part and functions of lungs.
3. To define structural elements air and a blood pressure at an ultramicroscopic level.

REQUIREMENTS TO THE INITIAL LEVEL OF KNOWLEDGE

For full mastering a theme it is necessary for student to repeat from normal anatomy a general plan of a structure of respiratory system

CONTROL QUESTIONS FROM RELATED SUBJECTS

1. The Structure air ways and respiratory part of respiratory system.
2. Elements of immune protection in respiratory system.

CONTROL QUESTIONS ON THE THEME

1. The general morpho-functional characteristic of respiratory system. Development.
2. Air ways: nasal cavity, larynx, trachea, bronchus, bronchioles, terminal bronchioles.
3. A structure of a respiratory part of a lung:

a) Acini, as structurally functional unit of a lung;
b) Respiratory bronchioles, alveolar ducts, alveolar sacs;
c) Alveolus, structure and functions;
d) Surfactant, chemical organization, formation and functions.

4. A pleura, a structure and function.
5. Elements of immune system in respiratory system organs.

6. Regeneration processes of respiratory system organs.

THE PRACTICAL PART

1. The Structure of various air ways organs – to fill the table (Exercise № 1 in album)
2. Microscopy of histological preparations and their sketch in an album (Exercise № 2 and 3 in album)
3. Embryonic development of respiratory system – to fill the table (Exercise № 4 in album)
4. Terminal bronches and sinus of the lung – to enter designations (Exercise № 5 in album)
5. The Structure of a wall of a lung – to enter designations (Exercise № 6 in album)
6. Blood- Air barrier – to enter designations (Exercise № 7 in album)

SLIDES
1. Trachea.
2. Lung.

QUESTIONS FOR SELF-CHECKING KNOWLEDGE
1. Basic morpho-functional characteristic of respiratory system.
2. Development of organ of respiratory system.
3. Structure of air passages:
   - nasal cavity.
   - larynx.
   - trachea.
   - bronchi of different size.
4. Structure of respiratory part of lung.
5. Structure and functions of alveolus.
6. System of surfactant in lungs.
7. Blood-air barrier.
8. Pleura. Structure and functions.
9. Elements of immune system in organs of respiratory system.
10. Regeneration of organs of respiratory system.

HISTOPHYSIOLOGY OF THE RESPIRATORY SYSTEM

The respiratory system consists of 2 parts:
I. Airways, consisting of the nasal cavity, nasopharynx, larynx, trachea and bronchi.
II. The respiratory section, consisting of respiratory bronchioles, alveolar passages, alveolar sacs.
The respiratory system performs a number of important functions:
I. The function of external respiration is associated with the absorption of oxygen from the inhaled air, the saturation of the blood with it and the removal of carbon dioxide from the body.
II. Non-respiratory functions.

1. Inactivation of a number of hormones occurs in the lungs (for example, serotonin).

2. The lungs are involved in the regulation of blood pressure, because. the endothelium of the capillaries of the lungs synthesizes a factor that promotes the conversion of angiotensin I to angiotensin II.

3. The lungs are involved in the processes of blood clotting, because. the endothelium of the capillaries of the lungs synthesizes heparin and its antipode thromboplastin.

4. Erythropoietins are produced in the lungs, which regulate the differentiation of erythrocytes in the red bone marrow.

5. The lungs are involved in lipid metabolism due to macrophages, which capture cholesterol from the blood and leave the body through the airways, providing physiological prevention of atherosclerosis.

6. Lungs – blood depot.

7. Lungs are involved in immune responses, because along the airways there are lymphoid nodules that together form broncho-associated lymphoid tissue.

8. Lungs take part in water-salt metabolism [1].

Stages of lung histogenesis.

Stage I – from the 3rd to the 5th week of intrauterine development. It begins with a protrusion of the ventral wall of the foregut, called the prechordal plate. This protrusion is the rudiment of the trachea, which bifurcates into 2 bags – the rudiments of the main bronchi and lungs.

Stage II – from the 5th week to the 4th month of intrauterine development and is called glandular. At this stage, the formation of the bronchial tree occurs.

Stage III – from the 4th to the 6th month of intrauterine development. The formation of respiratory bronchioles begins. This process is accompanied by capillarization of the bronchial tree.

Stage IV – from the 6th month of intrauterine development and continues for several years after birth. This stage is called alveolar, since during this period alveolar passages and sacs are formed [1].

The nasal cavity performs the following functions:

a) Cleansing, warming and humidifying the air.

b) The function of smell.

c) Sensitivity for reflexes such as sneezing.

The **nasal cavity** consists of 2 parts:

I. Vestibulum

II. Actually the nasal cavity.

The vestibule consists of:

1. Stratified squamous non-keratinized epithelium.

2. The connective tissue layer, in which the glands and roots of the bristle hairs are located.

In the nasal cavity itself, 2 areas are distinguished:

1. Respiratory and

2. Olfactory

The respiratory region is a **mucosa** represented by:

a) Single-layer multi-row ciliated epithelium – respiratory epithelium of the respiratory tract.

b) Lamina propria represented by loose fibrous connective tissue, with the vessels of the venous plexus located in it and the terminal sections of the proteinaceous mucous glands. The veins have a wide lumen and thin walls and act as a radiator for heating the air. When these vessels overflow with blood, a person experiences a feeling of nasal congestion.

The olfactory region of the nasal cavity is represented by the mucosa, mainly of the upper concha, and is the primary sensory organ of the senses.

Larynx.

In addition to participating in the conduction of air, it is an organ of sound formation.

The larynx is a cavity whose walls are supported by cartilage. The epiglottis separates the larynx from the pharynx. The epiglottis is formed by elastic cartilage covered with stratified squamous non-keratinizing epithelium. Below the epiglottis there are two pairs of folds of the mucous membrane: the upper ones, covered with respiratory epithelium – false vocal cords and the lower ones, covered with stratified squamous epithelium – true vocal cords.

Thus, the wall of the larynx consists of 3 shells:

I. Mucosa – has the same structure as the respiratory region of the nasal cavity.

II. Fibrocartilaginous – represented by both hyaline and elastic cartilages.

III. Adventitial – loose fibrous connective tissue [1 – 3].

Trachea – hollow tubular organ, consisting of 4 shells:

I. Mucosa

II. Submucosal

III. Fibro-cartilaginous

IV. Adventitia

The mucosa of the trachea consists of 2 layers:

1. Single-layer multi-row ciliated epithelium.

2. The submucosa, formed by loose fibrous connective tissue.

The cellular composition of the epithelium of the airways, including the trachea, is represented by the next cells.

Ciliated cells with cilia at the apical end. They perform a protective function, due to synchronous oscillations towards the exit from the airways, which ensures the movement of the mucous film towards the exit and its removal as a result of subsequent coughing.

Goblet cells – produce mucus that moisturizes the surface of the respiratory epithelium with the formation of a mucous film necessary for the adherence of microorganisms and foreign parts that enter the body along with the inhaled air.

Intercalated cells – are cambial.

Endocrine cells – they produce biologically active substances that regulate the secretion of glands and muscles of the airways. For example: serotonin, calcitonin.

Brush cells – are chemoreceptors.

The submucosa of the trachea is thin and, like the lamina propria, is formed by loose fibrous connective tissue, in which complex, branched alveolar-tubular glands are located. The mucous secretion produced by them moisturizes the surface of the tracheal epithelium and also promotes the adhesion of particles and microorganisms [1 – 5].

The fibrocartilaginous membrane of the trachea is represented by 16-20 half-rings of hyaline cartilage that are not closed along the posterior surface. The free ends of the semirings connect bundles of smooth muscle cells. Thanks to this, the back surface of the trachea is soft.

The adventitia is a loose fibrous connective tissue.

Lungs.

The lung consists of airways – the bronchi, which together form the bronchial tree and the respiratory section, which performs the function of gas exchange.

The bronchial tree begins with 2 main bronchi – the right and left, which are formed at the site of the bifurcation of the trachea. The main bronchi are divided into do-left – 3 in the right and 2 in the left lung. Zonal bronchi depart from the equity. The main, lobar and zonal bronchi are extrapulmonary. Further branching of the bronchial tree leads to the formation of intrapulmonary bronchi: segmental, subsegmental, interlobular and finally terminal bronchioles.

There is a classification of bronchi by diameter:

1) **Large**-caliber bronchi include lobar, zonal, segmental.

2) The bronchi of **medium** caliber include – subsegmental.

3) **Small**-caliber bronchi include interlobular and intralobular bronchi.

The bronchi have a general structural plan. However, as they branch, i.e. changes in the caliber of the bronchi, changes occur in the structure of their walls.

Large bronchus.

The wall of the large bronchus is formed by 4 membranes characteristic of the wall of the trachea. However, unlike the trachea, the mucosa of the large-caliber bronchi is folded. Folds are formed due to the contraction of *smooth muscle cells* of the **muscular plate** of the bronchial mucosa of large caliber. Recall that the muscular plate in the mucosa of the trachea is practically absent. In addition, unlike the trachea, the fibrous-cartilaginous membrane of the bronchi of large caliber is represented not by half rings, but by plates of hyaline cartilage.

Middle bronchus.

In bronchi of medium caliber, compared with large bronchi, the thickness of the mucosa decreases, the number of glands in the submucosa decreases, and large plates of hyaline cartilage are replaced by smaller islands of hyaline and elastic cartilage tissues.

Small bronchus.

Unlike large and medium bronchi, the wall of small-caliber bronchi contains not 4, but only 2 shells:

– mucosa

– adventitia.

The mucosa of the small bronchi forms deep folds. This is due to the fact that in the mucous membrane of small bronchi, the *muscular plate becomes thicker* in relation to the thickness of the entire wall. In chronic bronchitis, bronchial asthma, bronchospasm is observed precisely from the small bronchi, since they lack cartilage that prevents the narrowing of the lumen and the muscular plate is most developed. As for the epithelium of the bronchi of small caliber, the epithelium from multi-row becomes two-row and even single-row. In the epithelium of small bronchi, the number of goblet cells decreases [4, 5].

The final terminal bronchiole also has 2 membranes – mucosa and adventitia. However, the muscular plate is not expressed, so the mucosa does not form deep folds. The epithelium of the terminal bronchioles is single-row cubic. *Goblet cells disappear* in it and a

new type of cell appears – secretory cells or Clars cells. Clars cells have a domed apex. The main function of secretory cells is the production of enzymes (phospholipases) that break down surfactant.

Respiratory section of the lungs. The structural and functional unit of the respiratory department is **acinus** in which gas exchange takes place.

The acinus consists of 3 parts.

1) Respiratory bronchioles of the 3rd order.

2) Alveolar passages.

3) Alveolar sacs.

In the course of the respiratory section, structures that are called alveoli open. The number of alveoli along the respiratory section increases [4 – 6].

The **alveolus** is the structural and functional unit of the acinus and has the appearance of an open vesicle covered with a single-layer squamous epithelium. Among the cells of the alveolar epithelium, the following types of cells are distinguished.

1) **Alveolar type I cells**. These cells have a flattened shape and a poorly developed synthetic apparatus. The main alveolar type I cells function is gas exchange. A capillary comes close to the non-nuclear part of alveolar type I cells. So about between air and blood lies a set of structures that form the aero-hematic barrier. It consists of:

I) capillary endothelium;

II) its basement membrane;

III) basement membrane of the alveolar epithelium;

IV) alveolar type I cells;

V) surfactant.

Also, type alveolar type I cells are involved in water-salt metabolism, ensuring the removal of fluid and macromolecules from the surface of the alveoli.

2) **Alveolar type II cells**.

Larger cells with a well-developed synthetic apparatus. In the cytoplasm of alveolar type I cells, osmophilic dense bodies accumulate, in which phospholipids accumulate. Therefore, alveolar type I cells are involved in lipid metabolism. Alveolar type I cells also produce surfactant. Surfactant is a film of phospholipids, proteins and glypoproteids lining the alveolus [1 – 4, 6].

Surfactant functions:

1. Promotes the first breath of a newborn.

2. Reduces the surface tension of the alveoli, preventing them from sticking together on exhalation.

3. Prevents the penetration through the wall of the alveoli of microorganisms.

4. Prevents fluid transudation into the alveoli from capillaries and inter/alveolar septa.

5. The surfactant performs protective functions (IgA is found in the surfactant).

6. Surfactant prevents the alveolar epithelium from drying out.

7. Accelerates the absorption of O_2.

If the production of surfactant is disrupted, the alveoli collapse, resulting in ateleptase. The surfactant is constantly being exchanged. Its life span is 1-2 days. The surfactant is destroyed by macrophages and secretory Clars cells. The destruction of surfactant by Clara cells is carried out with the help of the enzyme phospholipose, which they secrete.

In the lungs, 3 subpopulations of macrophages can be distinguished:

a) alveolar macrophages – lie freely in the alveoli, migrating into the alveoli from the interalveolar connective/tissue septa;

b) septal macrophages;

c) intravascular.

The interalveolar septa of the lungs contain a large number of elastic fibers. Elastic fibers, braiding the alveoli, exert pressure on it and contribute to the expulsion of air from the alveoli. In a number of chronic lung diseases, elastic fibers are destroyed – air does not leave the alveoli. This condition is called emphysema.

Outside, the lungs are covered with pleura, composed from 2 sheets: visceral and parietal [3 – 6].

Innervation. Sensitive innervation is carried out by the dendrites of the neurons of 1-6 spinal nerves, sensory neurons of the vagus nerve. Motor innervation is carried out by the sympathetic and parasympathetic departments of the leading nervous system. **Sympathetic fibers** cause bronchial dilation, suppress mucus secretion and reduce blood supply. Parasympathetic fibers lead to a contraction of the muscles of the bronchi and to an increase in the secretion of the glands.

The blood supply to the lung goes through two vascular systems:

1. The lungs receive blood from the pulmonary arteries of the pulmonary circulation. The branches of the pulmonary artery divide into capillaries. surround the alveoli and participate in gas exchange (saturated with O_2). Further, the capillaries are collected in the system of pulmonary veins flowing into the left atrium.

2. Bronchial arteries that branch off from the aorta break up into capillaries and feed the lung break up into capillaries and feed the lung [1, 2].

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