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: 15:
HISTOPHYSIOLOGY OF CARDIOVASCULAR SYSTEM

Duration 4 hours

Authors:
Associate Professor Ph.D. Kravtsova I.L.
Associate Professor Ph.D. Solodova E.K.

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THE MOTIVATIONAL CHARACTERISTIC OF THE THEME

The cardiovascular system carries out such important functions as carrying out and distribution of blood in organs, a metabolism between blood, tissues etc. At infringement of structure and function of different partof cardiovascular system arise heavy diseases in an organism: heart diseases, myocardium infarction, atherosclerosis, hypertenssion, etc. All this makes necessary detailed studying of cardiovascular system for the future doctor.

THE PURPOSE

Studying micro- and a ultramicroscopic structure of heart, blood and lymphatic vessels.

PROBLEMS

The students should know:

1) The general plan of a structure and classification of vessels.
2) Features of a structure of vessels microcirculation network
3) Classification and a structure of arteries. Features of a structure of arteries elastic and muscular types in connection with hemodenamic conditions.
4) Classification and a structure of veins. Features of a structure of veins, in different parts of a body.
5) Characteristic differences of a structure of a wall of a vein from an artery.
6) The Structure of lymphatic vessels.
7) Structure of endocardium, a myocardium and epicardium.
8) The Structure epi-and a pericardium.

The students should be able:

1) To identify various types of arteries.
2) To characterize tissue structure of environments of arteries.
3) To identify on a total preparation of microcerculation.
4) To explain the general principle of interdependence of a structure of a wall of a vessel
5) To characterize representation about blood vessels and their age changes.

REQUIREMENTS TO THE INITIAL LEVEL OF KNOWLEDGE

For full mastering a theme it is necessary for student to repeat questions of an anatomic structure of organs of cardiovascular system from a rate of normal anatomy.

CONTROL QUESTIONS FROM RELATED SUBJECTS

1) The anatomic structure and topography of heart
2) Conducting system of heart
3) Classification of vessels

CONTROL QUESTIONS ON THE THEME

1) Heart. Sources of development. Layers of wall of tye heart, tissues structure. Valves. Conducting system of heart. Blood supply
2) Blood vessels. Development. Classification. A structure.
3) Arteries. Arteries elastic, the muscular, mixed type.
4) Microcirculation network
5) Veins. Veins of muscular and fibrous type.

6) Lymphatic vessels.

7) Blood supply. Innervations. Age changes. Regeneration.

THE PRACTICAL PART

1) The Scheme of development of heart – to enter designations (Exercise №1 in album)

2) The Structure of a wall of heart – to fill the table (Exercise №2 in album)

3) The Scheme of an ultramicroscopic structure of an inserted disk – to enter designations (Exercise № 3 in album)

4) The Structure of veins – to study and fill the table (Exercise №5 in album)

5) The Structure of arteries – to study and fill the table (Exercise №6 in album)

6) To list homodynamic the conditions defining morphological attributes of vessels (Exercise №7 in album)

7) The Scheme microcirculation – to enter designations (Exercise №9 in album)

8) Classification of capillaries – to enter designations (Exercise № 11 in album)

9) The Scheme of an ultramicroscopic structure of a wall of blood and lymphatic capillaries – to enter designations (Exercise №12 in album)

10) Microscopy and a sketch in an album of histological preparations (Exercise № 4,6,7,8 and 10in album)

11) Studying diagrams

SLIDES

1) Artery of elastic type (Aorta)

2) The artery of muscular type (femoral artery)

3) The vein with strong development of muscular elements (the femoral vein)

4) Capillaries, arterioles, venules

5) Heart

QUESTIONS FOR SELF-CHECKING KNOWLEDGE

1) Define cellular elements in structure of arterioles, capillaries and venolis specify the basic functions of these vessels. Make the table 1.

Table 1 – The cellular elements in structure of arterioles, capillaries and venolis

Vessels	Cellular structure	Functions
Arterioles Capillaries Venules		

2) Classification of the basic types of capillaries, specify, for what organs they are characteristic, and think over their functional value. Make the table 2.

Table 2 – The basic types of capillaries

Type of a capillary	Organs	Functions

3) Think over, to what type the veins specified in the table 3 concern.

Table 3 – The basic types of veins

Veins of brain	Cava superior	Cava inferior

4) List tissue elements of valves of heart.

HISTOPHYSIOLOGY OF THE CARDIOVASCULAR SYSTEM

Heart: sources of development.

The cardiovascular system consists of a pump represented by the heart and blood vessels, which provide the route by which blood circulates to and from all parts of the body [1, 2].

Heart is produced from two embryonic sources:

1) Myoepicardial plates;
2) Endocardial heart tubes.

Two myoepicardial plates are produced in mesoderm on the visceral layer of its splanchnotome.

Two accumulations of mesenchyme cells are produced just beneath every myoepicardial plate. These mesenchyme cells form two tubes called endocardial heart tubes.

Formation of lateral body's folds change an embryo body to be the tubular shape. In this two myoepicardial plates or myoepicardial mantle and two endocardial heart tubes fuse with each other to begin their differentiation into heart layers.

The heart tubes will became the internal heart endocardium. The myoepicardial mantle gives rise to the myocardium and epicardium [3].

Question 2. Endocardium, myocardium, epicardium: tissues and structural elements. Valves.

The heart is a muscular organ, containing four chambers – the right and left atria and right and left ventricles through which blood is pumped. Valves guard the exits of the chambers, preventing back flow of blood.

Heart valves consist of dense irregular connective tissue covering by endothelium on both their surfaces [13].

The wall of the heart is composed of three layers:

I. Endocardium:

1) endothelium;
2) subendothelial;
3) middle;
4) subendocardial .

II. Myocardium;

III. Epicardium.

The endocardium is inner layer of heart. It consists of 4 sublayers. An inner endothelium lining heart chambers is represented by simple squamous epithelium, developing from mesenchyme. All other three sublayers of heart endocardium are represented by fibrous connective tissue, but the middle contains smooth muscle cells also.

Subendocardial sublayer is continuous with the connective tissue of the myocardium. The conducting system of the heart is located in the subendocardial sublayer of the endocardium.

The myocardium, consisting of cardiac muscle, is the principal thickest component of the heart. The detailed histologic structure and function of cardiac muscle is discussed in teaching manual "Muscle tissue".

The epicardium is the visceral layer of serous pericardium, covering the outer surface of the heart. It consists of a mesothelium and thin underlying loose connective and adipose tissues. Mesothelium is a simple squamous epithelium [3].

Conductive system of the heart. Blood supply and nerves of the heart.

The electrical activity (impulses) that results in the rhythmic pulsations of the heart is initiated and propagated by the conducting system of the heart. The detailed histologic structure and function of conducting system of the heart is discussed in methodic manual "Muscle tissue".

The heart beats independently of any nervous stimulation. This spontaneous rhythm of the heart can be altered by nerve impulses from both sympathetic and parasympathetic divisions of the autonomic nervous system. The autonomic nerves do not initiate contraction of the cardiac muscle but rather regulate the heart rate, according to the body's immediate needs. Stimulation of the parasympathetic nerves decreases the heart rate. Stimulation of the sympathetic nerves increases the heart rate [4].

An interatrial septum and an interventricular septum separate the right and left sides of the heart. The right side of the heart pumps blood through pulmonary circulation. The right atrium receives blood returning from the body via the inferior and superior venae cavae. The right ventricle receives blood from the right atrium and pumps it to the lungs for oxygenation via the pulmonary arteries.

The left side of the heart pumps blood through systemic circulation. The left atrium receives the oxygenated blood returning from the lungs via the four pulmonary veins. The left ventricle receives blood from the left atrium and pumps it into the aorta for distribution into the remainder of the body [3].

Blood vessels: development, layers of vascular wall. Structure of the coats.

In our organism, all vessels are developed from mesenchyme and divided into:

1) Arteries;
2) Veins;
3) Microcirculatory bad.

Arteries are the vessels that pass blood from the heart to deliver it to the capillaries.

Veins are the vessels that pass blood to the heart from the capillaries. Small vessels such as arterioles, associated capillary network, and postcapillary venules form a microcirculatory bad.

The walls of arteries and veins are composed of three layers called tunics. The three layers of the vascular wall, from the lumen outward are the following:

I. **The tunica intima;**
II. **The tunica media;**
III. **The tunica adventitia**.

The tunica intima is the innermost layer of the vessel, consisting of three components: a single layer of squamous epithelial cells called endothelium lying on the basal lamina and the subendothelial layer, consisting of loose connective tissue.

The tunica media, or middle layer, consists primarily of circumferentially arranged layers of smooth muscle cells.

The tunica adventitia, or outermost connective tissue layer, is composed primarily of longitudinally arranged collagenous and elastic fibers. In addition, the tunica adventitia of large arteries and veins contains a system of vessels called the vasa vasorum that supplies blood to the vascular walls themselves, as well as a network of autonomic nerves called nervi vascularis that control contraction of the smooth muscle in the vessel walls [4 – 7]

Arteries: classifications, structure of the elastic and muscular types arteries.

There are several classifications of arteries. The arteries are classified into large, medium and small types on the basis of size. They are classified into elastic and muscular principle types on the characteristics of the tunica media (morphological classification).

Large arteries laying near the heart and their main branches belong to elastic type of arteries. The elastic arteries contain numerous elastic fiber in all three their tunics. It helps them to distend for heart systole (the contraction phase of the cardiac cycle) and then come back to their original size for heart diastole (the relaxation phase of the cardiac cycle) [7].

Muscular arteries

Medium and small arteries belong to the muscular types of arteries. Muscular arteries have more smooth muscle and less elastin in the tunica media than in elastic arteries. Contraction and relaxation of these smooth muscle cells will change the diameter of medium and small arteries affect blood pressure.

Medium and small arteries are distinguished from one another by the number of smooth muscle cell layers circular arranged in the tunica media. The tunica media of small arteries contains 3 to 8 layers of smooth muscle cells in the tunica media. The tunica media of medium arteries contains more, then 8 layers of smooth muscle cells in the tunica media [3].

The wall of muscular arteries consists of:

I. Tunica intima:

1. Endothelium;
2. Subendothelial connective tissue;
3. Internal elastic membrane.

II. Tunica media:

4. Smooth muscle cells, lying circular array; 5. Little collagen and elastic fibers;
6. External elastic membrane.

III. Tunica adventitia:

6. Collagen and elastic fibers;
7. Vasa vasorum and nerves [1 – 7].

Microcirculatory bed: arterioles, capillaries, venules. Arteriovenous anastomoses.

Microcirculatory bad includes small vessels such as arterioles, associated capillaries and postcapillary venules.

Arterioles

Arterioles are the smallest arteries of muscular type. They play an important role in regulating blood pressure and controlling the blood flow entering capillaries [3].

The wall of arteriole consists of:

I. **Tunica intima:**

1. Endothelium;
2. Subendothelial sublayer is very thin and often absent;
3. Internal elastic membrane is very thin and often absent;

II. **Tunica media:**

4. 1 to 2 layers of smooth muscle cells lying circular array.

III. **Tunica adventitia:**

5. Adventitial cells [3].

Capillaries

Capillaries are the smallest diameter blood vessels connecting arterioles to venules.

Capillaries form blood vascular networks, that

Allow, fluids containing gases, metabolites, nutrients and waste products to move through their thin walls. The very thin walls of capillaries consists of:

1. Endothelium;
2. Basal lamina of endothelial cells;
3. In some capillaries and postcapillary venules there are pericytes (Rouget cells).

Pericytes are loose connective tissue cells, surrounding the capillary, and are enclosed by a basal lamina that is continuous with that of the endothelium. Pericytes contain cytoplasmic processes to communicate with endothelium.

Pericytes are contractile cells and they provide vascular support and promote stability of capillaries and postcapillary venules through physical and chemical signaling with vascular endothelial cells [3, 7].

Types of capillaries

On the basis of their morphology there are three types of capillaries:

I. Continuous;

II. Fenestrated;

III. Discontinuous.

Continuous capillaries are typically found in muscle, lung, and the CNS. They have continuous endothelial cells and basal lamina.

Fenestrated capillaries are typically found in endocrine and kidney. They have endothelial cells that are perforated by small pores (fenestrations), often bridged by diaphragms and continuous basal lamina.

Discontinuous or sinusoidal capillaries (sinusoids) are typically found in the liver, spleen, and bone marrow. They are larger in diameter and characterized by discontinuous endothelium and basal lamina. Endothelium of sinusoids is interrupted by large pores, which perforate the cytoplasm of endothelial cells [3].

Venules

Venules are the smallest veins, receive blood from the capillary network. They gradually increased in size and can be categorized as:

1) **Postcapillary venules** (10-30 μm in diameter);
2) **Collecting venules** (30-50 μm in diameter);

3) **Muscular venules** (50-100 μm in diameter) [2, 3].

Thus, the postcapillary venules are smallest venules collecting blood from the capillary network. Structurally they look like capillaries and are characterized by the presence of endothelium with its basal lamina and pericytes. The endothelium of postcapillary venules is the principal site of action of vasoactive agents such as histamine and serotonin. Response to these agents results in releasing of fluid and emigration of leukocytes from the vessel during inflammation and allergic reactions

Postcapillary venules drain blood into the collecting venules. The walls of collecting venules contain endothelium with its basal lamina and a few smooth muscle cells. Usually, pericytes are not found in collecting venules.

Muscular venules are located distal to the collecting venules. They drain blood into the small veins. Whereas postcapillary and collecting venules have no tunics, the muscular venules have three tunics in their walls. The muscular venules have one or two layers of smooth muscle that constitute a tunica media [7].

Arteriovenous anastomoses

Arteriovenous (AV) anastomoses also called shunts are direct routes between the arteries and veins that divert blood from the capillaries. AV shunts are found in the skin of the finger tips, nose, lips, in the erectile tissue of the penis and clitoris. The arteriole of AV shunts is often coiled, has a relatively thick smooth muscle layer to produce the precapillary sphincter. The contraction of the arteriole smooth muscle of the AV shunt sends blood to a capillary bed; relaxation of the smooth muscle sends blood to a venule, bypassing the capillary bed [1 – 7].

Veins: muscular type.

Typically, veins have thinner walls than their accompanying arteries, and the lumen of the veins is larger than that of the arteries. The veins lumen is often collapsed. Many veins, especially those that convey blood against gravity, contain valves that allow blood to flow in only one direction, toward the heart.

The valves are projections of veins tunica intima consisting of a thin connective tissue core covered by endothelial cells.

Most veins belong to the muscular type. However, in some organs (retina, bones, spleen, placenta, pia mater) the veins don’t contain muscles in their walls.

Amount of smooth muscles in walls of veins depends on the diameter (small, medium and large) and localization of veins. So, veins, especially those that convey blood against gravity (veins of the limbs) have most amount of smooth muscles in the walls [7].

The wall of muscular vein consists of:

I. Tunica intima:

1. Endothelium;

2. Subendothelial connective tissue, containing some longitudinally arranged smooth muscle cells.

II. Tunica media:

3. Smooth muscle cells, lying circular array; 4. Little collagen and elastic fibers.

III. Tunica adventitia

5. Collagen and elastic fibers;

6. Bundles of longitudinally arranged smooth muscle cells;

7. Vasa vasorum [3].

Lymphatic vessels. Lymphatic capillaries.

Lymphatic vessels are vessels, that convey fluids from the tissues to the bloodstream. Unlike the blood vessels, which convey blood to and from tissues, the lymphatic vessels are unidirectional, conveying fluid only from tissues. The smallest lymphatic vessels are called lymphatic capillaries. The lymphatic capillaries begin as "blind-ended" tubes in the microcapillary beds. Lymphatic capillaries converge into larger vessels called lymphatic vessels. They unite to form two main channels that empty into the blood vascular system by draining into the large veins in the base of the neck. The largest lymphatic vessel, draining most of the body and emptying into the veins on the left side, is the thoracic duct. The other main channel is the right lymphatic trunk.

Lymphatic capillaries are essentially tubes of endothelium that, lack a basal lamina. Therefore, they have a high permeability. Anchoring filaments extend between the endothelium and the perivascular collagen [3].

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