THE HEART: ITS STRUCTURE, FUNCTION, AND DISEASES

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Annotation: This article provides general information about the structure and function of the heart, as well as the factors affecting its activity. It highlights the main types of heart diseases, their causes, and prevention methods. The article also includes useful lifestyle recommendations for maintaining a healthy heart and describes modern diagnostic techniques.

Keywords: heart, epicardium, myocardium, endocardium, infarction, stroke, intercalated discs, bundle of His, pacemaker cells.

Introduction

The human body is a complex and highly organized system, in which each organ has its own unique function. Within this system, the heart holds a special place. The heart is one of the most vital organs that sustains life by ensuring blood circulation throughout the entire body. With its help, cells receive blood rich in oxygen and nutrients, which directly influences the functioning of all organs.

According to the World Health Organization (WHO), cardiovascular diseases rank among the leading causes of death globally. Each year, millions of people lose their lives due to heart-related conditions. In particular, ischemic heart disease, heart attacks, and hypertension are widespread. These conditions not only affect the elderly but are increasingly seen among young people and even children, turning into a serious socio-economic problem.

Heart diseases often develop silently. In the early stages, their symptoms may go unnoticed. However, over time, signs such as fatigue, shortness of breath, and rapid heartbeat may appear, significantly reducing a person’s quality of life.

Another important point is that most heart diseases are preventable. A healthy diet, regular physical activity, stress management, avoiding harmful habits, and routine medical check-ups play a crucial role in maintaining heart health.

This article provides a detailed overview of the heart’s structure, main functions, factors negatively affecting its performance, causes and symptoms of heart diseases, and prevention methods. The article is written for a general audience, with scientific information presented in a clear and simple language.

The main goal of the article is to increase awareness about the heart, emphasize the importance of heart health, and promote a healthy lifestyle.

Methods

For this article, an analysis was conducted based on scientific articles, clinical studies, laboratory results, and epidemiological data from the period 2015-2023. The article reviews the types, causes, diagnostic methods, and treatment options for heart diseases. Additionally, the research examines the latest advancements in heart disease detection and treatment methods, including modern technologies like ultrasound and ECG for diagnosis and management.

Data Collection Methods:

ECG (Electrocardiogram): Analyzing the heart's electrical activity helps to study its rhythm and impulses, aiding in the detection of various heart diseases and problems. Studying the heart's electrical activity allows for the early detection of conditions such as coronary heart disease and arrhythmias.

Echocardiogram (Heart Ultrasound Examination): Plays a crucial role in evaluating the structure and function of the heart. This method provides detailed images of the heart, assessing the strength of the heart muscles, its contractions, and blood flow. As a result, anatomical changes in the heart, such as valve issues, myocardial infarction, or ischemic conditions, can be analyzed.

Laboratory Research: Blood tests help analyze biomarkers related to heart diseases, allowing for the study of inflammation processes and the body's response. Levels of creatinine, urea, lipids, and sodium help assess the condition of the heart and kidney function.

Angiography: Used to examine coronary arteries, this method helps identify blockages, clots, and atherosclerotic changes in blood vessels. Angiography is widely used to detect the risk of heart attacks or ischemic diseases.

Ultrasound Examinations (Doppler Method): Ultrasound is used to assess blood flow and the functioning of the heart. The Doppler method, in particular, is employed to measure blood flow in the left and right chambers of the heart and evaluate their performance.

Main Body: The Structure of the Heart

The heart (cor) is a muscular organ located in the thoracic cavity. It constantly contracts (systole) and expands (diastole) throughout an individual's life, except for brief pauses, and supplies blood to the entire body. Thus, the heart is the central organ in the circulatory system. In an average adult, the heart contracts approximately 70-75 times per minute, and 100,000 times per day. This is equivalent to lifting 20 tons of weight to a height of one meter within that time.

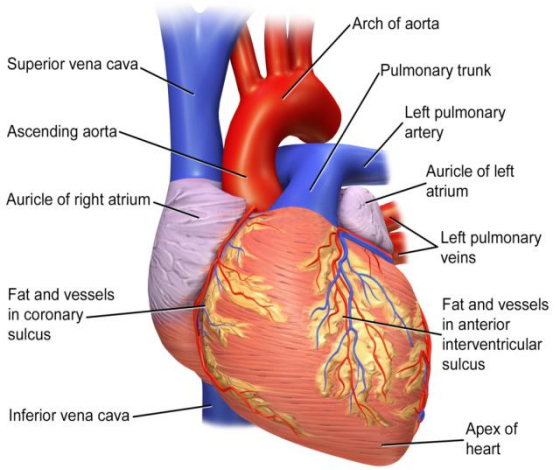
The heart of an average adult is slightly compressed when viewed from the front and back, and has a conical shape, roughly the size of the individual's clenched fist.

The heart consists of four chambers: two atria and two ventricles. The left atrium and left ventricle form the left or arterial part of the heart, while the right atrium and right ventricle form the right or venous part.

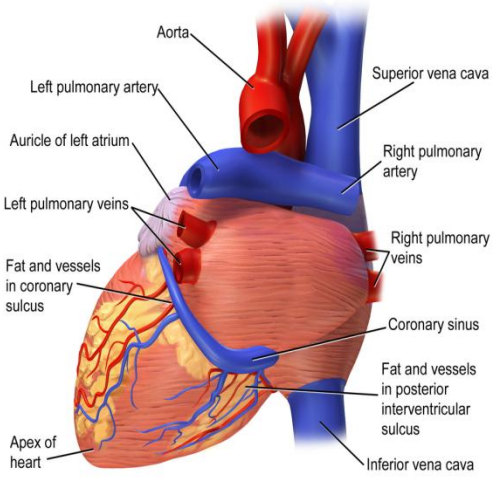
The average weight of the heart is 300 grams in men and slightly less, between 200-250 grams, in women. In adults, the heart's length ranges from 10-15 cm, its width (at the base) is 8-11 cm, and the thickness of the front and back walls is 6-8.5 cm. The sharp (right) and blunt (left) edges of the heart separate its anterior and posterior surfaces. The heart's weight accounts for about 1:200 or 1:75 of the total body weight.

In newborns, the heart is round in shape, positioned slightly higher, and weighs between 23-27 grams. In eight-month-old infants, the heart's weight is doubled; at ages 2-3, it triples, and by age 16, it increases 11-fold. The heart is asymmetrically positioned in the lower part of the anterior chest cavity. The major blood vessels extending from the heart hold it in place, while the diaphragm's central part touches the heart's lower surface. The heart is surrounded by the lungs and pleural sacs on the sides, partially touching the V-VI rib arches and the sternum in the front, excluding the lungs.

The position of the heart varies among individuals, depending on factors such as age, gender, body posture, and physique. Additionally, it is influenced by the movement of the diaphragm during breathing and the functioning of the heart. For example, in newborns, the heart is round in shape, and the diaphragm, being higher and more domed, is positioned more horizontally and higher. The heart is slightly displaced to the back due to the prominence of the diaphragm, which pushes it away from the sternum.



Superficial Heart Anatomy (Anterior)



Superficial Heart Anatomy (Posterior)

The structure of the front view of the heart. **The posterior view of the heart.**

The heart consists of four chambers: two atria and two ventricles. The atria receive blood from the veins, while the ventricles pump blood into the arteries. The right atrium is irregularly cuboidal in shape. The right atrium is separated from the left atrium by the interatrial septum, and from the right ventricle by the ostium atrioventricularis

dextrum. Externally, the right atrium is bounded by the right auricle. The inner surface of the auricle contains trabeculae muscles. The function of the right auricle is to increase the volume of the right atrium. The superior vena cava opening, inferior vena cava opening, right atrioventricular opening, as well as the openings of the sinus venosus (which collects blood from the heart veins) between the second and third openings, and the opening of the right ventricle's anterior vein, and small heart veins (20-30 Teberiev veins) located in the walls of both the right and left atria, drain into the right atrium through tiny openings.

The right ventricle is pyramid-shaped and positioned inversely. It has two openings at the upper wide base: the posterior atrioventricular opening and the anterior pulmonary trunk opening. Between the atrial and ventricular openings, three-layered valves are located. The left atrium is an irregular cubic shape. The left auricle is located in the anterior wall of the left atrium, with trabecular muscles inside. The auricle's function is to increase the volume of the left atrium. The left ventricle is cone-shaped, with the apex pointing downward. The upper wide base of the left ventricle contains two openings: the aortic opening on the right and the atrioventricular opening on the left. Between the atrioventricular openings, a two-leaflet valve is present.

The heart is a muscular organ. It is the main component responsible for driving blood through the circulatory system. The heart wall consists of three layers: the inner layer is the endocardium, the middle layer is the myocardium, and the outer layer is the epicardium. The heart is surrounded by a connective tissue membrane, the pericardium, also known as the heart sac. Between the epicardium and the pericardium is a cavity filled with fluid, which helps ease the heart's movements by reducing friction.

The endocardium is the heart's inner and relatively thin layer. It covers the inner surfaces of all the chambers of the heart, as well as the muscular ridges, tendon fibers, and valves. The myocardium is the thickest and most developed layer of the heart. It is made up of striated muscle tissue, with both typical and atypical muscle fibers. Typical muscle fibers are responsible for contraction, while atypical fibers conduct electrical impulses.

The epicardium is the outer layer of the heart wall and is made of thin connective tissue. It contains a certain amount of fat and numerous blood vessels. Its surface is covered by a single layer of flat cells (mesothelium). The heart wall is nourished by the coronary arteries, which branch out and direct blood to all three layers of the heart wall before dividing into capillaries. These capillaries merge to form the coronary veins, which drain into the right atrium or the vena cava. The heart also contains a special vascular system called the Thebesian veins, which directly drain into the heart chambers.

The pericardium is similar to the epicardium in structure but is covered by a double layer of mesothelium.

Physiology and Histology of the Heart

The myocardium is made up of striated muscle tissue, with typical and atypical muscle fibers distinguished within it. Typical muscle fibers are responsible for contraction, while atypical fibers are responsible for conduction of electrical impulses. Typical muscle fibers are formed by some contracting muscle cells, called cardiomyocytes. Cardiomyocytes differ from atypical muscle cells and skeletal striated muscle fibers in their structural and cytochemical properties. These cells are arranged sequentially to form muscle fibers. The muscle fibers are divided into segments or cell clusters via intercalated discs.

The structure of these cells is examined in the general histology section, muscle tissue chapter, and in the specific heart muscle tissue section. The contracting muscle cells of the heart are similar in shape to cylinders, with a length of 50–100 micrometers and a diameter of 17–20 micrometers. The central part of the cardiomyocytes contains an oval-shaped nucleus. The heart muscle fibers are surrounded by the sarcolemma.

This explanation touches on the fundamental histological and physiological characteristics of heart muscle tissue.

The electron microscope has revealed that the sarcolemma consists of an inner plasma membrane and an outer basal membrane. The sarcolemma participates in the formation of intercalated discs.

Conduction System of the Heart

This system is composed of conductive (atypical) heart muscle cells that generate impulses (excitations) and transmit them to the contractile (typical) heart muscle cells. The conduction system of the heart includes the sinoatrial or sinus (Kis Flak) node, the atrioventricular or atrioventricular (Ashof Tovar) node, the bundle of His, and its branches that transmit the excitation to the contractile myocytes. The bundle of His divides into right and left branches, from which the heart's special atypical fibers, known as Purkinje fibers, originate.

Three types of cells are distinguished in the conduction system. Impulses are generated in the sinoatrial node. The center of the node primarily contains self-contracting cells, also known as pacemaker cells. Surrounding the sinoatrial node are intermediate cells, which are especially numerous in the atrioventricular node, while pacemaker cells are relatively sparse in this node.

Intermediate cells are thin and elongated, with cross-sections smaller than those of typical cardiomyocytes. The cytoplasm of intermediate cells contains more miofibrils, which are often aligned parallel to each other, and A- and I-disks are clearly visible. Some intermediate cells contain short T-tubules. These cells transmit the excitation impulse from the pacemaker cells to the bundle of His cells and the contractile (typical) cardiomyocytes.

The function of the heart is based on the rhythmic contraction of the myocardium. The contraction phase is called systole, and the relaxation phase is called diastole. The heart contracts automatically. The impulses that ensure myocardial contraction are generated in the heart's conduction system. These impulses, normally produced 60–80 times per minute in the sinoatrial node, first spread to the atrial myocardium, then pass through the atrioventricular node, the bundle of His, and the Purkinje fibers to reach the ventricular myocardium, causing the ventricles to contract. During transmission to the ventricles, the speed of the impulses slows down. As a result, the atria complete their contraction before the ventricles.The cycle of contraction and relaxation of the heart forms the cardiac cycle. This cycle consists of atrial systole (0.1 sec), ventricular systole (0.33–0.35 sec), diastole (the phase in which both atria and ventricles relax), and a pause (0.4 sec). During atrial contraction, the blood pressure in the atria increases (from 1–2 mmHg up to 6–9 mmHg in the right atrium, and up to 8–9 mmHg in the left atrium), causing blood to flow into the ventricles through the valves. Only about 30% of the blood is pushed into the ventricles during atrial systole; the remaining 70% flows in passively during the general pause.Ventricular systole is also divided into phases. When ventricular pressure rises, the atrioventricular valves close, but the semilunar valves (aortic and pulmonary) remain shut. During this isometric contraction phase, all muscle fibers contract, increasing tension. When the ventricular pressure exceeds the pressure in the aorta and pulmonary trunk, the semilunar valves open and blood is ejected into the arteries—this marks the beginning of the ejection phase. In humans, blood is ejected into the vascular system when the pressure in the left ventricle reaches 65–75 mmHg and in the right ventricle 5–12 mmHg. Within 0.10–0.12 seconds, ventricular pressure sharply rises (110–130 mmHg in the left ventricle, 25–35 mmHg in the right ventricle) in the rapid ejection phase, followed by the slow ejection phase (lasting 0.10–0.15 sec).Next, the ventricles begin to relax; their pressure drops rapidly, the pressure in the large vessels rises, and the semilunar valves close. When ventricular pressure drops to 0 mmHg, the atrioventricular valves open, and blood starts flowing from the atria into the ventricles. This is divided into a rapid filling phase (0.08 sec) and a slow filling phase (0.07 sec). Ventricular diastole ends with the complete filling of the chambers.The duration of the phases in the cardiac cycle is variable and depends on heart rate. Thus, studying the phases of the cardiac cycle is an important method for assessing the function of the heart muscle. The cardiac output is the amount of blood ejected from the heart per minute. The volumes from the left and right ventricles are equal. In a resting adult, the average cardiac output is 4.5–5 liters per minute. The amount of blood pumped with each heartbeat is known as stroke volume, averaging 65–70 ml. The strength and rate of heart contractions adjust according to the body’s need for oxygen and nutrients. Although the impulses that stimulate the heartbeat originate within the heart, its activity is regulated by the nervous system. The vagus

nerve decreases the strength and rate of heart contractions, while the sympathetic nerves increase them. The heart muscle also possesses auto-regulation: the more blood that enters the heart, the more forcefully it contracts. The force of contraction depends on how stretched the muscle fibers are before contraction—this is their initial length. The more the muscle fiber is stretched, the stronger the contraction. This is known as the Frank-Starling law of the heart.

Heart Diseases

Arterial Hypertension

Arterial hypertension, or high blood pressure, is a serious condition that increases the risk of heart attacks and strokes. During heart contraction (systole), the pressure in the arteries of an adult typically ranges from 120–140 mmHg, while during relaxation (diastole), it falls to 80–90 mmHg. If these values are elevated, it indicates high blood pressure, which can lead to severe consequences.

In developed countries, the number of people suffering from hypertension is significantly high. In 90% of cases, this condition does not result from a single easily treatable cause, which is why a comprehensive treatment approach is necessary.

Ischemic Lesions

Myocardial Infarction

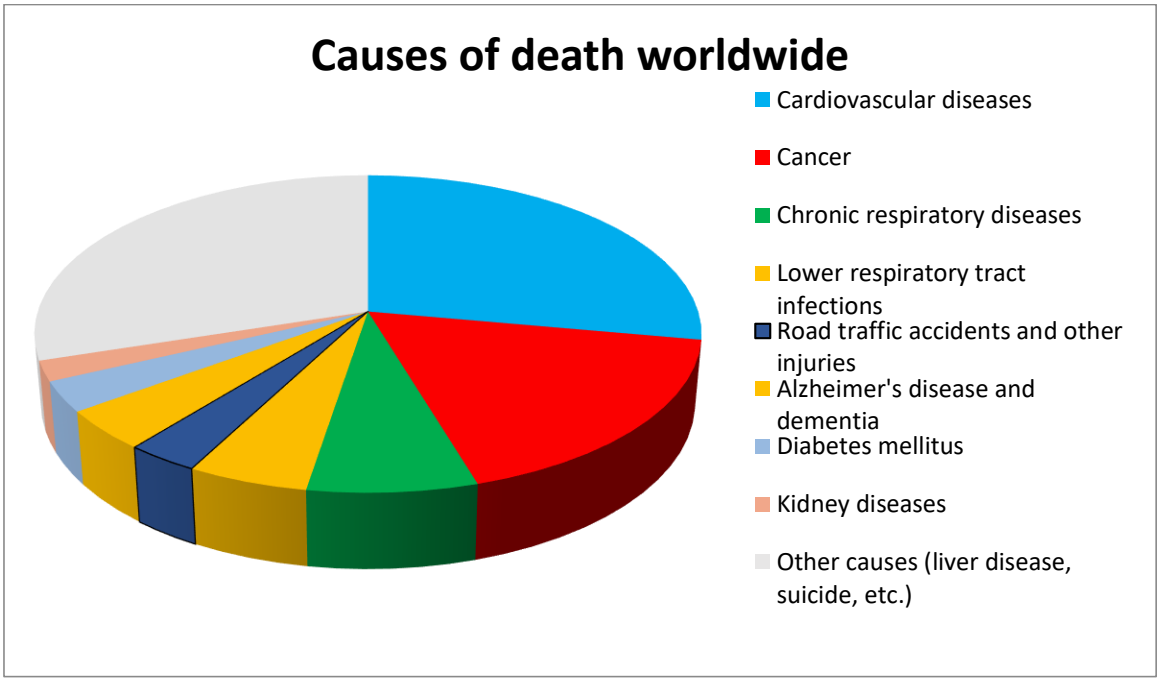
This acute condition is a clinical form of ischemic heart disease, caused by necrosis (tissue death) of the heart muscle (myocardium) due to complete or partial lack of blood supply. It disrupts the function of the entire cardiovascular system and poses a serious threat to the patient’s life.

The main and most common cause of myocardial infarction is impaired blood flow in the coronary arteries, which supply the heart muscle with blood and oxygen. This is often associated with atherosclerosis — the buildup of atherosclerotic plaques on the arterial walls.

Ischemic Heart Disease

This disease is characterized by a reduction in blood flow to the heart muscle. The heart works intensively, and any lack of blood supply immediately affects its function. The coronary arteries, which surround and nourish the heart muscle, are responsible for delivering this blood.

Symptoms of this condition may include shortness of breath and chest pain (angina). In nearly 90% of cases, coronary artery disease is caused by atherosclerosis, a condition that damages the walls of the arteries. While it was once considered a part of the natural aging process, it is now known that even children can suffer from atherosclerosis.



Valve Defects

Acquired Heart Defects

Among the most common heart defects are valve dysfunctions. Valve dysfunction in the heart involves the backflow of blood or insufficient opening. This condition is often a result of infectious damage or autoimmune reactions.

Congenital Heart Defects

Congenital heart defects usually arise due to hereditary diseases or disruptions during embryonic development.

Tetralogy of Fallot

The most severe form of congenital heart defects is Tetralogy of Fallot. This condition involves hemodynamic disturbances, reduced blood flow to the lungs, and venous blood flowing from the right ventricle to the aorta. The development of Tetralogy of Fallot involves four main factors:

Ventricular Septal Defect (VSD) — This defect, also known as an inter-ventricular septal defect (IVSD), connects the left and right sections of the heart. In Tetralogy of Fallot, the VSD is always large and non-restrictive. Typically, this is a perimembranous VSD, muscular VSD, or subarterial VSD.

Obstruction of the right ventricular outflow tract — This occurs due to one or a combination of the following anatomical components: infundibular (subvalvular) stenosis of the right ventricular outflow tract, pulmonary artery stenosis, obstruction due to hypertrophy of the right ventricular myocardium, and/or hypoplasia of the pulmonary artery trunk and/or its branches.

Dextroposition of the aorta — The aorta partially shifts to the right ventricle, or blood flow in the aorta remains dominant due to the activity of the left ventricle.

Right ventricular hypertrophy — Hypertrophy of the right ventricle muscle component develops over time as the individual ages.

Other Congenital Heart Defects

These include inter-ventricular and inter-atrial septal defects, valve stenosis, patent ductus arteriosus (blood bypasses the lungs), etc. Most of these conditions can be treated with surgical methods. The timing of surgery depends on the nature of the defect, its symptoms, and the severity of the condition.

Discussion:

The heart is a vital organ that sustains human life. Every beat ensures the delivery of oxygen and nutrients throughout the body. The heart works rhythmically and automatically through the cardiac cycle.

Today, heart diseases have become the number one cause of death worldwide. Among them, arterial hypertension and ischemic heart disease are the most common. In hypertension, blood pressure is elevated, placing excess strain on the heart. Ischemic heart disease involves reduced blood flow to the heart muscle. The most dangerous condition is myocardial infarction, which is the death of heart tissue due to lack of blood supply.

According to global statistics, cardiovascular diseases are the leading cause of mortality. Additionally, cancer, diabetes, kidney diseases, and respiratory disorders also significantly increase the risk of death.

To maintain heart health, a healthy lifestyle, regular physical activity, and proper nutrition are essential. Everyone should take care of their heart — to protect it is to protect life itself.

Conclusion

The heart is one of the most vital organs in the human body, and its constant, rhythmic, and healthy functioning determines the quality of life. This muscular organ ensures blood circulation throughout the body, supplying every cell with oxygen and nutrients. Any disruption in heart function negatively affects the entire body.

Heart health must always be a priority. Today, heart diseases are widespread globally and are a major cause of early death. Their main causes include unhealthy lifestyles, stress, harmful habits, poor diet, and lack of physical activity. However, early detection can prevent complications and even save lives.

Regular medical check-ups, monitoring blood pressure and heart rhythm, giving up harmful habits, eating healthy, and staying physically active are essential steps. A healthy heart is one of life’s greatest treasures — it is the key to a healthy life. Taking care of the heart is not just a personal duty, but also a responsibility towards family and society.

This article provided simple and clear information about the heart's structure, functions, diseases, and causes. Its main goal is to raise public awareness and encourage people to take action in protecting heart health.

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