MORPHOLOGICAL ASPECTS OF THE HEART: STRUCTURE, FUNCTION AND PATHOLOGICAL CHANGES

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Abstract: The article discusses the morphological structure of the heart, its histological layers, their functional significance, as well as changes occurring in various pathological conditions. Based on anatomical and histopathological analysis, the morphological basis of heart diseases is explained. In addition, a structural analysis of heart tissue is presented using modern morphological research methods, such as immunohistochemistry, electron microscopy and 3D reconstruction.

Key words: heart morphology, myocardium, endocardium, epicardium, histology, fibrosis, cardiomyocyte, pathomorphology.

INTRODUCTION

The heart is one of the most important organs of the human body, and its morphological structure directly provides its physiological functions. Recent advances in anatomy and histology have allowed us to gain a deeper understanding of the structural and cellular characteristics of cardiac tissue. This article systematically analyzes the normal morphological structure of the heart and changes observed in pathological conditions. The heart is a four-chambered organ consisting of two atria and two ventricles. The wall of the heart consists of three main layers[1,2]:

1. The endocardium is the innermost layer lining the chambers of the heart. It is covered with endothelial cells and is rich in elastic fibers.

2. The myocardium is the main muscular layer of the heart. Cardiomyocytes are specialized cells of the cardiac muscle tissue.

3. The epicardium is the outer serous layer of the heart, which, together with the pericardium, covers the heart.

The endocardium, lining the inner surface of the chambers of the heart, also contributes to the structure of the heart valves. Its inflammatory and degenerative changes (e.g. endocarditis, valvular fibroelastosis) are associated with clinical conditions such as valvular insufficiency or stenosis. Morphological deformations of the valves directly affect cardiac hemodynamics and lead to the development of heart failure.

The epicardium and pericardium cover the heart from the outside and ensure free movement of the heart, reducing friction. Pathological processes in the pericardial layers, such as pericarditis or pericardial effusions, exert excessive mechanical pressure on cardiac contractility. From a morphological point of view, inflammatory infiltration of the pericardium, fibrosis or accumulation of exudate can lead to impaired diastolic function of the heart.

HISTOLOGICAL STRUCTURE OF CARDIAC TISSUES

Cardiomyocytes - cardiomyocytes are connected to each other through intercalated discs, which play a decisive role in the conduction of electrical impulses. These cells contain a large number of mitochondria, which ensures continuous contraction of the heart. Conductive tissue system - the conductive tissue system of the heart includes the sinoatrial node, atrioventricular node, bundle of His, and Purkinje fibers. These structures regulate the heart rhythm.

Interstitial tissue - located between the myocardial cells, the interstitial tissue consists of fibroblasts, capillaries, and immune cells. It plays a role in maintaining cardiac homeostasis [3,4].

Morphological changes in pathological conditions - during myocardial infarction, a necrotic core is formed, an inflammatory response is activated, and infiltration by macrophages and neutrophils is observed. At a later stage, fibrous tissue is formed.Hypertrophic cardiomyopathy is characterized by hyperplasia of cardiomyocytes and enlargement of nuclei.

In dilated cardiomyopathy, the heart chambers are dilated, cardiomyocytes are stretched, and contractility is reduced.

Myocarditis is histologically characterized by inflammatory cellular infiltration, edema, necrosis, and interstitial fibrosis.

Endocarditis and epicarditis — infectious and autoimmune conditions lead to inflammatory infiltrates, thrombotic masses, edema, and fibrosis in the inner (endocardium) and outer (epicardium) layers of the heart.

MODERN MORPHOLOGICAL RESEARCH METHODS

1. Immunohistochemistry — the condition of cardiac cells is assessed using markers such as troponin, actin, and desmin.

2. Electron microscopy — evaluates ultrastructural changes, in particular the state of mitochondria and the structure of intercalated discs.

3. Genomic and transcriptomic studies — determine genetic single nucleotide polymorphisms and RNA profiles that predispose to heart disease.

SCIENTIFIC DISCUSSION AND ANALYSIS

The relationship between the morphological structure of the heart and its functional state lies at the intersection of cardiology and morphology as an important scientific problem. Understanding the structural components of cardiac tissues in their normal state, their spatial relationships and interactions at the cellular and tissue levels is essential to ensure optimal cardiac function [5,6]. Therefore, this article provides a comprehensive analysis of the main components of cardiac morphology — the endocardium, myocardium and epicardium — and discusses their physiological and pathological changes on a scientific basis. The myocardium is the main contractile layer of the

heart wall and is composed of specialized muscle fibers known as cardiomyocytes. Cardiomyocytes differ from other muscle tissues in the body in terms of the number of nuclei, the arrangement of sarcomeres, the presence of intercalated discs, the density of mitochondria, and the energetic processes. In particular, sarcomere activity in the heart directly provides mechanical function during systole and diastole. The cardiac conduction system, including the sinoatrial node, atrioventricular node, bundle of His, and Purkinje fibers, is composed of specially modified myocardial cells and constitutes the physiological basis of cardiac rhythm. Morphological analysis of this system is crucial for understanding the pathogenesis and morphogenesis of cardiac arrhythmias. Pathological damage to the conduction system, such as fibrosis, sclerosis, or postmyocardial destruction, can lead to rhythm disturbances. Among the pathological changes observed in the myocardium, the most common is myocardial infarction, which develops as a result of ischemic heart disease. Necrosis, inflammation and subsequent fibrosis in the infarction zone change the morphological and mechanical properties of the heart wall. Electron microscopy reveals mitochondrial edema, degradation of actin-myosin filaments and disruption of cell membranes. Immunohistochemical studies help to determine the expression levels of markers in cardiomyocytes, such as troponin, natriuretic peptides, actin and myosin, and to reveal the molecular basis of structural changes in the heart. In addition, regenerative processes in the heart, in particular the activity of cardiac progenitor cells and fibroblasts, angiogenesis (formation of new capillaries) and the degree of collagen synthesis, play an important role in assessing tissue remodeling caused by pathological conditions.The study of morphological changes in cardiac tissues is important not only for the diagnosis and treatment of diseases, but also for their prevention. In particular, modern genomic and proteomic studies reveal genetic polymorphisms that predispose to heart disease [7,8]. This opens the way for personalized prevention and therapy of heart disease based on individual genetic characteristics.

In general, a comprehensive study of the morphological structure of the heart and a deep analysis of pathological changes allow us to scientifically understand the causes, stages of development and consequences of cardiovascular diseases. This provides a critical scientific basis for accurate diagnosis, effective treatment strategies and advanced rehabilitation methods in clinical practice.

CONCLUSION

In this article, a morphological analysis of cardiac tissues was carried out using modern methods. Particular attention is paid to the structural and functional relationships of cardiomyocytes in the myocardium, histological features of the components of the conduction system and the role of interstitial tissue in inflammatory and fibrotic processes. Morphological changes observed in pathological conditions such as myocardial infarction, cardiomyopathy, myocarditis, endocarditis and epicarditis are among the main factors leading to cardiac dysfunction. These changes are mainly characterized by cellular necrosis, inflammatory infiltration, fibrosis and degeneration of muscle fibers. In addition, structural abnormalities within the cardia c conduction system serve as the morphological basis for arrhythmias and rhythm disturbances[9].

Modern morphological research methods - including immunohistochemistry, electron microscopy, molecular and genetic analysis - allow for in-depth study of the fine structure of cardiac tissues, their cellular state and pathological changes. These advances support early diagnosis, differential diagnosis and development of individualized treatments for heart disease.

From this point of view, a deep and systematic study of morphological changes in the heart is of crucial importance not only for scientific research but also for clinical practice. Expanding morphological knowledge forms a solid scientific basis for innovative approaches in cardiology, the development of new treatments, and strategic efforts to reduce the prevalence of heart disease.

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