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HISTOLOGY OF HEART VALVES

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Annotation: This article provides detailed information about the heart and its valves. It explains the structure of the heart and the histological structure of its parts.

Key words: heart, heart valves,cardiac cell

The heart is a four-chambered organ responsible for pumping blood throughout the body. It receives deoxygenated blood from the body, sends it to the lungs, receives oxygenated blood from the lungs, and then distributes the oxygenated blood throughout the body. At the histological level, the cellular features of the heart play a vital role in its normal function and adaptations.

The cells that constitute the heart are unique. It can initiate and propagate electricity throughout each cardiac cell. This physiology allows the heart to contract synchronously, permitting optimal function of circulating blood to the lungs and the rest of the distal organs.

The fibrous skeleton, cardiac muscle, and impulse conduction system constitute the basic framework of the heart. The base of the heart contains a highly dense structure known as the fibrous or cardiac skeleton. Functions of the fibrous skeleton include providing a strong framework for cardiomyocytes, anchoring the valvular leaflets, and acting as electrical insulation separating the conduction in the atria and ventricles. The wall of the heart separates into the following layers: epicardium, myocardium, and endocardium. These 3 layers of the heart are embryologically equivalent to the 3 layers of blood vessels: tunica adventitia, tunica media, and tunica intima, respectively. A

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double-layer, fluid-filled sac known as the pericardium surrounds the heart. The 2 layers of the pericardium are called the outer fibrous/parietal pericardium and the inner serous/visceral pericardium. The epicardium constitutes the visceral pericardium, underlying fibro-elastic connective tissue, and adipose tissue. Coronary arteries, veins, lymphatic vessels, and nerves run below the epicardium. The endocardium is composed of the endothelium and the subendothelial connective tissue layer. The subendocardium is between the endocardium and myocardium and contains the impulse-conducting system.

The impulse-conducting system has specialized cardiac cells to conduct electrical impulses throughout the heart. Electrical impulses initiate at the sinoatrial (SA) node at the junction of the superior vena cava and right atrium. These impulses travel throughout the atria until they reach the atrioventricular (AV) node between the interatrial and interventricular septum. As the fibers travel inferiorly, they penetrate the central fibrous body of the cardiac skeleton to form the bundle of His. These fibers are the Purkinje fibers after they divide within the interventricular septum and branch into the ventricles. Valves are an important component of the heart. Not only do they act as an exit gate, but they also prevent backflow into the chamber. The aortic valve, separating the aorta from the left ventricle, and the pulmonic valve, separating the pulmonary artery from the right ventricle, are known as semilunar valves. The 2 atrioventricular (AV) valves are the tricuspid and mitral valves. The tricuspid valve marks the separation between the right atrium and right ventricle, while the mitral valve separates the left atrium from the left ventricle. A unique aspect of the AV valves is their attachment to the ventricles, with the assistance of chordae tendinae inserted into the papillary muscle of the ventricles.

The heart's main function is to pump blood throughout the body. Cardiac function can be best represented by cardiac output, the amount of blood pumped out of the heart per minute. Many factors determine cardiac output. The product of stroke volume and heart rate equals cardiac output. Hence, cardiac output is directly alterable through variations in these 2 factors. Stroke volume is the blood volume ejected after

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ventricular contraction, calculated by taking the difference between end-diastolic volume and end-systolic volume. Contractility, afterload, and preload can change stroke volume. Preload is the stress placed on cardiomyocytes by the end-diastolic volume before systole. The end-diastolic volume is the best way to measure preload. On the other hand, afterload is the total tension the ventricle must overcome during systole. The law of LaPlace is the foundation for the definition of afterload. Therefore, pressure, radius, or wall thickness changes directly affect afterload.

Histological and cytological studies of the heart are necessary for diagnostic purposes, assessment of allograft rejection after a cardiac transplant, or evaluation of the effect of drug toxicity on the heart. An endomyocardial biopsy obtains cardiac tissue to be analyzed. During an endomyocardial biopsy, 1 to 2 mm3 of endocardium and myocardium are taken from the right ventricle. Peripheral proximity to the venous entry of the bioptome and a thicker wall relative to the atrium make the right ventricle an ideal location for a biopsy. The cardiac sample is then placed into a fixative, such as formalin, to preserve the tissue. These preserved samples are placed into cassettes, embedded in paraffin wax, thinly sliced, and mounted onto glass slides. Hematoxylin and eosin are initial, basic stains for visualization of the heart tissue under light microscopy. Depending on the purpose of the endomyocardial biopsy, the method to prepare the tissue may vary. For instance, if viral myocarditis is on the differential, a frozen sample is needed to identify the virus through a polymerase chain reaction.

Studying cells and tissue (histochemistry) and intracellular activities (cytochemistry) is useful for narrowing down the correct diagnosis. Immunohistochemistry uses antibodies to target specific antigens in a specimen. The antibody-antigen complex can then be stained to appreciate the presence of the particular antigen. This test can aid in the diagnosis of acute allograft rejection, amyloidosis, neoplasms, and cardiomyopathy. T-lymphocytes, seen in myocarditis, can also be identified with the help of immunohistochemistry. Immunofluorescence is very similar to immunohistochemistry. However, the antibodies contain a fluorescent

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dye, which is visible when the antibody is attached to an antigen. Immunofluorescence can assist with the diagnosis of allograft rejection and certain cardiomyopathies. Special stains highlight specific components in a specimen that might be difficult to visualize using hematoxylin and eosin. The Congo red and methyl violet stains are useful for detecting amyloid deposits in tissue. In myocarditis or allograft rejection, methyl green-pyronine stain can spot lymphocytes. Masson's elastic trichrome stains connective tissue, such as elastic fiber and collagen. In patients with iron-overload cardiomyopathy, possibly due to hemochromatosis, any iron deposition in the tissue can be stained using the Prussian blue stain.

Histologically, the heart is mainly composed of cardiomyocytes and connective tissue. Dense 2 connective tissue with elastic fibers is in the cardiac/fibrous skeleton. Certain stains, such as Masson's elastic trichrome stains, can help visualize these components. The pericardium is subdivided into 2 layers: a superficial fibrous layer and a deeper serous layer. The fibrous layer is composed of fibrous connective tissue. The serous layer further divides into 2 layers, an outer layer inseparable from the fibrous pericardium and an inner layer overlying the myocardium. These layers are histologically the same, composed of a continuous layer of mesothelial cells with microvilli facing the pericardial cavity. The fibrous pericardium and the outer serous pericardium combined are known as the parietal pericardium. The inner serous pericardium, or visceral pericardium, is also part of the epicardium. In between the outer and inner serous layer is a potential space known as the pericardial cavity containing pericardial fluid, which is produced and reabsorbed by the microvilli on the mesothelial cells.

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