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CARDIAC HISTOSTRUCTURE, FUNCTION AND FORMATION

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Annotation: The heart is a four-chambered organ responsible for pumping throughout the body. It receives deoxygenated blood from the body, sends it to the lung, 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 the normal function and adaptations of the heart.

Key words: Heart , blood, function, oxygen.

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.[1]

The wall of the heart separates into the following layers: epicardium, myocardium, and endocardium. These three layers of the heart are embryologically equivalent to the three layers of blood vessels: tunica adventitia, tunica media, and tunica intima, respectively. A double-layer, fluid-filled sac known as the pericardium surrounds the heart. The two 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.[2] Coronary arteries and 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 found between the endocardium and myocardium and contains the impulse-conducting system.

The impulse conducting system has specialized cardiac cells for the conduction of electrical impulses throughout the heart. Electrical impulses initiate at the sinoatrial (SA) node, situated at the junction of the superior vena cava and right atrium. These impulses travel throughout the atria until it reaches the atrioventricular (AV) node, located between the interatrial and interventricular septum. As the fibers travel inferiorly, it penetrates 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 two 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 attachments to the ventricles with the assistance of chordae tendinae inserted onto 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 two factors. Stroke volume is the blood volume ejected after 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 amount of 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, changes in pressure, radius, or wall thickness directly affect afterload.

The heart is a muscular pump that propels blood at high pressure round the body through the blood vessels. The heart contracts rhymically, and autonomously. Contractions begin at the apex of the heart and spreads through to the postero-basal region.

As with the rest of the circulatory system, the heart has three layers, as shown in the diagram below and the photo on the right:

epicardium (tunicaadventitia)
myocardium (tunicamedia)
endocardium (tunica intima)

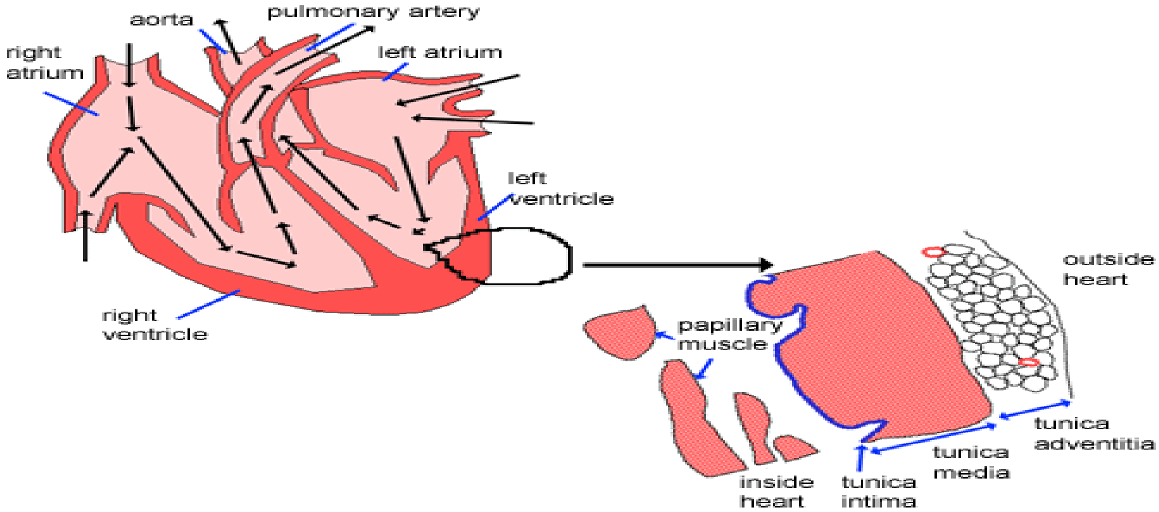
You also need to know about Purkinje fibres, which lie in the endocardium.

Tunica Adventitia (Epicardium)

This layer contains fibroelastic connective tissue, blood vessels, lymphatics and adipose tissue.

The simple squamous epithelium of the tunica adventitia layer is called the mesothelium

Tunica Media (Myocardium)

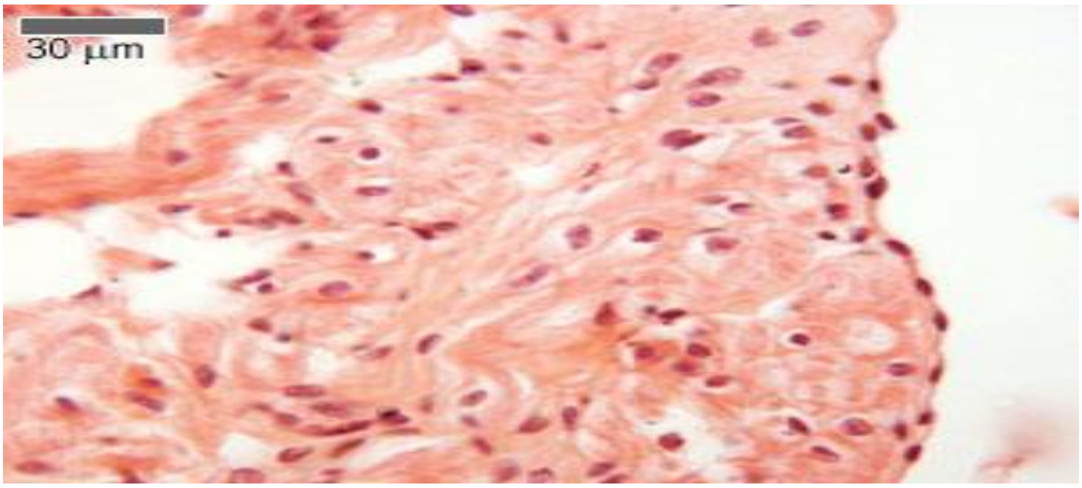


In the heart:

The tunica media layer is called the myocardium.

The myocardium is the largest of the three layers, and contains cardiac muscle fibres, and loose endomysial connective tissue that contains lots of capillaries.

Tunica Intima (Endocardium)



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The endocardium lines the atria and ventricles and covers the heart valves. As well as the endothelium and underlying basement membrane, there is a small layer of loose connective tissue and some adipose tissue.

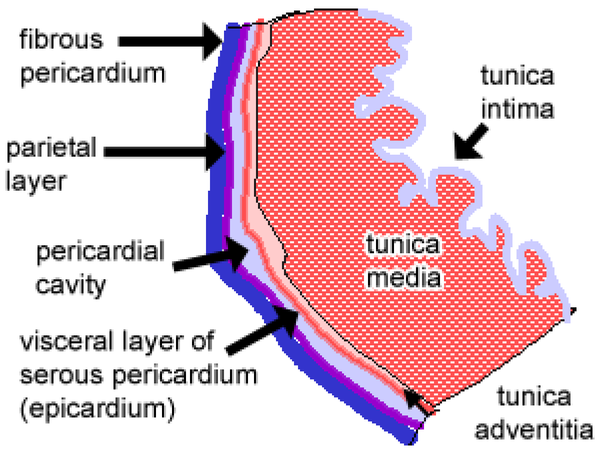
Can you identify the endothelium, and underlying connective tissue of the tunica intima layer in this photograph?

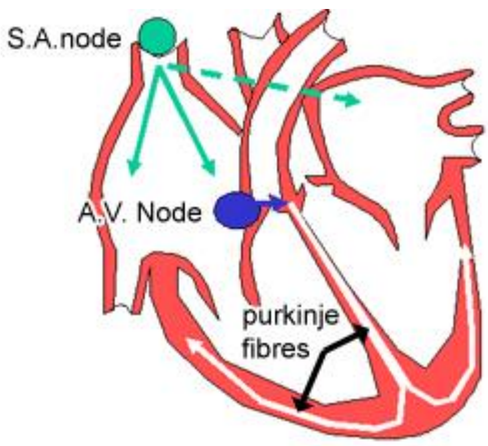
This diagram shows that the simple squamous epithelium of the tunica adventitia layer of the heart (mesothelium) is also the visceral layer of the serous pericardium.

The pericardium is a two-layered connective tissue sac that encloses the heart. The fibrous pericardium is the outer layer, and the serous pericardium is the inner layer.The space between the two layers is the pericardial cavity, that contains serous fluid. This facilitates the pumping action of the heart.

Background detail about heart contraction

First, impulses are generated by the sinoatrial node (SA), which is found in the wall of the superior vena cava. It is a small mass of specialised cardiac muscle fibres and associated connective tissue, and is supplied by nerve fibres from the autonomic nervous system. Excitation of the SA node sets of a wave of depolarisation around the atria via gap junctions between the muscle fibres.





Next the atrioventricular node (AV) starts impulse generation around the ventricles. The AV node lies in the interatrial septum. Impulses are sent from the AV node into the AV bundle, or bundle of his, which branches to form Purkinje fibres. The AV node is also supplied by nerve fibres from the autonomic nervous system that speed up and slow down the heart rate.

Purkinje fibres lie in the deepest layer of the endocardium and supply the papillary muscles. Hence the apex of the heart contracts first, followed by the papillary muscles, and then the wave of depolarisation spreads up the walls of the ventricles from the base upwards, as shown in the diagram.

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