RESEARCH ARTICLE

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The heart unveiled: Histological architecture, functional dynamics, and valvular mechanisms

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ABSTRACT The heart muscular organ located in the chest cavity between the lungs and above the diaphragm, covered by a strong fibrous sac called the pericardium, The heart consists of four chambers, the two thin-walled atria that form the upper and back parts of the heart, and the two thick-walled ventricles that form the front and lower parts of the heart. The right ventricle pumps blood to the lungs, while the left ventricle pumps blood to a network of capillary blood vessels within or near the tissues to all parts of the body. The heart consists of three distinct layers: the pericardium, the middle myocardium, and the inner endocardium. The myocardium, which is responsible for the contractile behavior of the heart, is located within the myocardium. Myocardium should be organized very accurately in terms of a hierarchy because it's associated with function. Heart tissue, for instance, has very crucial physiological characteristics; it does not need a direct stimulus externally applied to give an electrical stimulus on its cells; it could give an impulse and contract autonomously.

KEYWORDS heart muscular, myocardium, tunics, heart histological, frank-starling

1. INTRODUCTION

The heart muscular organ located in the chest cavity between the lungs and above the diaphragm, covered by a strong fibrous sac called the pericardium, The heart consists of four chambers, the two thin-walled atria that form the upper and back parts of the heart, and the two thick-walled ventricles that form the front and lower parts of the heart. The right ventricle pumps blood to the lungs, while the left ventricle pumps blood to a network of capillary blood vessels within or near the tissues to all parts of the body [1].

The heart is composed of three layers or tunics, the inner tunic is called the endocardium and consists of a single layer of squamous endothelial cells resting on a thin layer of connective tissue containing elastic and collagenous fibers and some smooth muscle fibers, and the endocardium represents the smooth inner surface of the heart chambers which allows blood to move easily through the heart. Then comes the myocardium, the thickest layer of the heart, and it consists of cardiac muscle cells arranged in layers surrounding the heart chambers in a complex spiral shape [2].

The muscle cells are joined to each other and to the neighboring cells through special networks known as intercalated discs. The last layer is the epicardium, which is considered the visceral layer of the pericardium, which is a serous membrane in which the heart is shown. There is a small amount of serous fluid between the visceral pericardium and its parietal layer that facilitates the movement of the heart. The heart contains two kinds of valves; its Atrioventricular valves, which are valves that separate the atrium and ventricle cavities on each side and allow blood to flow from the atrium to the ventricle and prevent it from returning when the ventricles contract. And Semilunar Valves: These are valves that separate the cavity of the right ventricle from the pulmonary artery and the left ventricle from the aorta. They prevent blood from returning from the ventricles to the arteries when the ventricles relax and the pressure in them decreases [3].

2. HEART ANATOMY

The heart is a hollow muscular organ at the center of the circulatory system, responsible for pumping oxygenated blood to produce nutrients throughout the body. The heart is located in the thoracic cavity between the lungs within the mediastinum behind the sternum and in front of the spine. It slants slightly to the left side of the body midline. Above the diaphragm is where it is placed so that two-thirds of its mass lies on the left, and the other one-third is on the right [4].

The heart is composed of three separate layers, which include the pericardium, the middle myocardium, and the inner endocardium. Myocardium is located within the myocardium, it being responsible for the contractile behavior of the heart. Myocardium needs an accurate hierarchical organization that is closely related to its function [5].

The heart is in a double-walled fibrous sac called the sacculus minor, which is divided into (a) the fibrous sac, and (b) the serosal sac. The fibrous sac covers the heart and communicates with the great blood vessels. The serosal sac is a closed sac formed by two layers - a multilayered lining or pericardium, the external lining of the great vessels and heart, and a layer of fibrous branches, the inner lining of the pericardium. The serosal sac contains little juice that forbids the friction between the heart and the pericardium [6].

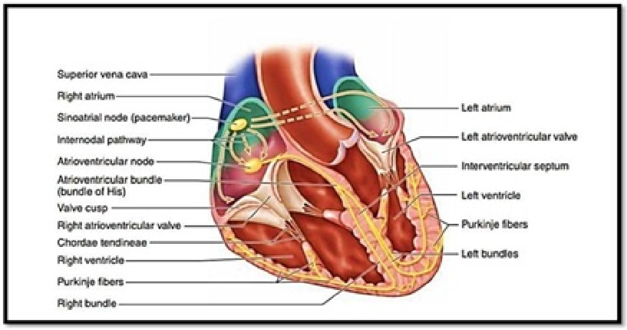

FIGURE 1. [7]

3. HEART FROM A HISTOLOGICAL

The heart tissue is an organ made up of several types of specialized tissues that work together to ensure its basic function as a blood pump. The heart consists of three main layers of tissue in addition to tissue specialized in electrical conduction and tissues that support the heart structure.

3.1. First: The endocardium

The endocardium is the inner lining of heart chambers and valves. It contains smooth cells which help to present a smooth surface thereby reducing the friction of flowing blood. Substances underneath are composed of a layer of rich connective tissue elastic and collagenous fibers supporting internal structures. In addition, the layer provides small blood vessel networks and capillaries responsible for the heart's nutrition [8].

3.2. Secondly, the epicardium

The epicardium is the outer layer of the heart and is part of the pericardium. It consists of connective tissue containing elastic fibers and a network of blood vessels. It also contains fat cells that supply the heart muscle with oxygen and nutrients. In addition, it contains fat cells that supply the heart muscle with oxygen and nutrients. In addition, the epicardium contains nerves that contribute to regulating the functions of the heart. This layer works to protect the heart from friction during chest movement [8], [9].

3.3. Third, the connective tissue in the heart

The connective tissue in the heart forms the fibrous structure that supports the heart chambers and valves. The fibrous structure also works to isolate electrical signals between the atria and the ventricles, which helps ensure that the atria and ventricles contract separately and in harmony. This tissue also supports the blood vessels that feed the heart muscle and help return blood to the right atria [10].

4. CHARACTERISTICS OF HEART TISSUE

It exhibits a number of important physiological properties, among them self-contraction where the heart cells generate electrical signals by themselves and don't need any external stimulus for it. Another important feature is rapid electrical conduction of the heart cells to ensure proper coordination of contractions of the heart. Additionally, the heart has a rhythmic movement, in which the muscle cells coordinate to provide an alternate rhythm of pumping blood into the body system [11].

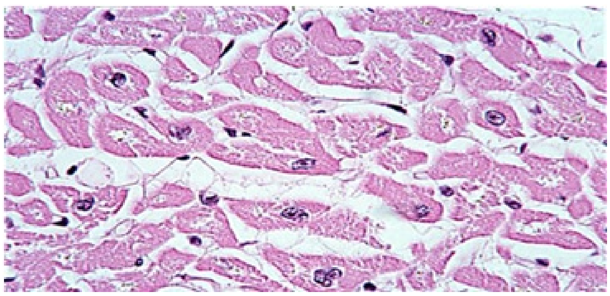

FIGURE 2. **Heart tissue** [11])

5. PHYSIOLOGICAL HEART

This makes the physiological function of the heart heavily reliant on its anatomical complexities. Blood within the heart has four valves directing the blood flow; the other two facilitate blood flow from the atria into the ventricles and two more enable the blood from the ventricles to reach the lungs and other parts of the body.

In a normal heartbeat, the left ventricle pumps oxygen-rich blood through the aortic root, which includes the apices, annulus, sin tubular junction, and sinus of Valsalva The apices allow blood to flow during ventricular contraction. The aortic valve is formed by three semicircular domes, known as leaflets, each of which is less than 1 mm thick. These are attached to the aortic root at the basal portion and form the hemodynamic connection between the aorta and the left ventricle. Thick fibrous tissue connects the leaflets to the root, forming a crown-shaped structure known as the annulus [12].

6. THE PHYSICAL MECHANISM OF THE HEART

The heart is the main pump of the circulatory system in the human body, and it works continuously to maintain the flow of blood through the blood vessels. The work of the heart depends on a precise physical mechanism regulated by coordinated mechanical and electrical processes. This process begins with the cardiac cycle, which includes regular contraction and relaxation, at the beginning of the cardiac cycle, blood enters the atria during the diastole phase, which is the phase in which the heart muscle relaxes, leading to a decrease in pressure inside the heart chambers. This decrease allows the atrioventricular valves, which are the mitral on the left side and the tricuspid on the right side, to open so that blood can flow freely from the atria to the ventricles. When the ventricles are full, the atrial systole phase occurs, where the atria contract to push the remaining amount of blood into the ventricles, ensuring that they are completely filled. Then, the ventricular systole phase starts, which is the strongest phase, when the ventricles contract and push blood into the great arteries. At this stage, the atrioventricular valves close to prevent backflow of blood into the atria, and the semilunar valves, namely aortic and pulmonary valves, open for blood to flow out of the heart [13].

Blood pumped from the left ventricle enters the aorta to be distributed throughout the body, while blood pumped from the right ventricle goes to the pulmonary artery, where it is oxygenated in the lungs, electrically, the heartbeat is regulated by a specialized conduction system. The electrical signal begins at the sinoatrial node (SA Node), which acts as a pacemaker. The signal then travels to the atrioventricular node (AV Node), where it is delayed slightly to allow the ventricles to fill with blood. The signal then spreads through Purkinje fibers, which transmit it to the ventricular myocardial cells, causing the ventricles to contract and pump blood [14].

7. FRANK-STARLING LAW

The Frank-Starling Law refers to the physiological principle regarding the adaptation of the heart to changes in the volume of blood entering it in order to preserve efficient pumping of blood to the body. This law works according to the relation between the stretching of cardiac muscle fibers and the force of their contraction [15].

When the ventricles fill with more blood during diastole, the muscle fibers of the heart walls stretch. This stretching improves the arrangement and interconnection of the protein filaments responsible for muscle contraction, namely actin and myosin, which leads to increased contraction efficiency, in other words, the more blood that reaches the ventricles during diastole (known as preload), the more forcefully the heart contracts, and therefore the more blood it pumps into the arteries (known as stroke volume). This process is a natural way to regulate cardiac output in proportion to the body's needs [16].

Due to this law, the heart achieves equilibrium between the volume of blood returning to it and the volume of blood that it pumps. For instance, if the amount of blood returning to the heart increases due to increased physical activity or dilation of blood vessels, the heart will increase the force of contraction and pump more blood to meet the increased needs of the body for oxygen and energy [7], [17].

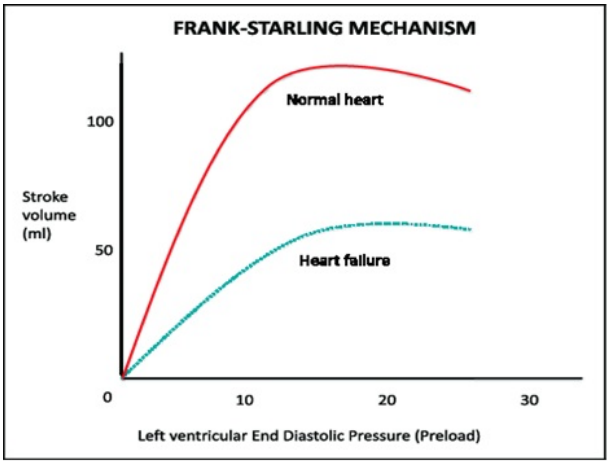

FIGURE 3. Frank-starling law [15]

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