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Preface

Physiology is a scientific discipline that has always been evolving and changing and it has importance in understanding the normal functioning of the body and has a close relationship with pathology and disease diagnosis. physiological information about cardiac system can be helpful in understanding and examining the pathological processes of the heart in detail. The current book which provides a concise overview of the topics in cardiac physiology along with fundamental concepts in this field has been prepared to meet the needs of students in various medical science disciplines. This book has been written based on years of my teaching experience in the field of cardiac physiology in medical, pharmacy, dentistry, paramedic, nursing and midwifery faculties, and considering the students need for various books and reputable articles. moreover, in certain sections of the book, under the title of (key point) information related to basic medical sciences tests is presented for beter understanding and retention. I hope that this book can provide effective assistance to students and colleagues in understanding and comprehending cardiovascular physiology. students notes and reminders of potential errors are commendable.

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In the name of good

Physiology is the study of normal function within living creatures and is a scientific discipline that has always been evolving and changing and it has importance in understanding the normal functioning of the body and has a close relationship with pathology and disease diagnosis. physiological information about cardiac system can be helpful in understanding and examining the pathological processes of the heart in detail.

1 Basic Principles of the heart

The titles of the recent chapter are as follows:

Abstract:

Myocardium

Anatomical position of the heart

The layers of the heart

Cardiac muscle classifications

Structure of cardiac muscles

The architecture of myocardial cells: the configuration and form of cardiac muscle tissue

The process of excitation-contraction coupling

Contractility

Heart Muscle Excitability

Heart Conduction System (Cardiac Conduction)

Mechanism of SA node self-stimulation

Phases of action potential within the nodal system

The mechanism of self-induced stimulation of the AV node

Myocardium:

The heart is an amazing organ. Its main function is to pump blood throughout the body, which continues the flow of fresh oxygen to various tissues and systems. The heart is partially so efficient because of its shape. The orientation of the different compartments of the heart allows for deoxygenated blood to enter, pass to the lungs to receive oxygen, and exit back to the body.

The human's heart is a muscular pump with about 200-300 g weight, which is a specialized vessel. Actually, heart include two separated pumps that every one of them mades of two cavities means atrium and ventricle.

Left heart receives the full of oxygen blood of lungs by left atrium and after entering blood to ventricle it pumps this blood to all internal members and organs. Right heart receives the blood of organs by right atrium and after interring of blood to ventricle it pumps that to longs by contracting (Figure 1-1).

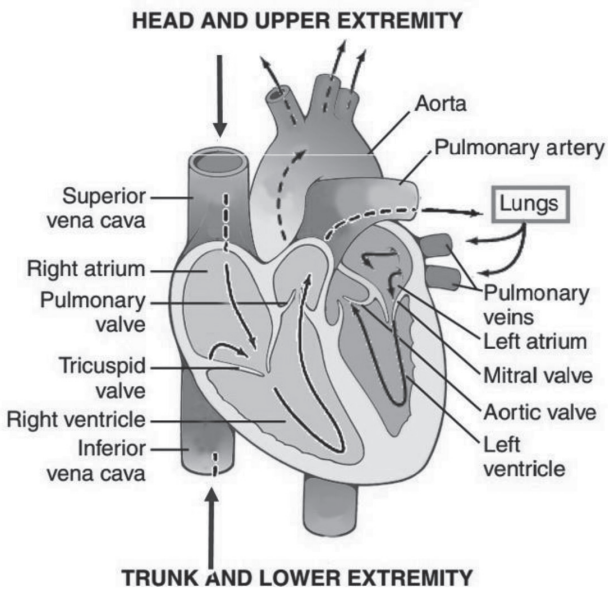

Figure 1-1: The structural of the heart, as well as the entry and exit of blood within its cavities

Heart has four cavities, two atriums and two ventricles. Every atrium and ventricle stand on one side of heart. The atrium and ventricle of every side separate of similar viscera in other side by a septum. Every atrium is associated with its ventricle by an orifice (atrioventricular orifice). This communication controls by atrioventricular valves (Figure 1-2).

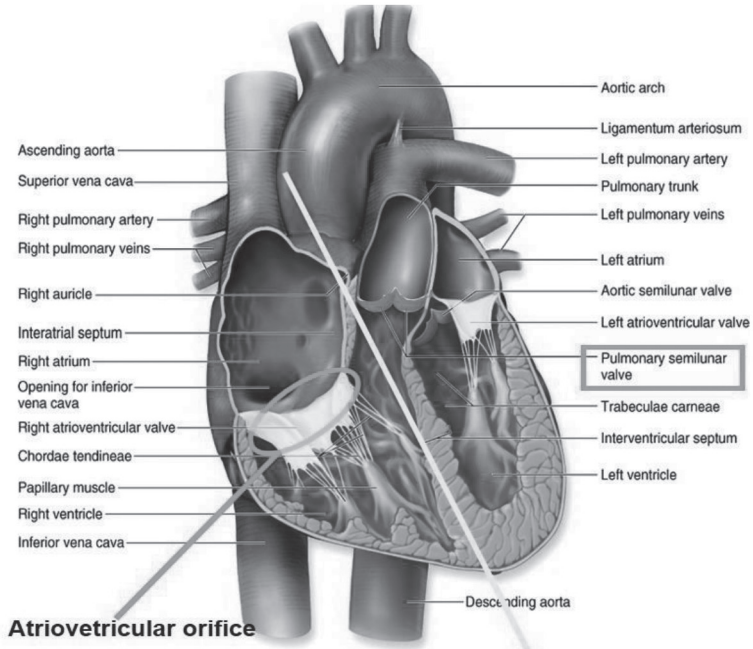

Figure 1-2: Heart has four cavities, two atriums and two ventricles. cavities, septum, orifice, and valves of the heart

The atrioventricular valve in right heart calls tricuspid valve and in left heart calls mitral valve.

When blood pressure in right and left atriums is upper than right and left ventricles, the cusps of tricuspid valve and mitral valve are opening and blood inters of atriums to their ventricles. While blood pressure in right or left ventricles is upper than right or left atriums, the valve's cusps close and prevent reverse blood circulation (circulate to atriums).

The valve's cusps made of endocardium. The base of cusps sticks to each other and their free margins stretch into ventricles and they connecting to some strings that we call them chordae tendineae. The papillary muscles are look like cone shaped which it's base connect to wall of the heart and its free head connects to chordae tendineae. The papillary muscles pull the cusps (vanes) of the valves inward the ventricles to prevent their bulging too far backward the atria during ventricular contraction (Figure 1-3).

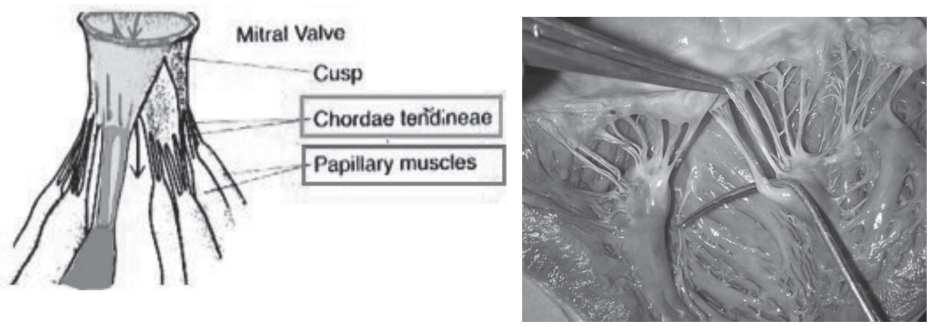

Figure 1-3: The atrioventricular valve and papillary muscles

In addition to atrioventricular valves, the semilunar valves are located at the connections between the pulmonary artery and the right ventricle, and the aorta and the left ventricle (Figure 1-4). The *opening and closing* of the AV *valves* are opposing with semilunar valves. In other words when the atrioventricular valves are open semi-lunar valves are closed and vice versa.

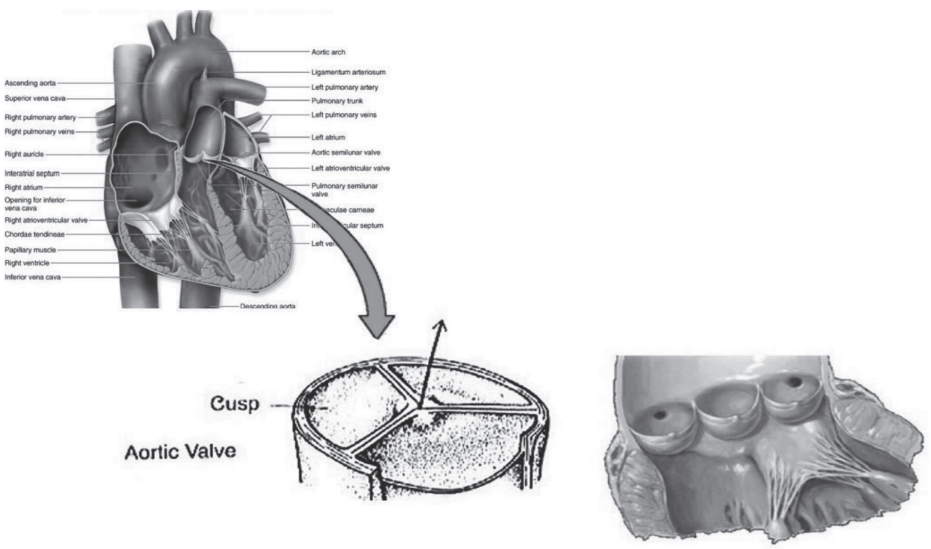

Figure 1-4: the semilunar valves are located at the connections between the pulmonary artery and the right ventricle, and the aorta and the left ventricle.

Clinical note:

- **Septal defects** occur when there is hole between the ventricles of the hear has it. This disease sometimes known as a hole in the heart.
- **Obstruction defects** occur when blood flow in the heart's atria is partially or completely blocked.
- **Cyanotic heart disease** due one or more defects in heart the oxygen not enough is pumped in body.
- **Mitral regurgitation** occurs when the mitral valves of the heart not closed properly and causes blood to return to the heart. Blood in people with mitral valves insufficiency is not distributed well in the body, the affected person feels tired and out of breath
- **Stenotic:** Atrioventricular valves may be significantly narrowed.
- **Mitral regurgitation and stenosis** These conditions create systolic and diastolic murmurs, respectively, which can be clearly heard at the apex of the heart.
- **Mitral valves prolapse:** This is a type of dysfunction of the mitral valve. The leaflets enlarge and are drawn toward the left atrium, sometimes suddenly closing with a sound during contraction, which may lead to blood flowing back into the left atrium (regurgitation). Prolapse or mitral valve prolapse actually refers to the syndrome where the mitral valve moves toward the left atrium during heart contraction. In this case, one or both leaflets may not close properly, leading to regurgitation. This regurgitation can result in a murmur or heart sound (an abnormal sound related to abnormal blood flow). Mitral regurgitation is usually mild.
- **Aortic insufficiency and stenosis** These conditions create diastolic and systolic murmurs, respectively, which can be heard in the second intercostal space on the right side of the sternum. The characteristics of these murmurs are an important guide in diagnosing valve diseases.
- **Wolf-Parkinson- White syndrome:** This is a congenital disorder and is the most common clinical condition in which a shortcut pathway is created as an accessory route between the atria and ventricles. It usually does not cause specific dysfunction and can be easily recognized on an ECG.

Anatomical position of the heart:

The human heart is located within the thoracic cavity, medially between the lungs in the

space known as the mediastinum in the form of an inverted and oblique cone. Its base is above and its apex is in the 5th intercostal space so that the heartbeat can be felt in that area. Figure 1-5 shows the position of the heart within the thoracic cavity.

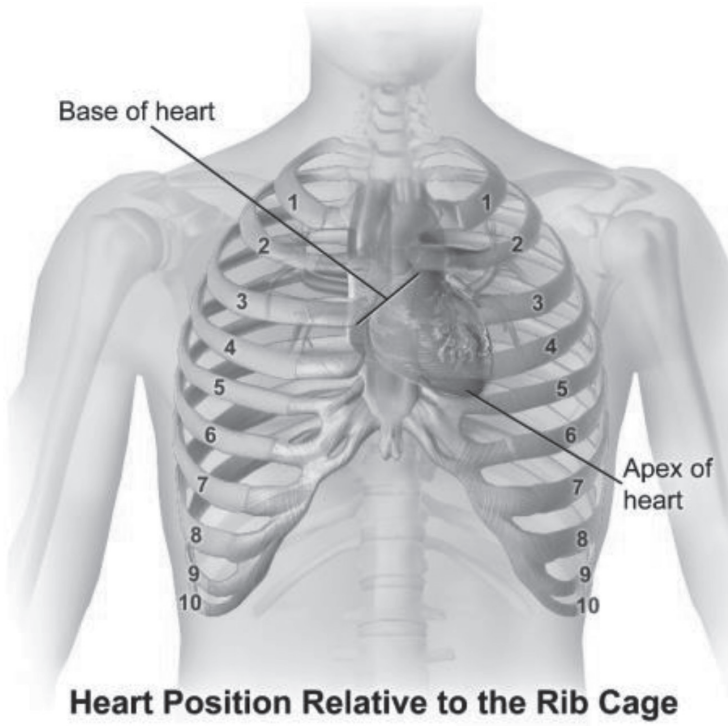

Figure 1-5: Anatomical position of the heart in the body

The layers of the heart:

The pericardium separates the heart from interference of other structures, protects it against infection and trauma, and lubricates the heart's movements.

The pericardium is a double-wall sac consisting of the outer, fibrous pericardium and the inner, serous pericardium.

The fibrous layer is the tough, outermost layer of pericardium. It's made of connective tissue that prevents heart from expanding too much.

The serous pericardium is itself divided into two layers: the **outer parietal layer** that lines the internal surface of the fibrous pericardium and the **internal visceral layer** that forms the outer layer of the heart (also known as the **epicardium**).

Found between the outer and inner serous layers is the **pericardial cavity**, which

contains a small amount of lubricating serous fluid. The serous fluid serves to minimize the friction (is the force felt between two surfaces when one attempts to slide against the other- attrition) generated by the heart as it contracts.

The heart wall is composed of three layers, the epicardium (outer), myocardium (middle), and endocardium (inner).

The epicardium is the outer layer that contains blood vessels include capillaries, lymphatic capillaries and nerves and is a protective layer for the heart. The myocardium is the middle layer that is composed of contractile tissues and is the important muscle tissue of the heart. (Figure 1-6)

The endocardium is the innermost layer and composes the valves, inner lining of the chambers, and contains loose elastic tissue, collagen bundles, nerves, and occasionally blood vessels.

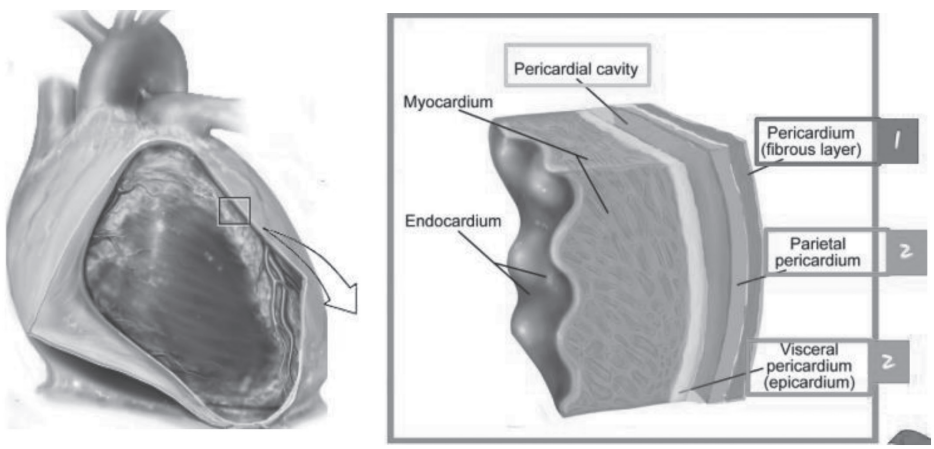

Figure 1-6: The layers around the heart and the layers of the heart tissue.

The pericardial space (or pericardial cavity) is located between the parietal layer and the visceral layer and contains pericardial fluid. The *pericardial* cavity, which is a virtual spacey containing 20–30 mL of *fluid* and this fluid prevents friction between the two layers.

Pericardial effusion is a collection of excess fluid in pericardium, the sac around the heart. The *fluid* accumulation increases *pressure* in the pericardial sac, leading *to* the compression of the *heart* (Figure 1-7). Quantitative and qualitative changes in the pericardial fluid cause disturbances in the heart work.

In quantitative changes, if the volume of pericardial fluid increases to 500-1000 cc,