THE HEART

I. Size and Location:

A. Fist-size weighing less than a pound (250 to 350 grams).

B. Located in the mediastinum between the 2nd rib and the 5th intercostal space.

1. **Tipped to the left, resting obliquely in the chest immediately above the diaphragm.**
2. **In the adult, the muscular tip or apex is located between the 5th and 6th ribs approximately 31/2 inches from the mid sternum.**
3. **The strongest heart sound is found at the location of the apex and is referred to as the Point of Maximum Intensity (PMI).**

II. Outer Coverings of the Heart:

A. The Pericardium - a double sac of serous membrane surrounding the heart

Parietal pericardium - a loose fitting outer membrane consisting of two layers:

1. **The fibrous layer - composed of tough, white fibrous tissue covering the heart and anchoring it to the diaphragm, sternum and large blood vessels.**
2. **The serous layer - a thin inner membrane composed of a thin fibrous layer on top of a simple squamous epithelium. This layer folds back over and adheres to the heart forming the visceral pericardium.**

<u>Visceral pericardium</u> - this layer is also called the epicardium. It is well integrated with the muscular wall of the heart. It is often infiltrated with fat.

<u>Pericardial cavity -</u> is a fluid-filled cavity located between the parietal and visceral membranes. The serous portions of the parietal and visceral membranes face the cavity and produce the pericardial fluid. This fluid prevents the heart and lungs from rubbing against each other during their actions. Pericarditis is an inflammation of the pericardium. It can produce painful adhesions between the membranes.

III. The Heart Wall - three layers:

<u>A. The Epicardium (described above)</u>

<u>B. The Myocardium</u> - the muscular wall of the heart composed of cardiac muscle and a reinforcing internal network of fibrous connective tissue called the "skeleton of the heart". This connective tissue serves two primary functions:

1. **It provides anchorage for the cardiac muscle and the atrioventricular valves. The portion of the skeleton anchoring the A-V valves is called the coronary trigone.**
2. **The elastic component of the skeleton provides the recoil that assists in filling the chambers following systole.**

C. The Endocardium - lines the chambers of the heart. In the chambers it consists of a simple squamous epithelium overlying a delicate layer of loose connective tissue. It lines the dense connective tissue of the cusps of the A-V valves. It is continuous with the endothelium of the blood vessels. Inflammation of this layer is called endocarditis.

IV. General Anatomy

A.The heart contains four cavities or chambers, two superior atria and two inferior ventricles.

B. The interatrial septum separates the right and left atria.

C. The interventricular septum separates the right and left ventricles.

D. On the surface of the heart, a number of grooves may be seen:

1. **They contain the right and left coronary arteries. These are the primary vessels supplying the myocardium with oxygenated blood.**

2. **The anterior interventricular sulcus marks the position of the interventricular septum on the anterior surface. It contains the anterior interventricular artery and the anterior (great) cardiac vein.The atrioventricular grooves are found between the upper and lower chambers.**

3. **Posterior interventricular sulcus marks the position of the interventricular septum on the posterior surface. It contains the posterior interventricular artery and the middle cardiac vein.**

E. The Atria - are reception chambers for blood returning to the heart from the body (right atrium) and the lungs (left atrium). The thin muscular walls of these chambers push the blood a short distance, i.e., to the lower chambers. The interior of the atrial walls shows woven ridges of cardiac muscle called pectinate muscle. The woven nature of this muscle permits a great strength of contraction with a minimum of muscle mass.
The median walls of the right atrium shows a shallow depression, the fossa ovalis. This is a remnant of an opening in the septum, the foramen ovale, a fetal adaptation to allow blood to shunt from the right to the left atrium bypassing the lungs.

F. Blood Vessels of the Atria

1. Right Atrium receives blood via:

a. Superior vena cava - returns blood from the head, shoulders, arms and neck.

b. Inferior vena cava - returns blood from the lower body

c. Coronary sinus - returns blood from the coronary circulation

2. Left Atrium receives blood via four pulmonary veins. These vessels enter the left atrium posteriorly bringing oxygenated blood back to the heart from the lungs.

G. The Ventricles - are blood ejecting chambers with thick muscular walls. Each ventricle receives blood from its respective atrium. The ventricles have the following structures in common:

1. An endocardium which is a continuation of the lining of the atria.

2. A thickly woven arrangement of cardiac muscle called trabeculae carneae. The appearance and function of this woven muscle is essential the same as the pectinate muscle.

3. Papillary muscle is seen as pimple-like projections of the inner myocardial wall. The chordae tendineae are often anchored on papillary muscle.

H. Blood Vessels of the Ventricles - Blood leaves the ventricles through large, thick-walled vessels. The pulmonary trunk carries blood from the right ventricle. The aorta carries blood from the left ventricle.

I. The Heart Valves - two types:

1. Atrioventricular valves:

a. They are located between the atria and ventricles on each side of the heart.

b. They prevent a backflow of blood from the ventricle to the atrium

c. They are formed from flap-like extensions of the endocardium called cusps. In the right A-V valve there are three cusps - the tricuspid valve. In the left A-V valve there are two cusps - the bicuspid (mitral) valve.

d. Each cusp is restrained from bending the wrong way, i.e., prolapsing by tendinous cords, the chordae tendineae.

e. The papillary muscles anchoring the cords to the heart wall will contract to counter any stretch in the cord during vigouous pumping of the heart.

f. Inflammation of the endocardium can damage heart valves. This maybe a complication of Rheumatic fever.

2. Semilunar valves:

a. They are found lining the walls of the pulmonary trunk (pulmonary valve) and the aorta (aortic valve).

b. Each valve consists of three pocket-like endocardial cusps.

c. During contraction of the ventricles (ventricular systole), the pockets are flattened against the walls of the ejecting vessels. As the ventricles begin to relax (diastole), the blood in the large arteries begins to fall back down into the ventricles. This causes the cusps to fill with blood and billow out closing the vessel and preventing a backflow.

J. Coronary Circulation - supplies oxygenated blood to the myocardium and returns blood back to the heart. Right and left coronary arteries supply oxygenated blood to the myocardial wall. They branch from the aorta just above the semilunar valve. The coronary sinus receives blood from the small cardiac, middle cardiac, great cardiac and posterior vein. This deoxygenated blood is then returned to the right atrium.

V. The Conduction System of the Heart - is designed to spread the waves of depolarization and repolarization rapidly through the myocardium. The system consists of modified cardiac muscle cells called Purkinje cells. These cells are organized into:

A. The sinoatrial node - is an accumulation of Purkinje cells located medial to the opening of the superior vena cava in the posterior wall of the right atrium. These cells depolarize at a rate of 70 to 80 times per minute. This is a faster rate of depolarization than any other portion of the heart and determines the normal heart rate, i.e., sinus rhythm. For this reason, the S-A node is referred to as the "pacemaker".

B. The atrioventricular node is located in the right atrium medial to the tricuspid valve. The A-V node receives the wave of depolarization about 50msec after it leaves the S-A node. However, the passage of the wave through the A-V node slows down and takes about three times longer to pass through the node (150 msec). This delay is crucial for the normal functioning of the heart. It permits the atrial myocardium to finish its contraction before the ventricular contractions begin.

C. The Bundle of His receives the wave of depolarization from the A-V node. The bundle passes into the interventricular septum. Here the bundle divides into the right and left bundle branches. These branches continue to divide forming the Purkinje fibers which carry the wave to every part of the ventricular myocardium. The fibers making up the bundle and bundle branches have a wider diameter and more numerous gap junctions than typical cardiac cells. As a result, they carry the wave at a great speed throughout the ventricular myocardium (about 175 msec). The total time elapsed from the origin of the wave in the S-A node to the arrival of the wave in the ventricular myocardium is 225/1000 of one second. At this time the atria have finished their contraction and the ventricles will begin their contraction.

THE ELECTROCARDIOGRAM –

A record of the entire electrical activity occurring in the heart during one cardiac cycle. The EKG tracing is composed of three distinct deflections or waves, as well as, well defined intervals.

1. **The P wave:**
    a. **Has a duration of 0.08 seconds.**
    b. **Corresponds to depolarization of atrial walls.**
    c. **Atrial contraction occurs approximately 0.1 seconds after the P wave begins.**
2. **The QRS wave:**
    a. **Has a duration of 0.08 seconds.**
    b. **Corresponds to depolarization of ventricular myocardium**
3. **The T wave:**
    a. **Has a duration of 0.16 seconds.**
    b. **Corresponds to ventricular repolarization.**
4. **The PR interval (actually the PQ interval):**

a. Has a duration of 0.16 seconds and extends from the beginning of the P wave to the beginning of the QRS wave.

b. Corresponds to the period during which the atria depolarize, contract and begin to relax (enter diastole).

5. The QT interval:

a. Has a duration of 0.36 seconds and extends from the beginning of the QRS wave through the T wave.

b. During this period the ventricles depolarize, repolarize, contract and relax.

SUMMARY OF EVENTS OCCURING DURING THE CARDIAC CYCLE

STAGE I - Atrial and Ventricular Diastole

1. Both the upper and lower chambers are filling.

2. The atriaoventricular valves are open.

3. The semilunar valves are closed.

STAGE II - Atrial Systole; Ventricular Diastole

1. The atria are contracting forcing extra blood into the ventricles which become distended.

2. Each ventricle now contains about 120 ml of blood.

3. The atrioventricular valves are open.

4. The semilunar valves are closed.

STAGE III - This stage is divided into two phases:

A. Phase 1 -The Isovolumetric phase (Atrial Diastole; Ventricular Systole)

1. The atria have finished their contraction and are beginning to fill. The ventricles are beginning to contract.

2. Due to the rising blood pressure in the ventricles, the atrioventricular valves close. This action produces the first heart sound "lub".

3. The semilunar valves remain closed.

4. The volume of the blood in the ventricles remains the same during this phase (isovolumetric).

B. Phase 2 - The Ejection phase (Atrial Diastole; Ventricular Systole finishes)

1. The atria continue to fill.

2. The ventricles finish their systole. This creates a high enough pressure on the blood in the ventricles to overcome the downward force of blood in the pulmonary trunk and aorta. This opens the semilunars and allow about 70 ml of blood to be ejected from each ventricle.

3. The atrioventricular valves remain closed.

STAGE IV - Atrial Diastole continues; Ventricular Diastole begins

1. The atria continue to fill.

2. The ventricles enter diastole and begin to fill. This produces a decrease in ventricular blood pressure. As a result, the blood in the pulmonary trunk and aorta begins to flow back down towards the ventricles. The cusps of the similunars fill with this blood and close the valve. This action produces the second heart sound "dup". The recoil of the descending blood against the cusps of the semilunars produces the slight, transient rise in aortic blood pressure called the "dicrotic notch".