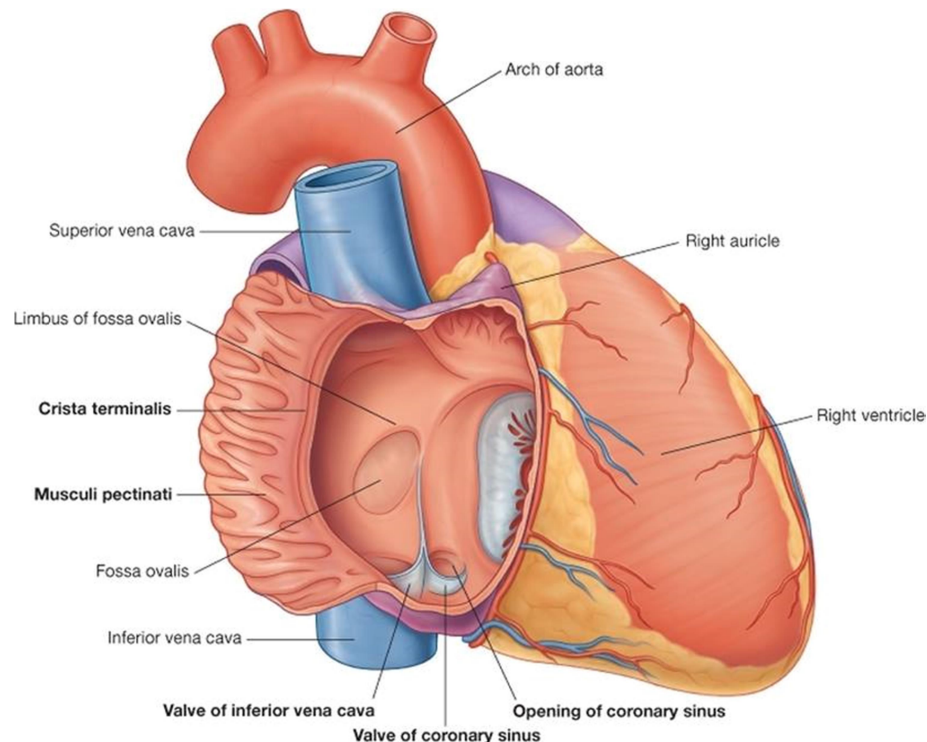


FLOW CHART- ANATOMY HEART –SHEET-77

Dr. Sanjiv Saxena Dept Of Rachana Sharir GAC Handia Prayagraj

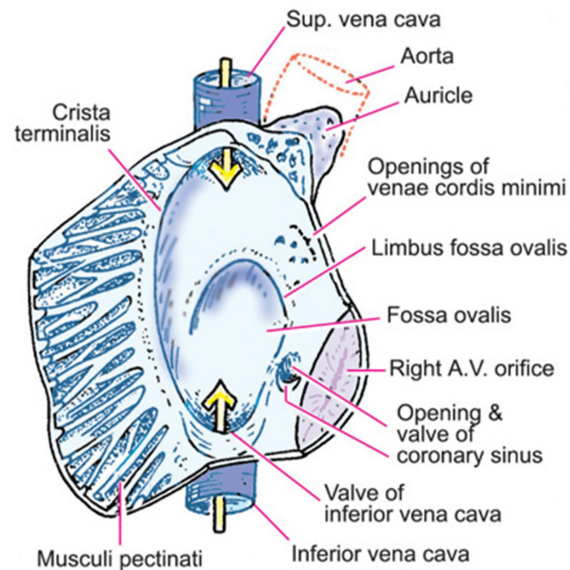
CHAMBERS OF HEART (PART -1)

- The heart consists of four chambers: the two atria and the **two ventricles**.
- Blood returning to the heart enters the atria, and is then pumped into the ventricles.
- From the right ventricle, it enters the **pulmonary circulation** via the pulmonary arteries.
- From the left ventricle, blood passes into the aorta and enters the systemic circulation.
- **ANATOMY OF RIGHT ATRIUM :**



- The right atrium receives deoxygenated blood from the superior and inferior vena cavae, and from the coronary veins.
- The right atrium is somewhat quadrilateral chamber situated behind and to the right side of the right ventricle.
- In the anatomical position, the right atrium forms the right border of the heart.
- It consists of a main cavity and extending from the antero-medial portion of the chamber is the right auricle (right atrial appendage).
- The right auricle is a muscular pouch that acts to increase the capacity of the atrium.
- **External features** : The right atrium is elongated vertically and receives superior vena cava (SVC) at its upper end and the inferior vena cava (IVC) at its lower end.
- The upper anterior part of the right atrium is prolonged to the left to form the right auricle. The margins of the auricle are notched.
- The right auricle overlaps the roots of the ascending aorta completely and infundibulum of the right ventricle partly.

- A shallow vertical groove called **sulcus terminalis** extends along the right border between the SVC and IVC .
- The upper part of the sulcus contains the **sinuatrial node (SA)** . It's detail is as following.
- The vertical right AV groove lodges the right coronary artery and the small cardiac veins.



- **Internal features** : The interior surface of the right atrium can be divided in to two parts each with a distinct embryological origin.
- These two parts are separated by a muscular ridge called the crista terminalis (externally seen as sulcus terminalis).
- The interior of the right atrium is divided in to two parts (a) the main smooth posterior part- the sinus venorum and , (b) the rough anterior part – the atrium proper.
- The two parts are separated from each other by crista terminalis. The difference between two parts are embryologically different described later.
- **Interatrial septum** : The interatrial septum is a solid muscular wall that separates the right and left atria.
- The septal wall in the right atrium is marked by a small oval shaped depression called the fossa ovalis. This is remnant of the foramen ovale in the fetal heart.
- Foramen ovale in the fetal heart allows right to left shunting of blood to bypass the lungs. It closes at the time of birth.
- Annulus ovalis or limbus fossa ovalis forms the distinct upper and lateral margin of the fossa ovalis.
- Inferiorly the annulus ovalis is continuous with the left end of the valve of IVC.
- **Triangle of Koch** : It is a triangular area bounded in front by the base of the septal leaflet of the tricuspid valve and behind by the opening of the coronary sinus. The AV node lies in this triangle.
- **Openings in to the right atrium** : There are a number of openings in the right atrium as following. Main openings are 5 in number.
- **1-Opening of SVC** : SVC opens at the upper end of the right atrium and has no valves . SVC brings deoxygenated blood from the upper part of the body.
- **2-Opening of IVC** : IVC opens at the lower end of the right atrium and brings deoxygenated blood from the lower part the body.
- Opening of IVC is guarded by a ‘ rudimentary’ non functioning semilunar valve called the valve of IVC or Eustachain valve.
- **3-Opening of the coronary sinus** : The coronary sinus drains most of the deoxygenated blood of the heart and opens in the right atrium between the IVC and right AV orifice

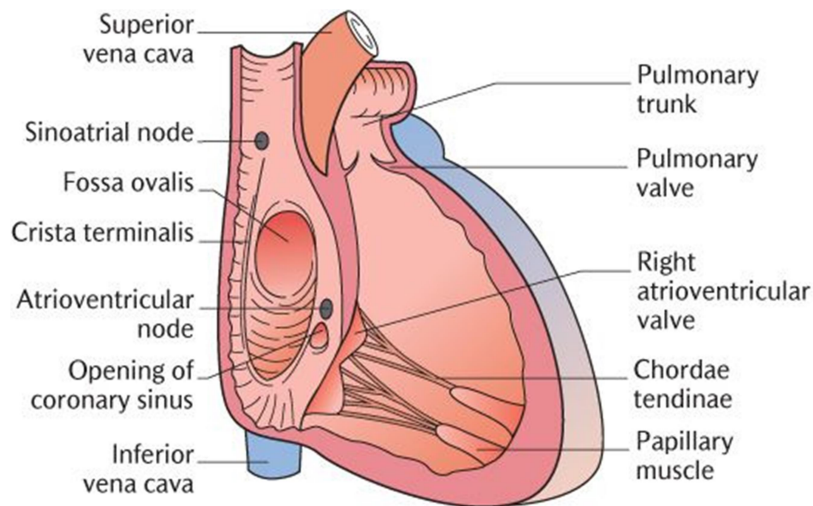
- It is guarded by a rudimentary nonfunctioning valve 'Thebesian valve'.
- **4-Right AV orifice** : It is the largest opening which communicates the chamber of right atrium with chamber of right ventricle.
- It lies anterior to the IVC opening and guarded by the tricuspid valve or right atrioventricular valve.
- -Many small orifices of small veins : These are the openings of venae cordis minimae or Thebesian veins. Anterior cardiac veins also open here.
- Differences between the smooth and rough parts of the right atrium:
- **Smooth posterior part**: It is located posterior to crista terminalis.
- It has smooth walls embryological derived from **sinus venosus**.
- All the venous channels except anterior cardiac veins open in to this part.
- **Rough anterior part** : It is located anterior to the crista terminalis and includes the right auricle.
- It is derived from the **primitive atrium**.
- It has rough , muscular walls formed by pectinate muscles.
- Pectinate Muscles : The pectinate muscles (musculi pectinati) are parallel muscular ridges in the walls of the atria of the heart.
- The pectinate muscles originate from the crista terminalis. The pectinate muscles are so-called because of their resemblance to the teeth of a comb, as in pecten.
- **LEFT ATRIUM** :
- The left atrium receives oxygenated blood from the four pulmonary veins , and pumps it through the left atrioventricular orifice (guarded by the mitral valve) in to the left ventricle.
- External Features : It is a thin walled quadrangular chamber situated posteriorly behind and to the left side of the right atrium.
- It forms the posterior border and base of the heart (left 2/3rd).
- It's upper end is prolonged anteriorly to form the left auricle , which overlaps the infundibulum of right ventricle.
- Behind the left atrium lies (a) an oblique sinus of the serous pericardium and (b) the fibrous pericardium , which separates it from the oesophagus.
- Internal features : The interior of the left atrium is smooth , but the left auricle possesses muscular ridges in the form of reticulum.
- The anterior wall of the left atrial cavity presents fossa lunata , which corresponds to the fossa ovalis of the right atrium.
- Openings in the left atrium :
- Openings of the four pulmonary veins in it's posterior wall , two on each side . They have no valves.
- Openings of venae cords minimae are numerous.
- Opening of left atrioventricular orifice (AV orifice) guarded by the mitral valve.
- The interior surface of the left atrium can be divided in to two parts , each with a distinct embryological origin.
- Inflow portion : It receives blood from the pulmonary veins . It's internal surface is smooth it is derived from pulmonary veins themselves.
- Outflow part : It is located anteriorly and includes the left auricle . It is lined by the pectinate muscles and is derived from the embryonic atrium.
- The left and right ventricles of the heart receive blood from the atria and pump it into the outflow vessels.
- The left ventricle pumps oxygenated blood though aorta to whole body.
- The right ventricle pumps deoxygenated blood to lungs by pulmonary artery/ trunk.

FLOW CHART- ANATOMY OF HEART –SHEET-78

Dr. Sanjiv Saxena Dept Of Rachana Sharir GAC Handia Prayagraj

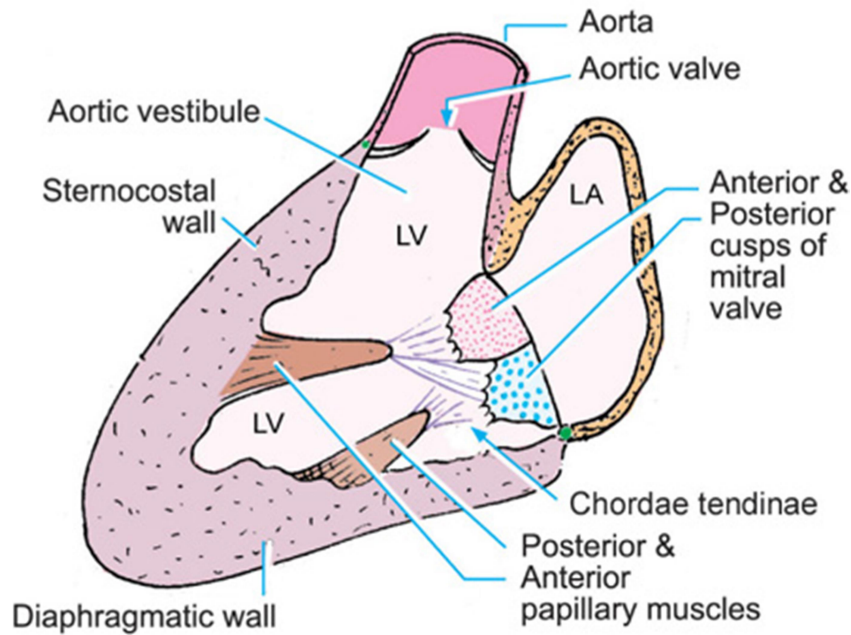
CHAMBERS OF HEART (PART -2)

- **Anatomy of The right ventricle :**



- The right ventricle receives deoxygenated blood from the right atrium, and pumps it through the pulmonary orifice (guarded by the pulmonary valve), into the **pulmonary artery/trunk**.
- External features : It is thick walled triangular in shape, and forms the majority of the **anterior** border of the heart and inferior border of the heart..
- It forms the most of the sternocostal surface and small part of the diaphragmatic surface of the heart.
- It is separated from the right atrium by a some what vertical coronary sulcus also called AV groove.
- Internal features : The right ventricle can be divided into an inflow and outflow portion, which are separated by a muscular ridge known as the **supraventricular crest**.
- The cavity of the right ventricle is flattened by the forward bulge of the interventricular septum. In the transverse section , it is crescent shaped.
- The wall of the right ventricle is thinner than that of the left ventricle.
- **Inflow Portion :**
- The interior of the inflow part of the right ventricle is covered by a series of irregular muscular elevations, called **trabeculae carnae**.
- They give the ventricle a 'sponge-like' appearance, and can be grouped into three main types:
- **Ridges** – Fixed in to form of ridges along the interior surface of the ventricle.

- **Bridges** – attached to the ventricle at both ends, but free in the middle.
- The most important example of this type is the **moderator band**, which extends between the interventricular septum and the anterior wall of the right ventricle. It has an important conductive function, containing the right bundle branches.(described later)
- **Pillars:** Pillars are represented by the papillary muscles –
- **Papillary Muscles** :Their bases are attached to the wall of the ventricles.
- There are three papillary muscles in the right ventricle : (a) anterior. (b) posterior or inferior and (c) Septal papillary muscles.
- Their apices are attached to fibrous cords called ‘chordae tendineae’. Which are in turn attached to the three **tricuspid valve** cusps.
- By contracting, the papillary muscles ‘pull’ on the chordae tendineae to prevent prolapse of the valve leaflets during ventricular systole.
- **Outflow Portion (Conus arteriosus):**
- The outflow portion (leading to the pulmonary artery) is located in the superior aspect of the ventricle.
- It is derived from the embryonic **bulbus cordis**.
- It is visibly different from the rest of the right ventricle, with smooth walls and no trabeculae carneae.
- Moderator band : It is also called septomarginal trabeculum.
- It is a thick muscular ridge extending from the ventricular septum to the base of the anterior papillary muscle (anterior ventricular wall) .
- It conveys the right branch of the AV bundle (bundle of His) , a part of the conducting system of the heart.
- It prevents the over distension of the heart.
- **Interventricular Septum:**
- The interventricular septum separates the two ventricles, and is composed of a superior **membranous** part and an inferior **muscular** part.
- The muscular part forms the majority of the septum and is the same thickness as the left ventricular wall.
- The membranous part is thinner, and part of the **fibrous skeleton** of the heart.
- **Anatomy of Left Ventricle:**
- The left ventricle receives oxygenated blood from the left atrium, and pumps it through the aortic orifice (guarded by the aortic valve) into the **aorta**.
- External features : In the anatomical position, the left ventricle forms the;
- (a) apex of the heart, as (b) left and diaphragmatic borders, (c) Small part of the sternocostal surface and left 2/3rd of the diaphragmatic surface.
- The left ventricle is a thick walled triangular chamber of the heart and communicates with the left atrium through the left AV orifice guarded by the bicuspid or mitral valve.
- The walls of the left ventricles are three times thicker than that of the right ventricle.
- Internal features :
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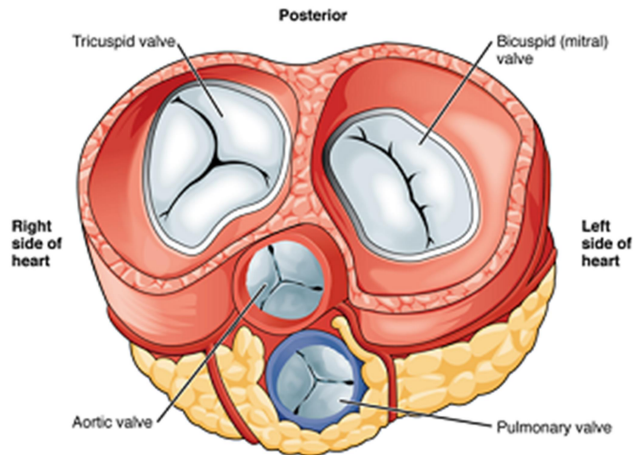
- Like the right ventricle, it can be divided into an inflow portion and an outflow portion.
- The cavity of the left ventricle is circular in cross section because the interventricular septum bulges into the right ventricle.
- **Inflow Portion**
- The walls of the inflow portion of the left ventricle are lined by **trabeculae carneae**, as described with the right ventricle.
- There are two large papillary muscles; anterior and posterior are attached to the cusps of the mitral valve by the chordae tendinae.
- It develops from the primitive ventricle.
- **Outflow Portion:** The outflow part of the left ventricle is known as the **aortic vestibule**.
- It is smooth-walled with no trabeculae carneae.
- It is a derivative of the embryonic **bulbus cordis**.

FLOW CHART- ANATOMY OF HEART –SHEET-79

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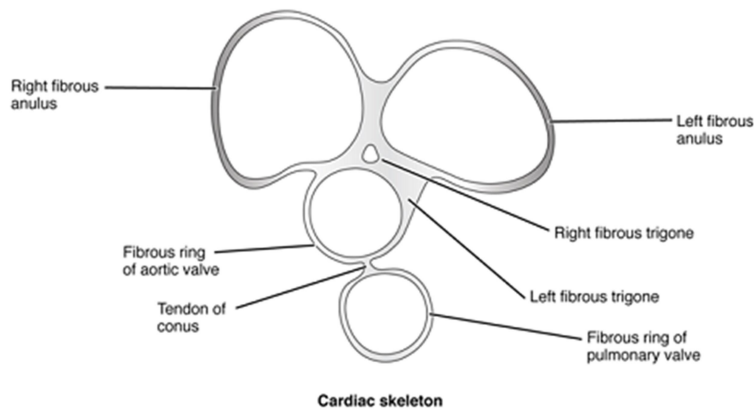
PART-3

• TOPIC –VALVES OF THE HEART AND SKELETON OF THE HEART



-
- The valves of the heart are structures which ensure blood flows in only one direction.
- They are composed of connective tissue and endocardium (the inner layer of the heart).
- There are four valves of the heart, which are divided into two categories:
- **Atrioventricular valves:** The tricuspid valve and mitral (bicuspid) valve.
- They are located between the atria and corresponding ventricle.
- **Semilunar valves:** The pulmonary valve and aortic valve.
- They are located between the ventricles and their corresponding artery, and regulate the flow of blood leaving the heart.
- Atrioventricular valves : The atrioventricular valves are located **between the atria and the ventricles**.
- They close during the ventricular contraction (systole) , producing the first heart sound. There are two AV valves.
- Right AV valve also known as tricuspid valve is located between the right atrium and the right ventricle.
- It consists of the three cusps; anterior , septal and posterior. The base of each cusp is strengthened by a fibrous ring that surrounds the orifice.
- Left AV valve also called as bicuspid or mitral valve because it has two cusps. The larger anterior /aortic cusp and a smaller posterior cusp.
- Structure : The AV valves are made up of two components i) a fibrous ring , ii) Cusps
- The fibrous rings surround the orifice . The cusps are formed by the fold of the endocardium enclosing some connective tissue within it.
- Each cusp has an attached and free margin with an atrial and ventricular surfaces.
- The atrial surface is smooth but ventricular surface is rough due to attachment of chordae tendinae.
- The mitral and tricuspid valves are supported by the attachment of fibrous cords (chordate tendinae) to the free edges of the valve cusps.
- The chordae tendinae are in turn attached to papillary muscles , located on the interior surface of the ventricles.
- These muscles contract during ventricular systole to prevent prolapsed of the valve leaflets in to the atria.
- There are five papillary muscles in total ; 3 in right AV valve (tricuspid) and 2 in left AV valve (bicuspid valve / mitral valve).

- Role of papillary muscles in acute cardiac failure : The papillary muscles prevent the the prolapsed of AV valves in to the atria during the ventricular systole. The rupture of theses muscles may lead to acute cardiac failure.
- **Semilunar Valves**
- The semilunar valves are located between the ventricles and outflow vessels.
- They close at the beginning of **ventricular relaxation** (diastole), producing the second heart sounds. There are two semilunar valves:
- These semilunar valves are tricuspid ;
- 1- **Pulmonary valve** – located between the right ventricle and the pulmonary trunk (pulmonary orifice). The valve consists of three cusps – left, right and anterior (named by their position in the foetus before the heart undergoes rotation).
- 2- **Aortic valve** – located between the left ventricle and the ascending aorta (aortic orifice). The aortic valve consists of three cusps – right, left and posterior.
- These valves do not have fibrous ring as present in tricuspid and bicuspid valves.
- The left and right aortic sinuses mark the origin of the left and right coronary arteries.
- As blood recoils during ventricular diastole, it fills the aortic sinuses and enters the coronary arteries to supply the myocardium.
- The pulmonary and aortic valves have a similar structure.
- The sides of each valve leaflet are attached to the walls of the outflow vessel, which is slightly dilated to form a **sinus**.
- The free superior edge of each leaflet is thickened (the **lunule**), and is widest in the midline (the **nodule**).
- At the beginning of ventricular diastole, blood flows back towards the heart, filling the sinuses and pushing the valve cusps together. This closes the valve.
- **SKELETON OF THE HEART**
- The cardiac skeleton or annulus fibrosus is not a bony structure, but a fibrous structural support for the heart chambers.
- It consists of 4 fibrous rings that surrounds the 1- Right atrioventricular orifice, 2- Left atrioventricular orifice, 3- Pulmonary orifice , 4- Aortic orifice.
- These rings provide a circular form and provide strength to the AV orifices and roots of the pulmonary trunk and aorta.
- Fibrous skeleton provides attachment to the valves and prevent dilatation of these orifices.
- This limits the risk of tears in the valvular cusps and prevents backflow of the blood into the chamber.
- **Anatomy of the fibrous skeleton :**
- The cardiac frame is composed of a dense connective tissue network that forms a fibrous skeleton.
- It reinforces the myocardial walls internally and anchors the cardiac muscle.
- The thickness of the collagen and elastin fibers of the anulus fibrosus varies from area to area and consists of 1- four rings, 2- two trigones and 3- one ligament.
- The exact position of this scaffolding can be clearly seen on the external side of the heart, where the great vessels exit and enter it, within the coronary sulcus.
- The left fibrous ring encircles the bicuspid valve and the right fibrous ring surrounds the tricuspid valve.
- The pulmonary ring encircle to the pulmonary valve and the aortic ring to the aortic valve.
- The right fibrous trigone runs around both the right fibrous ring and the aortic ring together.



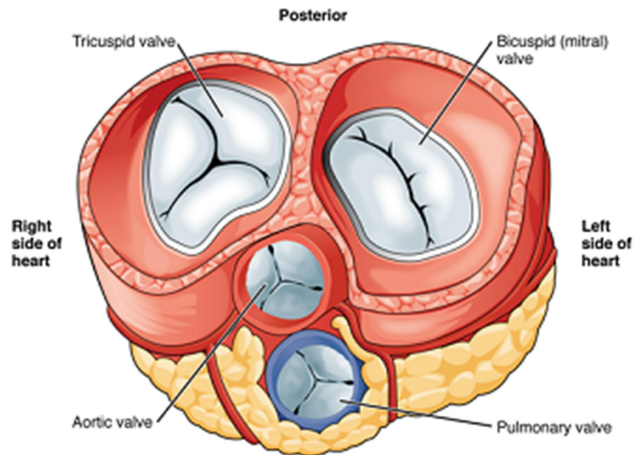
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- The left fibrous trigone runs around the left fibrous ring and the aortic ring.
- Lastly, a tendinous band known as the ligament makes up the posterior border of the conus arteriosus.
- **What is 'conus arteriosus' ?**
- It is also known as infundibulum. It is conical pouch formed from the upper and left angle of the right ventricle from where the pulmonary trunk arises. It develops from the bulbus cordis. Typically , the infundibulum refers to the corresponding internal structure whereas the conus arteriosus refers to the external structure. Defects in infundibulum development can result in heart condition known as ;tetralogy of Fallot'.
- **Functions of the cardiac skeletal system :**
- The skeleton of the heart allows cardiac muscle to contract against the rigid base.
- The fibrous rings support the bases of the cusps of the valves to prevent the valves from stretching and becoming impaired.
- The aortic ring is the strongest

FLOW CHART- ANATOMY OF HEART –SHEET-80

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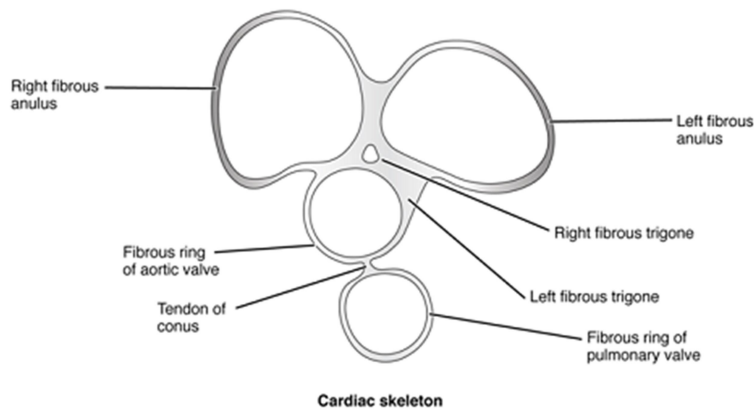
PART-4

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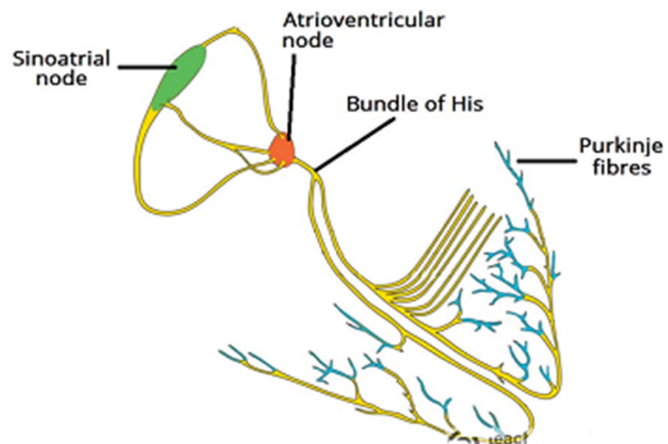
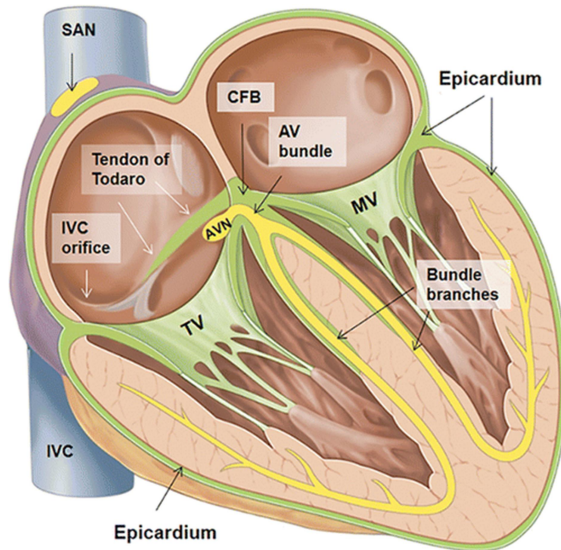
FLOW CHART- ANATOMY OF HEART –SHEET-81

Dr. Sanjiv Saxena Dept Of Rachana Sharir GAC Handia Prayagraj

PART-5

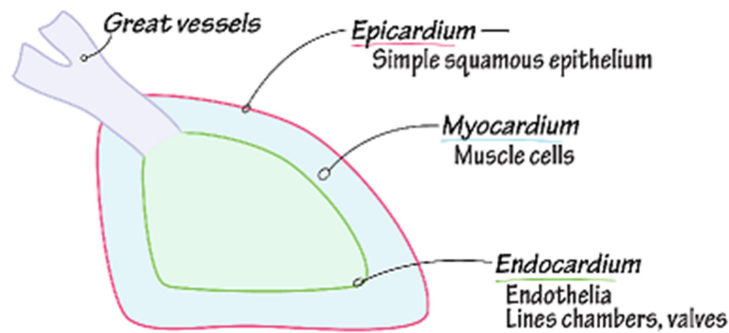
TOPIC – CONDUCTION SYSTEM OF THE HEART:

- The conducting system of the heart consists of **cardiac muscle cells and conducting fibers** (not nervous tissue) that are specialized for initiating impulses and conducting them rapidly through the heart .
- The conducting system provides the heart its automatic rhythmic beat.



- The **cardiac conduction system** is a collection of nodes and specialised conduction cells that initiate and co-ordinate contraction of the heart muscle.
- The conduction system of the heart is made up of the specialized cardiac muscle fibres (not the nervous tissue) and is responsible for the initiation and conduction of cardiac impulse.
- It consists of 5 components:
 - **1-Sinoatrial node (SA Node)**
 - **2-Atrioventricular node (AV Node)**
 - **3-Atrioventricular bundle (bundle of His)**
 - **4-Right and left branches of the bundle of His**
 - **5-Purkinje fibres**
- The sequence of electrical events during one full contraction of the heart muscle.
- An excitation signal (an action potential) is created by the sinoatrial (SA) node.
- The wave of excitation spreads across the atria , causing them to contract.
- Upon reaching the atrioventricular (AV) node , the signal is delayed.
- It is then conducted into Bundle of His, down the interventricular septum.
- The bundle of His and Purkinje fibres spread the wave impulses along the ventricles , causing them to contract.
- Components of the Cardiac Conduction System
- Sinoatrial Node:
 - 1-The **sinoatrial (SA) node** is a collection of specialized myocardial cells (pacemaker cells),horse shoe shaped mass.
 - It is located in the upper wall of the right atrium, at the junction where the superior vena cava enters.
 - It is also called 'Node of the Keith Flack' .

- These pacemaker cells can spontaneously generate **electrical impulses about 70/min** and produces heart beat.
- The wave of excitation created by the SA node spreads via gap junctions across both atria, resulting in atrial contraction (atrial systole).
- The rate at which the SA node generates impulses is influenced by the autonomic nervous system:
- **Sympathetic nervous system** – increases generation rate of the SA node, and thus increases heart rate.
- **Parasympathetic nervous system** – decreases generation rate of the SA node, and thus decreases heart rate.
- **2-Atrioventricular Node:**
- After the electrical impulses spread across the atria, they converge at the **atrioventricular node** .
- It is located within the atrioventricular septum, near the opening of the coronary sinus.
- It is also called Node of Tawara and is smaller than the SA node.
- The AV node is capable of generating impulses at the rate of the 60/ minute.
- The AV node acts to delay the impulses to ensure the atria have enough time to fully eject blood into the ventricles before ventricular systole.
- The wave of excitation then passes from the atrioventricular node into the atrioventricular bundle.
- Atrioventricular Bundle (Bundle Of His)
- **3- Atrioventricular bundle** (bundle of His) is a continuation of the specialised tissue of the AV node.
- It serves to transmit the electrical impulse from the AV node to the Purkinje fibres of the ventricles.
- **4-Right and left branches of the bundle of His.**
- The electrical impulse from the AV node descends down in to the interventricular septum, before dividing in to two main bundles.
- **Right bundle branch** – conducts the impulse to the Purkinje fibres of the right ventricle.
- **Left bundle branch** – conducts the impulse to the Purkinje fibres of the left ventricle.
- The right branch passes down the right side of the internventricular septum and then becomes subendocardial on the right side of the septum.
- A large part of it continues in the septomarginal trabeculum (moderator band) to reach the anterior papillary muscle and anterior wall of the ventricle.
- Purkinje Fibres :
- They are the terminal branches of the right and left branches of the Bundle of His .
- **5-Purkinje fibres** (sub-endocardial plexus of conduction cells) are a network of specialised cells. They are abundant with glycogen and have extensive gap junctions.
- These cells are located in the **subendocardial surface** of the ventricular walls, and are able to rapidly transmit cardiac action potentials from the atrioventricular bundle to the myocardium of the ventricles.
- This rapid conduction allows **coordinated ventricular contraction** (ventricular systole) and blood is moved from the right and left ventricles to the pulmonary artery and aorta respectively.
- Arterial supply of the Conducting System :
- The whole of the conducting system of the heart is supplied by the right coronary artery except a part of the left branch of the AV bundle that is supplied by the left coronary artery.
- **HISTOLOGY OF HEART WALL:**



- The heart wall itself can be divided into three distinct layers: the **endocardium**, **myocardium**, and **epicardium**. **Endocardium:**
- **Endocardium** : The innermost layer of the cardiac wall is known as the endocardium.
- It lines the **cavities** and **valves** of the heart. Structurally, the endocardium is comprised of loose connective tissue and simple squamous epithelial tissue .
- it is similar in its composition to the endothelium which lines the inside of blood vessels.
- The endocardium also regulates contraction of heart chambers.
- **Subendothelial layer** : Subendothelial layer lies between the endocardium and myocardium .
- It joins both layers. It consists of Layer of loose fibrous tissue , containing the vessels and nerves of the conducting system of the heart.
- The Purkinje fibres are located in this layer. As the subendocardial layer contains the conducting system of the heart, damage to this layer may lead to arrhythmias.
- **Myocardium:** The myocardium is composed of cardiac muscle and is an involuntary striated muscle.
- The myocardium is responsible for contractions of the heart.
- **Epicardium** : The epicardium is the outermost layer of the heart, formed by the visceral layer of the pericardium. It is composed of connective tissue and fat.
- The connective tissue secretes a small amount of lubricating fluid into the **pericardial cavity**.
- The epicardium is lined by on its outer surface by simple squamous **epithelial** cells.

