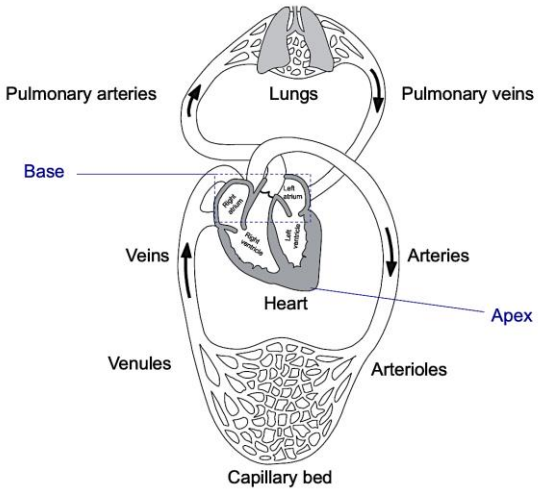
VISCERA AND VISCERAL SYSTEMS

SEMESTER TWO

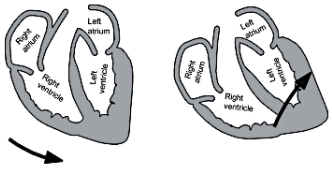
L5: Heart and Pericardium

Circulatory System Overview

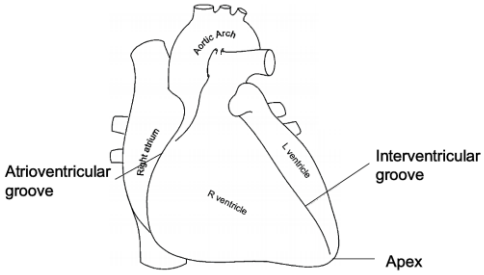


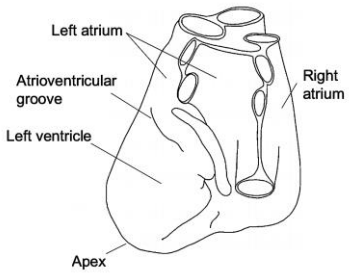
- Heart is organised in a particular way to supply blood to the body/lungs and back.
    - It has **4 chambers** with different functions.
        - Atria receives blood.
        - Ventricles push blood out.
    - It has **2 sides** (left/right) with **2 chambers** (atria/ventricles) each.
        - Right side receive deoxygenated blood from the body and pushes it out to the lungs → For oxygenation of blood.
        - Left side receive oxygenated blood from the lungs and pushes it out to the body.

Orientation of the Heart



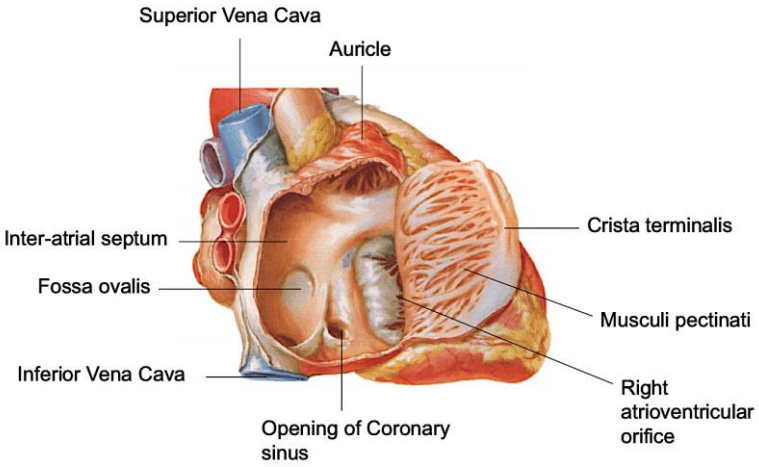
- Heart goes through a process of really complex rotations during development to assume its position in the Mediastinum (central core of thorax):
    - Apex of heart points to the left side of thorax → Right side of the heart rotates upwards, so that it sits anteriorly.

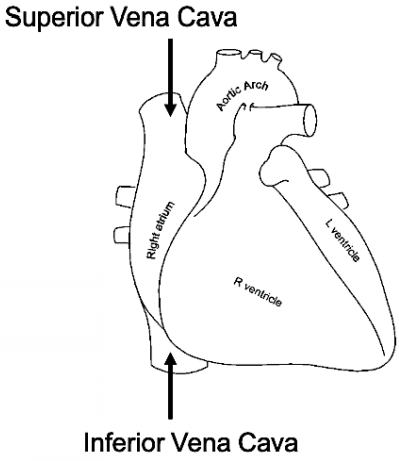




    - **Left Image**: Anterior view of the heart.
        - Apex points to the right; Majority of the view is obscured by the right side of the heart:
        - Atrioventricular Groove: Between right atrium and right ventricle.
        - Interventricular Groove: Between right and left ventricles.
    - **Right Image**: Posterior view of the heart.
        - Apex points to the left; Majority of the view is obscured by the left side of the heart.
        - Atrioventricular Groove: Between left atrium and left ventricle.

Right Atrium





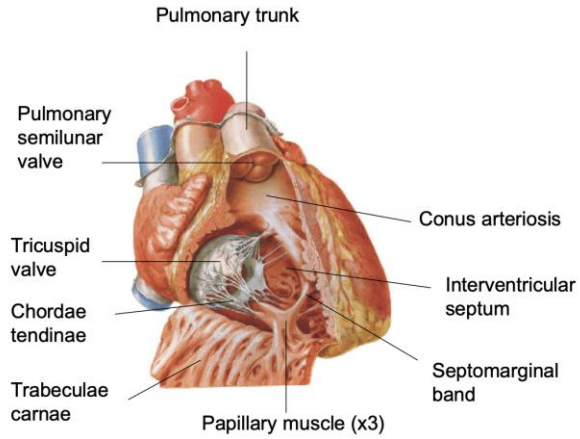
- Right Atrium receives blood from the body (mostly deoxygenated blood) via **2 main collecting vessels** that empty into right atrium:
    - Superior Vena Cava (SVC): Drains blood from head, upper limb and thorax.
    - Inferior Vena Cava (IVC): Drains blood from below the level of diaphragm.

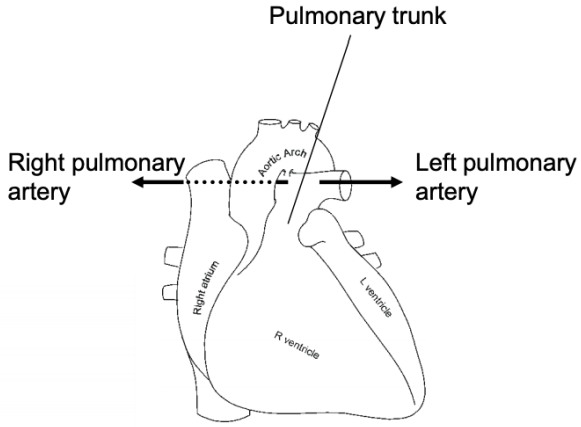
- **Medial Surface** of the right atrium is smooth and is part of the Interatrial Septum (separates the two atria):
    - Contains the Right Atrioventricular Orifice:
        - Allows passage of venous return from SVC/IVC to the right ventricle.
        - Guarded by an atrioventricular valve called Tricuspid Valve.
    - Contains the Opening of Coronary Sinus:
        - Sits just in between the opening of IVC and the right atrioventricular orifice.
        - Returns all blood from coronary circulation.
    - Contains the Fossa Ovalis:
        - Small depression in the interatrial septum that formed from the closure of Foramen Ovale:
            - An opening that develops during foetal development → Allows passage of blood from right atrium to left atrium.
            - Blood that enters the right atrium during development is oxygenated (because foetus is receiving maternal blood circulation).
            - So, blood doesn't need to be oxygenated → Bypass the right ventricle and the pulmonary circulation by going through the foramen ovale.
        - At birth, foramen ovale closes and becomes fossa ovalis.

- **Anterior Surface** (from inside) has rough muscular ridges called Musculi Pectinati.
    - Crista Terminalis is another ridge of muscle that runs vertically down the plane of SVC and IVC (I.e. the plane at which the cut was made).
        - It separates the rough wall part from the smooth wall part of right atrium.
        - Most superior point (looks swollen) is the location of Sinoatrial Node → Conduction system of the heart.
    - On the outer surface of right atrium, there might be a little groove/depression at the location of crista terminalis, and this is referred to as the Sulcus Terminalis:
        - Can be used to locate the SA node.

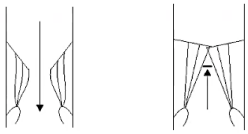
- There is a superior projection of the right atrium called Auricle:
    - Internal surface is rough walled.
    - Projects over the root of great vessels.

Right Ventricle



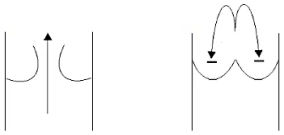


- **Anterior Surface** (from inside) has rough muscular ridges called Trabeculae Carnae:
    - Trabeculae carnae is more obvious than musculi pectinati because the right ventricle does more work → Thick walled.
        - Right ventricle must pump blood into pulmonary circulation → Require stronger muscle.
        - It's essentially the same thing as musculi pectinati but with different names.
    - Few of these ridges may be more obvious and developed → Present as **3** Papillary Muscles:
        - Connected to Chordae Tendinae and helps to anchor the tricuspid valve.
        - Anterior Papillary Muscle is most obvious and developed → It has a thick muscular band called Septomarginal Band → connects the anterior surface to the medial surface of heart.
            - Heart's conduction system travels through this band to get to the papillary muscle.



- As blood is pushed from right atrium to right ventricle, it pushes through the Tricuspid Valve (**3 cusps**):
    - **However**, when the ventricle contracts, blood pushes the tricuspid valve upwards; and has the potential for reflux (I.e. flow back into right atrium):
        - To prevent reflux of blood, papillary muscles, which are connected to the tricuspid valve via chordae tendinae, contracts to make chordae tendinae taut → Locks the tricuspid valve in the plane where they are shut (as seen above).

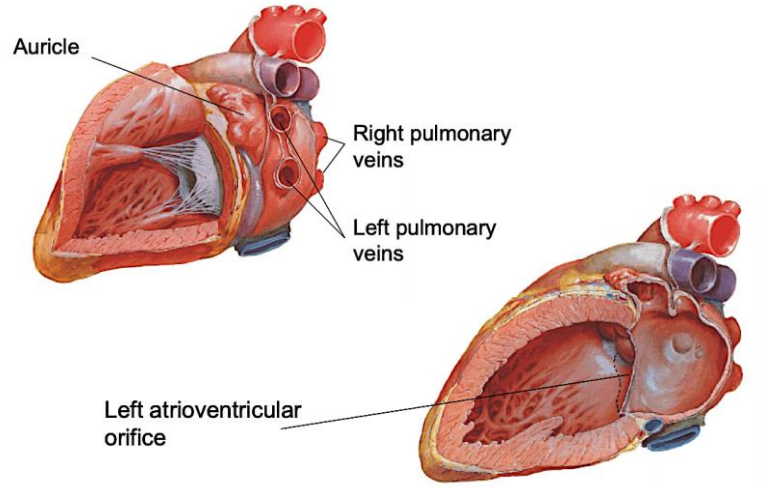
- Mechanism above enables unidirectional flow of blood into the Pulmonary Trunk, which later bifurcates into Left/Right Pulmonary Arteries → Take blood into lungs for oxygenation.

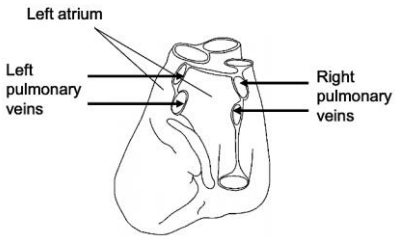


    - Pulmonary Semilunar Valve guards the bottom of the pulmonary trunk → Important in preventing back flow of blood back into right ventricles.
        - During ventricular systole (I.e. contraction of ventricle), blood moves into pulmonary trunk.
        - During ventricular diastole (I.e. relaxation of ventricles), blood in pulmonary trunk will want to fall back down due to gravity.
        - **However**, blood falling back down fills up the cusps of the valve and pushes them closed.
            - This is more of a passive mechanism compared to the mechanism that locks the tricuspid valve closed.
    - Smooth part of the right ventricle leading to the pulmonary trunk is referred to as Conus Arteriosis.

- **Medial Surface** of the right ventricle is part of the Interventricular Septum (separates the two ventricles).

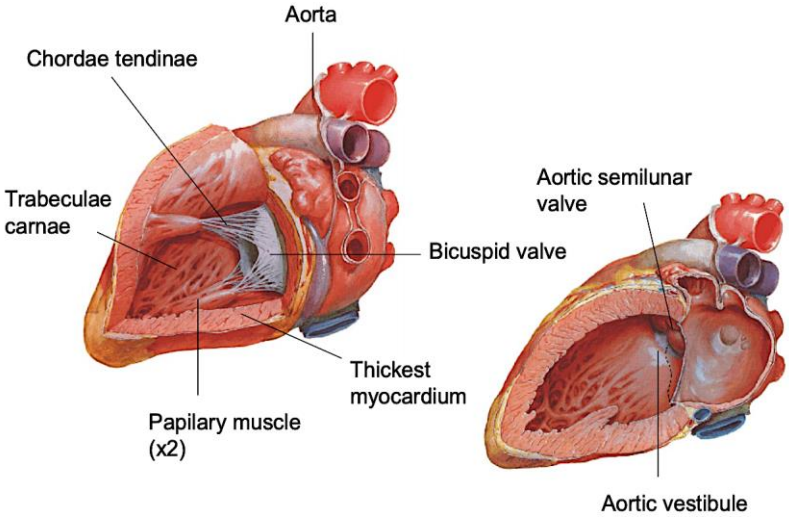
Left Atrium

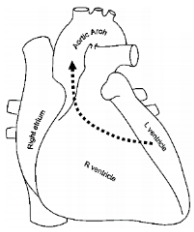




- Features of left atrium coincides with the features of right atrium; but:
    - Left atrium receives **4** Pulmonary Veins from the lung:
        - **2** x Left Pulmonary Veins.
        - **2** x Right pulmonary Veins.
    - Left Atrioventricular Orifice exists between the left atrium and ventricles.
    - Depression of Fossa Ovalis can be seen on the medial surface of left atrium.
    - Left atrium also has an Auricle that projects anteriorly and over the roots of great vessels.

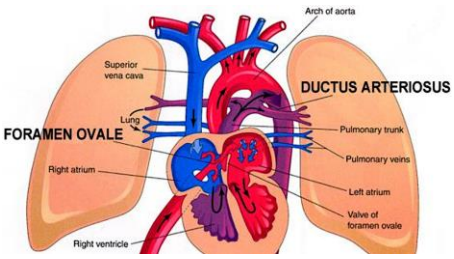
Left Ventricle





- Left Ventricle is the **thickest** walled chamber of the whole heart → Because it must pump blood out through the aorta and through whole systemic circulation (and get it through the capillary beds).
    - Left atrioventricular orifice is guarded by another atrioventricular valve called Bicuspid Valve (or Mitral Valve) → Connected to trabeculae carnae via chordae tendinae and **2** papillary muscles.
        - Same mechanism helps to lock the bicuspid valve at the plane where it's shut → Prevent reflux of blood.
- When the left ventricle contracts, blood is forced through the Aortic Semilunar Valve:
    - To prevent backflow of blood into left ventricles, aortic semilunar valve utilises the same mechanism as the pulmonary semilunar valve.
    - Smooth part of the left ventricle leading to the aorta is referred to as Aortic Vestibule.
        - Located just inferiorly to the aortic semilunar valve.

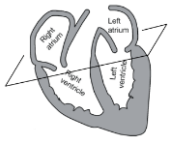
Foetal Heart and Circulation



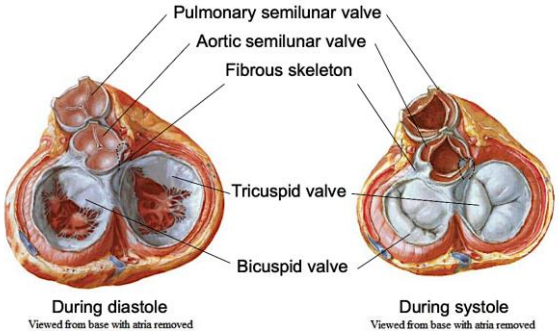
- Before birth (I.e. In utero), our lungs have no oxygen in them and so, we don't need to invest in getting all of our blood from our heart to the lungs and back → There are **2 bypasses** that enables the blood to bypass the pulmonary circulation:
    - Foramen Ovale: Opening in the interatrial septum.
        - **Oxygenated Blood** (from maternal circulation via umbilicus) returning to the right atrium via IVC has the tendency to move into the interatrial septum.
            - Foramen ovale allows flow of blood from IVC to enter the left atrium.
            - Blood entering the left atrium moves into the left ventricles, and contraction of left ventricle forces the blood into the aorta → Systemic circulation.
        - Remains in adult as Fossa Ovalis.
    - Ductus Arteriosis: Communication between top of the pulmonary trunk and bottom of aortic arch.
        - **Deoxygenated blood** returning to right atrium via **SVC** has the tendency to move into the right ventricle via the atrioventricular orifice.
        - Contraction of right ventricle forces the blood into the pulmonary trunk:
            - As there is no need for the blood to get to the lungs, the blood entering the pulmonary trunk is shunted into the aorta via the ductus arteriosis.
            - **Note**: Flow of blood through the aorta tend to suck blood up from the pulmonary trunk through the ductus arteriosis and into systemic circulation → Avoid movement of blood through the pulmonary arteries and into the lungs.
        - Remains in adult as Ligamentum Arteriosum.
    - Thus, via these 2 mechanisms, we get oxygenated blood from the maternal circulation, and deoxygenated blood from the foetus, all mixing in the heart, and ultimately bypassing the pulmonary circulation to enter systemic circulation → This only works because a large part of returning blood is oxygenated from maternal circulation.

- At birth, when 'first' breath happens, there's a large pressure gradient that allows air to rush into the lungs of the baby → Expansion of the lungs → Release of different hormones:
    - Hormones act on the smooth muscles around the ductus arteriosus and it snaps shut.
        - Blood is now forced to enter pulmonary circulation and return back to the heart.
    - Blood returning to left atrium from the lungs pushes the flap of foramen ovale and seals it shut.
        - Now, there is uni-directional flow of blood in the heart.

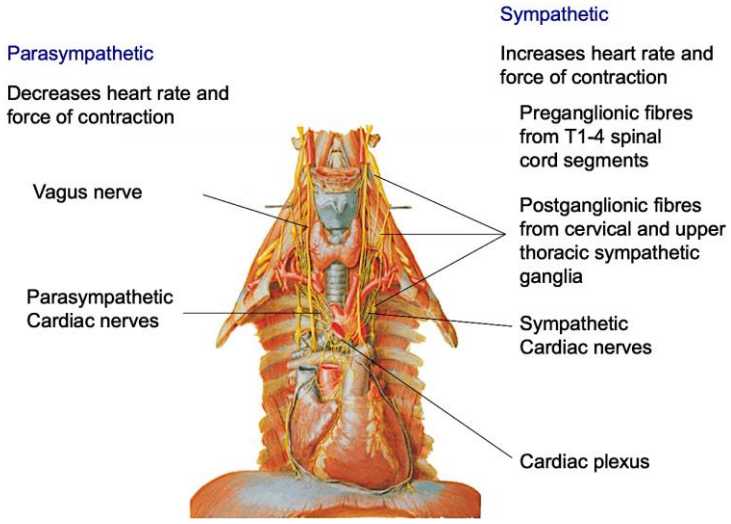
Fibrous Skeleton and Valves of Heart



- Fibrous Skeleton of heart is a bit of connective tissue that sits in the atrioventricular plane:
    - Connective tissues that wraps around each of the valves, which sits in the same plane.
- It forms anchoring points for cardiac muscle:
    - Ventricular cardiac muscle attaches to the fibrous skeleton from below.
    - Atrial cardiac muscle attaches to the top of fibrous skeleton.
    - So, fibrous skeleton isolates the muscle compartments of atria from the ventricles (also electrically isolates them).

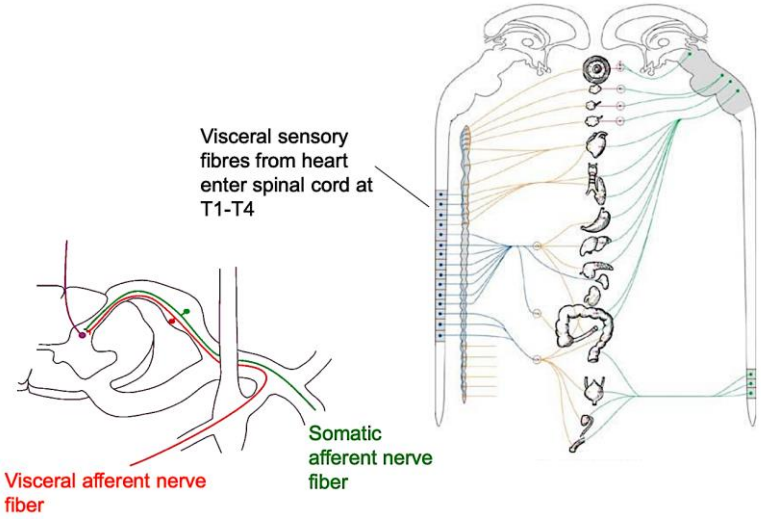


Nerve Supply to Heart



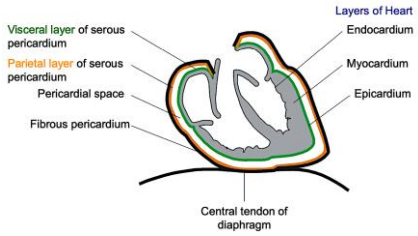
- Heart itself contains a conduction system that controls the pace of cardiac muscle beatings; but there is also autonomic nerve supply feeding into this conduction system:
    - **Sympathetic**:
        - **Origin**: Pre-ganglionic fibres from **T1-4** spinal cord segments synapse onto post-ganglionic fibres from cervical and upper thoracic sympathetic ganglia.
            - Post-ganglionic fibres travel towards the heart through Cardiac Plexus and innervates the pacemaker cells of the heart.
        - **Function**: Increases heart rate and force of contraction – I.e. 'mobilising' body energies.
    - **Parasympathetic**:
        - **Origin**: Pre-ganglionic fibres from the brainstem travels through the vagus nerve.
            - Vagus nerve gives rise to many parasympathetic cardiac nerves that travels towards the heart through cardiac plexus.
        - **Function**: Decreases heart rate and force of contraction – I.e. 'conserving' body energies.

Pain Referred from Heart



- Visceral sensory fibres from heart follows the path of sympathetic nerve supplies and enter the spinal cord at **T1-T4**.
    - Pain is referred to the T1-T4 dermatomes → Thoracic wall and proximal part of upper limbs.

Pericardium and the Layers of Heart

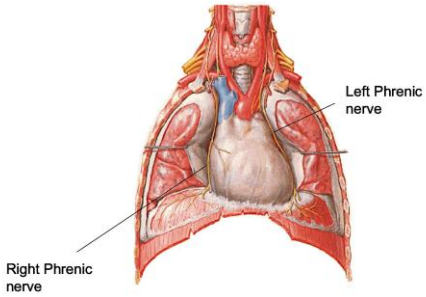


- Double layered serous membrane around the heart is called Serous Pericardium:
    - Visceral Layer lines the heart.
    - Parietal Layer is fused to and inseparable from the inner surface of Fibrous Pericardium.
        - Fibrous pericardium is a thicker connective tissue sheathe along the outside of the heart.
            - It is part of the pericardium as a whole, but not part of the serous pericardium.
            - It's attached to the central tendon of the diaphragm → Anchors the heart in place.
    - Pericardial Cavity contains serous fluid:
        - Lubricates to provide frictionless environment for the beating of heart.

- Heart can be divided into a number of layers:
    - **Inner Layer**: Endocardium.
    - **Middle Layer**: Myocardium (muscular layer).
    - **Outer Layer**: Epicardium → Actually the same thing as the visceral layer of serous pericardium.
        - Depends on whether you are talking about the pericardium or the heart itself.

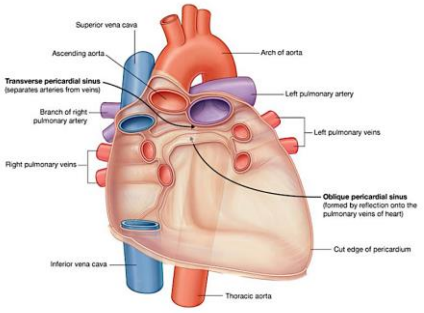
Innervation of Pericardium

- Right/Left Phrenic n. supplies sensory innervation to the fibrous pericardium and the parietal layer of serous pericardium:
    - Any irritation of fibrous pericardium or the parietal layer of serous pericardium will be referred through the phrenic nerve to C3-5 dermatomes → Pain around neck.



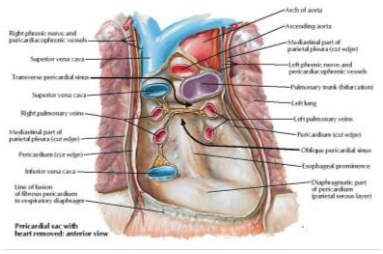
- Visceral layer of serous pericardium is innervated by the viscerosensory nerves of the heart → Follows the sympathetic pathways back through the spinal cord segments T1-4 → Pain around thorax and upper limbs.

Pericardial Sinuses



- Pericardial Sinuses are spaces formed by the extensions of the pericardial cavity into and around different great vessels:
- There are **2 pericardial sinuses**:
    - Oblique Sinus: Formed by visceral layer reflecting off the pulmonary veins and continuing as parietal layer.
    - Transverse Sinus: Sits just behind the pulmonary trunk and aorta.

- In supine position, oblique sinus is the lowest point of pericardial cavity → Any fluid or effusion in the pericardial cavity will accumulate and causes problems:
    - Affects the movement of left ventricle and atrium if there's too much fluid; it may even compress the pulmonary veins → Backpressure on pulmonary circulation.
    - I.e. Atrium/ventricle don't receive as much blood or push as much blood out.



- Transverse sinus enables you to surgically ligate the aorta and pulmonary trunk during a cardiac surgery.