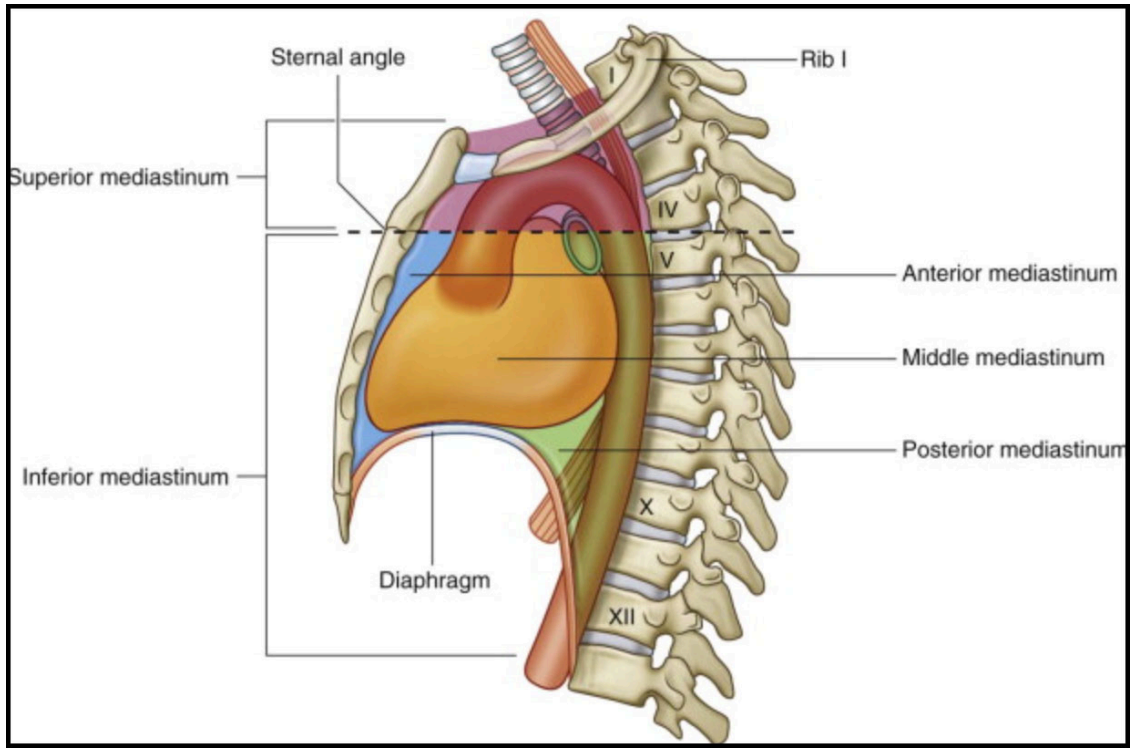
PowerPoint Handout: Lab 2, Thorax

Regions of the Mediastinum

The **transverse thoracic plane** passing through the **sternal angle** (commonly intersecting the T4/T5 intervertebral disc) divides the mediastinum into two subdivisions.

- The **superior mediastinum** spans the space between superior thoracic aperture and transverse thoracic plane.
- The **inferior mediastinum** spans the space between the transverse thoracic plane and the diaphragm. It can be further divided into the following regions.
  - The **anterior mediastinum** is the smallest subdivision of the mediastinum.
  - The **middle mediastinum** is the largest subdivision of the mediastinum. The major structure within the middle mediastinum is the heart in its pericardial sac.
  - The **posterior mediastinum** is located posterior to the pericardium.



Structures Within Each region of the Mediastinum

Superior Mediastinum

- Aortic arch and its branches
- Superior 1/2 of vena cava
- Brachiocephalic veins
- Trachea
- Esophagus
- Phrenic nerves
- Vagus nerves
- Superior part thymus (atrophied in adults)

Inferior Mediastinum

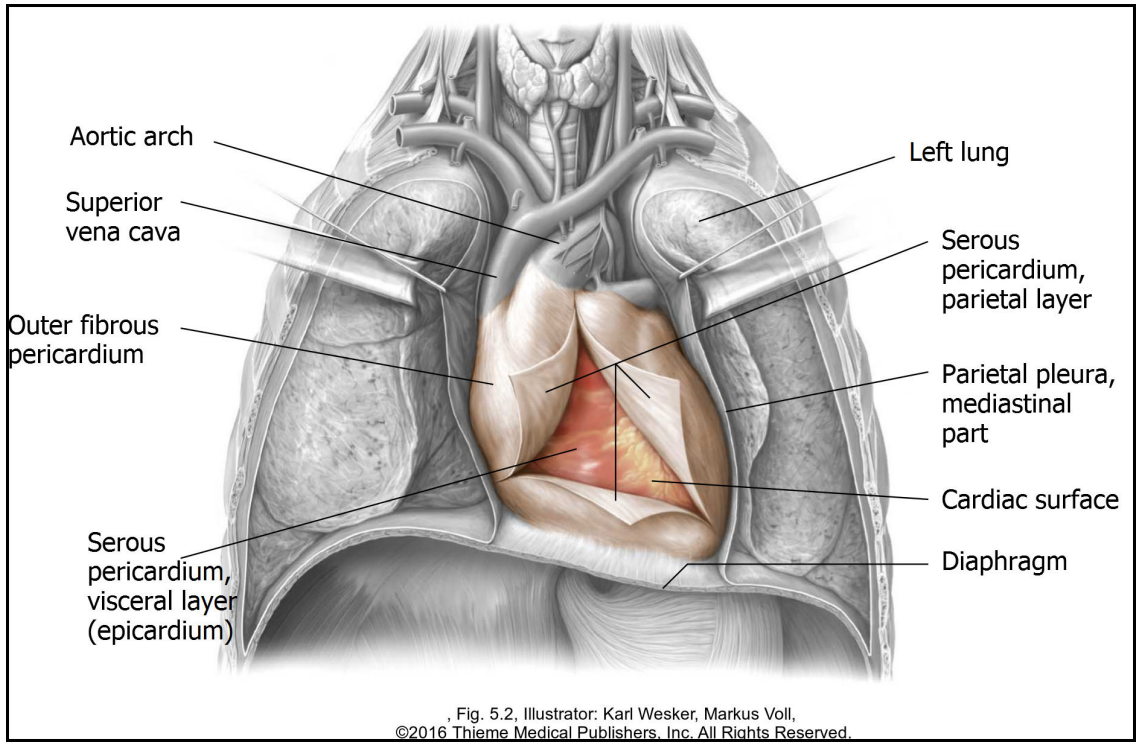
Anterior	Middle	Posterior
• Inferior part of thymus (atrophied in adults)	• Heart • Pericardium • Inferior 1/2 of SVC • Ascending aorta • Pulmonary trunk • Right and left main bronchi • Pulmonary arteries • Pulmonary veins • Phrenic nerves • Lymphatic structures	• Thoracic aorta • Thoracic duct • Azygos system of veins • Sympathetic trunks • Esophagus • Thoracic splanchnic nerves (greater, lesser, least)

Pericardium/Pericardial Sac

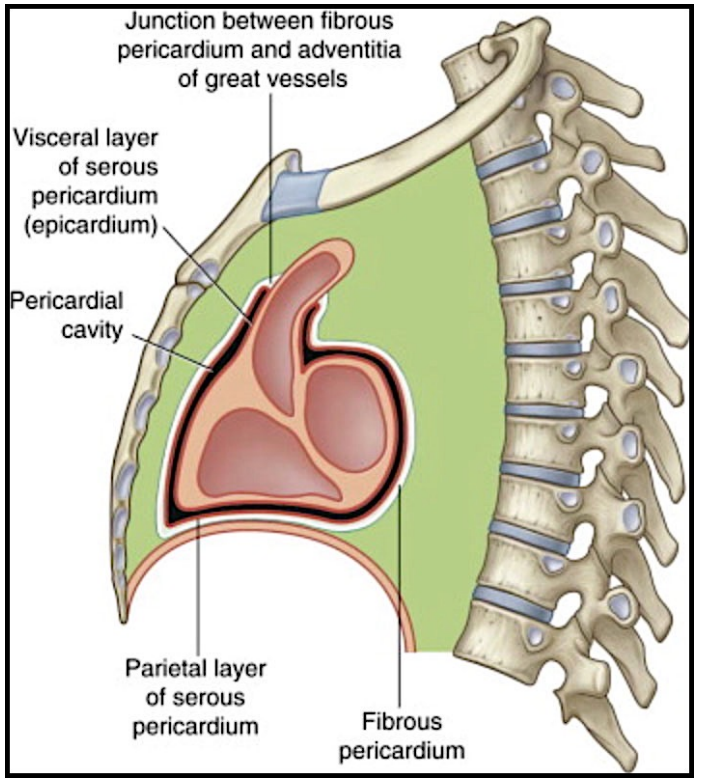
The **pericardium**, also called the **pericardial sac**, is a two-layered sac that encloses the heart and the roots of the great vessels.

- Fibrous pericardium: The **fibrous pericardium**, consisting of dense fibrous connective tissue, forms the tough outer layer of the pericardial sac. Its dense tissue is continuous with the central tendon of the diaphragm and the outer connective tissue (tunica adventitia) covering of the great vessels. In addition to an attachment to the posterior sternum, these connection sites anchor the heart within the mediastinum. The inflexibility of the fibrous pericardium functions to prevent sudden overfilling of the heart with blood, however, the fibrous pericardium is capable of remodeling *slowly* over time to accommodate increases in heart size.
- Serous pericardium is a continuous layers that lines the inner surface of the fibrous pericardium and the heart's outer surface. However, it is divided into two regions based upon the structures it covers.
    - **Parietal Layer**: The region of serosa covering the inner surface of the fibrous pericardium is called the **parietal (layer of serous) pericardium**.
    - **Visceral Layer**: The region of serosa covering the heart is called the **visceral (layer of serous) pericardium**. The name change occurs when the serosa transitions from lining the fibrous pericardium to lining the heart/great vessels. Because the visceral pericardium is the outer layer of the heart wall, it is also called **epicardium**. The visceral pericardium is not easy to separate from the heart muscle (myocardium).

The space between the visceral and parietal pericardial layers is called the **pericardial cavity**. This space contains a small amount of serous fluid, which is produced by both serous layers. The smooth surfaces of the layers and the serous fluid allow the layers to easily glide against each other during heart contraction and relaxation.

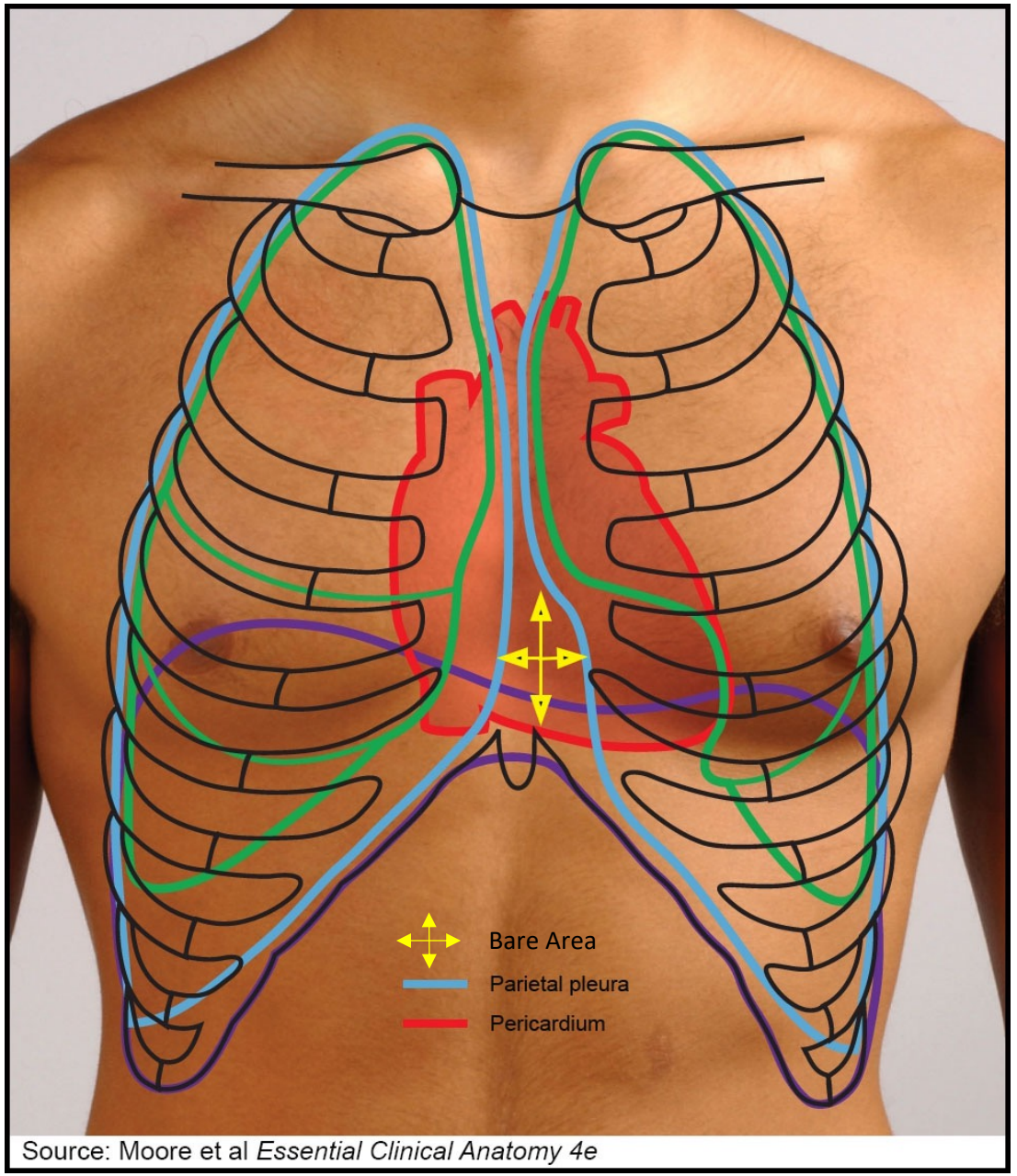


, Fig. 5.2, Illustrator: Karl Wesker, Markus Voll,



Pericardium: Bare Area

The **bare area of the pericardium** is an accessible location where the lungs/parietal pleura don't overlap the heart mainly due to the parietal pleura following the curve of left lung's cardiac notch. The exact location of the bare area of the pericardium is posterior to the sternum and slightly left of the sternal border between the levels of the 4th and 6th ribs.



Source: Moore et al *Essential Clinical Anatomy 4e*

Cardiac Tamponade

CLNICAL ANATOMY: **Cardiac tamponade** (heart compression) is a potentially lethal condition caused by pathological accumulation of fluid in the pericardial cavity (Figures 1 and 2). Conventional radiography may reveal a "water bottle" heart (Figure 1: AP CXR), in which the cardiac silhouette is enlarged symmetrically; primary DDW is cardiomegaly. Echocardiogram is the study of choice (Figure 2). Rapid accumulations of as little as 150mL of fluid (normally, the pericardium contains 20-50 mL of serous fluid) can result in significant increase in pericardial pressure and lead to low cardiac output. A marked reduction in diastolic filling results when transmural distending pressures (i.e., forces extending across the entire thickness of the wall of an organ – in this case, the heart) become insufficient to overcome the increased pressure of excess fluid in the pericardial cavity. Tachycardia is the initial cardiac response to these changes to maintain the cardiac output. Because the heart is compressed throughout the cardiac cycle due to the increased intrapericardial pressure, systemic venous return is impaired and right atrial and right ventricular collapse occurs. This results in reduced cardiac output and venous return.
(Source: http://emedicine.medscape.com/article/152083).

Pericardiocentesis is the aspiration of fluid from the pericardial cavity. This procedure can be life saving in patients with cardiac tamponade (Figure 3).

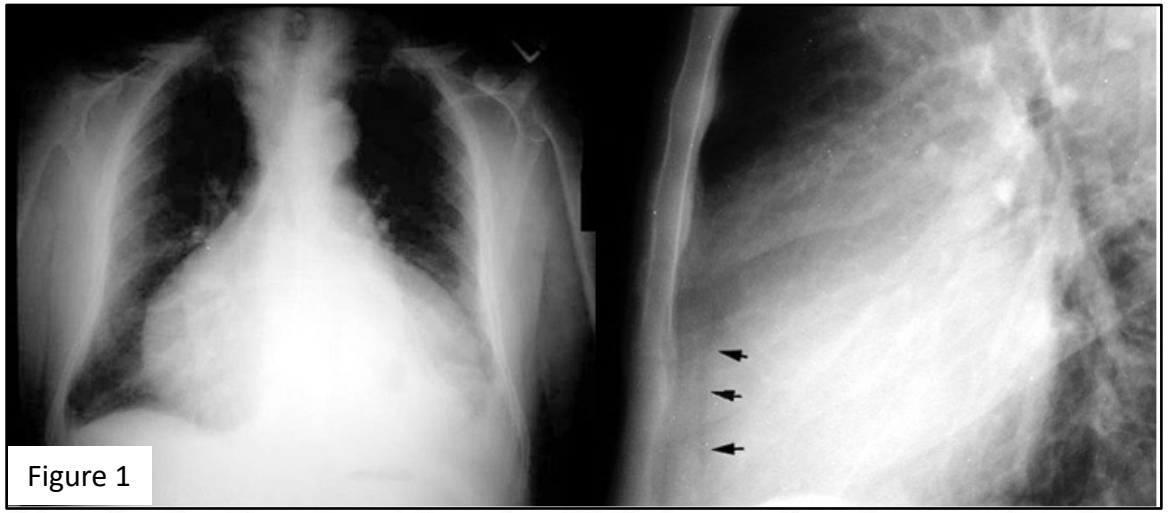


Figure 1

Enlarged cardiac silhouette could be pericardial effusion or cardiac enlargement. Lateral chest radiograph shows dorsally displaced epicardial fat pad (arrows), which indicates that the cardiac silhouette is due to pericardial effusion.

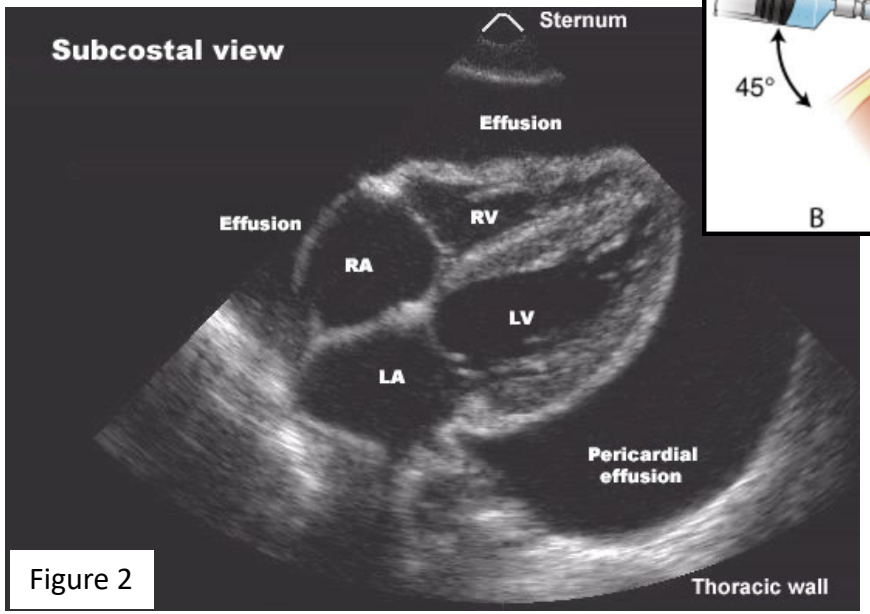
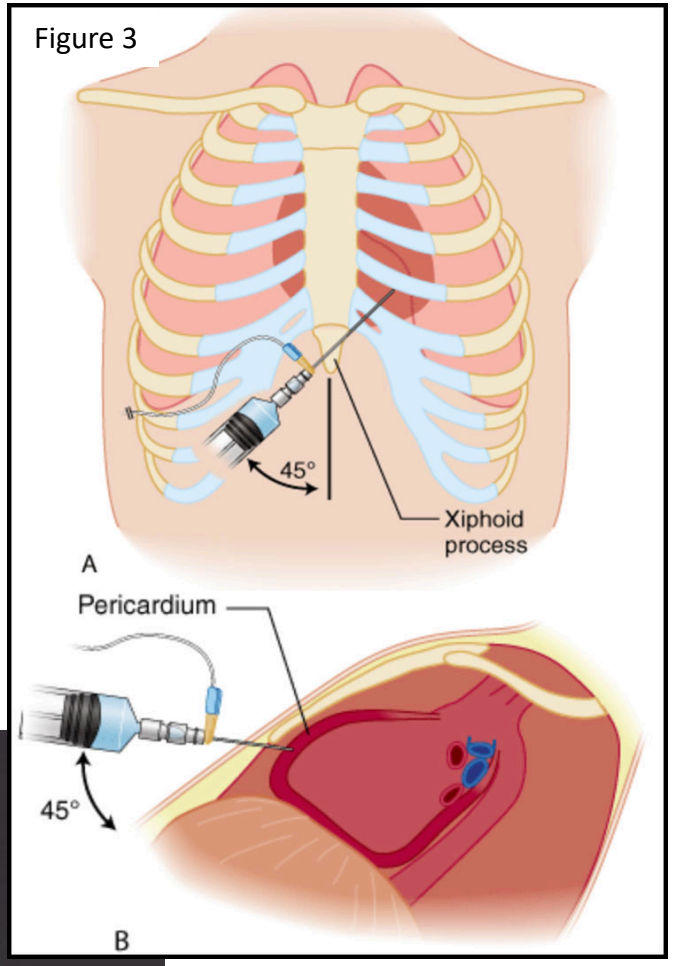


Figure 2

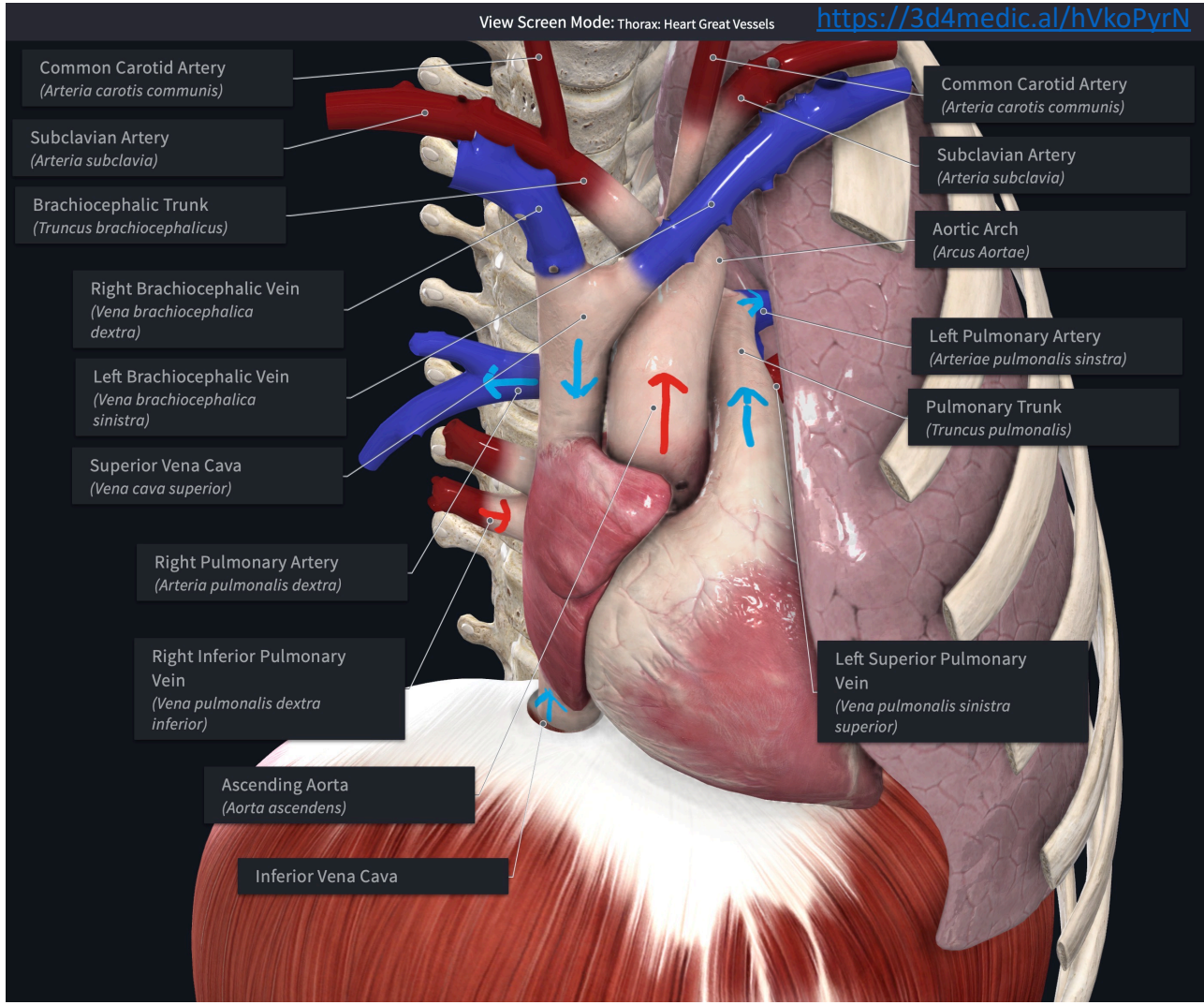
Figure 3



Heart Great Vessels

The heart's great vessels are conduits through which blood travels to enter and exit the heart during the cardiac cycle.

- The **aorta** transports oxygenated blood away from the heart's left ventricle into the systemic circulation. In the thorax the aorta can be divided into three parts. Each part is listed below along with its branches.
  - **Ascending aorta**: The **coronary arteries** are the first branches of the aorta.
  - **Aortic arch**:
    - **Brachiocephalic trunk** (branches into right subclavian artery and right common carotid artery)
    - **Left common carotid artery**
    - **Left subclavian artery**
  - **Descending (thoracic) aorta**: The descending aorta courses through the thorax and pierces the diaphragm to become abdominal aorta. Its branches supply the bronchi, esophagus, mediastinum, diaphragm, and pericardium.



- The **pulmonary trunk** transports deoxygenated blood away from the heart's right ventricle into the pulmonary circulation. It bifurcates to form the pulmonary arteries.
  - **Left pulmonary artery**
  - **Right pulmonary artery**

- The four pulmonary veins transport oxygenated blood into the heart's left atrium from the pulmonary circulation.
  - **Right superior pulmonary vein**
  - **Right Inferior pulmonary vein**
  - **Left superior pulmonary vein**
  - **Left inferior pulmonary vein**

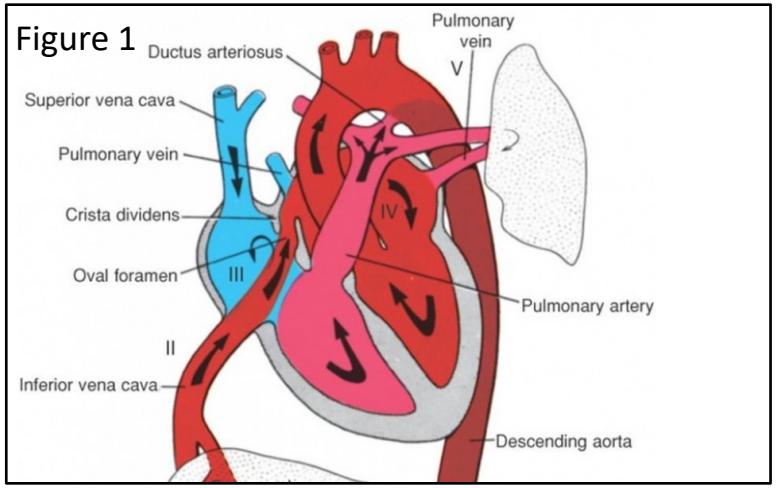
- The **superior vena cava and inferior vena cava** transport deoxygenated blood into the heart's right atrium from the systemic circulation.

Ligamentum Arteriosum & Recurrent Laryngeal Nerves

The **ligamentum arteriosum**, which connects the aortic arch to the proximal end of the left pulmonary artery, is a remnant of the fetal **ductus arteriosus** (Figure 1).

- The ductus arteriosus provides a pathway for blood exiting the right ventricle to bypass the pulmonary circulation and instead enter the systemic circulation.
- In the fetal heart, bypassing the pulmonary circulation with the majority of blood from the right ventricle is necessary because the lungs are fluid-filled and nonfunctional.
- During the initial inflation of the lungs after birth, bradykinin is released from lung tissue resulting in vasoconstriction of the ductus arterious. Complete anatomical obliteration of the lumen of the ductus by proliferation of the intima is thought to take 1-3 months. In the adult, the obliterated ductus arteriosis forms the **ligamentum arteriosum**.

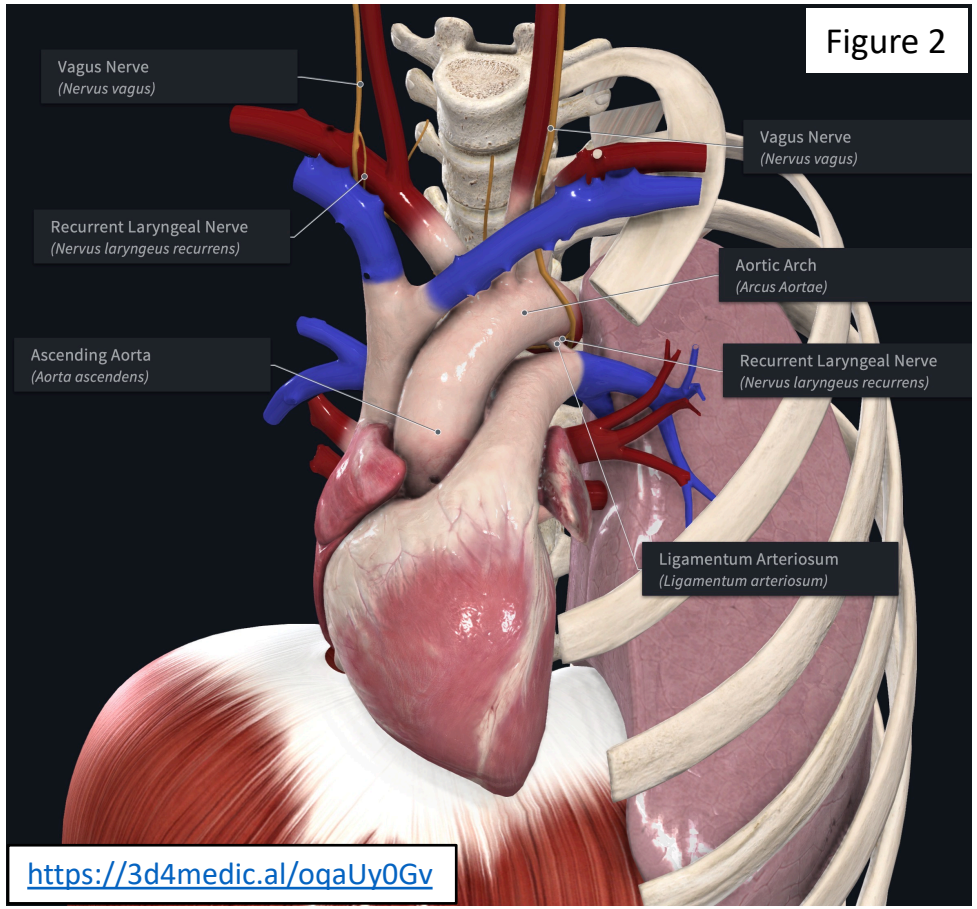
Figure 1



CLINICAL ANATOMY: One of the more common vascular anomalies is failure of the ductus arteriosus to close after birth. This malformation (**patent ductus arteriosis**) occurs with a higher than normal incidence in pregnancies complicated by rubella or hypoxia. At least half of infants with this condition experience no symptoms, but over many years the strong flow of blood from the higher-pressure systemic circulation into the pulmonary circulation overloads the vasculature of the lungs, resulting in pulmonary hypertension and ultimately heart failure.

After passing inferior to the aortic arch, the **left recurrent laryngeal nerve** turns superiorly to reach the tissues of the larynx it supplies. Along its course inferior to the aortic arch, the left recurrent laryngeal nerve is located *posterior* to the **ligamentum arteriosum** (Figure 2). Recall from MBB, that the right recurrent laryngeal nerve passes inferior to the subclavian artery before ascending to the larynx (Figure 2).

Figure 2



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Pericardial Cavity Sinuses

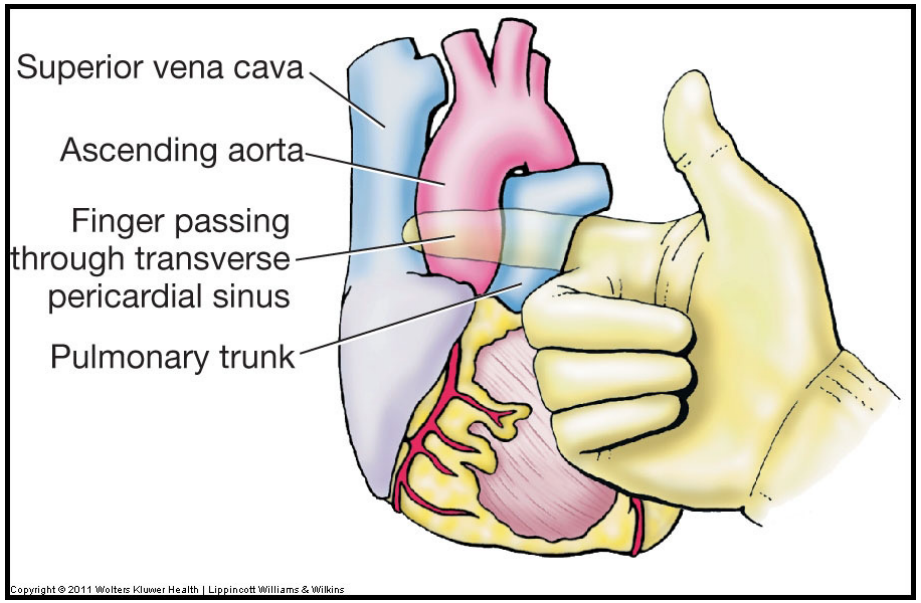
The **transverse pericardial sinus** is a space within the pericardial sac. When the pericardial sac is opened, it is easy to place a finger into the transverse pericardial sinus. Its location is outlined below.

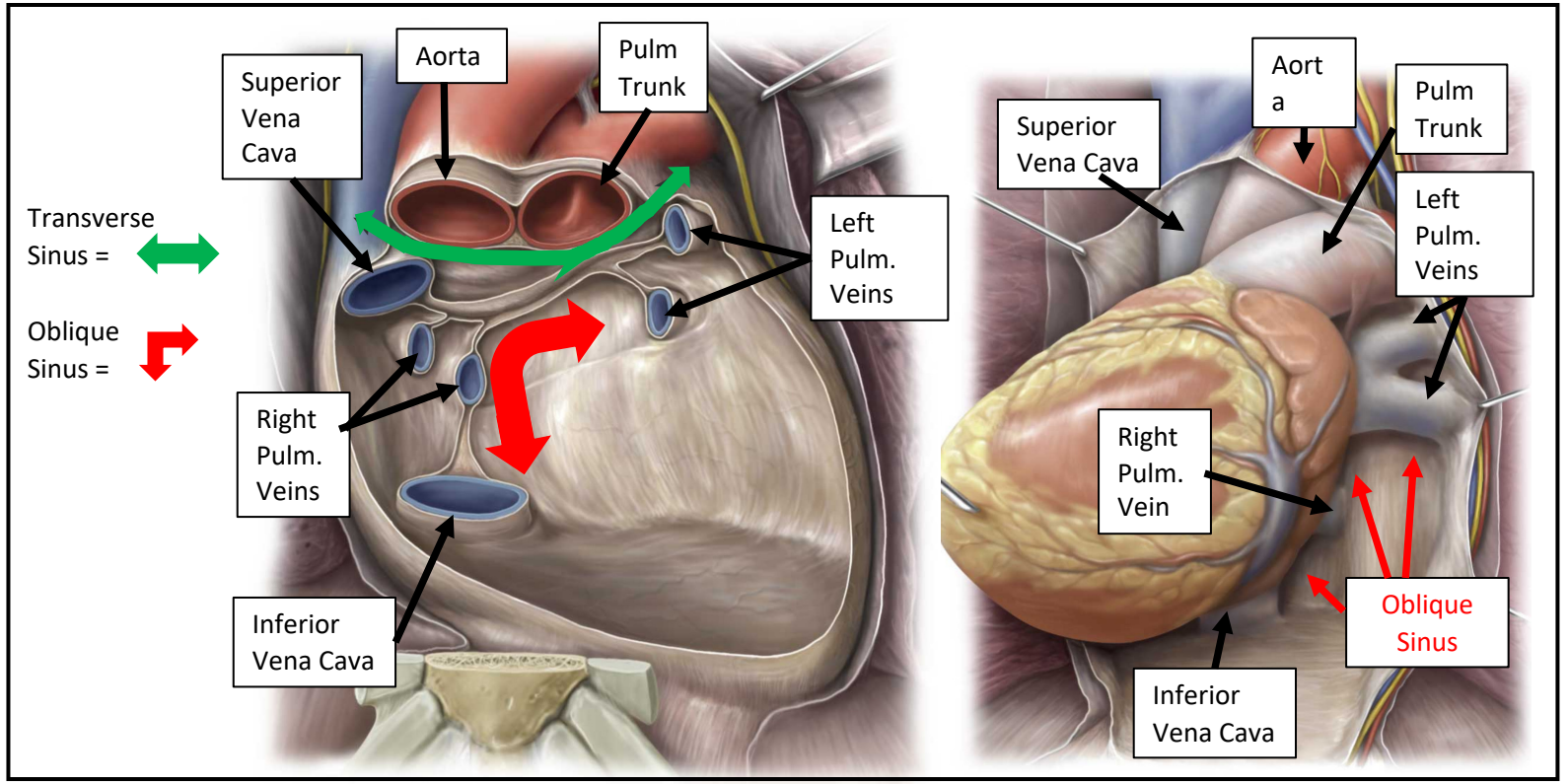
- posterior to the pulmonary trunk and ascending aorta
- anterior to the superior vena cava,
- Superior to the left atrium.

CLINICAL ANATOMY: During cardiac surgery, the transverse pericardial sinus is used to place a ligature or clamp around aorta and pulmonary trunk. The blood in these vessels can then be diverted to a coronary bypass machine during the procedure.

The **oblique pericardial sinus** is an arch-shaped space posterior to the heart in the pericardial cavity.

- The boundary on the right side of the oblique sinus is the reflection of serous pericardium onto the inferior vena cava and the right pulmonary veins.
- The boundary on the left side of the oblique sinus is the reflection of serous pericardium onto the left pulmonary veins.





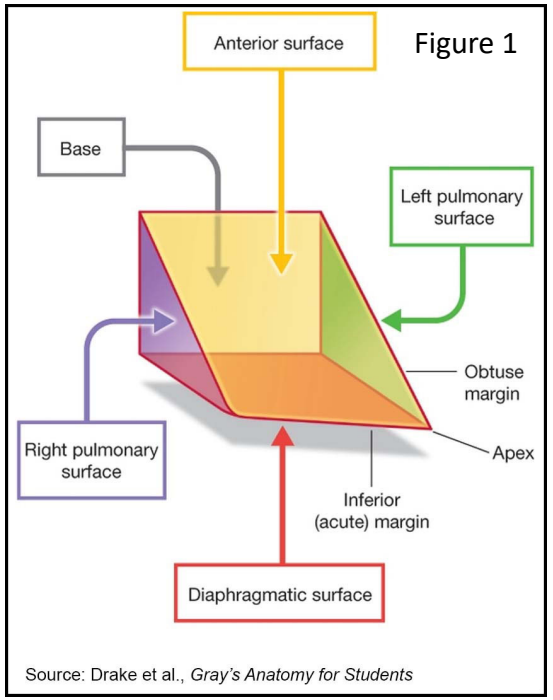
Heart Surfaces

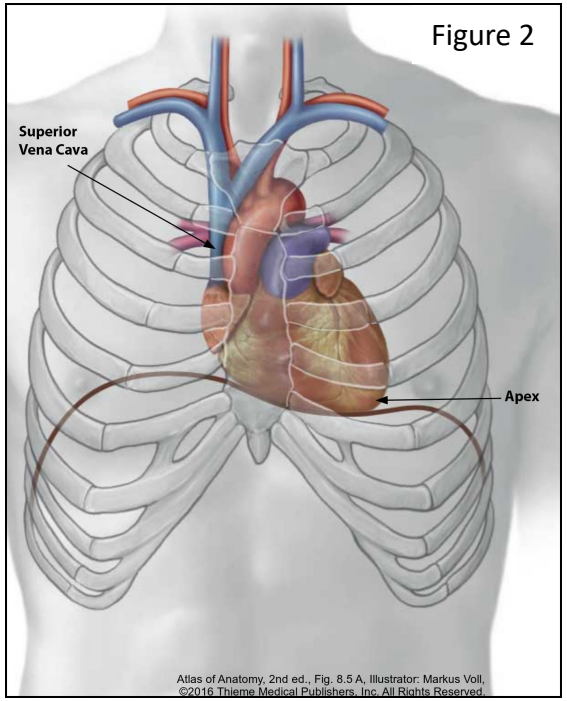
The heart is pyramidal in shape, consists of an apex, base and four surfaces (Figure 1). It is situated obliquely in the thoracic cavity, with its apex directed anteriorly and to the left (Figures 1 and 2). In addition, the inferior and superior venae cavae are oriented along a vertical line (Figure 2).

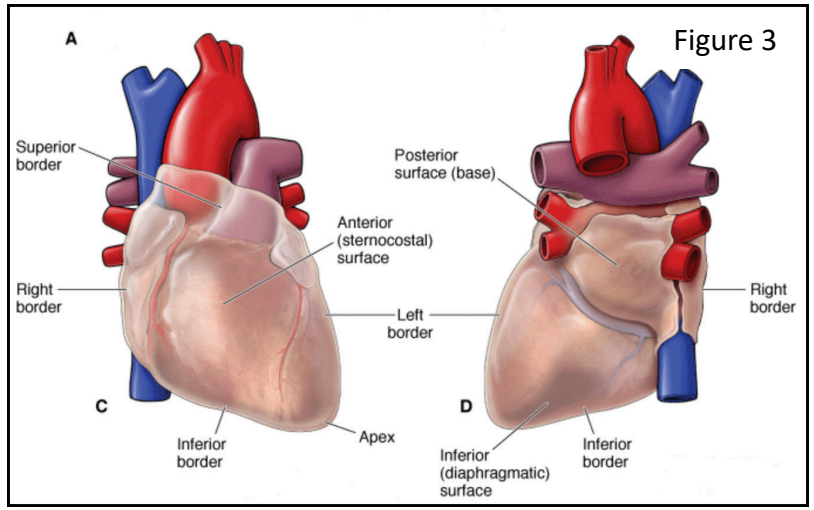
- The **apex** is the most inferior pointed region of the heart that projects anterior and to the left. It is formed by the inferior lateral part of the left ventricle and is located posterior to the left fifth intercostal space in adults (Figures 1 and 2).
- The base (posterior aspect) is the heart's posterior aspect and is formed mainly by the left atrium with a small contribution from the right atrium. It is the location where the pulmonary veins and the superior and inferior vena cava join the heart (Figures 1 and 3).

The four surfaces of the heart are described below (Figures 1 and 3).

- **Anterior (sternocostal) surface** is the region of the heart that faces the sternum and the costal cartilages. It is a surface feature of the right ventricle, with a small contribution from the left ventricle.
- The **inferior (diaphragmatic) surface** is the region of the heart that is in contact with the central tendon of the diaphragm. It is a surface feature of mostly the left ventricle with a small contribution from the right ventricle.
- The **left pulmonary surface** is the region of the heart responsible for the cardiac impression on the left lung. It is a surface feature of mainly the left ventricle.
- The **right pulmonary surface** is the region of the heart responsible for the cardiac impression on the right lung. It is a surface feature of the right atrium.



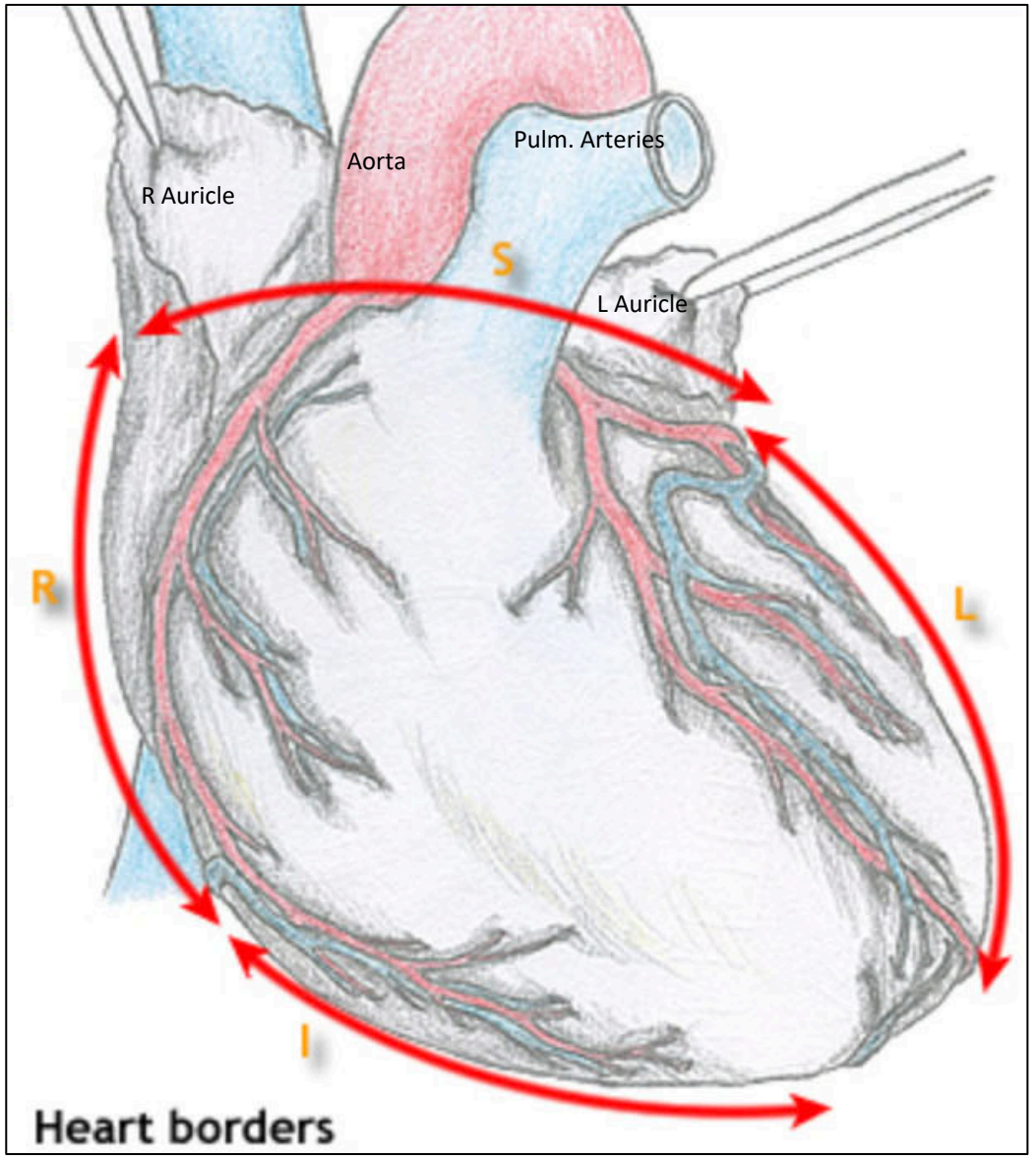




Heart Borders

The borders of the heart are the edges that outline the heart when it is viewed from an anterior or posterior direction. (Understanding which structures form the heart's borders is important during radiological evaluation of the heart)

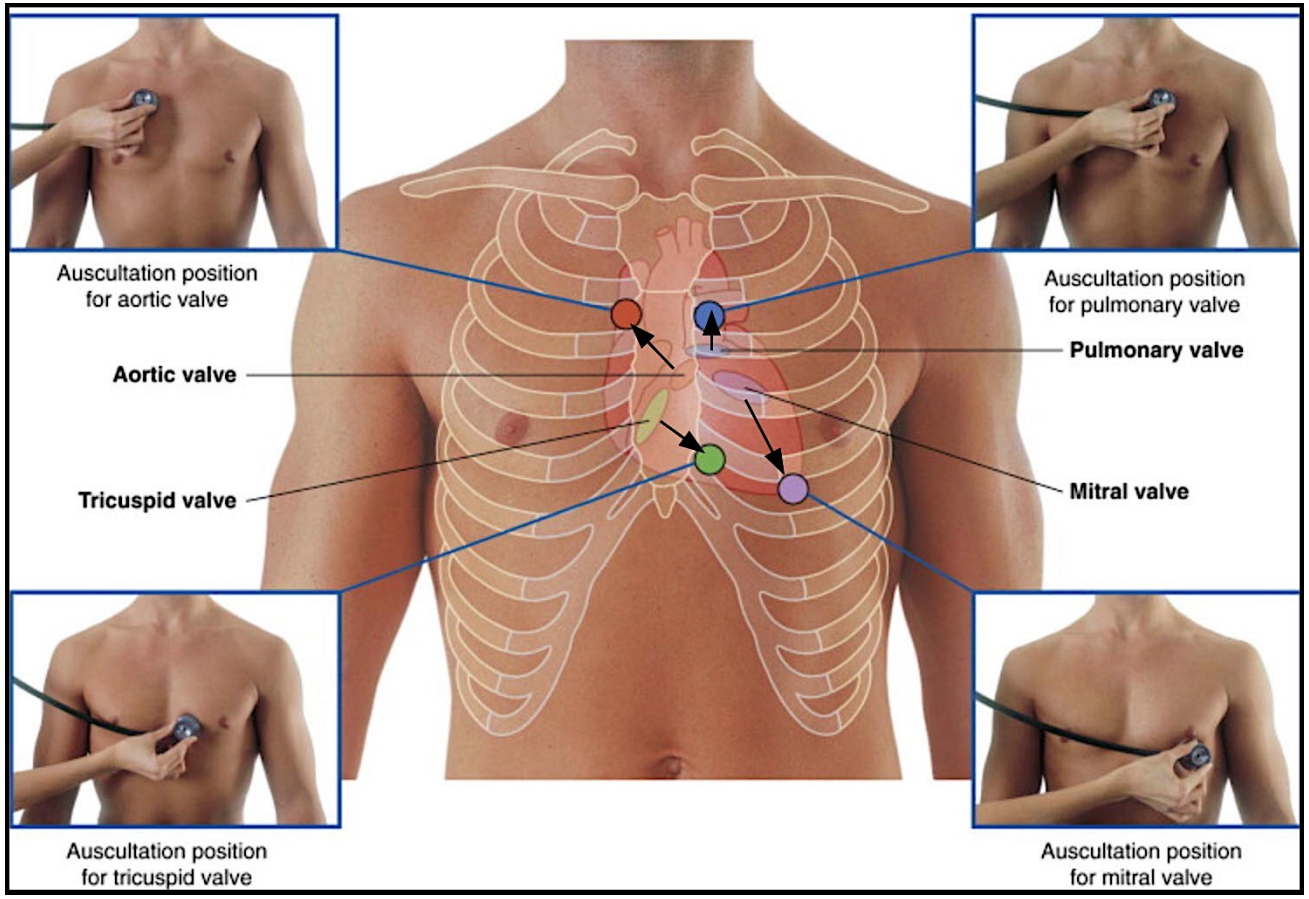
- The **right border/margin** (R in Figure) is a slightly convex border. It is formed by the following vessels:
  - Superior vena cava
  - inferior vena cava
- The **left (obtuse) border/margin** (L in Figure) is the rounded lateral wall of the left ventricle a the junction of the left pulmonary surface with the sternocostal surface. It is formed by the following structures:
  - Mostly left ventricle
  - Small contribution from left atrium
- The **inferior (acute)** (I in Figure) **border** begins at the atrioventricular junction and extends to the apex and is at the junction between the sternocostal and inferior (diaphragmatic surface). It is formed by the following structures:
  - Mostly by right ventricle
  - Small contribution from left ventricle
- The **superior border** (S in Figure) is the inferior boundary of the transverse pericardial sinus. The aorta and pulmonary trunk emerge from the heart along the superior border. In addition, the superior vena cava enters the heart at the right side of the superior border. It is formed by the following structures:
  - Right atrium and auricle (atrial appendage)
  - Left atria and auricle (atrial appendage)



Surface Correlates of Heart Borders & Valve Auscultation

Surface Correlates of Heart Borders

- The **superior border** corresponds to a line that spans from the left 2nd intercostal space immediately lateral to the sternal border to the right 3rd costal cartilage.
- The **right border** corresponds to a line spanning the distance between the 3rd right costal cartilage immediately lateral to the sternal border to to the right 6th costal cartilage.
- The **left border** corresponds to an oblique line from the left 2nd intercostal space to the heart apex (4th or 5th intercostal space), near the midclavicular line.
- The **apex** is located at the left 4th or 5th intercostal space along the midclavicular line (6–10 cm from the midline).
- The **inferior border** corresponds to a line spanning from the right 6th costal cartilage to the apex, located in the left 4th or 5th intercostal space.



Heart Valve Auscultation Sites

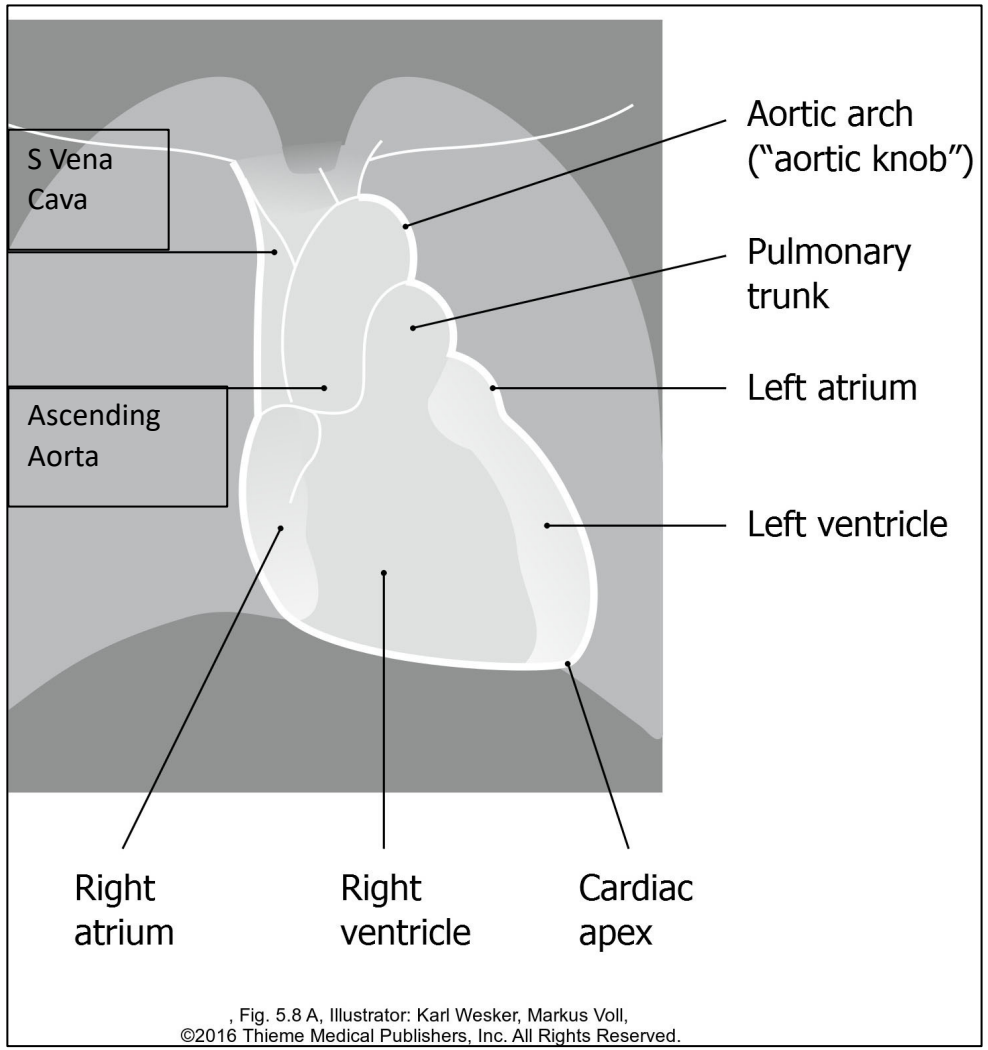
Heart sounds are produced as a result of turbulent blood flow that occurs when the semilunar and atrioventricular valves close. Heart sounds are best heard ”downstream” from where blood passed through each valve..

- The **aortic valve** is auscultated at the **right 2nd intercostal space** just lateral to the right sternal border.
- The **pulmonic valve** is auscultated at the **left 2nd intercostal space** just lateral to the left sternal border.
- The **tricuspid valve** is auscultated at the **left 5th intercostal space** just lateral to left sternal border.
- The **mitral valve** is auscultated in the **left 5th intercostal space** along the midclavicular line. This position also represents the surface projection of the apex and **point of maximal impulse (PMI) of the heart**.

Heart Borders: CXR

On a chest radiograph (CXR), the borders of the heart shadow are expanded to include the great vessels.

- The **right border** includes the right atrium and the superior vena cava.
- The **left border** includes the left ventricle, left atrium, the pulmonary trunk, and the aortic arch (aortic knob).
- The **inferior border** includes the right ventricle and a small contribution from the left ventricle.



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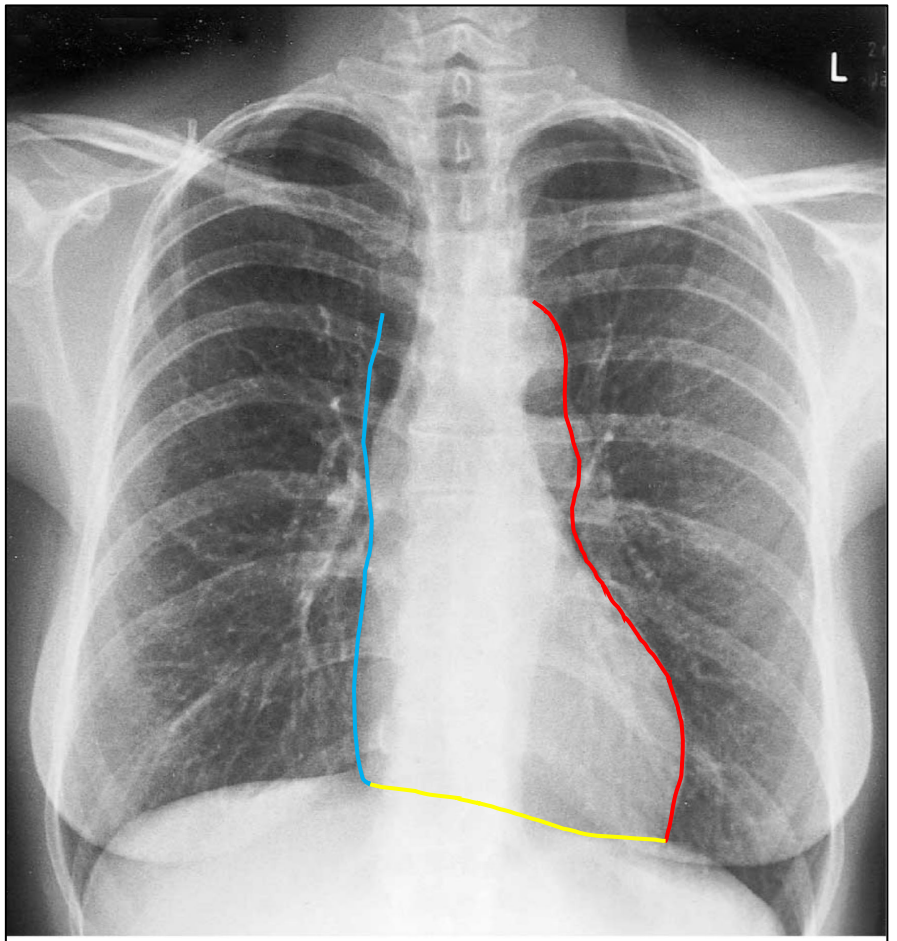

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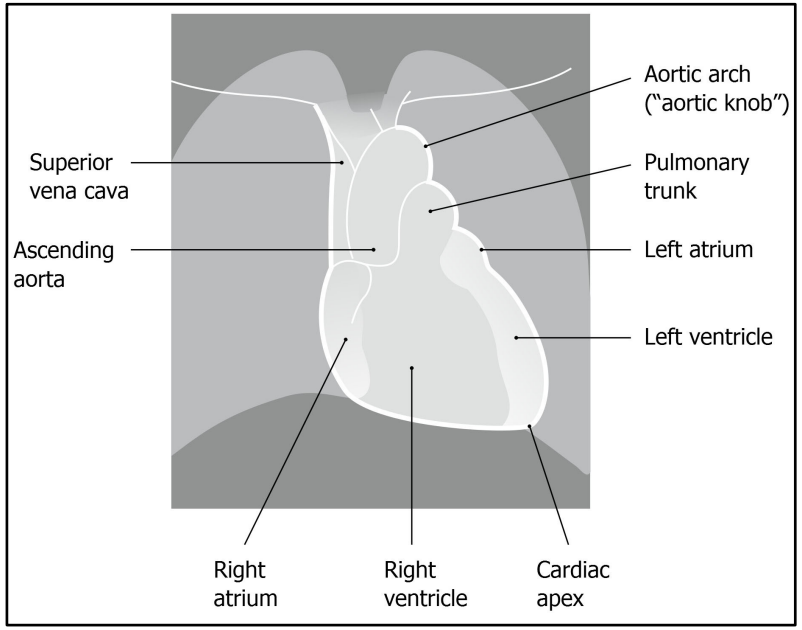
Aortopulmonary Window

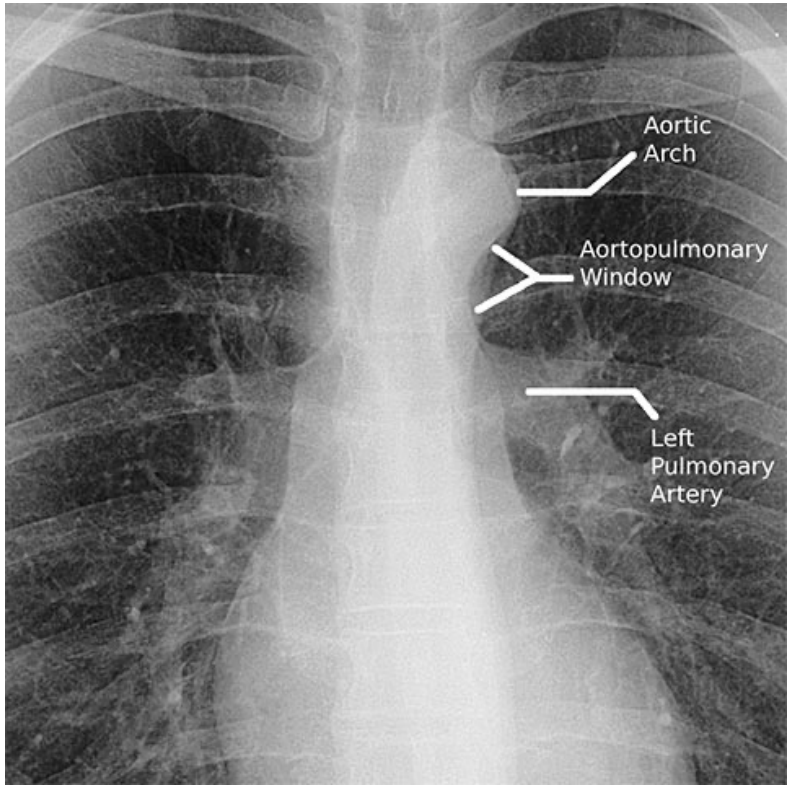
Identify the anatomical boundaries of the **aortopulmonary window**, which is a "space" identified on frontal chest radiographs. The anatomical boundaries of the aortopulmonary window are listed below.

- Superior: aortic arch
- Inferior: left pulmonary artery
- Anterior: ascending aorta
- Posterior: descending aorta
- Medial: trachea, left main bronchus, and esophagus
- Lateral: left lung

CLINICAL ANATOMY: On a frontal chest radiograph, the lateral border of the AP window should have a concave appearance. However, a straight lateral border can be considered normal if unchanged from the previous chest x-ray. A newly straightened or convex lateral border is considered abnormal and has a number of causes.

- The most common cause is a mediastinal lymphadenopathy.
- mediastinal fat (normal variant)
- aneurysm of the aorta or bronchial artery
- malignancy





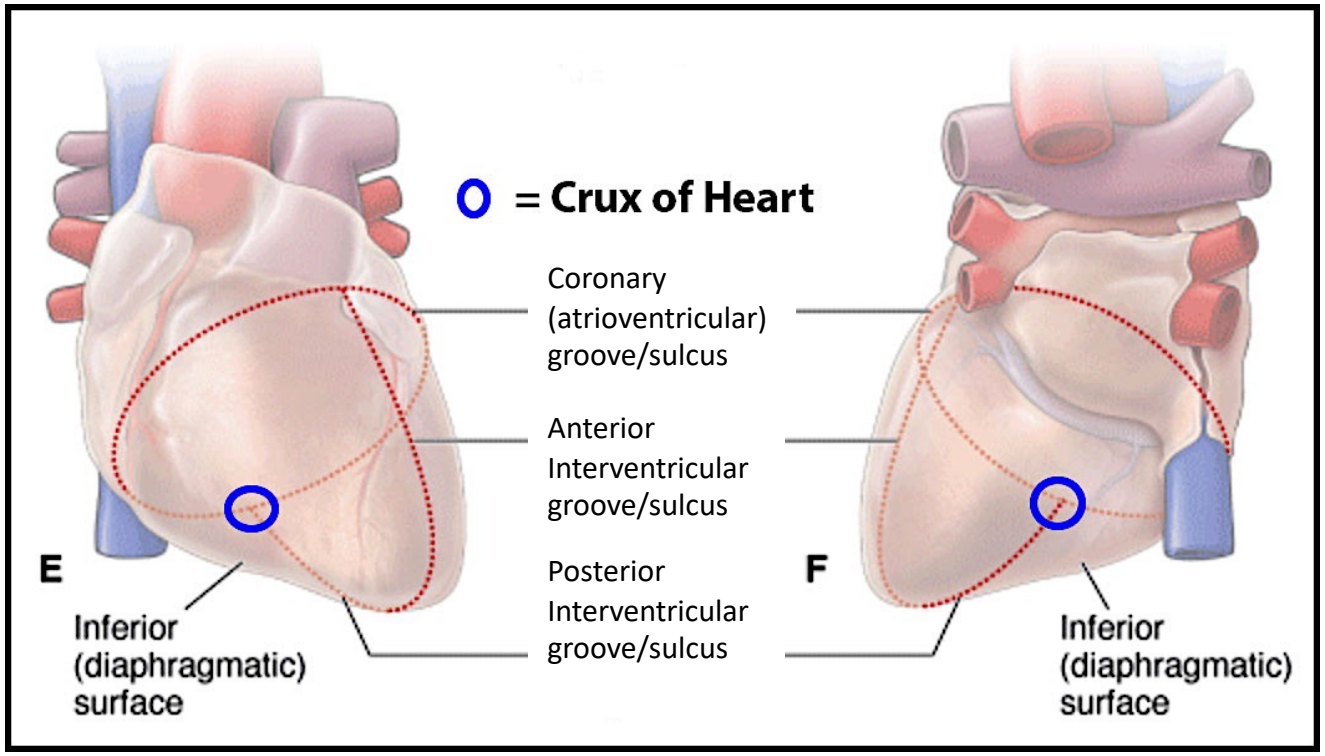
Heart Sulci

The **coronary (atrioventricular) sulcus** is a shallow groove on the heart's surface located at the junction between the atria and the ventricles.
It encircles the heart and contains the following vessels.

- The right coronary sulcus contains the **right coronary artery and the small cardiac vein**.
- The left coronary sulcus contains the **circumflex artery and the proximal portion of the great cardiac vein**.
- The posterior region of the coronary sulcus contains the **coronary sinus**.

The **anterior interventricular sulcus** is a groove on the anterior surface of the heart that corresponds to the location where the interventricular septum joins the anterior heart wall, which means it is a surface landmark that represents the separation between the two ventricles on the heart's anterior side. It contains the following vessels.

- **Anterior interventricular artery (left anterior descending artery)**
- Distal portion of the **great cardiac vein**



The **posterior interventricular sulcus** is groove on the posterior of the heart that that corresponds to the location where the interventricular septum joins the posterior heart wall, which means that is a surface landmark that represents the separation between the two ventricles on the heart's posterior side. In addition, it contains the following g vessel.

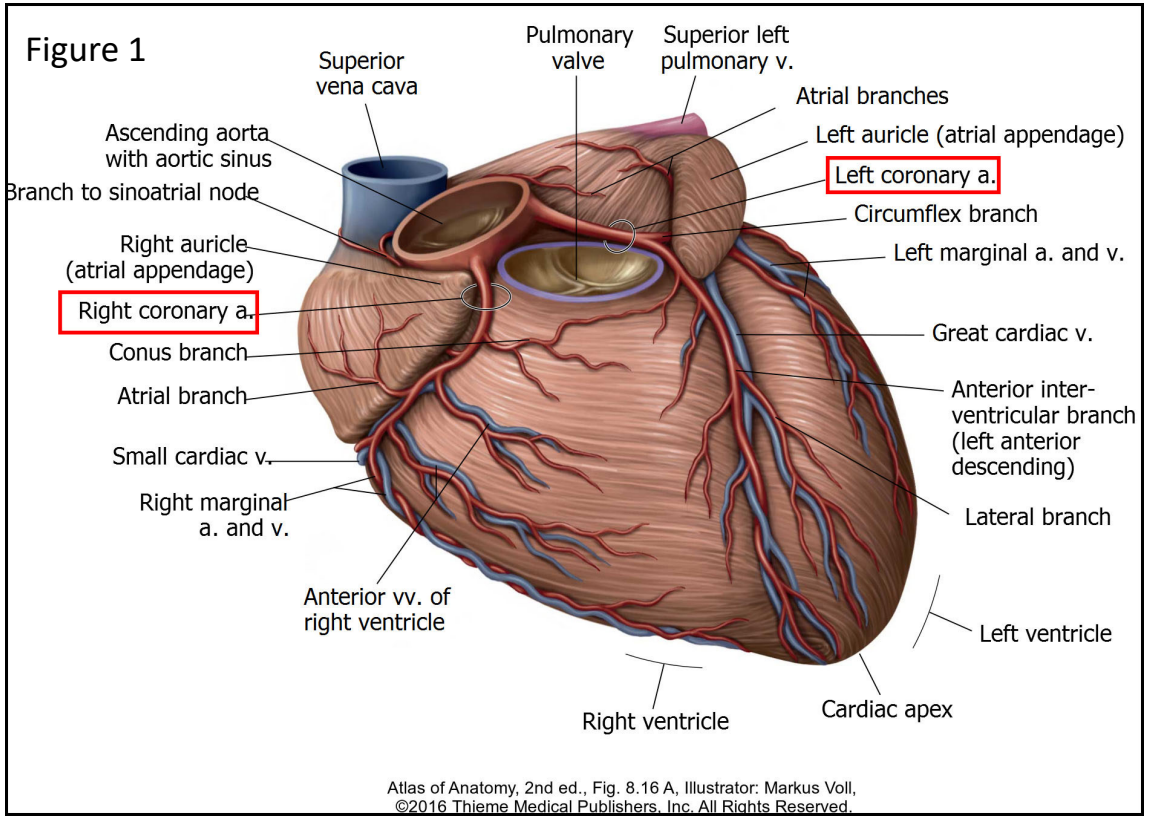
- **Posterior interventricular artery (posterior descending artery-PDA)**
- **Middle cardiac vein**

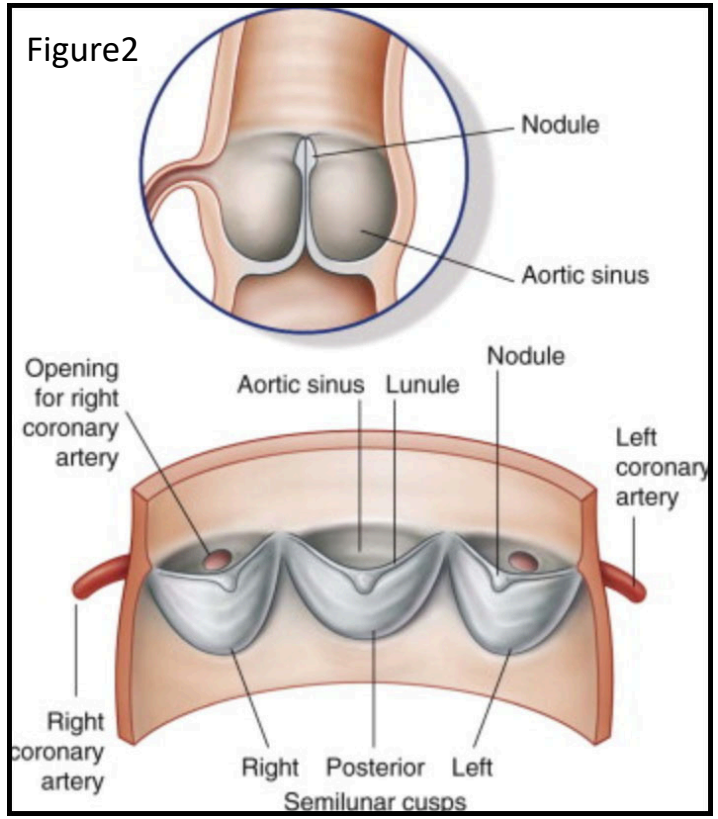
The **crux** of the heart is located on the heart's posterior surface at the intersection of the coronary and interventricular sulci. The atrioventricular (AV) nodal artery arises near this location.

Coronary Vessels

The vessels that supply the heart wall are called coronary arteries and cardiac veins. They are typically surrounded by a variable amount of fat and located between the epicardium (serous visceral pericardium) and the surface of the heart muscle. Coronary arteries supply the epicardium and myocardium with oxygen-rich blood. The endocardium, which consists of a simple squamous epithelium and its underlying connective tissue that lines the chambers of the heart, receives its oxygen and nutrients directly from blood in the heart chambers.

- The right and left coronary arteries (Figure 1) arise from the base of the aorta at the aortic sinuses (Figure 2), which are pouch-like spaces between each valve cusp and the aortic wall. The aortic wall in this location is slightly dilated and contains the opening into each coronary artery.
  - The **right aortic sinus** contains the opening into the **right coronary artery**.
  - The **left aortic sinus** contains the opening into the **left coronary artery**.
  - NOTE: The **posterior/non-coronary sinus** does not contain an opening into a coronary artery.

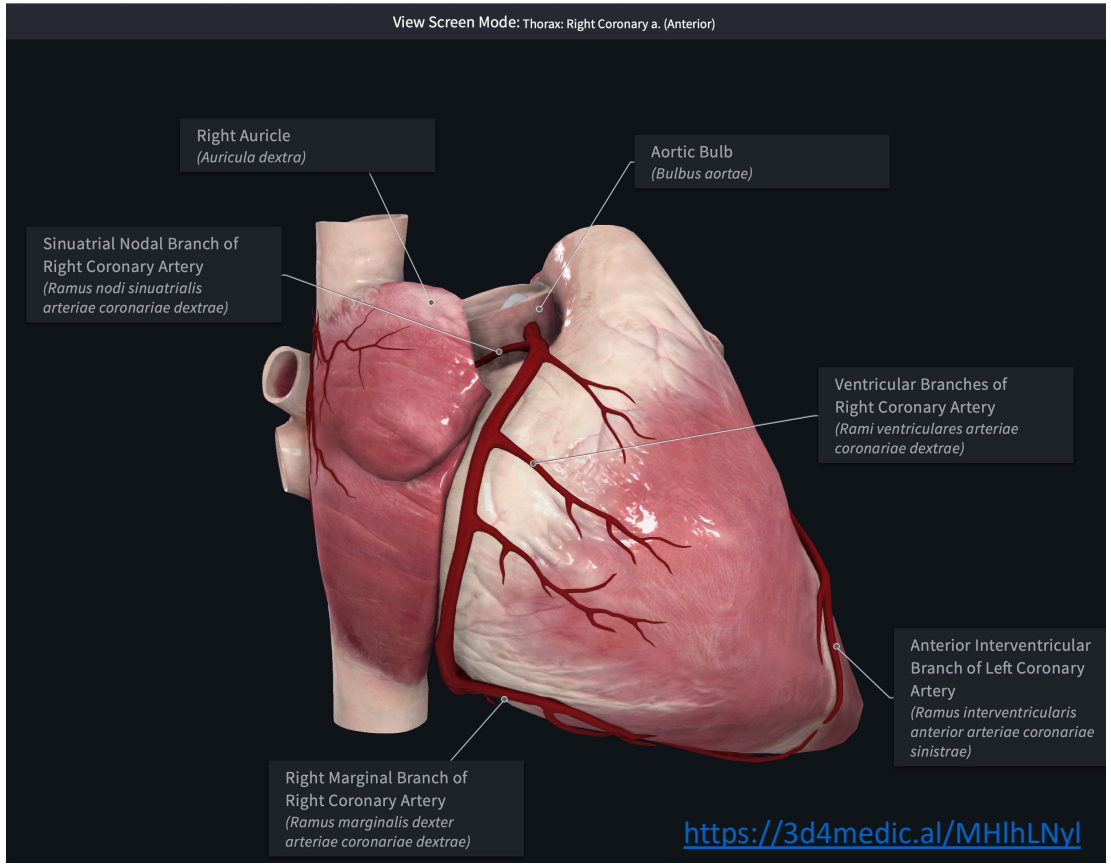


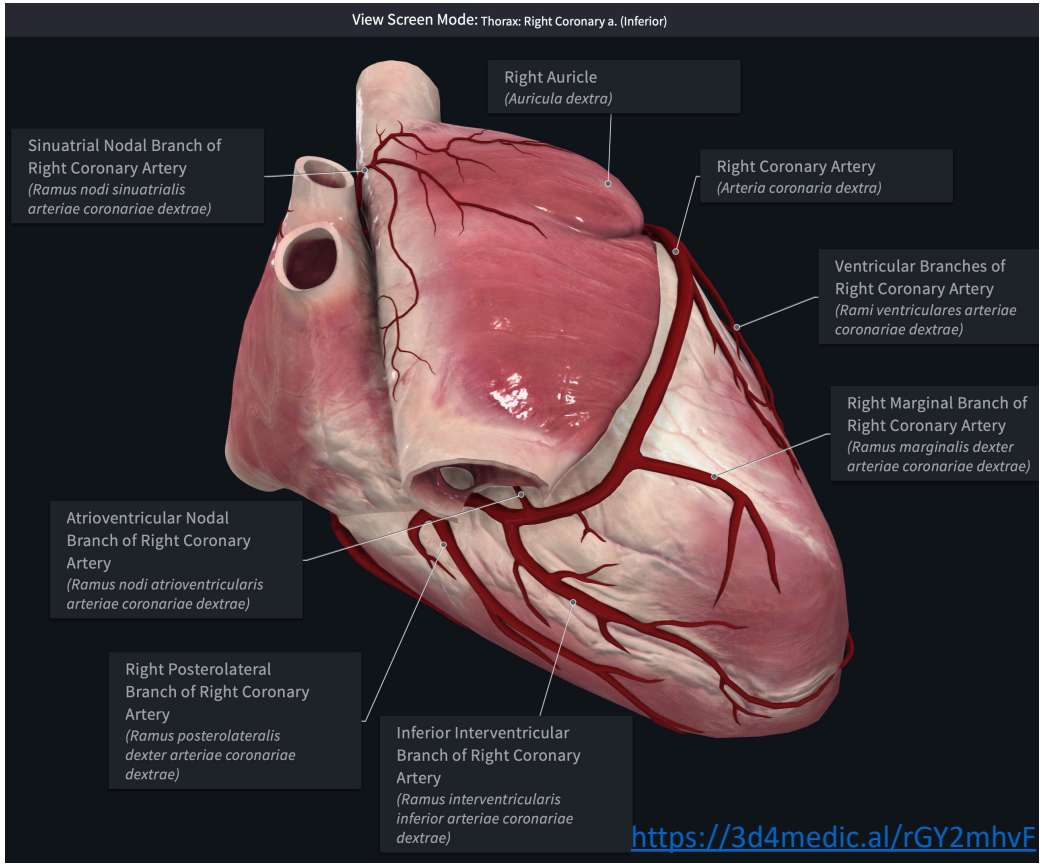


Right Coronary Artery and Branches

The **right coronary artery** branches from the aorta at the right aortic sinus to pass anteriorly between the right auricle and the right side of the pulmonary trunk. It then travels inferiorly to enter the (right) coronary sulcus in which it courses to the posterior side of the heart to become the posterior descending (interventricular) artery (most of the time—see slide 19 on heart dominance). The major branches of the right coronary artery are listed below.

- The **sinu-atrial nodal artery** supplies the right atrium and the SA node.
- The **right (acute) marginal artery** supplies the right ventricle and apex of the heart.
- The **posterior interventricular artery** (also known as posterior descending artery, PDA) supplies the right and left ventricle and the posterior 1/3 of interventricular septum.
- **The atrioventricular (AV) nodal artery** is a branch of the right coronary prior to the branch site of the posterior interventricular artery. It supplies the AV node.

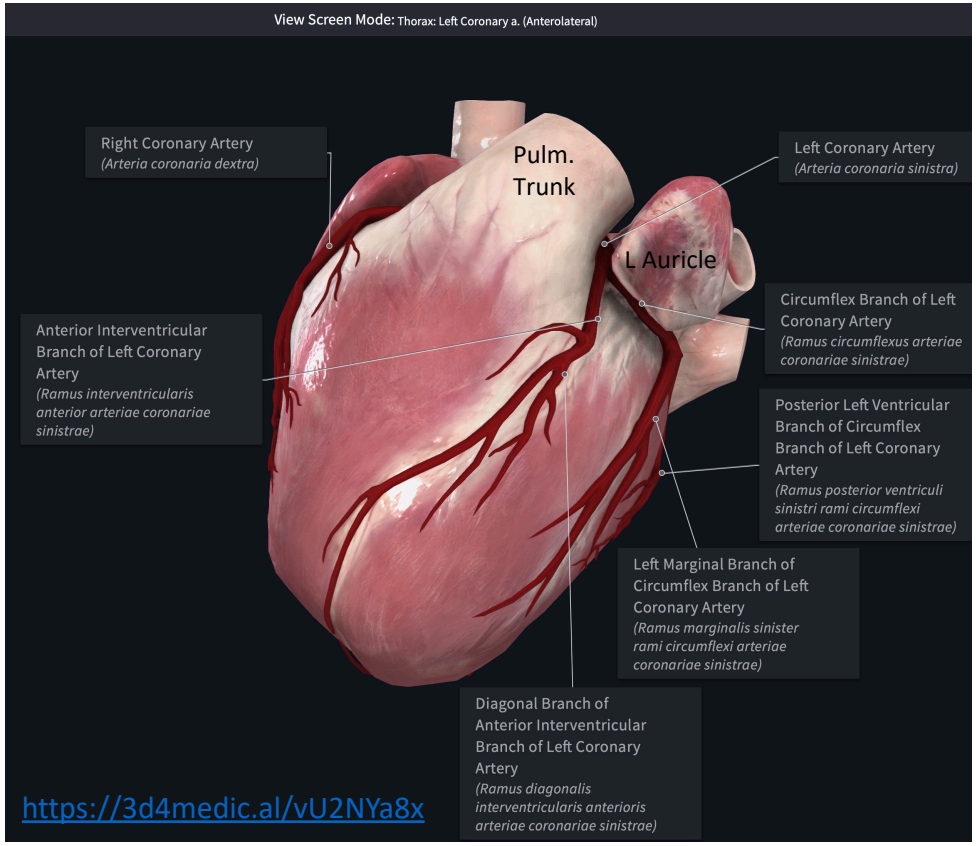


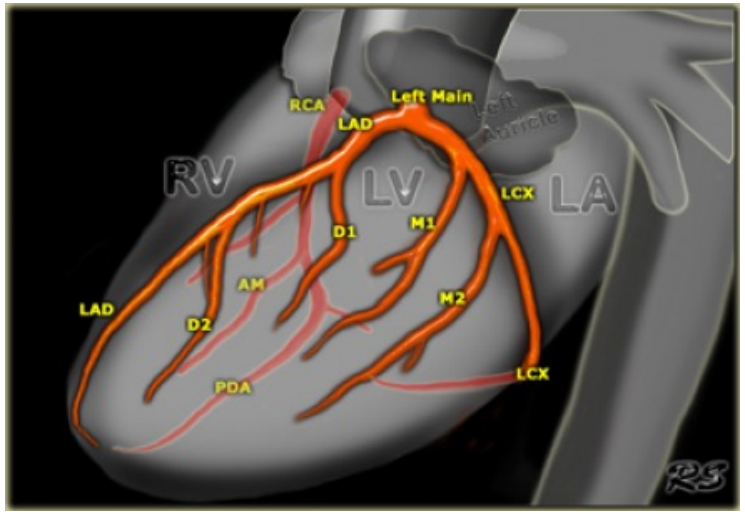


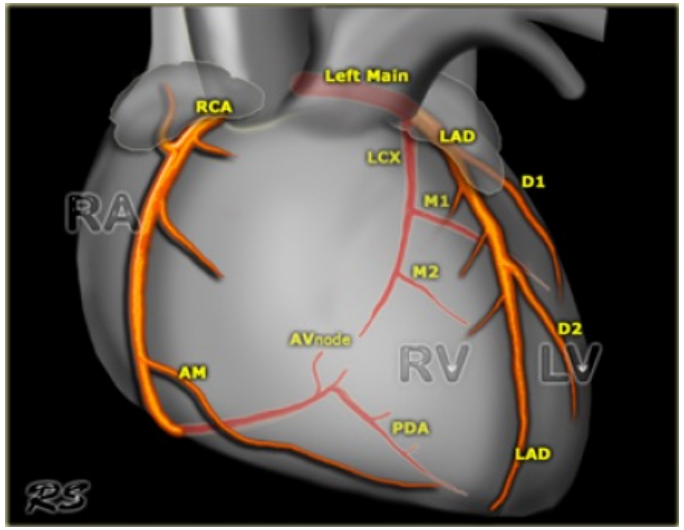
Left Coronary Artery and Branches

The **left coronary artery** branches from the ascending aorta at the left aortic sinus to pass between the left auricle and the left side of the pulmonary trunk. It then courses for a short distance in the coronary sulcus until it bifurcates at the intersection of the coronary sulcus with the anterior interventricular groove. The left coronary artery bifurcates to form the following branches.

- The **anterior interventricular artery** (know to clinicians as the **left anterior descending artery– LAD**) courses within the anterior interventricular sulcus toward the apex of the heart to supply the right and left ventricles and the anterior 2/3 of the interventricular septum. In many situations the LAD anastomosis with the PDA at the apex of the heart.
    - Diagonal arteries branch from the LAD at acute angles toward the acute (left) margin and the apex to supply blood to the anterior and anterolateral walls of the left ventricle. If present, they run parallel to each other and are variable in number. The naming of diagonal arteries is accomplished by assigning them numbers (D1, D2, etc.) as the branch from the LAD along its path from proximal to distal.



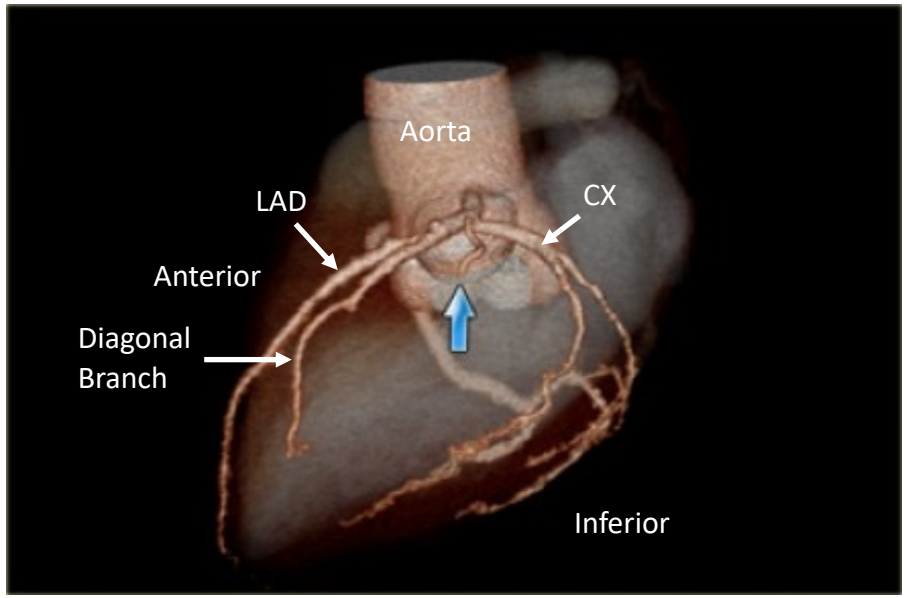


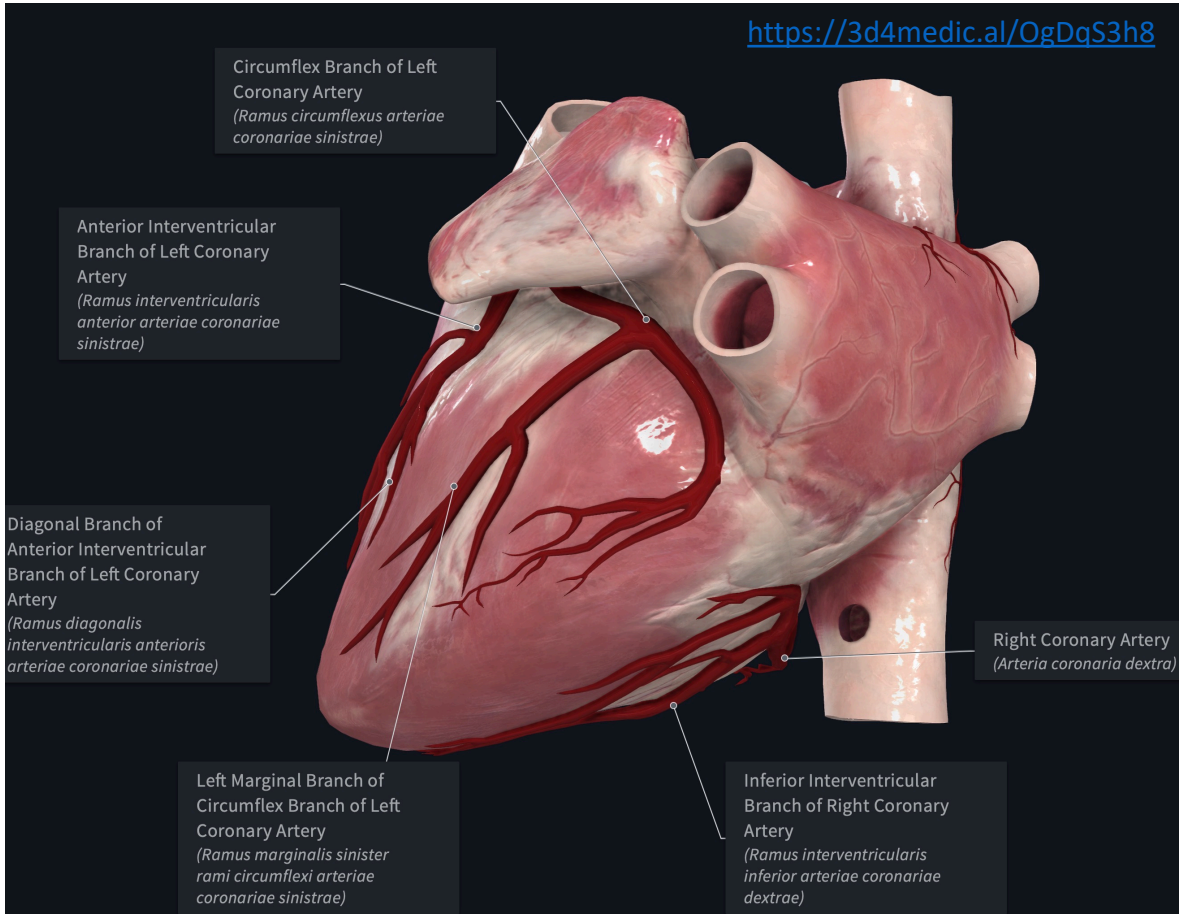


Left Coronary Artery and Branches (Continued)

- The **circumflex artery (Cx)** courses within the the (left) coronary sulcus around the left border of the heart to reach the posterior surface of the heart. Along its path is supplies the left atrium and the left ventricle. Typically the circumflex artery terminates prior to reaching the crux of the heart, but in about 30% of people its termination is parallel to, or within the posterior interventricular groove.
    - The **left (obtuse) marginal artery** is a branch of the circumflex artery that traverses along the left margin of the heart toward its apex supplying the left ventricle along its path. There can be one or more obtuse marginal arteries. When more than one is present, the naming of obtuse marginal arteries is accomplished by assigning them numbers (OM1, OM2, etc.) as the branch from the Cx artery along its path from proximal to distal.

- In a small number of individuals, (15%) a third branch (Blue Arrow Figure 2) of the left coronary artery arises between the LAD and the Cx. This vessel is named the ramus intermedius or intermediate branch.

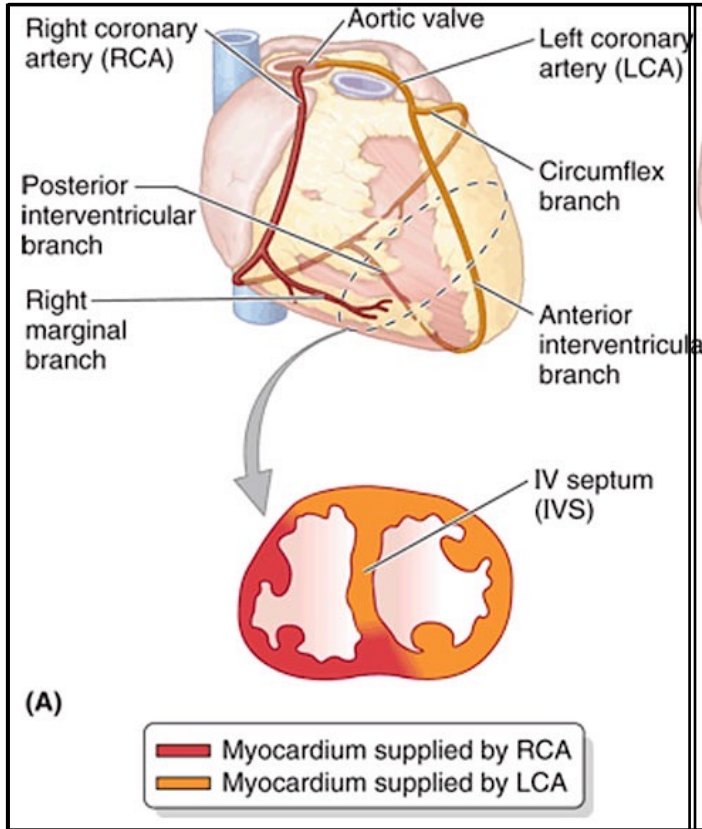




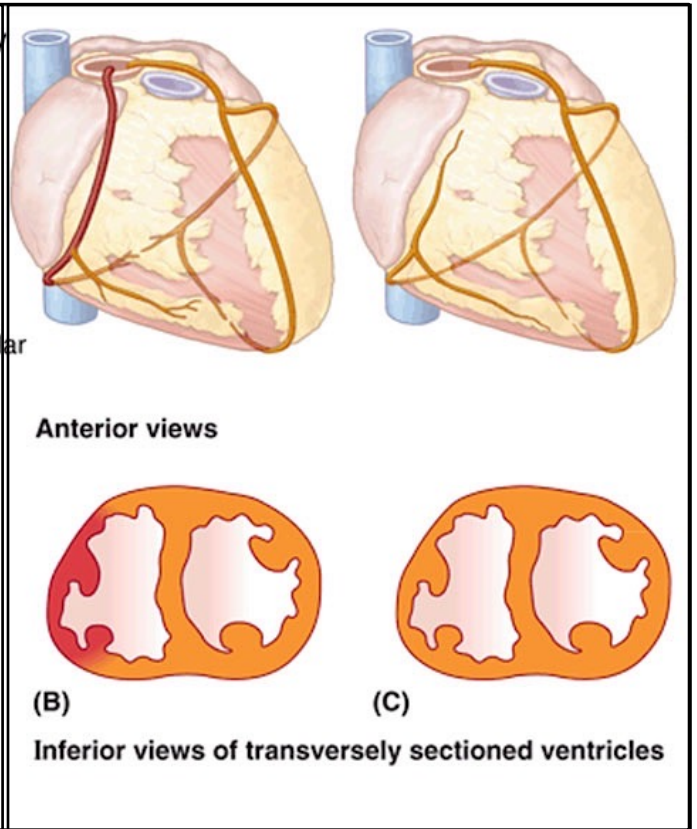
Heart Dominance

CLINICAL ANATOMY: Variations in the branching patterns of coronary arteries are common. The term “dominance” with respect to the heart refers to the coronary artery from which the posterior interventricular artery (posterior descending artery: PDA) originates. The posterior interventricular artery supplies the posterior portion of the interventricular septum, and often part of the posterolateral wall of the left ventricle (Figure 4.5).

- Right dominant circulation (A in Figure) is when the the PDA and AV nodal artery originate from the right coronary artery. This occurs in approximately 70-80% of the population.
- Left dominant (B and C in Figure) circulation is when the PDA originates from circumflex artery. This occurs in approximately 5-10% of the population.
- Co-dominant circulation (Not Shown in Figure) is when the PDA receives blood from both the circumflex and the right coronary artery. This occurs in the remaining percentage of the population.



A = Right Dominant

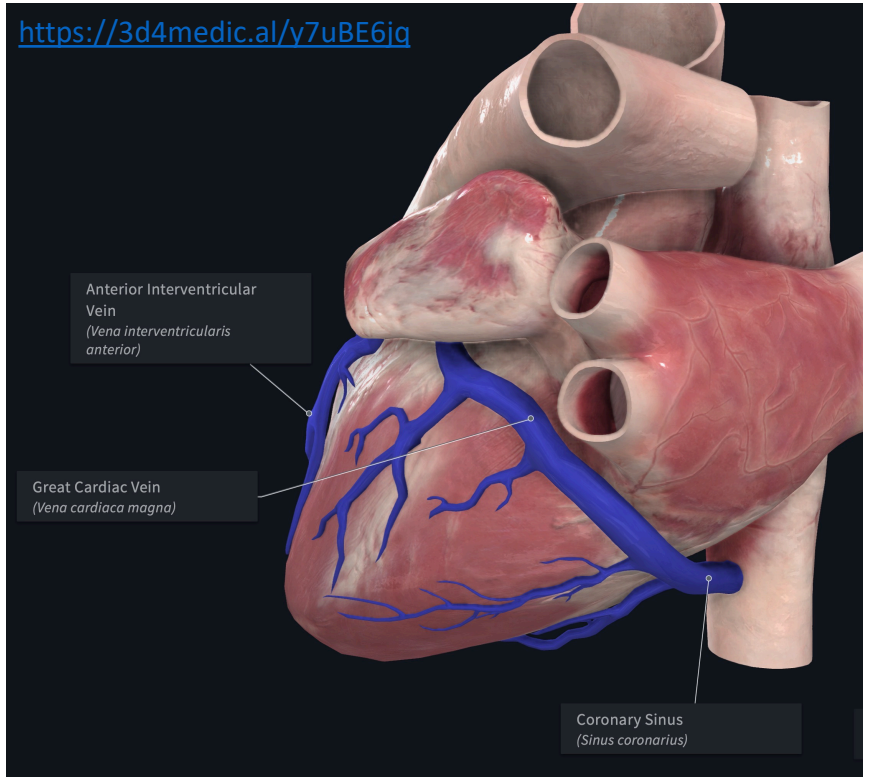


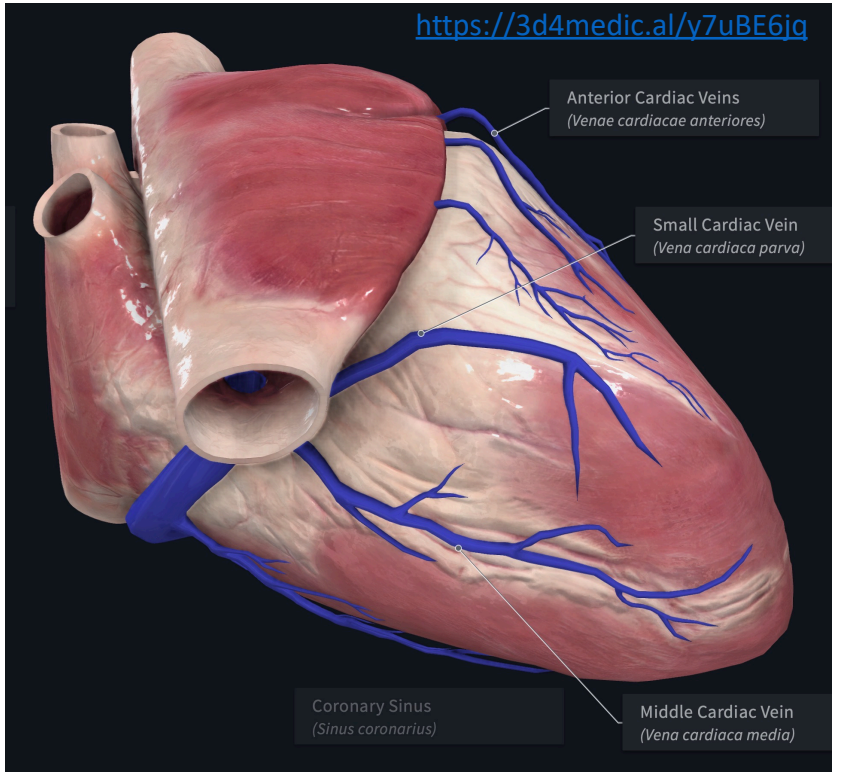
B & C = Left Dominant

Veins of the Heart

The **coronary sinus** is a 2–2.5cm dilated part of the cardiac venous system located in the posterior region of the coronary sulcus. It collects blood from most of the cardiac veins and drains the collected venous blood into the right atrium. All of the major cardiac veins listed below terminate by draining into the coronary sinus.

- The **great cardiac vein** begins as the anterior interventricular vein at the apex of the heart and parallels the LAD into the junction between the interventricular sulcus and the coronary sulcus. At this junction, it exits the interventricular sulcus to enter the (left) coronary sulcus. Within the (left) coronary sulcus, the vein travels with the circumflex artery to the posterior side of the heart where it drains into the coronary sinus. It is responsible for draining the region of the heart *supplied* by the LAD and circumflex artery.
- The **middle cardiac vein** courses alongside the posterior interventricular artery (posterior descending artery). It drains blood from the area supplied by the posterior interventricular artery (posterior ventricular walls and the posterior 1/3 of the interventricular septum) into the coronary sinus.
- The **small cardiac vein** parallels the marginal artery into the (right) coronary sulcus. In the coronary sulcus, the small cardiac vein takes a 90 degree turn and continues to the posterior side of the heart by coursing alongside the right coronary artery. It drains the area supplied by the right marginal artery and the right coronary artery into the coronary sinus (right atrium and lateral right ventricle).





Internal Heart Features: Right Atrium

- The **crista terminalis** is a ridge of muscle on the anterior side of the right atrial wall spanning the distance between the superior vena cava and the inferior vena cava. It separates the right atrium's smooth posterior portion (derived from sinus venarum) from its rough anterior portion (derived from the primordial atrium).

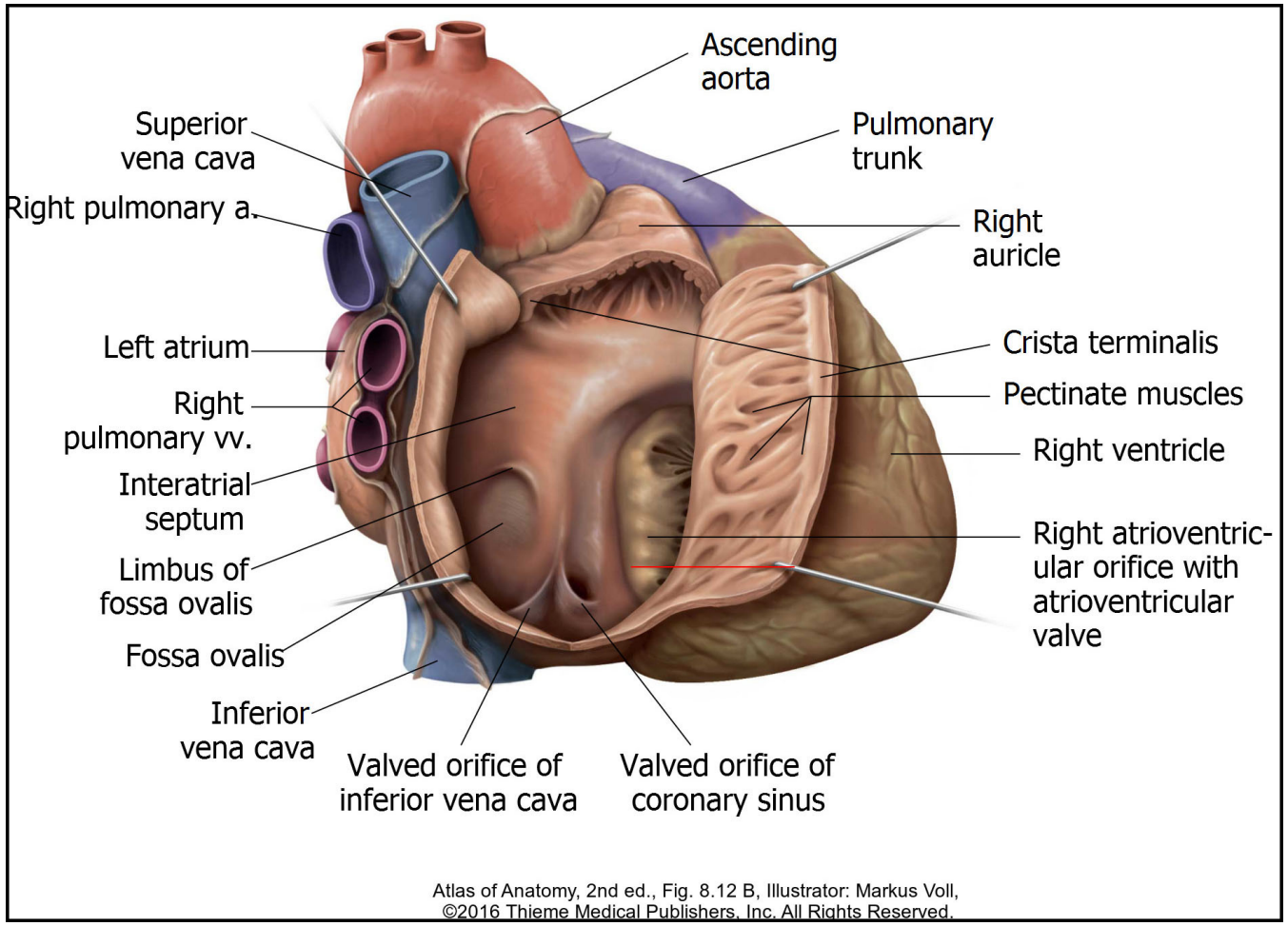
- The **superior vena cava (SVC**), inferior vena cava (IVC), and **coronary sinus** all open into the smooth-walled posterior portion of the atrium (derived from sinus venarum).

- The **pectinate muscles** are muscular ridges visible on the internal surface of the right atrium anterior to the crista terminalis. The muscular ridges account for the roughened appearance anterior to the crista terminalis.

- The **interatrial septum** is the atrial wall separating the right and left atria. Place your right index finger in the right atrium and your left index finger in the left atrium attempting to touch your fingertips against each other. The thin tissue wall between your fingertips is the interatrial septum.

- The **fossa ovalis** is an oval depression on the interatrial septum, which is the remnant of the foramen ovale that was present in the fetal heart.

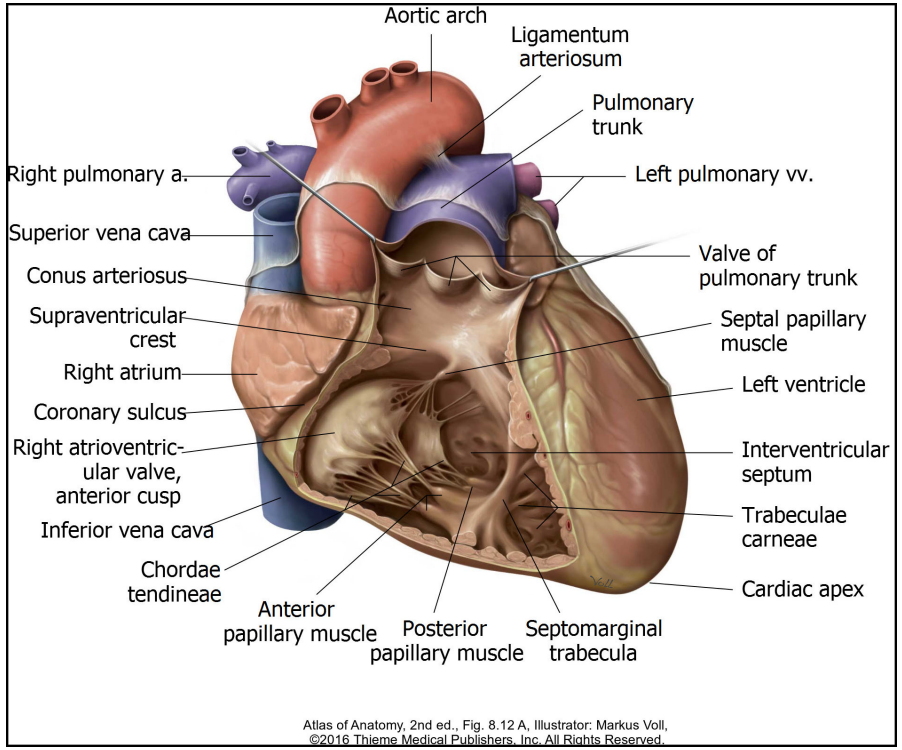
- The **orifice** of the **tricuspid (atrioventricular) valve** allows passage of blood from the right atrium to the right ventricle during (ventricular) diastole.

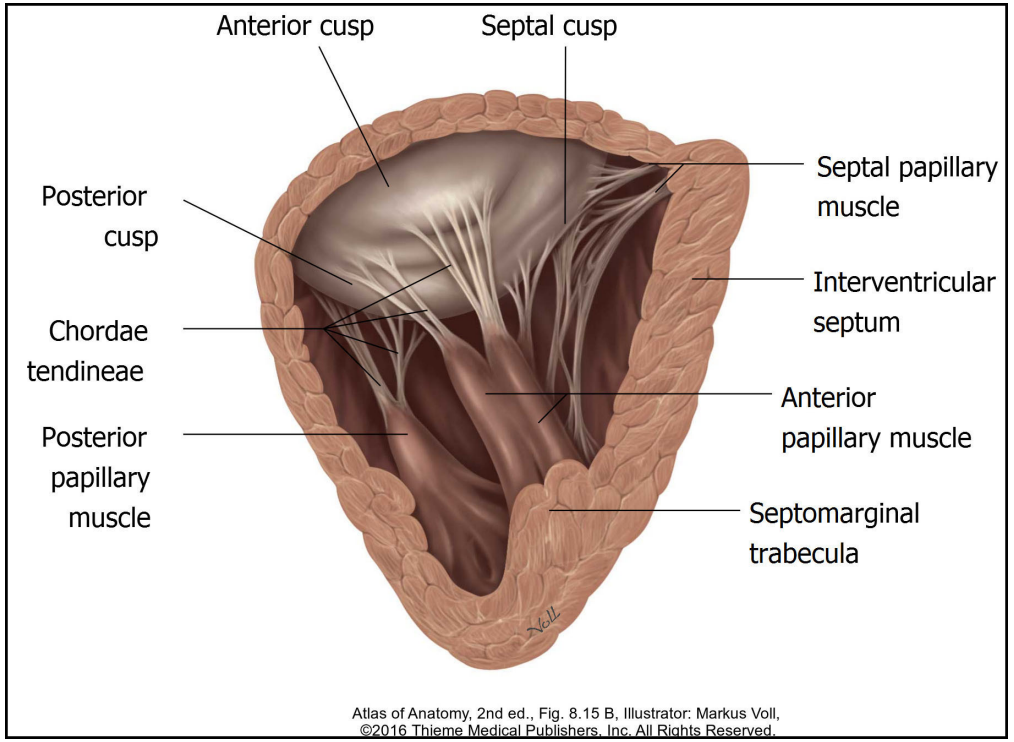


Atlas of Anatomy, 2nd ed., Fig. 8.12 B, Illustrator: Markus Voll,

Internal Heart Features: Right Ventricle

- The **trabeculae carneae** are muscular bundles lining the wall of inflow portion of the right ventricle, which is the region into which blood is collected during ventricular relaxation (diastole).
- The **conus arteriosus (infundibulum)** is a smooth, cone-shaped portion of the right ventricle that functions as the outflow tract for blood as the blood is pumped into the pulmonary trunk during ventricular contraction.
- The **tricuspid (right atrioventricular) valve** has been given this name because it usually consist of three valve leaflets or cusps. Each of the three leaflets is tightly attached to a fibrous ring around the perimeter of the atrioventricular orifice.
- The free edges of the tricuspid valve are attached to **chordae tendineae**, which are cord-like tendons that connect the valve cusps to papillary muscles. When a ventricle contracts, the **papillary muscles** also contract to exert a pulling force on the valve via the chordae tendineae, which prevents the valve cusps from being forced into the atrium when intraventricular pressure increases.
- **Papillary muscles** are conical muscular extensions from the ventricular walls that attach to the tricuspid valve cusps by chordae tendineae.
- The **septomarginal trabecula (moderator band)** is a muscular band that connects the interventricular septum to the base of the anterior papillary muscle. It contains a branch of conductive tissue from the right atrioventricular bundle. This branch of conductive tissue creates a "shortcut" for action potentials traveling to the anterior papillary muscle, which increases conduction time to coordinate its contraction. Because of its appearance as a bridge of tissue projecting from the interventricular septum, early anatomists thought its function was to prevent over distention of the right ventricle, which is why it was named the moderator band.





Internal Heart Features: Pulmonary (Semilunar) Valve

The **pulmonary (semilunar) valve** consists of three **cusps** located at the apex of the right ventricle's conus arteriosus.

- Each **cusp** of the semilunar valve is the shape of a half-moon when viewed from above (Figure 1).
- The **pulmonary sinuses** are pouch-like spaces between the wall of the pulmonary trunk and the semilunar valve cusps (Figure 2).

FUNCTIONAL ANATOMY: During ventricular systole, the semilunar cusps of the pulmonary and aortic valves are forced open against the walls of the pulmonary trunk and the aorta by the outflowing blood. During diastole, blood flows back toward the heart and into the sinuses. As the sinuses fill with blood, the cusps come in opposition at the center of the lumen, which tightly closes the orifice and prevents backflow (Figure 3).

Figure 1

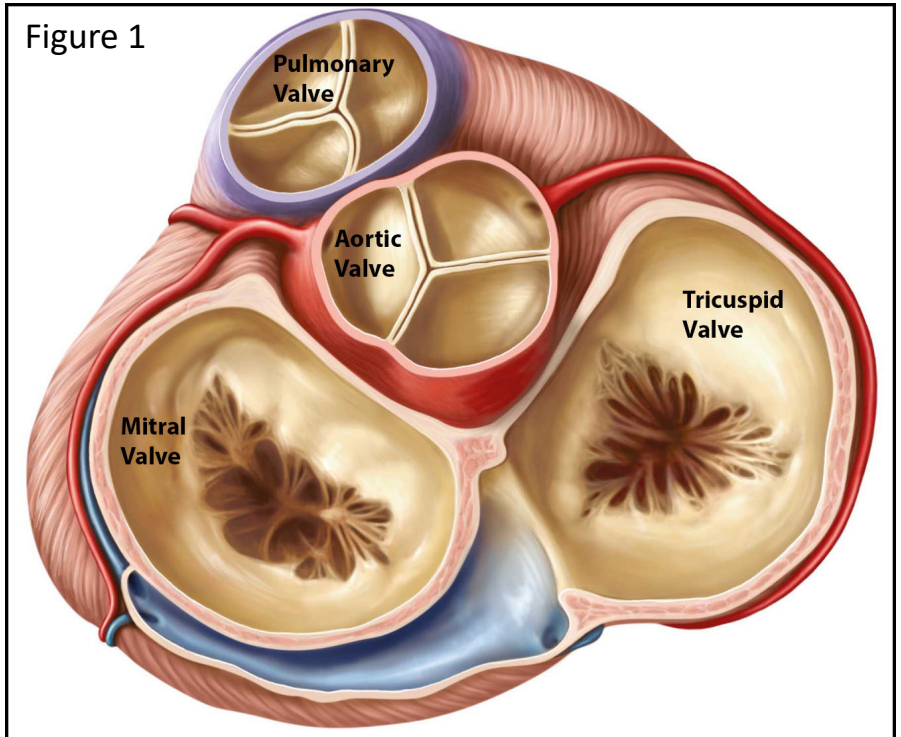


Figure 2

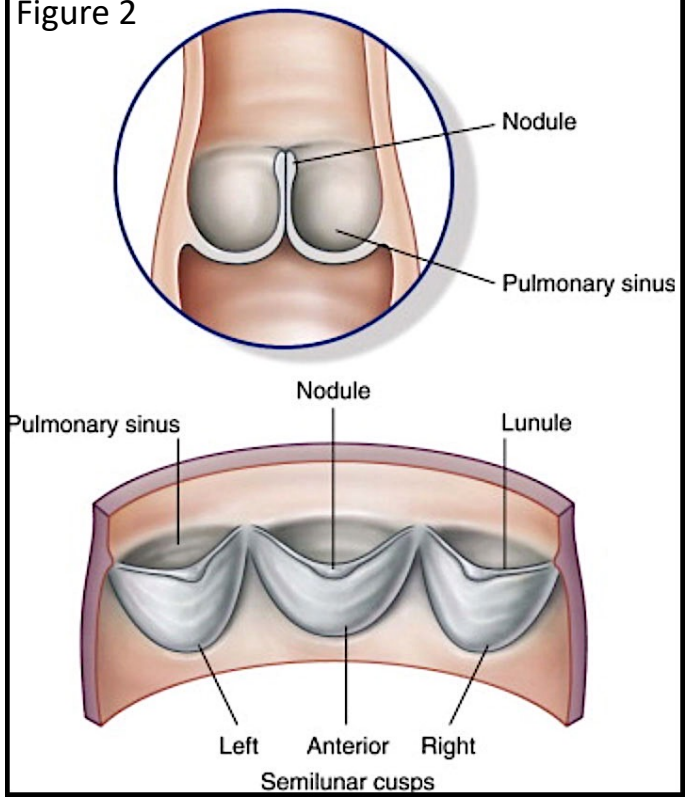
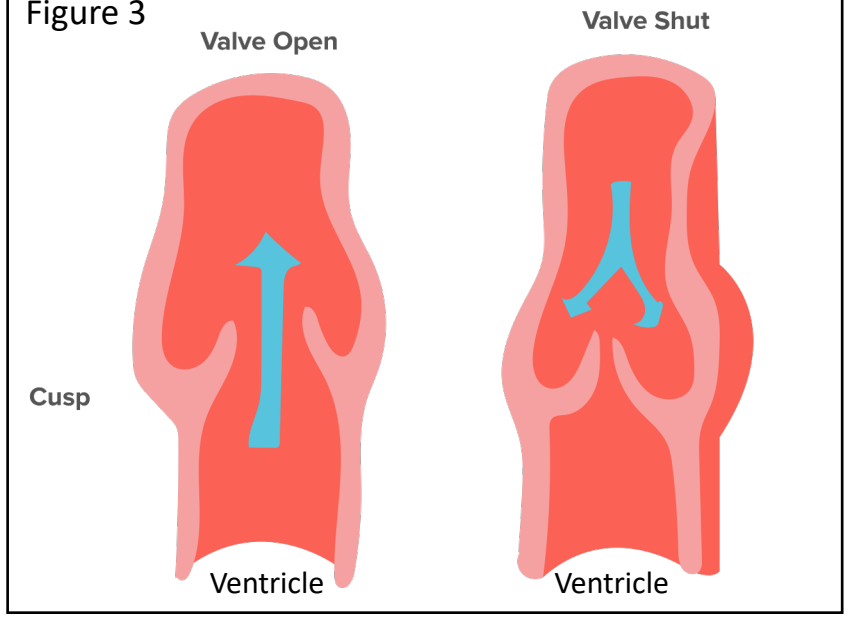
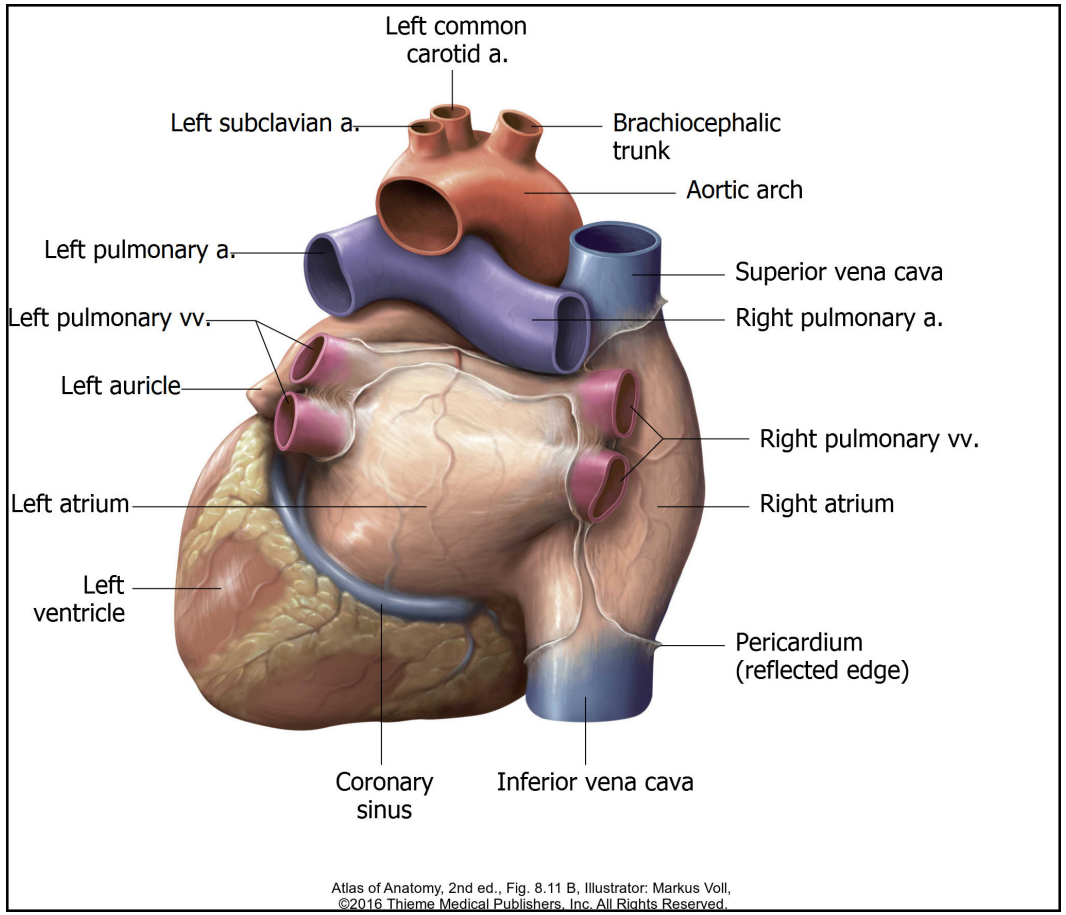


Figure 3

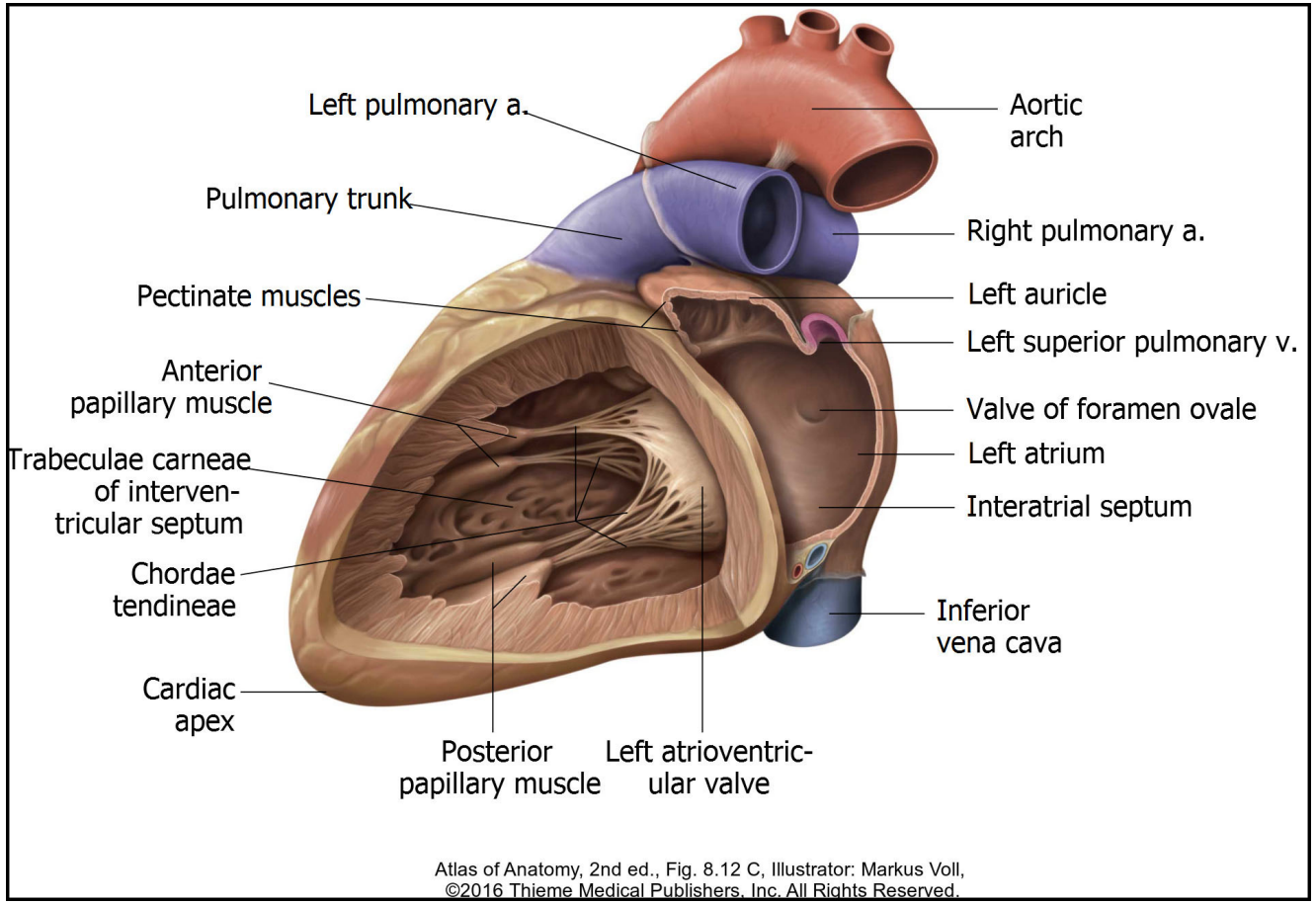


Internal Features Heart: Left Atrium

- The majority of the left atrium's interior consists of a smooth wall, which is ideal for receiving blood from the four **pulmonary veins**.
- Muscular ridges formed by **pectinate muscles** line the walls of the anterior half of the left atrium and the entire left auricle.
- The **orifice** of the **mitral (left atrioventricular) valve** allows passage of blood from the left atrium to the left ventricle during (ventricular) diastole.



Atlas of Anatomy, 2nd ed., Fig. 8.11 B, Illustrator: Markus Voll,



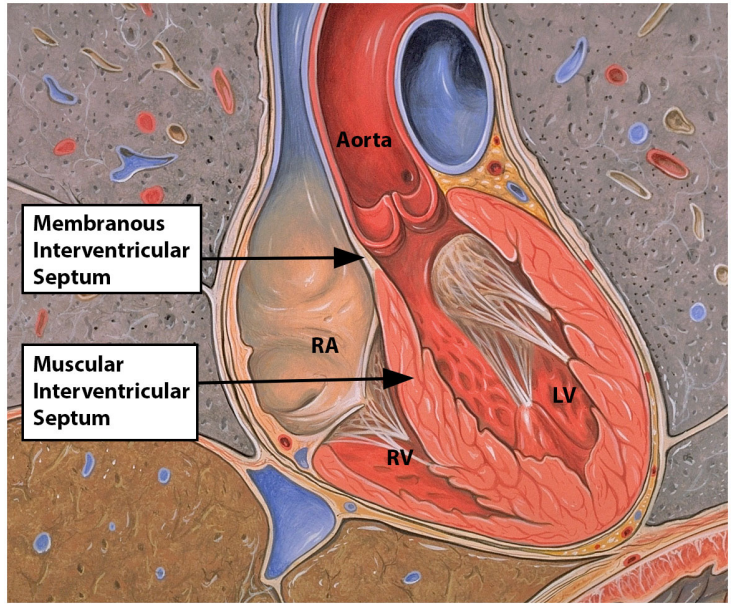
Atlas of Anatomy, 2nd ed., Fig. 8.12 C, Illustrator: Markus Voll,

Internal Features Heart: Left Ventricle

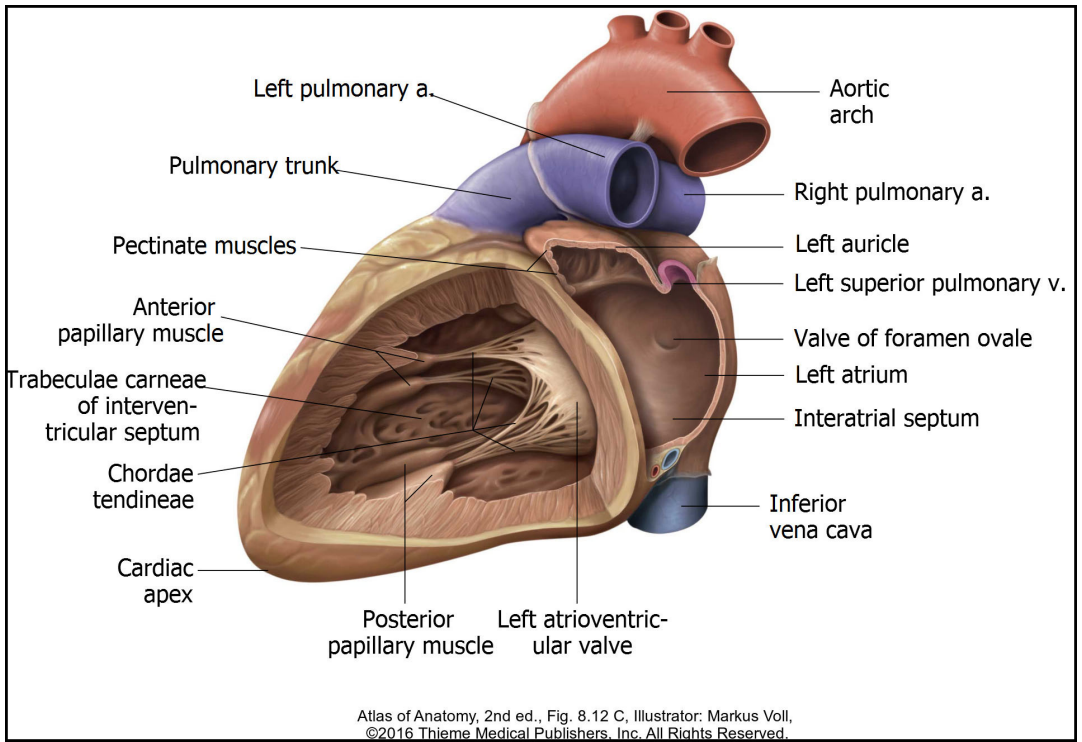
- The interior chamber of the left ventricle is conical and larger than the right ventricle
- The myocardium of the left ventricular wall is 2-3 times thicker than the right ventricle
- The **trabeculae carnae** in the left ventricle are finer and more numerous than those in the right ventricle
- The **mitral valve** consists of two cusps compared to three cusps of the tricuspid valve.
- The **papillary muscles** in the left ventricle are larger and fewer in number than the right.
- The **chordae tendineae** extend from the papillary muscles to the valve cusps. Note that they are similar on both sides of the heart.

The **interventricular septum** consists of two regions.

- The thick, inferior region is the **muscular portion**.
- The thin, superior region is the **membranous portion.**



CLINICAL ANATOMY: Isolated ventricular septal defects (VSDs) account for 25% of congenital heart anomalies. An isolated ventricular septal defect (VSD) occurs in approximately 2-6 of every 1000 live births. After bicuspid aortic valves, VSDs are the most commonly encountered congenital heart defects. Most (80%) VSDs occur in the membranous part of the septum and resolve with age.



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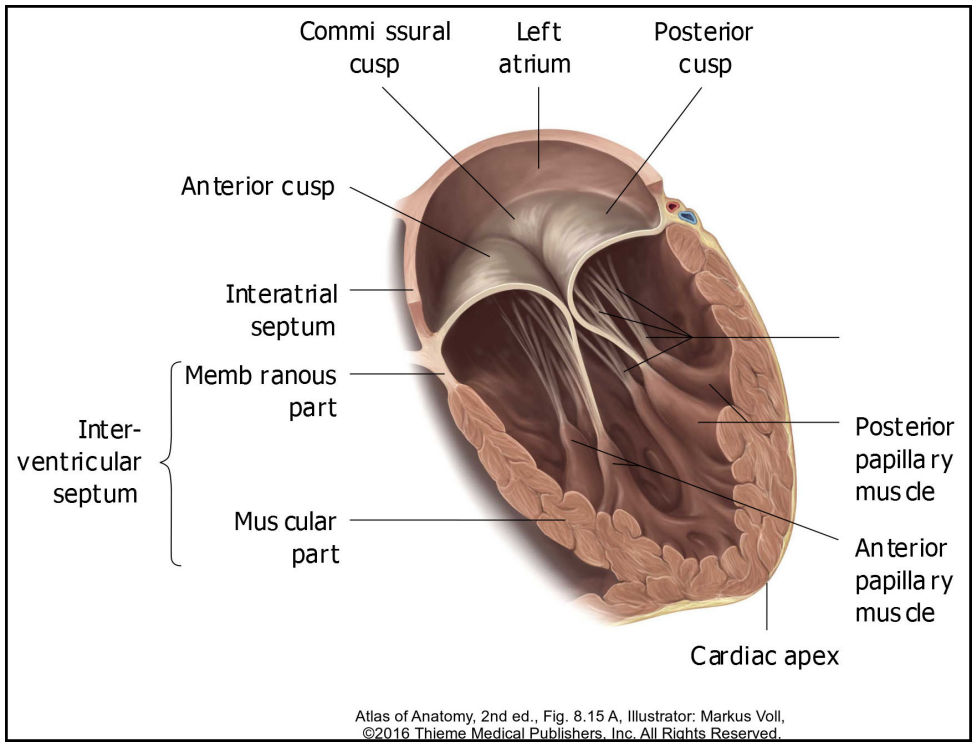

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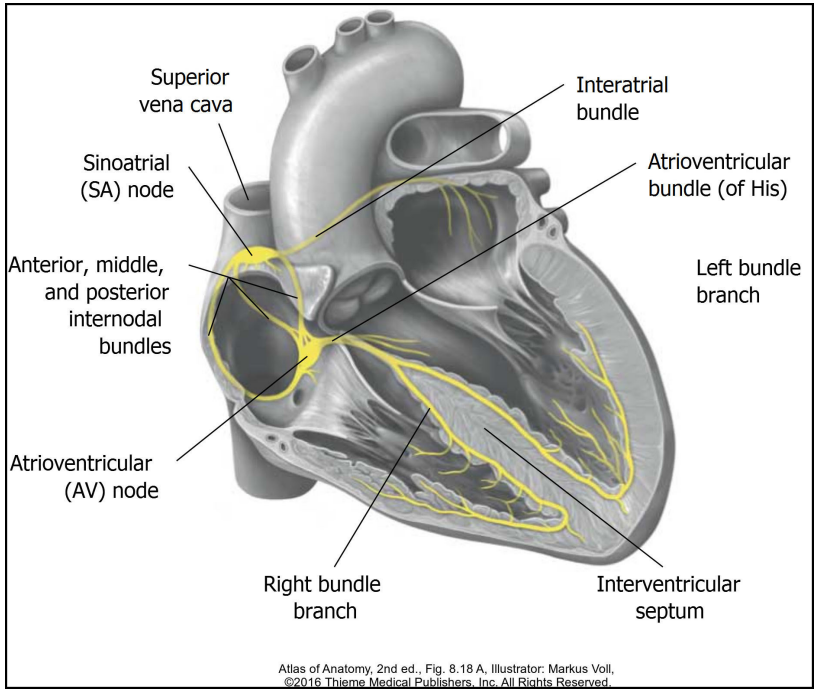
Cardiac Conduction System

- The **sinu-atrial (SA) node** is located in the wall of the right atrium at the junction of the superior vena cava and right atrium. The SA node is considered the “pacemaker” of the heart because its cells generate action potentials that determine the rate of the cardiac cycle.
- The **atrioventricular (AV) node** is located on the right side of the interatrial septum, just superior to the opening of the coronary sinus. The **atrioventricular (AV) bundle (of His)** is located in the membranous portion of the interventricular septum.
- The **AV bundle** splits into right and **left bundle branches** that travel on right and left sides of the muscular inter ventricular septum.
- The **subendocardial branches (Purkinje fibers)** are networks of conducting fibers from the right and left bundle branches located in the walls and papillary muscles of the right and left ventricles.



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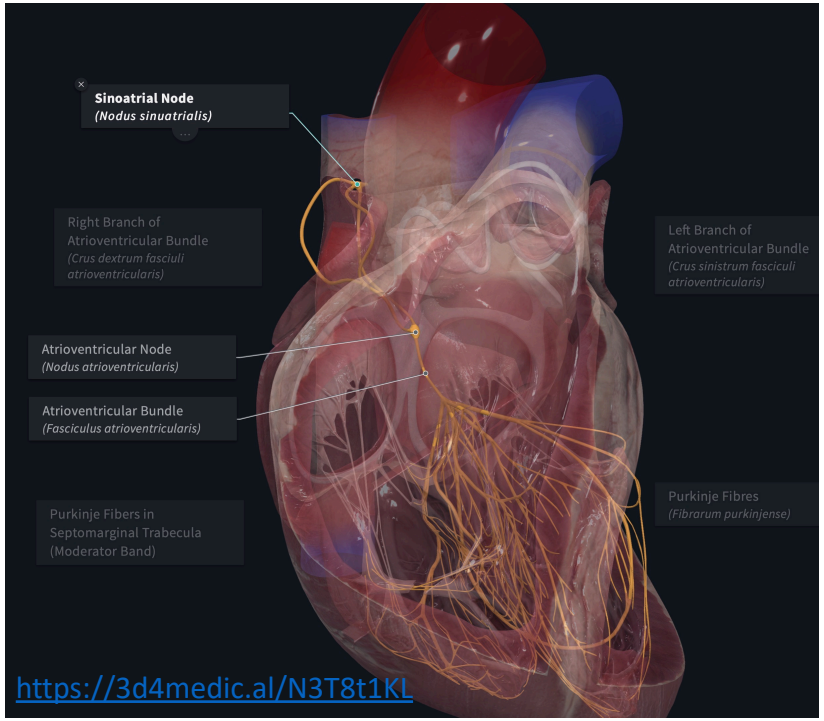

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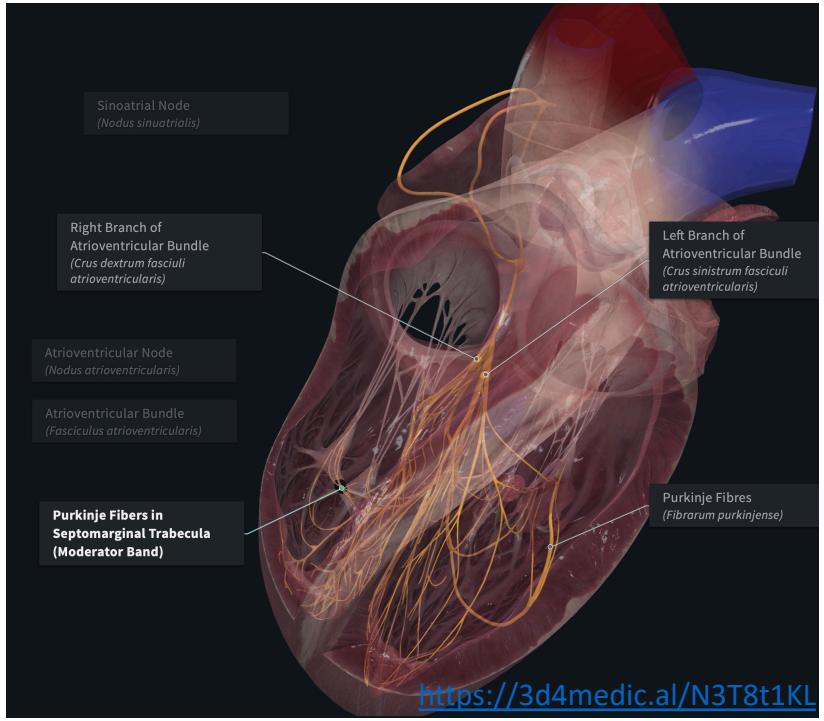

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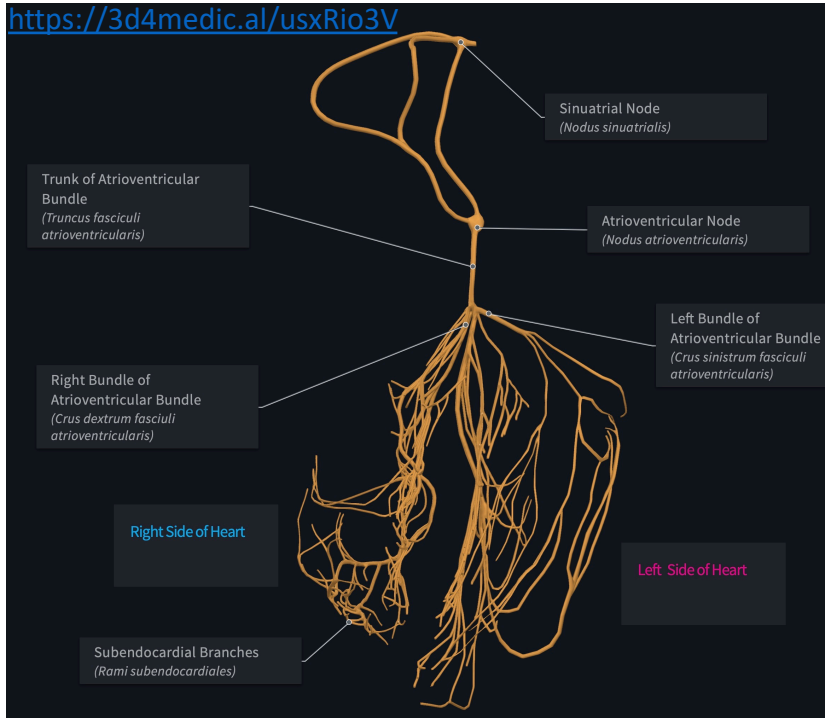


Blood Supply to Conduction System

- The **SA node** is supplied by the **sinu-atrial nodal artery**, which is most often (approx. 65% of individuals) a branch of the **right coronary artery** (Figure 1).
- The **AV node** is supplied by the **atrioventricular nodal artery**, which is usually the first branch of the **posterior interventricular artery** (continuation of right coronary a. in right dominant heart) (Figure 1).
- The **AV bundle** traverses through the middle of the interventricular septum. The anterior 2/3 of the interventricular septum is supplied by the LAD branch of the left coronary artery, which means blood is supplied to the **AV Bundle** via the **LAD** (Figures 1 and 2).

Figure 1

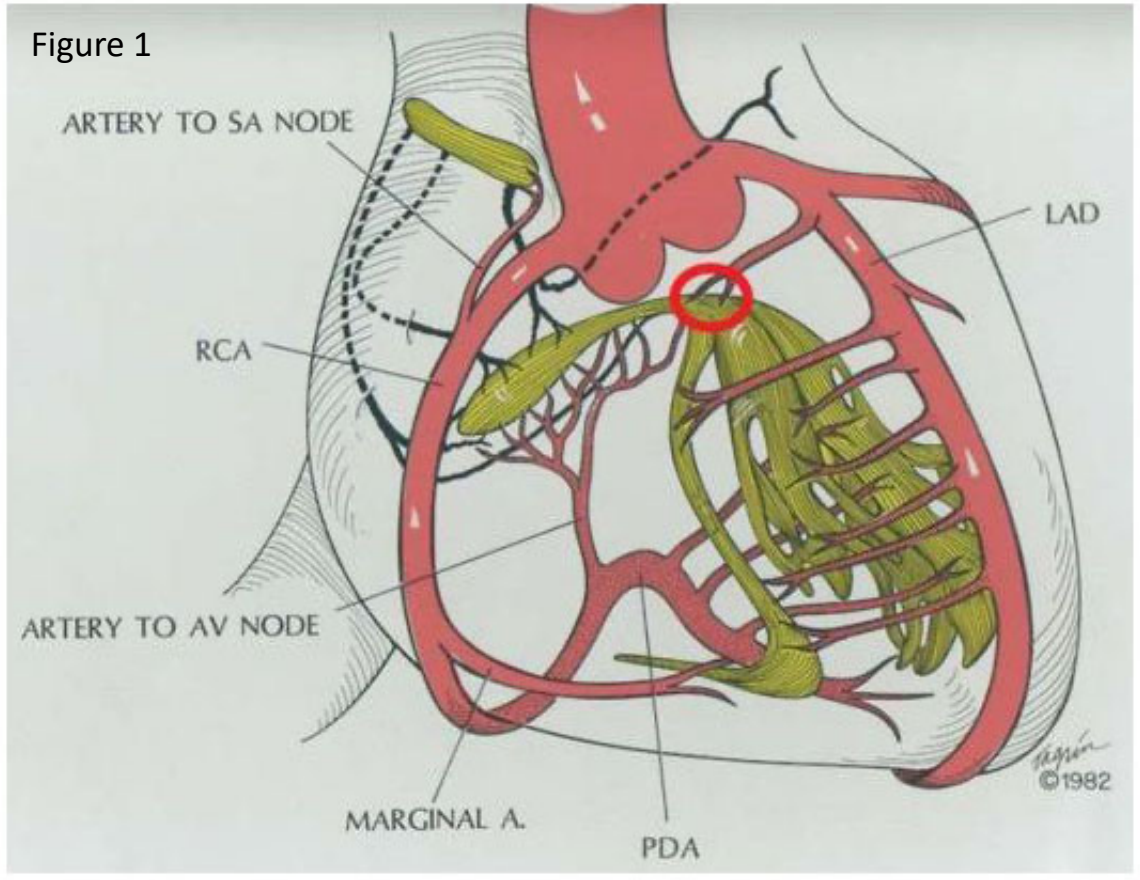
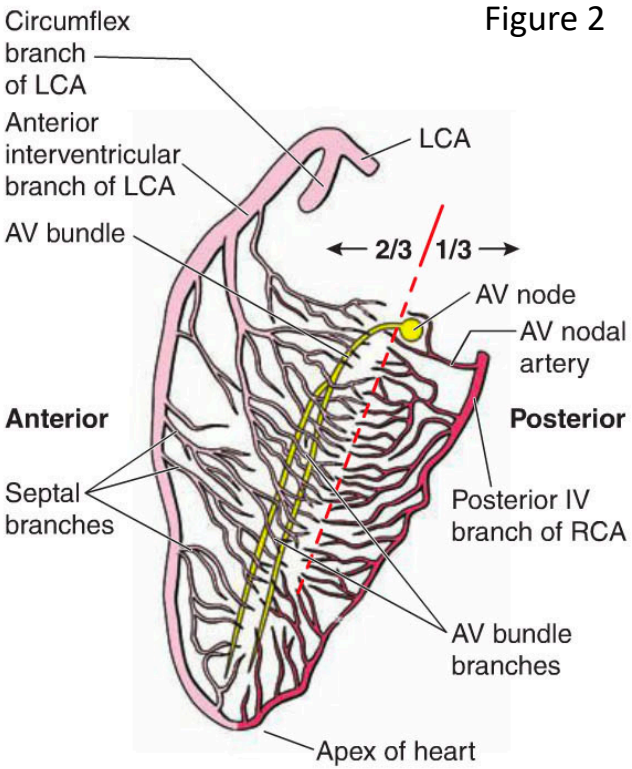


Figure 2



B **Arteries of isolated interventricular septum (from left side)**

Cardiac Plexus

Axons of the autonomic nervous system (sympathetic and parasympathetic) that supply the heart form a network of nerves called the **cardiac plexus**.
The cardiac plexus is divided anatomically into a superficial part and a deep part.

- The **superficial cardiac plexus** is located between the aortic arch and the pulmonary artery (Figure 1).
- The **deep cardiac plexus** is located between the aortic arch and the tracheal bifurcation (Figure 2).

Figure 1

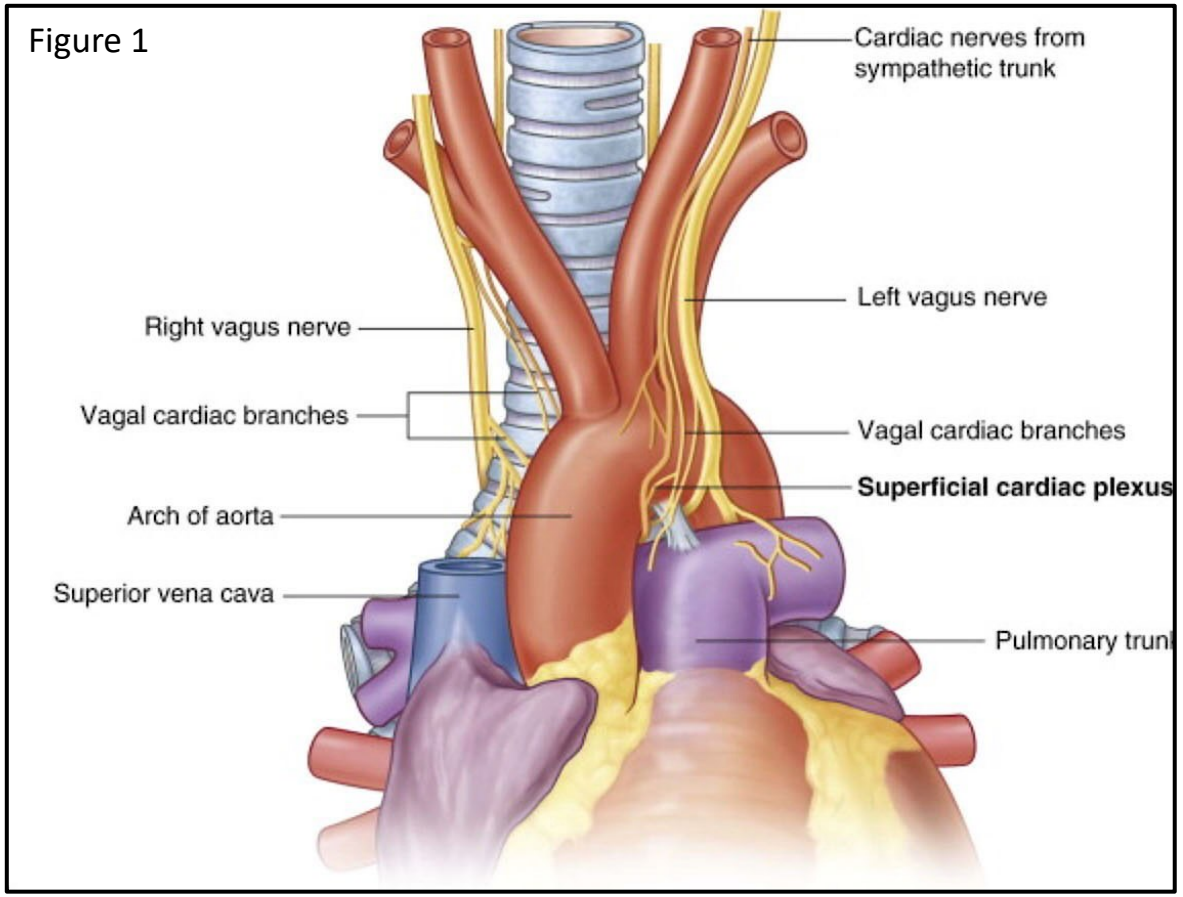
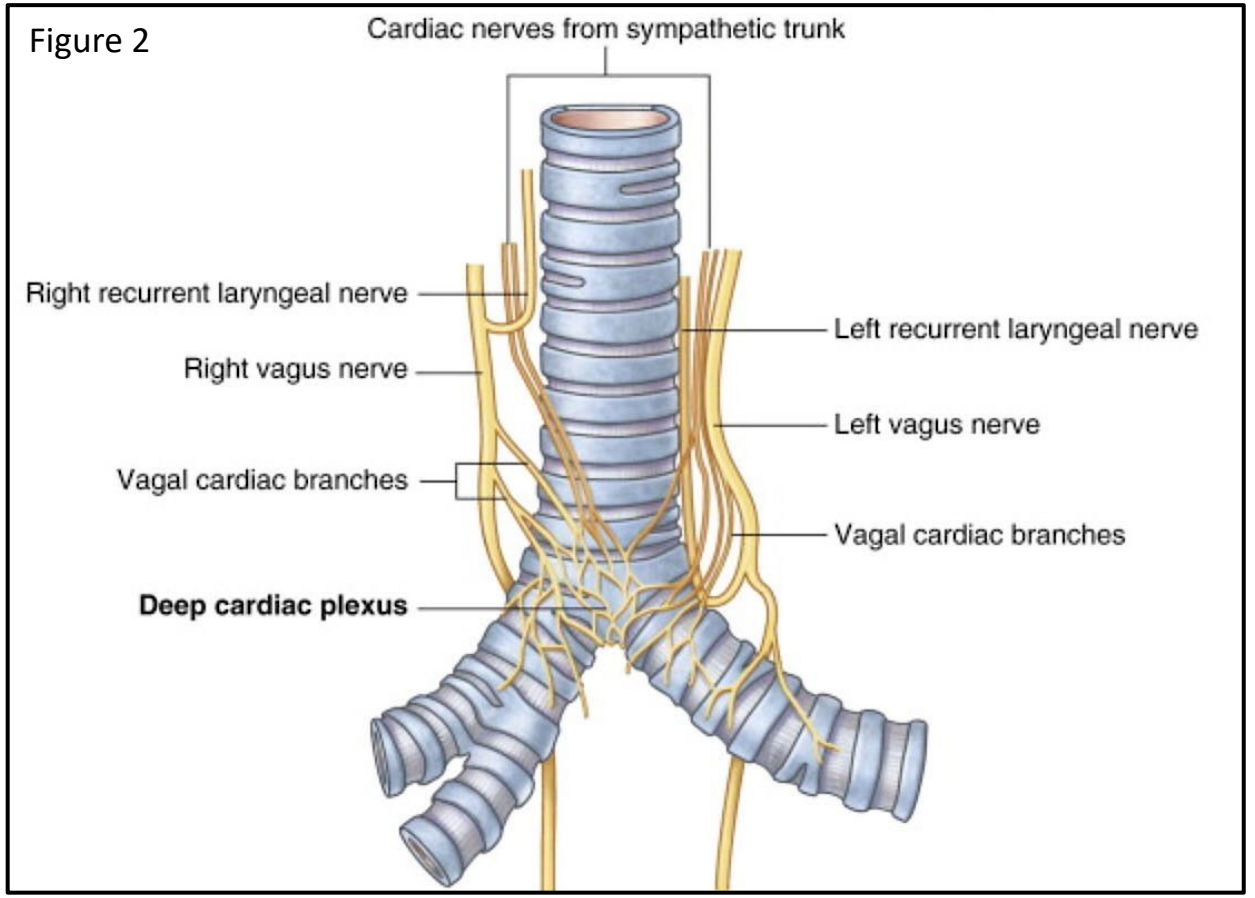


Figure 2



Autonomic Innervation of the Heart

The **superficial and deep cardiac plexus** both receive fibers from the sympathetic AND parasympathetic divisions of the autonomic nervous system.

- Sympathetic nervous system innervation to the heart is via cardiac nerves branching from both cervical and thoracic ganglia of the sympathetic trunk (Figure 1).
  - Preganglionic sympathetic fibers originate in the lateral horns (intermediolateral lateral columns) of the spinal cord gray matter at the spinal cord levels T1-5/6.
  - The preganglionic sympathetic fibers exit the spinal cord via the ventral root and enter the **sympathetic trunk** via **white rami communicantes**.
  - Prior to synapsing, preganglionic fibers can take one of two routes.
    - Preganglionic sympathetic fibers can synapse with postganglionic sympathetic fibers within thoracic sympathetic ganglia. After synapsing, the postganglionic fibers can exit the thoracic sympathetic ganglia as thoracic cardiac nerves.
    - Within ganglia of the sympathetic trunk, preganglionic fibers can ascend to a cervical ganglion to synapse with a postganglionic fiber. After synapsing, the postganglionic fibers can exit the sympathetic cervical ganglia as cervical cardiac nerves.
  - The postganglionic fibers proceed to the cardiac plexus as cervical and thoracic cardiac nerves.

- Parasympathetic nervous system innervation to the heart is via the vagus nerves. Preganglionic parasympathetic fibers enter the cardiac plexus as branches of the **right and left vagus nerves**. The preganglionic parasympathetic fibers synapse in ganglia located within the plexus or in the atrial walls.