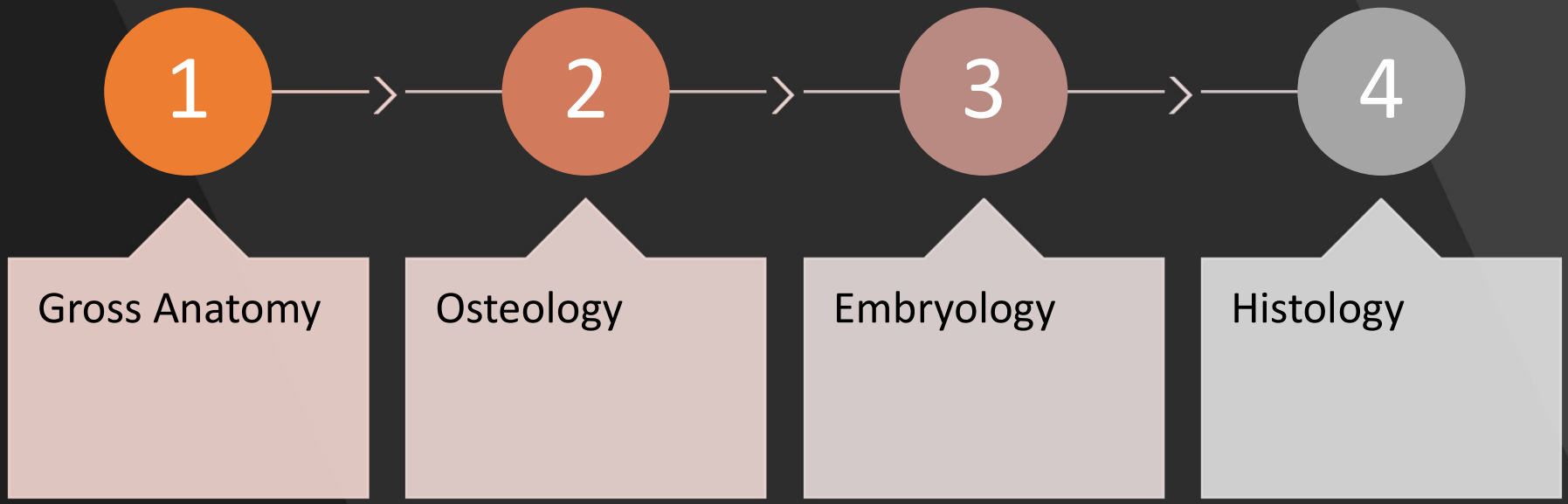
ANATOMY

ANATOMY



ANATOMY

THE BASICS | HEAD | NEUROANATOMY | NECK | THORAX

BACK | UPPER LIMB | LOWER LIMB | ABDOMEN | PELVIS

3D BODY | QUICK QUIZ

ANATOMY

THORAX

ANATOMY

AREAS	BONES	MUSCLES	ORGANS	VASCULATURE
• Superior Mediastinum • Anterior Mediastinum • Middle Mediastinum • Posterior Mediastinum	• Ribs • Sternum • Thoracic Spine	• Thoracic Cage • Diaphragm	• Thymus Gland • Mammary Glands • Heart • Lungs • Tracheobronchial Tree • Pleurae	• Aorta • Superior Vena Cava

THORAX

ORGANS

- **THYMUS GLAND**
- **MAMMARY GLANDS**
- **HEART**
- **LUNGS**
- **TRACHEOBRONCHIAL TREE**
- **PLEURAE**

THYMUS GLAND

Contents

- Introduction
- Structure and position
- vasculature

Thymus Gland

- The thymus gland is a pink, lobulated lymphoid organ, located in the thoracic cavity and neck. In the adolescent, it is involved in the development of the **immune system**. After puberty, it decreases in size and is slowly replaced by fat.
- Embryologically, the thymus gland is derived from the **third pharyngeal pouch**.
- In this article, we shall look at the anatomy of the thymus gland – its structure, position and vasculature

Thymus Gland

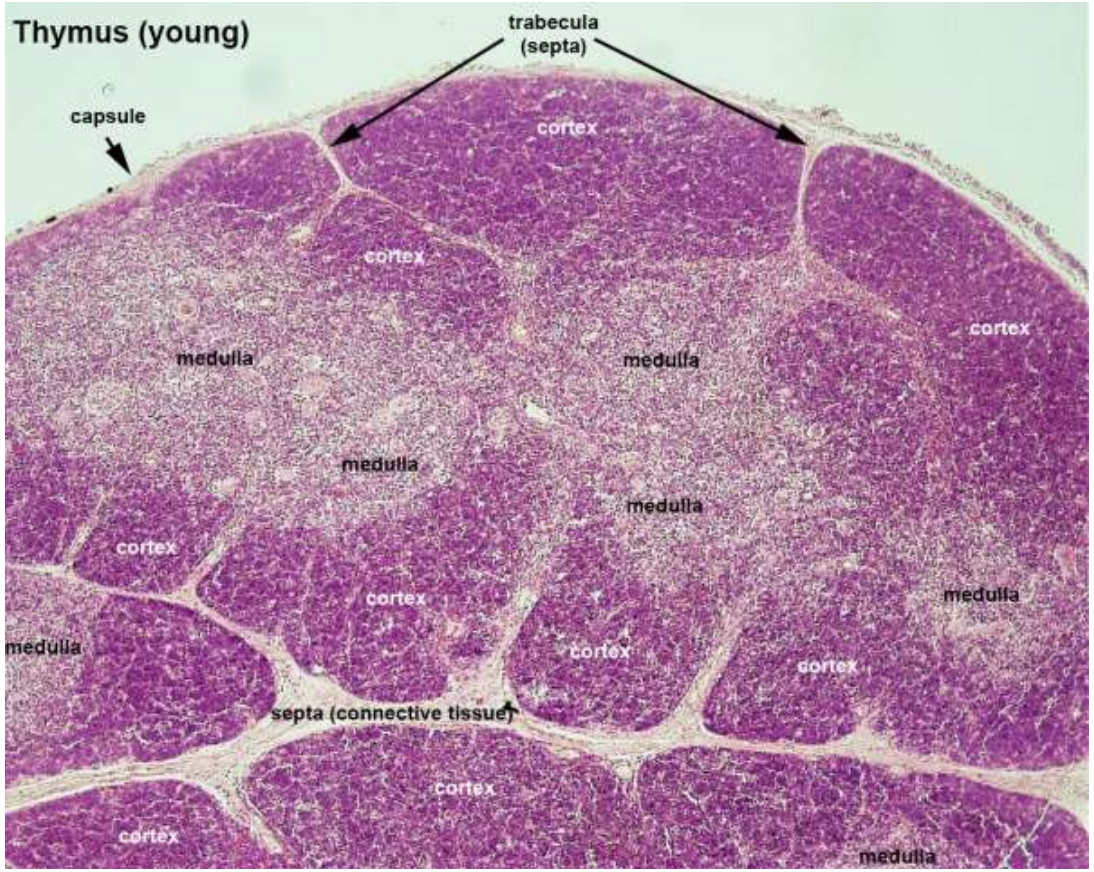
Anatomical Structure and Position

The thymus gland has an asymmetrical flat shape, with a lobular structure. The lobules are comprised of a series of follicles, which have a medullary and cortical component:

- **Cortical portion** – Located peripherally within each follicle. It is largely composed of lymphocytes, supported epithelial reticular cells.
- **Medullary portion** – Located centrally within each follicle. It contains fewer lymphocytes than the cortex, and an increased number of epithelial cells. Hassall's corpuscles are also present – these are concentric arrangements of epithelial reticular cells. Their function is unclear.

Thymus

Histology

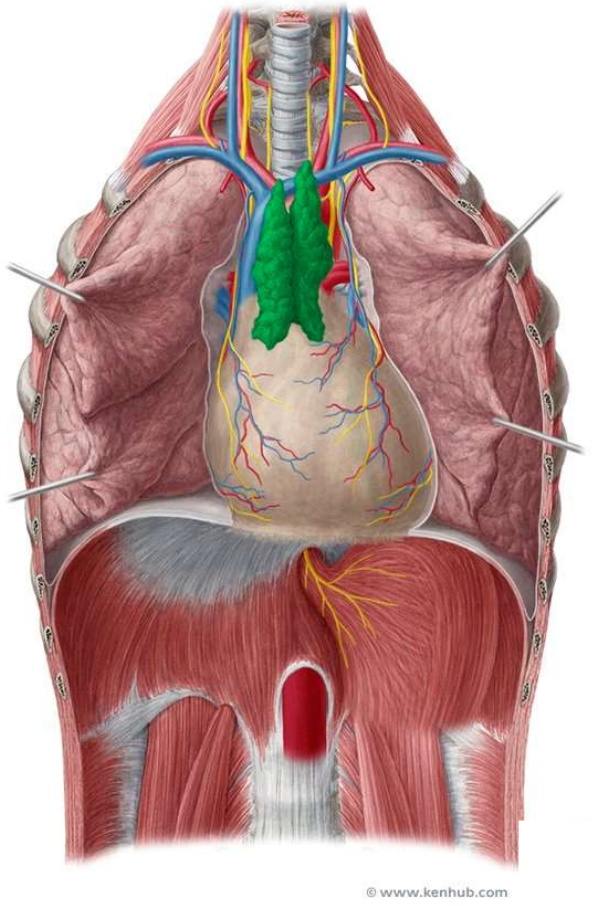


Thymus Gland

The gland is mainly located within the thoracic **superior mediastinum,** posterior to the manubrium of the sternum. However, in some individuals, it can extend superiorly into the neck (reaching the thyroid gland), and inferiorly into the **anterior mediastinum** (lying in front of the fibrous pericardium).

THYMUS

Location



Thymus

Vasculature

- The arterial supply to the thymus gland is via the anterior intercostal arteries and small branches from the **Internal thoracic arteries**. Venous blood drains into the **left brachiocephalic** and internal thoracic veins.

THYMUS

Clinical Relevance:

DiGeorge Syndrome

- DiGeorge syndrome is a genetic syndrome caused by the deletion of part of chromosome 22. The clinical findings vary greatly between individuals. The most common features of the syndrome can be memorised using the mnemonic ‘CATCH’:
- **C**ongenital heart defects
- **A**bnormal facies
- **T**hymic aplasia
- **C**left palate
- **H**ypoparathyroidism.
- Individuals with an absent or aplastic thymus are susceptible to recurrent infections due to an underdeveloped immune system.

DiGeorge Syndrome

THORAX

ORGANS

- THYMUS GLAND
- MAMMARY GLANDS
- HEART
- LUNGS
- TRACHEOBRONCHIAL TREE
- PLEURAE

MAMMARY GLAND

Contents

- Surface Anatomy
- Anatomical Structure
- Vasculature
- Lymphatics
- Nerve Supply
- Clinical Relevance: Breast Cancer

MAMMARY GLAND

The breasts are paired structures located on the anterior thoracic wall, in the pectoral region. They are present in both males and females, yet are more prominent in females following puberty.

- In females, the breasts contain the Mammary glands – an accessory gland of the female reproductive system. The mammary glands are the key structures involved in lactation.
- In this article, we shall look at the anatomy of the breasts – their structure, innervation, vascular supply and any clinical relevance.

Note: This article will consider the structure of the breasts in the female.

Mammary Gland

Surface antomy

The breast is located on the anterior thoracic wall. It extends horizontally from the lateral border of the sternum to the **mid-axillary line**. Vertically, it spans between the 2nd and 6th**intercostal cartilages**. It lies superficially to the pectoralis major and serratus anterior muscles.

The breast can be considered to be composed of two regions:

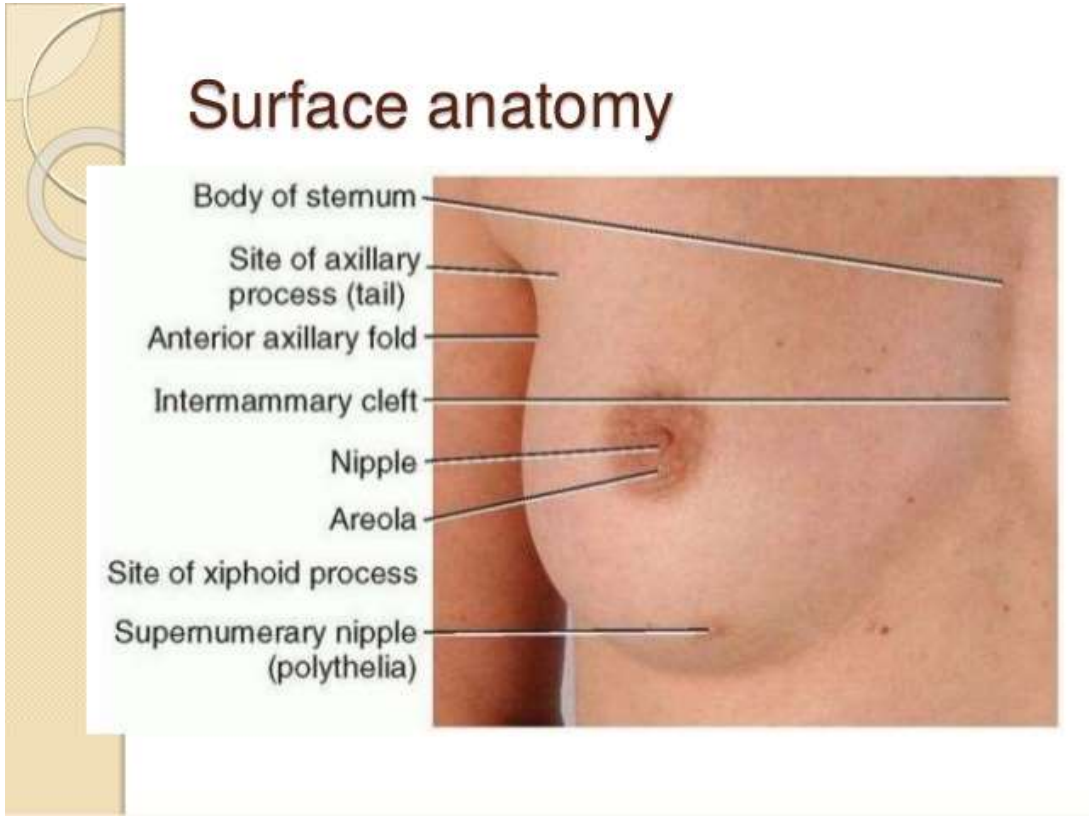
- **Circular body** – largest and most prominent part of the breast.
- **Axillary tail** – smaller part, runs along the inferior lateral edge of the pectoralis major towards the Axillary fossa.

MAMMARY GLAND

At the centre of the breast is the **nipple**, composed mostly of smooth muscle fibres. Surrounding the nipple is a pigmented area of skin termed the **areolae**. There are numerous **sebaceous glands** within the areolae – these enlarge during pregnancy, secreting an oily substance that acts as a protective lubricant for the nipple.

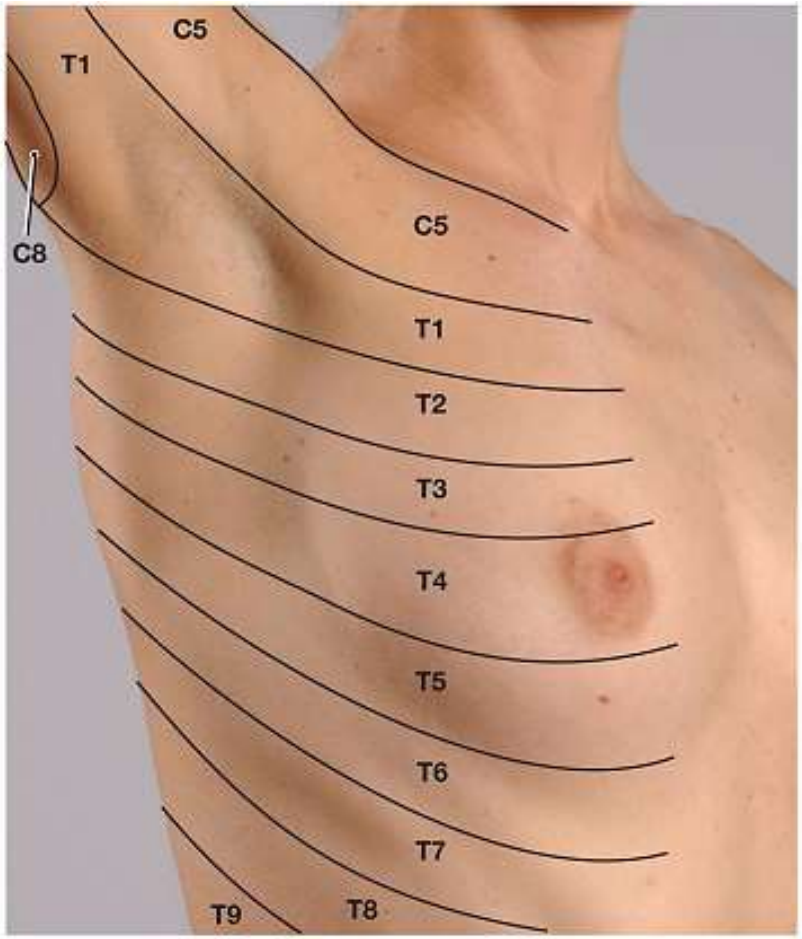
Mammary Gland

Surface Anatomy



MAMMARY Gland

Surface Marking

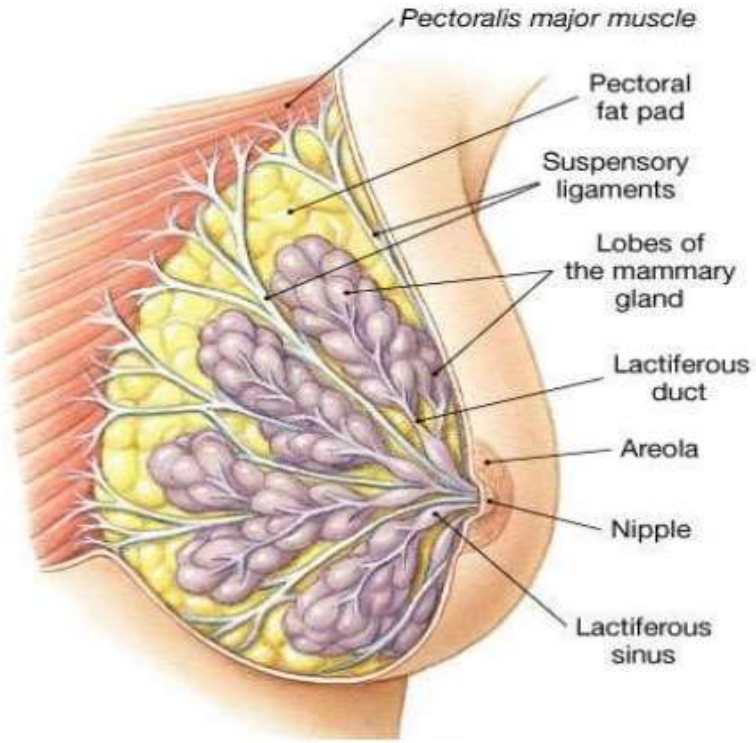


MAMMARY GLAND

Anatomical Structure

- The breast is composed of Mammary glands surrounded by a connective tissue stroma.
- **Mammary Glands**
- The mammary glands are modified sweat glands. They consist of a series of ducts and secretory lobules (15-20).
- Each lobule consists of many alveoli drained by a single **lactiferous duct**. These ducts converge at the **nipple** like spokes of a wheel.

Mammary Gland



Lobes

Lobules

Ducts

sinuses

Mammary Gland

Connective Tissue Stroma

- The connective tissue stroma is a supporting structure which surrounds the Mammary glands. It has a fibrous and a fatty component.
- The **fibrous stroma** condenses to form suspensory ligaments (of Cooper). These ligaments have two main functions:
- Attach and secure the breast to the dermis and underlying pectoral fascia.
- Separate the secretory lobules of the breast.

Mammary Gland

Pectoral Fascia

- The base of the breast lies on the **Pectoral Fascia** – a flat sheet of connective tissue associated with the pectoralis major muscle. It acts as an attachment point for the suspensory ligaments.
- There is a layer of loose connective tissue between the breast and pectoral fascia – known as the **retromammary space**. This is a potential space, often used in reconstructive plastic surgery.

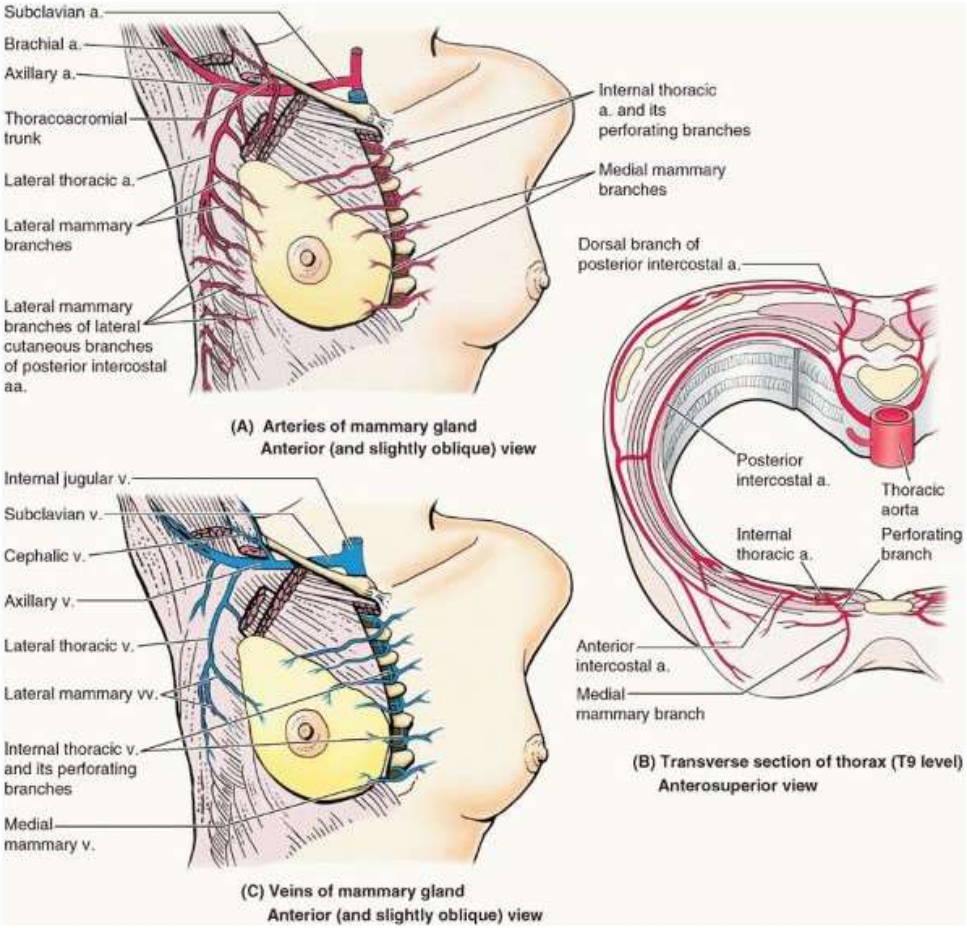
Mammary Gland

Vasculature

- Arterial supply to the medial aspect of the breast is via the **internal thoracic artery**, a branch of the subclavian artery.
- The lateral part of the breast receives blood from four vessels:
- **Lateral thoracic and thoracoacromial branches** – originate from the axillary artery.
- **Lateral mammary branches** – originate from the posterior intercostal arteries (derived from the aorta). They supply the lateral aspect of the breast in the 2^{nd} 3^{rd} and 4^{th}intercostal spaces.
- **Mammary branch** – originates from the anterior intercostal artery.
- The veins of the breast correspond with the arteries, draining into the **axillary** and **internal thoracic veins**.

Mammary Gland

Vasculature



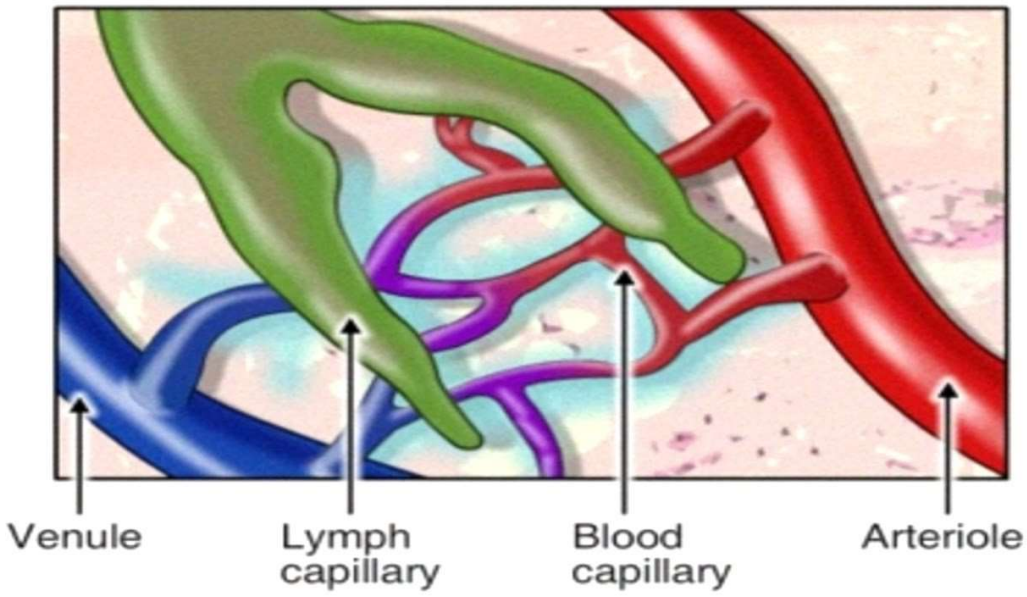
Mammary Gland

Lymphatics

- The lymphatic drainage of the breast is of great clinical importance due to its role in the **metastasis** of breast cancer cells.
- There are three groups of lymph nodes that receive lymph from breast tissue – the axillary nodes (75%), parasternal nodes (20%) and posterior intercostal nodes (5%).
- The skin of the breast also receives lymphatic drainage:
- **Skin** – drains to the axillary, inferior deep cervical and infraclavicular nodes.
- **Nipple and areola** – drains to the subareolar lymphatic plexus.

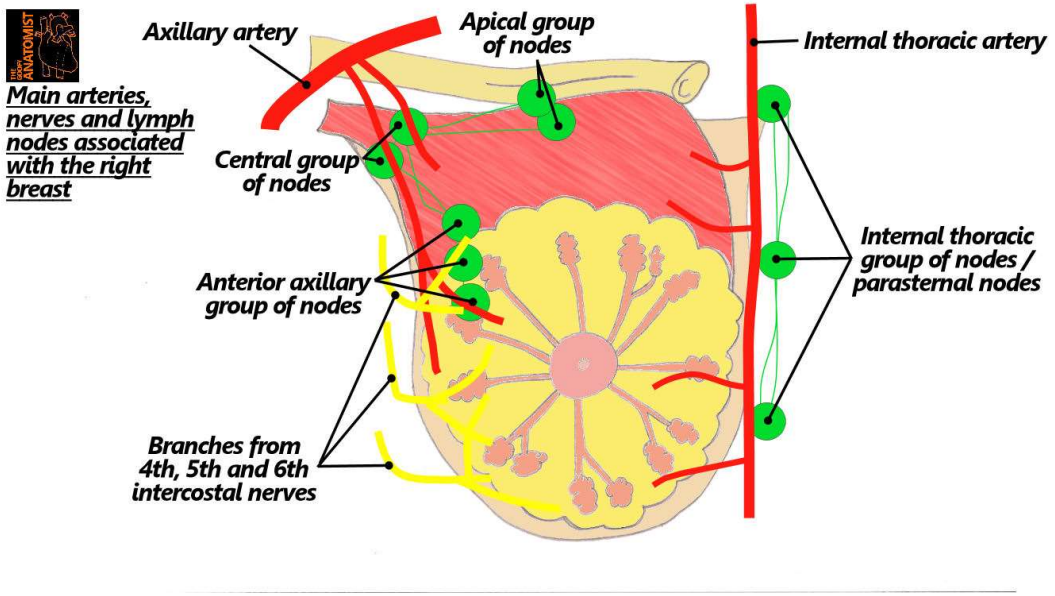
Mammary Gland

Lymphatics



Mammary Gland

Lymphatics



Mammary Gland

Nerve Supply

- The breast is innervated by the **anterior** and **lateral cutaneous branches** of the 4th to 6th intercostal nerves. These nerves contain both sensory and autonomic nerve fibres (the autonomic fibres regulate smooth muscle and blood vessel tone).
- It should be noted that the nerves do not control the secretion of milk. This is regulated by the hormone prolactin, which is secreted from the **anterior pituitary gland**.

Mammary Gland

Clinical Relevance: Breast Cancer

- Breast cancer is the most common type of cancer to be diagnosed within the UK. After lung cancer it has the second highest death rate due to cancer. It is more common in women than men.
- Common presentations associated with breast cancer are due to blockages of the **lymphatic drainage**. Excess lymph builds up in the subcutaneous tissue, resulting in clinical features such as nipple deviation and retraction, and prominent skin between small dimpled pores (peau d'orange). Larger dimples are generally caused by cancerous invasions and fibrosis. This causes traction of the **suspensory ligaments**, causing them to shorten.
- Metastasis commonly occurs through the lymph nodes. It is most likely to be the **axillary lymph nodes** that are involved. They become stony hard and fixed. Following this, the cancer can spread to distant places such as the liver, lungs, bones and ovary.

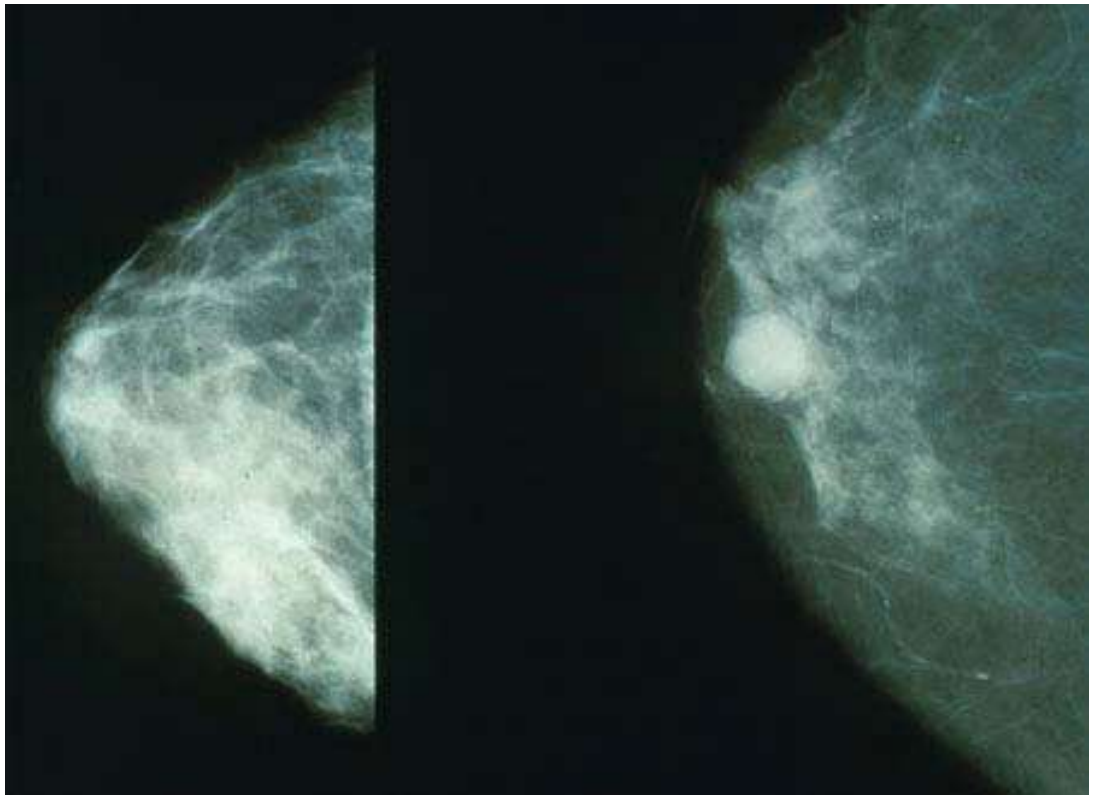
Mammary Gland

Clinical Anatomy

- To assess a suspected breast cancer a triple assessment is carried out. This involves clinical examination, imaging using a **mammogram** and ultrasound scan and finally a biopsy.
- The staging of breast cancer uses the I-IV system or the Tumour Node Metastasis (TNM) system.
- **Surgical** treatment with adjuvant radiotherapy is the recommended treatment option. The operation is local and aims to remove only the affected tissue area. Failing this it is considered that a **mastectomy** is the best option. Adjuvant chemotherapy is also known to improve survival rates.

Mammary Gland

Mammogram



Organs of Thorax

- **THYMUS GLAND**
- **MAMMARY GLANDS**
- **HEART**
- **LUNGS**
- **TRACHEOBRONCHIAL TREE**
- **PLEURAE**

Organs of Thorax

Heart

HEART

Great vessels of the heart

Surface Anatomy of heart

Chamber of the heart

The conducting system

The Heart Wall

Pericardium

Valves of the wall

Vasculature of the Wall

Great Vessels of Heart

Contents

GREAT VESSELS OF THE HEART

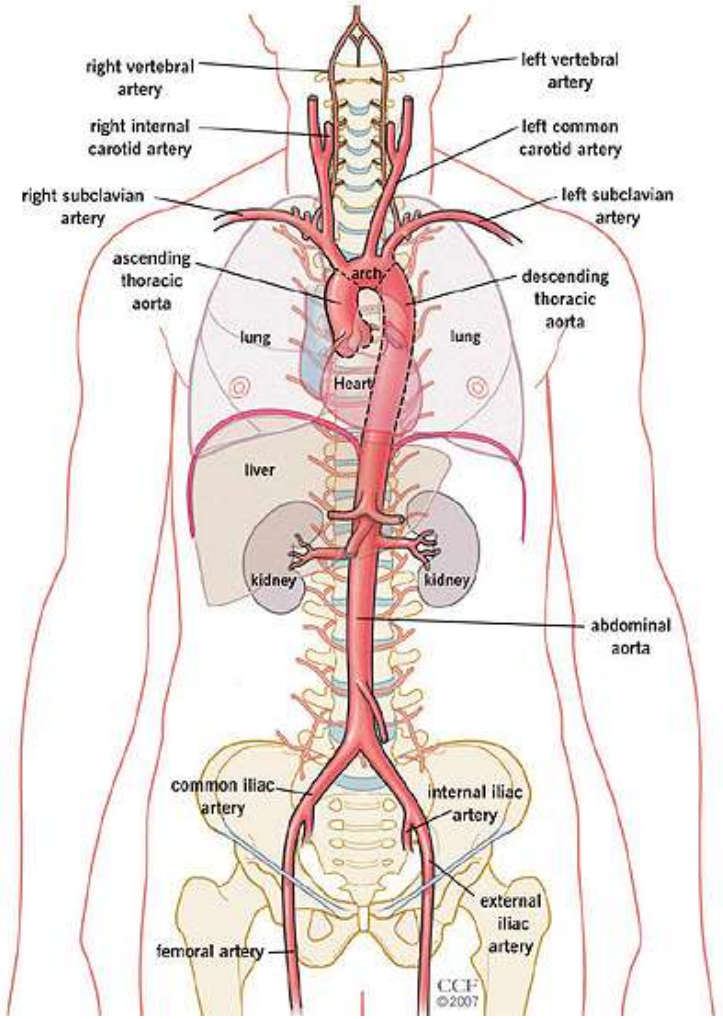
The great vessels of the heart function to carry blood to and from the heart as it pumps, located largely within the middle mediastinum.

GREAT VESSLES OF THE HEART

Aorta

- The aorta is the largest artery in the body. It carries oxygenated blood (pumped by the left side of the heart) to the rest of the body.
- The aorta arises from the **aortic orifice** at the base of the left ventricle, with inflow via the **aortic valve**. Its first segment is known as the **ascending aorta**, which lies within the pericardium (covered by the visceral layer). From it branch the coronary arteries. The second continuous segment is the arch of the aorta, from which branch the major arteries to the head, neck and upper limbs. These are:
- **Brachiocephalic trunk**
- **Left common carotid artery**
- **Left subclavian artery**
- After the arch of the aorta, the aorta then becomes the **descending aorta** which continues down through the diaphragm into the abdomen.

Aorta


right vertebral artery
left vertebral artery
right internal carotid artery
left common carotid artery
right subclavian artery
left subclavian artery
ascending thoracic aorta
arch
descending thoracic aorta
lung
lung
Heart
liver
kidney
kidney
abdominal aorta
common iliac artery
internal iliac artery
external iliac artery
femoral artery
CCF
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GREAT VESSELS FO THE HEART

Clinical Relevance

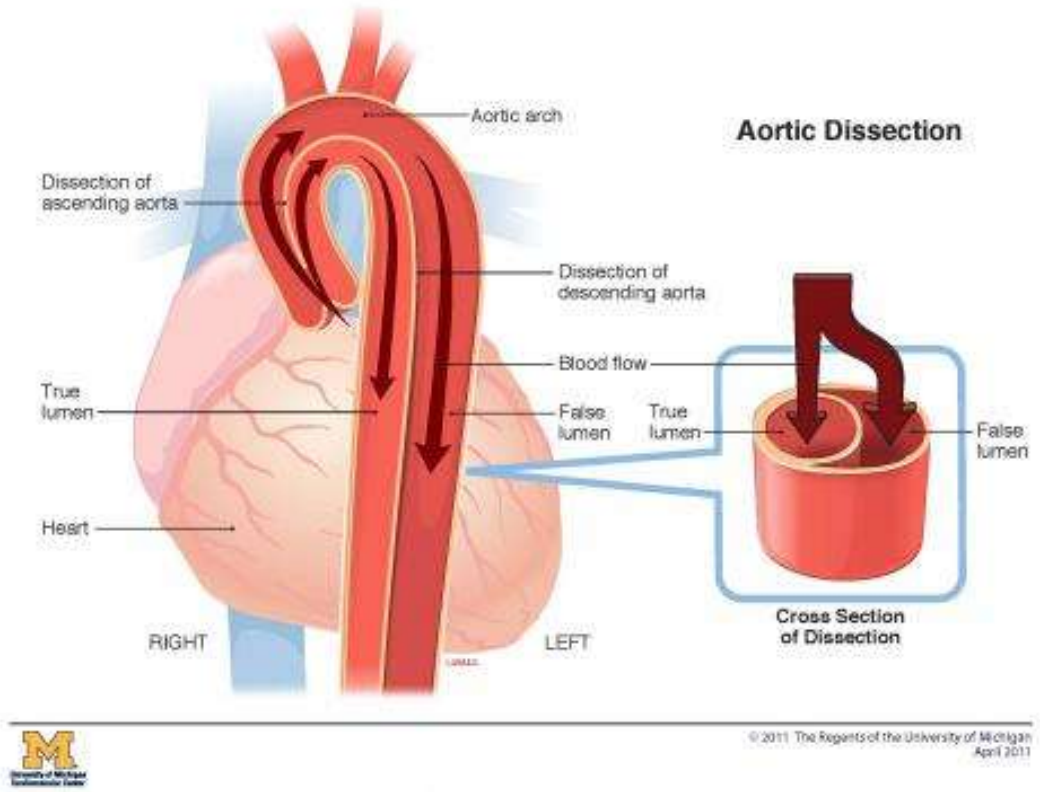
Aortic dissection

Refers to a tear in the **inner wall** of the aorta. The tear creates two channels for blood flow; one is the normal lumen of the aorta, another is into the wall, where the blood becomes stationary.

Blood entering the wall can constrict the aortic lumen, reducing blood flow to the rest of the body. It can also cause further weakness and **dilation** of the wall, potentially leading to an aortic aneurysm.

HEART

GREAT VESSLES OF THE HEART



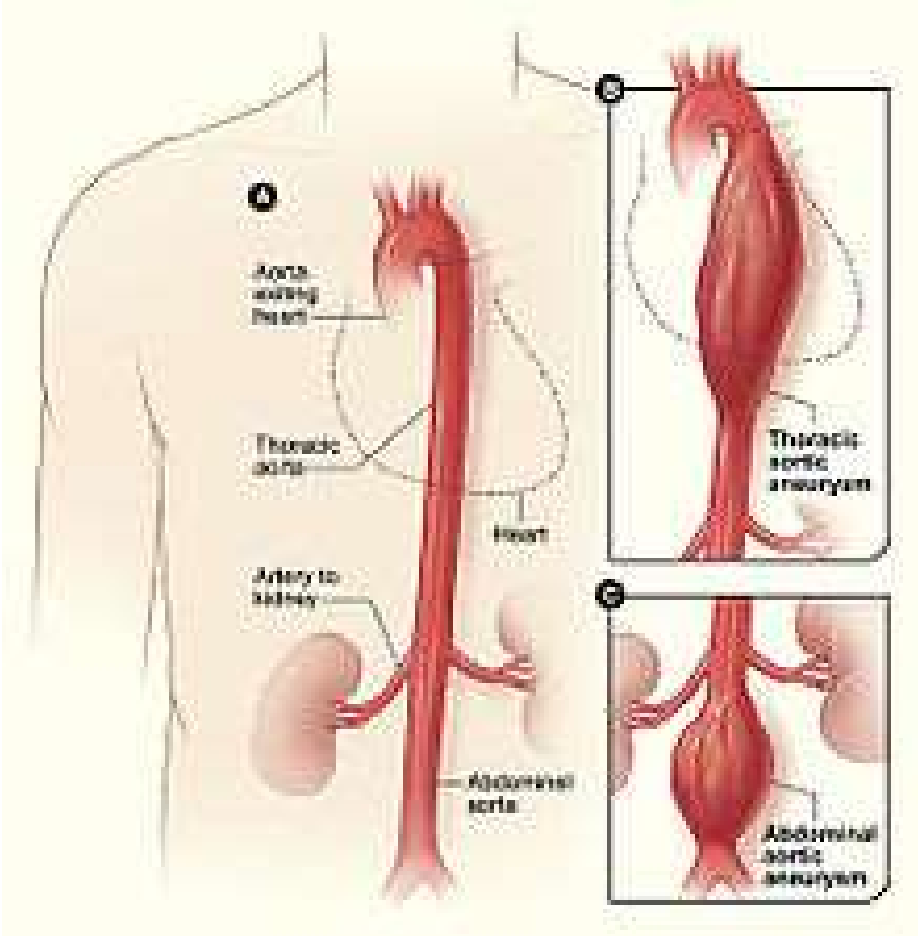
GREAT VESSLES OF THE HEART

Aortic Aneurysm

- An **aneurysm** is a dilation (expansion) of an artery, which is greater than 50% of the normal diameter. An aortic aneurysm is due to an underlying weakness of the walls (such as Marfan's syndrome), or a pathological process (such as aortic dissection).
- The main concern with an aortic aneurysm is rupture of the aorta, which if not treated, will lead to death

Great vessels of the Heart

Aortic Aneurysm



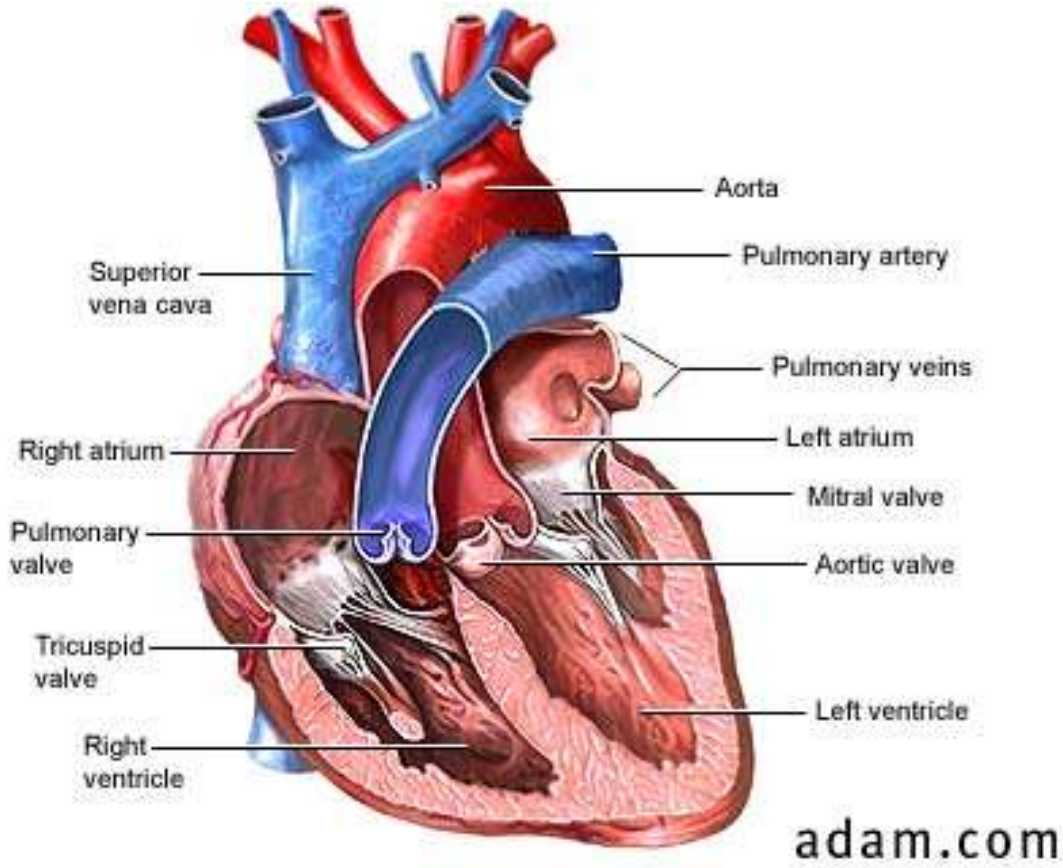
GREAT VESSLES OF THE HEART

Pulmonary Arteries

- The pulmonary arteries receive **deoxygenated** blood from the right ventricle, and deliver it to the lungs for gas exchange to take place.
- The arteries begin as the pulmonary trunk, a thick and short vessel, which is separated from the right ventricle by the **pulmonary valve**. The trunk is located anteriorly and medially to the right atrium, sharing a common layer of pericardium with the ascending aorta. It continues upwards, overlapping the root of the aorta and passing posteriorly.
- At around the level of T5-T6, the **pulmonary** trunk splits into the right and left pulmonary arteries. The left pulmonary artery supplies blood to the left lung, bifurcating into two branches to supply each **lobe** of the lung. The right pulmonary artery is the thicker and longer artery of the two, supplying blood to the right lung. It also further divides into two branches

Vessels of the Heart

Pulmonary Artery



Great vessels of the Heart

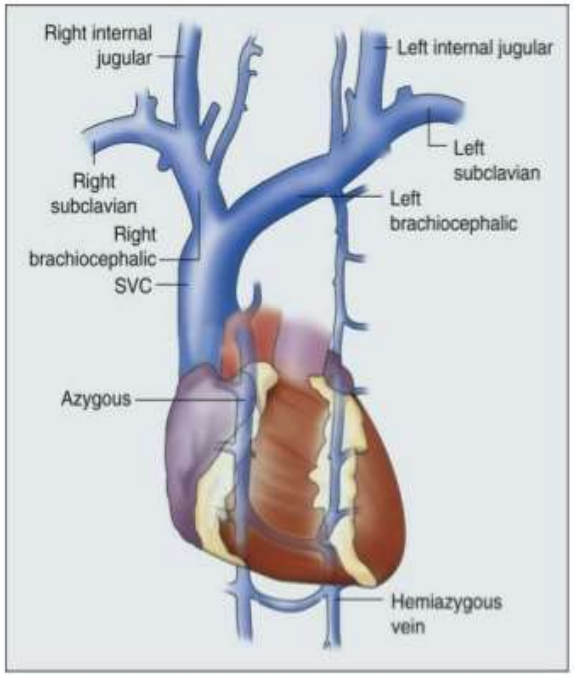
Superior Vena Cava

- The superior vena cava receives **deoxygenated** blood from the upper body (superior to the diaphragm, excluding the lungs and heart), delivering it to the right atrium.
- It is formed by merging of the **brachiocephalic veins**, travelling inferiorly through the thoracic region until draining into the superior portion of the right atrium at the level of the 3rd rib.
- As the superior vena cava makes its descent it is located in the right side of the superior mediastinum, before entering the middle mediastinum to lie beside the ascending aorta.

Great Vessels of the Heart

Superior Vena cava

Anatomy



- Thin walled.
- Low pressure vessel.
- Drainage of venous blood from upper half of body.
- 7cm in length.
- 20-22mm in diameter.

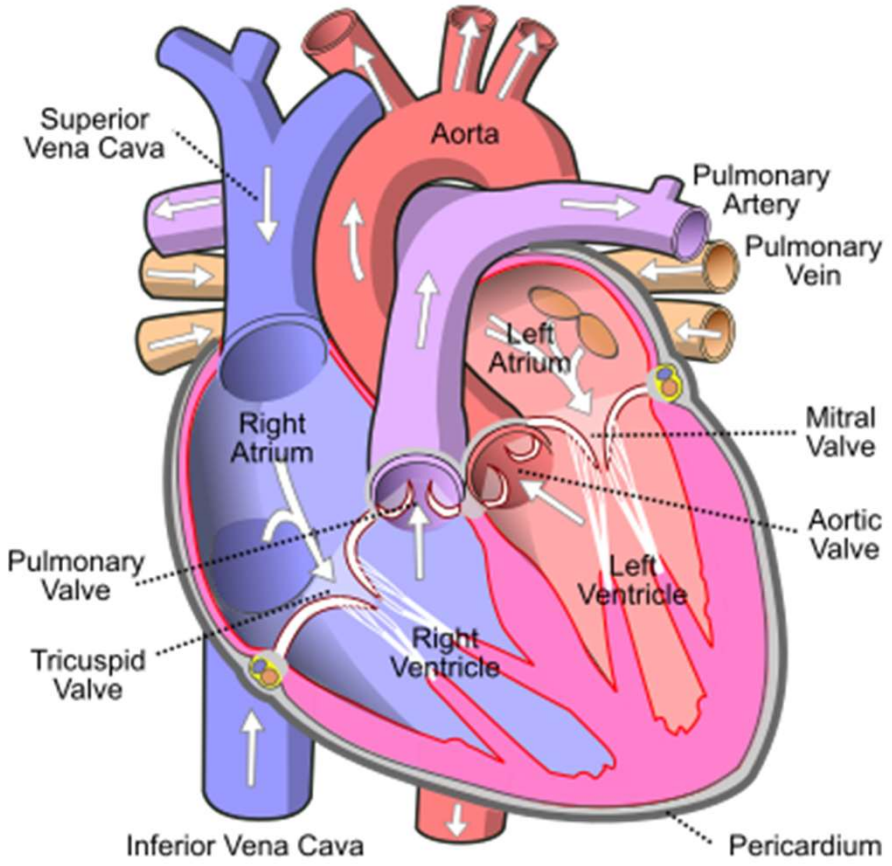
Great Vessels of the Heart

Inferior Vena Cava

- The inferior vena cava receives **deoxygenated** blood from the lower body (all structures inferior to the diaphragm), delivering it back to the heart.
- It is initially formed in the pelvis by the **common iliac veins** joining together. It travels through the abdomen, collecting blood from the hepatic, lumbar, gonadal, renal and phrenic veins. The inferior vena cava then passes through the diaphragm, entering the pericardium at the level of T8. It drains into the inferior portion of the right atrium.

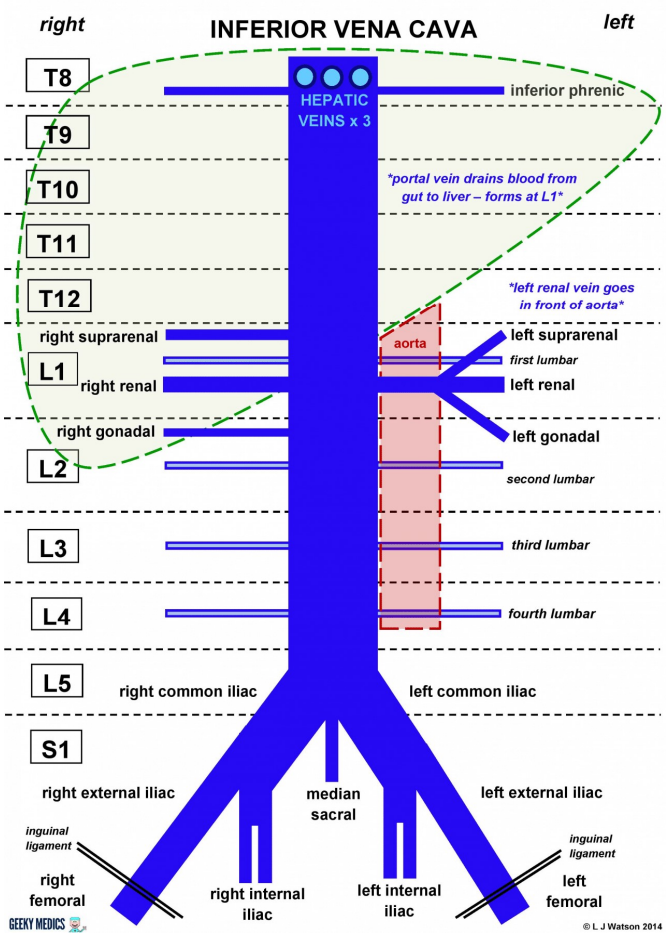
Great Vessels of the Heart

Inferior Vena cava



Vessels of the Heart

Inferior Vena cava



Heart

Surface Anatomy of the Heart

1 Orientation and Surfaces

2 Borders

3 Sulci of the Heart

4 Pericardial Sinuses

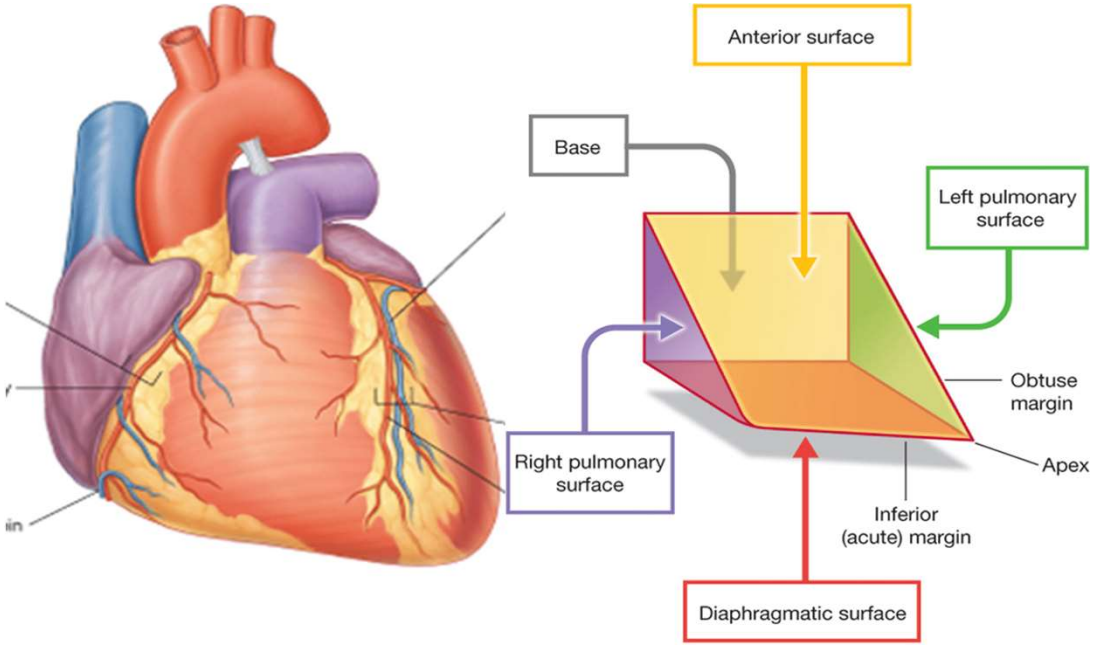
- 4.1 Clinical Relevance: Transverse Pericardial Sinus

Heart

Orientation and Surfaces

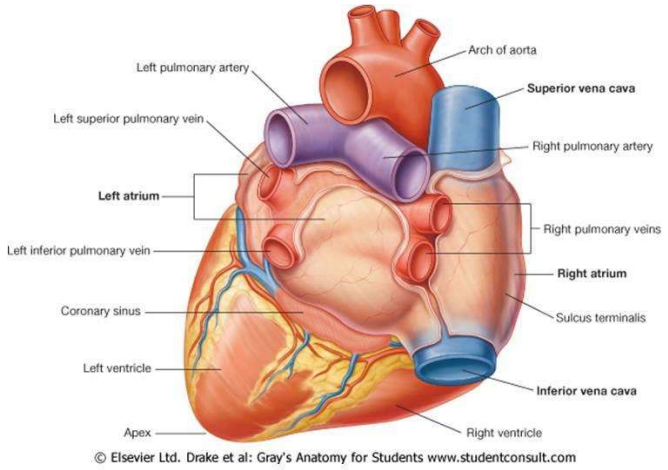
- The heart has been described by many texts as “a pyramid which has fallen over”. The **apex** of this pyramid pointing in an anterior-inferior direction.
- In its typical anatomical orientation, the heart has 5 surfaces, formed by different internal divisions of the heart:
- **Anterior (or sternocostal)** – Right ventricle.
- **Posterior (or base)** – Left atrium.
- **Inferior (or diaphragmatic)** – Left and right ventricles.
- **Right pulmonary** – Right atrium.
- **Left pulmonary** – Left ventricle.

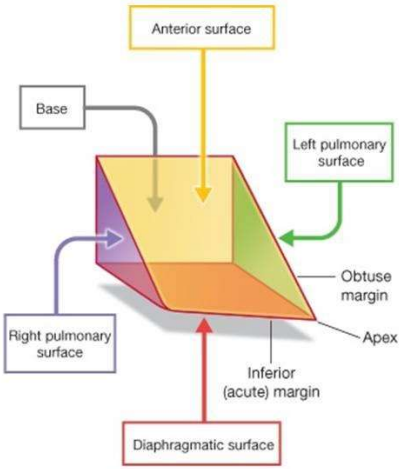
Surfaces of the Heart



Surface Anatomy Of Heart

Surface of the Heart





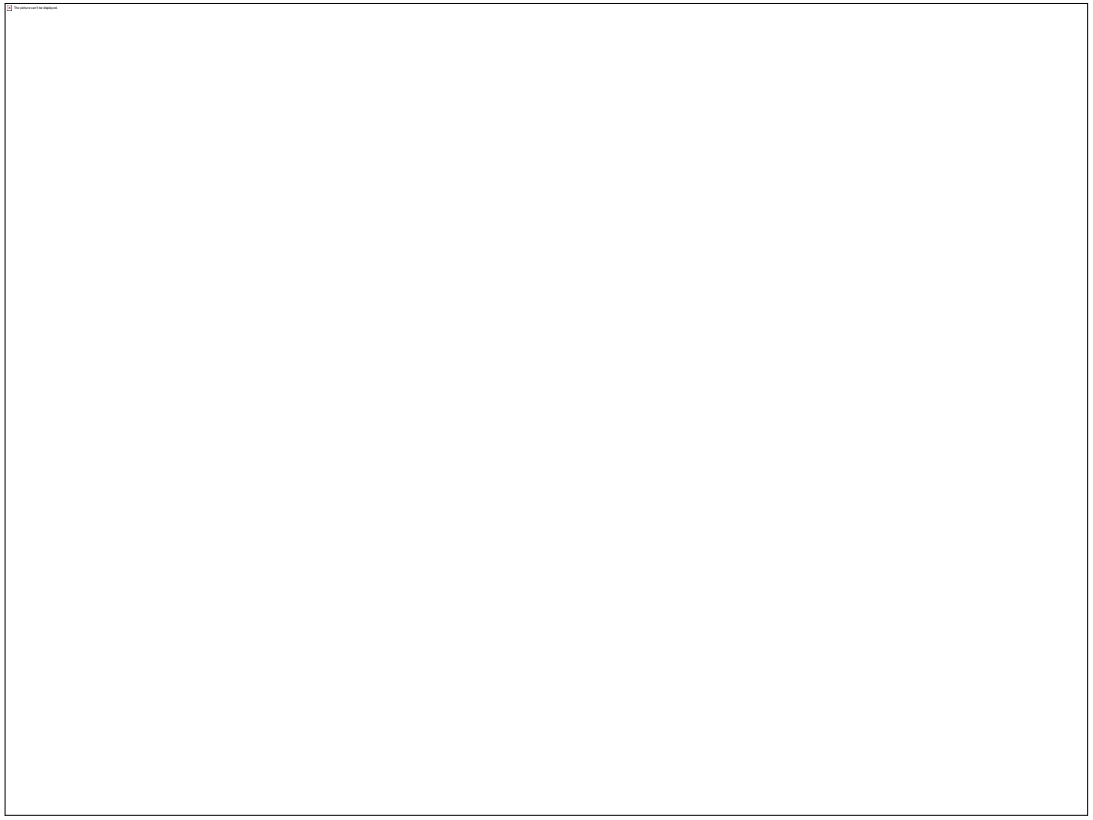
Heart

Borders

- Separating the surfaces of the heart are its borders. There are four main borders of the heart:
- **Right border** – Right atrium
- **Inferior border** – Left ventricle and right ventricle
- **Left border** – Left ventricle (and some of the left atrium)
- **Superior border** – Right and left atrium and the great vessels

Surface Anatomy of heart

Border



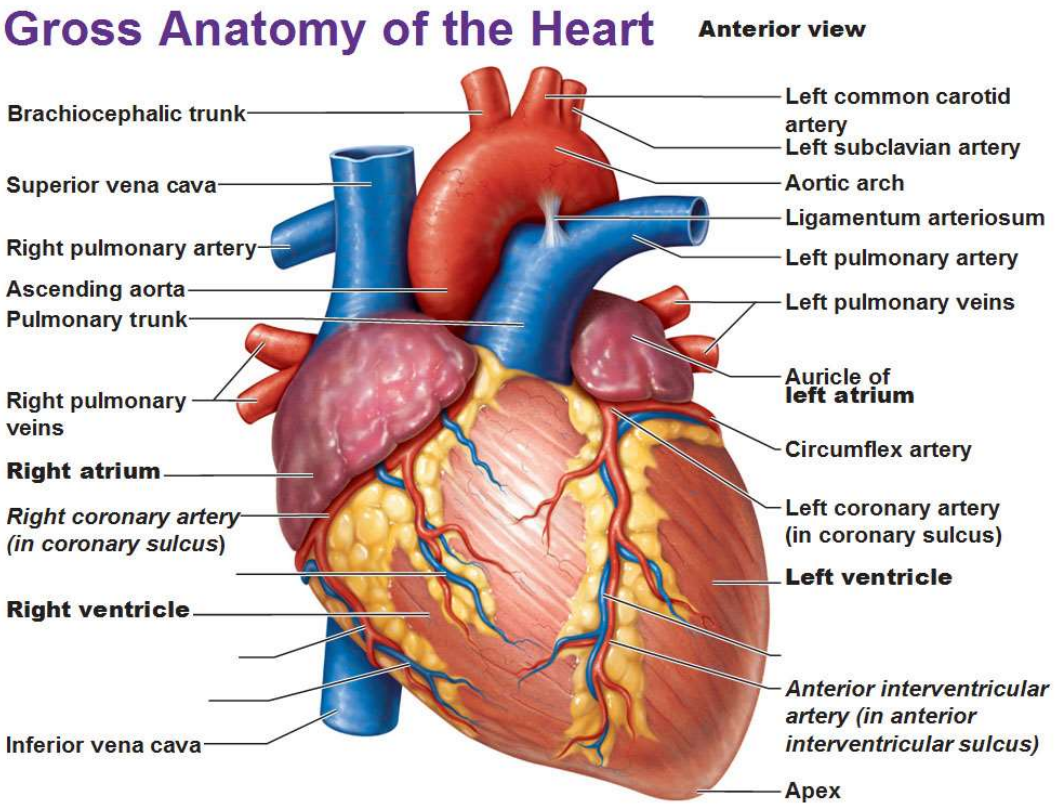
Heart

Sulci of the Heart

- The heart is a hollow structure. On the interior, it is divided into four chambers. These divisions create grooves on the surface of the heart – these are known as sulci.
- The **coronary sulcus** (or atrioventricular groove) runs transversely around the heart – it represents the wall dividing the atria from the ventricles. The sinus contains important vasculature, such as the right coronary artery.
- The **anterior** and **posterior interventricular** sulci can be found running vertically on their respective sides of the heart. They represent the wall separating the ventricles.

Surface anatomy of Heart

Sulci of Heart



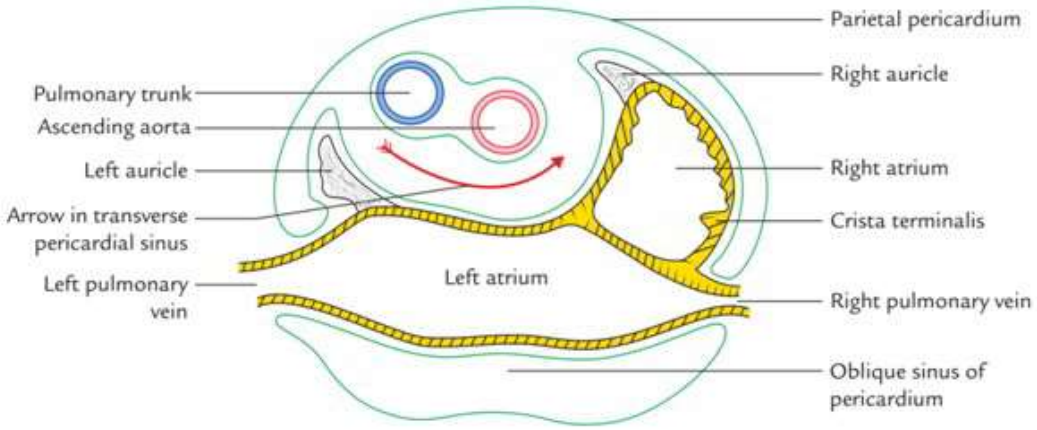
Heart

Pericardial Sinuses

- The pericardial sinuses are **not** the same as 'anatomical sinuses' (such as the paranasal sinuses). They are **passageways** formed the unique way in which the pericardium folds around the great vessels.
- The **oblique pericardial sinus** is a blind ending passageway ('cul de sac') located on the posterior surface of the heart.
- The **transverse pericardial sinus** is found superiorly on the heart. It can be used in coronary artery bypass grafting – see below.

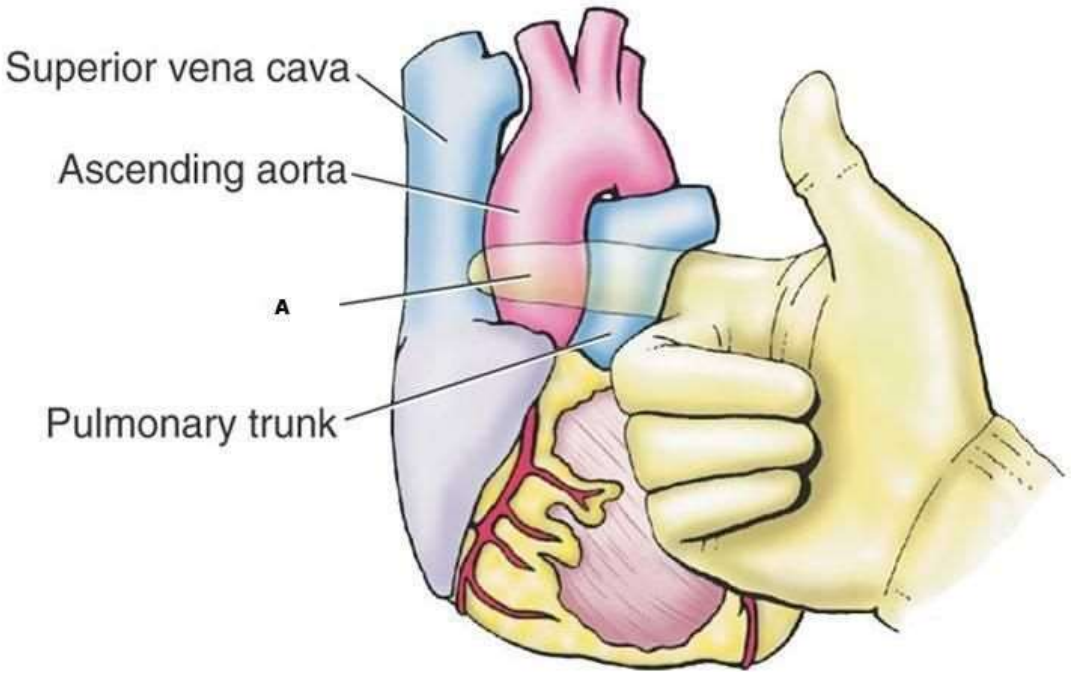
Surface Anatomy of Heart

Pericardial Sinus



Surface Anatomy of Heart

Pericardial Sinus



Heart

Clinical Relevance: Transverse Pericardial Sinus

The location of the transverse pericardial sinus is:

- **Posterior** to the ascending aorta and pulmonary trunk.
- **Anterior** to the superior vena cava.
- **Superior** to the left atrium.
- In this position, the transverse pericardial sinus **separates** the arterial vessels (aorta, pulmonary trunk) and the venous vessels (superior vena cava, pulmonary veins) of the heart.
- This can be used to identify and subsequently ligate (to tie off) the **arteries** of the heart during coronary artery bypass grafting.

The Heart

The Chambers of the Heart

Chamber of the Heart

Chambers of the Heart

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 left ventricle, blood passes into the aorta and enters the **systemic circulation**. From the right, it enters the **pulmonary circulation** via the pulmonary arteries.
- In this article we shall look at the anatomy of the atria and the ventricles, and we will consider their clinical correlations.

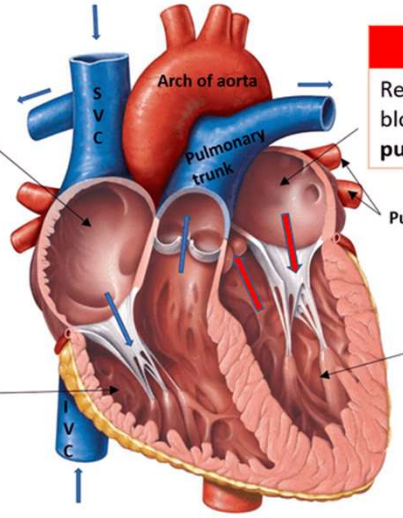
Chambers of The Heart

RIGHT ATRIUM

Receives deoxygenated blood from the body via **SVC, IVC and coronary sinus**

RIGHT VENTRICLE

Receives deoxygenated blood from right atrium via **Right atrioventricular orifice** and sends it to lungs via **Pulmonary trunk**.



LEFT ATRIUM

Receives oxygenated blood from the lungs via **pulmonary veins.**

LEFT VENTRICLE

Receives oxygenated blood from left atrium via **Left atrioventricular orifice** and sends it to body via **aorta.**

Chambers of the Heart

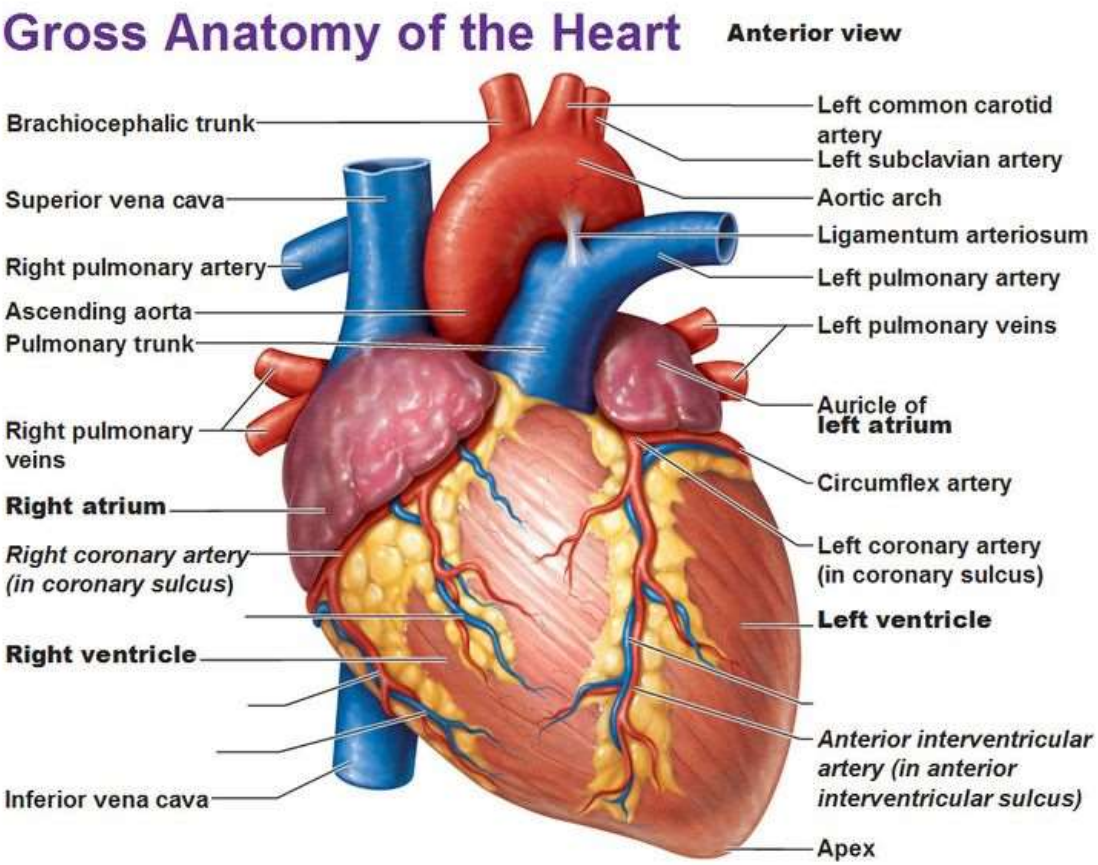
Atria

Right Atrium

- The right atrium receives deoxygenated blood from the superior and inferior **vena cavae**, and from the coronary veins. It pumps this blood through the right **atrioventricular orifice**(guarded by the tricuspid valve) into the right ventricle.
- In the anatomical position, the right atrium forms the **right border** of the heart. Extending from the antero-medial portion of the chamber is the **right auricle** (right atrial appendage) – a muscular pouch that acts to increase the capacity of the atrium.
- The interior surface of the right atrium can be divided into two parts, each with a distinct embryological origin. These two parts are separated by a muscular ridge called the **crista terminalis**:

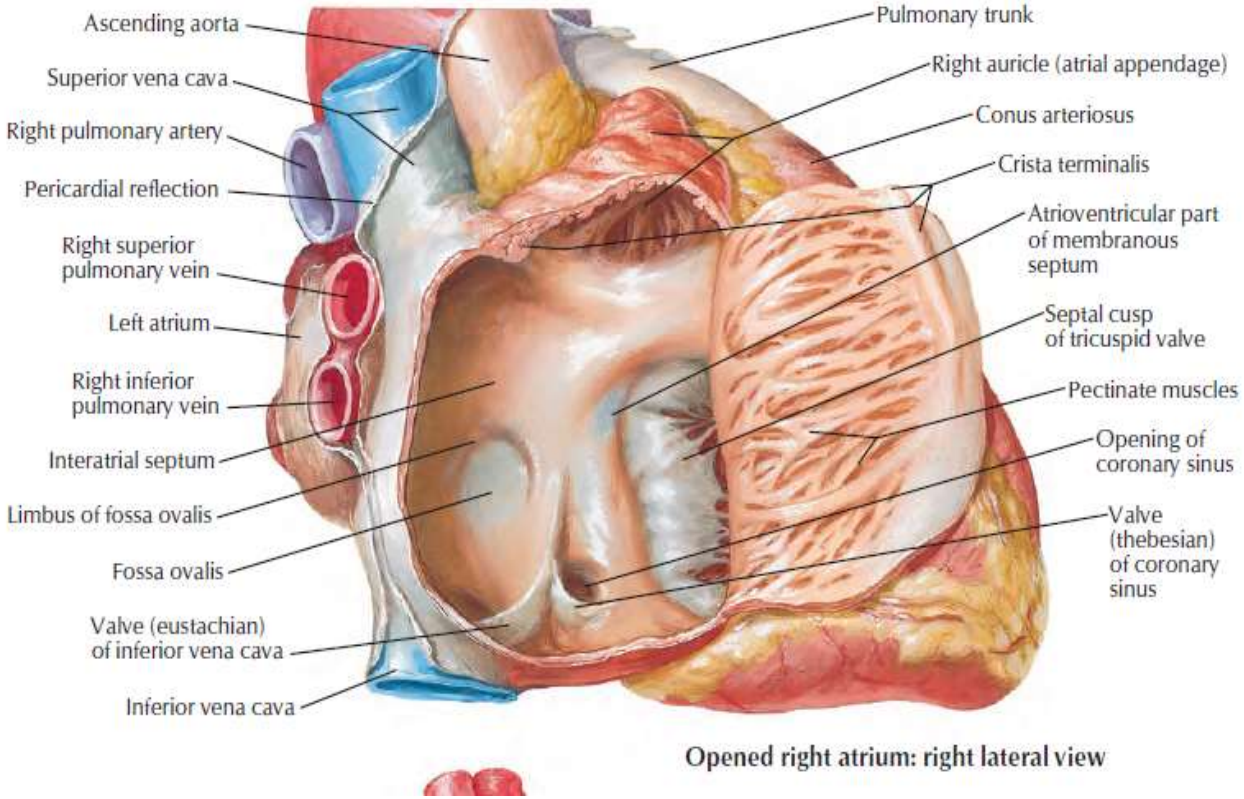
Chambers Of the Heart

Right Atrium



Chambers Of the Heart

Right Atrium



Opened right atrium: right lateral view

Chambers of the Heart

- **Sinus venarum** – located posterior to the crista terminalis. This part receives blood from the superior and inferior vena cavae. It has smooth walls and is derived from the embryonic sinus venosus.
- **Atrium proper** – located anterior to the crista terminalis, and includes the right auricle. It is derived from the primitive atrium, and has rough, muscular walls formed by pectinate muscles.
- The **coronary sinus** receives blood from the coronary veins. It opens into the right atrium between the inferior vena cava orifice and the right atrioventricular orifice.
-

The Chamber of the Heart

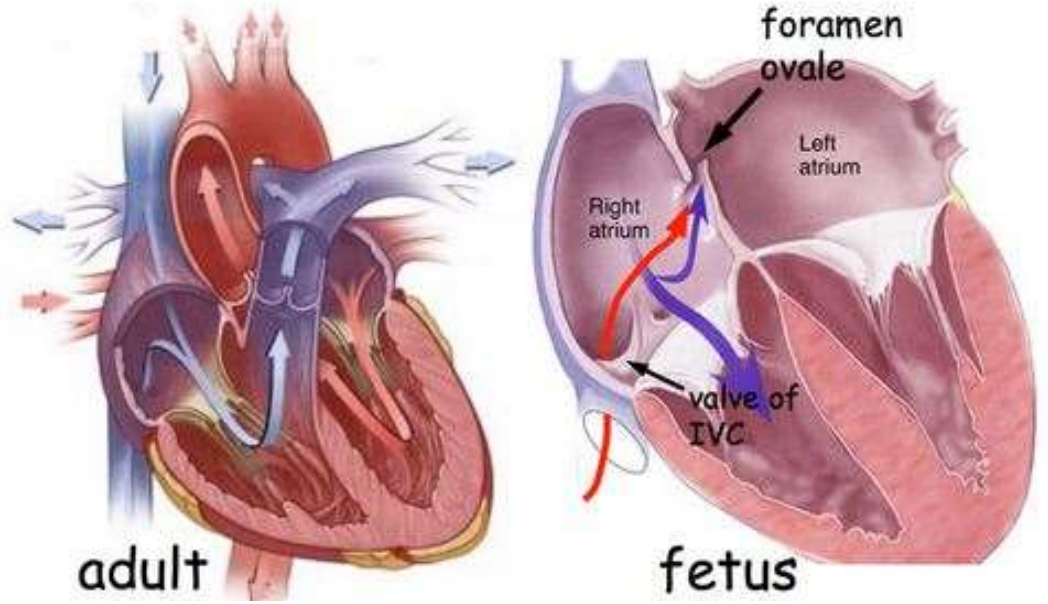
Interatrial Septum

- 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 the remnant of the **Foramen ovale** in the foetal heart, which allows right to left shunting of blood to bypass the lungs. It closes once the new born takes its first breath.

Chambers of the Heart

Inter Atrial Septum

Fossa ovalis – vestige of former foramen ovale (a shunt from right atrium to left atrium, allowing fetal blood to bypass non-ventilated lungs)



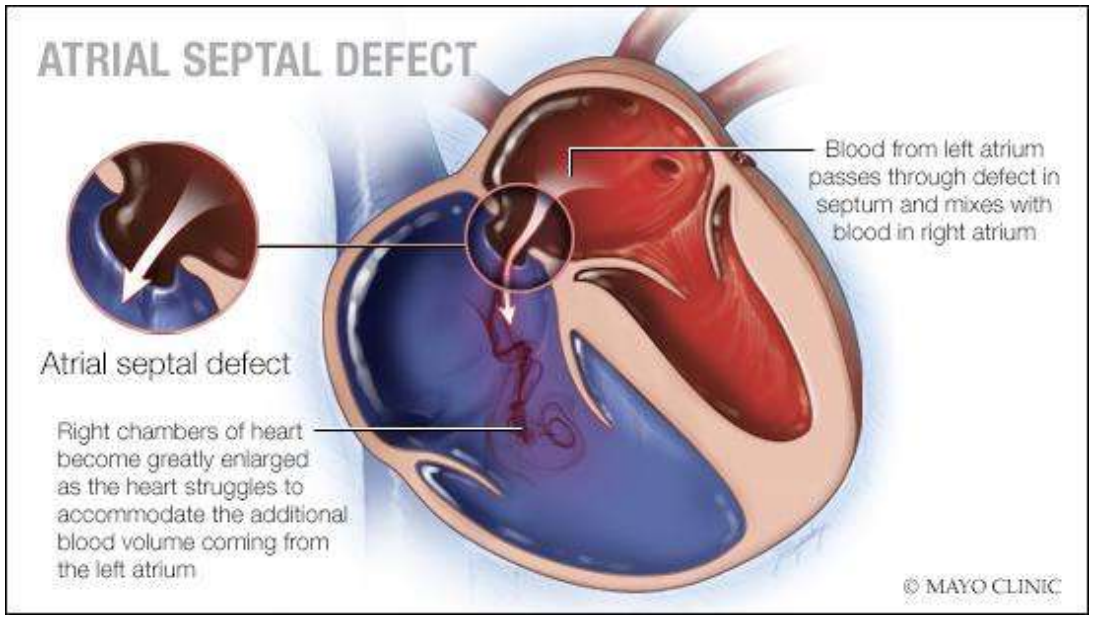
Chambers of the Heart

Clinical Relevance: Atrial Septal Defect

- An atrial septal defect is an abnormal opening in the interatrial septum, persistent after birth. The most common site is the **foramen ovale,** and this is known as a patent foramen ovale.
- In the adult, left atrial pressure is usually greater than that of the right atrium, so blood is shunted through the opening from left to right. In large septal defects, this can cause right ventricular overload, leading to pulmonary hypertension, right ventricular hypertrophy and ultimately **right heart failure**.
- Definitive treatment is closure of the defect by surgical or transcatheter closure.

Chambers of the Heart

Atrial Septal Defect



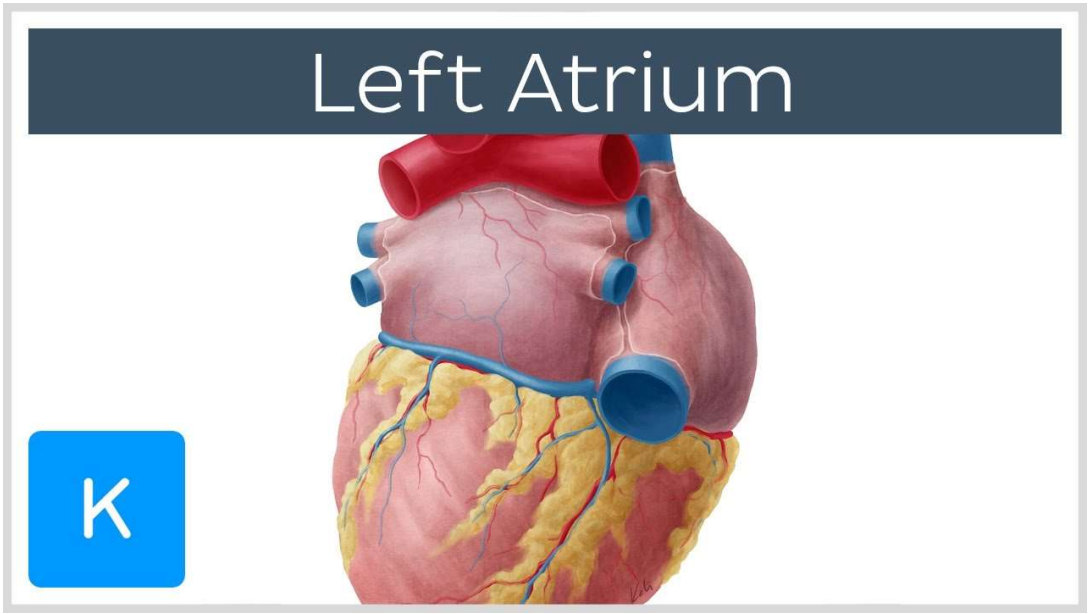
The chambers of the Heart

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) into the left ventricle.
- In the anatomical position, the left atrium forms the **posterior** border (base) of the heart. The **left auricle** extends from the superior aspect of the chamber, overlapping the root of the pulmonary trunk.
- The interior surface of the left atrium can be divided into two parts, each with a distinct embryological origin:
- **Inflow portion** – receives blood from the pulmonary veins. Its internal surface is smooth and it is derived from the pulmonary veins themselves.
- **Outflow portion** – located anteriorly, and includes the left auricle. It is lined by pectinate muscles, and is derived from the embryonic atrium.

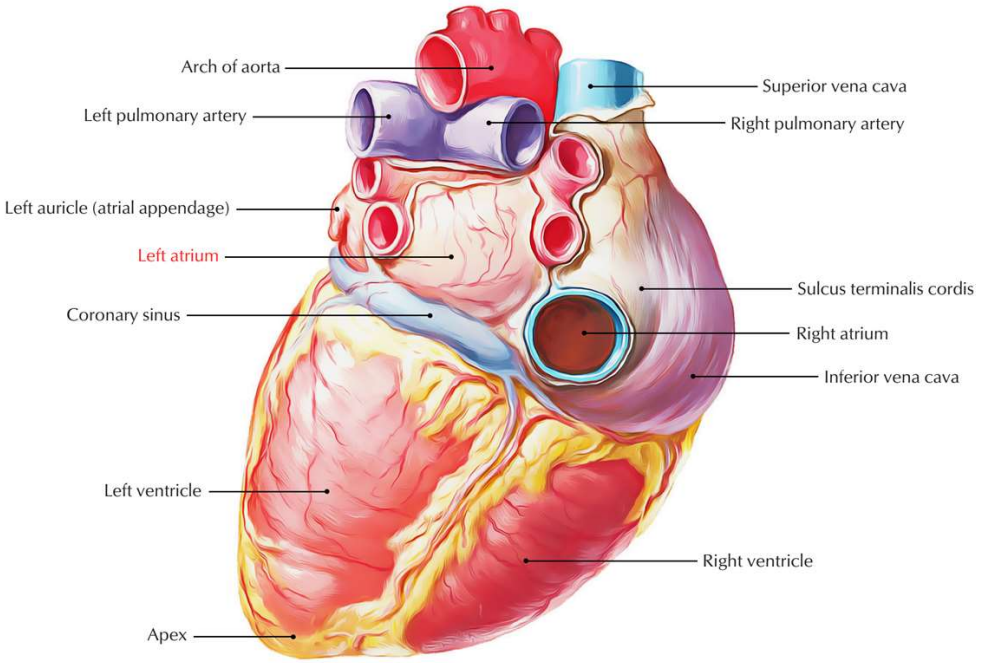
Chamber of the Heart

Left Atrium



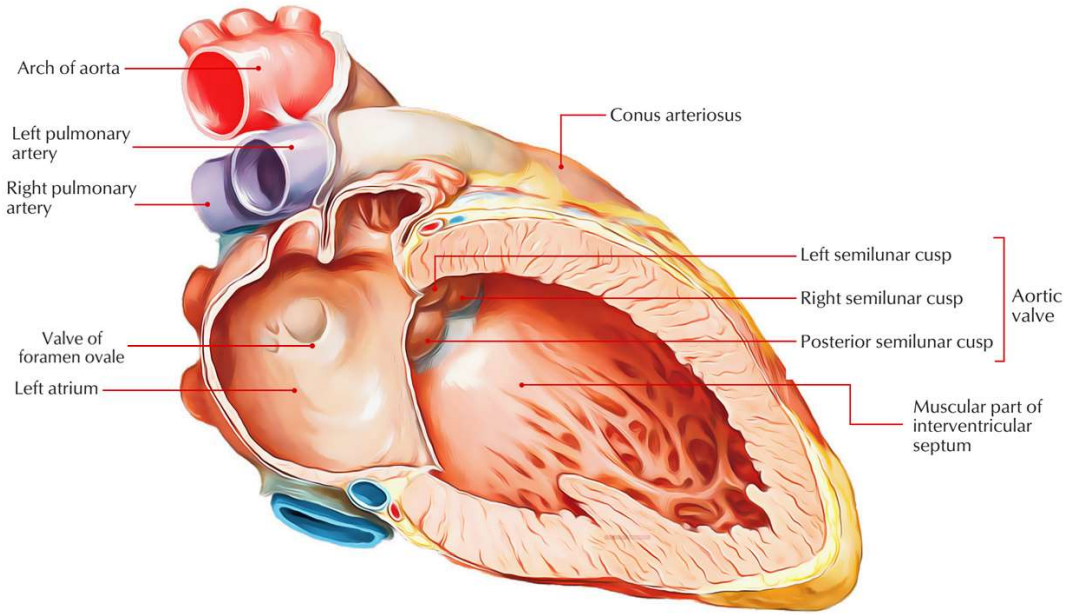
Chamber of the Heart

Left Atrium



Chambers of the Heart

Left Atrium



Chambers Of the Heart

Ventricles

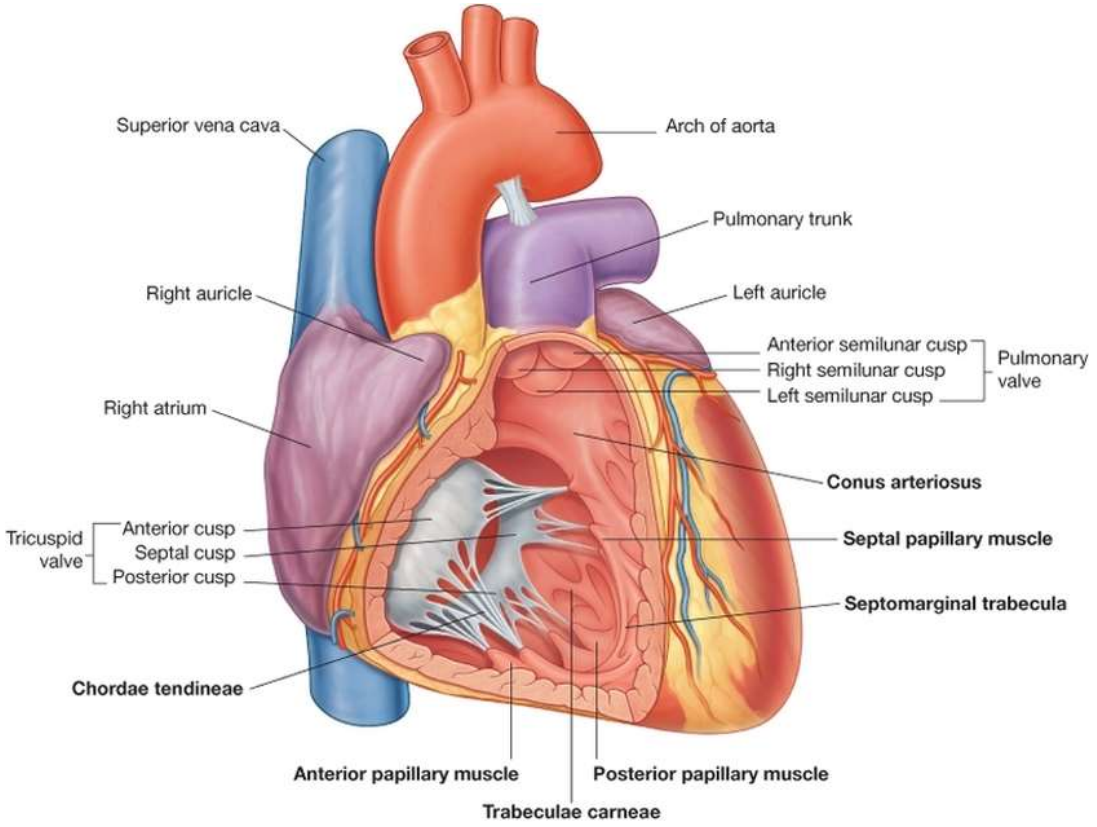
- The left and right ventricles of the heart receive blood from the atria and pump it into the outflow vessels; the **aorta** and the **pulmonary artery** respectively.

Right Ventricle

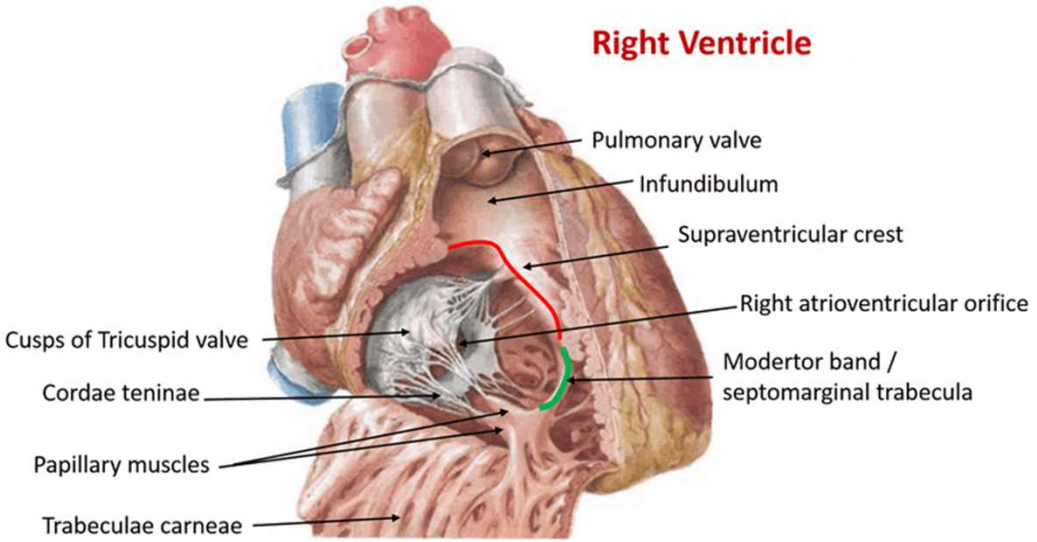
- The right ventricle receives deoxygenated blood from the right atrium, and pumps it through the pulmonary orifice (guarded by the pulmonary valve), into the **pulmonary artery**.
- It is triangular in shape, and forms the majority of the **anterior** border of the heart. The right ventricle can be divided into an inflow and outflow portion, which are separated by a muscular ridge known as the **supraventricular crest**.

Chambers of the Heart

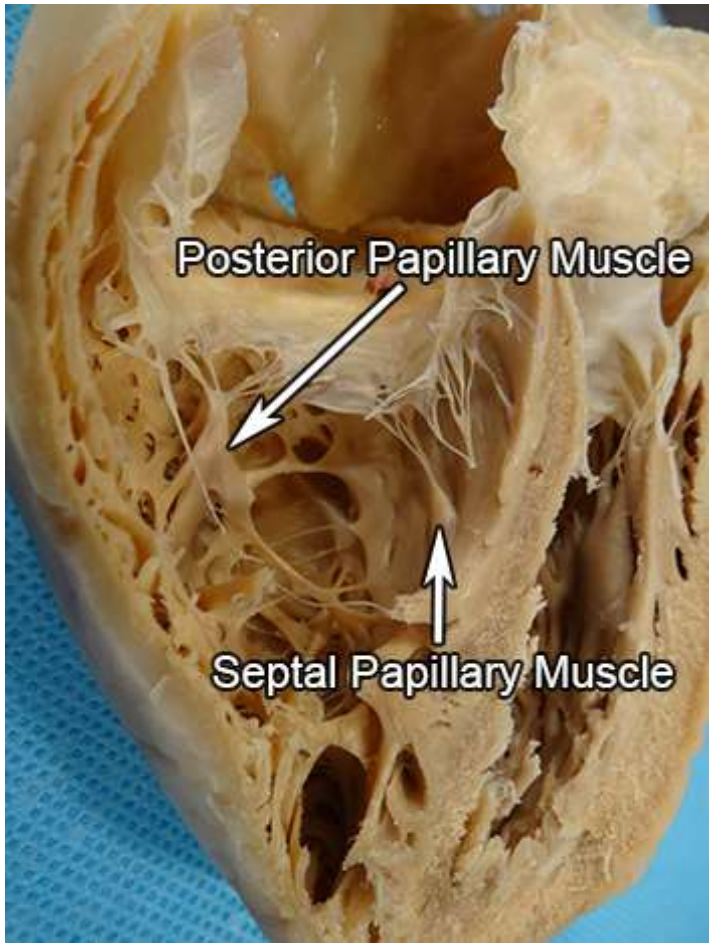
Right Ventricles



Right Ventricle



Right Ventricle



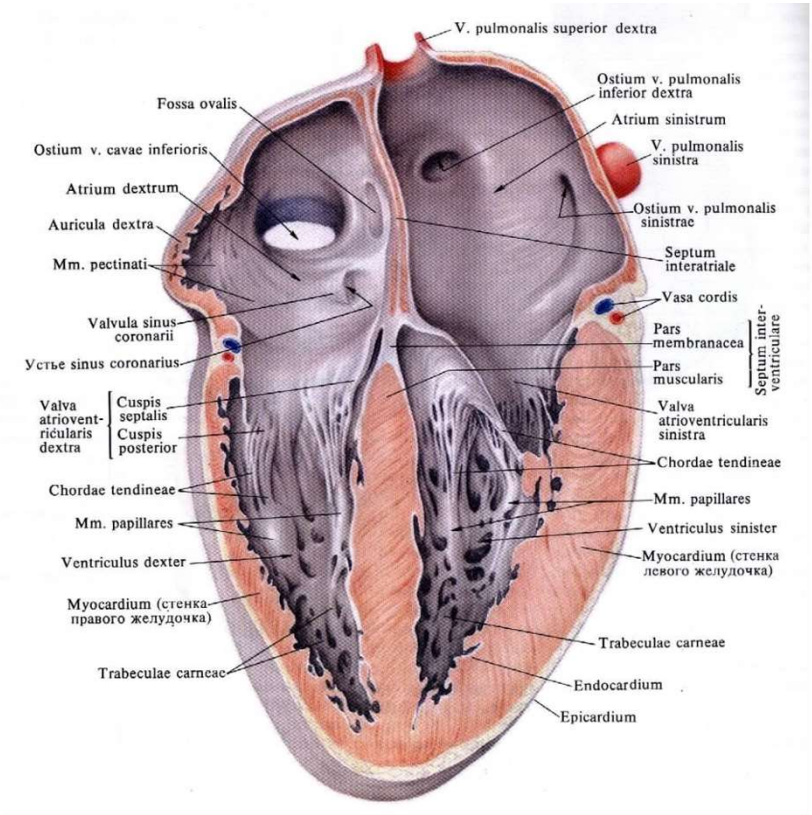
Chambers of the Heart

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** – attached along their entire length on one side to form 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 spans between the interventricular septum and the anterior wall of the right ventricle. It has an important conductive function, containing the right bundle branches.
- **Pillars** (papillary muscles) – anchored by their base to the ventricles. Their apices are attached to fibrous cords (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.

Chambers of the Heart

Right Ventricles



Chambers of the Heart

Right Ventricles

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.

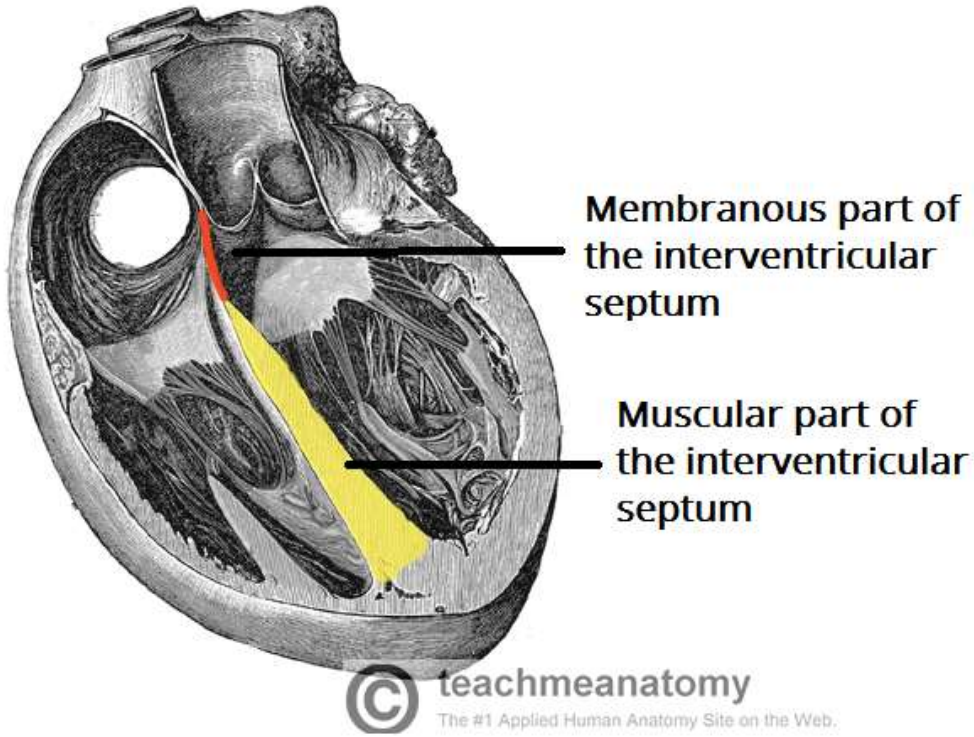
Chambers of the Heart

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.

Chmabers of the Heart

Interventricular Septum



Chambers of the Heart

Left Ventricle

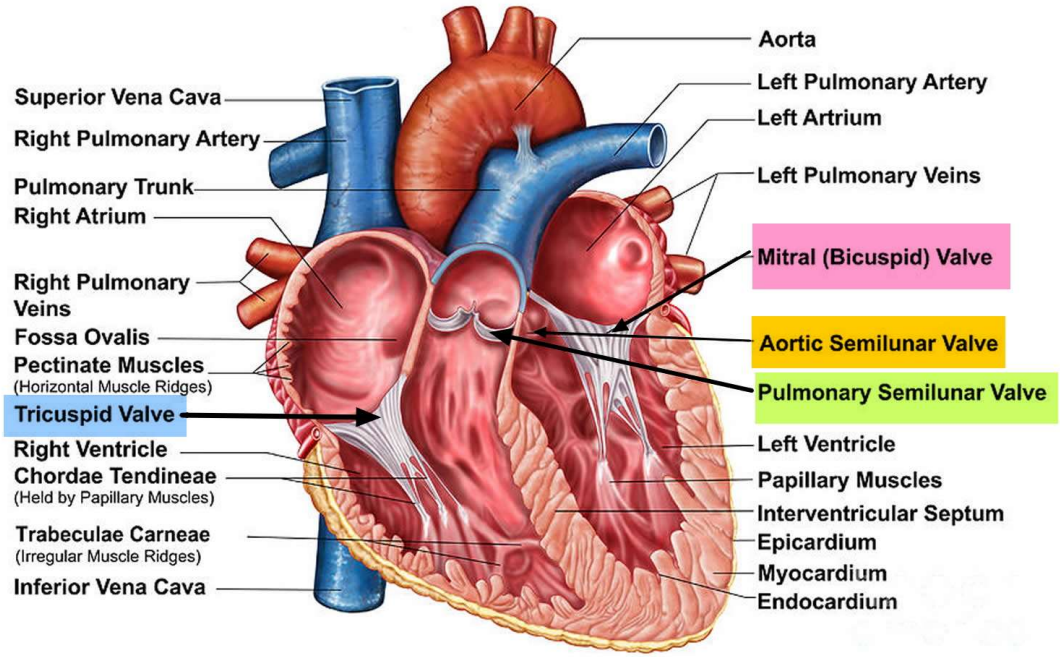
- The left ventricle receives oxygenated blood from the left atrium, and pumps it through the aortic orifice (guarded by the aortic valve) into the **aorta**.
- In the anatomical position, the left ventricle forms the apex of the heart, as well as the left and diaphragmatic borders. Much like the right ventricle, it can be divided into an inflow portion and an outflow portion.

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 papillary muscles present which attach to the cusps of the mitral valve.

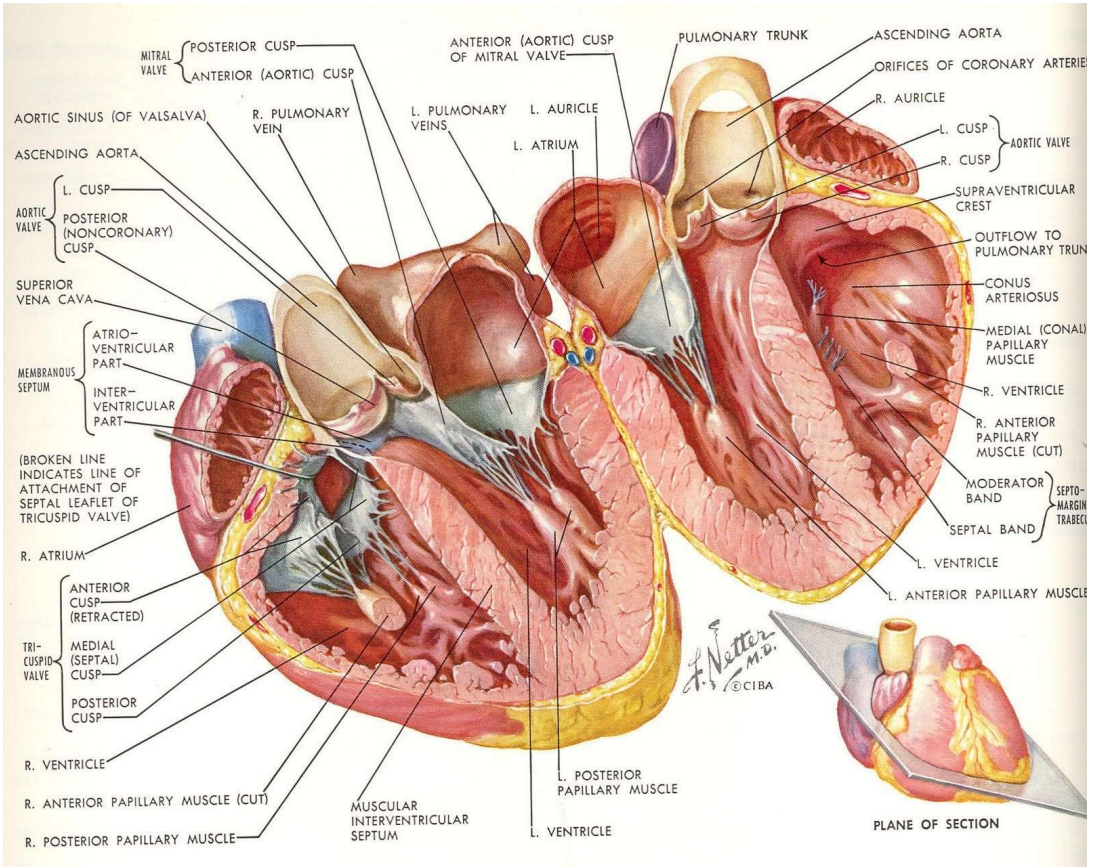
Chambers of the Heart

Left Ventricles



Chamber of the Heart

Left Ventricles



Chambers of the Heart

Outflow Portion

The outflow part of the left ventricle is known as the **aortic vestibule**. It is smooth-walled with no trabeculae carneae, and is a derivative of the embryonic **bulbus cordis**.

Chambers of the Heart

Clinical Relevance: Tetralogy of Fallot

- Tetralogy of Fallot is a cyanotic congenital heart disease, comprising four abnormalities as a result of a single development defect. The four abnormalities are:
- Ventricular septal defect
- Overriding aorta (this is where the aorta is positioned directly over the VSD)
- Pulmonary valve stenosis
- Right ventricular hypertrophy
- Stenosis of the pulmonary valve increase the force needed to pump blood through it, resulting in **right ventricular hypertrophy**. Eventually, the pressure in the right ventricle becomes higher than that of the left – and blood then shunts from right to left through the ventricular septal defect. The overriding aorta lies over the ventricular septal defect, resulting in deoxygenated blood passing into the aorta.
- It is usually treated surgically in the first few months of life or in severe cases, soon after birth.

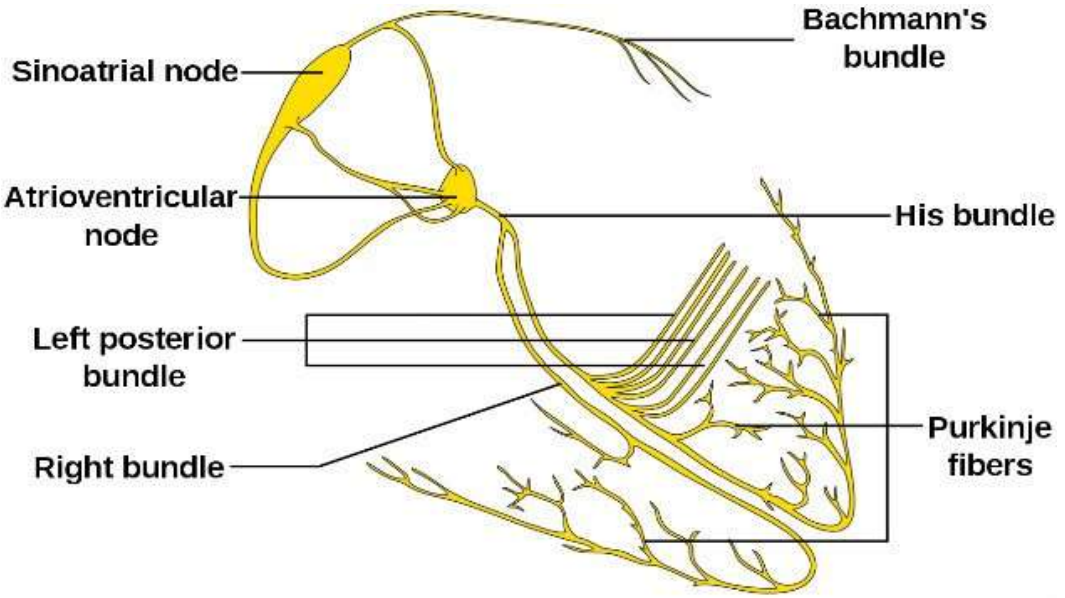
Heart

Conducting System of the Heart

Conducting System of the Heart

Contents

Conducting System of Heart

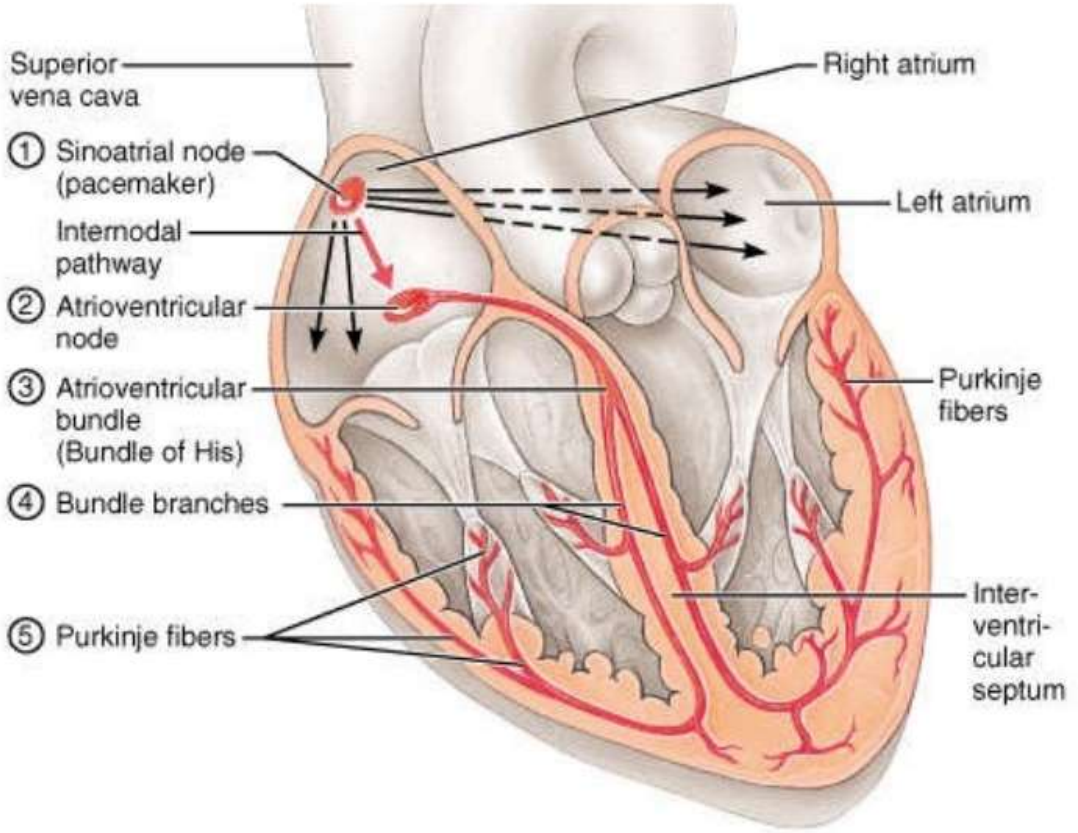


Conducting system of the Heart

The **cardiac conduction system** is a collection of nodes and specialised conduction cells that initiate and co-ordinate contraction of the heart muscle. It consists of:

- Sinoatrial node
- Atrioventricular node
- Atrioventricular bundle (bundle of His)
- Purkinje fibres

Conducting System of the Heart



Conducting System of the Heart

Overview

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 the **bundle of His**, down the interventricular septum.
- The bundle of His and the **Purkinje fibres** spread the wave impulses along the ventricles, causing them to contract.
- We will now discuss the anatomy of the individual components involved in the conducting system.

Conducting System Of the Heart

Components of the Cardiac Conduction System

- **Sinoatrial Node**
- The **sinoatrial (SA) node** is a collection of specialised cells (pacemaker cells), and is located in the upper wall of the right atrium, at the junction where the superior vena cava enters.
- These pacemaker cells can spontaneously generate **electrical impulses**. The wave of excitation created by the SA node spreads via gap junctions across both atria, resulting in atrial contraction (atrial systole) – with blood moving from the atria into the ventricles.
- The rate at which the SA node generates impulses is influenced by the autonomic nervous system:
- **Sympathetic nervous system** – increases firing rate of the SA node, and thus increases heart rate.
- **Parasympathetic nervous system** – decreases firing rate of the SA node, and thus decreases heart rate.

Conducting System Of the Heart

Atrioventricular Node

- After the electrical impulses spread across the atria, they converge at the **atrioventricular node** – located within the atrioventricular septum, near the opening of the coronary sinus.
- The AV node acts to delay the impulses by approximately **120ms**, 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.

Conducting System Of Heart

Atrioventricular Bundle

- The **atrioventricular bundle** (bundle of His) is a continuation of the specialised tissue of the AV node, and serves to transmit the electrical impulse from the AV node to the Purkinje fibres of the ventricles.
- It descends down the membranous part of the interventricular septum, before dividing into 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.

Conducting System Of the Heart

Purkinje Fibres

- The **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.

Conducting System Of the Heart

Clinical Relevance: Artificial Pacemaker

- An **artificial pacemaker** is a small electrical device commonly fitted to monitor and correct heart rate and rhythm. It is inserted into the chest under the left clavicle, with wires connected to the heart via the venous system.
- The most common indication for a pacemaker is **bradycardia**. Once inserted, the pacemaker monitors the heart rate, and only fires if the rate becomes too slow. Pacemakers can also be used to treat some tachycardias, certain types of heart block and other rhythm abnormalities.

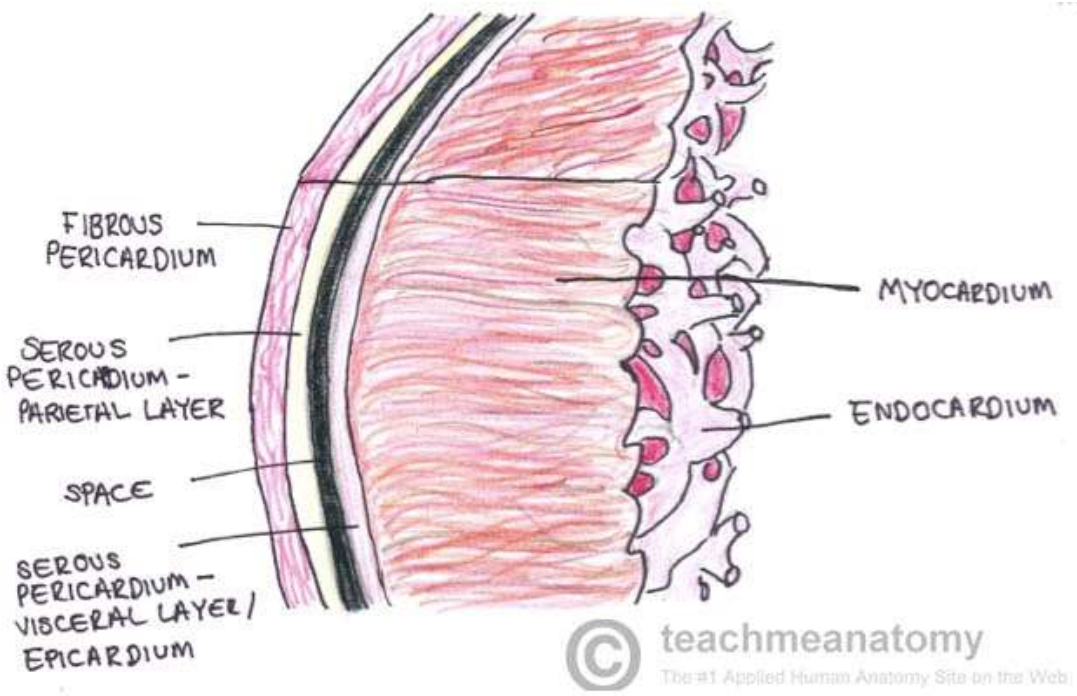
HEART

WALL OF THE HEART

WALL OF THE HEART

Contents

Heart Wall


FIBROUS PERICARDIUM
SEROUS PERICARDIUM – PARIETAL LAYER
SPACE
SEROUS PERICARDIUM – VISCERAL LAYER / EPICARDIUM
MYOCARDIUM
ENDOCARDIUM
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WALL OF THE HEART

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.
- In addition to lining the inside of the heart, the endocardium also **regulates contractions** and aids cardiac **embryological development**.

WALL OF THE HEART

Clinical Relevance: Endocarditis

- Endocarditis refers to inflammation of the endocardium. It most commonly occurs on the **valves** of the heart, which the endocardium lines.
- The main form of endocarditis is **infective endocarditis** – caused by a pathogen. Bacteria colonise the heart valve, and cause small clumps of material called **vegetations** to develop. The resulting inflammation can cause **permanent damage** to the valve, creating a murmur which is heard when the patient is examined. Furthermore, the damaged valve is more likely to be colonised in the future, resulting in re-infection.

Wall Of the Heart

Subendocardial layer

- The subendocardial layer lies between, and joins, the **endocardium** and the **myocardium**. It consists of a 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 houses the conducting system of the heart, damage to this layer can result in various **arrhythmias**.

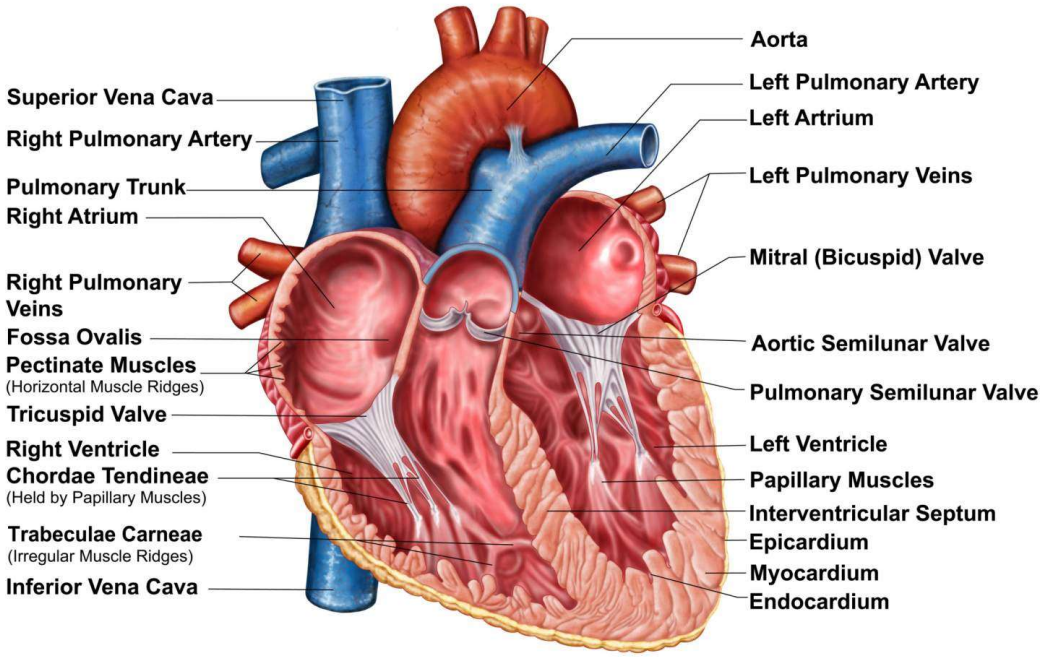
Walls of the Heart

Myocardium

The myocardium is composed of cardiac muscle and is an involuntary striated muscle. The myocardium is responsible for contractions of the heart.

Heart Wall

Myocardium



Walls of the Heart

Clinical Relevance: Disorders of the Myocardium

Myocarditis

- Myocarditis refers to an inflammation of the heart muscle, often due to viruses such as **adenovirus** and **coxsackie B**. Symptoms depend on the severity of the inflammation, but often include chest pain, shortness of breath, and tachycardia.
- The common sequelae of myocarditis is damage to the cardiac muscle of the myocardium. This can result in cardiac arrhythmias and heart failure.

Walls of the Heart

Clinical Relevance

Myocardial Infarction

A myocardial infarction (heart attack) is caused by a blockage in a **coronary artery**. The myocardium loses its oxygen supply, and undergoes ischaemic change.

- The most common cause of a myocardial infarction is an **atheroma** (lipid collection in the artery walls. Risk factors for myocardial infarctions include obesity, high blood pressure, smoking and diabetes.

Walls of the Heart

Angina

- Angina refers to **chest pain** which arises as a result of **temporary** myocardial ischaemia. In this condition, the coronary arteries are narrowed but not completely blocked, in the overwhelming majority as a result of atherosclerosis. The reduced blood flow causes intermittent ischaemia when the oxygen demand exceeds supply.

There are two types of angina:

- **Stable angina** can predicted, with symptoms of chest pain developing after exercise or under stress.
- **Unstable angina** does not require exertion to set off symptoms.
- Both these conditions can be treated with GTN spray. Unstable angina is the more serious of the two, and is more likely to progress to a myocardial infarction.

Walls Of the Heart

Subepicardial layer

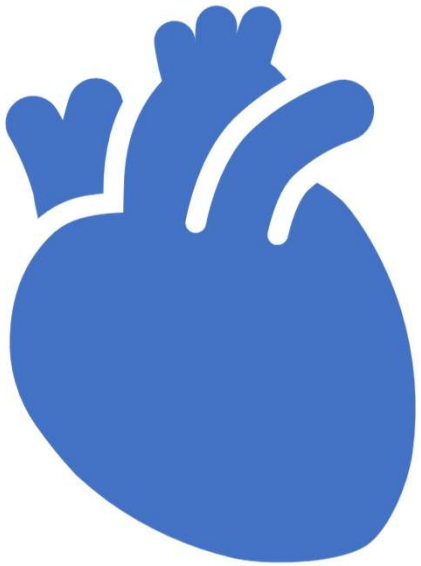
- The subepidcardial layer lies between, and joins, the **myocardium** and the **epicardium**.

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**.
- In addition to the connective tissue and fat, the epicardium is lined by on its outer surface by simple squamous **epithelial** cells.

Heart

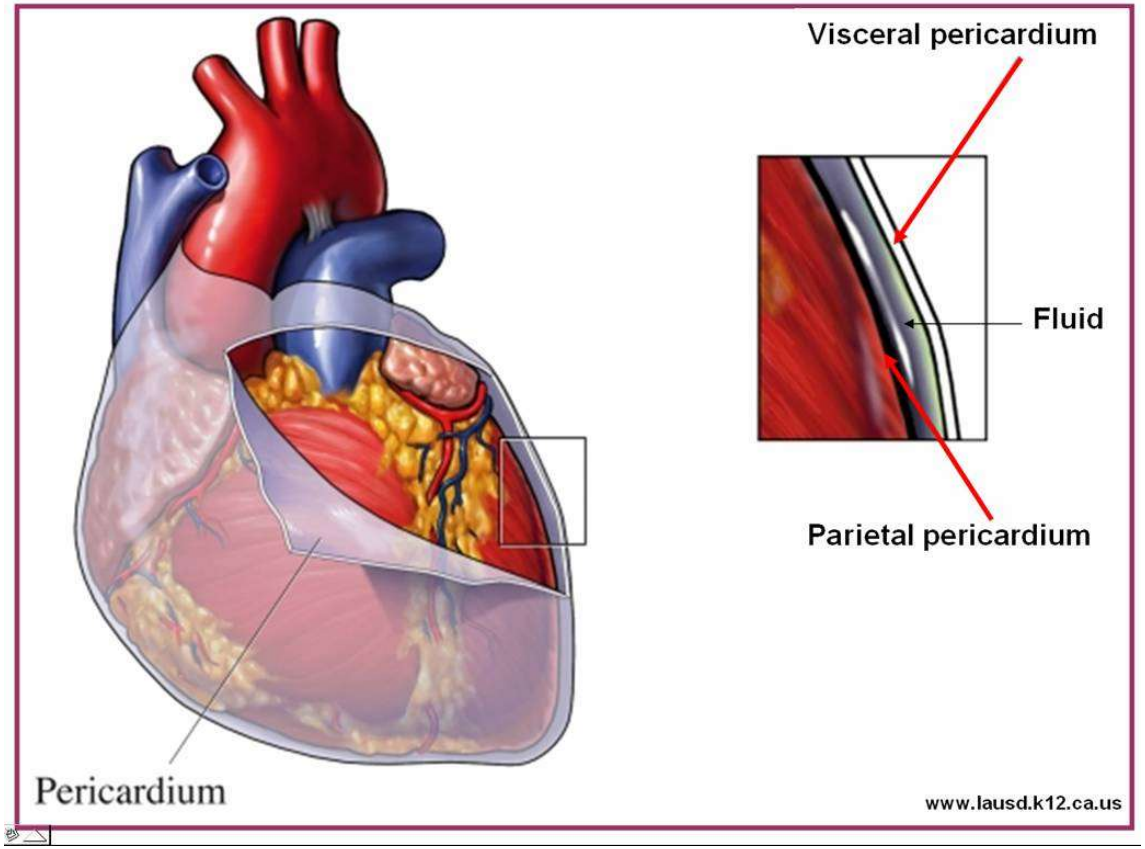
Pericardium



Pericardium

Contents

Pericardium



Pericardium

If the heart is the fun, interesting inside bit of an orange, the **pericardium** could be compared to the peel around it. Like peel, it can seem vaguely unexciting – that is until you learn some of its very important (appeeling. ahem.) physiological functions [1].

- In scientific terms, the pericardium is a **fibroserous**, fluid-filled sack that surrounds the muscular body of the heart and the roots of the great vessels (the aorta, pulmonary artery, pulmonary veins, and the superior and inferior vena cavae).
- This article will give an outline of the functions, structure, innervation, and clinical significance of the pericardium.

Pericardium

Anatomical Structure

- The pericardium is made up of two main layers: a tough external layer known as the **fibrous pericardium,** and a thin, internal layer known as the **serous pericardium** (to overextend the orange metaphor, the outer peel could be thought of as the fibrous layer, with the inner white stuff being the serous layer).

Pericardium

Fibrous Pericardium

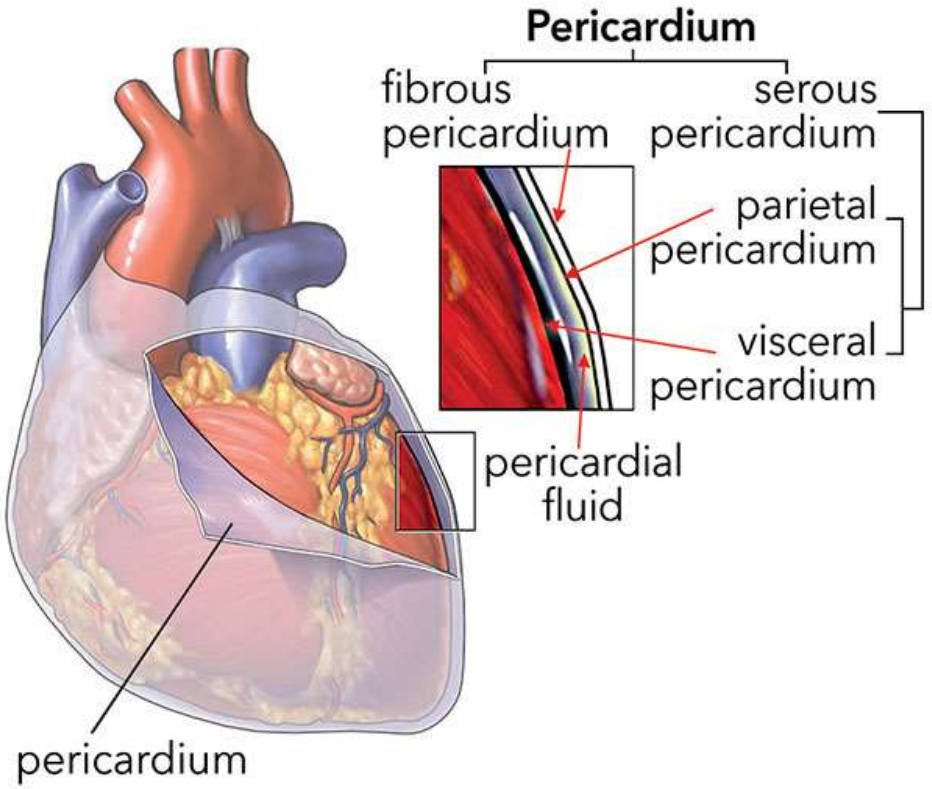
- Continuous with the central tendon of the diaphragm, the fibrous pericardium is made of tough connective tissue and is relatively non-distensible. Its rigid structure prevents rapid overfilling of the heart, but can contribute to serious clinical consequences (see cardiac tamponade).

Serous Pericardium

- Enclosed within the fibrous pericardium, the serous pericardium is itself divided into two layers: the **outer parietal layer** that lines the internal surface of the fibrous pericardium and the **internal visceral layer** that forms the outer layer of the heart (also known as the **epicardium**). Each layer is made up of a single sheet of epithelial cells, known as mesothelium.
- Found between the outer and inner serous layers is the **pericardial cavity**, which contains a small amount of lubricating serous fluid. The serous fluid serves to minimize the friction generated by the heart as it contracts.

Pericardium

Layers of Pericardium



Pericardium

*The order of these layers can be remembered using the acronym **F**art **P**olice **S**mell **V**illains:*

- ***F** – Fibrous layer of the pericardium*
- ***P** – Parietal layer of the serous pericardium*
- ***S** – Serous fluid*
- ***V** – Visceral layer of the serous pericardium*

Pericardium

Functions

The pericardium has many physiological roles, the most important of which are detailed below: The pericardium has many physiological roles, the most important of which are detailed below.

- **Fixes the heart** in the mediastinum and limits its motion. Fixation of the heart is possible because the pericardium is attached to the diaphragm, the sternum, and the tunica adventitia (outer layer) of the great vessels
- **Prevents overfilling** of the heart. The relatively inextensible fibrous layer of the pericardium prevents the heart from increasing in size too rapidly, thus placing a physical limit on the potential size of the organ
- **Lubrication**. A thin film of fluid between the two layers of the serous pericardium reduces the friction generated by the heart as it moves within the thoracic cavity
- **Protection from infection**. The fibrous pericardium serves as a physical barrier between the muscular body of the heart and adjacent organs prone to infection, such as the lungs.

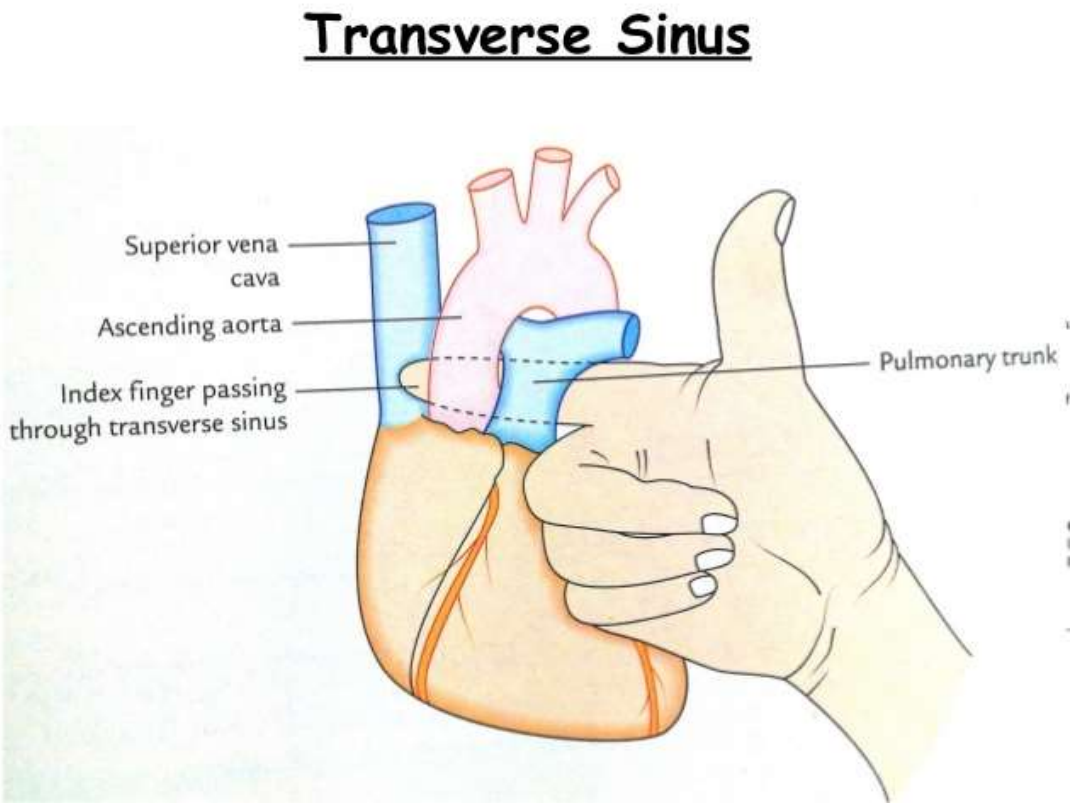
Pericardium

Clinical Relevance: Transverse Pericardial Sinus

- Formed as a result of the embryological folding of the heart tube, the **transverse pericardial sinus** is a passage through the pericardial cavity.
- It is located:
- **Posterior** to the ascending aorta and pulmonary trunk.
- **Anterior** to the superior vena cava.
- **Superior** to the left atrium.
- In this position, the transverse pericardial sinus **separates** the heart's arterial outflow (aorta, pulmonary trunk) from its venous inflow (superior vena cava, pulmonary veins).
- The transverse pericardial sinus can be used to identify and subsequently ligate the arteries of the heart during coronary artery bypass grafting.

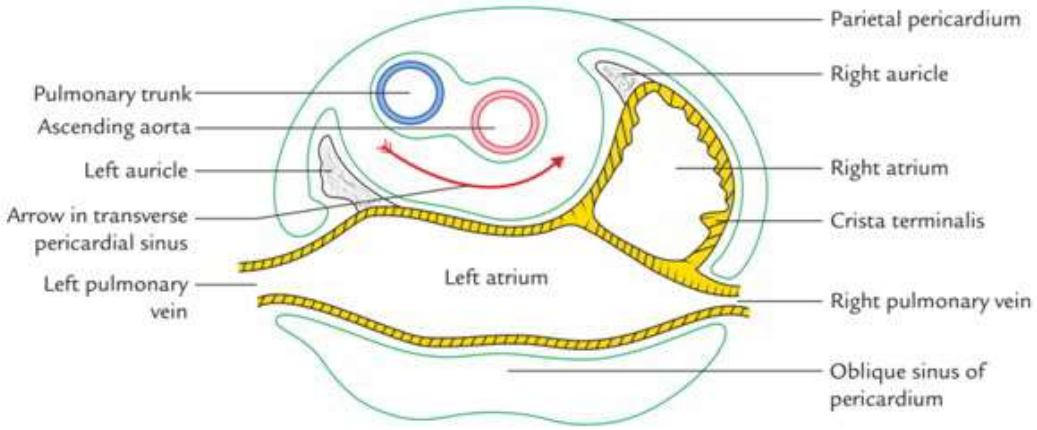
Pericardium

Sinuses



Pericardium

Sinuses



Pericardium

Innervation

- The **phrenic nerve** (C3-C5) is responsible for the somatic innervation of the pericardium, as well as providing motor and sensory innervation to the diaphragm. Originating in the neck and travelling down through the thoracic cavity, the phrenic nerve is a common source of **referred pain,** with a key example being shoulder pain experienced as a result of pericarditis.

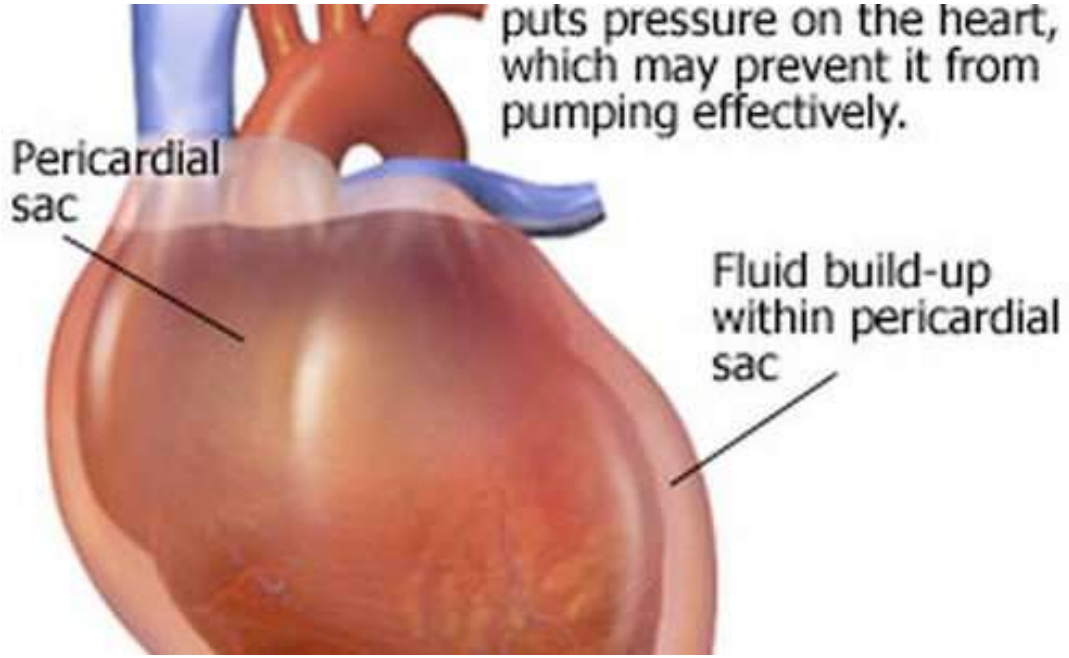
Pericardium

Clinical Relevance

- **Cardiac Tamponade**
- The relatively **inextensible** fibrous pericardium can cause problems when there is an accumulation of fluid, known as **pericardial effusion**, within the pericardial cavity.
- The rigid pericardium cannot expand, and thus the heart is subject to the resulting increased pressure. The chambers can become compressed, thus compromising cardiac output.

Pericardium

Cardiac Tamponade



Pericardium

Pericarditis

- **Pericarditis**, or inflammation of the pericardium, has myriad causes, including bacterial infection and myocardial infarction. The main symptom is chest pain, and the condition can cause acute cardiac tamponade due to an accumulation of fluid in the pericardial cavity.

Heart

Valves of the Heart

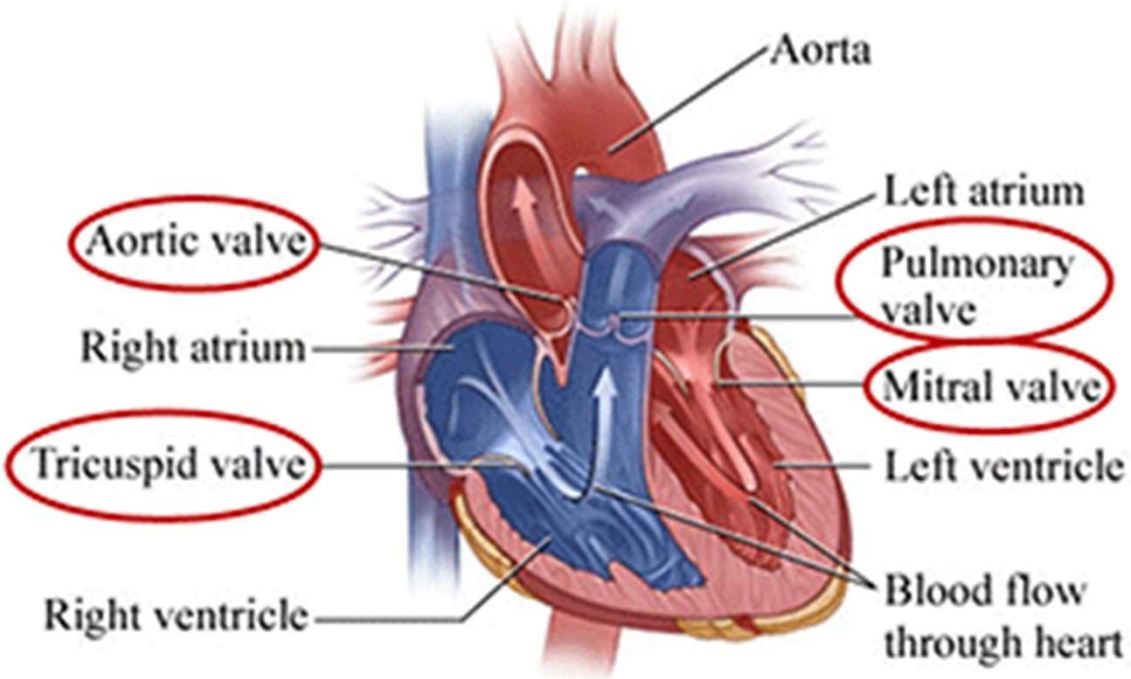
Valves of the Heart

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.

Valves of Heart



Valves of the Heart

Atrioventricular Valves

The atrioventricular valves are located between the atria and the ventricles. They close during the start of **ventricular contraction** (systole), producing the first heart sound. There are two AV valves:

Tricuspid valve – located between the right atrium and the right ventricle (right atrioventricular orifice). It consists of three cusps (anterior, septal and posterior), with the base of each cusp anchored to a fibrous ring that surrounds the orifice.

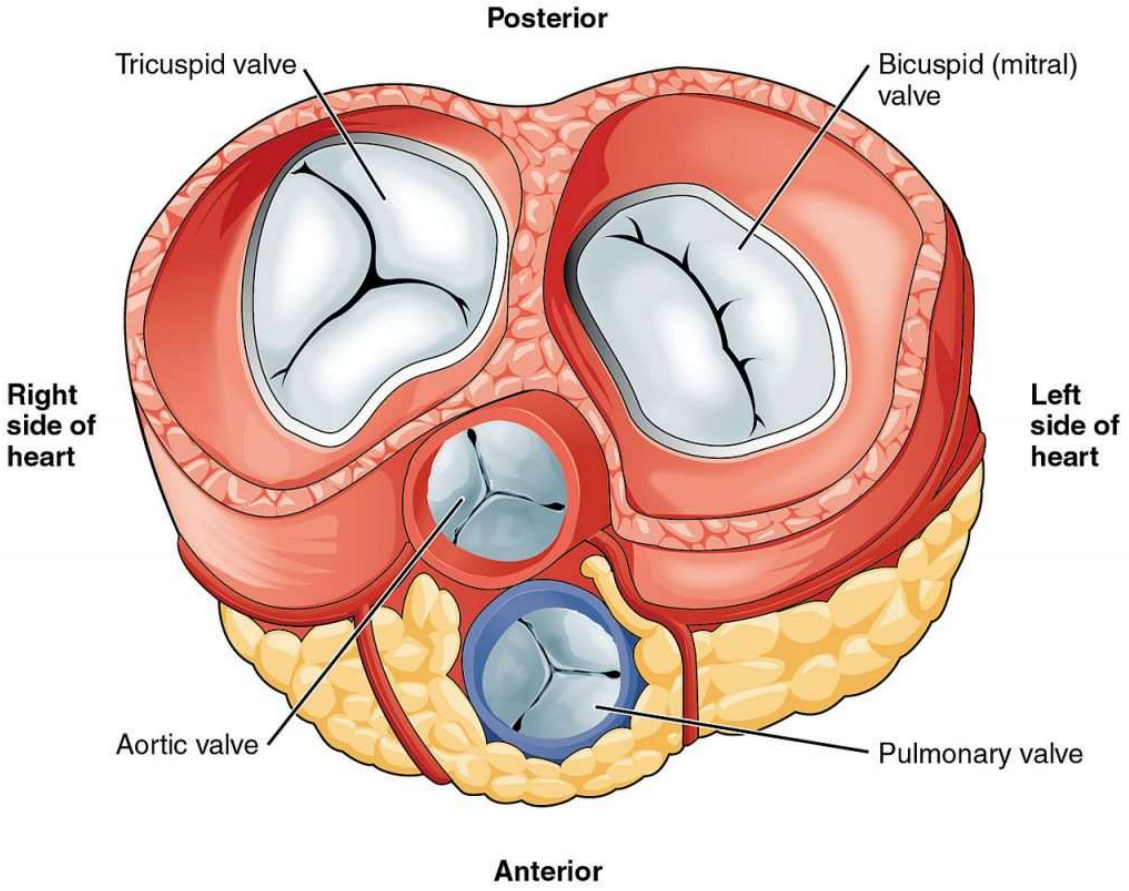
- **Mitral valve** – located between the left atrium and the left ventricle (left atrioventricular orifice). It is also known as the bicuspid valve because it has two cusps (anterior and posterior). Like the tricuspid valve, the base of each cusp is secured to fibrous ring that surrounds the orifice.

Valves of the Heart

The mitral and tricuspid valves are supported by the attachment of fibrous cords (**chordae tendineae**) to the free edges of the valve cusps. The chordae tendineae are, in turn, attached to **papillary muscles**, located on the interior surface of the ventricles – these muscles contract during ventricular systole to prevent prolapse of the valve leaflets into the atria.

- There are **five** papillary muscles in total. Three are located in the right ventricle, and support the tricuspid valve. The remaining two are located within the left ventricle, and act on the mitral valve.

Valves of Heart



Valves of the Heart

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:

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).

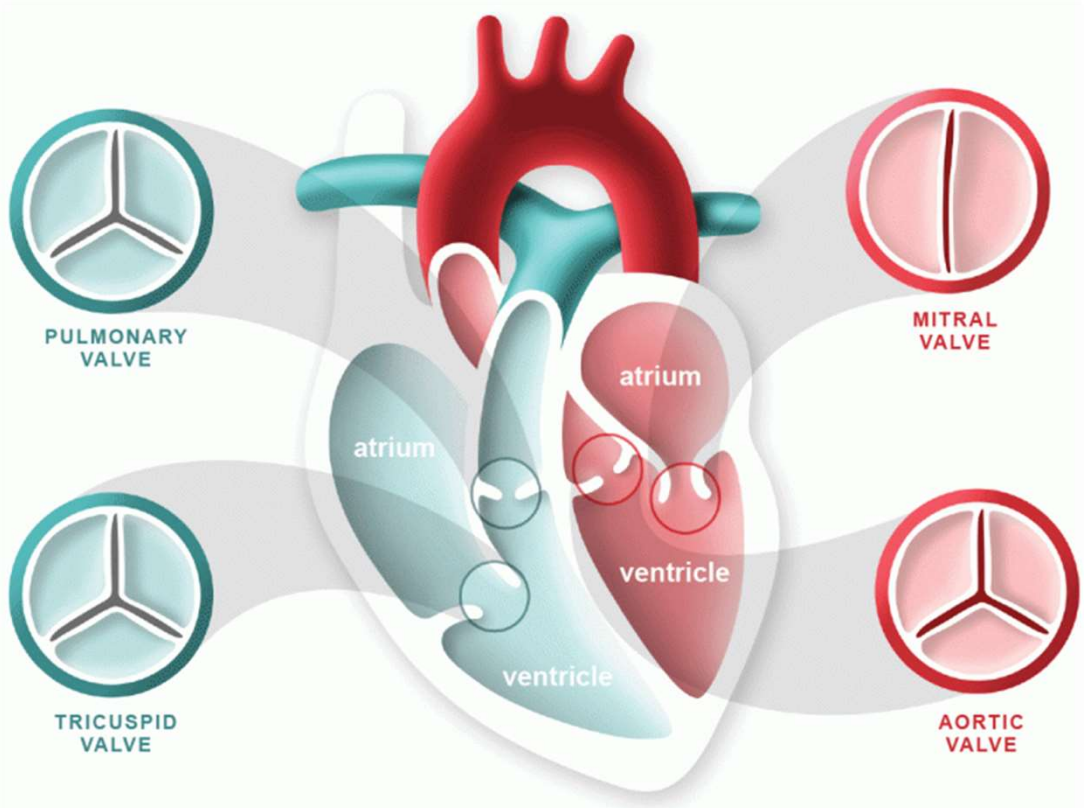
Aortic valve –

located between the left ventricle and the ascending aorta (aortic orifice). The aortic valve consists of three cusps – right, left and posterior.

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.

Valves Of Heart

Cusps of heart Valves



Valves Of the Heart

- 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.

Valves of the Heart

Clinical Relevance:

Aortic Stenosis

Aortic stenosis refers to narrowing of the aortic valve, restricting the flow of blood leaving the heart. The main three causes are:

- Age-related calcification
- Congenital defects
  - Most commonly a bicuspid aortic valve, which predisposes the valve to calcification later in life.
- Rheumatic fever
- The classical triad seen in severe aortic stenosis is shortness of breath, syncope and angina. The increasing workload for the left ventricle can also result in **left ventricular hypertrophy**.
- Definitive treatment is surgical, and can be achieved via valve replacement or **balloon valvuloplasty**.

Heart

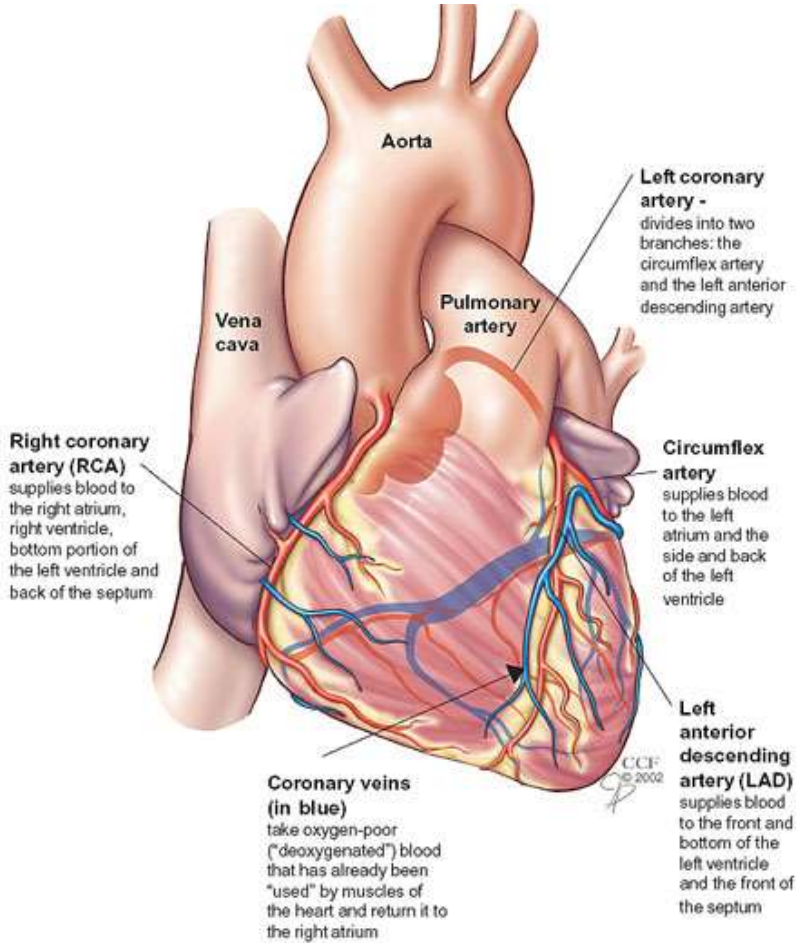
Vasculature of the Heart

Vasculature of the Heart

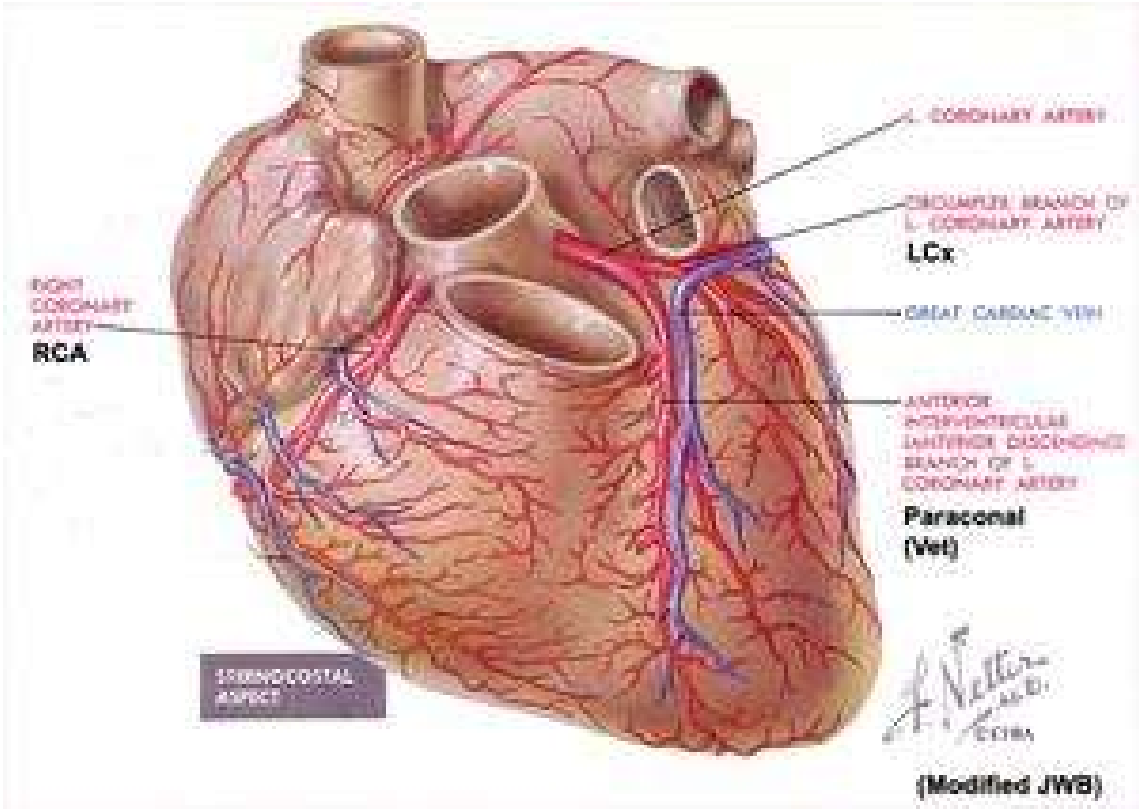
Contents

Vasculature of the Heart

Coronary Arteries



Vasculature of the Heart



Vasculature of Heart

- The entire body must be supplied with nutrients and oxygen via the **circulatory system** and the heart is no exception. The coronary circulation refers to the vessels that supply and drain the heart. Coronary arteries are named as such due to the way they encircle the heart, much like a crown.
- This article will outline the naming, distribution, and clinical relevance of vessels in the **coronary circulation**.

Vasculature of the Heart

Naming

Coronary Arteries

- There are two main coronary arteries which branch to supply the entire heart. They are named the left and right coronary arteries, and arise from the left and right **aortic sinuses** within the aorta.
- The aortic sinuses are small openings found within the aorta behind the left and right flaps of the **aortic valve**. When the heart is relaxed, the back-flow of blood fills these valve pockets, therefore allowing blood to enter the coronary arteries.

Vasculature of the Heart

- The **left coronary artery** (LCA) initially branches to yield the left anterior descending (LAD), also called the anterior interventricular artery. The LCA also gives off the left marginal artery (LMA) and the left circumflex artery (Cx). In ~20-25% of individuals, the left circumflex artery contributes to the posterior interventricular artery (PIv).
- The **right coronary artery** (RCA) branches to form the right marginal artery (RMA) anteriorly. In 80-85% of individuals, it also branches into the posterior interventricular artery (PIv) posteriorly.

Vasculature of the Heart

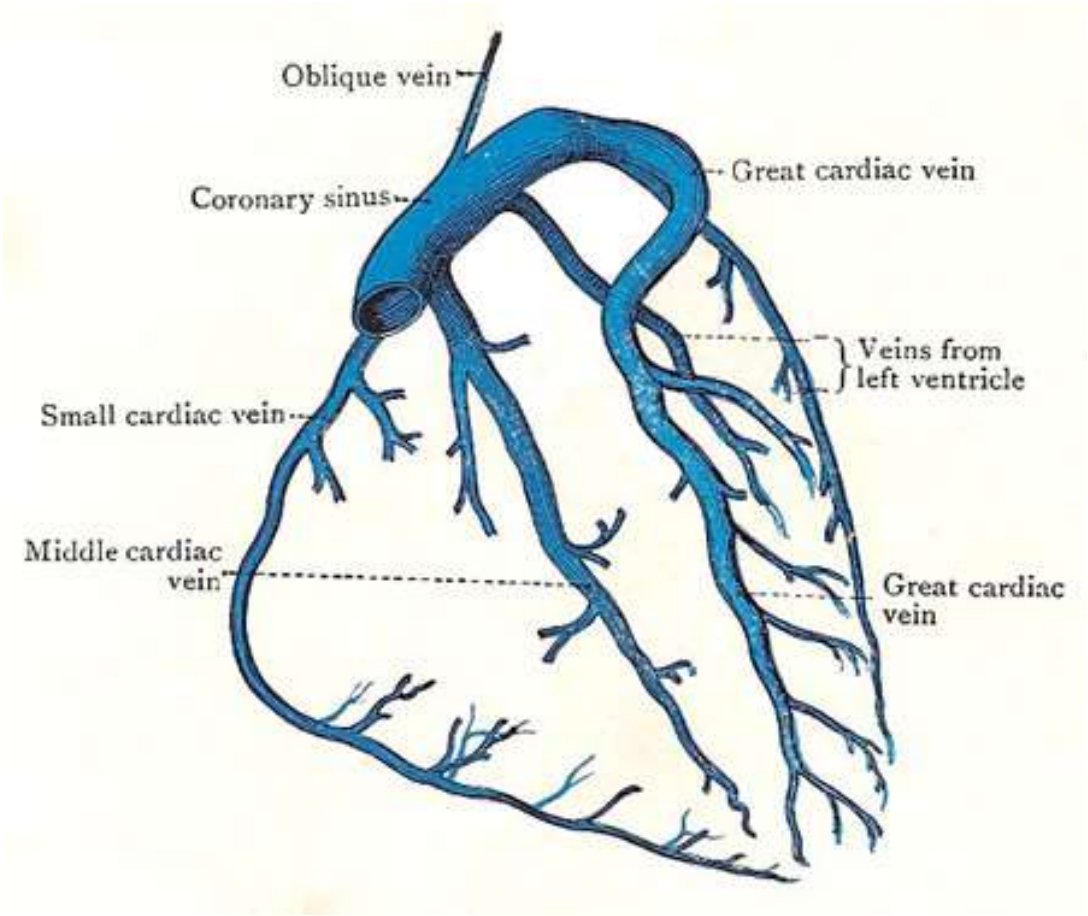
Cardiac Veins

Cardiac Veins

- Blood travels from the subendocardium into the **thebesian veins**, which are small tributaries running throughout the myocardium. These in turn drain into larger veins that empty into the **coronary sinus**. The coronary sinus is the main vein of the heart, located on the posterior surface in the **coronary sulcus**, which runs between the left atrium and left ventricle. The sinus drains into the **right atrium**. Within the right atrium, the opening of the coronary sinus is located between the right atrioventricular orifice and the inferior vena cava orifice.

Vasculature Of Heart

Cardiac Veins



Vasculature of the Heart

There are **five tributaries** which drain into the coronary sinus:

- The **great cardiac vein** is the main tributary. It originates at the apex of the heart and follows the anterior interventricular groove into the coronary sulcus and around the left side of the heart to join the coronary sinus.
- The **small cardiac vein** is also located on the anterior surface of the heart. This passes around the right side of the heart to join the coronary sinus.
- Another vein which drains the right side of the heart is the **middle cardiac vein.** It is located on the posterior surface of the heart.
- The final 2 cardiac veins are also on the posterior surface of the heart:
- On the left posterior side is the **left marginal vein**.
- In the centre is the **left posterior ventricular vein** which runs along the posterior interventricular sulcus to join the coronary sinus.

Vasculature of the Heart

Distribution of the Coronary Arteries

- In general, the area of the heart which an artery passes over will be the area that it perfuses. The following describes the anatomical course of the coronary arteries.
- The RCA passes to the right of the **pulmonary trunk** and runs along the coronary sulcus before branching. The right marginal artery arises from the RCA and moves along the right and inferior border of the heart towards the **apex**. The RCA continues to the posterior surface of the heart, still running along the **coronary sulcus**. The posterior interventricular artery then arises from the RCA and follows the posterior interventricular groove towards the apex of the heart.
- The LCA passes between the left side of the pulmonary trunk and the **left auricle**. The LCA divides into the anterior interventricular branch and the circumflex branch. The anterior interventricular branch (LAD) follows the **anterior interventricular groove** towards the apex of the heart where it continues on the posterior surface to anastomose with the posterior interventricular branch. The **circumflex branch** follows the coronary sulcus to the left border and onto the posterior surface of the heart. This gives rise to the left marginal branch which follows the left border of the heart.

Vasculature Of the Heart

Artery	Region supplied	Vein draining region
Right coronary	Right atrium SA and AV nodes Posterior part of interventricular septum (IVS)	Small cardiac vein Middle cardiac vein
Right marginal	Right ventricle Apex	Small cardiac vein Middle cardiac vein
Posterior interventricular	Right ventricle Left ventricle Posterior 1/3 of IVS	Left posterior ventricular vein
Left coronary	Left atrium Left ventricle IVS AV bundles	Great cardiac vein
Left anterior descending	Right ventricle Left ventricle Anterior 2/3 IVS	Great cardiac vein
Left marginal	Left ventricle	Left marginal vein Great cardiac vein
Circumflex	Left atrium Left ventricle	Great cardiac vein

Vasculature of the Heart

Clinical Relevance

Coronary artery Disease

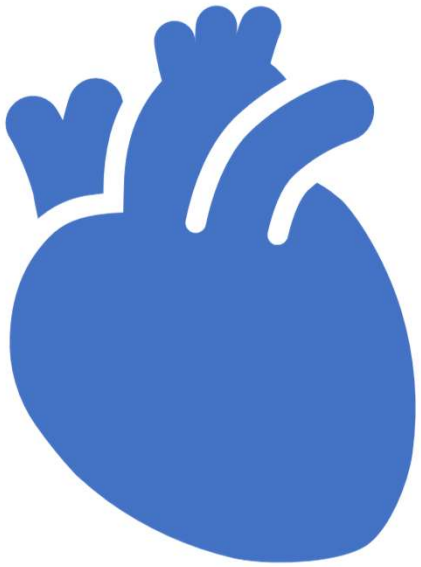
- Angina pectoris is one consequence of CHD. **Angina pectoris** describes the **transient** pain a person may feel on exercise as a result of lack of oxygen supplied to the heart. This pain is felt across the chest but is quickly resolved upon rest. Exercise is a trigger for angina as the coronary arteries fill during the **diastolic period** of the cardiac cycle. On exercising, the diastolic period is shortened meaning that there is less time for blood flow to overcome a blockage in one of the coronary vessels in order to supply the heart.
- If left untreated, angina can soon progress to more severe consequences, such as a **myocardial infarction**. The sudden occlusion of an artery results in infarction and necrosis of the myocardium. This means a section of the heart is unable to beat (which part of the heart depends on which artery has become occluded). The ECG leads on which an MI change appears can be used to locate the artery that had been occluded as shown in the table.

Vasculature of the Heart

Description	ECG leads with changes	Artery occluded
Inferior	II, III, aVF	RCA
Anteroapical	V3 and V4	Distal LAD
Anteroseptal	V1 and V2	LAD
Anterolateral	I, aVL, V5 and V6	Circumflex artery
Extensive anterior	I, aVL, V2-V6	Proximal LCA
True posterior	Tall R in V1	RCA

Organs of Thorax

- **THYMUS GLAND**
- **MAMMARY GLANDS**
- **HEART**
- **LUNGS**
- **TRACHEOBRONCHIAL TREE**
- **PLEURAE**



Organs of Thorax

LUNGS

LUNGS

Contents

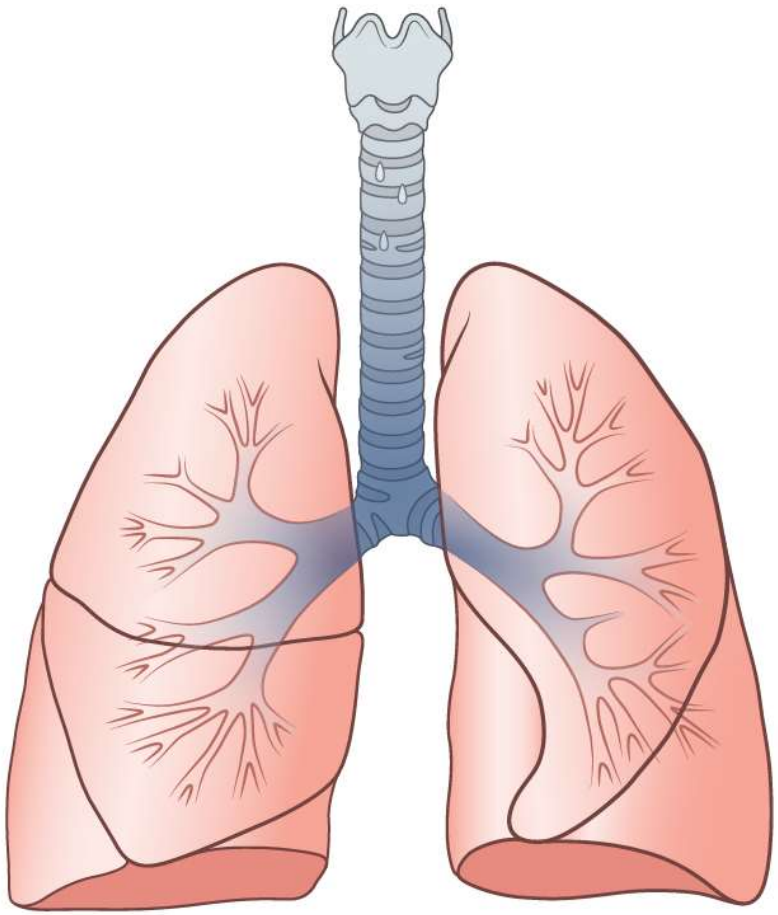
Lungs

Introduction

- The lungs are the major organs of respiration. They are located in the chest, either side of the mediastinum.
- The function of the lungs is to oxygenate blood. They achieve this by bringing inspired air into close contact with oxygen-poor blood in the pulmonary capillaries.
- In this article, we shall look at the anatomical position, structure and neurovascular supply of the lungs.

Lungs

Introduction



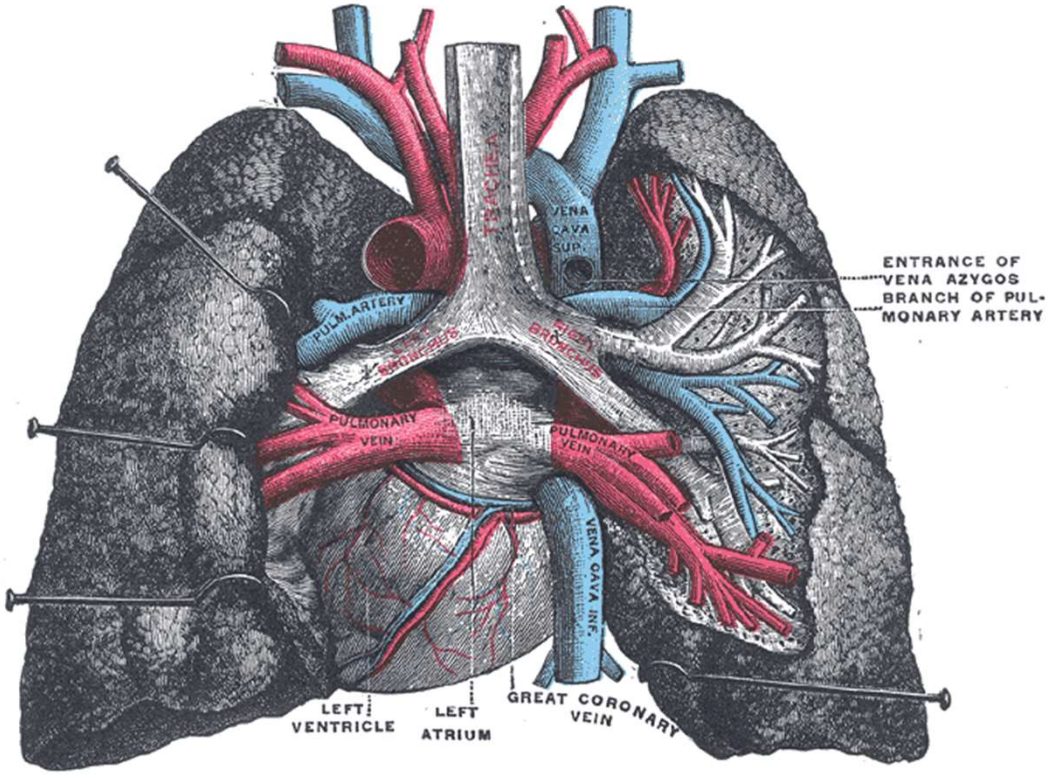
Lungs

Anatomical Position and Relations

- The lungs lie either side of the mediastinum, within the thoracic cavity. Each lung is surrounded by a pleural cavity, which is formed by the visceral and parietal pleura.
- They are suspended from the mediastinum by the **lung root** – a collection of structures entering and leaving the lungs. The medial surfaces of both lungs lie in close proximity to several mediastinal structures:

Lungs

Anatomical Position and relations



Lungs

Anatomy and Relation

Left Lung	Right Lung
Heart Arch of aorta Thoracic aorta Oesophagus	Oesophagus Heart Inferior vena cava Superior vena cava Azygous vein

Lungs

Lung Structure

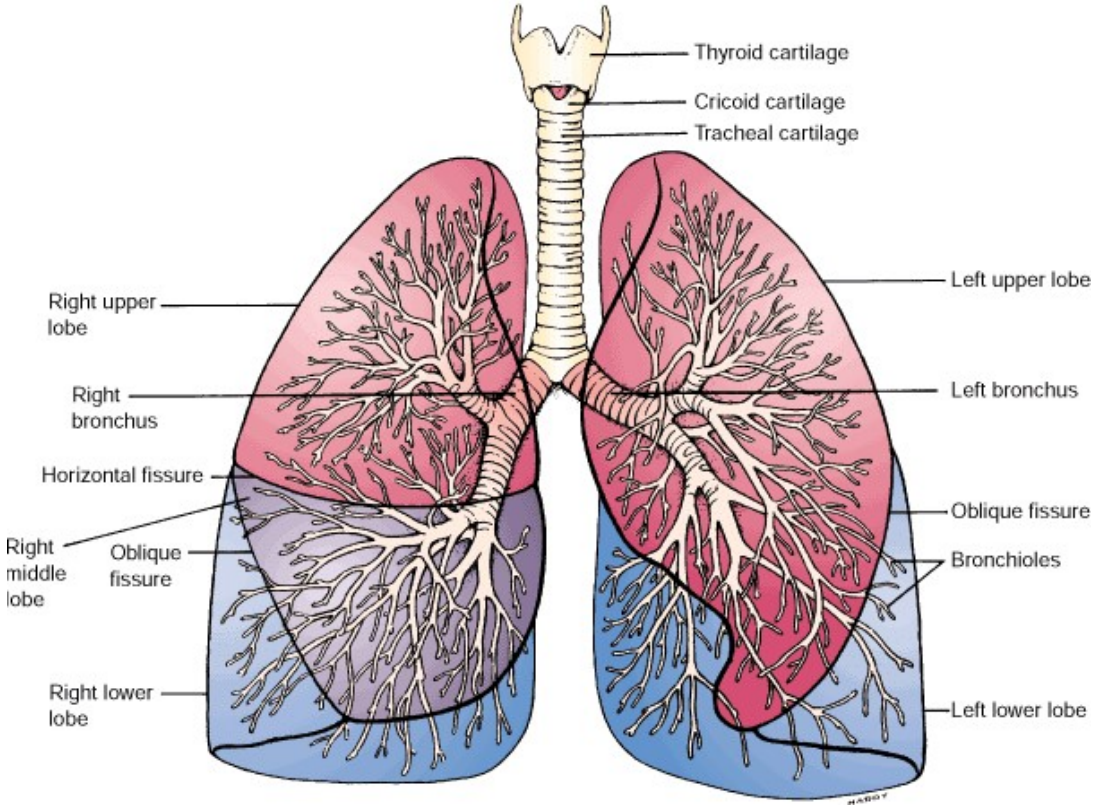
- The lungs are roughly **cone** shaped, with an apex, base, three surfaces and three borders. The left lung is slightly smaller than the right – this is due to the presence of the heart.

Each lung consists of:

- **Apex** – The blunt superior end of the lung. It projects upwards, above the level of the 1st rib and into the floor of the neck.
- **Base** – The inferior surface of the lung, which sits on the diaphragm.
- **Lobes** (two or three) – These are separated by fissures within the lung.
- **Surfaces** (three) – These correspond to the area of the thorax that they face. They are named costal, mediastinal and diaphragmatic.
- **Borders** (three) – The edges of the lungs, named the anterior, inferior and posterior borders.

Lungs

Structure



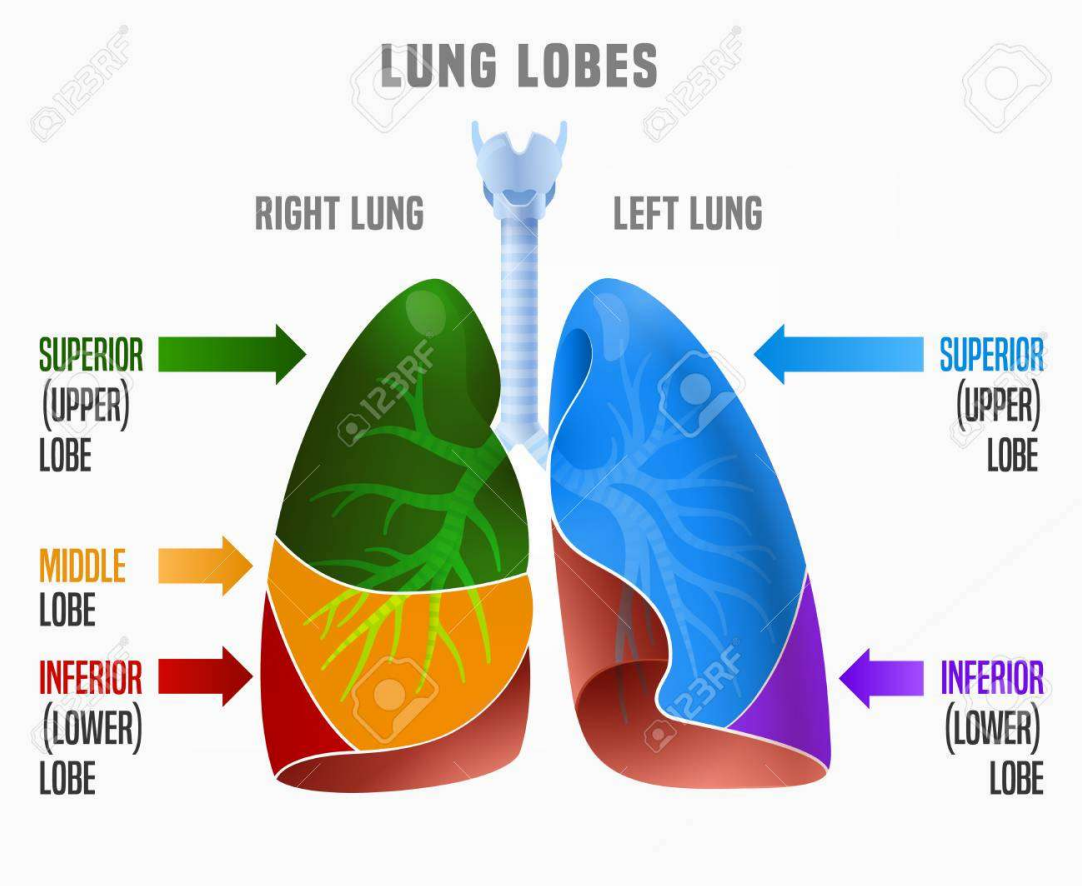
Lungs

Lobes

- The right and left lungs do not have an identical lobular structure.
- The right lung has **three lobes**; superior, middle and inferior. The lobes are divided from each other by two fissures:
- **Oblique fissure** – Runs from the inferior border of the lung in a super posterior direction, until it meets the posterior lung border.
- **Horizontal fissure**– Runs horizontally from the sternum, at the level of the 4th rib, to meet the oblique fissure.
- The left lung contains superior and inferior lobes, which are separated by a similar oblique fissure.

Lungs

Lobes


LUNG LOBES
RIGHT LUNG
LEFT LUNG
SUPERIOR (UPPER) LOBE
MIDDLE LOBE
INFERIOR (LOWER) LOBE
SUPERIOR (UPPER) LOBE
INFERIOR (LOWER) LOBE

Lungs

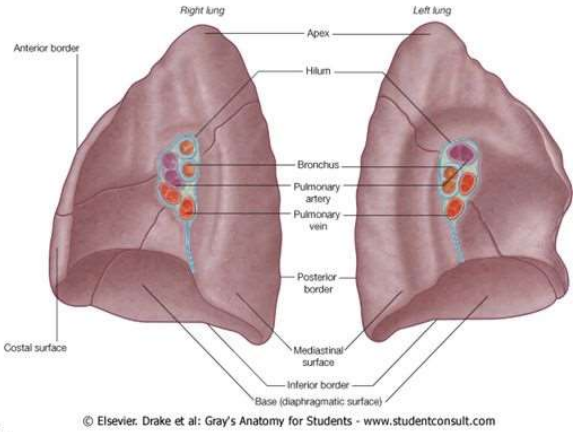
Surfaces

- There are three lung surfaces, each corresponding to an area of the thorax.
- The **mediastinal surface** of the lung faces the lateral aspect of the middle mediastinum. The lung **hilum** (where structures enter and leave the lung) is located on this surface.
- The base of the lung is formed by the **diaphragmatic surface**. It rests on the dome of the diaphragm, and has a concave shape. This concavity is deeper in the right lung, due to the higher position of the right dome overlying the liver.
- The **costal surface** is smooth and convex. It faces the internal surface of the chest wall. It is related to the costal pleura, which separates it from the ribs and innermost intercostal muscles.

Lungs

Surfaces of Lungs

- **The lungs are situated one on each side of the mediastinum.**
- **Each lung has:**
- **An apex.**
- **A concave base.**
- **A convex costal surface.**
- **A concave mediastinal surface.**
- **At about the middle of mediastinal surface is the hilum, a depression in which the bronchi, vessels, and nerves that form the root of the lung enter and leave the lung.**



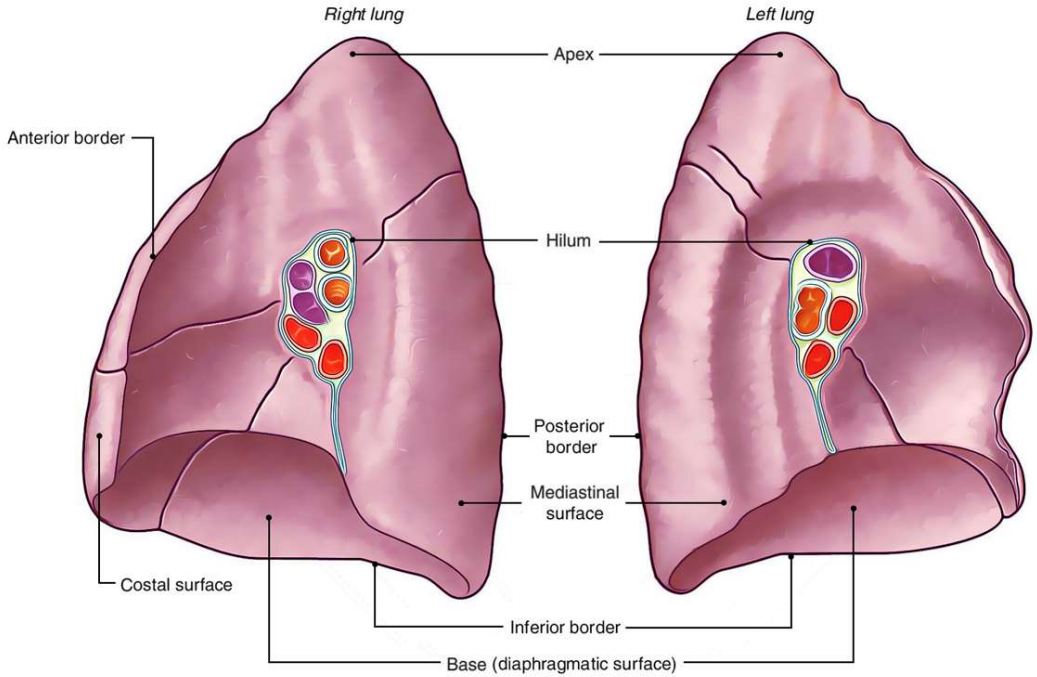
Lungs

Borders

- The **anterior border** of the lung is formed by the convergence of the mediastinal and costal surfaces. On the left lung, the anterior border is marked by a deep notch, created by the apex of the heart. It is known as the **cardiac notch**.
- The **inferior border** separates the base of the lung from the costal and mediastinal surfaces.
- The **posterior border** is smooth and rounded (in contrast to the anterior and inferior borders, which are sharp). It is formed by the costal and mediastinal surfaces meeting posteriorly.

Lungs

Borders of Lungs



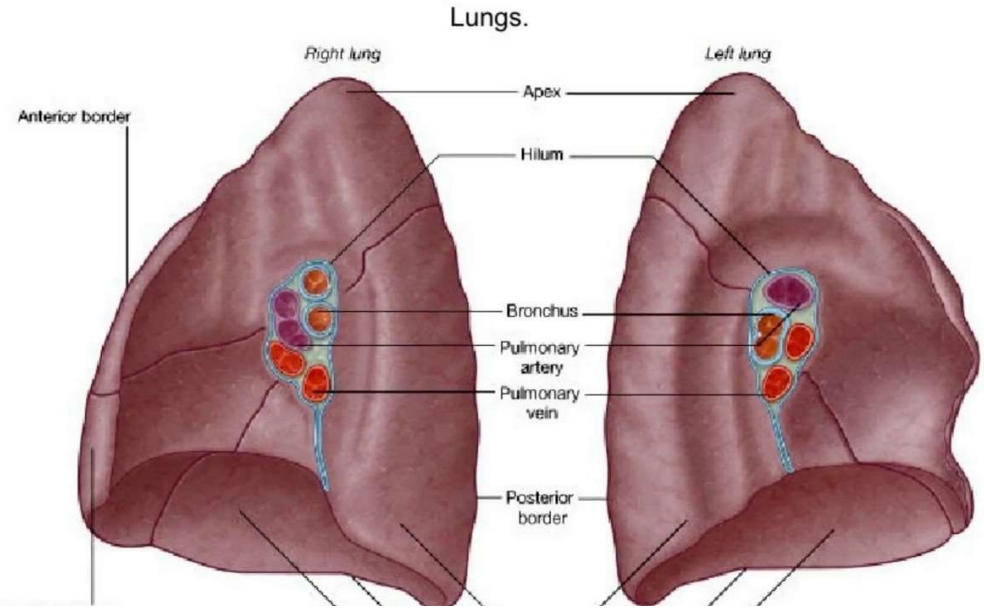
Lungs

Root and Hilum

- The lung **root** is a collection of structures that suspends the lung from the mediastinum. Each root contains a bronchus, pulmonary artery, two pulmonary veins, bronchial vessels, pulmonary plexus of nerves and lymphatic vessels.
- All these structures enter or leave the lung via the **hilum** – a wedge shaped area on its mediastinal surface.

Lungs

Roots and Hilum



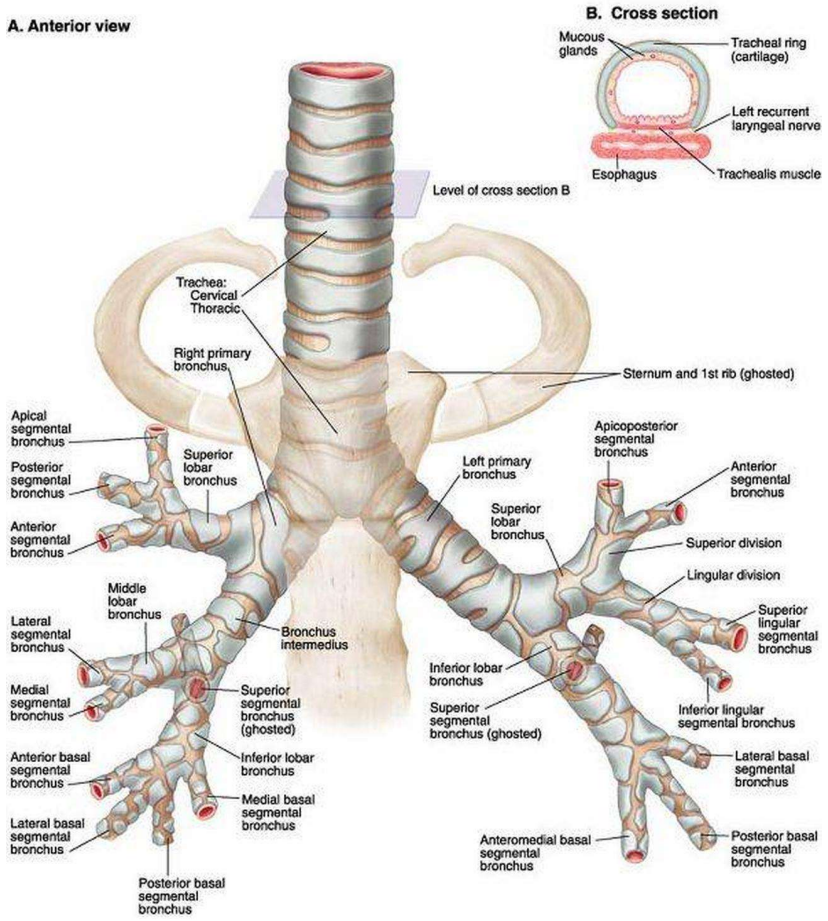
Lungs

Bronchial Tree

- The bronchial tree is a series of passages that supplies air to the alveoli of the lungs. It begins with the **trachea**, which divides into a left and right bronchus
- *Note: The right bronchus has a higher incidence of foreign body inhalation due to its wider shape and more vertical course.*
- Each bronchus enters the root of the lung, passing through the hilum. Inside the lung, they divide to form **lobar bronchi** – one supplying each lobe.

Lungs

Bronchial tree



Lungs

- Each lobar bronchus then further divides into several tertiary **segmental bronchi**. Each segmental bronchus provides air to a bronchopulmonary segment – these are the functional units of the lungs.
- The segmental bronchi give rise to many conducting bronchioles, which eventually lead into **terminal bronchioles**. Each terminal bronchiole gives off respiratory bronchioles, which feature thin walled outpocketings that extend from their lumens. These are the alveoli – the site of gaseous exchange

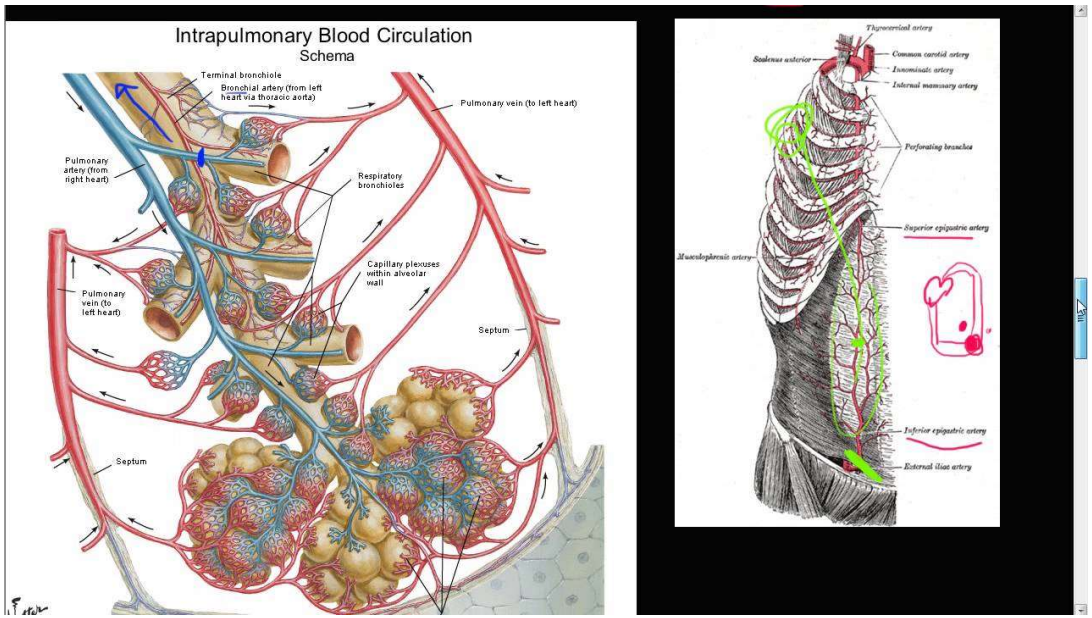
Lungs

Vasculature

- The lungs are supplied with deoxygenated blood by the paired **pulmonary arteries**. Once the blood has received oxygenation, it leaves the lungs via four **pulmonary veins** (two for each lung).
- The bronchi, lung roots, visceral pleura and supporting lung tissues require an extra nutritive blood supply. This is delivered by the **bronchial arteries**, which arise from the descending aorta.
- The bronchial veins provide **venous drainage**. The right bronchial vein drains into the azygos vein, whilst the left drains into the accessory hemiazygos vein.

Lungs

Pulmonary Artery



Lungs

Nerve Supply

- The nerves of the lungs are derived from the **pulmonary plexuses**. They feature sympathetic, parasympathetic and visceral afferent fibres:
- **Parasympathetic**: Derived from the vagus nerve. They stimulate secretion from the bronchial glands, contraction of the bronchial smooth muscle, and vasodilation of the pulmonary vessels.
- **Sympathetic**: Derived from the sympathetic trunks. They stimulate relaxation of the bronchial smooth muscle, and vasoconstriction of the pulmonary vessels.
- **Visceral afferent**: Conduct pain impulses to the sensory ganglion of the vagus nerve.

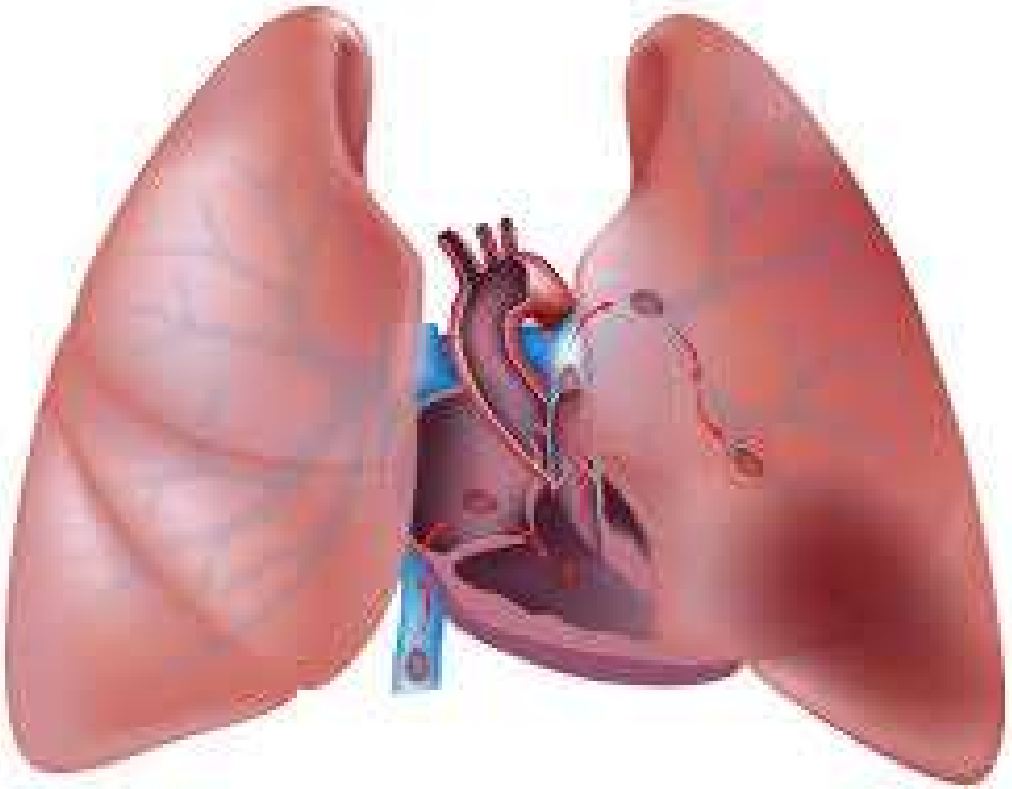
Lungs

Clinical Relevance – Pulmonary Embolism

- A pulmonary embolism refers to the obstruction of a pulmonary artery by a substance that has travelled from elsewhere in the body. The most common emboli are:
- **Thrombus** – responsible for the majority of cases and usually arises in a distant vein.
- **Fat** – following a bone fracture or orthopaedic surgery.
- **Air** – following cannulation in the neck.
- The effect of a pulmonary embolism is a **reduction in lung perfusion**. This results in decreased blood oxygenation, and the accumulation of blood in the right ventricle of the heart. Clinical features include dyspnoea, chest pain, cough, haemoptysis and tachypnoea. In clinical medicine, the Wells' score is used to assess the probability of PE.
- Definitive treatment involves **anticoagulation** and **thrombolytic therapy**. This reduces the size of the embolus, and prevents further clotting.

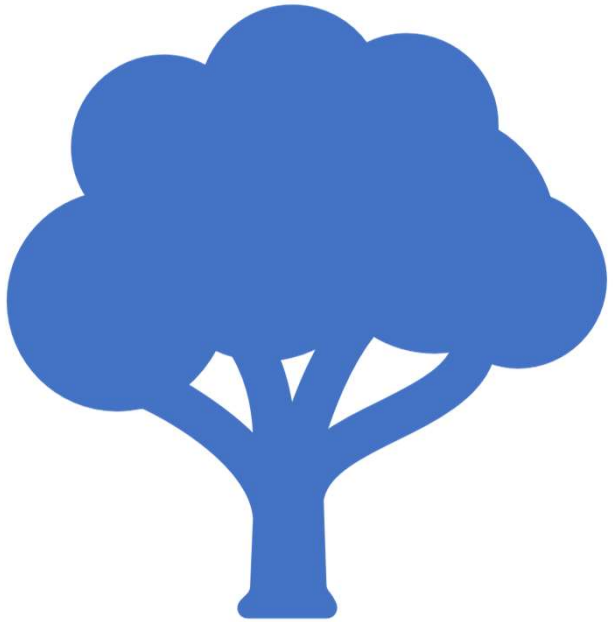
Lungs

Pulmonary Embolism



Organs of the Thorax

THE TRACHEOBRONCHIAL TREE

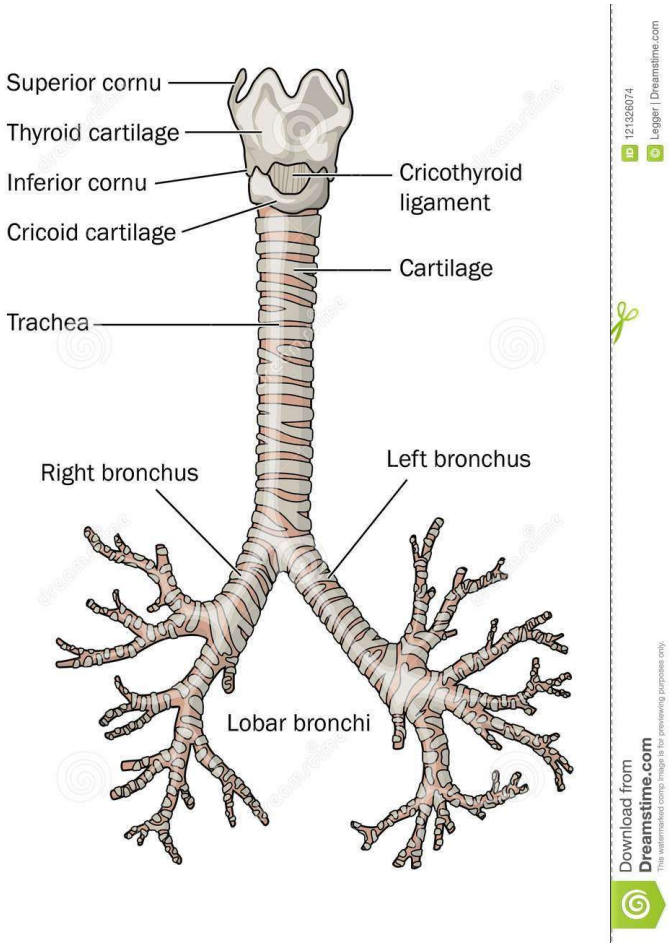


Tracheobronchial Tree

Contents

Tracheobronchial Tree

Trachea



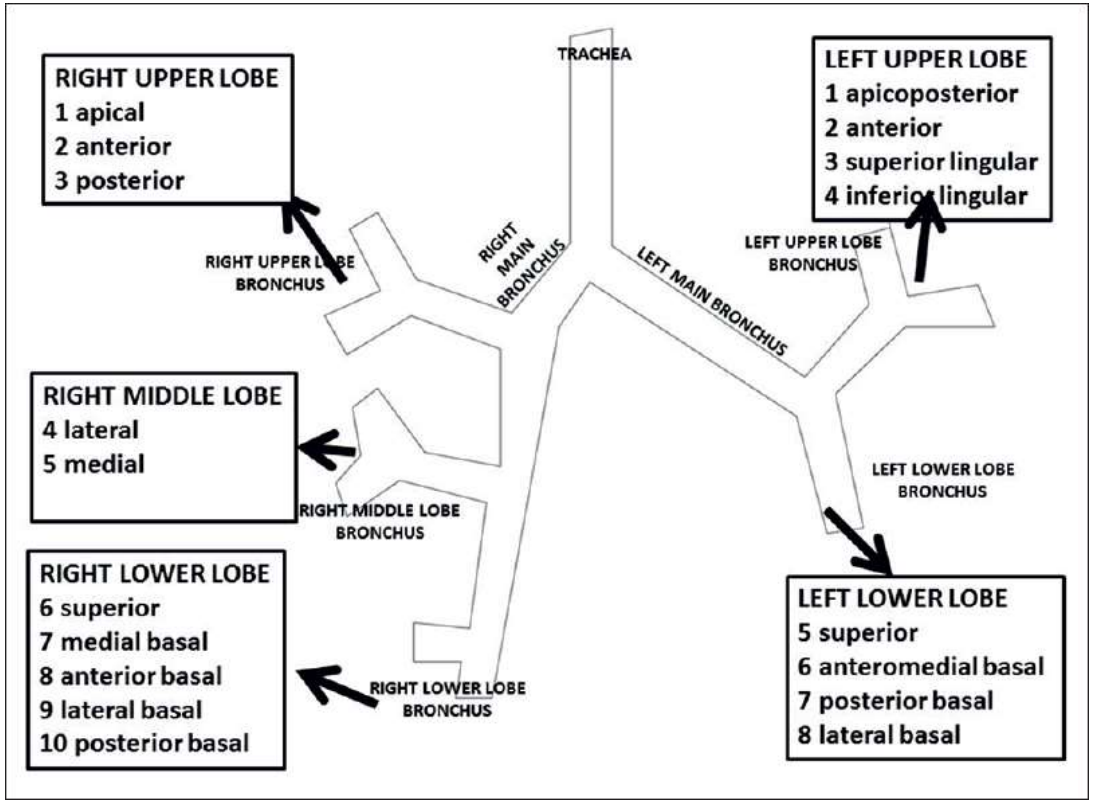
Tracheobronchial Tree

Introduction

- The trachea, bronchi and bronchioles form the **tracheobronchial tree** – a system of airways that allow passage of air into the lungs, where gas exchange occurs. These airways are located in the neck and thorax.
- In this article we will look at the anatomical position, structure and neurovascular supply of the airways; as well as considering their clinical relevance.

Tracheobrochial Tree

Lobes



Tracheobronchial Tree

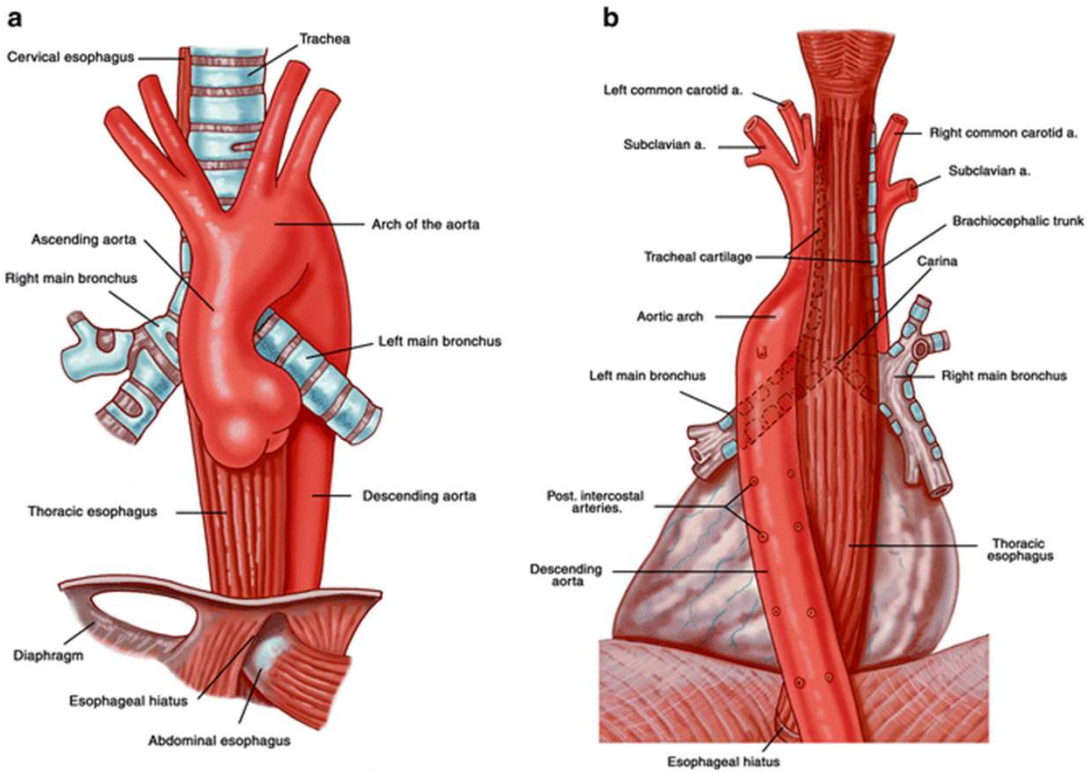
The Trachea

Anatomical Position

- The trachea marks the beginning of the tracheobronchial tree. It arises at the lower border of **cricoid cartilage** in the neck, as a continuation of the larynx.
- It travels inferiorly into the **superior mediastinum**, bifurcating at the level of the sternal angle (forming the right and left main bronchi). As it descends, the trachea is located anteriorly to the **oesophagus**, and inclines slightly to the right

Trachea

Anatomical Position



Tracheobronchial Tree

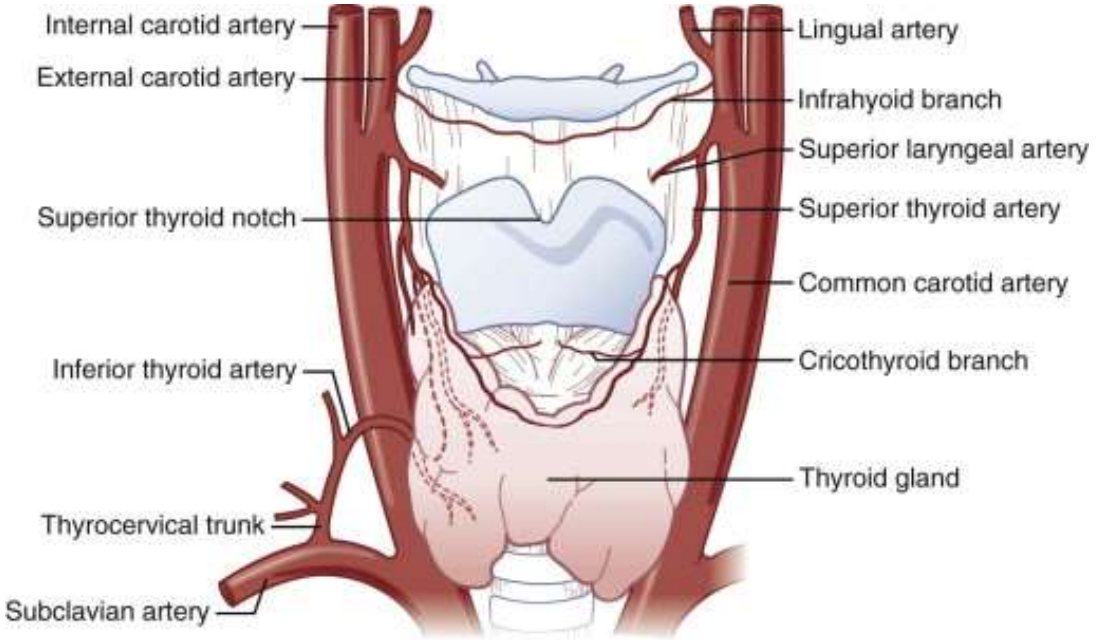
Trachea

Structure

- The trachea, like all of the larger respiratory airways, is held open by cartilage – here in **C-shaped** rings. The free ends of these rings are supported by the **trachealis muscle**.
- The trachea and bronchi are lined by ciliated pseudostratified columnar epithelium, interspersed by **goblet cells**, which produce mucus. The combination of sweeping movements by the cilia and mucus from the goblet cells forms the functional **Mucociliary escalator**. This acts to trap inhaled particles and pathogens, moving them up out of the airways to be swallowed and destroyed. This acts to trap inhaled particles and pathogens, moving them up out of the airways to be swallowed and destroyed.
- This acts to trap inhaled particles and pathogens, moving them up out of the airways to be swallowed and destroyed.
- At the bifurcation of the primary bronchi, a ridge of cartilage called the **carina** runs anteroposterior between the openings of the two bronchi. This is the most sensitive area of the trachea for triggering the cough reflex, and can be seen on bronchoscopy.

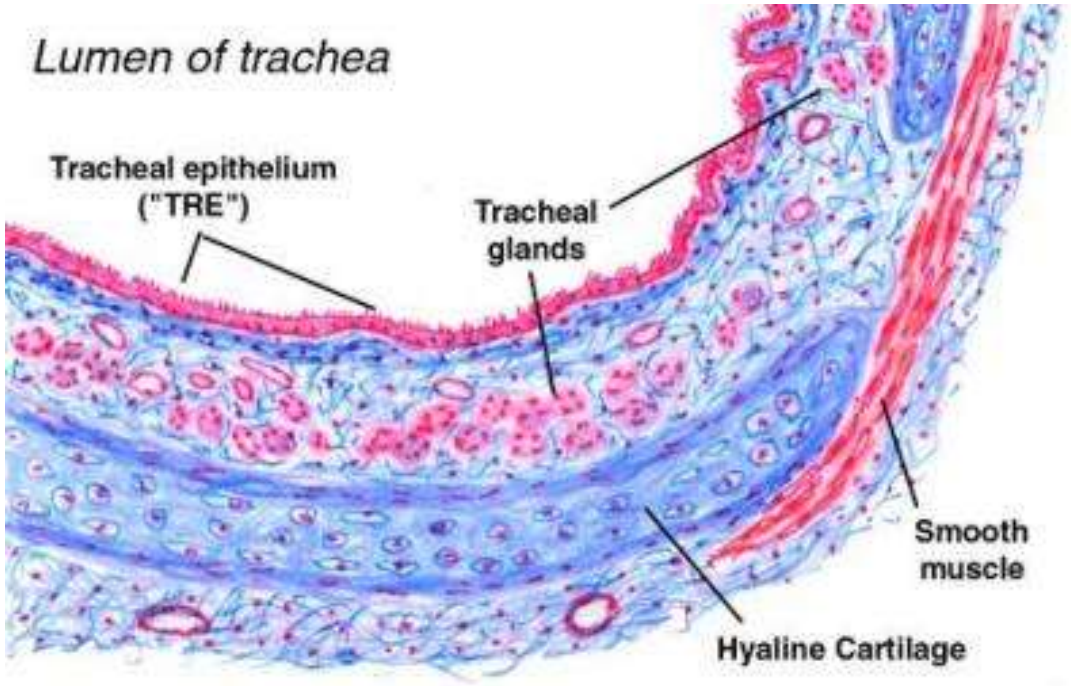
Trachea

Blood Supply



Trachea

Histology



Tracheobronchial Tree

Trachea

Neurovascular Supply

- The trachea receives sensory innervation from the **recurrent laryngeal nerve.**
- Arterial supply comes from the tracheal branches of the **inferior thyroid artery**, while venous drainage is via the brachiocephalic, azygos and accessory hemiazygos veins.

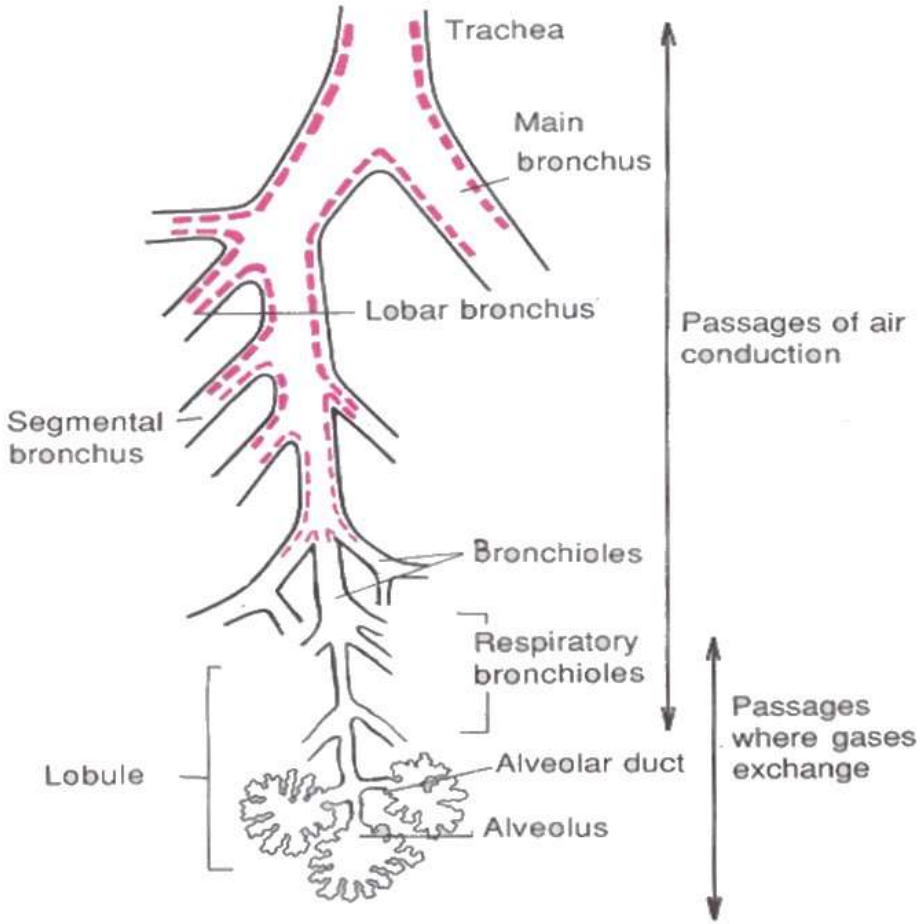
Tracheobronchial Tree

Bronchi

- At the level of the sternal angle, the trachea bifurcates into the right and left main bronchi. They undergo further branching to produce the secondary bronchi. Each secondary bronchi supplies a lobe of the lung, and gives rise to several segmental bronchi.
- Along with branches of the pulmonary artery and veins, the main bronchi make up the **roots** of the lungs.

Tracheobronchial tree

Bronchi



Tracheobronchial Tree

Bronchi

Structure

- **Right main bronchus** – wider, shorter, and descends more vertically than its left-sided counterpart. Clinically, this results in a higher incidence of foreign body inhalation. The right superior lobar bronchus arises before the right main bronchus enters the hilum.
- **Left main bronchus** – passes inferiorly to the arch of the aorta, and anteriorly to the thoracic aorta and oesophagus in order to reach the hilum of the left lung

Tracheobronchial Tree

Bronchi

Structure

- Within the lungs, the main (primary) bronchi branch into **lobar (secondary) bronchi**. Each secondary bronchi supplies a lobe of the lung, thus there are 3 right lobar bronchi and 2 left. The lobar bronchi then bifurcate into several **segmental (tertiary) bronchi**, each of which supplies a **bronchopulmonary segment.** Bronchopulmonary segments are subdivisions of the lung lobes, and act as the functional unit of the lungs.
- The structure of bronchi are very similar to that of the trachea, though differences are seen in the shape of their cartilage. In the main bronchi, cartilage rings **completely encircle** the lumen. However in the smaller lobar and segmental bronchi cartilage is found only in **crescent shapes**.

Trachea

Neurovascular Supply

- The bronchi derive innervation from pulmonary branches of the **Vagus nerve** (CN X). Blood supply to the bronchi is from branches of the **bronchial arteries,** while venous drainage is into the **bronchial veins**.

Tracheobronchial Tree

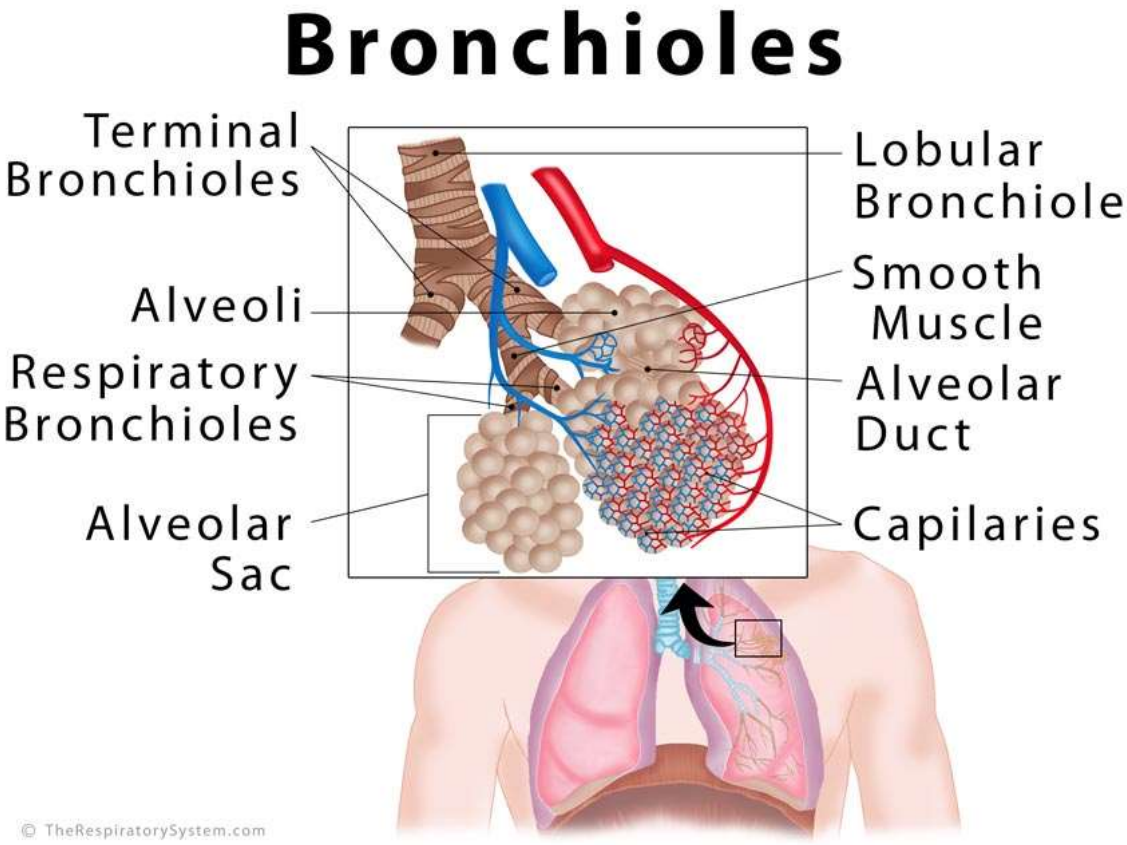
Bronchioles

- The segmental bronchi undergo further branching to form numerous smaller airways – the bronchioles.

Structure

- The smallest airways, bronchioles do not contain any cartilage or mucus-secreting goblet cells. Instead, **club cells** produce a **surfactant lipoprotein** which is instrumental in preventing the walls of the small airways sticking together during expiration.
- Initially there are many generations of **conducting bronchioles**, which transport air but lack glands and are not involved in gas exchange. Conducting bronchioles then eventually end as **terminal bronchioles.** These terminal bronchioles branch even further into **respiratory bronchioles**, which are distinguishable by the presence of **alveoli** extending from their lumens.
- **Alveoli** are tiny air-filled pockets with thin walls (simple squamous epithelium), and are the sites of gaseous exchange in the lungs. Altogether there are around 300 million alveoli in adult lungs, providing a large surface area for adequate gas exchange.

Bronchioles



Tracheobronchial tree

Clinical Correlations: Asthma

- Asthma is a chronic inflammatory disorder of the airways, characterised by hypersensitivity, reversible outflow obstruction and bronchospasm.
- There is remodelling of the small airways, causing increased **smooth muscle** thickness around the bronchioles, damaged epithelium and a thickened basement membrane.
- "Asthma attacks" are acute exacerbations of the condition whereby a trigger (e.g. allergens, exercise) causes sudden inflammation and contraction of the smooth muscle around bronchioles (bronchospasm). This narrows the airways, causing difficulty in breathing and **wheezing**, a characteristic feature of asthma.

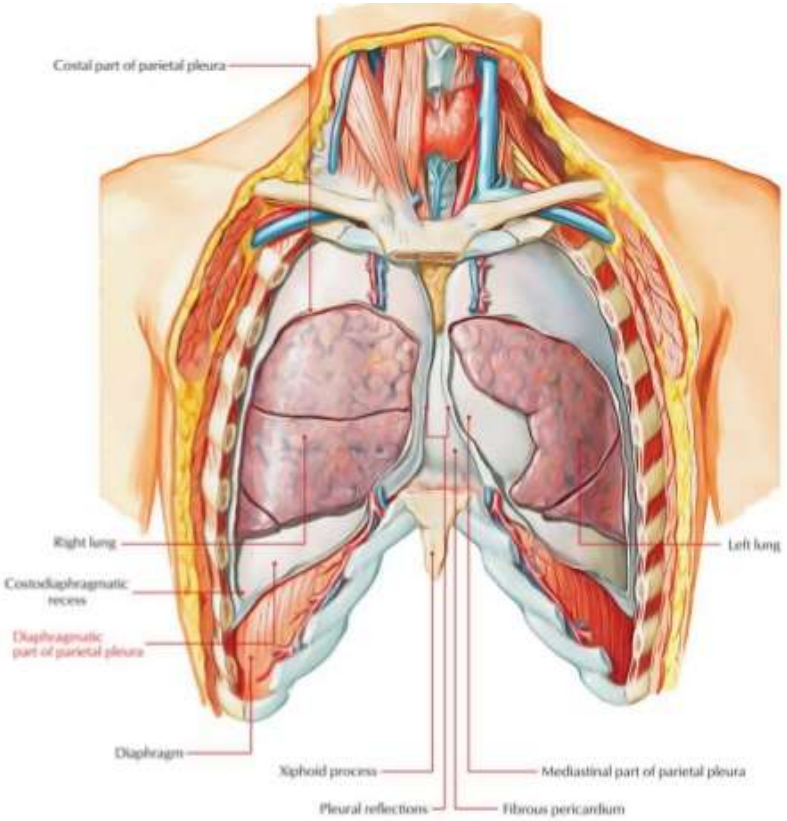
Organ of Thorax

The Pleurae

Pleurae

Contents

Pleurae

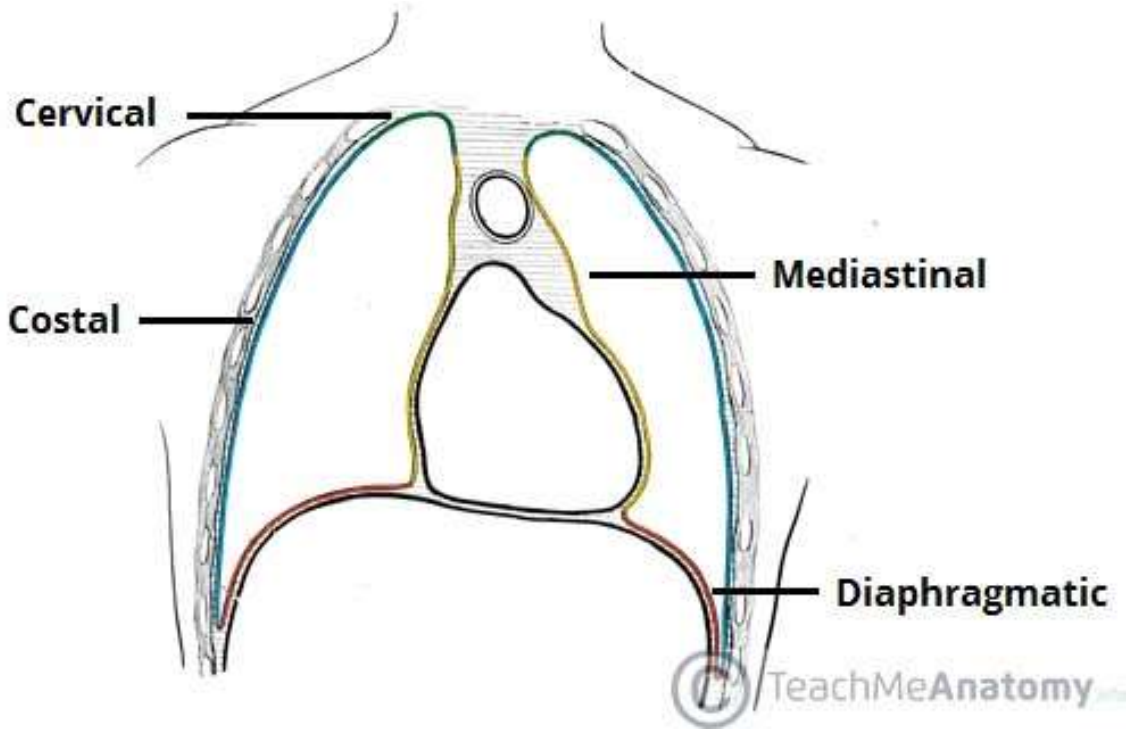

Costal part of parietal pleura
Right lung
Left lung
Costodiaphragmatic recess
Diaphragmatic part of parietal pleura
Diaphragm
Xiphoid process
Pleural reflections
Mediastinal part of parietal pleura
Fibrous pericardium

Pleurae

Introduction

The pleurae refer to the **serous membranes** that line the lungs and thoracic cavity. They permit efficient and effortless respiration. This article will outline the structure and function of the pleurae, as well as considering the clinical correlations.

Pleurae


Cervical
Costal
Mediastinal
Diaphragmatic
TeachMeAnatomy

Pleurae

Structure of the Pleurae

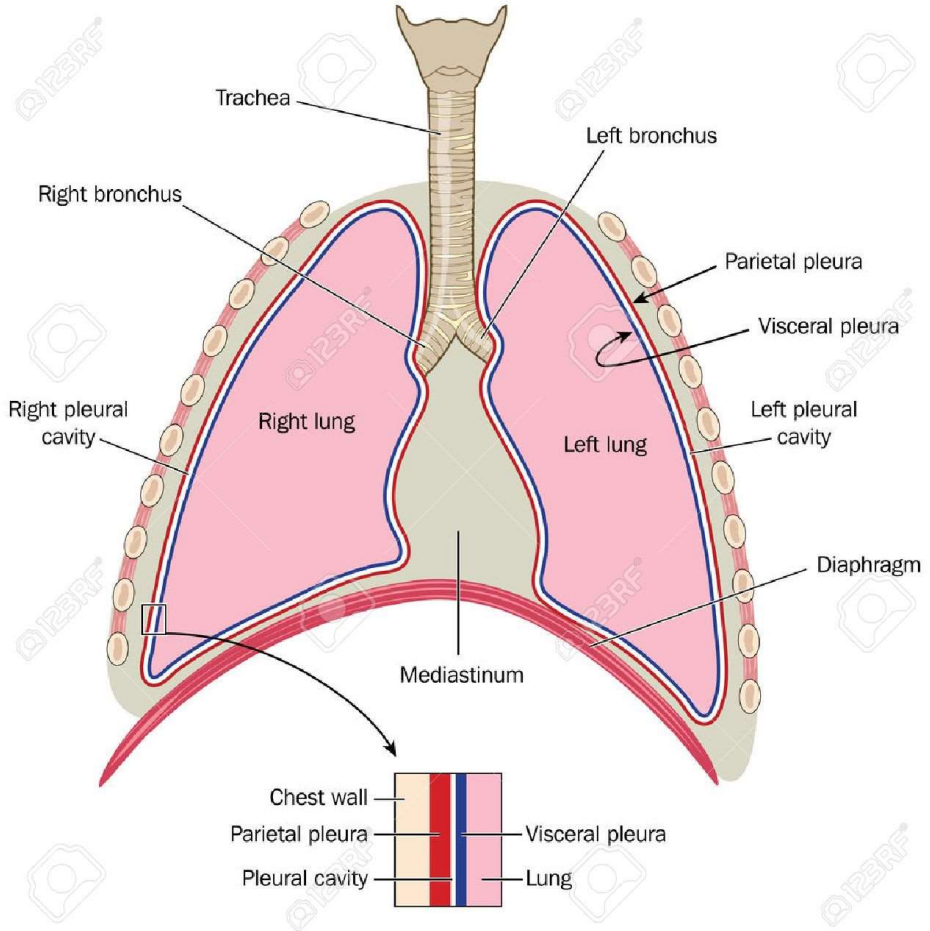
- There are two pleurae in the body – one covering each lung. They consist of a **serous membrane** – a layer of simple squamous cells, supported by connective tissue. This simple squamous epithelial layer is also known as the mesothelium.

Each pleura can be divided into two parts:

- **Visceral pleura** – covers the lungs.
- **Parietal pleura** – covers the internal surface of the thoracic cavity.
- These two parts are continuous with each other at the **hilum** of each lung. There is a potential space between the viscera and parietal pleura, known as the pleural cavity.

Pleurae

Structure of Pleurae



Pleurae

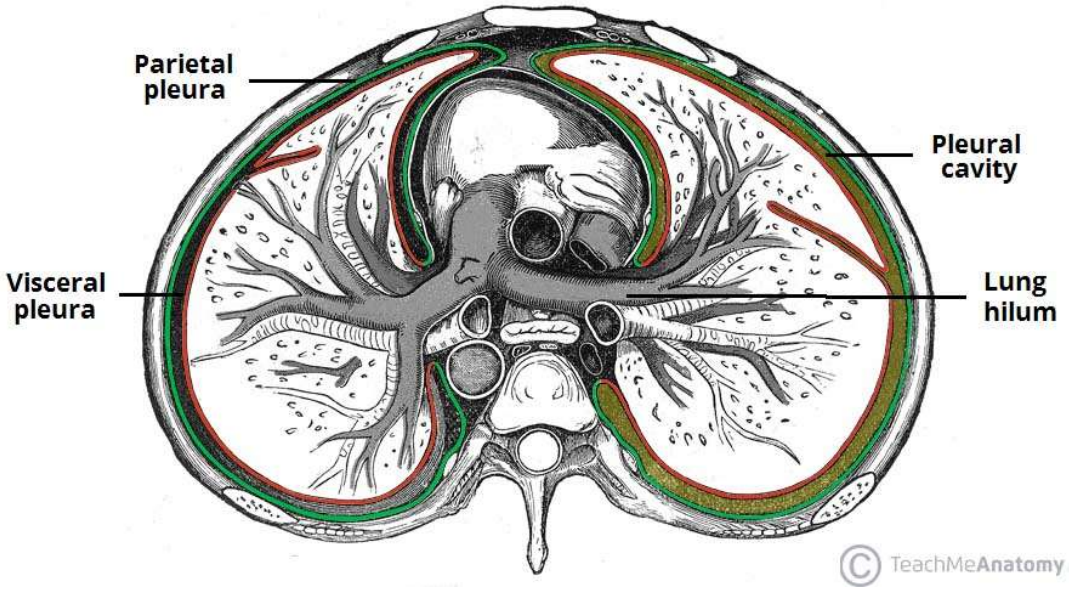
Parietal Pleurae

The parietal pleura covers the internal surface of the thoracic cavity. It is thicker than the visceral pleura, and can be subdivided according to the part of the body that it is contact with:

- **Mediastinal pleura** – Covers the lateral aspect of the mediastinum (the central component of the thoracic cavity, containing a number of organ).
- **Cervical pleura** – Lines the extension of the pleural cavity into the neck.
- **Costal pleura** – Covers the inner aspect of the ribs, costal cartilages, and intercostal muscles.
- **Diaphragmatic pleura** – Covers the thoracic (superior) surface of the diaphragm.

Pleurae

Layers of Pleurae



Pleurae

Visceral Pleura

- The visceral pleura covers the outer surface of the lungs, and extends into the interlobar fissures. It is continuous with the parietal pleura at the **hilum** of each lung (this is where structures enter and leave the lung).

Pleurae

Pleural Cavity

- The pleural cavity is a **potential space** between the parietal and visceral pleura. It contains a small volume of serous fluid, which has two major functions.
- It lubricates the surfaces of the pleurae, allowing them to slide over each other. The serous fluid also produces a surface tension, pulling the parietal and visceral pleura together. This ensures that when the thorax expands, the lung also expands, filling with air.
- *(Note: if air enters the pleural cavity, this surface tension is lost – a condition known as pneumothorax)*

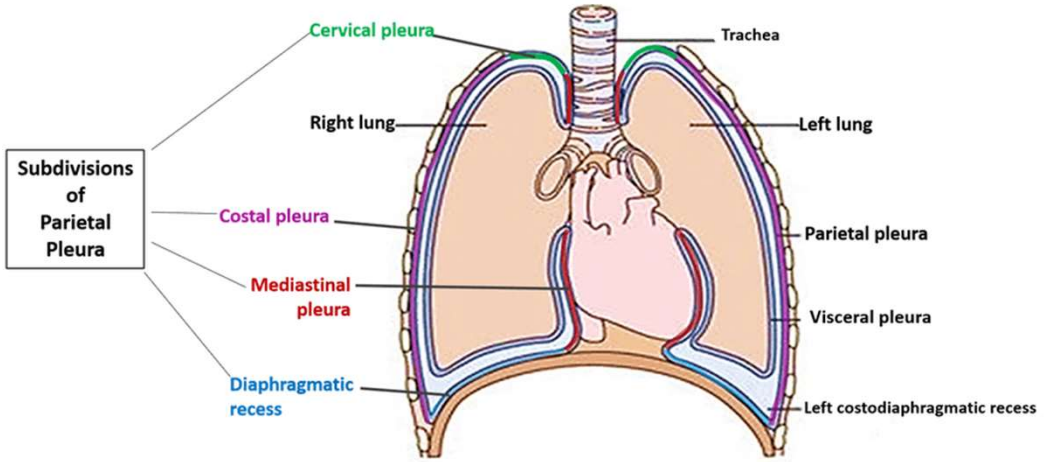
Pleurae

Pleural Recesses

- Anteriorly and posteroinferiorly, the pleural cavity is not completely filled by the lungs. This gives rise to **recesses** – where the opposing surfaces of the parietal pleura touch.
- There are two recesses present in each pleural cavity:
- **Costodiaphragmatic** – located between the costal pleurae and the diaphragmatic pleura.
- **Costomediastinal** – located between the costal pleurae and the mediastinal pleurae, behind the sternum.
- These recesses are of clinical importance, as they provide a location where fluid can collect (such as in a pleural effusion).

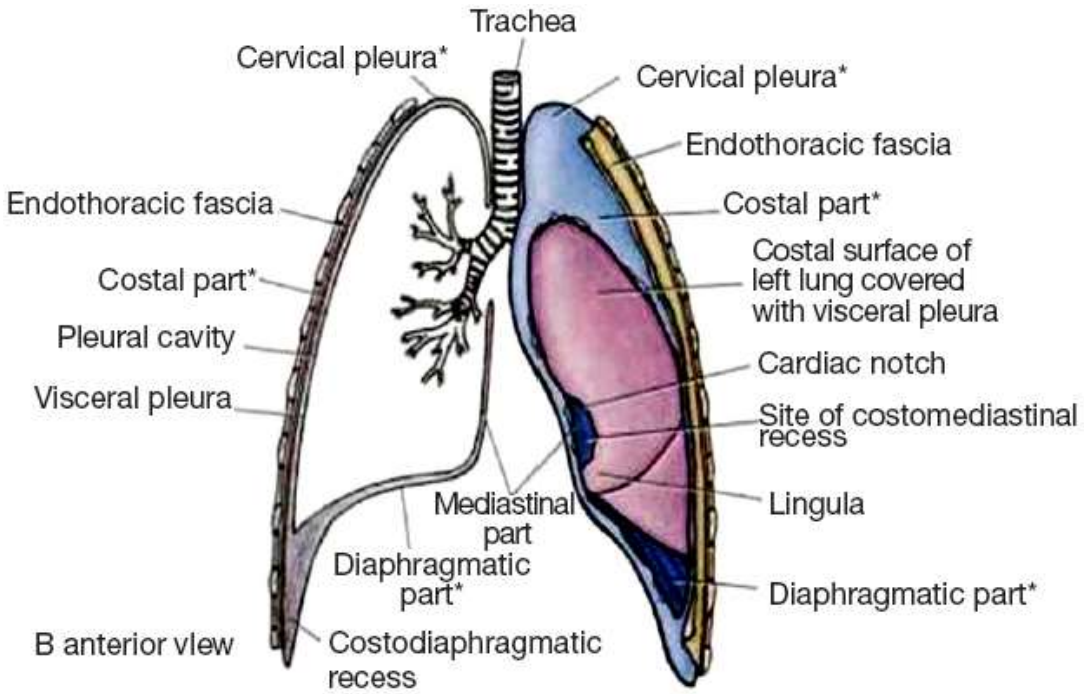
Pleurae

Pleural Recess



Pleurae

Pleural Recess



Pleaurae

Neurovascular Supply

The two parts of the pleurae receive a different neurovascular supply:

- **Parietal Pleura**
- The parietal pleura is sensitive to pressure, pain, and temperature. It produces a well localised pain, and is innervated by the **phrenic** and **intercostal nerves**.
- The blood supply is derived from the **intercostal arteries**.
- **Visceral Pleura**
- The visceral pleura is not sensitive to pain, temperature or touch. Its sensory fibres only detect stretch. It also receives autonomic innervation from the **pulmonary plexus** (a network of nerves derived from the sympathetic trunk and vagus nerve).
- Arterial supply is via the **bronchial arteries** (branches of the descending aorta), which also supply the parenchyma of the lungs.

Pleurae

Clinical Relevance: Pneumothorax

- A **pneumothorax** (commonly referred to a collapsed lung) occurs when air or gas is present within the pleural space. This removes the surface tension of the serous fluid present in the space, reducing lung extension.
- Clinical features include chest pain, and shortness of breath, and asymmetrical chest expansion. Upon percussion, the affected side may be **hyper-resonant** (due to excess air within the chest).
- There are two main classes of pneumothorax – spontaneous and traumatic.

Pleurae

- **Spontaneous:** A spontaneous pneumothorax occurs without a specific cause. It is sub-divided into primary (no underlying respiratory disease) and secondary (underlying respiratory disease present).
- **Traumatic:** A traumatic pneumothorax occurs as a result of blunt or penetrating chest trauma, such as a rib fracture (often seen in road traffic collisions).
- Treatment depends on identifying the underlying cause. Primary pneumothoraces tend to be small and generally require minimal intervention, whereas secondary and traumatic pneumothoraces may require decompression to remove the extra air/gas in order for the lung to reinflate (this is achieved via the insertion of a **chest drain**).