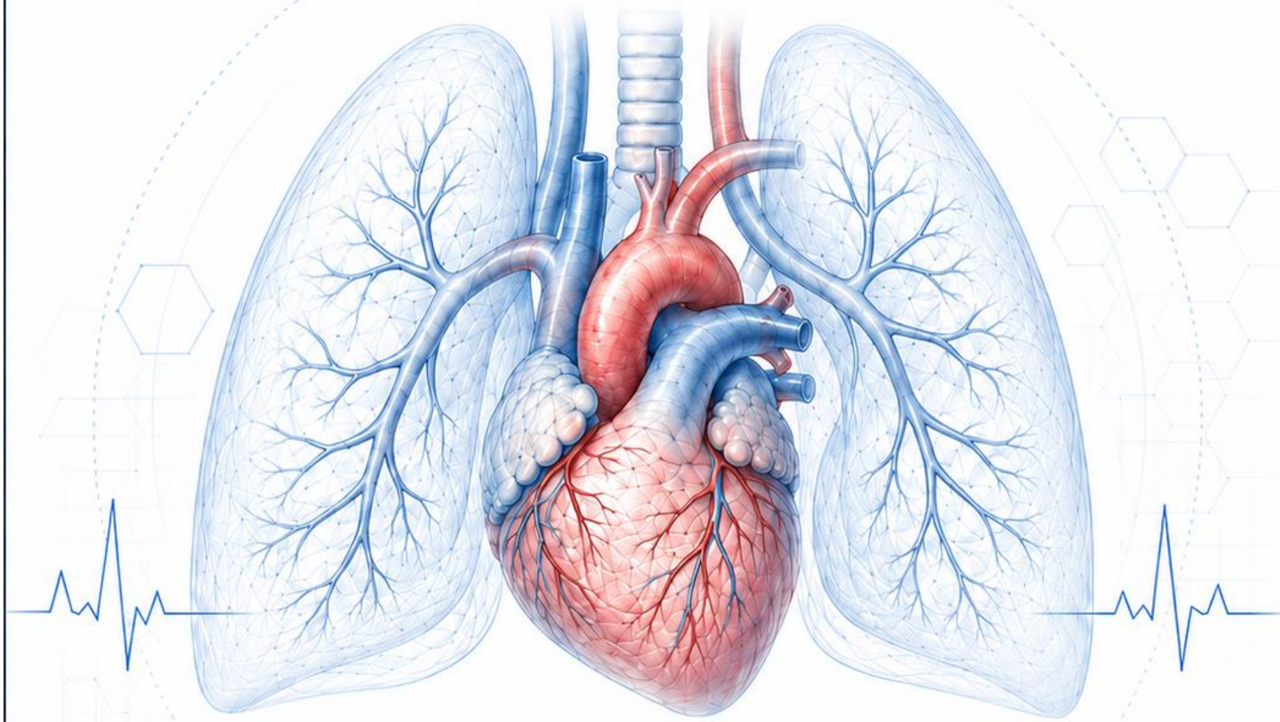
# Cardiothoracic Surgery Handbook

*A medical student-focused guide to core cardiac, thoracic and congenital procedures*



This handbook is intended as an educational guide for medical students and early clinical learners observing cardiothoracic surgery. It summarises key anatomy, operative principles, theatre etiquette and common procedures. It is not a substitute for local policy, consultant guidance or formal clinical training.

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## Contents

# Cardiothoracic General Principles

## Common Incisions in Cardiothoracic Surgery

Surgical access in cardiothoracic surgery depends on the planned operation (Cardiac vs. Thoracic), pathology, patient anatomy, urgency and surgeon preference. The approach should provide safe exposure while minimizing unnecessary tissue trauma.

### Median Sternotomy

Median sternotomy is the most commonly used approach for open cardiac surgery. It provides excellent exposure of the heart, great vessels and anterior mediastinum, making it suitable for a wide range of cardiac and selected thoracic procedures.

***The broad operative steps include:***

- The patient lies in the supine position
- A midline skin incision is made from the sternal notch to around the xiphoid process
- This is followed by careful dissection through the subcutaneous tissue and pectoralis fascia
- The midline of the sternum is identified and divided using a sternal saw
- The two sternal edges are retracted to provide exposure
- Periosteal bleeding is controlled using bone wax, packs or cautery

***Common indications include:***

- Valve surgery, most commonly aortic or mitral valve procedures
- Coronary artery bypass grafting (CABG) - In patients who have previously undergone CABG, look for leg scars suggesting saphenous vein harvest
- Cardiac transplantation
- Congenital heart defects, for example TOF, complex ASD or VSD, atrioventricular septal defects, TGA and TAPVR
- Anterior pleuropulmonary and mediastinal pathology, including thymic and mediastinal tumour surgery.
- Pulmonary thromboendarterectomy (PTE)

## Thoracotomy

A thoracotomy is an incision used to access the pleural cavity. Common approaches include posterolateral, anterolateral and axillary thoracotomy.

## Posterolateral Thoracotomy

Posterolateral thoracotomy is a traditional, gold-standard open approach for thoracic surgery. It provides excellent access to the lung, hilum, middle and posterior mediastinum and oesophagus.

***The broad operative steps include:***

- The patient lies in the lateral decubitus position
- A long-curved incision is made along the lateral chest wall
- It typically begins between the paraspinal region and scapula, then extends laterally towards the anterior axillary line
- This is followed by careful dissection through the subcutaneous tissue and relevant muscle layers, including latissimus dorsi and, in some cases, serratus anterior
- Posteriorly, trapezius and rhomboid fibres may be divided when additional posterior exposure is required
- After muscle dissection, the appropriate intercostal space is identified and entered by dividing the intercostal muscles carefully to avoid injury to the neurovascular bundle
- A rib spreader is then opened gradually to reduce the risk of rib fracture and provide access to the pleural cavity

***Common indications include:***

- Pulmonary resections, including lobectomy and pneumonectomy
- Oesophageal surgery (Particularly in the USA where thoracic surgeons perform oesophageal surgery)
- Diaphragmatic repair
- Open lung biopsies
- Lung volume reduction surgery or bullectomy
- Unilateral lung transplantation

## Anterolateral Thoracotomy

Anterolateral thoracotomy provides good access to the upper lobes, right middle lobe and anterior hilum. Although mainly used in thoracic surgery, it may also be used for selected cardiac or oesophageal pathology.

***The broad operative steps include:***

- The patient lies in the supine position
- A skin incision is made at approximately the fourth or fifth intercostal space, usually along the inframammary crease, extending towards the anterior axillary line
- Dissection proceeds through the subcutaneous tissue, pectoralis fascia and intercostal muscles
- The latissimus and serratus muscles are retracted to provide access to the pleural space

It is important to note that patients can also have a clamshell thoracotomy, or bilateral anterolateral thoracotomy, which provides wide exposure of the thoracic cavity and may be used when bilateral access is required, for example in major trauma, bilateral lung transplantation or selected malignancy cases.

***Common indications include:***

- Unilateral lung transplantation
- Emergency management of penetrating cardiac or thoracic injuries.

## Axillary Thoracotomy

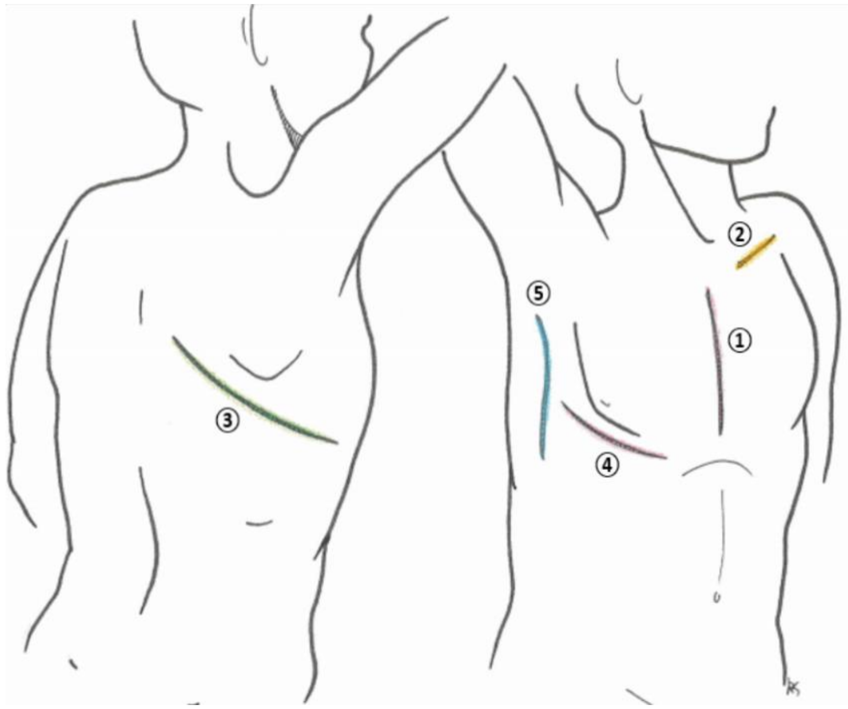
Axillary thoracotomy is a muscle-sparing approach to the thoracic cavity. With the development of VATS, it is now used less frequently.

***The broad operative steps include:***

- The patient lies in the lateral decubitus position
- A skin incision is made between the posterior border of pectoralis major and the anterior border of latissimus dorsi
- The latissimus dorsi and serratus anterior are split or retracted
- After identifying the fourth or fifth intercostal space, the intercostal muscles are divided to access the pleural cavity

***Common indications include:***

- Surgery for pneumothorax management
- Pneumonectomy
- Thoracic outlet procedures




https://teachmesurgery.com/examinations/cardiorespiratory/cardiothoracic-incisions/

*Figure: Common cardiothoracic incisions:*

1 = median sternotomy;

2 = pacemaker scar;

3 = posterolateral thoracotomy;

4 = anterolateral thoracotomy;

5 = axillary thoracotomy.


https://shc.amegroups.org/article/view/3819/html

https://geekymedics.com/cardiothoracic-incisions/

https://teachmesurgery.com/examinations/cardiorespiratory/cardiothoracic-incisions/

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https://www.optechtcs.com/article/S1522-2942(03)70019-1/fulltext

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https://www.optechtcs.com/article/S1522-2942(03)70026-9/fulltext

https://mmcts.org/tutorial/1151

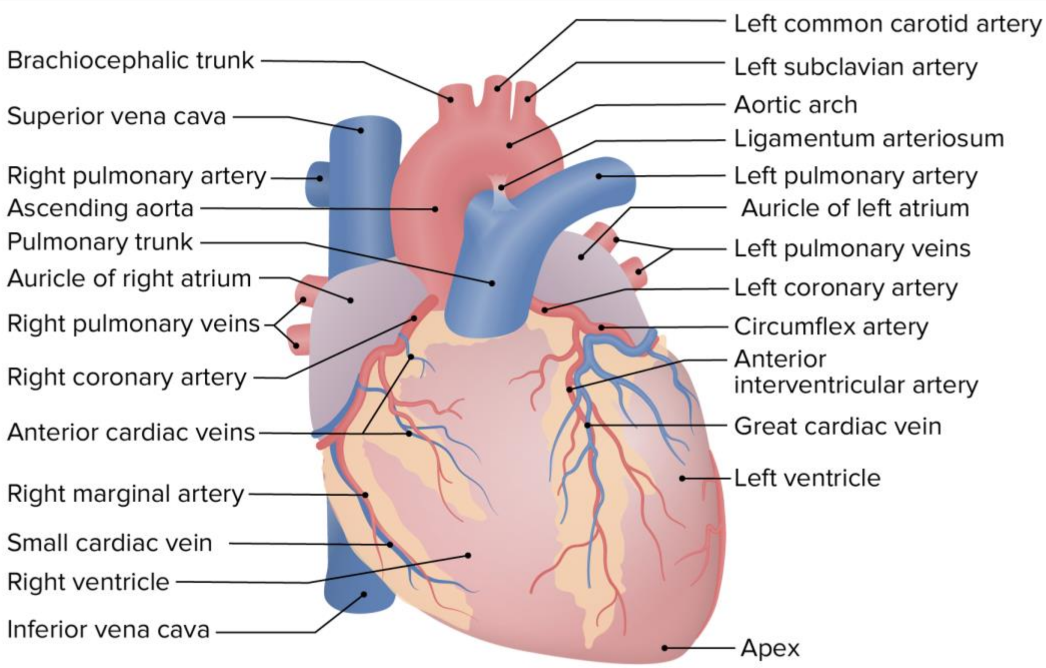
# Anatomy and Physiology

## Cardiac Anatomy and Physiology

A thorough understanding of cardiac anatomy is fundamental to the safe and effective practice of cardiothoracic surgery. The heart is a muscular, four-chambered organ located within the middle mediastinum. It lies obliquely within the thoracic cavity, enclosed by the pericardium, and rests superior to the diaphragm. Its close anatomical relationship with the neurovascular structures, lungs and ooesophagus, necessitates precise spatial awareness during surgery.

### Cardiac Chambers and Blood Flow

| | |
|---|---|
| **Right atrium:** | The right atrium receives deoxygenated blood from the systemic circulation via the superior and IVC. Blood passes from the right atrium into the right ventricle through the tricuspid valve. |
| **Right ventricle:** | The right ventricle pumps deoxygenated blood into the pulmonary circulation via the pulmonary trunk and pulmonary arteries, through the pulmonary valve. |
| **Left atrium:** | The left atrium receives oxygenated blood from the lungs via the pulmonary veins. Blood then flows into the left ventricle through the mitral valve. |
| **Left ventricle:** | The left ventricle generates the highest pressures within the heart, ejecting oxygenated blood into the systemic circulation via the ascending aorta through the aortic valve. |




https://www.lecturio.com/concepts/anatomy-of-the-heart/

## Coronary Circulation

As a highly metabolically active muscle, the myocardium requires a dedicated blood supply, provided by the coronary arteries. The right and left coronary arteries arise from the ascending aorta immediately above the aortic valve.

***RCA:***

The RCA typically supplies the right atrium, right ventricle, and various portions of the inferior and posterior interventricular septum.

***LCA:***

***The LCA divides into two major branches:***

- LAD artery, which supplies the anterior wall of the left ventricle, the apex, and the anterior two-thirds of the interventricular septum.
- Left circumflex artery, which supplies the left atrium and the lateral and posterolateral walls of the left ventricle.

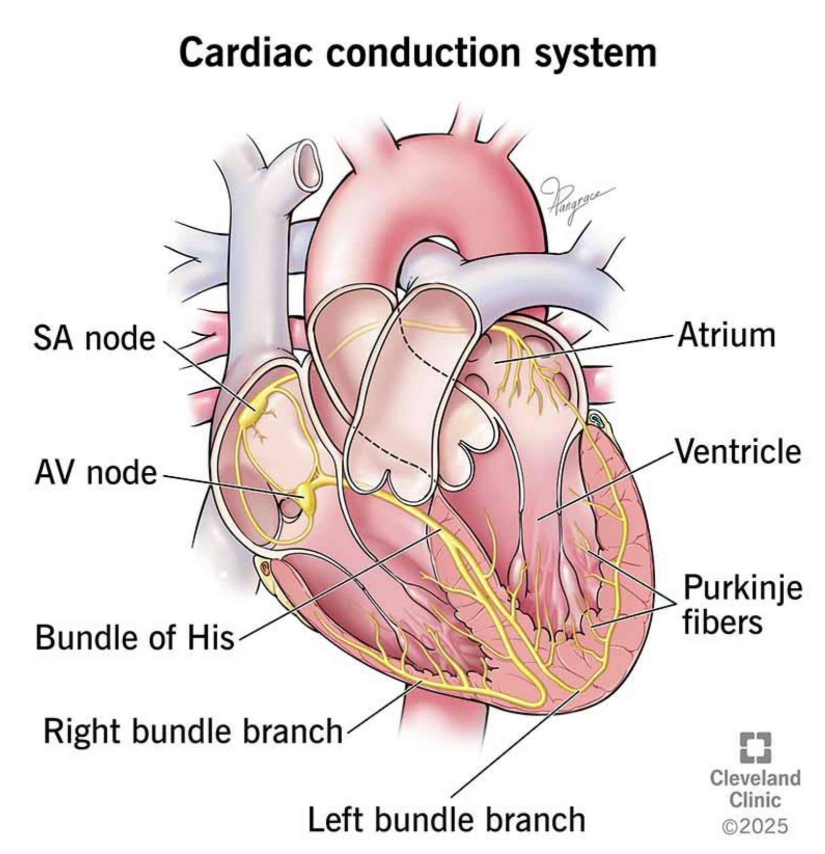
Venous drainage of the myocardium occurs predominantly via the coronary sinus, which collects blood from the cardiac veins and drains into the right atrium.

## Cardiac Conduction System

The heart is unique among muscles in its ability to generate and propagate electrical impulses independently of direct nervous system input. This is called autorhythmicity. This automaticity is mediated by a specialised cardiac conduction system composed of pacemaker cells and organised electrical pathways. The coordinated activity of this system ensures that atrial and ventricular contraction occurs in a precise, rhythmic sequence, thereby maintaining effective cardiac output and systemic perfusion.

The Components of the Cardiac Conduction System

| | |
|---|---|
| **SA node:** | The SA node is located in the superior aspect of the right atrial wall, near the junction with the SVC. It functions as the heart's primary pacemaker, generating spontaneous electrical impulses at an intrinsic rate of approximately 60 - 100 BPM. These impulses spread through the atrial myocardium, resulting in coordinated atrial contraction, and are subsequently conducted to the atrioventricular node. |
| **AV node:** | The AV node is situated in the inferior part of the inter-atrial septum at the atrioventricular junction. It serves a critical physiological role by introducing a brief delay in impulse conduction, allowing time for complete atrial emptying into the ventricles before their contraction. The impulse is then transmitted from the AV node into the Bundle of His. |
| **Bundle of His (AV bundle):** | The bundle of His arises from the AV node and courses through the superior portion of the interventricular septum. It divides into right and left bundle branches, which conduct the electrical impulse rapidly down the interventricular septum toward the ventricular apex and into the Purkinje fibres. |
| **Purkinje fibres:** | The Purkinje fibre network extends from the terminal bundle branches throughout the ventricular myocardium. Rapid impulse propagation through this system results in near-simultaneous ventricular depolarisation and coordinated contraction. |




https://my.clevelandclinic.org/health/body/21648-heart-conduction-system

## Pericardium

The heart is a vital organ and therefore requires both structural protection and positional stability within the thoracic cavity. These are provided in part by the pericardium, a double-layered fibroserous sac that encloses the heart and the proximal portions of the great vessels.

The fibrous pericardium forms the tough outer layer and serves to anchor the heart within the mediastinum. It provides mechanical protection and limits acute cardiac overdistension, particularly during sudden increases in venous return.

Deep to the fibrous pericardium lies the serous pericardium, which is further divided into two layers. The parietal layer lines the inner surface of the fibrous pericardium, while the visceral layer (also known as the epicardium) closely invests the surface of the heart. Between these two serous layers is the pericardial cavity, which contains a small volume of pericardial fluid. This fluid acts as a lubricant, minimising friction between the pericardial layers during cyclical cardiac contraction.

https://www.kenhub.com/en/library/anatomy/heart

https://www.britannica.com/science/heart

https://geekymedics.com/the-hearts-conduction-system/

https://simplemed.co.uk/subjects/cardiovascular/anatomy-of-the-cardiovascular-system

## Thoracic Anatomy and Physiology

A comprehensive understanding of thoracic and respiratory anatomy is essential for the safe and effective practice of thoracic surgery. Surgical access to the lungs, pleura, mediastinum, and chest wall requires detailed knowledge of anatomical relationships, regional vasculature, and individual anatomical variation. With the increasing adoption of minimally invasive techniques (VATS and RATS), the ability to interpret thoracic anatomy via indirect visualisation has become a core surgical skill. Unlike open procedures, these approaches rely on camera-based imaging, often with restricted viewing angles and limited tactile feedback. Surgeons must therefore be able to mentally reconstruct three-dimensional anatomical relationships from a two-dimensional monitor image in order to operate safely around major vascular, airway, and neural structures.

## Thoracic Cavity and its Boundaries

The lungs are located within the thoracic cavity, which is bounded by the following anatomical structures:

- Anteriorly: Sternum and costal cartilages
- Posteriorly: Thoracic vertebral column
- Laterally: Ribs and intercostal muscles
- Inferiorly: Diaphragm

Within the thoracic cavity are two principal compartments. The mediastinum occupies the central region and contains the heart, great vessels, trachea, ooesophagus, and other vital structures. On either side of the mediastinum lie the pleural cavities, each housing a lung.

## Lungs and Lobes

There are two lungs: a right lung and a left lung, situated within their respective pleural cavities on either side of the mediastinum.

The right lung is composed of three lobes: superior, middle, and inferior - separated by the horizontal and oblique fissures. It is typically subdivided into 10 bronchopulmonary segments, each of which represents a functionally and surgically discrete unit supplied by its own vascular and airway branches.

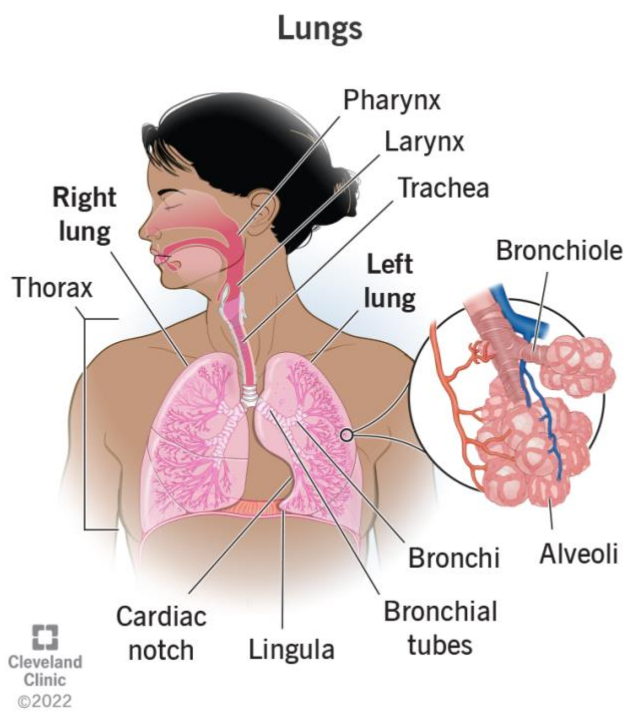
The left lung is composed of two lobes: superior and inferior - separated by an oblique fissure. The reduction to two lobes reflects the limited space within the left hemithorax due to the presence of the heart. The left lung is typically divided into 8-10 bronchopulmonary segments, with recognised anatomical variation.

## Bronchial Tree and Airways

Effective pulmonary gas exchange depends on the delivery of air from the external environment to the alveoli. This is achieved via the bronchial tree, a highly organised branching network of airways. The bronchial tree serves two principal functions: the distribution of air throughout the lungs and the protection of the distal airways through mucociliary clearance, which traps and removes inhaled particulates and pathogens.

***Components of the Bronchial Tree:***

| | |
|---|---|
| **Trachea:** | The trachea is the largest airway of the bronchial tree. It begins at approximately the level of the sixth cervical vertebra (C6), inferior to the larynx, and extends to the carina, where it bifurcates into the right and left main bronchi. The trachea is supported by C-shaped cartilaginous rings that maintain airway patency while allowing posterior flexibility. Its mucosa contains mucus-secreting glands and ciliated epithelial cells, which together form the mucociliary escalator. |
| **Primary (main) bronchi:** | The trachea divides at the carina into the right and left primary bronchi. Each enters the corresponding lung at the hilum and subsequently divides into secondary bronchi. These airways are supported by cartilaginous rings similar to those of the trachea. The right main bronchus is typically wider, shorter, and more vertical than the left, a feature of clinical relevance in aspiration and airway management. |
| **Secondary (lobar) bronchi:** | The primary bronchi divide into secondary (lobar) bronchi, with one lobar bronchus supplying each lung lobe. Consequently, the right lung has three lobar bronchi and the left lung has two. Within each lobe, the lobar bronchi further divides into segmental bronchi. |
| **Tertiary (segmental) bronchi:** | Tertiary bronchi arise from the lobar bronchi and supply individual bronchopulmonary segments. Each segment is anatomically and functionally discrete, with its own bronchial and arterial supply, a feature that underpins segmental lung resection. These bronchi divide progressively into smaller conducting airways. |
| **Bronchioles:** | Bronchioles are small-diameter airways (typically <1 mm) that arise from the segmental bronchi. They lack cartilaginous support. Terminal bronchioles give rise to respiratory bronchioles, which lead to the alveolar ducts. |
| **Alveoli:** | The alveoli represent the terminal portion of the bronchial tree and are the primary site of gas exchange. These microscopic air sacs are optimised for diffusion, possessing thin walls and a large SA:V. The alveolar lining consists predominantly of type I pneumocytes, which facilitate gas exchange, and type II pneumocytes, which secrete surfactant to reduce surface tension and prevent alveolar collapse. |




https://my.clevelandclinic.org/health/body/8960-lungs

## Pulmonary and Bronchial Circulation

The respiratory system is supported by a dual vascular supply that serves both its respiratory and metabolic requirements: the pulmonary circulation and the bronchial circulation.

The pulmonary circulation is responsible for gas exchange. Deoxygenated blood is ejected from the right ventricle into the pulmonary trunk and pulmonary arteries, which branch extensively to form a dense capillary network surrounding the alveoli. Within this network, gas exchange occurs, resulting in oxygenation of the blood. Oxygenated blood then returns to the heart via the pulmonary veins, which drain into the left atrium.

The bronchial circulation arises primarily from branches of the descending thoracic aorta and provides oxygenated blood to the conducting airways, supporting tissues of the lungs, and visceral pleura. Venous drainage of the bronchial circulation occurs via the bronchial veins, which typically drain into the azygos and hemiazygos venous systems.

## Pleura

The lungs are enclosed within a protective serous membrane known as the pleura, which serves important mechanical and physiological functions in respiration. The pleura consists of two layers:

- The visceral pleura, which closely adheres to the surface of the lungs and extends into the interlobar fissures.

- The parietal pleura, which lines the inner surface of the thoracic cavity, including the chest wall, diaphragm, and mediastinum.

Between these two layers lies the pleural cavity, containing a small volume of pleural fluid. This fluid reduces friction during respiratory movements and helps maintain close apposition of the lungs to the thoracic wall, facilitating efficient lung expansion during inspiration.

## Respiratory Muscles and Breathing Mechanics

Ventilation depends on the coordinated activity of respiratory muscles, which generate pressure gradients within the thoracic cavity to enable inspiration and expiration. By altering thoracic volume, these muscles allow lung expansion during inspiration and passive recoil during expiration. In addition to their role in ventilation, respiratory muscles contribute to postural stability and are recruited during increased respiratory demand or distress.

## Primary Respiratory Muscles

- Diaphragm:
  The diaphragm is the principal muscle of inspiration. During contraction, it flattens and descends, increasing thoracic volume and generating negative intrathoracic pressure. It forms the inferior boundary of the thoracic cavity, separating it from the abdominal cavity. The diaphragm is innervated by the phrenic nerve, arising from cervical nerve roots C3-C5 (* "C3, C4, C5 keeps the diaphragm alive")

- Intercostal muscles:
  The intercostal muscles occupy the spaces between adjacent ribs and are arranged in three layers, innervated segmentally by the corresponding intercostal nerves:

  - External intercostals, which elevate the ribs during inspiration

  - Internal intercostals, which depress the ribs during forced expiration

  - Innermost intercostals, which contribute to stabilisation of the thoracic wall

## Accessory Respiratory Muscles

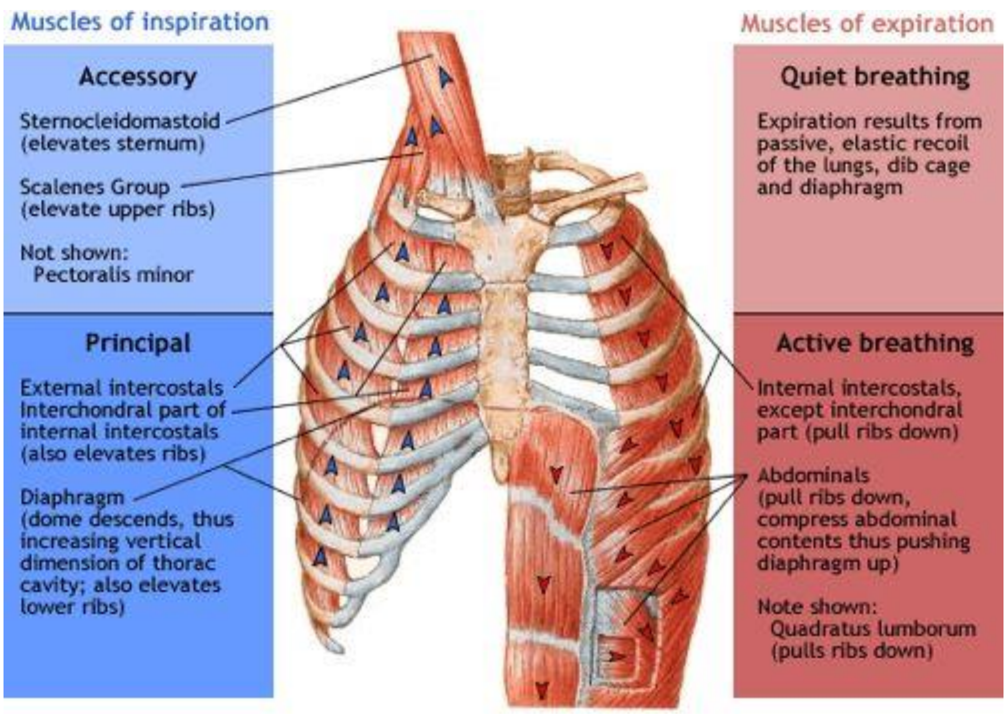
Accessory muscles are recruited during increased ventilatory demand, such as exercise, laboured breathing, or respiratory compromise. These include:

- Sternocleidomastoid muscles, which elevate the sternum

- Scalene muscles, which elevate the first and second ribs

- Pectoralis minor, serratus anterior, and latissimus dorsi, which assist in rib elevation and chest wall expansion when the upper limbs are fixed

- Abdominal wall muscles (rectus abdominis, internal and external obliques, and transversus abdominis), which increase intra-abdominal pressure to displace the diaphragm superiorly and facilitate forced expiration




https://www.physio-pedia.com/Muscles_of_Respiration

https://www.kenhub.com/en/library/anatomy/thorax

https://teachmeanatomy.info/thorax/organs/lungs/

https://teachmeanatomy.info/thorax/organs/tracheobronchial-tree/

# Cardiothoracic Theatre Etiquette

Cardiothoracic surgery is performed in a very specialised operating theatre environment which can be characterised by long procedures, complex physiological processes, and close coordination between surgical, anaesthetic, perfusion, and nursing teams. Attending cardiothoracic operating theatres can be an intimidating experience for medical students, given the complexity of the procedures and the highly specialised nature of the environment. The purpose of this section, therefore, is to highlight theatre etiquette specific to cardiothoracic surgery, so students can feel more confident when attending cardiothoracic theatres.

## Preparation

Before entering cardiothoracic theatres, students should be familiar with the basics, including the patient's diagnosis, the indication for surgery, and the broad objectives of the planned operation. For example, a student observing CABG should understand the rationale behind surgical revascularisation and have a foundational knowledge of coronary artery anatomy, while those attending valve surgery should be familiar with the relevant valve pathology. Arriving early is strongly encouraged, as cardiothoracic cases frequently begin with complex anaesthetic preparation, monitoring, and team briefings that are very valuable to observe.

In the operating theatre, students should introduce themselves to the scrub nurse, circulating staff, anaesthetist, and a member of the surgical team. In theatre, the scrub nurse will often record the names of all staff present, so making an early introduction is useful. Students should also introduce themselves to the lead surgeon for the case.

## Scrubbing and Participation in the Procedure

Medical students should scrub in when invited to do so. If the opportunity arises, students who feel confident and comfortable can also ask the lead surgeon whether they may scrub for the procedure. When scrubbing in, it is important to follow instructions regarding gowning and positioning. In cardiothoracic surgery, the extent of student involvement can vary, depending on experience and confidence. Students, however, should try not anticipate operative steps or adjust instruments without guidance, particularly during critical stages of the procedure. It is completely acceptable to ask for clarification if unsure at any point, as this is appreciated positively rather than negatively.

When scrubbed, students should maintain appropriate hand position and orientation, with hands above the waist at all times. Any concern regarding contamination should be immediately mentioned to the scrub nurse, who can then advise on the next steps.

## During Cardiothoracic Procedures

Cardiothoracic operations often involve phases that require more concentration from the entire team, for example initiation of cardiopulmonary bypass, application and release of the aortic cross-clamp. During these periods, it is ideal to remain silent and have minimal movement, avoiding conversations. The timing of questions is also important, and good opportunities arise around wound closure, periods of physiological stability, or after the operation has finished. It is important to be attentive to verbal and non-verbal cues from the surgical team, recognising when discussion is welcome and when it is best to observe quietly.

Throughout the operation, students should be mindful of where they are standing, so as not to obstruct the surgeon's view, the scrub nurse's access to instruments, or the anaesthetist's access to the airway and monitoring equipment. The perfusionist's workspace should also be respected at all times, and students should not interfere with the bypass machine, cannulae, or associated tubing.

## Multidisciplinary Respect and Team Dynamics

Cardiothoracic surgery is fundamentally very team-based. Anaesthetists manage complex haemodynamic changes and ventilation strategies, while perfusionists are responsible for maintaining cardiopulmonary bypass and systemic perfusion. Scrub and circulating nurses ensure sterility and procedural flow. Students must demonstrate respect for all members of the team and recognise that patient safety depends on effective collaboration between disciplines.

## Managing Fatigue and Physical Wellbeing

Cardiothoracic cases can be lengthy, and prolonged standing may lead to fatigue or light-headedness, particularly for students new to long theatre sessions. If a student feels unwell, they should step away from the sterile field and inform a member of staff immediately.

Ultimately, cardiothoracic theatres are excellent learning environments, and students who arrive prepared and show respect for the team are welcomed and encouraged to make the most of the experience!

https://geekymedics.com/theatre-etiquette/

# Cardiac Surgery

## Core Principles

### CPB

CPB is used during many cardiac operations to temporarily take over the function of the heart and lungs. This allows the surgeon to operate on a still, bloodless heart while maintaining circulation and oxygen delivery to the rest of the body. It is required for most procedures involving intracardiac structures, including CABG, valve surgery, repair of congenital defects, and surgery on the ascending aorta.

During CPB, venous blood is drained from the right atrium or vena cava via cannulation, and passed through an extracorporeal circuit. Within the circuit, blood flows through an oxygenator (where gas exchange occurs) and a heat exchanger, which allows the patient to be cooled or rewarmed in a controlled way. The oxygenated blood is then returned to the arterial system, usually via the ascending aorta.

Because blood is exposed to artificial surfaces within the circuit, there is a risk of clot formation. Patients are therefore anticoagulated with unfractionated heparin before bypass is initiated, and the effect is monitored intra-operatively using the activated clotting time (ACT). At the end of the procedure, heparin is reversed with protamine sulphate.

https://www.anaesthesiajournal.co.uk/article/S1472-0299(18)30107-3/abstract

### Cardioplegia

Cardioplegia is used to deliberately stop the heart during cardiac surgery and protect the myocardium while coronary blood flow is interrupted. Most cardioplegic solutions are high in potassium, which causes the heart to arrest in diastole. This significantly reduces myocardial oxygen demand and helps preserve cardiac function during surgery.

Cardioplegia can be delivered in different ways. Antegrade delivery is via the aortic root into the coronary arteries, while retrograde delivery is via the coronary sinus and is useful when antegrade flow is limited, such as in severe coronary artery disease. The solution is usually given cooled to further reduce metabolic demand, and is repeated at intervals to maintain myocardial protection.

Both crystalloid and blood-based solutions are used in practice. The choice of cardioplegia depends on surgeon preference, procedure type, and expected cross-clamp time.

https://academic.oup.com/ejcts/article/67/2/ezae354/8011475

https://academic.oup.com/icvts/article/30/2/161/5579824

https://www.jcvaonline.com/article/S1053-0770(19)30073-4/fulltext

## Chest Drains

Chest drains are routinely placed at the end of cardiac surgery to remove air and fluid from the mediastinum and pleural spaces. Their main roles are to prevent complications such as cardiac tamponade or haemothorax, allow the lungs to re-expand, and provide a method to monitor postoperative bleeding.

Drain output is closely monitored in the immediate postoperative period. High or persistent output may indicate ongoing bleeding and can prompt further investigation or even a return to theatre.


https://gbukgroup.com/products/surgical-critical-care/chest-drainage/

https://jtd.amegroups.org/article/view/34402/html

https://www.jtcvstechniques.org/article/S2666-2507(24)00151-2/fulltext

### Temporary Pacing Wires

Temporary epicardial pacing wires are commonly placed at the end of cardiac surgery to allow management of postoperative arrhythmias. They are sutured onto the surface of the atrium and/or ventricle and brought out through the chest wall, where they can be connected to an external pacemaker if needed.

Post-operative rhythm disturbances are relatively common and can occur due to surgical manipulation, myocardial oedema, or ischaemia. Temporary pacing wires provide a simple and effective way to manage bradyarrhythmias or heart blocks in the early postoperative period.

Once the patient has a stable intrinsic rhythm and pacing is no longer required, the wires are usually removed on the ward prior to discharge.

https://link.springer.com/article/10.1007/s11748-022-01831-5

https://link.springer.com/article/10.1186/s13019-024-02619-9

https://www.annalsthoracicsurgery.org/article/S0003-4975(04)01423-7/fulltext

## Coronary

CABG: On-pump vs Off-pump

A CABG is performed to improve blood flow to the myocardium in patients with significant coronary artery disease. It is commonly indicated in patients with left main stem disease, triple-vessel disease, or complex multivessel disease, particularly in those with diabetes or impaired left ventricular function, where complete revascularisation is important.

In on-pump CABG, the operation is performed using CPB. The aorta is cross-clamped, and the heart is arrested with cardioplegia, providing a still and bloodless field for the surgeon. This allows precise construction of coronary anastomoses and remains the standard approach in most centres. However, the use of CPB is associated with a systemic inflammatory response and can contribute to short-term postoperative complications.

In off-pump CABG, surgery is performed on the beating heart without CPB. Special stabilisation devices are used to immobilise the target coronary artery. Avoiding CPB may be beneficial in certain higher-risk patients, such as those with significant aortic atherosclerosis. Outcomes are generally comparable in experienced centres, although off-pump surgery can be technically more demanding.

In both approaches, grafts are attached distal to the site of coronary stenosis to restore blood flow. Vein grafts are usually connected proximally to the ascending aorta, while arterial grafts (such as the internal mammary artery) are often left attached to their origin and connected directly to the coronary artery.

### Graft Types

The choice of conduit is a key factor in the long-term success of a CABG procedure. In general, arterial grafts are preferred because they have better long-term patency than vein grafts.

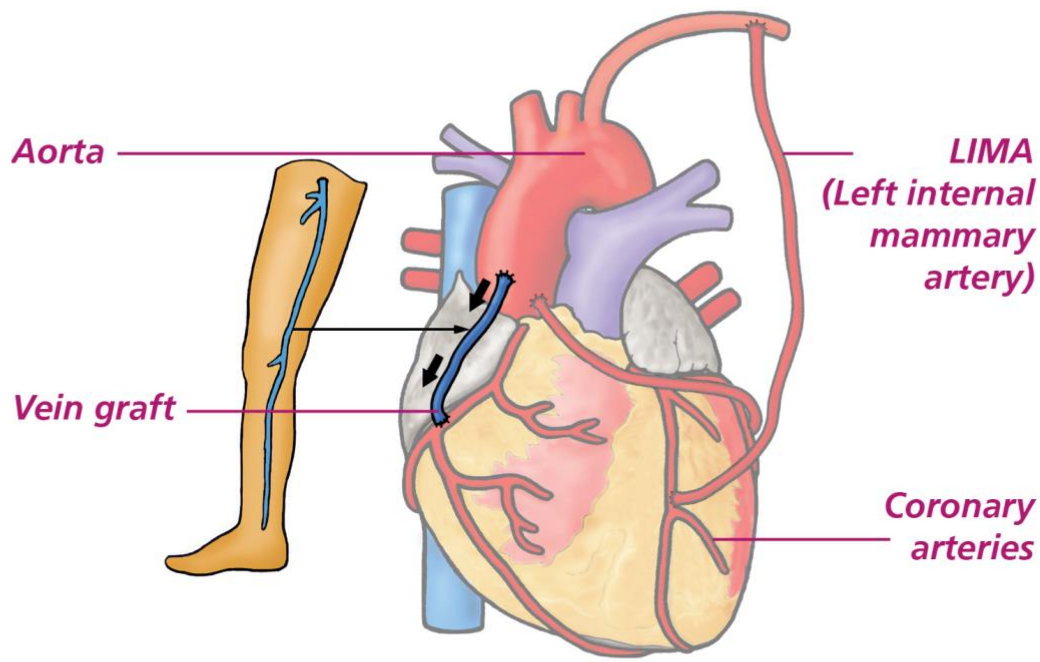
The LIMA is the most important graft and is routinely used to bypass the LAD artery. It has excellent long-term patency and is associated with improved survival, making it the cornerstone of CABG.

The RIMA can also be used, either as a second in-situ graft or as part of a composite graft. Using both internal mammary arteries may improve long-term outcomes in selected patients, although it carries a higher risk of sternal wound complications.

The radial artery is increasingly used as an additional arterial conduit. It performs well when grafted to significantly stenosed vessels, but requires preoperative assessment of collateral circulation to the hand.

The GSV remains widely used due to its availability and ease of harvest. However, vein grafts have lower long-term patency due to progressive degeneration and atherosclerosis.

In practice, LIMA to LAD is standard, and arterial grafts are used where feasible due to their superior durability compared with venous conduits. However, vein grafts like the GSV, remain widely used, particularly in multivessel disease. The overall aim of CABG is to achieve complete and durable revascularisation, tailored to the patient's coronary anatomy, clinical context, and long-term prognosis.




https://www.leedsth.nhs.uk/patients/resources/your-journey-through-heart-surgery-2/

https://www.ncbi.nlm.nih.gov/books/NBK507836/

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https://www.droracle.ai/articles/577235/what-are-the-current-recommendations-for-managing-patients-undergoing-CABG

# Valves

Valvular heart disease commonly includes stenosis or regurgitation of any of the four heart valves, most commonly involving the aortic valve and mitral valve. Clinically, this manifests as aortic stenosis (AS), aortic regurgitation (AR), mitral regurgitation (MR), or mitral stenosis (MS).

These conditions over time can lead to cardiac remodelling such as left ventricular hypertrophy or dilation. Progressive disease can ultimately lead to heart failure, arrhythmias, and mortality. Management is driven by decisions made by the patient’s cardiologist, which is dependent on multiple factors like symptom status and severity on echocardiography.

## Valve Repair vs Replacement: Mitral and Aortic Valves

The choice between valve repair and replacement is important in the management of valvular heart disease and depends on the valve involved, underlying pathology, and patient-specific factors. Valve repair involves preserving and reconstructing the patient’s valve, whereas valve replacement involves removal of the diseased valve and implantation of a prosthetic valve (which can be mechanical or bioprosthetic).

During repair, the valvular and subvalvular apparatus is maintained, preserving ventricular function and avoiding the need for lifelong anticoagulation. It is preferred in the mitral valve, where repair for mitral valve regurgitation has better outcomes in terms of lower operative mortality, better long-term survival, and fewer valve-related complications like endocarditis or structural degeneration.

In contrast, the aortic valve is more commonly replaced, as it is exposed to high systemic pressures and repair can be technically challenging. Replacement may use a mechanical valve, often favoured in younger patients because of durability but requiring lifelong anticoagulation with warfarin, or a bioprosthetic valve, often favoured in older patients because it avoids long-term anticoagulation but has limited durability.

Mechanical and Tissue Mitral Valves

https://myheart.net/articles/heart-valve-surgery-mechanical-vs-bioprosthetic-which-is-better/

https://zerotofinals.com/medicine/cardiology/valvularheartdisease/

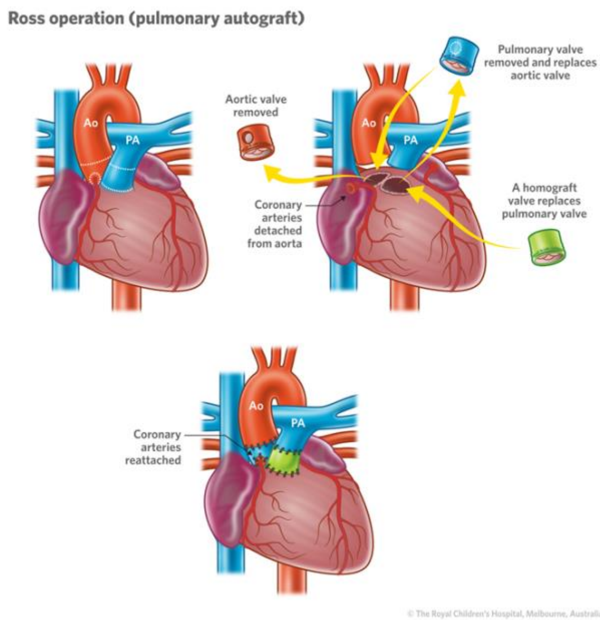
https://pmc.ncbi.nlm.nih.gov/articles/PMC12342954/

https://academic.oup.com/ejcts/article/60/6/1369/6280186?login=false

## Ross Procedure

The Ross procedure is a form of aortic valve replacement, usually performed in carefully selected younger patients with severe aortic valve disease, particularly aortic stenosis or regurgitation, where avoiding a mechanical valve and lifelong anticoagulation is desirable.

In this technically challenging operation, the patient's own pulmonary valve is removed and used to replace the diseased aortic valve. This pulmonary graft is then replaced with a donor pulmonary homograft or other suitable conduit. The key advantage is that the new aortic valve is living tissue, has good haemodynamic performance, and does not usually require long-term warfarin anticoagulation.




https://www.genesis-foundation.net/blog/learning-about-the-ross-procedure/

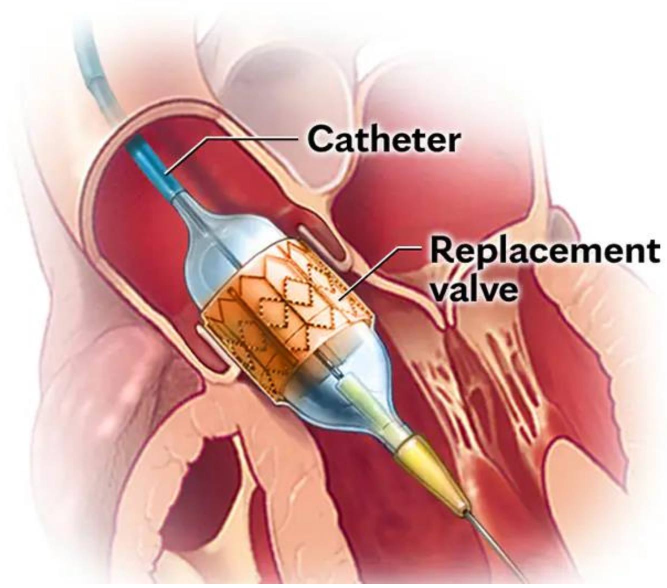
https://www.optechtcs.com/article/S1522-2942(21)00007-6/fulltext

## TAVI/TAVR

Transcatheter aortic valve implantation/replacement (TAVI/TAVR) is a minimally invasive alternative to surgical aortic valve replacement in selected patients. The procedure involves delivering a bioprosthetic valve via a catheter, most commonly through the femoral artery, and deploying it within the diseased native valve without sternotomy or cardiopulmonary bypass. It is now widely used and is considered alongside surgery in a multidisciplinary heart team setting.

Although initially reserved for high-risk or inoperable patients, indications for TAVI have expanded. It may now be considered in intermediate-risk and selected lower-risk patients depending on anatomical suitability, frailty, comorbidities and life expectancy. It is particularly favoured in older patients where avoiding open surgery is beneficial.

Key complications of TAVI include vascular injury, stroke, and paravalvular leak. Conduction abnormalities requiring permanent pacemaker insertion are common due to the proximity of the valve to the conduction system. Compared to surgical replacement, TAVI offers shorter recovery times but may have higher rates of the above complications.




https://www.mayoclinic.org/medical-professionals/cardiovascular-diseases/news/how-minimally-invasive-tavr-technology-helps-patients-with-aortic-valve-stenosis/mac-20579205

https://www.ncbi.nlm.nih.gov/books/NBK431075/

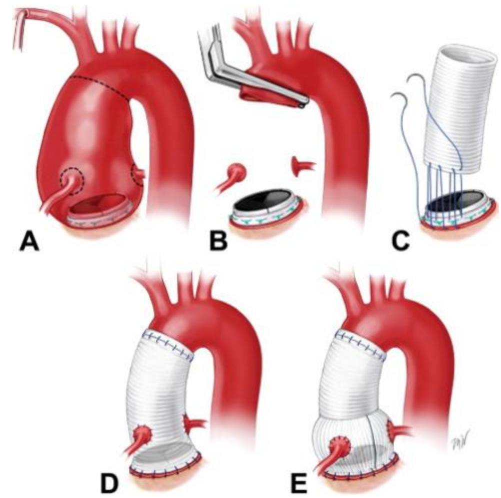
## Aortic Surgery

### Bentall Procedure

The Bentall procedure is a full aortic root replacement. It is used when both the aortic root and the aortic valve require replacement, such as in patients with an aortic root aneurysm with significant aortic valve disease, connective tissue disorders, acute type A aortic dissection involving the root, or infective endocarditis.

In this operation, the diseased aortic valve, aortic root, and often the proximal ascending aorta are replaced with a specific type of graft called the Composite Graft. This Composite Graft contains either a mechanical or bioprosthetic valve. The coronary arteries are detached as buttons and then reimplanted into the graft so that myocardial blood supply is restored.

A mechanical Bentall is durable but requires lifelong warfarin. A biological Bentall avoids lifelong warfarin in many patients but has a higher risk of structural valve degeneration over time.



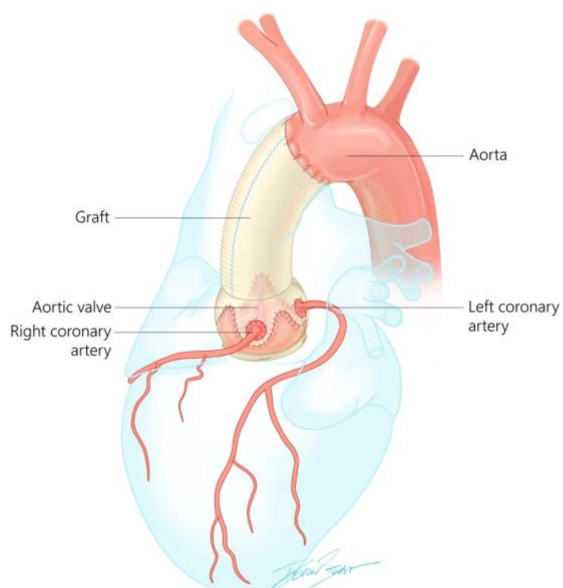

https://www.annalsthoracicsurgery.org/article/S0003-4975%2811%2900533-9/fulltext#fig1

https://mmcts.org/tutorial/2054

## David Procedure

A David Procedure is a valve sparing aortic root replacement. It is performed when the aortic root is dilated, but the aortic valve leaflets are suitable to preserve. This is particularly useful in patients with aortic root aneurysm and aortic regurgitation caused by root dilatation rather than primary leaflet disease.

The diseased aortic root is replaced with a Dacron graft while preserving the patient's own aortic valve. The aortic valve is reimplanted inside the graft, which supports the aortic annulus and root. The coronary arteries are detached as buttons and then re-implanted into the graft.




https://nyulangone.org/conditions/aortic-aneurysm/treatments/surgery-for-aortic-aneurysm

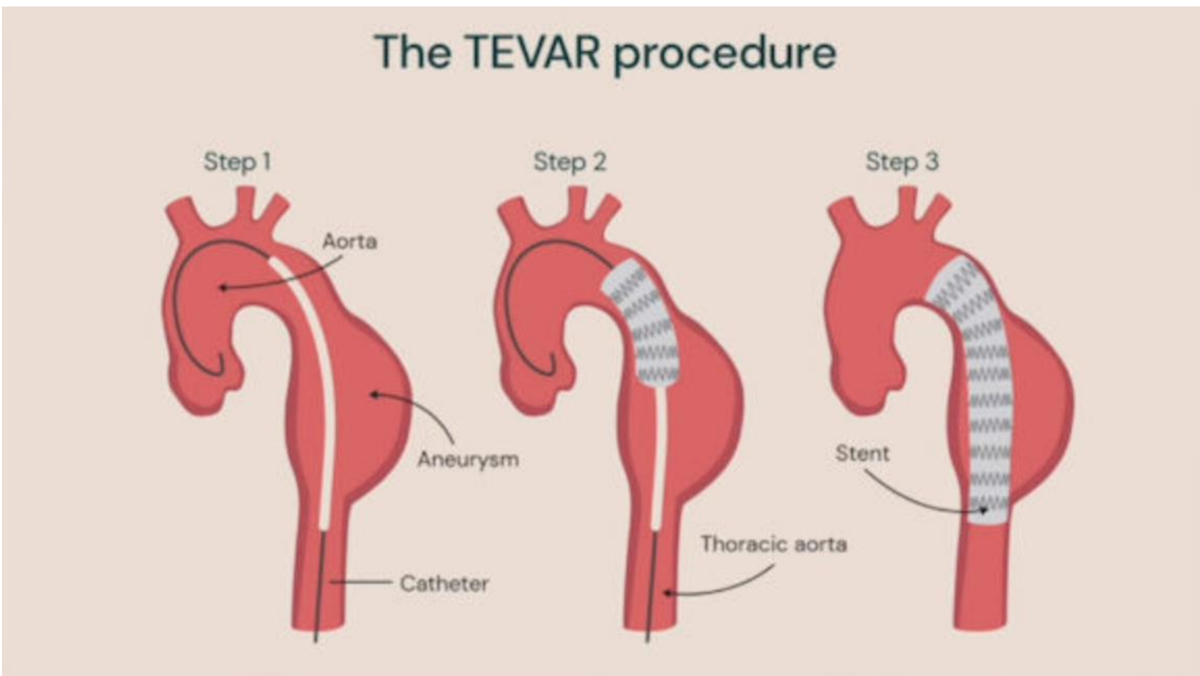
https://www.optechtcs.com/article/S1522-2942(09)00097-X/fulltext

## Thoracic Endovascular Aortic Repair (TEVAR)

Thoracic endovascular aortic repair (TEVAR) is a minimally invasive endovascular technique performed in a hybrid operating theatre or catheterisation laboratory. It is used to treat diseases of the descending thoracic aorta, including descending thoracic aortic aneurysm, complicated type B aortic dissection and traumatic aortic injury.

TEVAR does not require a sternotomy/thoracotomy, and instead, a stent graft is delivered through the common femoral artery, which is advanced under fluoroscopic imaging into the thoracic aorta with the help of guidewires and catheters.

The graft creates a new channel for blood flow and excludes the aneurysm or covers the entry tear in a dissection. Complications of a TEVAR include persistent leaks, stent migration, blood vessel injury, stroke, spinal cord ischaemia, and renal injury.




https://www.heart-valve-surgery.com/learning/aortic-aneurysm-repair-catheter/

https://pmc.ncbi.nlm.nih.gov/articles/PMC4540616/

Other specialist aortic procedures include aortic arch replacement and the Frozen Elephant Trunk (FET) procedure, which are used for more complex disease involving the aortic arch and descending thoracic aorta. These are advanced topics and can be explored further during specialist aortic placements.

# Transplantation and Mechanical Support

## Bridges to Transplantation: LVAD, RVAD, BiVAD and ECMO

Mechanical circulatory and respiratory support can be used temporarily to manage patients who are listed for heart or lung transplantation, or who are critically unwell with severe cardiac or respiratory failure. The two main classifications are ventricular assist devices (VADs) and extracorporeal membrane oxygenation (ECMO).

## Ventricular Assist Devices

A ventricular assist device, or VAD, is a mechanical pump used to support the function of the heart. It is commonly indicated in patients with severe heart failure or significant arrhythmias where the heart is unable to pump blood effectively. VADs can be used in several ways: as a bridge to transplant, where the device supports the patient while they wait for a donor heart; as destination therapy, where the device provides long-term or permanent support for patients who are not eligible for heart transplantation; or as a bridge to recovery, where the device is used temporarily while waiting to see if the heart function improves.

The main components of a VAD include an inflow cannula, a pumping chamber, an outflow cannula, and a driveline. The inflow cannula is usually implanted into the left ventricle and draws blood from the heart into the pump. The pumping chamber then pushes the blood through the outflow cannula, which is usually connected to the aorta or, in some cases, the pulmonary artery. From the aorta, the blood is distributed throughout the body. The driveline contains the external control and power cables, which extend from the internal pump to the outside of the body. The external controller is worn outside the body and manages the pump’s power and function.

VADs can be classified based on which side of the heart they support. A left ventricular assist device, or LVAD, takes blood from the left atrium or left ventricle and pumps it into the aorta. A right ventricular assist device, or RVAD, takes blood from the right atrium or right ventricle and pumps it into the pulmonary artery. A biventricular assist device, or BiVAD, supports both sides of the heart using an LVAD and RVAD in parallel. In some cases, a dual-chamber device may be used as a total artificial heart, or TAH, which replaces the function of both ventricles.

VADs can also be classified as pulsatile or non-pulsatile devices. Pulsatile devices aim to mimic the natural pumping action of the heart during the cardiac ejection cycle. Non-pulsatile devices use a motor running at fixed speeds to maintain a continuous flow of blood into the systemic circulation.

Another way to classify VADs is by whether they are intracorporeal or extracorporeal. Intracorporeal devices are implantable, with the pump placed inside the body, usually below the heart within the thoracic or upper abdominal cavity, while the power source remains outside the body. Extracorporeal devices have both the pump and power source outside the body.

### Extracorporeal Membrane Oxygenation

Extracorporeal membrane oxygenation, or ECMO, is similar to cardiopulmonary bypass, but it is modified so that it can be continued for days rather than only during surgery. ECMO is used in critically ill patients who need temporary cardiac and/or respiratory support. Indications include acute heart failure, primary graft failure following cardiac or lung transplantation, massive pulmonary embolism, and severe acute respiratory distress syndrome, or ARDS.

ECMO works by connecting the patient to a circuit using large cannulas, which may be placed in the groin, axilla, or neck. Blood is drained from the patient's body and pumped through an oxygenator, where carbon dioxide is removed and oxygen is added. The blood is then returned to the patient through the circuit using a pump.

There are two main types of ECMO: veno-venous ECMO and veno-arterial ECMO. In veno-venous ECMO, venous blood is taken from a large central vein, such as the femoral vein, passed through the oxygenator, and then returned to the venous system near the right atrium. This type of ECMO provides respiratory support only, because it oxygenates the blood but does not directly support systemic circulation.

In veno-arterial ECMO, blood is drained from the venous system, commonly through a cannula in the common femoral vein, passed through the oxygenator, and then returned to the arterial system through a cannula in the femoral artery. This means that veno-arterial ECMO provides both respiratory support and haemodynamic support, as it oxygenates the blood and also helps maintain circulation when the heart is failing.

https://teachmesurgery.com/cardiothoracic-surgery/general-principles/bridge-to-transplantation/

## Arrhythmia and Electrophysiology Surgery

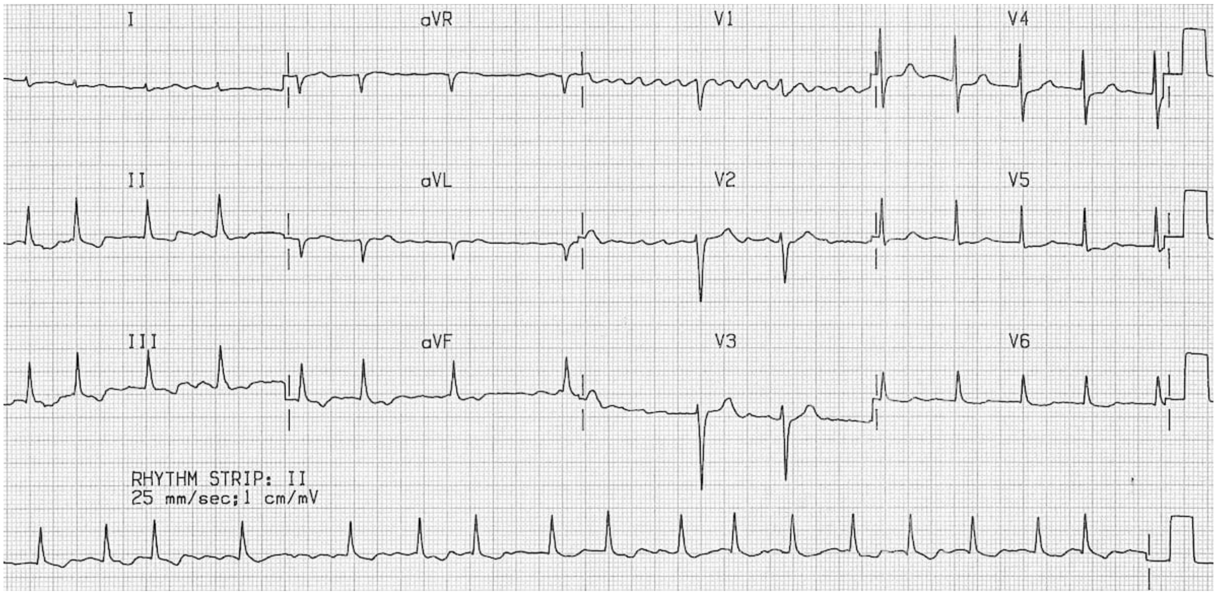
In cardiothoracic surgery, arrhythmia management is usually encountered in the context of AF or postoperative conduction problems. These procedures are frequently undertaken alongside other cardiac operations.

### Maze Procedure

The Maze procedure is a surgical treatment for atrial fibrillation, aimed at restoring sinus rhythm and reducing the long-term complications associated with AF. It is most commonly performed in patients who already require cardiac surgery, particularly those with mitral valve pathologies, where AF can be common.

The basic principle of the Maze procedure is to interrupt the abnormal electrical circuits within the atria that sustain AF. This is done by creating a series of controlled lesions in the atrial tissue. While the original procedure involved surgical incisions ("cut-and-sew"), modern techniques now use radiofrequency or cryoablation, which achieve the same effect with less tissue trauma.

The procedure is usually performed on CPB. When successful, it can restore sinus rhythm and improve atrial function, although outcomes can vary depending on patient factors and their AF history.




https://litfl.com/atrial-fibrillation-ecg-library/

## Left Atrial Appendage Occlusion or Excision

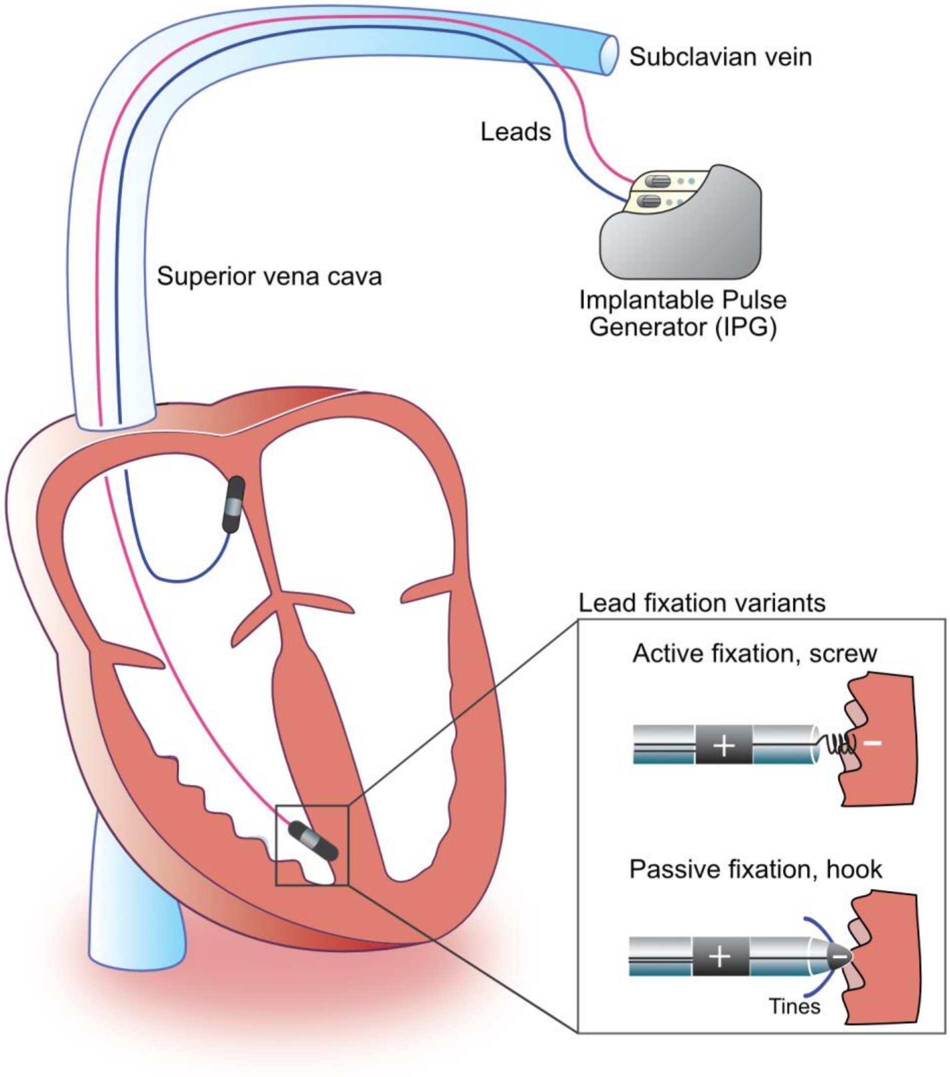
The left atrial appendage is the main site where thrombi form in patients with AF. During cardiac surgery, it is often removed or closed to reduce the risk of a future ischaemic stroke secondary to AF.

This is typically performed as an adjunct to existing cardiac procedures, such as CABG or valve surgery, in patients with AF. Techniques include surgical excision or internal closure from within the left atrium.

## Pacemaker Insertion

Permanent pacemaker insertion may be required following cardiac surgery if conduction abnormalities persist. This is most commonly seen after valve surgery, particularly aortic or mitral procedures, where there is a potential risk of injury to the cardiac conduction system.

A pacemaker is typically inserted via a transvenous approach, with leads positioned in the right atrium and/or ventricle, and a generator placed in a subcutaneous pocket (usually in the chest wall). Temporary pacing wires are often used immediately after surgery, but if conduction abnormalities persist postoperatively then a permanent device may be required.




https://ecgwaves.com/topic/how-pacemakers-work/

https://academic.oup.com/ejcts/article/44/5/777/353448

https://www.sciencedirect.com/science/article/pii/S0002914924003345

https://cardiothoracicsurgery.biomedcentral.com/articles/10.1186/s13019-024-02796-7

https://www.ncbi.nlm.nih.gov/books/NBK291309/

https://link.springer.com/article/10.1186/s13019-025-03378-x

https://www.acc.org/latest-in-cardiology/articles/2024/10/01/01/42/focus-on-ep-value-of-cardiac-eps-in-perioperative-cardiac-surgical-care

# Pericardial Procedures

## Pericardiocentesis

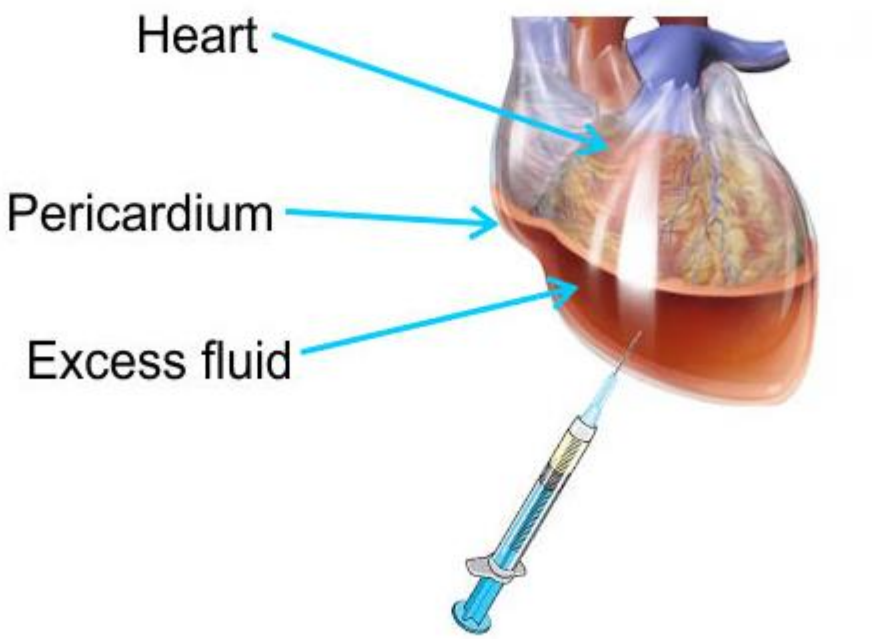
Pericardiocentesis is the percutaneous drainage of fluid from the pericardial space, most commonly performed in the setting of cardiac tamponade. In tamponade, fluid accumulates within the pericardial space creating pressure that restricts ventricular filling. This leads to a reduced cardiac output and haemodynamic compromise potentially causing obstructive shock.

Patients may present with features of Beck's triad*, along with tachycardia and pulsus paradoxus in some cases. In clinical practice, echocardiography is the key investigation to confirm the presence of a pericardial effusion and signs of cardiac compression.

** Beck's triad can be remembered with the 3 D's: Distended JVP + Decreased BP (Hypotension) + Distant (muffled) heart sounds*

This procedure is usually performed under echocardiographic guidance to improve its safety. The subxiphoid approach is most commonly used, although parasternal or apical approaches may be chosen depending on where the fluid is located. A needle is inserted into the pericardial space, fluid is then aspirated, and a drain may be left in-situ if ongoing drainage is required. Some of the complications can include myocardial injury, arrhythmias, or pneumothorax.

Pericardiocentesis can be performed as an emergency or electively. In an acute setting of cardiac tamponade with haemodynamic compromise, it is a life-saving procedure rapidly relieving pressure on the heart and restoring cardiac output.




https://medscope.umaryland.edu/apps/interactive%20dissector/Clinical_Procedures/ClinicalProcedure_Pericardiocentesis.html

### Pericardiectomy

Pericardiectomy is the surgical removal of the pericardium, most commonly performed for treating constrictive pericarditis. In this condition, the pericardium becomes thickened and non-compliant, restricting normal diastolic filling of the heart.

Patients often present with features of right-sided heart failure, including peripheral oedema, ascites, hepatomegaly, and a raised JVP. Imaging with echocardiography, CT, or MRI can support the diagnosis, while cardiac catheterisation may show characteristic equalisation of diastolic pressures.

Definitive treatment for symptomatic constrictive pericarditis is with surgical pericardiectomy. The aim is to remove the rigid pericardium and allow the heart to fill normally again. This is usually performed via a median sternotomy, enabling a more complete resection. In general, a more extensive pericardiectomy leads to better haemodynamic improvement.

https://academic.oup.com/eurheartj/article/36/42/2921/2293379
https://www.sciencedirect.com/science/article/pii/S0025619611612592
https://heart.bmj.com/content/89/12/1496
https://www.ahajournals.org/doi/10.1161/01.CIR.100.13.1380
https://www.jacc.org/doi/10.1016/j.jacc.2003.11.048
https://www.annalsthoracicsurgery.org/article/S0003-4975(12)02336-7/fulltext

## Miscellaneous Cardiac Procedures

### Cardiac Tumour Excision

Primary cardiac tumours are rare. Most are benign, with atrial myxoma being the most common in adults. Malignant primary tumours, such as sarcomas, are much less common and generally carry a poor prognosis. In clinical practice, metastatic involvement of the heart is more common than primary cardiac malignancy.

Patients can present in a number of ways depending on the size and location of the tumour. Symptoms can result from the obstruction of blood flow within the heart (e.g. dyspnoea or syncope), embolisation, or arrhythmias. Some patients may also have more general symptoms such as weight loss or fatigue.

Echocardiography is usually the first-line investigation and often identifies the tumour. Further imaging with TOE or cardiac MRI may be used to better define the lesion and plan surgery.

Surgical excision is the mainstay of treatment for most primary cardiac tumours, particularly myxomas. Surgery is typically performed via median sternotomy using CPB, allowing the tumour to be removed safely. The aim is complete excision, often with a small margin of surrounding tissue to reduce the risk of recurrence.

Outcomes are generally very good following removal of benign tumours. In contrast, malignant tumours are more challenging to treat, and often require a combination of surgery and oncological therapies, although overall prognosis remains limited.

https://www.nejm.org/doi/full/10.1056/NEJM199512143332407
https://www.ncbi.nlm.nih.gov/nlmcatalog/9302930
https://www.sciencedirect.com/science/article/pii/S1470204505700237
https://www.annalsthoracicsurgery.org/article/S0003-4975(03)00492-8/fulltext

# Thoracic Surgery

## Lung Resections

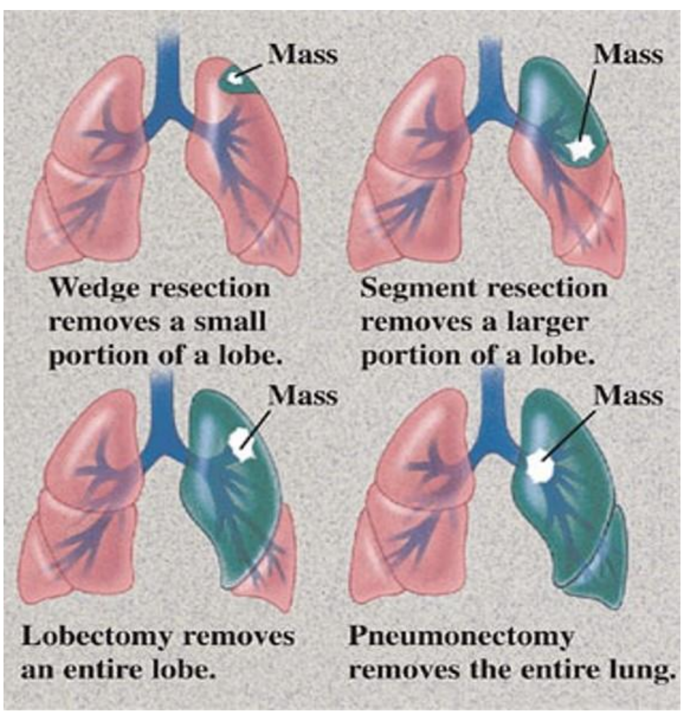
Lung resection is a central part of thoracic surgery and is most commonly performed for primary lung cancer, as well as metastatic disease and selected benign conditions. The type of resection depends on the size and location of the lesion, the underlying pathology, and the patient's preoperative pulmonary reserve.

Surgery may be performed via an open thoracotomy or using minimally invasive approaches such as VATS or RATS. In general, the aim is to achieve complete removal of disease while preserving as much functional lung as possible.

### Wedge, Segmentectomy, Lobectomy and Pneumonectomy

***Pulmonary resections are classified based on how much lung tissue is removed:***

- A wedge resection is a non-anatomical resection of a small portion of lung containing the lesion, along with a margin of surrounding tissue. It does not follow anatomical boundaries and is commonly used for diagnostic biopsies, small nodules, or metastatic lesions.
- A segmentectomy is an anatomical resection of one or more bronchopulmonary segments, including the segmental bronchus and vessels. It preserves more lung tissue than a lobectomy and is often considered for small peripheral tumours or in patients with limited respiratory reserve.
- A lobectomy involves removal of an entire lobe and is considered the standard surgical treatment for most operable NSCLC. It provides good oncological clearance and allows for appropriate lymph node assessment.
- A pneumonectomy involves removal of an entire lung. Because of its significant physiological impact, it is reserved for cases where a smaller resection would not achieve complete tumour clearance, such as centrally located tumours involving major bronchi or vessels.




https://www.leedsth.nhs.uk/services/lung-cancer/condition-and-treatments/

## Bullectomy

Bullectomy is the surgical removal of large emphysematous bullae. These are non-functioning, air-filled lung spaces that usually develop in patients with emphysema or COPD.

Large bullae can compress surrounding healthy lung tissue, contributing to symptoms of breathlessness or recurrent pneumothoraces. Removing them allows the adjacent lung to re-expand, which can improve symptoms and respiratory function. This procedure is most commonly performed using VATS.

## Lung Volume Reduction Surgery (LVRS)

LVRS is performed in carefully selected patients with severe emphysema, particularly those with upper-lobe predominant disease and significant lung hyperinflation.

The procedure involves removing the most diseased portions of the lung, which reduces hyperinflation and improves the mechanics involved with breathing. This allows the diaphragm to function more effectively and can improve exercise tolerance and quality of life. However, LVRS is not suitable for all patients and requires careful preoperative assessment, as the risks can be significant.

https://www.nejm.org/doi/full/10.1056/NEJM199508173330701

https://erj.ersjournals.com/content/34/1/17

https://www.nejm.org/doi/full/10.1056/NEJMoa030287

https://www.nejm.org/doi/full/10.1056/NEJMoa2212082

https://journal.chestnet.org/article/S0012-3692(13)60228-1/fulltext

https://jtd.amegroups.org/article/view/22160/17461

## Lung Transplantation

Around 200 heart and lung transplants are performed in the UK each year. Lung transplantation is indicated for patients with end-stage lung disease, including end-stage COPD, pulmonary fibrosis, cystic fibrosis, and bronchiectasis. It is considered when the patient has a high risk of death, usually greater than 50%, from lung disease within two years if transplantation is not performed. The patient should also have a high likelihood of surviving after the operation, with an expected survival of greater than 80% for at least 90 days following lung transplantation.

Contraindications to lung transplantation include active malignancy, dysfunction of another major organ system, chronic infection, and significant chest wall or spinal deformity.

### *Surgical Technique*

Donors are matched using blood group, HLA status, and expected lung capacity. Lung transplantation can be performed as a single lung transplant, a double lung transplant, or, very rarely, as a combined heart-lung transplant. A double lung transplant may be performed as sequential bilateral single lung transplantation, which is preferred, or by transplanting both lungs simultaneously as an en-bloc transplant.

### *Donor Procedure*

During the donor procedure, the lungs are retrieved following heart retrieval and are gently ventilated to reduce atelectasis. The lungs are dissected from the pulmonary ligaments, and the pulmonary vessels are flushed with heparinised solution. Typically, the right lung is freed first, followed by the left lung.

The remaining pericardium is left intact with the left atrium and pulmonary veins, as well as the pulmonary artery above the bifurcation. The lungs are inflated before stapling across the divided trachea, and they are then removed in their anatomical position. After retrieval, the lungs are placed into ice-cold storage or attached to an ex-vivo perfusion system.

### *Recipient Procedure*

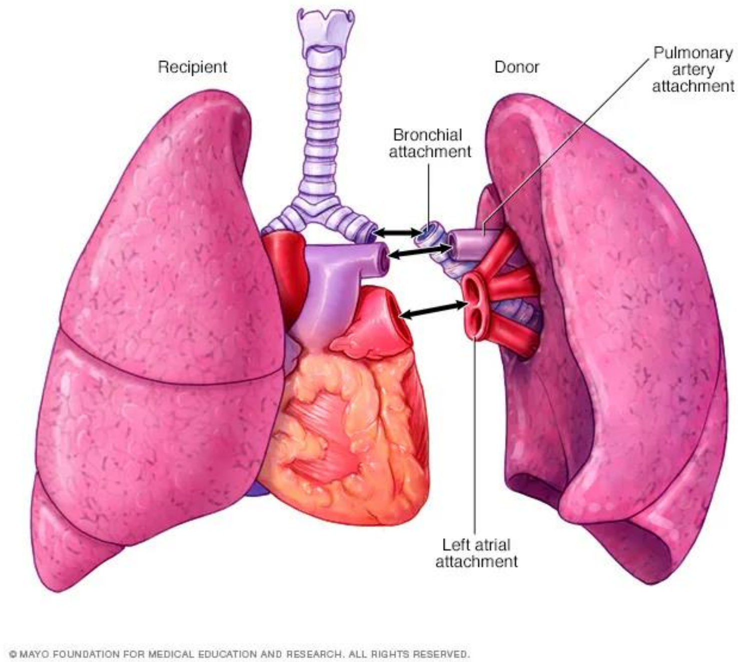
In the recipient procedure, clamshell thoracotomies are typically used. For a single lung transplant, a lateral thoracotomy incision may be used. bypass or ECMO can be used during the operation. The diseased lungs are removed, and the donor lungs are placed into the chest. The anastomoses are usually performed in the sequence of bronchus first, followed by the pulmonary artery, and then the pulmonary veins.

### *Complications*

Early complications of lung transplantation include reperfusion injury and primary graft dysfunction. Primary graft dysfunction presents with progressive hypoxaemia and patchy alveolar infiltrates. It is caused by ischaemia-reperfusion injury and may require ECMO support. Other early complications include postoperative infections and dehiscence of the bronchial anastomoses, which can cause an air leak into the mediastinum.

Late complications are often related to immunosuppression and disrupted mucociliary clearance mechanisms, which increase the risk of recurrent or atypical infections. Other late complications include nephrotoxicity and malignancies, such as post-transplant lymphoproliferative disorder. Bronchiolitis obliterans syndrome is another important late complication, involving severe damage to the bronchioles, and typically occurs within the first year after transplantation.

The left recurrent laryngeal nerve can be damaged during dissection of the left main pulmonary artery proximal to the ligamentum arteriosum.




https://www.mayoclinic.org/tests-procedures/lung-transplant/about/pac-20384754

https://teachmesurgery.com/transplant-surgery/organ-transplantation/lung-transplantation/

## Minimally Invasive Procedures

### Video-Assisted Thoracoscopic Surgery (VATS)

VATS stands for Video-Assisted Thoracoscopic Surgery. It is a minimally invasive approach to thoracic surgery where the surgeon operates through small incisions using a thoracoscope and long instruments. The image is displayed on a monitor, allowing surgery to be performed without a large thoracotomy or rib spreading in many cases.

It has become an important part of thoracic surgery because it can reduce postoperative pain, shorten hospital stay and support faster recovery compared with open thoracotomy.

***Typical operative steps include:***

- The patient is usually placed in the lateral decubitus position.
- Small incisions/ports are made in the chest wall.
- A thoracoscope is inserted to visualise the pleural cavity and operative field.
- Long thoracoscopic instruments are used to perform dissection, stapling, biopsy, or resection.
- Specimens are removed using a protected retrieval bag when required.
- Chest drains are placed before closure.

Conversion to a thoracotomy can be done during these cases if exposure or bleeding control is inadequate.

https://my.clevelandclinic.org/health/treatments/17617-video-assisted-thoracic-surgery-vats

## Robotic-Assisted Thoracoscopic Surgery (RATS)

RATS stands for Robotic-Assisted Thoracoscopic Surgery. It is another minimally invasive approach used in thoracic surgery - similar to VATS, but performed with the help of a robot. The surgeon sits at a console and controls robotic instruments placed through small ports in the chest. The system provides a magnified 3D view with improved range of motion of instruments.

RATS can be used for many of the same operations as VATS, including lobectomy, segmentectomy, mediastinal tumour surgery, thymectomy, and selected chest wall procedures.

***Typical operative steps include:***

- The patient is usually placed in the lateral decubitus position.
- Ports are placed for the robotic camera and instruments.
- The robot is docked and the surgeon operates from the console.
- An assistant remains at the bedside to exchange instruments, apply staplers, suction, and help manage unexpected bleeding.
- At the end, specimens are removed and chest drains are placed.

As with VATS, the team is prepared to convert to open thoracotomy if needed for patient safety.

https://www.researchgate.net/publication/357213812_Comparison_of_perioperative_outcomes_of_robotic-assisted_versus_video-assisted_thoracoscopic_right_upper_lobectomy_in_non-small_cell_lung_cancer/figures?lo=1

https://pmc.ncbi.nlm.nih.gov/articles/PMC10209319/

# Chest Wall Surgery

## Nuss Procedure: Pectus Excavatum

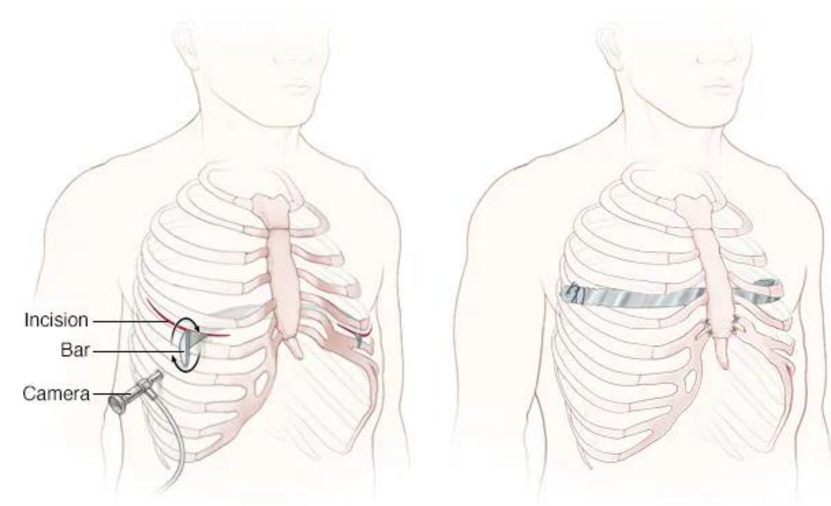
Pectus excavatum is a chest wall deformity where the sternum is depressed, giving a sunken chest appearance. It may be primarily cosmetic, but in more severe cases it can be associated with symptoms such as reduced exercise tolerance, chest pain, breathlessness, or psychological distress.

The Nuss procedure is a minimally invasive repair of pectus excavatum. The aim is to elevate the sternum into a more normal position using one or more curved metal bars placed behind the sternum. The bar acts as an internal brace and is usually left in place for several years before removal.

***Typical operative steps include:***

- The patient is placed under general anesthetic
- Small lateral chest wall incisions are made on both sides
- A curved metal bar is passed behind the sternum and then rotated to push the sternum anteriorly
- The bar is secured using stabilisers to reduce the risk of displacement
- The bar is removed in a later operation after the chest wall has been remodeled

Good postoperative analgesia and physiotherapy are important because chest wall pain can be quite significant early after surgery.






https://www.mayoclinic.org/diseases-conditions/pectus-excavatum/multimedia/img-20485818

https://mmcts.org/tutorial/587

https://www.optechtcs.com/article/S1522-2942(14)00096-8/fulltext

### Rib Resection and Chest Wall Tumour Resection

Chest wall tumour resection involves removing benign or malignant tumours arising from or invading the ribs, sternum, cartilage, intercostal muscles, or soft tissues of the chest wall. Tumours may be primary chest wall tumours, metastatic lesions, or direct invasion from lung, breast, or other thoracic malignancies.

## Pleural Procedures

Pleural disease includes conditions such as pneumothorax, pleural effusion, empyema, and malignant pleural disease. Management often involves removing air or fluid from the pleural space, allowing the lung to re-expand, and reduce the likelihood of recurrence. Depending on the clinical situation, this can range from bedside procedures to more complex surgical interventions.

### Chest Drain Insertion

Chest drain (also known as intercostal drain) insertion is a fundamental procedure used to remove air (from a pneumothorax), fluid (from a pleural effusion), blood (from a haemothorax), or pus (from an empyema) from the pleural space.

The drain is typically inserted within the “triangle of safety” (bounded by the lateral border of pectoralis major, anterior border of latissimus dorsi, the fifth intercostal space, and the base of the axilla) to minimise the risk of injury to underlying neurovascular structures.

In thoracic surgery, chest drains are routinely placed at the end of procedures such as lung resections. They allow the lung to re-expand and provide a way to monitor for postoperative air leaks or bleeding.

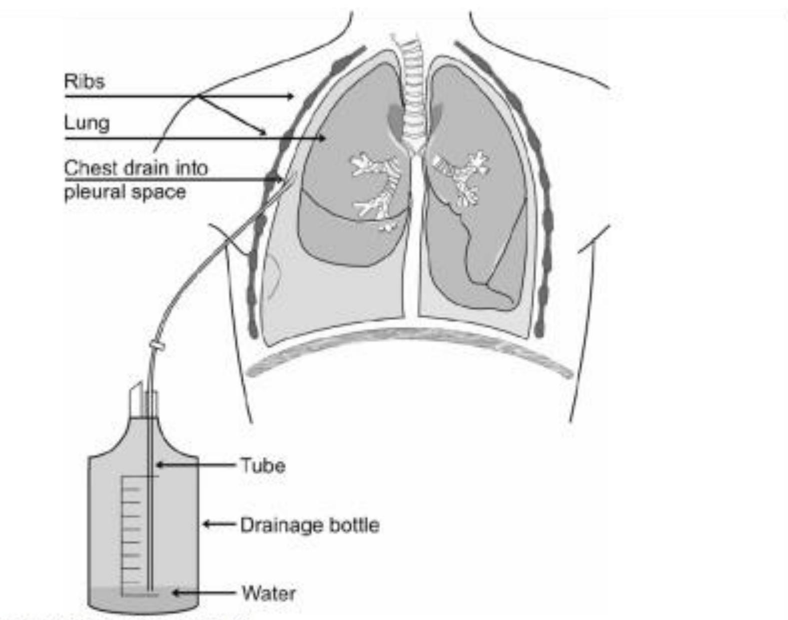



Diagram to show a chest drain.

https://www.nth.nhs.uk/resources/insertion-of-a-chest-drain/

### Pleurodesis

Pleurodesis is a procedure that aims to reduce the pleural space by inducing adhesion between the visceral and parietal pleura. It is most commonly performed to prevent recurrence of pneumothorax or malignant pleural effusions.

This can be achieved chemically (e.g. with talc) or surgically (e.g. pleural abrasion or partial pleurectomy), often performed via VATS. The inflammatory reaction promotes fibrosis (scar/adhesion formation) to hold the pleural layers together, preventing further fluid or air accumulation in the pleural space.

### Decortication

Decortication is a surgical procedure involving removal of a thickened fibrous layer (pleural peel) from the lung surface, chest wall, or diaphragm. It is most commonly indicated in chronic empyema, where organised fibrous tissue restricts lung expansion.

The operation involves removing this layer to release the trapped lung, allowing it to re-expand and improving respiratory function. It may be performed using VATS in selected cases, but more advanced disease often requires an open thoracotomy.

Decortication is a more complex intervention compared to chest drain insertion or pleurodesis and is typically reserved for patients who fail medical management or have established organised pleural disease.

https://thorax.bmj.com/content/65/Suppl_2/ii61

https://thorax.bmj.com/content/65/Suppl_2/ii41

https://www.nejm.org/doi/full/10.1056/NEJMoa1012740

https://ascopubs.org/doi/10.1200/JCO.2005.03.292

https://academic.oup.com/ejcts/article/48/5/642/2465048

## Mediastinal

The mediastinum contains several vital thoracic structures, including the heart, great vessels, trachea, ooesophagus, and lymphatic tissue.

### Thymectomy

Thymectomy is the surgical removal of the thymus gland. It is most commonly performed for thymoma, and in selected patients with myasthenia gravis, where removal of the thymus can improve symptoms and disease control.

The operation can be performed via median sternotomy, or using minimally invasive approaches such as VATS or RATS, which are increasingly used in clinically suitable patients. The key surgical aim is complete removal of the thymus and any associated tumour, as complete resection is the most important factor influencing long-term outcomes in thymoma.

In practice, thymectomy is usually performed for anterior mediastinal masses that are thought to be thymic in origin.

### Mediastinoscopy

Mediastinoscopy is a procedure used to obtain tissue from mediastinal lymph nodes, most commonly for lung cancer staging. It is performed under general anaesthesia through a small incision just above the sternum. A mediastinoscope is inserted into the superior mediastinum, allowing biopsy of lymph node stations such as the paratracheal and subcarinal nodes.

Although less invasive techniques such as EBUS are now widely used, mediastinoscopy remains important when imaging suggests nodal disease or when previous biopsies are inconclusive.

Accurate assessment of mediastinal lymph nodes is essential for determining lung cancer resectability, and therefore whether a patient is an appropriate candidate for surgery.

https://www.jto.org/article/S1556-0864(15)33464-9/fulltext

https://www.annalsthoracicsurgery.org/article/S0003-4975(15)01556-6/fulltext

https://academic.oup.com/ejcts/article/45/5/787/407693

https://journal.chestnet.org/article/S0012-3692(13)60230-X/fulltext

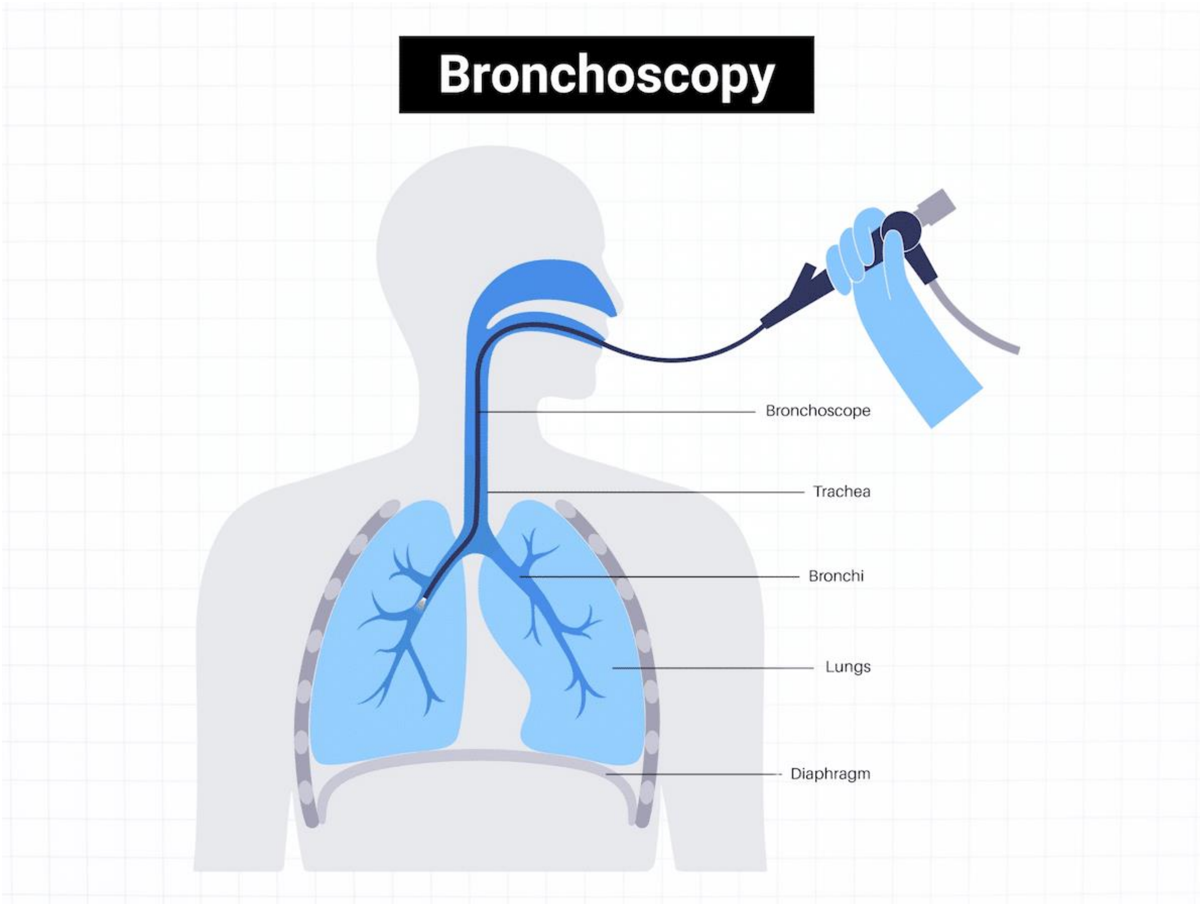
## Bronchoscopy

Bronchoscopy is a key diagnostic and therapeutic procedure used to directly visualise the internal surfaces of the trachea and bronchial tree. A bronchoscope is passed via the mouth or nose into the airways, allowing for the assessment of airway anatomy and pathology.

In thoracic surgery, bronchoscopy is commonly used in the investigation and staging of lung cancer, assessment of airway lesions, and as part of the preoperative work-up for lung resection. It is also frequently used intra-operatively to confirm correct placement of double-lumen endotracheal tubes, which are required for single-lung ventilation during most thoracic procedures.

There are two main types of bronchoscopy used in clinical practice: flexible and rigid.

- Flexible bronchoscopy is the most commonly performed technique. It uses a flexible fibre-optic or video bronchoscope and is usually carried out under local anaesthetic with sedation. It is primarily used for diagnostic purposes, including bronchoalveolar lavage, endobronchial biopsy, and transbronchial biopsy, particularly in the investigation of suspected malignancy.
- Rigid bronchoscopy is performed under general anaesthesia in theatre using a rigid metal scope. Although used less frequently, it is particularly important in thoracic surgery for therapeutic airway procedures, such as tumour debulking, managing airway obstruction, and inserting airway stents.




https://www.respiratorytherapyzone.com/bronchoscopy/

## Endobronchial Valves

Endobronchial valves are small one-way valves placed bronchoscopically into segmental or lobar bronchi. They allow air and secretions to exit during expiration but prevent air entry during inspiration, leading to the gradual collapse of the targeted lung segment.

They are mainly used in carefully selected patients with severe emphysema, where reducing hyperinflation can improve breathing mechanics and exercise tolerance. In thoracic surgical practice, they can also be used to manage persistent postoperative air leaks following lung resection by isolating the affected segment.

https://thorax.bmj.com/content/68/Suppl_1/i1

https://www.atsjournals.org/doi/full/10.1164/rccm.201803-0590OC

https://pubmed.ncbi.nlm.nih.gov/29787288/

# Thoracic Oncology Basics

## Lung Cancer Screening

Lung cancer screening aims to detect malignancy at an early, potentially curable stage. Current practice is based on the use of LDCT in high-risk individuals, particularly those aged 55-74 with a significant smoking history. Screening has been shown to reduce lung cancer specific mortality by enabling earlier diagnosis and increased rates of smaller surgical resection.

Patients with suspicious findings on screening imaging are referred for further investigation, which may include PET-CT, bronchoscopy, or biopsy. Screening is important because it increases the number of patients diagnosed with early-stage, operable disease, where surgical resection offers the best chance of cure.

## TNM Staging

Accurate staging is essential in lung cancer, as it determines both prognosis and management. The TNM system is used to classify disease based on:

- T (Tumour): size and local invasion
- N (Nodes): involvement of regional lymph nodes
- M (Metastasis): presence of distant spread

Staging typically involves CT and PET-CT, along with invasive nodal sampling where required (e.g. EBUS or mediastinoscopy). From a surgical perspective, staging is crucial in deciding whether a tumour is resectable and what type of operation is appropriate.

Management decisions are made through a multidisciplinary team (MDT), which includes surgeons, respiratory physicians, oncologists, radiologists, and pathologists.

***Treatment is often multimodal:***

- Neoadjuvant therapy (given before surgery) may be used to shrink tumours and improve resectability.
- Adjuvant therapy (given after surgery) is used to reduce the risk of recurrence, particularly in patients with nodal disease or more advanced tumours. This may include chemotherapy, targeted therapy, or immunotherapy depending on tumour characteristics.

https://www.nejm.org/doi/full/10.1056/NEJMoa1102873

https://www.nejm.org/doi/full/10.1056/NEJMoa1102873

https://www.jto.org/article/S1556-0864(15)33388-7/fulltext

https://www.annalsofoncology.org/article/S0923-7534(19)31666-8/fulltext

https://thorax.bmj.com/content/65/Suppl_3/iii1

## Robotics in Thoracic Surgery

RATS is an increasingly used minimally invasive approach in thoracic surgery. It is commonly applied to procedures such as lung resections, mediastinal surgery, and thymectomy, and can be thought of as a development of VATS.

In RATS, the surgeon operates from a console, controlling robotic instruments while viewing the operative field through a high-definition 3D camera. This provides a magnified and more detailed view of thoracic structures compared to standard thoracoscopic techniques.

One of the main advantages of the robotic platform is improved precision and control. The instruments have wristed movement, allowing greater dexterity than conventional VATS, along with tremor filtration and more stable movements. This can be particularly helpful when working in confined areas such as the mediastinum or when dissecting around important structures like pulmonary vessels and bronchi.

From a patient perspective, RATS offers similar benefits to other minimally invasive approaches, including less postoperative pain, shorter hospital stay, and quicker recovery compared to open thoracotomy.

However, it is important to recognise that robotic surgery requires specialised training, is associated with longer operating times during the learning phase, and depends on access to expensive equipment.

https://www.intuitive.com/en-us/products-and-services/da-vinci

https://pubmed.ncbi.nlm.nih.gov/29031947/

https://pubmed.ncbi.nlm.nih.gov/24090577/

https://www.annalsthoracicsurgery.org/article/S0003-4975(16)30134-5/fulltext

https://www.jtcvs.org/article/S0022-5223(09)01616-X/fulltext

# Congenital Cardiothoracic Surgery

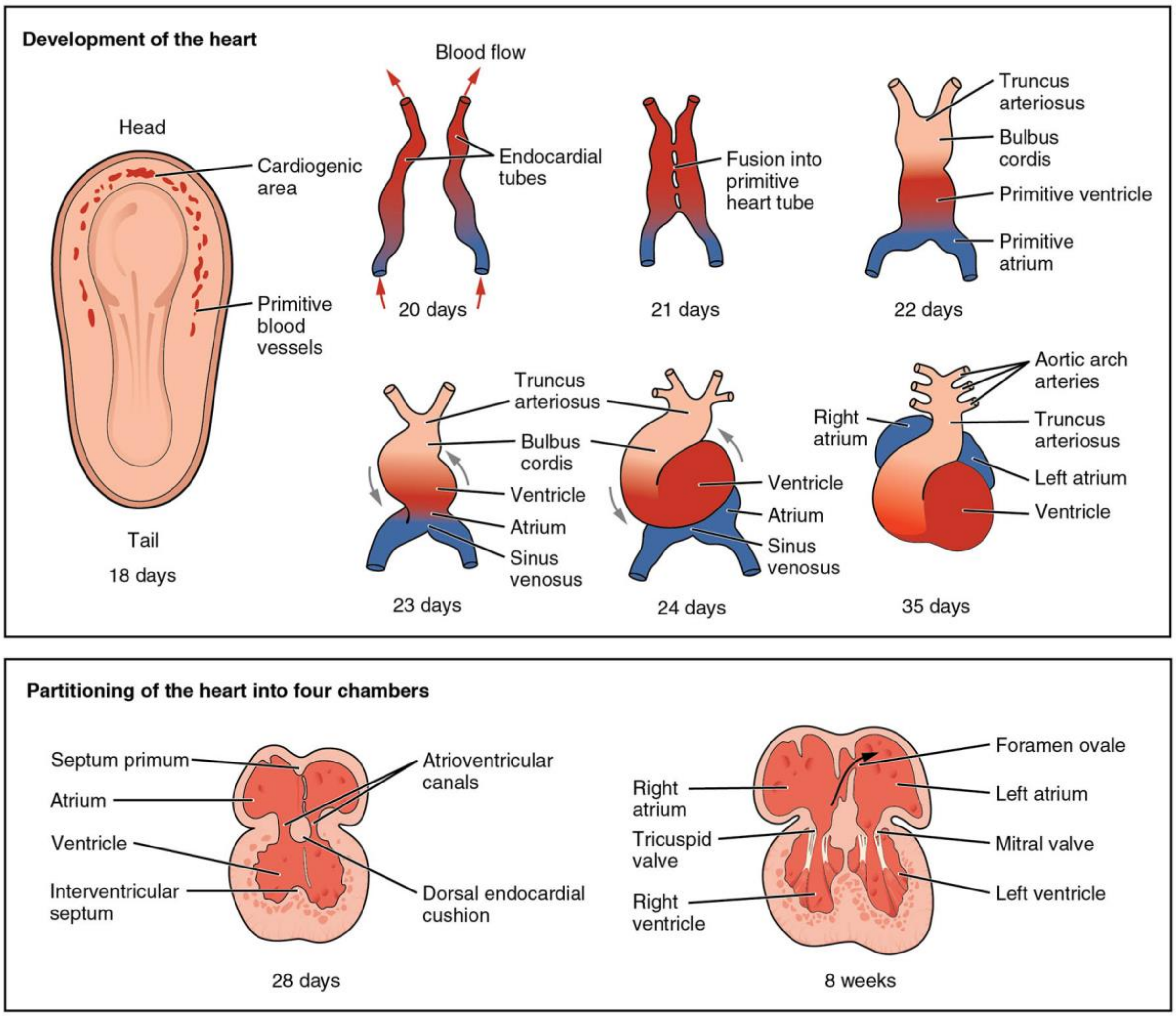
## Embryology Basics

A basic understanding of cardiac embryology helps explain how congenital heart defects arise. The heart begins as a primitive heart tube, which undergoes a series of coordinated processes including looping, septation, and outflow tract division to form the mature four-chambered heart.

Cardiac looping establishes the spatial arrangement of the atria and ventricles. Subsequent septation of the atria and ventricles forms the interatrial and interventricular septa, separating the right and left-sided cardiac circulation. At the same time, the truncus arteriosus divides into the aorta and pulmonary artery.

Disruptions at different stages of development give rise to specific congenital defects:

- Failure of septation can result in ASD or VSD
- Abnormal outflow tract development can lead to conditions such as TOF or TGA
- Persistence of fetal structures results in lesions such as PDA




https://anatomynote.com/exploring-the-embryological-development-of-the-human-heart/

## Acyanotic and Cyanotic Congenital Heart Disease

Congenital heart disease is broadly divided into acyanotic and cyanotic conditions, based on how blood flows through the heart and whether this leads to reduced oxygen levels in the systemic circulation.

Acyanotic lesions usually involve left-to-right shunting or obstructive defects, meaning oxygenated blood is recirculated through the lungs without causing systemic hypoxaemia. In contrast, cyanotic lesions usually involve right-to-left shunting, causing deoxygenated blood to enter the systemic circulation, resulting in hypoxaemia and visible cyanosis.

### *Acyanotic*

Acyanotic lesions are typically associated with increased pulmonary blood flow and may present with features such as heart failure, poor feeding, or recurrent respiratory infections in infancy.

An ASD is an abnormal communication between the atria, allowing left-to-right shunting (due to the left atrial pressure being greater than the right atrial pressure). Smaller defects may be asymptomatic, but larger ones often require closure, either percutaneously or surgically.

A VSD is one of the most common congenital heart defects and involves an abnormal communication between the ventricles, again allowing for left-to-right shunting. Larger defects can lead to pulmonary hypertension and usually require surgical repair.

A PDA is persistence of the fetal connection between the aorta and pulmonary artery (the ductus arteriosus), resulting in continuous left-to-right shunting from the aorta to the pulmonary artery. It may be managed medically (e.g. with NSAIDs such as indomethacin in neonates) or closed surgically or via catheter-based techniques.

### *Cyanotic*

Cyanotic congenital heart disease involves right-to-left shunting, resulting in reduced oxygen saturation and clinical cyanosis. These conditions often present earlier and may require urgent or staged surgical intervention.

***TOF is the most common cyanotic congenital heart defect. It consists of:***

- VSD
- Right ventricular outflow tract obstruction
- Overriding aorta
- RVH

Surgical repair involves closing the VSD and relieving the outflow obstruction.

TGA occurs when the aorta and pulmonary artery are switched, creating two parallel circulations. This is not compatible with life unless there is some mixing of blood due to another acyanotic congenital heart condition (e.g. PDA). Definitive treatment is the arterial switch operation, usually performed in the neonatal period.

Truncus arteriosus is a rare condition in which a single arterial trunk supplies both systemic and pulmonary circulations. Surgical repair involves separating these circulations and reconstructing the right ventricular outflow tract.

https://heart.bmj.com/content/98/15/1170

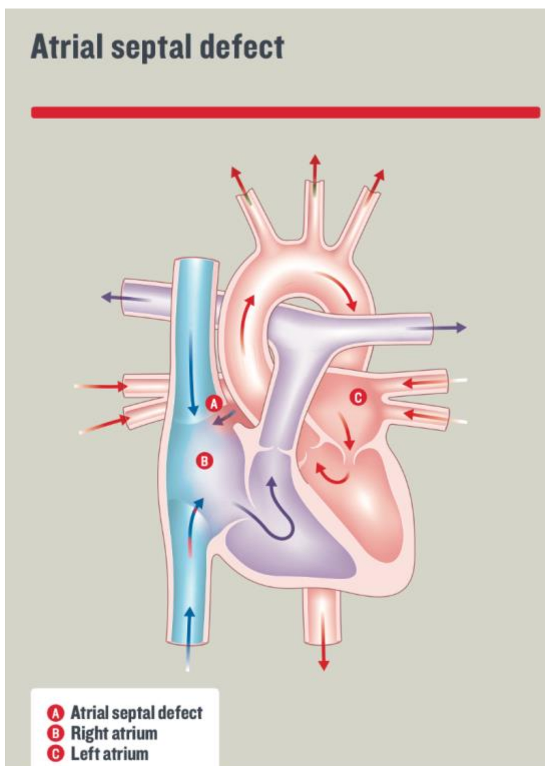
# Common Congenital Procedures

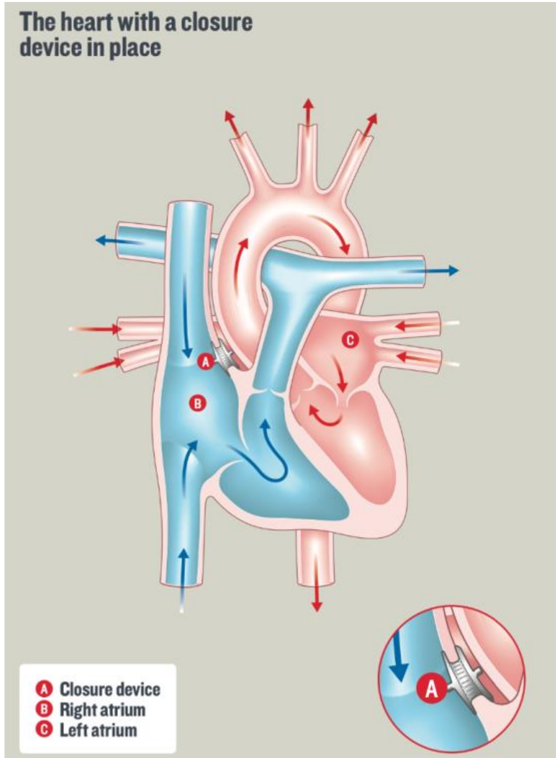
## Atrial and Ventricular Septal Defect Closure

ASD and VSD closures are common congenital cardiac procedures. The aim is to close abnormal communications between cardiac chambers, reduce unnecessary pulmonary blood flow, prevent right heart volume overload, and reduce the risk of long-term complications such as pulmonary hypertension and arrhythmias.

An ASD is a communication between the atria. Because left atrial pressure is normally higher than right atrial pressure, blood usually shunts from left to right. This increases blood flow to the right atrium, right ventricle, and pulmonary circulation.

ASDs can be closed using catheters or surgery. Catheter ASD closure usually involves femoral venous access, TOE or intracardiac echo guidance, crossing the ASD, and deploying a closure device across the defect. Over time, tissue grows over the device.Surgical ASD closure is performed under general anaesthetic using CPB. The defect is closed either directly with sutures or using a pericardial/synthetic patch.

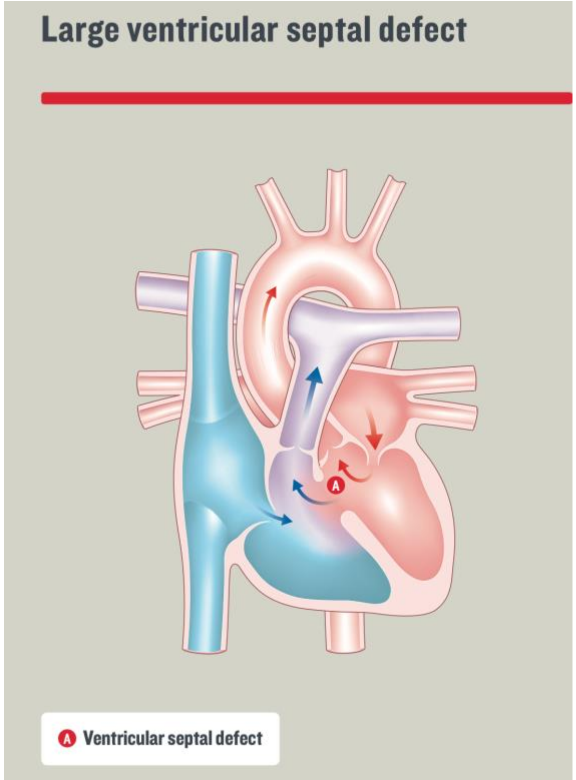





https://www.pecsig.co.uk/media/leaflets-bhf/bhf-asd.pdf

A VSD is a communication between the ventricles. Larger VSDs can cause significant left-to-right shunting, pulmonary overload, heart failure, and pulmonary hypertension. Many small muscular VSDs close spontaneously, but large or symptomatic VSDs usually require closure.

Surgical VSD closure is typically performed on CPB. A patch, often made of synthetic material or pericardium, is sewn over the defect. Care is needed because some VSDs are close to the conduction system, creating a risk of heart block and need for pacing.




https://www.pecsig.co.uk/media/leaflets-bhf/bhf-vsd.pdf

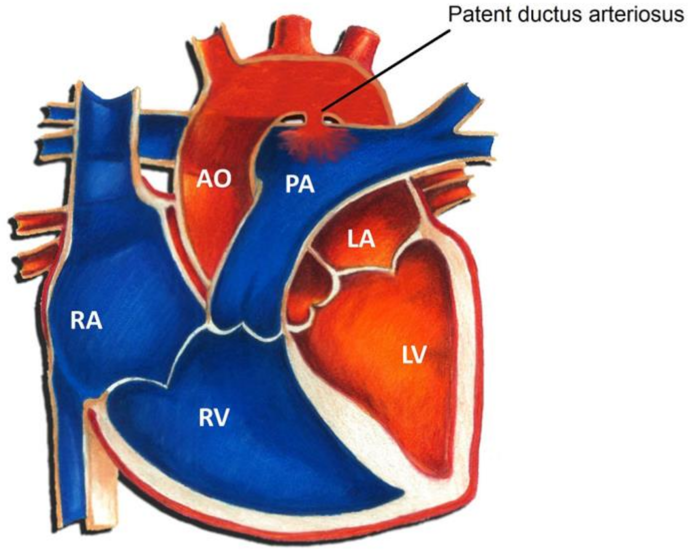
Pulmonary artery banding may be used as a palliative option in selected infants who are too small or too unwell for definitive repair. The band reduces pulmonary overcirculation by narrowing the pulmonary artery, but it requires careful calibration and is usually a bridge to later definitive surgery.

## Patent Ductus Arteriosus

The ductus arteriosus is a normal fetal vessel connecting the pulmonary artery to the descending aorta. It allows blood to bypass the fetal lungs as these are not functional in fetal life. After birth, it usually closes as pulmonary vascular resistance falls and oxygenation increases. A Patent Ductus Arteriosus (PDA) occurs when this vessel continues to remain open.

A PDA usually causes left-to-right shunting from the aorta to the pulmonary artery. Small PDAs may be asymptomatic, while larger PDAs can cause pulmonary overcirculation, heart failure, poor feeding, failure to thrive, and pulmonary hypertension.

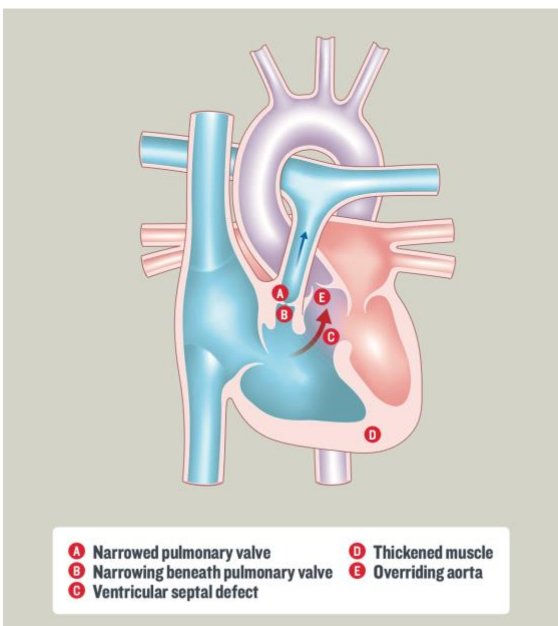
Treatment depends on age, size, symptoms, and anatomy. Options include medical closure with NSAIDs in selected neonates, catheter device closure, or surgical ligation.




https://pediatricheartspecialists.com/heart-education/15-congenital-heart-defects/172-patent-ductus-arteriosus

https://www.ncbi.nlm.nih.gov/books/NBK430758/

### Tetralogy of Fallot




https://www.pecsig.co.uk/media/leaflets-bhf/bhf-tetralogy.pdf

Tetralogy of Fallot (TOF) is the most common cyanotic congenital heart defect. It consists of four key features:

- VSD
- Overriding aorta [aorta is positioned right over the VSD, instead of over the left ventricle]
- Pulmonary stenosis
- Right ventricular hypertrophy

The severity of cyanosis depends mainly on the degree of **right ventricular outflow tract (RVOT) obstruction**.

The aim of repair is to close the VSD and relieve the obstruction to pulmonary blood flow. Complete repair is often performed in infancy, although timing depends on the patient's anatomy, symptoms, oxygen saturations, and centre practice. Some babies with severe cyanosis or small pulmonary arteries may need a palliative shunt before complete repair.

These are the broad operative principles -

- The patient is placed on CPB.
- The VSD is closed with a patch so that the aorta receives oxygenated blood from the left ventricle.
- The right ventricular outflow tract (RVOT) obstruction is relieved by resecting obstructive muscle bundles.
- The pulmonary valve and pulmonary arteries are assessed.
- A pulmonary valvotomy, patch augmentation, or transannular patch may be used if the outflow tract is too narrow.

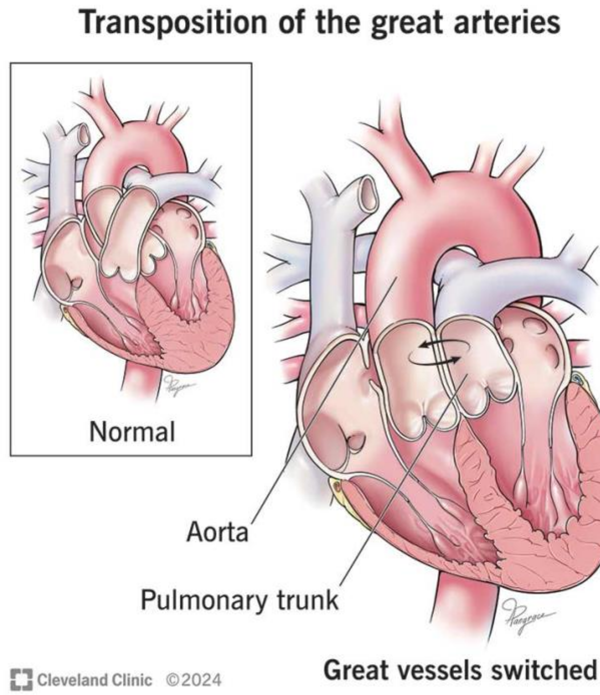
## Transposition of the Great Arteries

The arterial switch operation helps to fix transposition of the great arteries (TGA). In TGA, the aorta arises from the right ventricle and the pulmonary artery arises from the left ventricle. Survival depends on mixing through an ASD, VSD, or PDA.

Before surgery, prostaglandin may be used to keep the ductus arteriosus open. Definitive repair is usually performed early in the neonatal period while the left ventricle is still conditioned to systemic pressures.

These are the basic steps of the operation -

- The operation is performed through a median sternotomy using CPB
- The aorta and pulmonary artery are divided above the valves
- The coronary arteries are carefully detached from the original aorta
- The great arteries are switched so that the aorta arises from the left ventricle and the pulmonary artery from the right ventricle
- The coronary arteries are reimplanted into the neo-aorta
- Associated defects such as VSD or ASD may be closed at the same operation if appropriate




https://my.clevelandclinic.org/health/diseases/23387-transposition-of-the-great-arteries

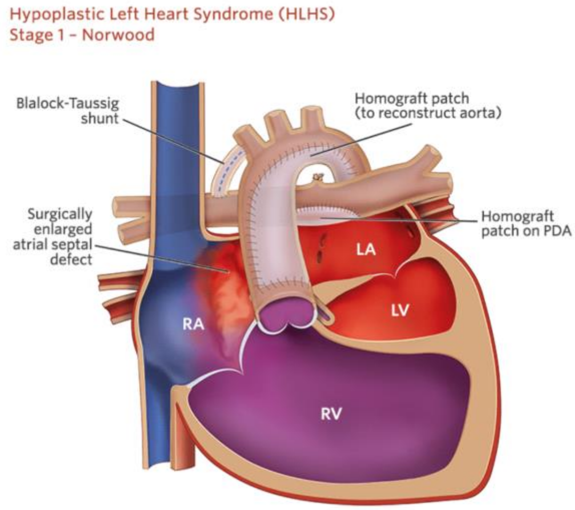
https://www.optechtcs.com/article/S1522-2942(07)70036-3/fulltext

## Hypoplastic Left Heart Syndrome

Hypoplastic Left Heart Syndrome (HLHS) is a severe congenital disorder where the left-sided heart structure is underdeveloped, including the left ventricle, mitral valve, aortic valve, and sometimes the ascending aorta. As a result of this, the left ventricle cannot support the systemic circulation.

In the newborn period, systemic blood flow depends on the PDA. Prostaglandin infusion is therefore used to keep the duct open before surgery.

Definitive management is surgical, which is divided into 3 main stages: Norwood, Glenn, and Fontan.



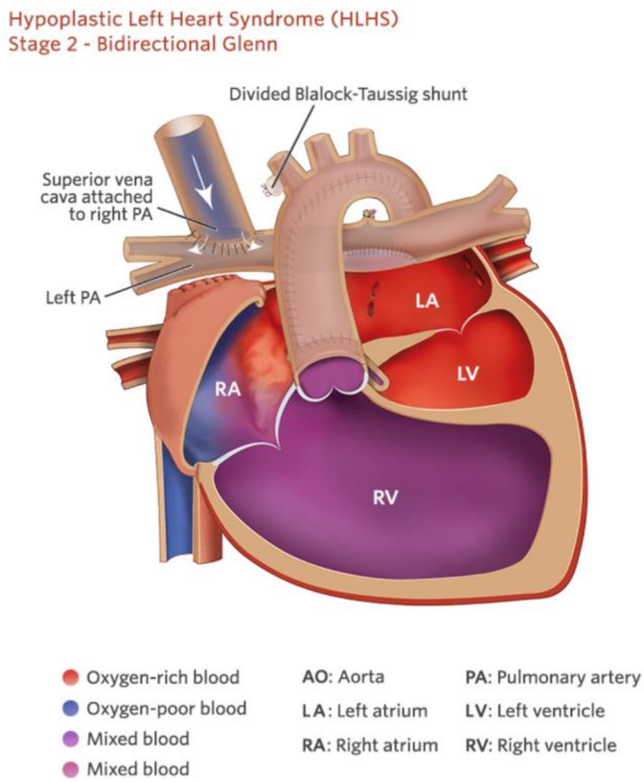

https://www.chop.edu/conditions-diseases/hypoplastic-left-heart-syndrome-hlhs

The Norwood procedure is the first stage and is usually performed in the neonatal period. The aim is to allow the right ventricle to pump blood to the systemic circulation by reconstructing the aorta and creating a controlled source of pulmonary blood flow.

These are the broad aims of the Norwood procedure -

- Create a neo-aorta by joining the main pulmonary artery to the small native aorta and arch reconstruction
- Ensure unobstructed systemic blood flow from the right ventricle to the body
- Provide pulmonary blood flow using either a modified Blalock-Taussig shunt or an RV-to-PA conduit (Sano Shunt)

After Norwood, the child has a single right ventricle that supplies both the body and lungs. Balance between systemic and pulmonary blood flow is critical, and these patients require intensive monitoring.



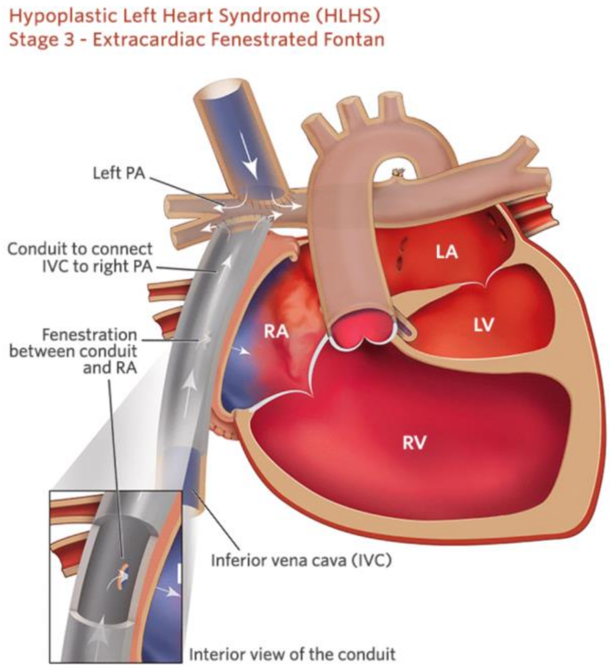

The Glenn shunt is the second stage for HLHS repair.

The principle is to connect the SVC directly to the pulmonary arteries. This allows venous blood from the upper body to flow passively into the lungs without passing through the heart and creating load on it. It reduces the workload of the single ventricle and improves oxygenation compared with the initial neonatal circulation.

The Glenn is typically performed at around 4-6 months of age.

These are the basic steps -

- The SVC is disconnected from the right atrium.
- The SVC is connected to the right pulmonary artery, allowing flow to both lungs.
- Any previous shunt may be taken down if no longer required.
- The aim is to reduce ventricular volume load and prepare the circulation for later Fontan completion.




The Fontan procedure is the final stage of HLHS repair. After Fontan completion, systemic venous blood from both the SVC and IVC is directed to the pulmonary arteries without passing through a ventricle. The single ventricle is then used mainly to pump oxygenated blood to the systemic circulation.

The Fontan is usually performed in early childhood after the Glenn stage.

These are the aims of the Fontan procedure -

- Separate most systemic venous blood from oxygenated pulmonary venous blood.
- Improve systemic oxygen saturations.
- Reduce volume load on the single ventricle.
- Create a stable circulation for longer-term survival in single ventricle disease.

Fontan circulation is palliative rather than curative. Lifelong specialist congenital cardiology follow-up is required.

https://www.ncbi.nlm.nih.gov/books/NBK603741/

https://www.aats.org/tsra-primer-surgical-techniques-2-bt-shunt-pa-band-glenn-and-fontan

https://www.optechtcs.com/article/S1522-2942(06)00033-X/fulltext

# Abbreviations

| ABBREVIATION | DEFINITION |
|---|---|
| AF | Atrial fibrillation |
| APTT | Activated Partial Thromboplastin Time |
| AR | Aortic Regurgitation |
| AS | Aortic Stenosis |
| ASD | Atrial Septal Defect |
| AV | Atrioventricular |
| BP | Blood Pressure |
| BPM | Beats Per Minute |
| BiVAD | Biventricular Assist Device |
| CABG | Coronary Artery Bypass Graft |
| COPD | Chronic Obstructive Pulmonary Disease |
| CPB | Cardiopulmonary bypass |
| CT | Computed Tomography |
| EBUS | Endobronchial Ultrasound |
| ECMO | Extracorporeal Membrane Oxygenation |
| FET | Frozen Elephant Trunk |
| GSV | Great Saphenous Vein |
| HLHS | Hypoplastic Left Heart Syndrome |
| ICS | Intercostal Space |
| IVC | Inferior Vena Cava |

| | |
|---|---|
| JVP | Jugular Venous Pressure |
| LAA | Left Atrial Appendage |
| LAD | Left Anterior Descending |
| LCA | Left Coronary Artery |
| LDCT | Low-Dose Computed Tomography |
| LIMA | Left Internal Mammary Artery |
| LVAD | Left Ventricular Assist Device |
| LVRS | Lung Volume Reduction Surgery |
| MDT | Multidisciplinary Team |
| MR | Mitral Regurgitation |
| MRI | Magnetic Resonance Imaging |
| MS | Mital Stenosis |
| NSAIDs | Non-Steroidal Anti-Inflammatory Drugs |
| NSCLC | Non-Small Cell Lung Cancer |
| PDA | Patent Ductus Arteriosus |
| PET | Positron Emission Tomography |
| PTE | Pulmonary Thromboendarterectomy |
| RATS | Robotic-Assisted Thoracoscopic Surgery |
| RCA | Right Coronary Artery |
| RIMA | Right Internal Mammary Artery |
| RVAD | Right Ventricular Assist Device |
| RVH | Right Ventricular Hypertrophy |
| SA | Sino-Atrial |

| | |
|---|---|
| SA:V | Surface Area : Volume Ratio |
| SCLC | Small Cell Lung Cancer |
| SVC | Superior Vena Cava |
| TAPVR | Total Anomalous Pulmonary Venous Return |
| TAVI | Transcatheter Aortic Valve Implantation |
| TAVR | Transcatheter Aortic Valve Replacement |
| TEVAR | Thoracic Endovascular Aortic Repair |
| TGA | Transposition of the Great Arteries |
| TMVR | Transcatheter Mitral Valve Replacement |
| TNM | Tumour Node Metastasis |
| TOE | Transoesophageal Echocardiography |
| ToF | Tetralogy of Fallot |
| VATS | Video-Assisted Thoracoscopic Surgery |
| VSD | Ventral Septal Defect |
| 3D | Three Dimensional |

## Acknowledgements

Cardiothoracic surgery is a highly specialized and rapidly evolving field, combining anatomy, physiology, technical skill, teamwork, and clinical judgement. This handbook has been designed to give medical students and early clinical learners a clear foundation before entering cardiothoracic theatres, clinics or placements.

We would like to thank Mr Jason Ali for his supervision and guidance during the development of this handbook.

Prepared by,
Ananya Mathur and Ethan Alford

Supervised by,
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SCTS Student Education Committee, 2025-27