HEART AND PERICARDIUM

PR.M.D.EL AMRANI DR.CHAIMA KASSI

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I – INTRODUCTION:

The heart, a hollow muscle with automatic contractile function, is the driving organ of arterial circulation. It is a fibro-muscular organ encased in a membrane, the pericardium.

Interest of the topic:

- *Physiological: This noble organ is vital for its role as the pump that drives blood into the blood vessels of the human body through its rhythmic contractions.*
- *Pathological: In industrialized countries, heart diseases represent the leading cause of death.*
- *Therapeutic: The heart is the subject of numerous surgical interventions, particularly the implantation of valve prostheses and heart transplants.*

II - DESCRIPTIVE ANATOMY:

1. General overview:

a. Situation:

- Contained within the pericardial sac, the heart occupies the lower two-thirds of the anterior mediastinum, to the left of the right border of the sternum.

- It rests on the diaphragm, moving in sync with its movements.

b. Shape:

The heart has the shape of a triangular pyramid, with its long axis directed obliquely to the left, forward, and downward.

c. Appearance and consistency:

- The heart has a reddish color and is scattered with fatty deposits on its surface, primarily at the level of the sulci.

- Its consistency is soft in the atria and firm in the ventricles.

d. Volume:

Its volume varies with the cardiac cycle (systole and diastole).

Note:
Its capacity can be assessed through radiological and hemodynamic investigations, which help define specific parameters of myocardial contractility for the left ventricle, such as the stroke volume and ejection fraction.

e. Dimensions:

- **Diameters:**
  - The long axis measures approximately 12 cm.
  - The largest transverse diameter, perpendicular to the long axis, is 9 cm.

Note:
In practice, these measurements are performed using the cardiac radiological silhouette.

- **Weight:**

The average weight of the heart is 300 g in men and 250 g in women, with a higher weight observed in athletic individuals.

2. External configuration:

- The heart is described as having:
  - Three surfaces:
    - a right ventral surface, also called sternocostal;
    - a left lateral surface, also called pulmonary;
    - and an inferior surface, also called diaphragmatic.
  - A base, posterior, facing backward and to the right.
  - An apex, directed forward and to the left, which belongs to the left ventricle.

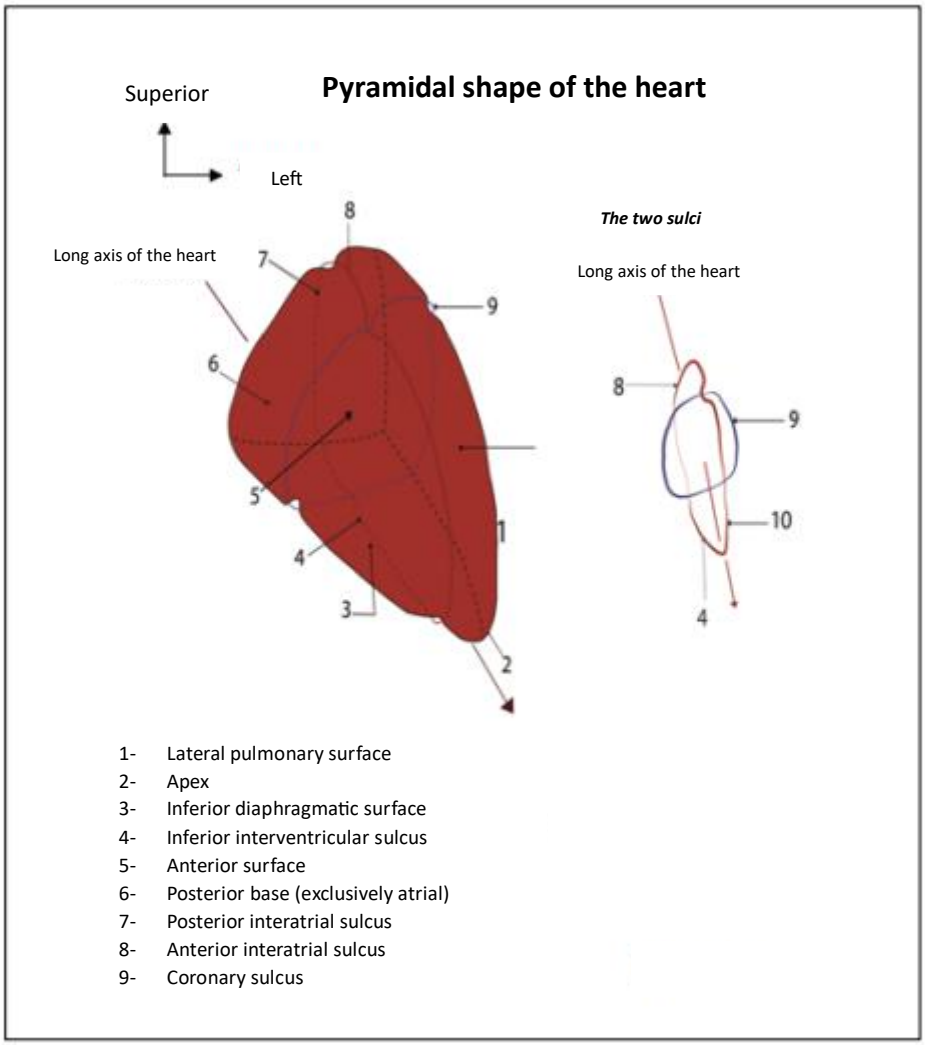
- The heart is composed of four cavities, paired in two sets, which distinguish a right heart and a left heart that normally do not communicate with each other.
- The boundaries between these cardiac cavities appear on the surface of the heart as three sulci:

- Inter-atrial sulcus;
- Inter-ventricular sulcus;
- Inter-atrio-ventricular sulcus, or coronary sulcus.

- Each face is divided by the coronary sulcus into two segments:

    - An anterior segment, ventricular ;
    - And a posterior segment, atrial.

Note:
The main trunks of the coronary arteries and their major collateral branches travel within these sulci. It is at this level that they are accessed during coronary bypass surgery.



a. Surfaces of the heart:

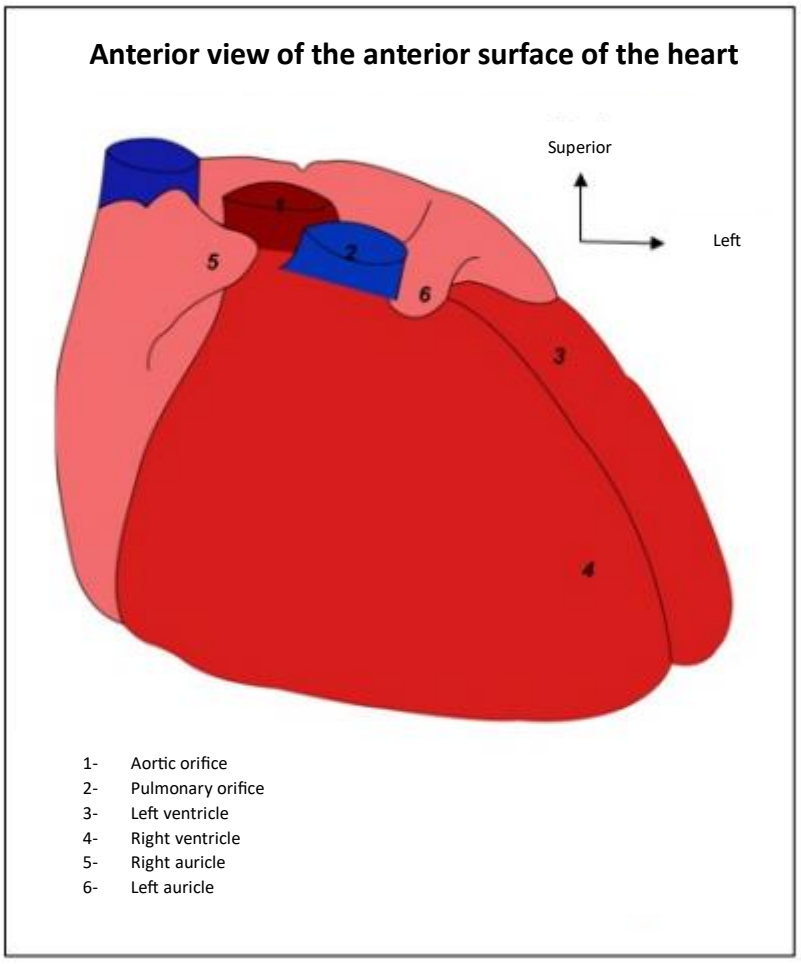
➢ Sternocostal (anterior) surface:

The sternocostal surface is divided into two segments:

- The anterior ventricular segment, which is further divided into two zones:
  - A posterior-superior zone, or arterial zone, occupied by the orifices of the major arterial trunks:
    - The aortic orifice, located posteriorly and to the right.
    - The pulmonary orifice, located anteriorly and to the left.
  - A antero-inferior zone, specifically ventricular, subdivided by the anterior interventricular sulcus into two areas:

- A left area, narrow, corresponding to the left ventricle.
- And a right area, broad, corresponding to the right ventricle.

- The posterior atrial segment includes:
    - The right atrial appendage: triangular, partially covering the initial portion of the aorta and the right coronary artery, with its apex reaching the inter-aorto-pulmonary sulcus.
    - The left atrial appendage: S-shaped, extending over the left side of the pulmonary artery.



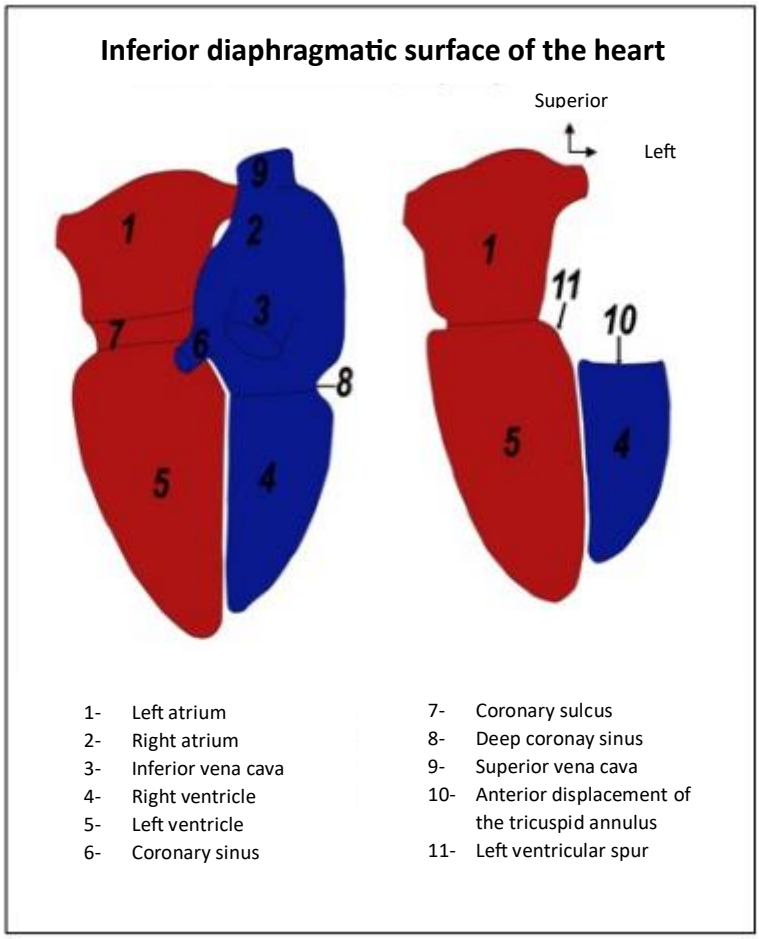
➢ Diaphragmatic (inferior) surface:

- The diaphragmatic surface is almost flat, facing downward and slightly forward.

  It is divided into two segments by the coronary sulcus:

  - The anterior ventricular segment, which is further subdivided into two unequal areas by the inferior interventricular sulcus:
    - The right area, corresponding to the right ventricle.
    - And the left area, corresponding to the left ventricle.

Note: *The posterior (or inferior) interventricular branch of the right coronary artery, which runs in the interventricular sulcus, is frequently accessed surgically for the implantation of a graft.*



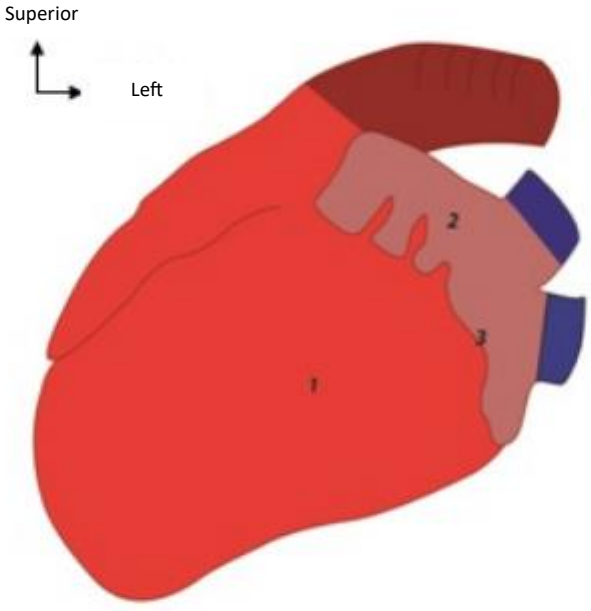
➢ Pulmonary (left lateral) surface:

It is convex from top to bottom, facing backward and to the left, and is divided into two segments by the left portion of the coronary sulcus:

- The posterior atrial segment, corresponding to the left atrial appendage.
- The anterior ventricular segment, corresponding to the left ventricle, where the marginal branches of the circumflex artery run on its surface.

Note:
It is in this region that these marginal arteries are accessed for the implantation of revascularization grafts.

Left lateral view of the heart



1- Left ventricle
2- Left auricle
3- Left part of the coronary sulcus

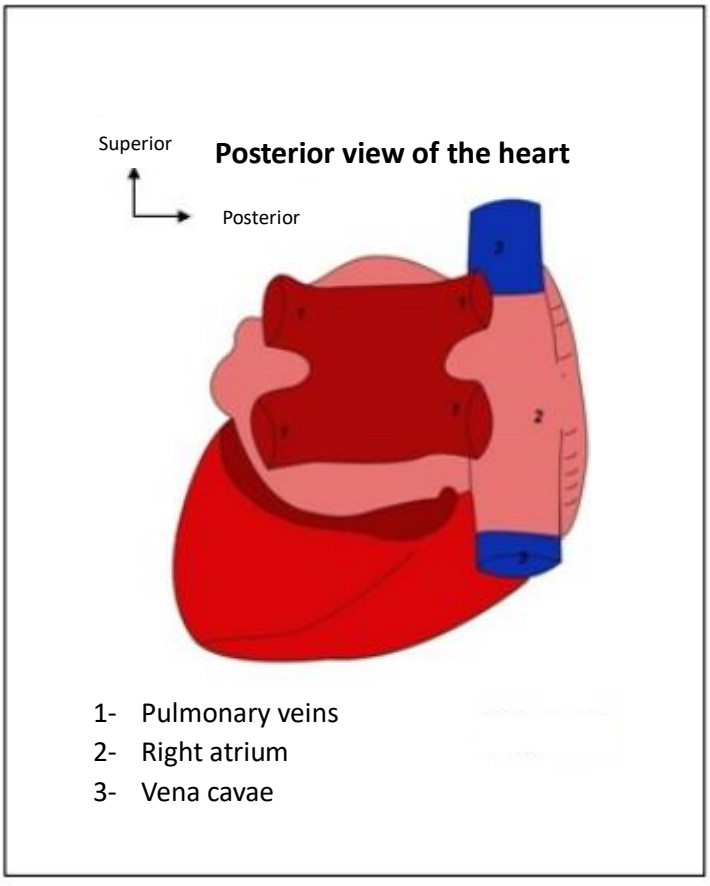
The three faces of the heart are separated by three edges:

- A right edge, sharp, separating the sternocostal and diaphragmatic surfaces.
- And two left edges, rounded, where the sternocostal, pulmonary, and diaphragmatic surfaces merge smoothly.

b. Base of the heart:

- The base of the heart is posterior, facing backward and to the right, transversely convex, and is entirely related to the atria.

- It is divided into two segments by the inter-atrial sulcus:
  - A left segment, corresponding to the left atrium, transversely elongated between the orifices of the four pulmonary veins, and facing backward.
  - A right segment, corresponding to the right atrium, facing strongly to the right, and subdivided into two parts by a vertical sulcus, the crista terminalis:
    - The right part, derived from the primitive atrium.
    - And the left part, elongated from top to bottom between the two vena cavae.



c. Apex of the heart:

Located forward and to the left, it corresponds to the left ventricle (with the anterior interventricular sulcus remaining more medial).

3. Internal configuration:

- "The right heart" and "the left heart" are separated by a septum and each consists of an atrium and a ventricle.

- The atrium is a globular cavity, roughly spherical, opening anteriorly into the ventricle.

- The ventricle is a pyramidal cavity that has two orifices at its base: one atrioventricular orifice that connects the atrium and ventricle, and the other arterial orifice that allows for the ventricular ejection.

a. Septa of the heart:

- **Inter-atrial septum**:

This is a thin fibrous membrane that separates the two atria. It is obliquely oriented, anteriorly and to the left.

***Note**:*
It is divisible across its entire width in the upper two-thirds.

- **Atrioventricular septum**:

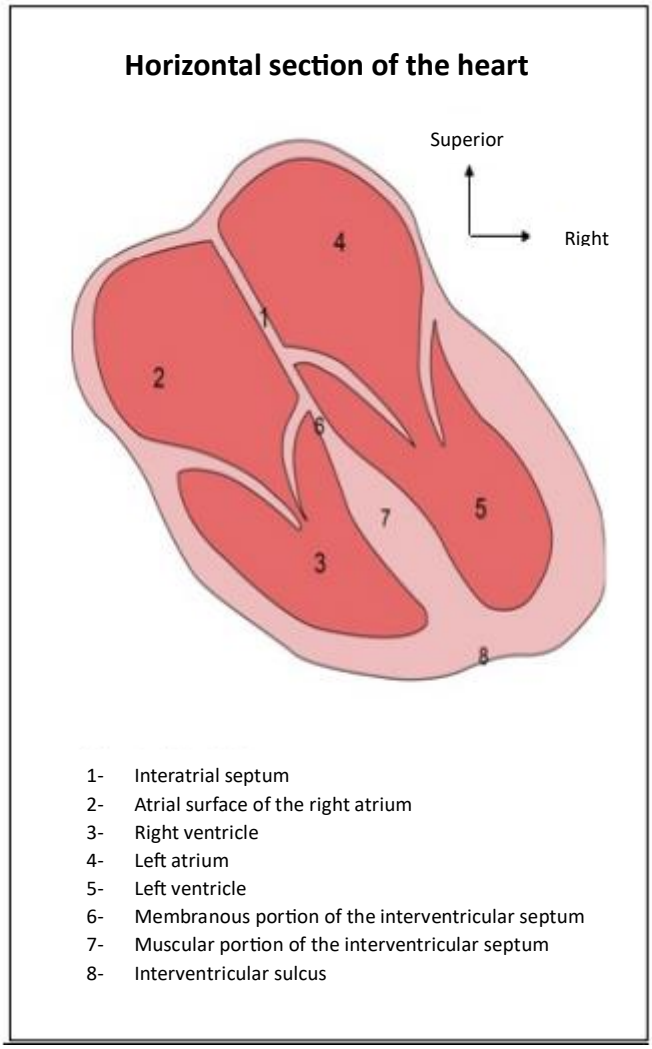
This is a short septum located between the inter-atrial septum posteriorly and the interventricular septum anteriorly. It separates the right atrium from the left ventricle, and it is oblique downward, forward, and to the right.

***Note**:*
In pathology, direct communications between the right atrium and left ventricle may exist.

➢ Interventricular septum:

This septum separates the two ventricles. It extends from the sternocostal face to the diaphragmatic face of the heart, and is oblique forward and to the left.

It consists of two parts: one membranous and the other muscular.



b. Right heart:

The right heart receives desaturated blood and pumps it into the pulmonary circulation, where it will become oxygenated. It consists of an atrium and a ventricle, separated by the right atrioventricular orifice.

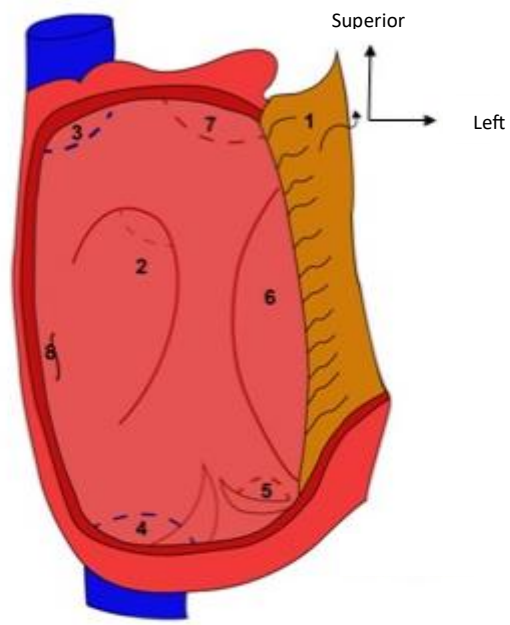
➢ Right atrium (right atrial appendage):

The right atrium extends between the two vena cavae and continues anteriorly to the aorta by the right atrial appendage. It is described with six walls:

- A internal or septal wall, presenting a central depression, the fossa ovalis (which is the remnant of the physiological inter-atrial communication in the fetus), encircled anteriorly, superiorly, and inferiorly by a prominent ridge, the limbus of the fossa ovalis.
- A lateral wall, showing the pectinate muscles.
- A superior wall, presenting the orifice of the superior vena cava, which is circular, about 20 mm, and avalvular.
- A lower wall, occupied by the valvular venous orifices of the inferior vena cava and the coronary sinus:
    - The orifice of the inferior vena cava, located at the junction of the inferior and posterior walls.
    - The orifice of the coronary sinus, more anterior and medial.
- A posterior wall, presenting two prominences:
    - One located near the septal wall, equidistant from the two vena cavae: the intervenous tubercle (Lower).
    - The other running between the right edges of the two vena cavae: the crista terminalis (His).
- An anterior wall, corresponding to the right atrioventricular (tricuspid) orifice, with the right atrial appendage opening above it, at the junction of the anterior, superior, and lateral walls.

***Note**:*
After opening the pericardium, its external surface becomes visible, at which point pouches are created for venous cannulation of the vena cavae during cardiac surgeries involving extracorporeal circulation. This surface represents the usual access route to the right atrium. Surgical access can be achieved through a vertical, posterior, or arcuate incision.

Lateral view of the right atrium



1- Lateral wall
2- Oval fossa
3- Superior vena cava orifice
4- Inferior vena cava orifice
5- Coronary sinus orifice
6- Right atrioventricular orifice
7- Right auricle

➢ Right ventricle:

The right ventricle has a triangular pyramidal shape, located anteriorly to the right atrium, with a posterior base and an anterior apex.

It presents **three walls.**

- Anterior wall: Also known as the sternocostal wall, it features the anterior papillary muscle in its middle part.

Note :

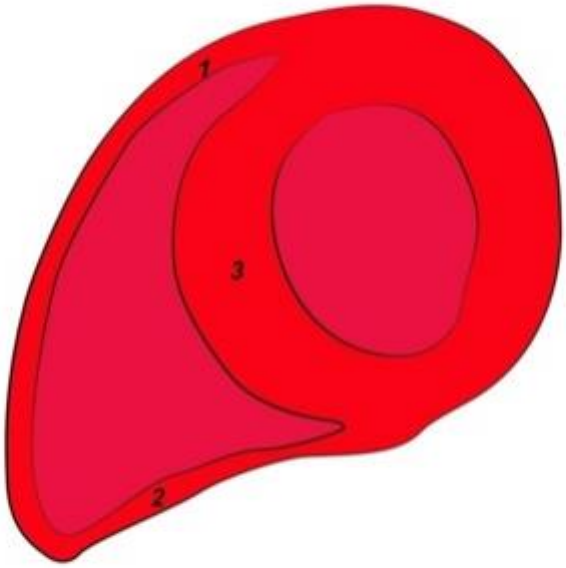
This is the usual surgical access face for the right ventricular cavity. The approach can be horizontal (transversal), from the anterior right coronary sulcus to the anterior interventricular sulcus, or vertical (longitudinal), along the axis of the pulmonary artery.

- Septal wall: This wall corresponds to the interventricular septum and features the supraventricular crest in its posterosuperior part. The crest separates a smooth upper zone, the arterial cone, from a lower zone, where the septal papillary muscles and the septomarginal trabecula are attached.

***Note**:*
The septomarginal trabecula, which connects the ventricular walls, counteracts the dilating forces of the right ventricle.

- Inferior wall: This wall corresponds to the diaphragmatic surface and provides insertion for the posterior papillary muscle and the septomarginal trabecula.

Section of the heart perpendicular to its long axis



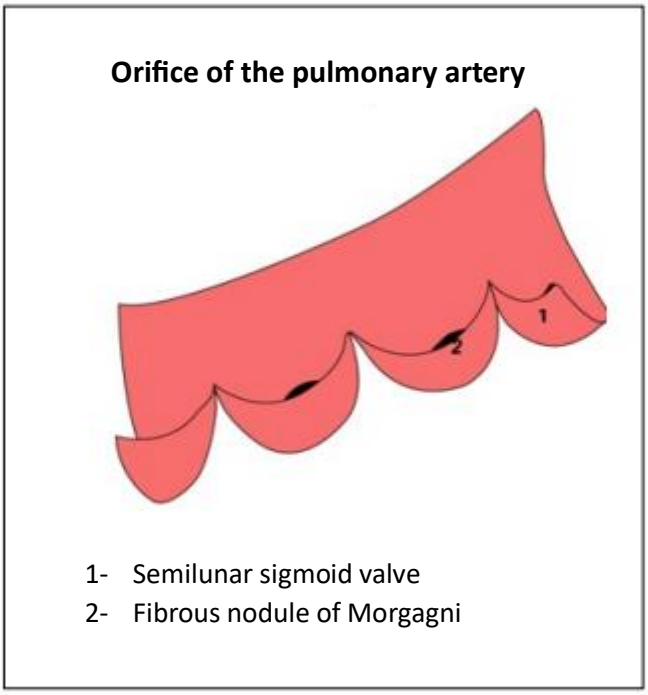
1- Anterior wall
2- Inferior wall
3- Septal wall

Apex: The apex of the right ventricle is located near the heart's apex.

Base: The base is occupied by the pulmonary artery orifice and the atrioventricular orifice.

- **Right atrioventricular arifice** (or tricuspid orifice):
    - The tricuspid orifice connects the right atrium and right ventricle.
    - It is an annular orifice, slightly elongated transversely, measuring 35 to 40 mm in diameter, and is directed backward, to the right, and upward.
    - It is closed during ventricular systole by the right atrioventricular valve (or tricuspid valve), which is inserted into a fibrous ring.
    - The right atrioventricular valve is divided into three cusps (separated by three commissures):
        - Anterior,
        - Septal (or internal),
        - Posterior (or inferior)
    - Each cusp is connected to the ventricular wall by tendinous cords originating from the papillary muscles, divided into three groups:
        - Cordae of the anterior papillary muscle,
        - Cordae of the septal papillary muscles,
        - Cordae of the posterior papillary muscles.

- **Pulmonary artery orifice**:
    - The pulmonary artery orifice connects the right ventricle and pulmonary artery. It is circular, measuring 24 to 28 mm, and is directed upward, backward, and to the left.
    - It is closed during ventricular diastole by three semilunar sigmoid valves in a pigeon's nest configuration, with the free edge presenting a fibrous nodule (Morgani), forming the pulmonary valve.



1- Semilunar sigmoid valve
2- Fibrous nodule of Morgagni

c. Left heart:

The left heart receives oxygenated blood (99% saturation) and pumps it into the systemic circulation. It consists of an atrium and a ventricle, separated by the atrioventricular orifice (also known as the mitral orifice).

➢ Left atrium (left auricle) :

The left atrium is roughly ovoid, with a transversal long axis extending from one pulmonary vein pedicle to the other. It has six walls:

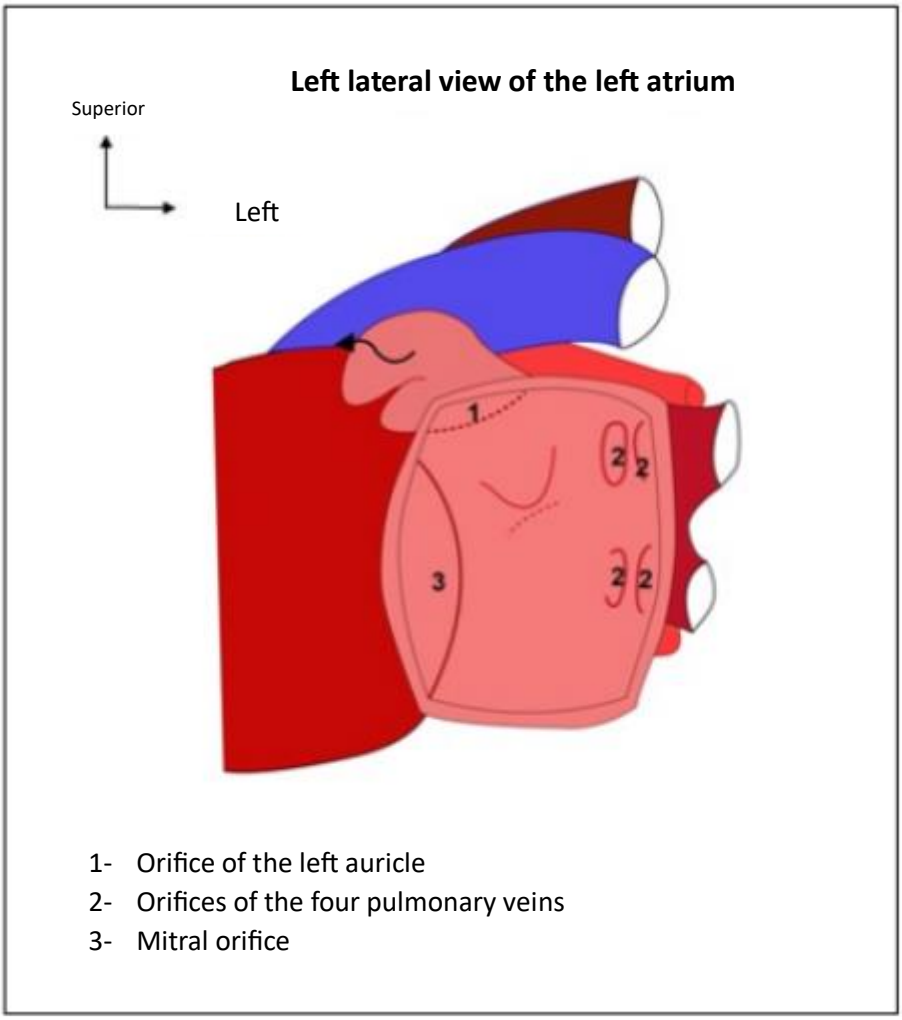
- Lateral (left) wall: This wall presents the orifice of the left auricle anteriorly.

Note :

This is the area where a dilator (or finger) can be introduced into the atrium and then into the mitral orifice during mitral commissurotomy (performed with the "closed heart" technique) to treat mitral stenosis.

- Septal (internal) wall: Formed by the interatrial septum, which contains the valve of the oval foramen.

- Superior and inferior walls: These are narrow, smooth, and concave.
- Posterior wall: This wall features the orifices of the four pulmonary veins.
- Anterior wall: Occupied by the left atrioventricular orifice (mitral orifice).



1- Orifice of the left auricle
2- Orifices of the four pulmonary veins
3- Mitral orifice

➢ Left ventricle :

The left ventricle is the essential component of the heart. It has a somewhat flattened conical shape and presents two walls, two edges, a apex, and a base.

The walls:

- Septal wall (right): This wall is adjacent to the interventricular septum and the atrioventricular septum at the top. It is smooth at the back and features numerous muscular protrusions at the front.

- Lateral wall (left): This wall is adjacent to the left lateral face of the heart and features many muscular protrusions, notably the two papillary muscles of the left atrioventricular valve.

The two walls are separated by two edges (antero-superior and postero-inferior), and they give rise to the following muscles: anterior papillary muscle and posterior papillary muscle.

The apex:

Rounded, it occupies the entire apex of the heart (the interventricular sulcus crossing the right border of the heart 2 cm inward from the tip).

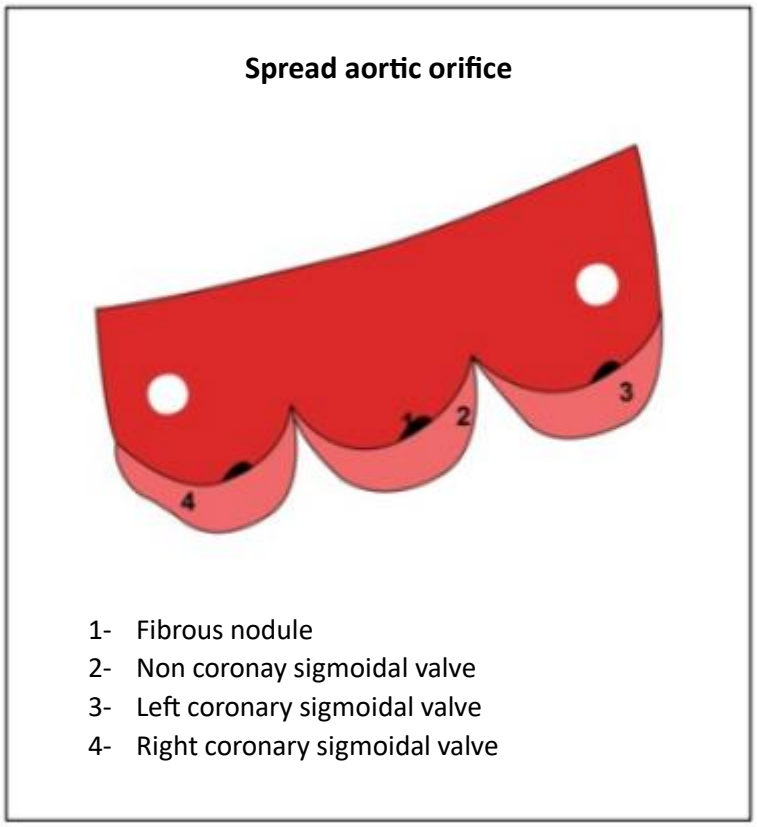
The base:

It is entirely occupied by the orifices: arterial (aortic) and atrioventricular (mitral).

- **The left atrioventricular orifice**: This orifice connects the left atrium and left ventricle. It is an annular orifice, measuring 30 to 35 mm in diameter. It is closed during ventricular systole by the left atrioventricular valve (or mitral valve):
    - It is inserted on the fibrous ring,
    - Divided into two cusps by the two commissures: posterior-right and anterior-left. Each cusp is attached to the ventricular wall by tendinous cords from the anterior and posterior papillary muscles.

- **The aortic orifice**: This orifice connects the left ventricle and the aorta. It is a circular orifice of 25 mm in diameter, located behind the pulmonary orifice, facing backward, upward, and to the right. It is closed during ventricular diastole by three semilunar sigmoid valves, with a superior concavity. The free margin of these valves presents a fibrous nodule, and the adherent margin is fixed to the aortic ring. These valves are defined as:
    - One non-coronary sigmoid valve,

- Two coronary sigmoid valves, the left coronary and right coronary valves. These three valves are separated by three commissures.



4. Heart structure:

- The heart is primarily composed of a thick muscle: the myocardium, which forms the cavities of the heart.

- This thick muscular layer is covered:
  - Internally by a thin membrane: the endocardium,
  - Externally by the visceral layer of the pericardium: the epicardium.

- In addition to these layers, the heart is structured by a cardiac skeleton or fibrous framework of the heart.

III – ANATOMICAL RELATIONS OF THE HEART:

The heart is located in the lower part of the anterior mediastinum. It is thus in relation with:

- **Anteriorly:** the sternal and costal wall,
- **Posteriorly:** the elements of the posterior mediastinum, including the thoracic esophagus,
- **Laterally:** the pleural cavities and their contents,
- **Inferiorly:** the diaphragm,
- **Superiorly:** the large vascular trunks.

Note: *The anterior relations are the basis for the topographic elements in the semeiology of cardiac auscultation. It is important to recall that the auscultation areas of the valvular orifices project onto the thoracic wall as follows:*

- *Aortic orifice: medial part of the 2nd right intercostal space,*
- *Pulmonary orifice: medial part of the 2nd left intercostal space,*
- *Mitral orifice: lateral part of the 5th left intercostal space along the axillary line,*
- *Tricuspid orifice: at the level of the xiphoid process.*

IV – PERICARDIUM:

The pericardium is a fibroserous sac surrounding the heart and the adjacent part of the large vessels. It consists of two layers:

- Serous pericardium,
- Fibrous pericardium.

Note: *The serous pericardium can become inflamed, a condition known as pericarditis. This may lead to fluid accumulation (effusion), and the volume of this fluid can cause severe hemodynamic cardiac disturbances.*

1. Serous pericardium:

- The serous pericardium consists of two layers:
  - Visceral layer (or epicardium): Applied against the heart and vessels,
  - Parietal layer: Applied against the deep surface of the fibrous pericardium.
- These two layers continue with each other at the pericardial reflection line, forming a virtual space called the pericardial cavity.

Schematic section of the heart along its long axis

1- Visceral layer
2- Parietal layer
3- Pericardial cavity
4- Fibrous pericardium
5- Aorta
6- Right branch of the pulmonary artery
7- Transverse sinus

➢ Pericardial reflection line around the arterial pedicle:

The serous pericardium forms a complete serous sheath around the arterial vascular column within the large pericardial cavity. The line of reflection follows this path:

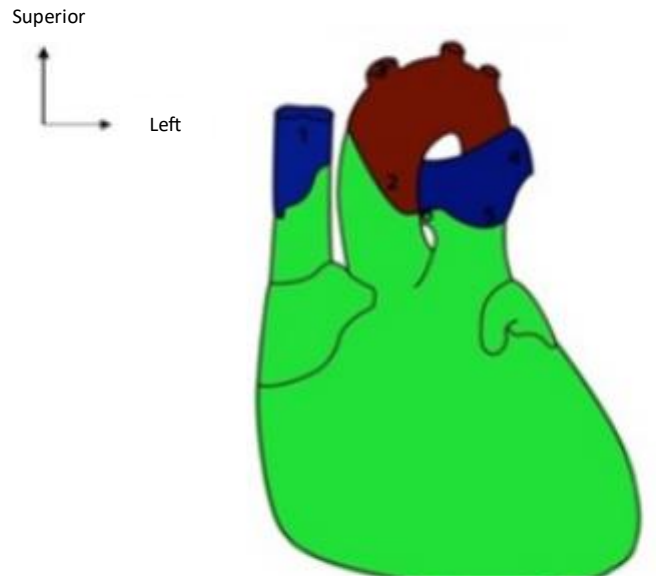
- Starts at the right border of the aorta, opposite the origin of the brachiocephalic trunk,
- Descends obliquely downward and left, in front of the aorta and the bifurcation of the pulmonary artery,
- Crosses the origin of the left pulmonary artery from front to back,

- Lays horizontally behind the bifurcation of the pulmonary artery and then the right pulmonary artery,
- Finally crosses the posterior surface of the aorta and ascends obliquely upward and right to meet its starting point.

Thus, in front, the reflection line forms a concave curve upward and left (the Haller's crossing), with two horns:

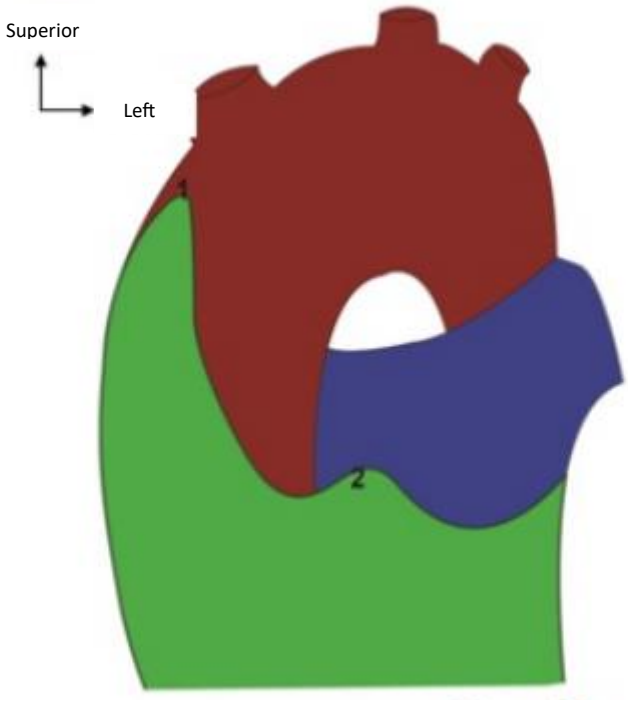
- Superior horn at the origin of the brachiocephalic trunk,
- Inferior horn between the aorta and the bifurcation of the pulmonary artery.

Pericardium on anterior view of the heart



1- Superior vena cava
2- Ascending aorta
3- Arterial brachiocephalic trunk
4- Left pulmonary artery
5- Left pulmonary artery trunk
6- Line of reflexion

Line of reflection (anterior view of the arterial pedicle)



1- Superior horn
2- Inferior horn

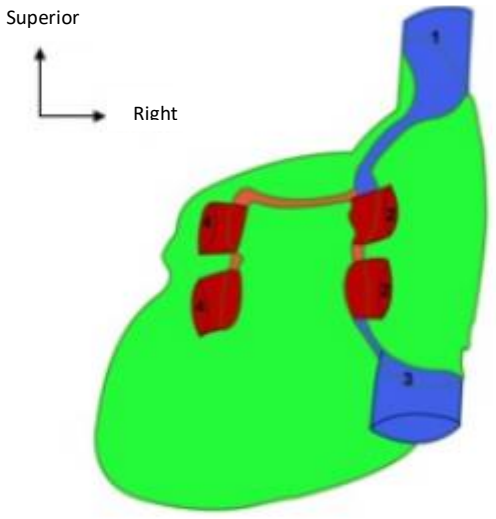
➢ **Around the venous pedicle**:

The serous pericardium forms a very short sheath, insinuating itself into the intervals, separating the vessels to form cul-de-sacs, and is incomplete posteriorly, where a depericardized area persists, forming a true "meso."

- It starts from the anterior face of the superior vena cava, 3 cm from its junction with the atrium, and curves around it on the right, obliquely downward and backward.
- It then descends vertically, crossing the right side of both right pulmonary veins, superior and inferior.
- It curves around the inferior vena cava, 1 cm from its junction with the atrium, first passing to the right, then anteriorly, and finally to the left.
- It ascends vertically, crossing the left side of the right pulmonary veins.
- It then moves horizontally to the left.
- It descends vertically to the right of the left pulmonary veins, curves around the inferior vein, and ascends vertically to their left.

- Finally, it moves transversely to the right, reaching the left side of the superior vena cava, which it curves around anteriorly.

Posterior view of the venous pedicle showing the lines of reflection



1- Superior vena cava
2- Right pulmonary veins
3- Inferior vena cava
4- Left pulmonary veins

➢ "Meso" and diverticula:

The meso:

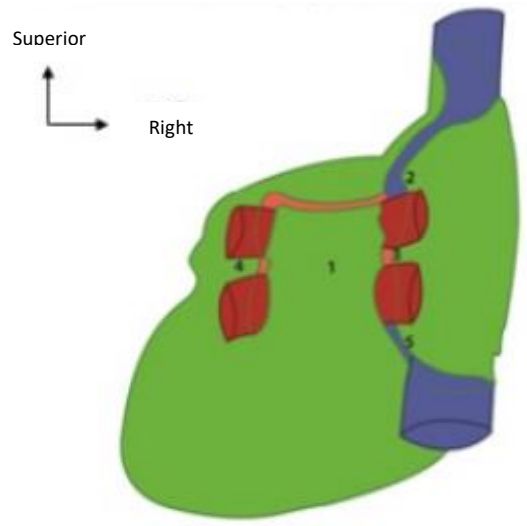
The line of reflection creates a true "meso" at the posterior face of the atria, consisting of three sections:

- Horizontal section, between the two superior pulmonary veins,
- Left vertical section, around the two left pulmonary veins,
- Finally, the right vertical section, around the two vena cavae and the two right pulmonary veins.

The diverticula:

This reflected line limits the formation of diverticula within the large pericardial cavity: the oblique sinus of the pericardium, or Haller's cul-de-sac, the most significant, located posterior to the left atrium, and therefore bounded by the three sections of the meso described above.

Meso and diverticula (posterior view of the venous pedicle)



1- Oblique sinus of the pericardium
2- Retro-caval fossa
3- Right interpulmonary recess
4- Left interpulmonary recess
5- Inferior caval recess

➢ **The pericardial cavity**:

- The pericardial cavity is located between the two layers of the serous pericardium and is normally a virtual space.

***Note**:This cavity may become the site of fluid effusions, sometimes leading to compressive conditions.*

- The pericardial cavity has two parts:
  - The main pericardial cavity,
  - And its diverticula:
    - Diverticula formed around the venous pedicle,
    - Transverse sinus of the pericardium, or Theile's sinus, situated between the venous and arterial pedicles.

- This sinus has three walls:

- The anterior wall is formed by the visceral layer lining the posterior face of the arterial pedicle,
- The posterior wall, formed by the visceral layer lining the anterior face of the atria and the superior vena cava,
- The superior wall, formed by the parietal layer (connecting the arterial reflection line to the venous reflection line).

- It opens at both ends into the main pericardial cavity:
  - The right orifice is located between:
    - On the left: the aorta,
    - On the right: the superior vena cava,
    - Below: the right auricle,
    - Above: the pericardium bridging from the aorta to the superior vena cava.
  - The left orifice is located between:
    - On the right: the trunk of the pulmonary artery,
    - On the left and below: the left auricle and left atrium,
    - Above: the left branch of the pulmonary artery.

***Note**: This sinus is particularly important for cardiac surgeons. After opening the pericardial sac, a finger can be inserted into this sinus by passing behind the pulmonary trunk and ascending aorta. In cardiac surgeries under extracorporeal circulation, such as coronary artery bypass grafting (CABG), the surgeon can stop or reroute the blood flow in these large vessels by placing a clamp, a ligature, and inserting tubes for the bypass machine, then tightening the ligature.*

2. Fibrous pericardium:

- The fibrous pericardium forms a tough, fibrous sac, attached to the parietal layer of the serous pericardium. It continues with the adventitia of the large afferent and efferent blood vessels of the heart.
- It has the shape of a flattened horn trunk from front to back, and can be described with a base, a summit, and four faces.

  - Its base is attached to the diaphragm by the phrenopericardial ligament.

- Its anterior face is united with the sternum by the superior and inferior sternopericardial ligaments.
- Its posterior face faces the posterior mediastinum.
- Its summit is anchored to the viscera by the tracheopericardial ligament and the esophagopericardial ligament, and to the prevertebral lamina by the vertebropericardial ligaments.

3. Vascularization – innervation – lymphatic drainage:

It is important to distinguish two groups of vessels and nerves.

- Deep group: This group is destined for the visceral layer of the serous pericardium, reliant on the vessels and nerves of the heart.

- Superficial group: This group is destined for the parietal layer of the serous pericardium and the fibrous pericardium.

➢ Arterial vascularization:

The arteries originate from:

- The internal thoracic arteries,
- The superior phrenic arteries,
- And, occasionally, from visceral branches (thymic arteries, middle thyroid artery, esophageal arteries, and bronchial arteries).

➢ Venous vascularizartion:

The veins are satellites of the arteries and are drained by:

- The azygos veins, posteriorly,
- And the superior phrenic veins, laterally.

➢ Lymphatic drainage:

The lymphatics drain into the lower tracheobronchial nodes and mediastinal nodes.

➢ **Innervation:**

The nerves derive from the phrenic nerves, vagus nerves, and sympathetic nerves.

IV – FUNCTIONAL ANATOMY:

Throughout the day, the heart circulates about 900 liters of blood. The activity of the myocardium alternates between relaxation and contraction, ensuring both filling (diastole) and ejection (systole).

1. Diastole:

- Diastole consists of a filling phase and an isovolumetric contraction phase.

- During the filling phase, the atrioventricular valves open. Blood flows into the ventricles due to the depression created by ventricular relaxation, followed by atrial contraction.

- During isovolumetric contraction, both the atrioventricular and semilunar valves are closed, and intravenous pressure increases rapidly.

2. Systole:

- Systole contains a ventricular ejection phase and an isovolumetric relaxation phase. During ventricular ejection, under the effect of intravenous pressure induced by myocardial contraction, the semilunar valves open, and blood is ejected into the aorta and pulmonary trunk.
- During isovolumetric relaxation, the semilunar valves close due to the drop in intravenous pressure, which becomes lower than arterial pressure. This period is shortened by the rise in intra-atrial pressure, which causes the atrioventricular valves to open.

3. Heart sounds:

During cardiac auscultation, two heart sounds are typically audible:

- B1: At the beginning of systole, induced by the closing of the atrioventricular valves (tricuspid and mitral). Its tone is dull and maximal at the apex of the heart.

- B2: At the beginning of diastole, caused by the closing of the semilunar valves (aortic and pulmonary). Its tone is higher and dry, maximal at the base of the heart.

V – CLINICAL APPLICATIONS:

➢ Valvular pathologies:

- The pathological disturbances of the heart valves affect the efficiency of the heart pump.

- A valvular heart disease can lead to either stenosis (narrowing) or insufficiency.

- A stenosis prevents a valve from opening fully, slowing down the blood flow from a cardiac chamber.

- On the other hand, insufficiency or regurgitation prevents a valve from closing fully, usually due to the formation of nodules on the cusps (or scarring that retracts them), preventing their edges from meeting or closing properly. This allows a variable amount of blood (depending on the severity of the lesion) to flow backward into the chamber from which it was just ejected.

- Both stenosis and insufficiency increase the heart's workload. The passage of blood through a narrowed opening in a large vessel or cardiac chamber (stenosis and regurgitation) causes turbulence. This turbulence creates small vortices responsible for vibrations that are audible as murmurs.

- Valvular diseases are linked to mechanical issues, and often a damaged or defective valve can be surgically replaced by valvuloplasty. For this, artificial valve prostheses made from synthetic materials are used, but also xenografts (valve transplants taken from animals, such as pigs) are performed.

➢ Pericarditis, cardiac effusion, and cardiac tamponade:

The pericardium can be involved in several pathological processes:

- Pericarditis (inflammation of the pericardium) generally causes chest pain, and certain inflammatory diseases can lead to the formation of pericardial effusion.

- A chronically inflamed and thickened pericardium can eventually calcify and seriously compromise heart function.

- Usually, the adjacent serous pericardial layers do not produce any audible sound upon auscultation. However, pericarditis makes these layers rigid, and the resulting friction (called pericardial friction rub) is heard with the stethoscope as the sound of silk rubbing.

- If there is a significant pericardial effusion, the excess fluid prevents the heart from fully expanding, which tends to limit the blood flow into the ventricles. This phenomenon – cardiac tamponade – is a potentially fatal condition because the fibrous pericardium is resistant and lacks elasticity. As a result, the heart's volume is increasingly limited by the fluid accumulating outside it in the pericardial cavity.

- Pericardial drainage is done either by puncture or pericardiocentesis, or by pericardial fenestration or open pericardotomy.

➢ **Exploration methods**:

- **Standard radiography**:

A chest X-ray is a basic exam in the non-invasive exploration of the heart. It provides information about the heart silhouette and the major vessels, as well as pulmonary hemodynamics. A normal image does not exclude heart disease, but an abnormal heart silhouette indicates an issue that requires further exploration.

- **Transthoracic Doppler echocardiography**:

Transthoracic Doppler echocardiography (TTE) is a non-invasive and non-radiating imaging technique. It allows for dynamic visualization of the heart, particularly its cavities and valves, and also, through Doppler, characterizes blood flow and tissue movement at the cardiac level. Therefore, it is of crucial importance in the diagnosis and follow-up of cardiovascular diseases.

- **Transesophageal Doppler echocardiography**:

The principle of transesophageal Doppler echocardiography is the same as that of transthoracic Doppler echocardiography, except that the probe is not external but is attached to an endoscope and introduced through the mouth into the patient’s esophagus, allowing for better image quality. It thus allows for better visualization of structures that are difficult to see by transthoracic approach.

VI – SURGICAL APPROACHES:

- **Sternotomy**:

The skin incision is median and vertical. The incision is vertical and median, starting 1 to 2 cm below the sternal notch (to avoid being visible at the base of the neck) and descending about 1 cm below the xiphoid process. This approach easily exposes the anterior pericardium, the heart, the ascending aorta, and the pulmonary artery trunk.
This is the reference approach for valvular surgery (mitral, aortic, tricuspid, pulmonary), as well as pericardial surgery.

- **Thoracotomies**:

Access to cardiovascular structures through an intercostal space and into the pleural cavity. Depending on which part of the intercostal space is used, this is referred to as either an antero-lateral or postero-lateral thoracotomy, on the right or left side. The left thoracotomy is a useful approach in emergency situations, particularly for exploring cardiac wounds.
The right thoracotomy allows for the repair, with the heart still closed, of certain congenital heart diseases.

VII - CONCLUSION:

- The heart is the central organ of the cardiovascular system. It is a true "pump," responsible for circulating blood throughout the body through its rhythmic contractions.
- It is closely linked to the respiratory system.
- It can be the site of serious pathologies that may compromise the vital prognosis.
- Paraclinical exams aim to detect physiological and anatomical abnormalities, allowing the practitioner to make the correct diagnosis.