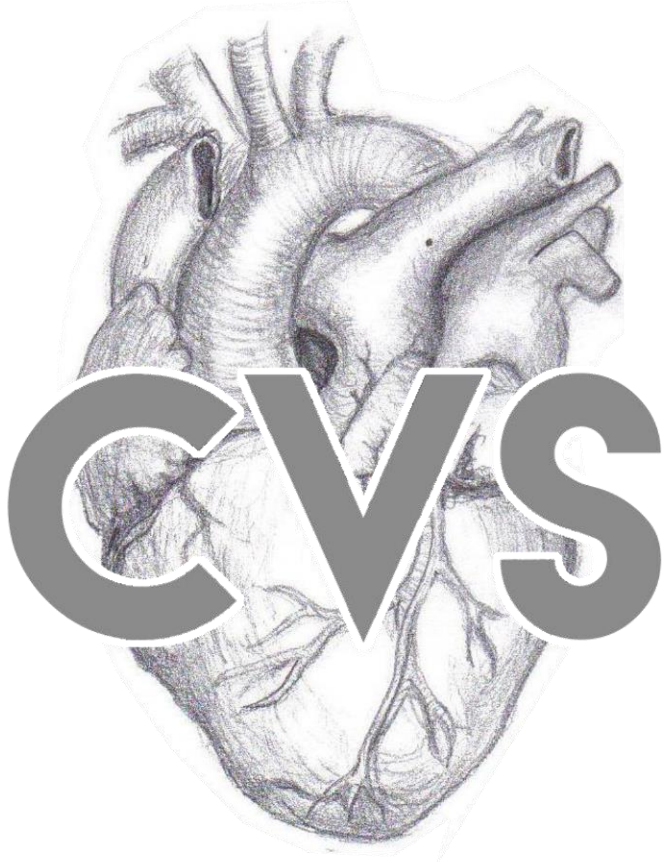

CVS

ANATOMY / HISTOLOGY

☑ Sheet ○ Slide ○ Handout

Number

3

Subject

Anatomy of the heart

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Date: 18/10/2016

Price:

Quick Review

- For the millionth time, arterioles are the *MAJOR RESISTANCE VESSELS*, they undergo vasoconstriction and vasodilation

- Vasoconstriction by contraction of the smooth muscles in their walls narrowing the lumen (high peripheral resistance)

- While in vasodilation, the smooth muscles will relax widening the lumen (low peripheral resistance)

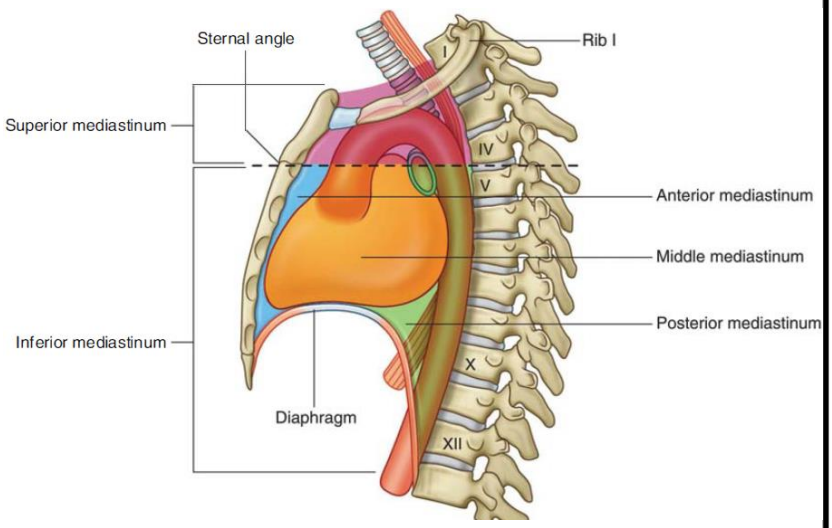
- Factors that induce vasoconstriction:
  - Sympathetic stimulation
  - Increased myogenic activity
  - Increased oxygen in the blood
  - Decreased carbon dioxide in the blood
  - Some hormones like angiotensin II (the most powerful vasoconstrictor) and vasopressin
  - Cold weather

- Factors that induce vasodilation:
  - Decreased myogenic activity
  - Hypoxia
  - Increased carbon dioxide in the blood
  - Histamine release
  - Heat

The thoracic cavity:

- It's subdivided into three major compartments:
  - Right and left pleural cavities, each containing a lung.
  - The mediastinum.

- The pleural cavities are completely separated from each other by the mediastinum.



❖ If we drew an imaginary line from the sternal angle to the lower border of T_{IV}, it would divide the mediastinum into:

1. The superior mediastinum, and its boundaries are:

   Posteriorly: the upper four thoracic vertebrae.
   Anteriorly: the manubrium sterni.
   Superiorly: the inlet of thorax.
   Inferiorly: the imaginary line.

   Contents: the arch of the aorta and its branches and relations.

2. The inferior mediastinum, and its boundaries are:

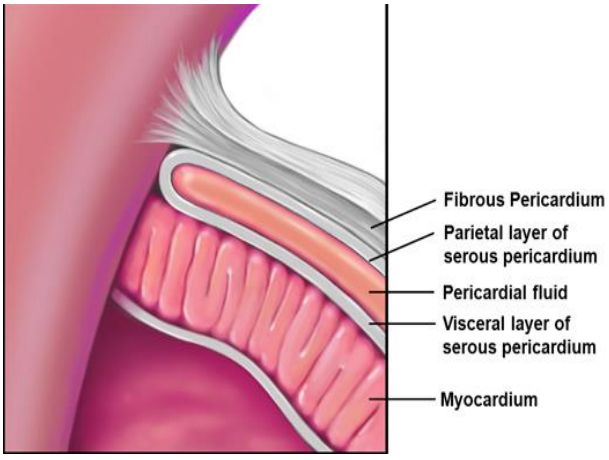
   Posteriorly: lower eight thoracic vertebrae.
   Anteriorly: body of the sternum**.**
   Superiorly: the imaginary line.
   Inferiorly: the diaphragm.

The inferior mediastinum is further divided into:

- Anterior mediastinum: contains fat and lymph nodes.
- Middle mediastinum: contains the heart within the pericardium, the phrenic nerves and part of the lungs laterally on each side.
- Posterior mediastinum: contains the esophagus, the descending aorta and the two bronchi.

The pericardium:

❖ It is a *fibroserous* sac surrounding the heart and the roots of the great vessels. It consists of two components, the fibrous pericardium and the serous pericardium.

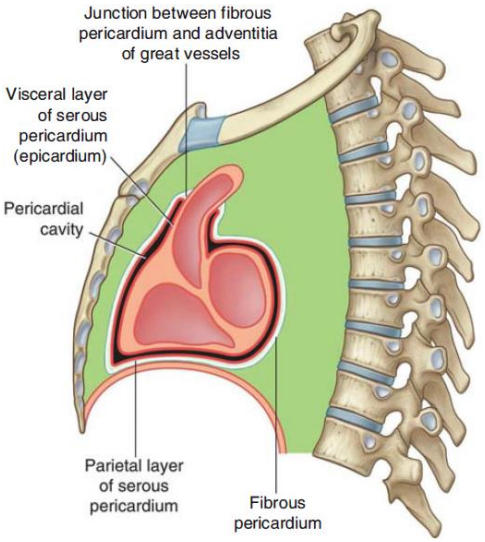


❖ The serous pericardium is inside the fibrous pericardium and consists of two parts:

- The **parietal layer** of serous pericardium and it lines the inner surface of the fibrous pericardium.
- The **visceral layer** (**epicardium**) of serous pericardium and it adheres to the heart and forms its outer covering.

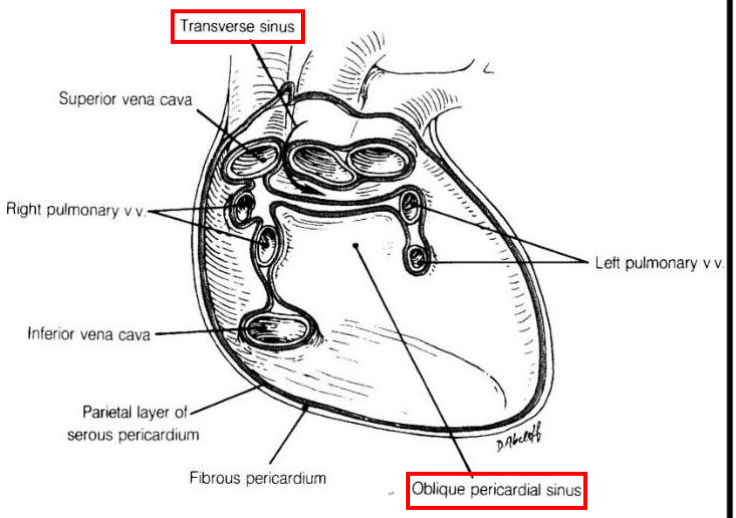
- The **fibrous pericardium** and the **parietal layer** of serous pericardium are both pain sensitive, supplied by the phrenic nerve. On the other hand, the **visceral layer** is supplied by autonomic nerves, and is not pain sensitive.
  - Therefore, an infection in the fibrous pericardium and the parietal layer (pain sensitive area) will result in pericarditis, represented by a retro-sternal pain.
  - Between the parietal and visceral layer of serous we find the pericardial cavity which contains minimal amounts of serous fluid. As a result of pericarditis, this fluid could increase in volume causing **pericarditis with effusion**. Any further increase in fluid volume will obstruct normal ventricular function and the heart will fail. This phenomona is called **cardiac temponade**.
  - Now how much fluid will cause cardiac temponade?
    It's variable, and it depends on the rate of accumulation not the vloume. For example: if the fluid accumulated within hours/days, cardiac temponade will occur. But if it takes longer than that (months) cardiac temponade will not occur even if the volume reaches 200ml.

- Unlike the heart (as we'll discuss later), the pericardium has its **apex** pointed upwards and it fuses with the roots of the aorta and the pulmonary trunk, and its **base** pointed downwards and it fuses with the diaphragm. As shown in the figure to the right.
- The pericardium also connects with the back of the sternum **anteriorly** by sternopericardial ligaments.
- **Posteriorly**, we find the descending aorta and the esophagus.



- Contents of the pericardium:
  - The four chambers of the heart.
  - The ascending aorta and the pulmonary trunk.
  - Lower half of superior vena cava.
  - Terminal parts of inferior vena cava and pulmonary veins.
  - Transverse and oblique sinuses.

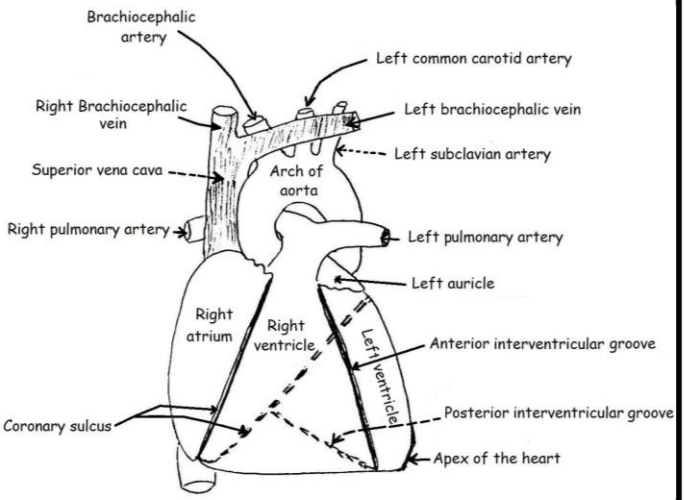
- The **transverse sinus** is located posterior to the major arteries (aorta and pulmonary), and anterior to the superior vena cava. Surgeons use it to ligate the vessels during surgeries.
- The **oblique sinus** is found between the <u>left atrium and the pericardium</u> and has no clinical importance.
- The left atrium is located between the two sinuses.



- The **ascending aorta** and the **pulmonary trunk** are covered by the same layer of serous pericardium, which points out that in fetal life those two arteries were a single artery called **truncus arteriosus**.
- The **superior** and **inferior** venae cavae and the four **pulmonary veins** are also surrounded by one serous layer. Why?
  - Because the heart looked like a tube in the fetus, and at a certain point it folded on itself forming a U-shaped tube that has an **arterial end**, which represents the <u>aorta and the pulmonary trunk</u>, and a **venous end** that represents the <u>superior and inferior venae cavae and the pulmonary veins</u>.
  - Between the two ends, a mesentery was attached. During the development of the fetus, the mesentery disappeared leaving a space, which later became the **transverse sinus**. Another space appeared, posterior to the venous end, and later became the **oblique sinus**.

Anatomy of the heart:

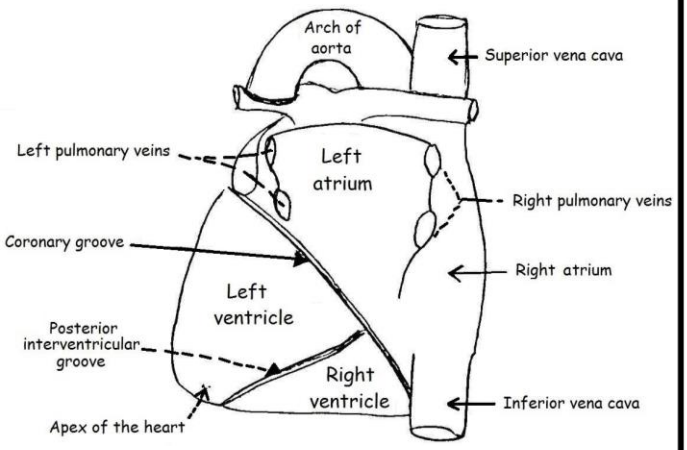
- Borders of the heart:
  - **Right border:** formed by the right atrium.
  - **Left border:** oblique, formed by the left ventricle and the auricle of the left atrium.
  - **Upper border:** slightly oblique and formed by the two atria, chiefly the left atrium.
  - **Inferior border:** formed by the right ventricle.



Anterior view of the heart

❖ Surfaces of the heart:

- **Anterior surface (sternocostal):** formed mostly by the right ventricle, 2/3 of the right atrium and some of the left ventricle.
- **Posterior surface (base):** formed mostly by the left atrium and a small portion of the right atrium.
- **Diaphragmatic surface**: formed mostly by the left ventricle and the rest of the right ventricle.



Posterior view of the heart

❖ Above the heart, coming out of the right ventricle is the pulmonary trunk, which passes inferior to the aortic arch, and then divides into a left branch (to the left lung) and a longer right branch (to the right lung).

❖ The ascending aorta comes out of the left ventricle forming the arch. It then gives three branches from anterior to posterior:

- Brachiocephalic artery (divides into right common carotid and right subclavian)
- Left common carotid artery
- Left subclavian artery

❖ The left brachiocephalic vein passes anterior to the branches from right to left, joins the right brachiocephalic vein forming the superior vena cava.

❖ The rotation of the heart "discussed in the embryology lectures" puts **two thirds** of the heart to the left.

Grooves (or sulci) of the heart:

❖ **Atrioventricular groove** or coronary groove: as it circles the heart it separates the atria from the ventricles (anteriorly and posteriorly). It contains the trunks of the coronary arteries, the coronary sinus, which collects blood from the heart, and the small cardiac vein.

❖ The **anterior** and **the posterior interventricular groove:** separate the two ventricles.

- The anterior groove is on the anterior surface and contains the anterior interventricular artery (left anterior descending "LAD") a branch from the left coronary. In addition to the great cardiac vein.
- The posterior groove is on the diaphragmatic surface and contains the posterior interventricular artery, a branch from the right coronary. And it also contains the middle cardiac vein.

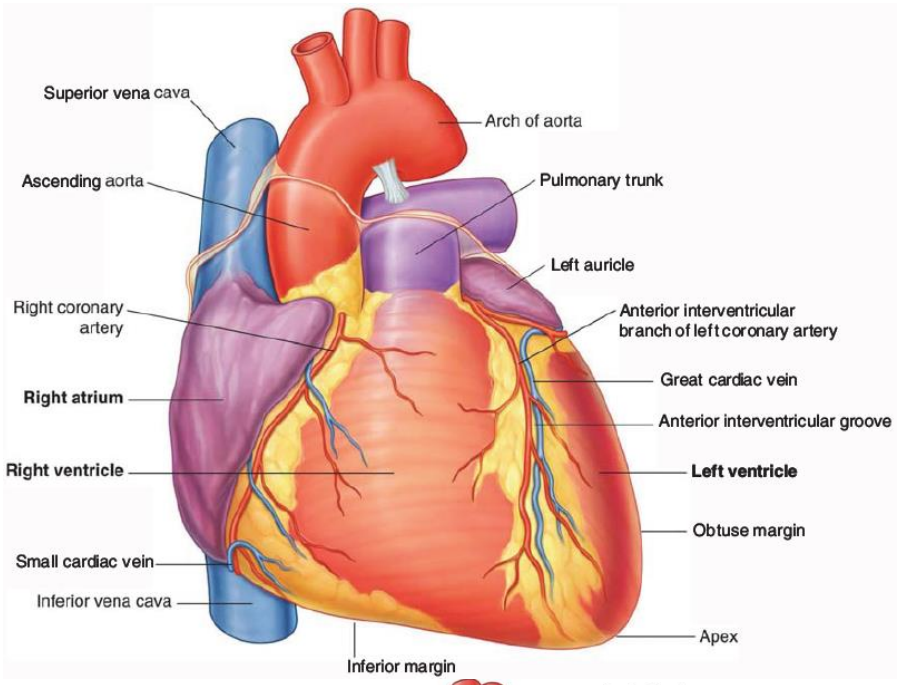
❖ **Interatrial groove**: It has no importance.

The apex:

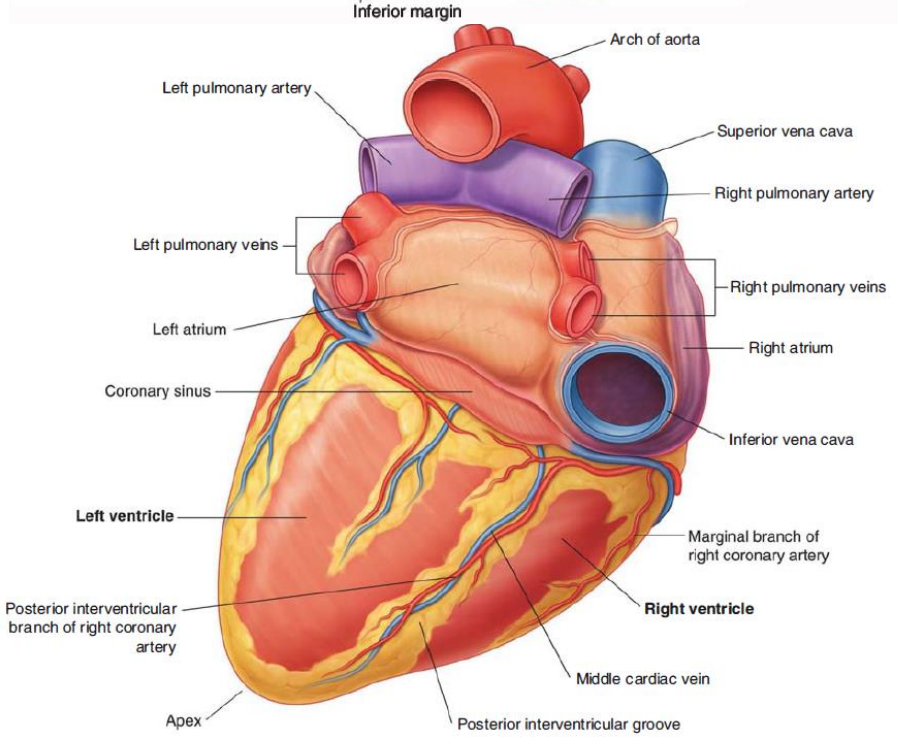
- Formed by the left ventricle.
- It's directed downward, forward into the left, 9cm away from the midline (3 In).
- Present in the left 5th intercostal space.
- Although it is covered by the anterior border of the left lung, we can still feel the so-called apex beat (the heartbeat against the chest wall).

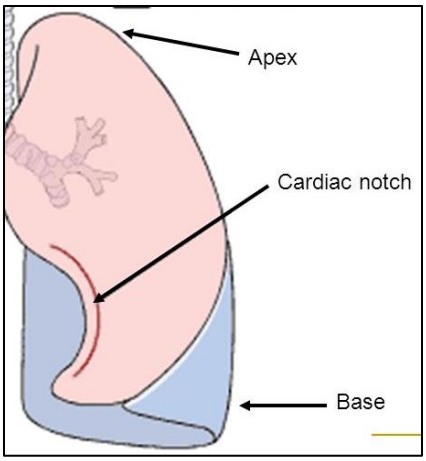
- Now look at these figures for a clearer image:

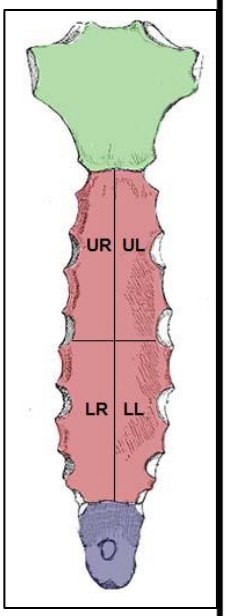
Anterior view of the heart



Posterior view of the heart







- The pericardium lies posterior to the body of the sternum, covered by lung tissue, except the lower left quadrant (LL).

- So, if you tap on one of the other three quadrants you'll hear **reasonance** sound, because they lie anterior to the lung which is basically air. And if you tap on the lower left quadrant, you'll hear **dullness** sound, because it lies anterior to the pericardium. We call this quadrant **area of superfacial cardiac dullness.**

- If we look at the anterior border of the left lung, there's a depression called cardic notch, and that explains the absence of lung tissue posterior to the lower left quadrant.

Chambers of the heart:

Right atrium:

- Forms the right border of the heart, part of the anterior surface and part of the base. It receives blood from all over the body except the lungs, through **superior and inferior venae cavae**. It also receives blood from the heart itself through the **coronary sinus**.

- Normally, the blood flows to the right atrium, it increases in pressure, creating a pressure diffrence between the atrium and the ventricle opening the tricuspid valve (some books refer to it as the filling pressure of the right ventricle).

- If a patient presents to you with a low blood pressure (70/50 for example), it could be due to **blood loss**. Because if we lose blood, less blood will flow back to the right atrium, and less blood means less vloume and therefore less pressure.
  In this case (hypovolemia), the patient should be given fluids to restore normal pressure.

- If the patient did not lose blood, it could be **cardiomyopathy** or **infarction**, and both weaken the pumping action of the heart. In this case, if you give the patient fluids, you will end his life. Because you will increase the burden on a heart that is already failing. Instead, the patient should be given a drug that improves the cardiac muscle action.

- How can we tell?
  We measure the blood pressure inside the right atrium (or the superior vena cava)

- How do we measure the blood pressure inside the right atrium?
  We insert a central venous line (a guide wire) through a needle inside the internal jugular vein (usually), the line will reach the brachiocephalic vein, and through the superior vena cava to the right atrium, and then a device will measure the blood pressure. We call this procedure **central venous access**. It's only done if the patient is in danger.

  - For example: a 70 year old male with a low blood pressure, denying any blood loss (But it might be an **internal bleeding**, he might have lost a liter in his stomach due to peptic ulcer).

  - Normally, the blood pressure inside the right atrium equals zero (atmospheric). If it's lower than normal, it must be blood loss. If it's higher, that indicates an increase in blood volume.

  - Why would the volume increase in the right atrium?
    Because the right ventricle is failing to pump the blood. So the blood will accumulate in the right atrium.

  - Note: blood pressure and right atrial pressure are two different things. Blood pressure is normally 120/80 while right atrial pressure is zero. A high atrial pressure indicates a failing heart and thus low blood pressure.

<u>Inside the right atrium</u>:

- We see two parts devided by a muscular projection called **crista terminalis** which appears as a groove on the **external** aspect of the right atrium, called sulcus terminalis.

- The anterior part is rough walled and has **pectinate muscles**. The posterior part is smooth walled and has the opening of the superior and inferior venae cavae in addition to the opening of the coronary sinus and the venae cordis minimae (small veins open directly in the atrial wall)

- At the upper end of crista terminalis near the opening of superior vena cava, we find the **SA node** (pacemaker of the heart).

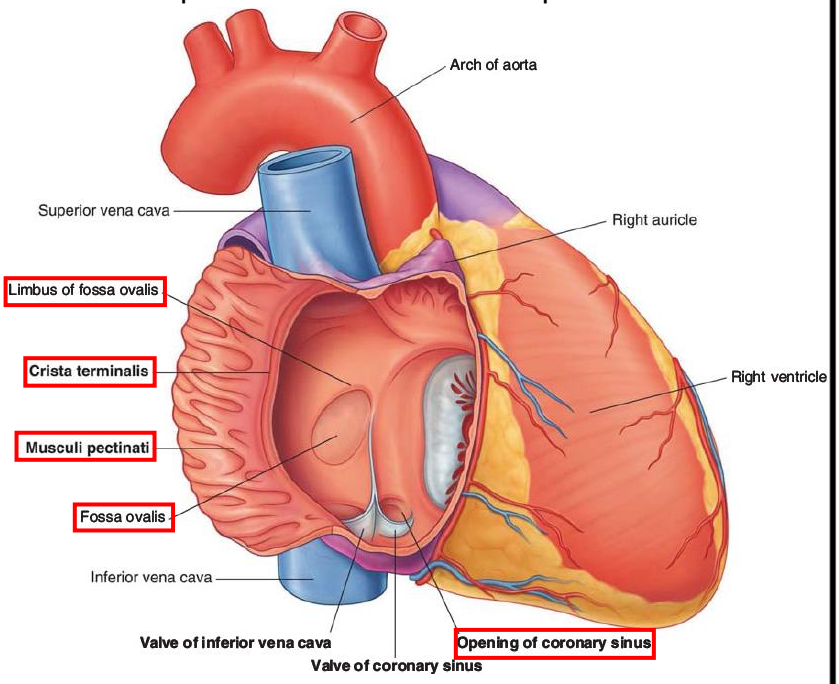
- The posterior wall is the **interatrial septum**. So, <u>the left atrium is, to a great extent, posterior to the right</u>.

- In the fetal heart, an opening called **foramen ovale**, allows blood to flow from the right to the left atrium. Bypassing the pulmonary circulation. At birth, the foramen closes and forms the **fossa ovalis**.

- The fossa ovalis is a depression in the interatrial septum. It has a floor and a prominent oval margin called **annulus ovalis** or **limbus fossae ovalis**.

- In the embryo, the **inferior vena cava** and the **right atrium** are separated by the valve of the inferior vena cava (also known as the Eustachian valve). This valve helps direct the flow of blood from the right atrium into the left atrium and away from the right ventricle.

- In the adult this valve typically has totally **regressed** or remains as a small fold of endocardium.



Right ventricle:

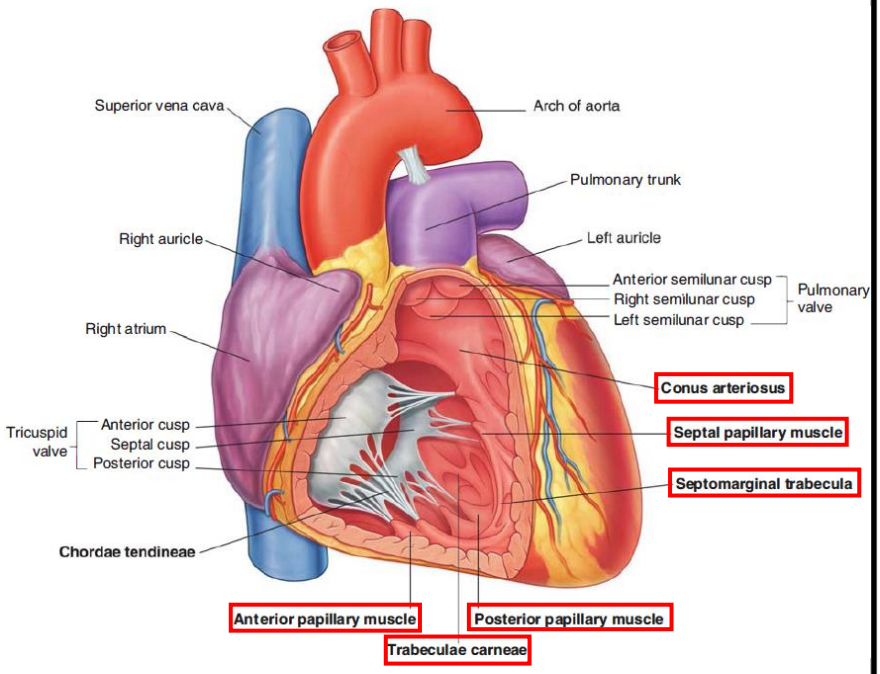
- Forms most of the anterior surface (sternocostal surface) and a small part of the diaphragmatic surface. It also forms the inferior border.

- Blood flows from the right atrium to the right ventricle through the **tricuspid** opening, and it is then pumped to the lungs.

Inside the right ventricle:

- The lower part (near the tricuspid opening) is called trabeculated part. It is rough walled, and has irregular muscular structures called **trabeculae carnae**. Most of these are either attached to the ventricular wall throughout their length forming ridges, or attached at both ends forming bridges.

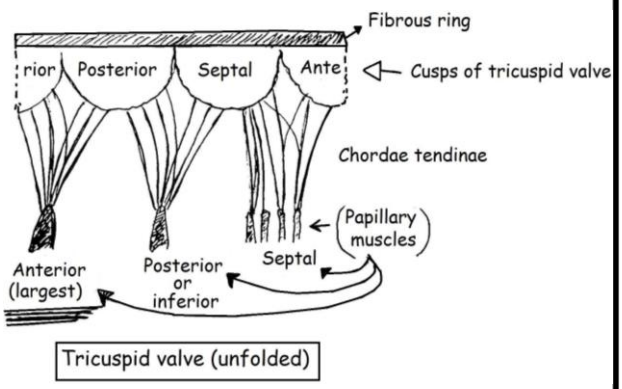
- A few trabeculae carnae (**papillary muscles**) have only one end attached to the ventricular surface, while the other end is attached to the **tricuspid valve** via the **cordae tendineae**.



- The upper part (near the pulmonary opening) is called the **infundibulum** (Gray's also called it "conus arteriosus"). It is smooth walled.

- There are three papillary muscles in the right ventricle:
  - Anterior papillary muscle (largest)
  - Posterior papillary muscle
  - Septal papillary muscles (smallest)

- The tricuspid valve has three cusps:
  - Septal cusp between the two ventricles
  - Posterior cusp on the posterior wall
  - Anterior cusp



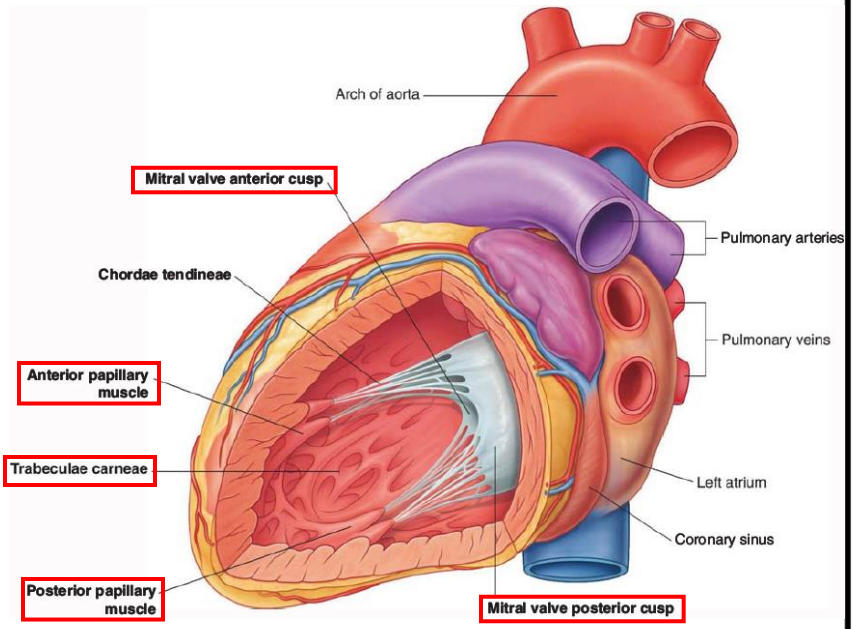
- <u>Each papillary muscle attaches via cordae tendineae to two cusps</u>, to **assure** good closure of the valve.

- Another feature in the right ventricle is the **moderator band** (septomarginal trabecula) which is a muscular band that attaches the interventricular septum to the anterior wall near the anterior papillary muscle.

  - It was believed that this band used to prevent the overextension of the ventricle. But later it was found that its function is to **carry** part of the right branch of the AV bundle, **aiding** in the transmission of action potential.

- The right ventricle is a low-pressure pump. Why?
  Because it pumps against a low resistance, (arterioles in the lungs contain few smooth muscles).

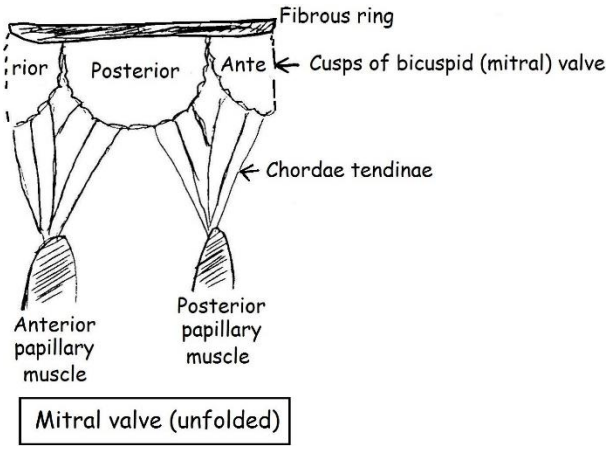
Left ventricle:



- Forms the apex, the left border, a small part of the sternocostal surface and part of the diaphragmatic surface by two thirds.
- It has a **thicker** wall than the right ventricle and it's a high pressure pump, because it pumps the blood against a high resistance.
- Blood flows from the left atrium to the left ventricle through the mitral opening, it is then pumped to all tissues (except the lungs) through the aorta.

Inside the left ventricle:

- We have a **bicuspid valve** (mitral valve) between the left atrium and the left ventricle, and it has two cusps:
  - Anterior cusp near the aortic valve
  - Posterior cusp
- We also have **two** papillary muscles (anterior and posterior), each muscle attaches to the two cusps via the chordae tendineae. There is a third muscle but it's so small.



Mitral valve (unfolded)

- Each muscle is actually a group of smaller papillary muscles, but we refer to each one as a single big muscle.
- Similar to the right ventricle, the **lower part** of the left ventricle is rough walled, also called **trabeculated part**. The upper part is smooth walled but here it's called **aortic vestibule.**
- The anterior cusp of the mitral valve is bigger than the posterior cusp, and it's exposed to **two currents of blood flow**; first one is the blood flowing from the left atrium to the left ventricle. The other one is the blood pumped to the tissues through the aorta. This feature is only found in the anterior cusp of bicuspid.

- The **aortic vestibule** is found near the membranous part of the interventricular septum (thin walled).
    - This **membranous part** is subjected to a defect, either congenitally or by a trauma. If that happens, we call it *ventricular septal defect*.
    - The surgeon should be careful while trying to close the ventricular defect, because he might accidentally hit the AV bundle.

The Sheet is Over