



PHYSIOLOGY

بِسْمِ اللَّهِ الرَّحْمَنِ الرَّحِيمِ



MID | Lecture 1

CVS

Introduction

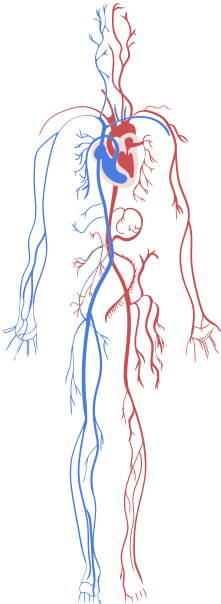
Written by: Laith Alhuniti

Reviewed by: Almothana Khalil



وَلَقَدْ خَلَقْنَا الْإِنْسَانَ وَنَعَلَهُ مَا تَوَسَّوَسُ بِهِ نَفْسُهُ وَنَحْنُ أَقْرَبُ إِلَيْهِ مِنْ جَبَلِ الْوَرِيدِ

اللهم إِنَّا نَعُوذُ بِكَ مِنْ شَرِّهِ وَأَنْفُسِنَا وَمِنْ سَيِّئَاتِ أَعْمَالِنَا



Cardiovascular System-1

Faisal I. Mohammed, MD, PhD

General information – 1

- The cardiovascular system is composed of two main components: the cardiac part (the heart) and the vascular part (the blood vessels). It is one of the earliest systems to develop during embryonic life.
- By around the fourth week of gestation, the embryonic heart begins to beat, and this heartbeat can sometimes be detected shortly afterward. The early development of the cardiovascular system reflects its vital role in delivering oxygen and nutrients to the rapidly growing tissues of the embryo.

General information - 2

- In any emergency, such as a car accident, the priority is to assess the patient's vital signs – particularly heartbeat, blood pressure, and respiration. Evaluating the cardiac and respiratory functions is essential for determining if the person is alive and stable.
- This is the basis of CPR (CardioPulmonary Resuscitation), a life-saving procedure that supports both the heart and lungs when they stop functioning. Therefore, a solid understanding of the cardiovascular system is crucial for every healthcare professional.

Clinical Problem

This is an introductory case; details are probably not for CVS physiology exam purposes. Feel free to click [here](#) to watch Dr. Faisal's explanation.

A 54 years old man seen in the cardiology clinic complaining of **severe weakness, fatigue, dry cough, weight gain and difficulty in breathing**. He feels **severe shortness of breath while walking up stairs** of his second floor apartment. He still complains of lesser severity of symptoms at rest. He states he often **awakens at night feeling like he was suffocating**. He is now sleeping with **three pillows under his head**. Lately he has taken to fall asleep while he is sitting watching T.V. He also complains of having to **urinate 3-4 times per night**. He was hospitalized with heart problem two months ago and was told that the **efficiency of his heart is less than 30%** and he **needs ??** and has to **wait until??**. On examination his weight is 95Kg, height is 165 cm, blood pressure was 140/85 mmHg, his heart rate 90 beats/min and regular, his resp. rate is 28/min and labored.

Auscultation of the heart reveals abnormal heart sounds

Objectives:

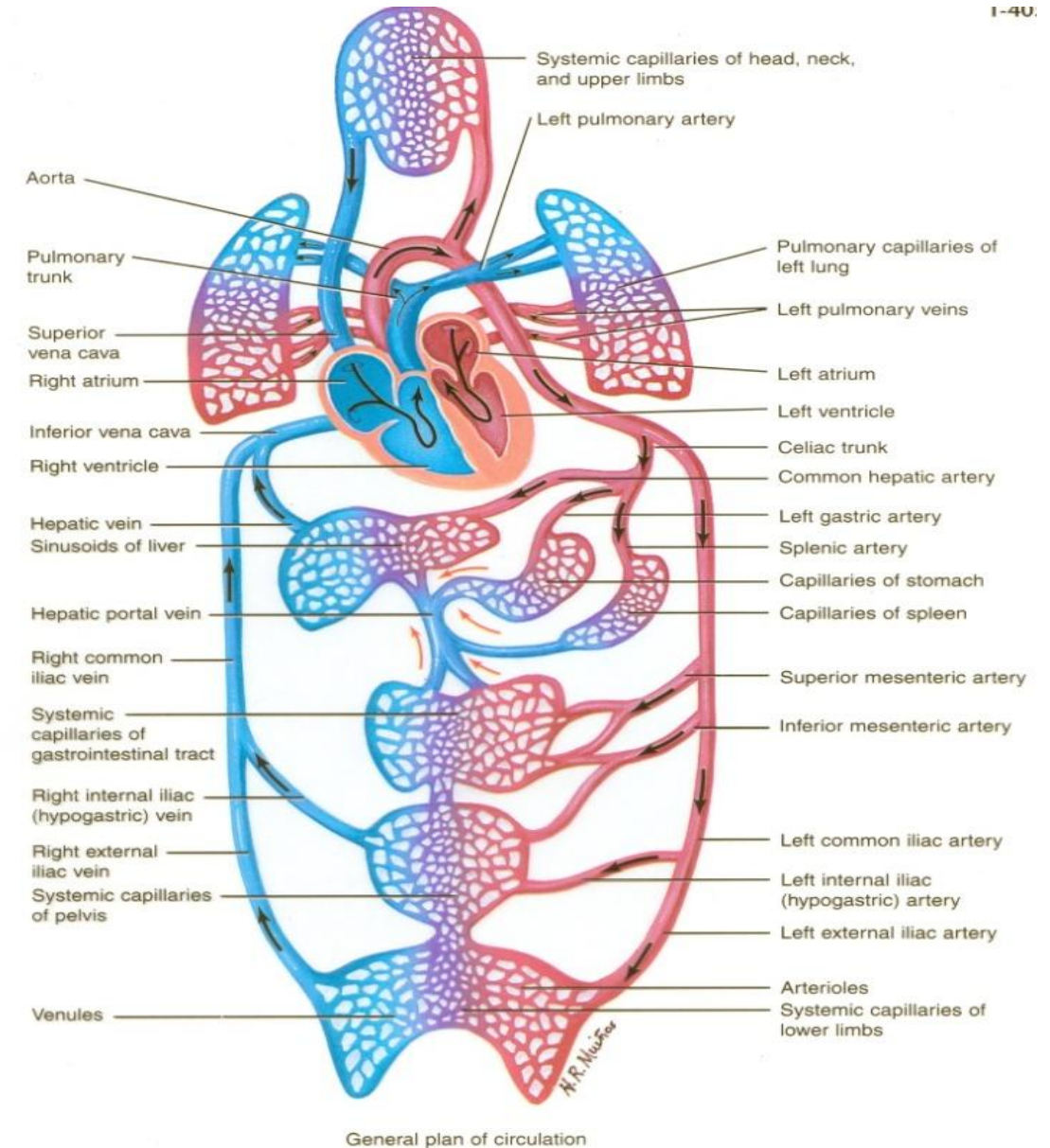
- Introduction to the CVS physiology
- Review the anatomy of the CVS.
- List the functions of the CVS
- Comprehend the pump nature of the heart

Cardiovascular System Anatomy

The vascular system includes arteries and veins:

- An artery is defined as a vessel that carries blood away from the heart, regardless of whether the blood is oxygenated or deoxygenated.
- A vein is a vessel that returns blood to the heart, again regardless of its oxygen content.

Mainly arteries carry oxygenated blood, and veins carry deoxygenated blood, however the pulmonary vessels (arteries and veins) are the major exception where the opposite occurs. This is because the lungs are responsible to provide for the oxygen carried in the blood.



History of cardiac Transplant

HISTORICAL DETAILS ARE NOT
INCLUDED FOR THE EXAM;
KNOW THE CONCEPTS

- **In 1967**, Christiaan Barnard in Cape Town, South Africa transplanted the first Human Heart removed from a 25-year-old woman who had died following an auto accident and placed it in the chest of Louis Washkansky, a 55-year-old man dying of heart damage. The patient survived for 18 days. The problem was Rejection- Cyclosporine –immunosuppressant -decreased that.
 - In the early attempts at heart transplantation, many patients experienced organ rejection because effective immunosuppressive drugs were not yet available.
 - One of the most important immunosuppressants used today is cyclosporine, which was not discovered or used at the time of the first transplants.
 - As a result, the transplanted organs were rejected by the recipient's immune system, leading to the patient's death.

History of cardiac Transplant

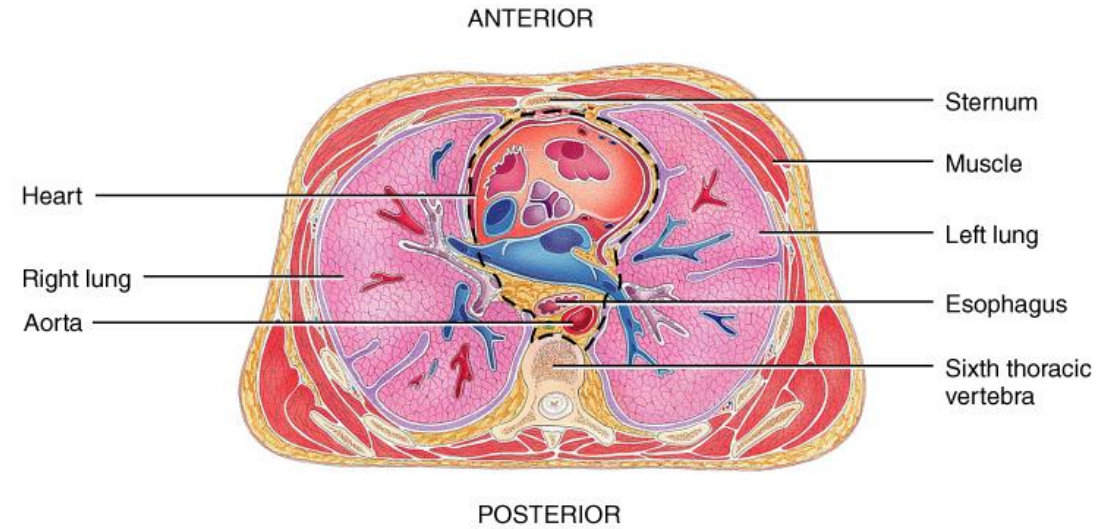
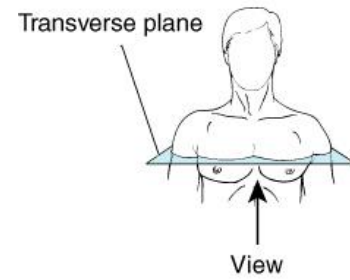
HISTORICAL DETAILS ARE NOT
INCLUDED FOR THE EXAM;
KNOW THE CONCEPTS

- **In 1984, the world's first successful pediatric heart transplant** was performed at Columbia on a four-year-old boy. He received a second transplant in 1989 and continues to live a productive life today.
- **In 1984**, in Linda Loma, California, Leonard Bailey, implanted a baboon heart into a 12-day-old girl, she survived for twenty days.

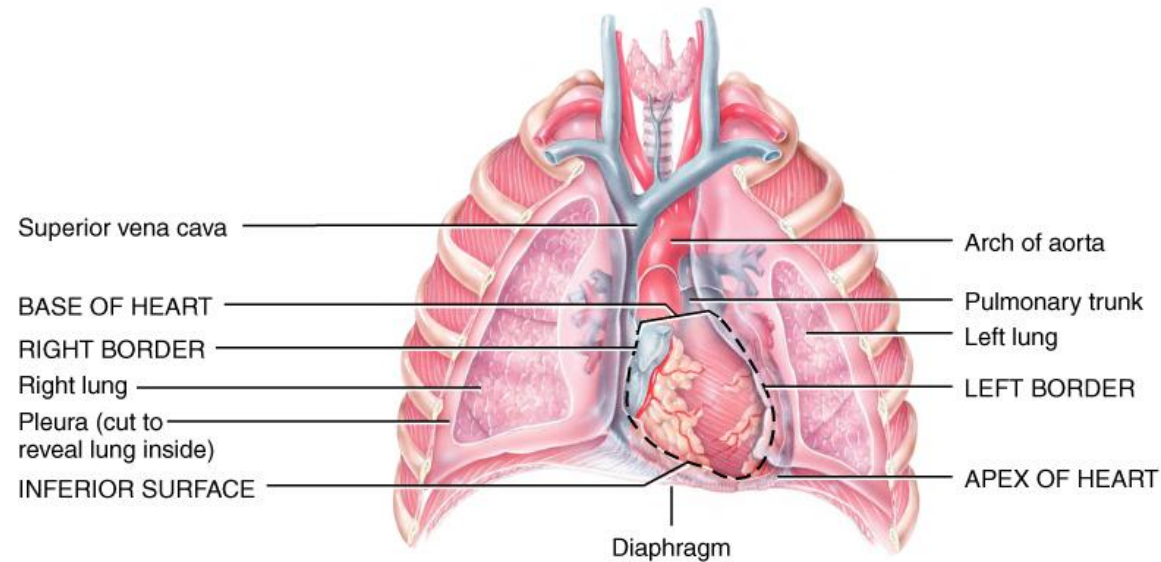
Also, there was rejection here.

- **In 1982** in University of Utah, the first Total Artificial Heart was implanted in the chest a dentist Barney Clark by William DeVries. Clark survived for 112 days-The problem was blood clotting.

Blood clotting occurred because of the presence foreign body (intrinsic pathway).



(a) Inferior view of transverse section of thoracic cavity showing the heart in the mediastinum



(b) Anterior view of the heart in the mediastinum

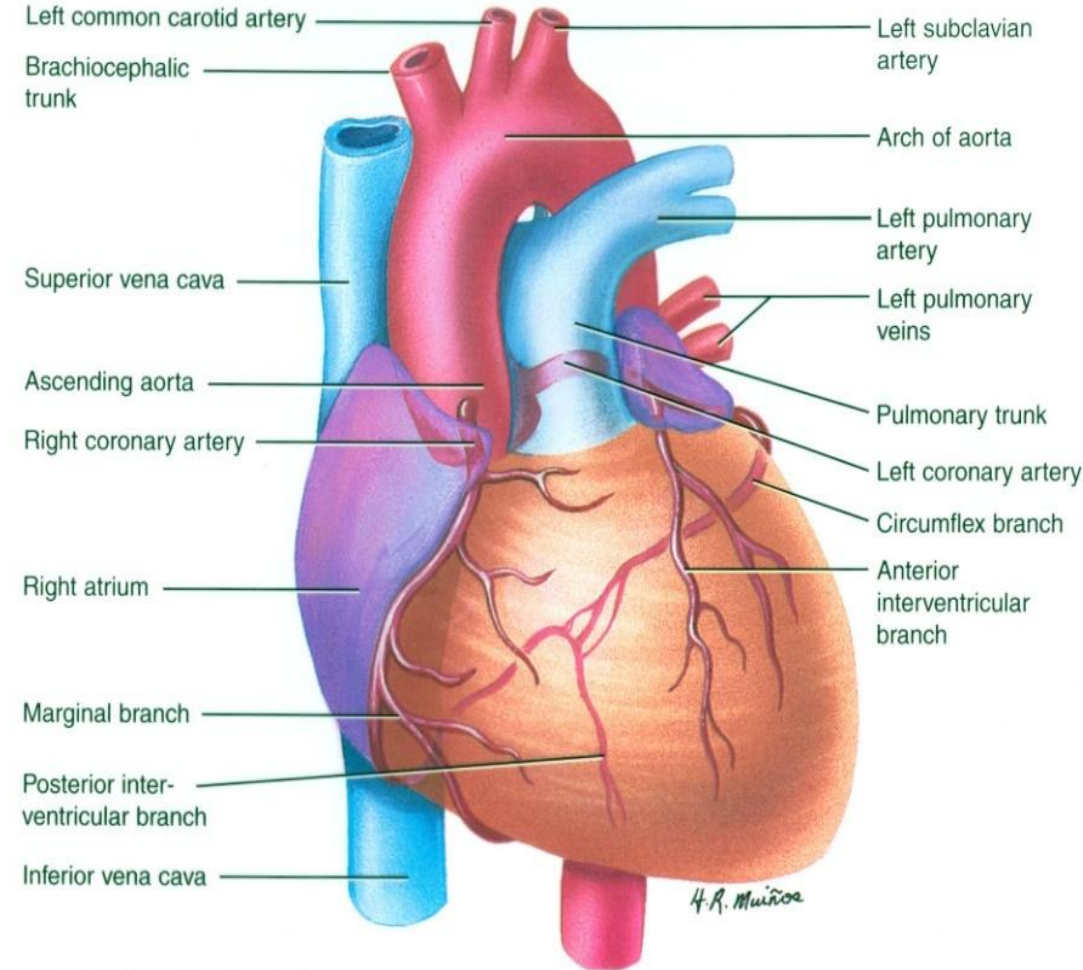
Anatomy of the heart

In the anterior view of the heart, the central and most prominent structure is the muscular part of the heart (the myocardium, covered by pericardium).

Surrounding it are the **major blood vessels** connected to the heart:

- **Superior vena cava (SVC):** returns deoxygenated blood from the upper part of the body to the right atrium.
- **Inferior vena cava (IVC):** returns deoxygenated blood from the lower part of the body to the right atrium.
- **Aortic arch:** curves from anterior to posterior and gives rise to three main branches:
 1. Brachiocephalic trunk, which divides into the right subclavian artery (supplying the right upper limb) and the right common carotid artery (supplying the right side of the head and neck).
 2. Left common carotid artery, which supplies the head and brain.
 3. Left subclavian artery, which supplies the left upper limb.

The aorta then continues downward as the descending thoracic aorta, and after passing through the diaphragm, it becomes the descending abdominal aorta.



The heart receives its own blood supply through the coronary circulation.

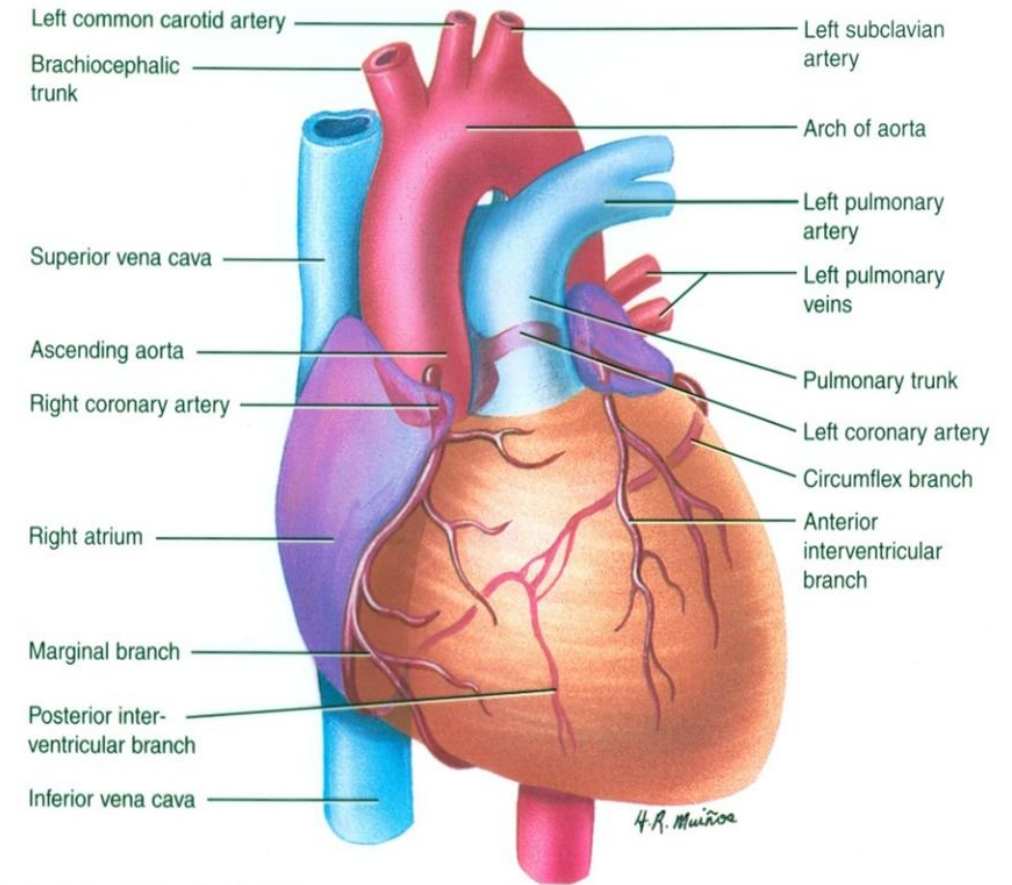
There are two main coronary arteries:

- The right coronary artery
- The left coronary artery

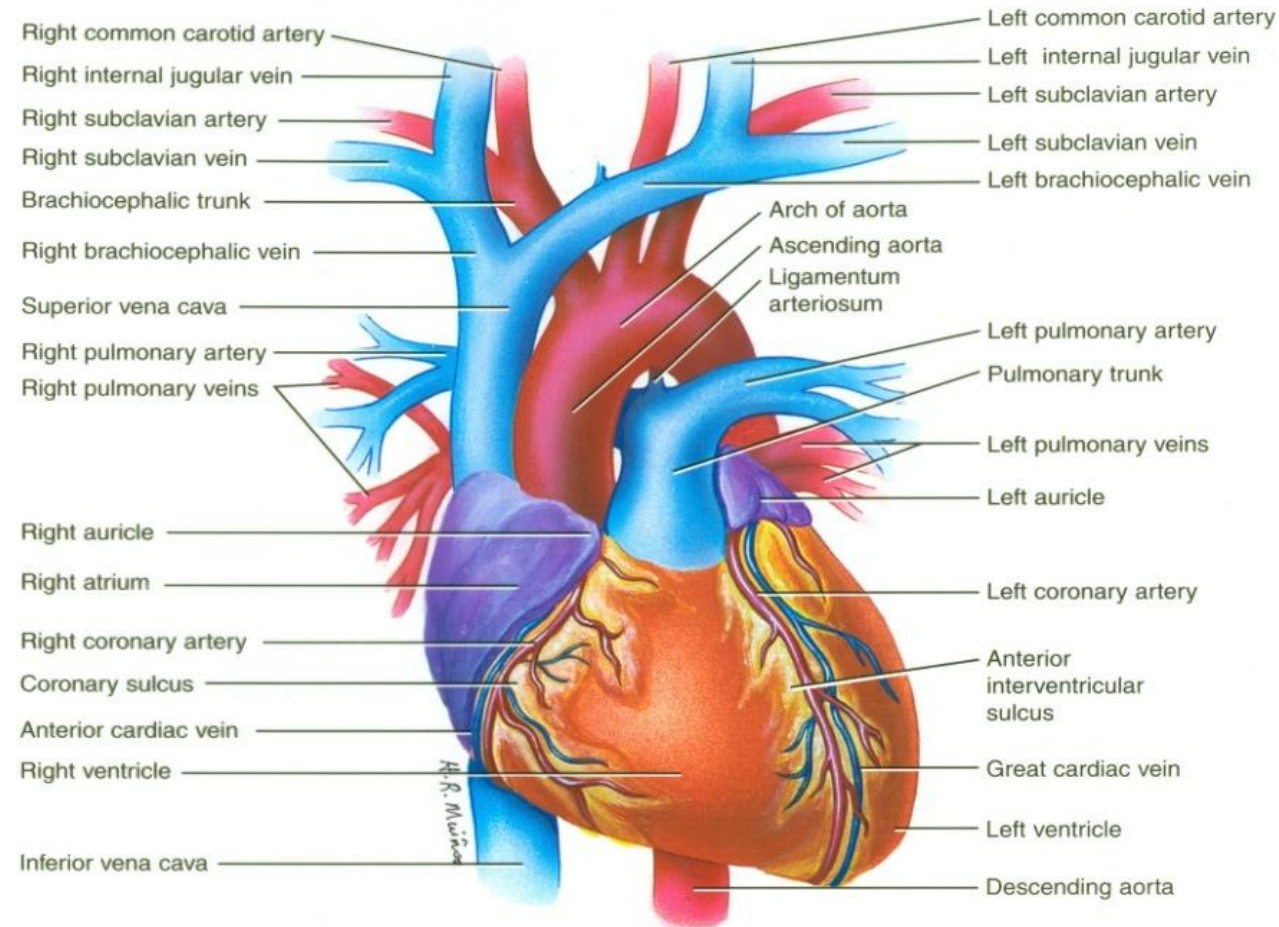
If one of these arteries becomes **partially blocked**, the blood flow to the heart muscle decreases – a condition known as **angina pectoris**, which is caused by ischemia due to the compromised blood flow and oxygen content.

If the artery becomes **completely blocked**, there is total cessation of blood flow, leading to **myocardial infarction (MI)**, which causes irreversible damage.

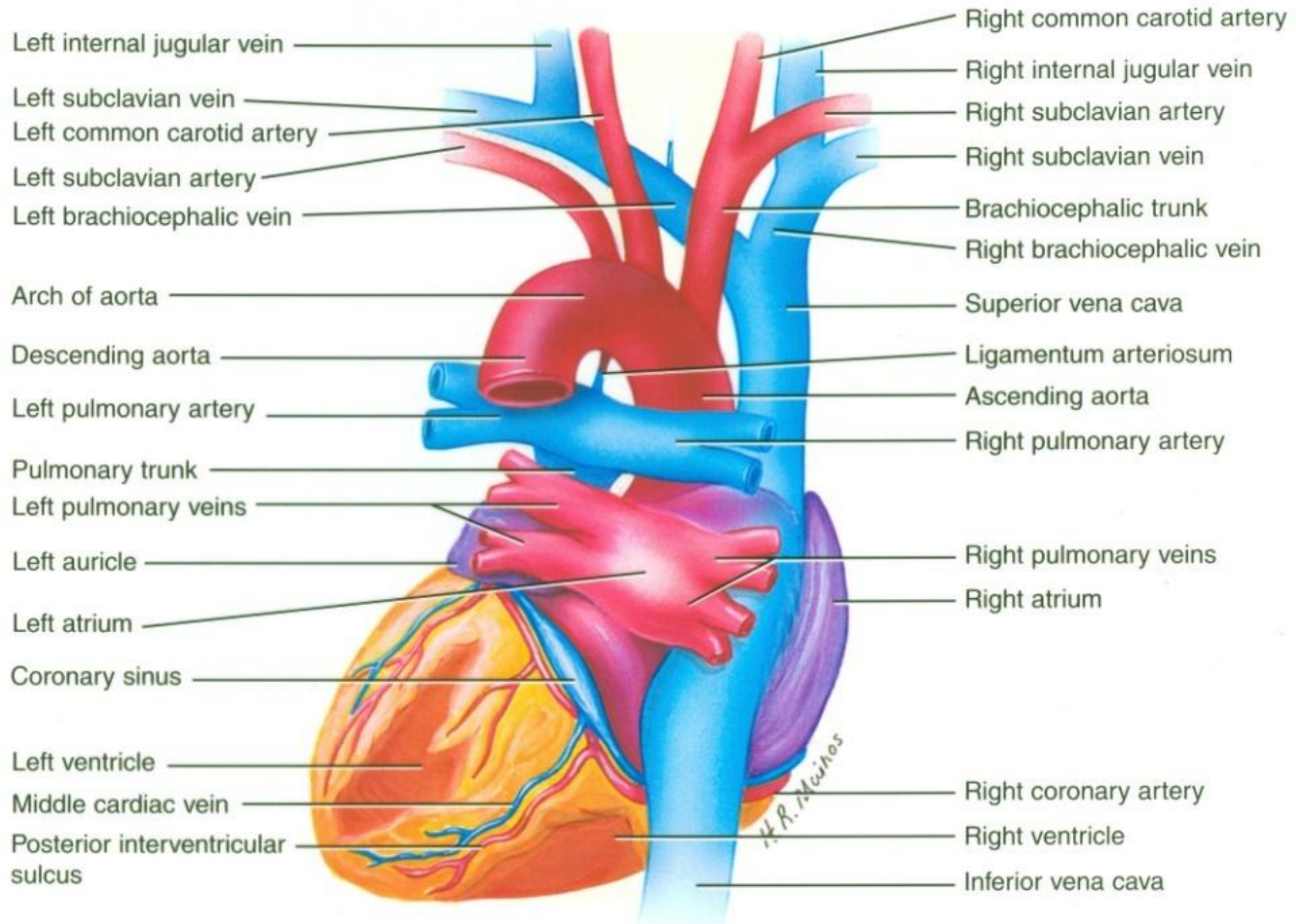
Angina pectoris is usually defined as >70% decrease in blood flow, causing reversible ischemia.



Anatomy of the heart



Anterior External View of Structure of Heart, Fig# 20.4a



Posterior External View of Structure of Heart, Fig# 20.4c

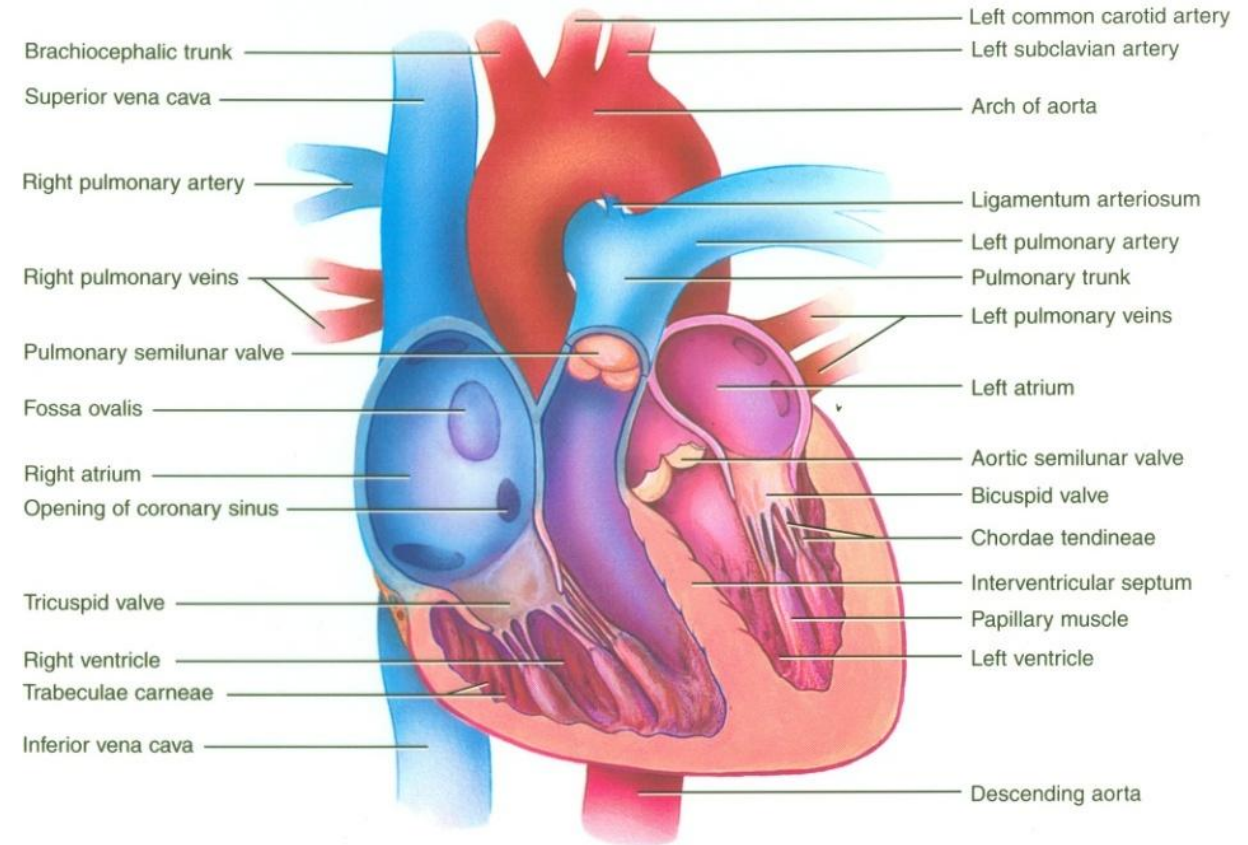
Cardiac Valves

The heart is divided into four chambers – two upper chambers (atria) and two lower chambers (ventricles).

- The atria are separated from each other by the interatrial septum.
- The ventricles are separated by the interventricular septum.

Sometimes, these septal walls are not completely closed, leading to septal defects:

- A defect in the interatrial septum causes an Atrial Septal Defect (ASD).
- A defect in the interventricular septum causes a Ventricular Septal Defect (VSD).



Anterior View of Frontal Section of Structure of Heart, Fig# 20.4d

Cardiac Valves

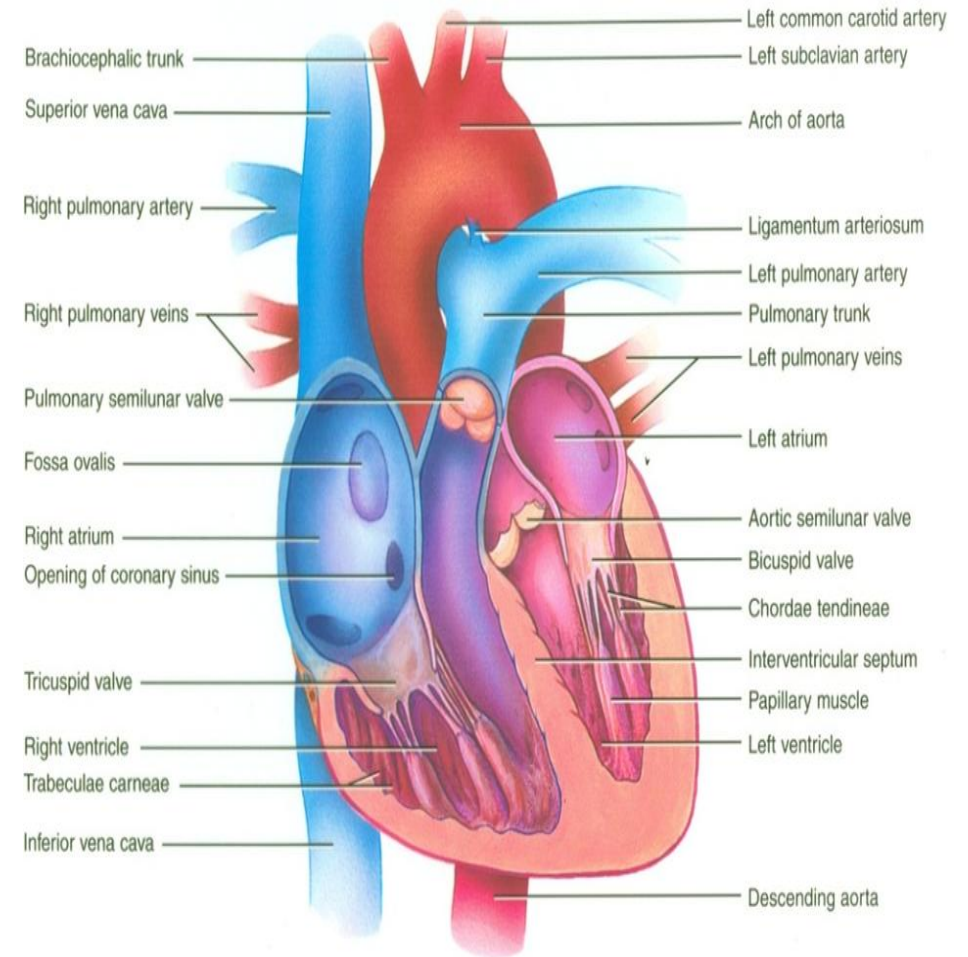
Each atrium is separated from its corresponding ventricle by an atrioventricular (AV) valve.

- Right side: tricuspid valve, which has three cusps.
- Left side: bicuspid (mitral) valve, which has two cusps.

The edges of these valve cusps are attached to tendinous cords known as the **chordae tendineae**, which are anchored to the papillary muscles projecting from the ventricular myocardium.

During ventricular contraction, the papillary muscles contract, tightening the chordae tendineae and **preventing** valve leaflets from **prolapsing** backward into the atria. This maintains the unidirectional blood movement (atrium → ventricle).

In other words, when the pressure inside the ventricle increases, it pushes the valve leaflets toward the atria. However, the papillary muscles and chordae tendineae resist this pressure by holding the valve leaflets in place, preventing them from inverting. If this mechanism fails and the valve leaflets prolapse into the atrium, blood may flow backward into the atrial chamber – a condition known as atrioventricular (AV) valve regurgitation.



Anterior View of Frontal Section of Structure of Heart, Fig# 20.4d

Cardiac Valves

The exit of blood from the ventricles into the arteries is also regulated by valves known as the semilunar valves (due to their cusps' shape):

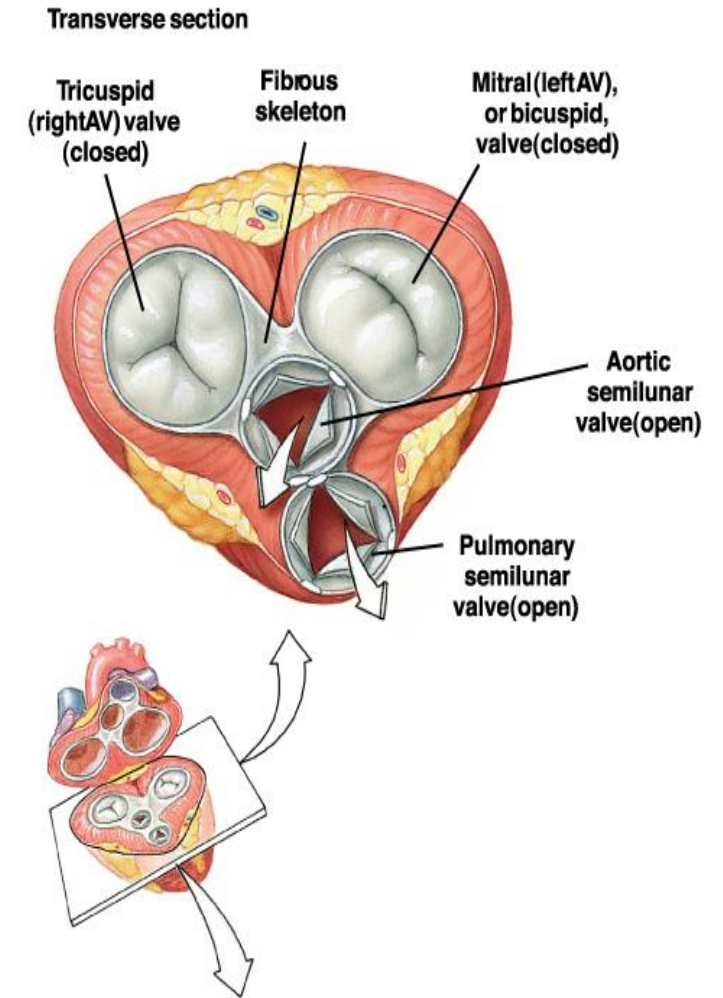
- On the right side, blood flows from the right ventricle into the pulmonary artery, through the pulmonary valve.
- On the left side, blood flows from the left ventricle into the aorta, through the aortic valve.

Mechanism of opening and closing:

- The semilunar valves open when ventricular pressure exceeds arterial pressure (during ventricular systole), allowing blood to flow into the aorta or pulmonary artery.
- The semilunar valves close when arterial pressure exceeds ventricular pressure, preventing the backflow of blood into the ventricles.

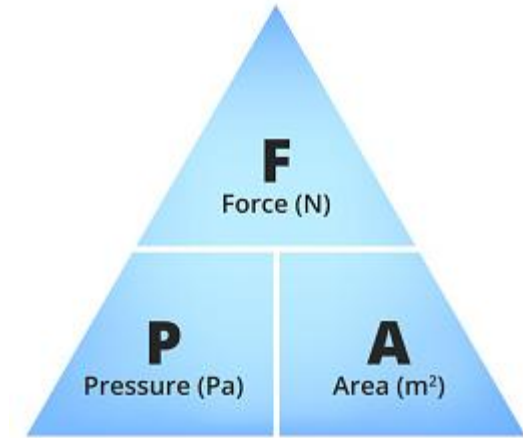
Similarly, the atrioventricular (AV) valves open and close passively based on pressure differences:

- The AV valves open when atrial pressure > ventricular pressure (allowing blood to fill the ventricles).
- The AV valves close when ventricular pressure > atrial pressure (preventing backflow into the atria).



Important Note

- The open/closed state of all 4 cardiac valves solely depends on the pressure gradient across them.
- Chordae tendineae only prevent prolapse and are not mainly involved in opening or closing the valves.
- For example, in the mitral valve, when the left ventricular pressure is higher than left atrial pressure (during systole), the mitral valve closes because the pressure is higher inside the ventricle.
- The force on the valve by the fluid, favors an outward movement from the ventricle, causing the cusps of the mitral valve to close, and causing the cusps of the aortic semilunar valve to open.
- The effect of high ventricular pressure is opposite on both valves because of anatomical restriction, i.e., the shape and direction of the cusps are opposite in relation to the ventricle.

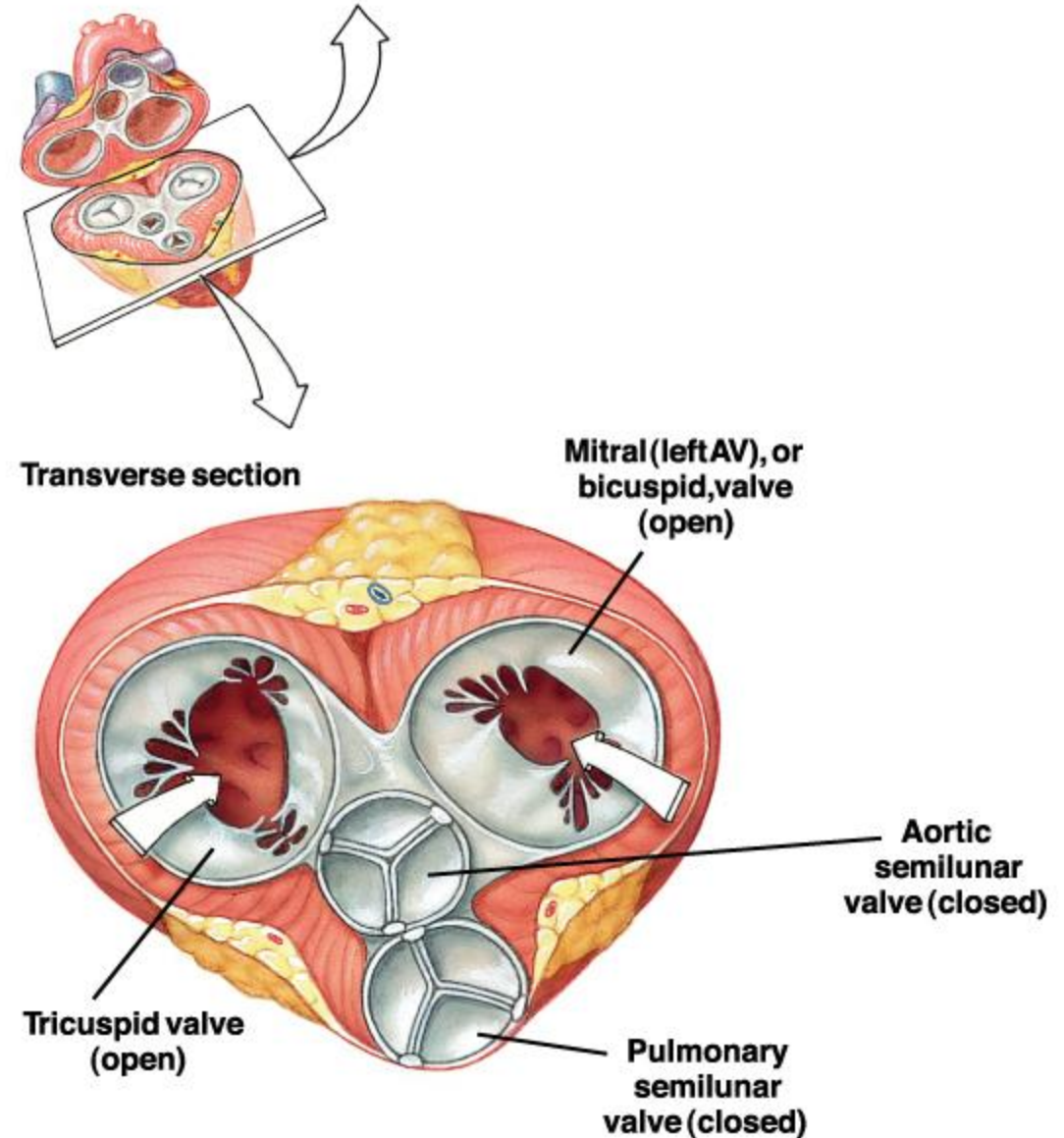


Force (F) =
Blood force
caused by
pressure (P)
of the fluid
itself on the
area (A) of
the cusps.

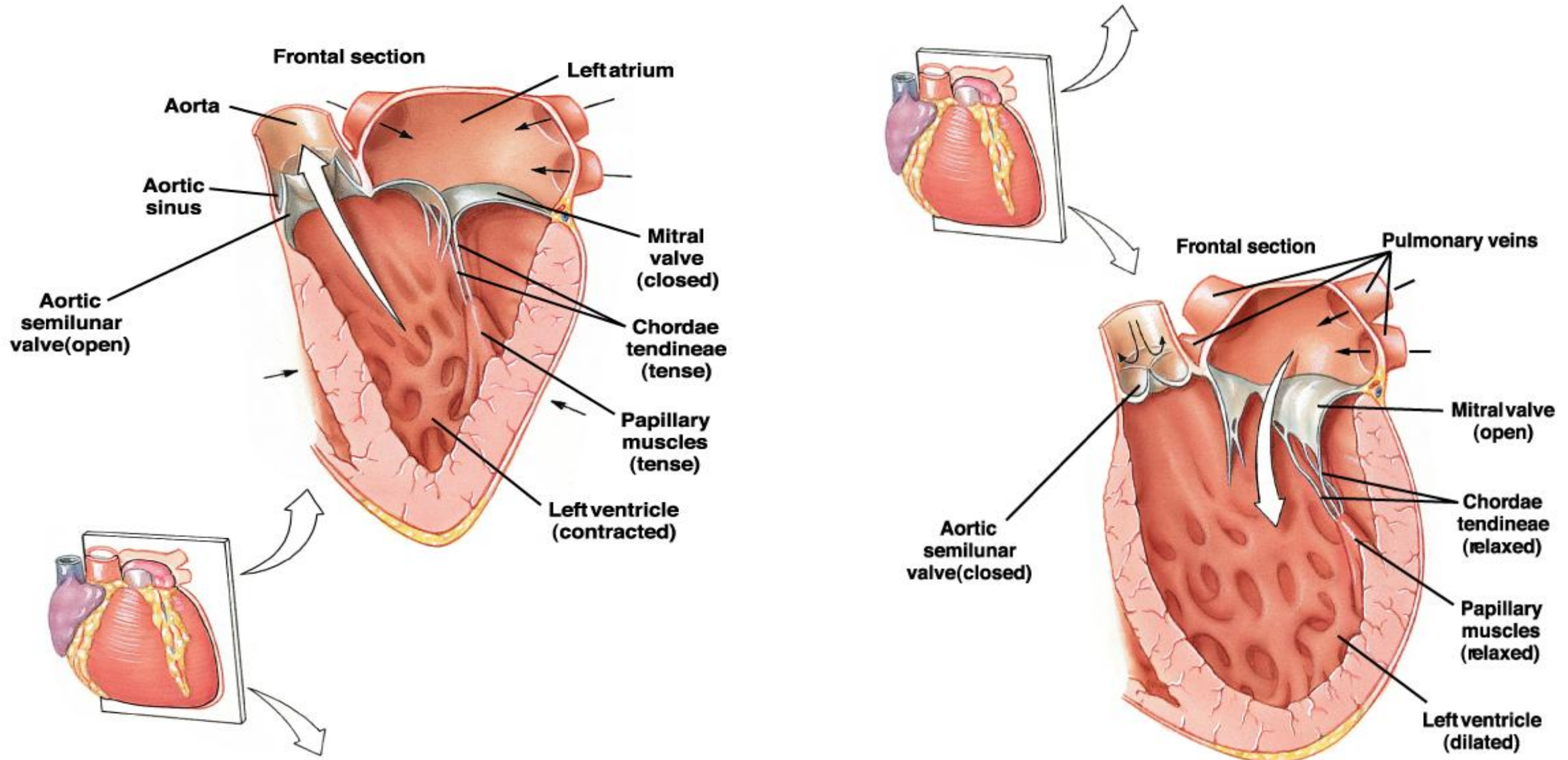
Cardiac Valves Open and Close Passively

Think about it.

Is this picture during
systole or diastole?

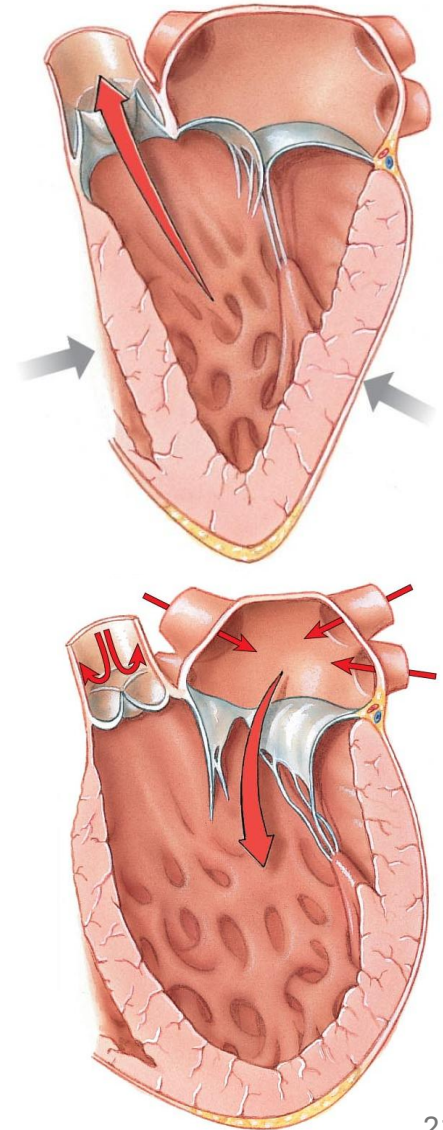


Importance of Chordae Tendineae



Functional Anatomy of the Heart Valves

- Function is to prevent backflow
 - Atrioventricular Valves (**Tricuspid and Mitral**)
 - Prevent backflow to the atria
 - Prolapse is prevented by the chordae tendineae
 - Tensioned by the papillary muscles
 - Semilunar Valves (**Aortic and Pulmonary**)
 - Prevent backflow into ventricles
- Abnormal heart sounds, called murmurs, can indicate valve dysfunction. For example, aortic regurgitation, mitral regurgitation, or other forms of valvular insufficiency.
- Murmurs can occur when blood flows backward through a valve, such as from the ventricle back into the atrium, producing an abnormal turbulent sound.



Movement of blood in the heart

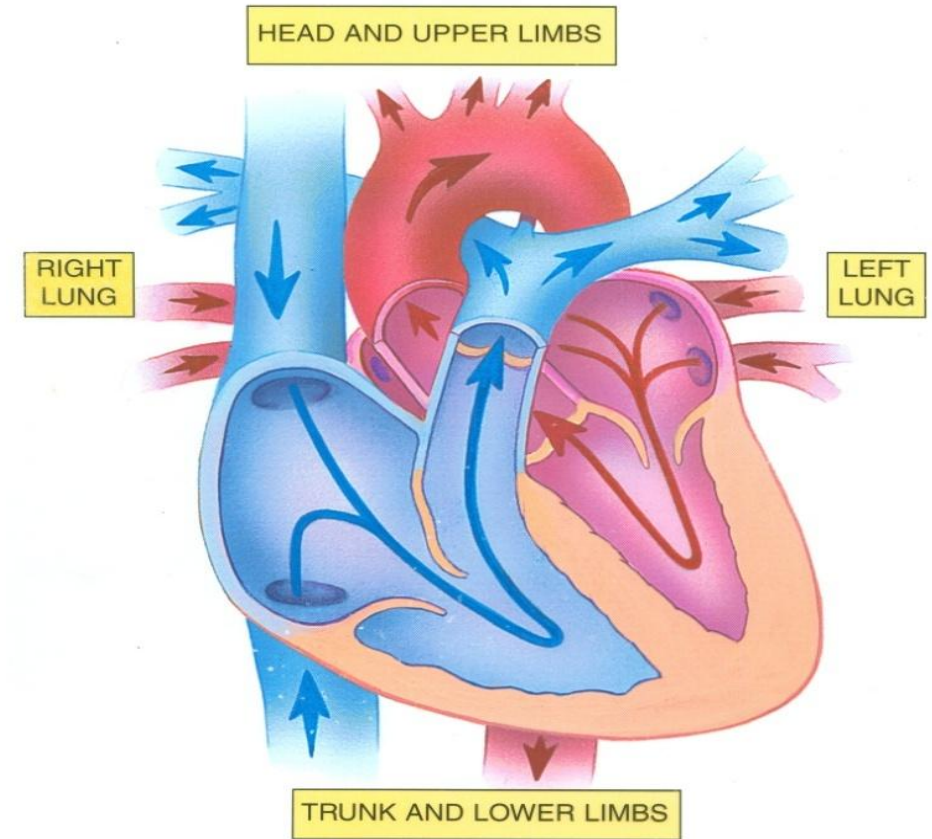
According to the direction of blood flow through the heart:

- Blood enters the right atrium from the superior vena cava (SVC) and inferior vena cava (IVC).
- When the right atrium contracts, blood flows through the tricuspid valve into the right ventricle.
- From the right ventricle, blood is pumped through the pulmonary valve into the pulmonary artery, which carries it to the lungs for oxygenation.

After gas exchange in the lungs, oxygenated blood returns to the left atrium via the pulmonary veins, then passes through the mitral valve into the left ventricle. The left ventricle pumps blood through the aortic valve into the aorta, which distributes it to the rest of the body.

So, the body has two main circulations:

- **Pulmonary circulation** – also called the lesser circulation because it is short and limited to the pathway between the heart and the lungs.
- **Systemic circulation** – also called the greater circulation because it delivers blood to nearly all body tissues.



Blood Flow: Path of Blood Through Heart, Fig# 20.6a



PHYSIOLOGY QUIZ

LECTURE 1

External Resources

رسالة من الفريق العلمي

Additional sources:

1. Guyton and Hall
Textbook of Medical
Physiology, Unit III, Ch9

بِسْمِ اللَّهِ الرَّحْمَنِ الرَّحِيمِ

قَالَ رَبِّ بِمَا أَغْوَيْتَنِي لَأُزَيِّنَنَّ لَهُمْ فِي الْأَرْضِ
وَلَأُغْوِيَنَّهُمْ أَجْمَعِينَ

[الحجر: الآية ٣٩]

أي: أزيّن لهم الدنيا وأدعوهم إلى إثارتها على الأخرى، حتى
يكونوا منقادين لكل معصية.

قال إبليس: رب بسبب ما أغويتني وأضلتني لأحسننّ لذرية
آدم معاصيك في الأرض، ولأضلنهم أجمعين عن طريق
الهدى، إلا عبادك الذين هديتهم فأخلصوا لك العبادة وحدك
دون سائر خلقك.

التفسير الميسر - السعدي

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Corrections from previous versions:

Versions	Slide # and Place of Error	Before Correction	After Correction
V0 → V1			
V1 → V2			