Lecture eight:

Heart physiology

The heart could be called the engine of life. This organ works constantly, never pausing. Composed of a type of muscle found nowhere else in the body.

The heart works as:

1- Pump blood throughout the body, delivering oxygen-rich blood to organs and tissues and

2- Returning oxygen-poor blood to the lungs.

The heart chambers and great vessels:

The heart contains four hollow chambers.

1- The two upper chambers are called atria (singular: atrium).

2- The two lower chambers are called ventricles.

3- Attached to the heart are several large vessels that transport blood to and from the heart. Called great vessels.

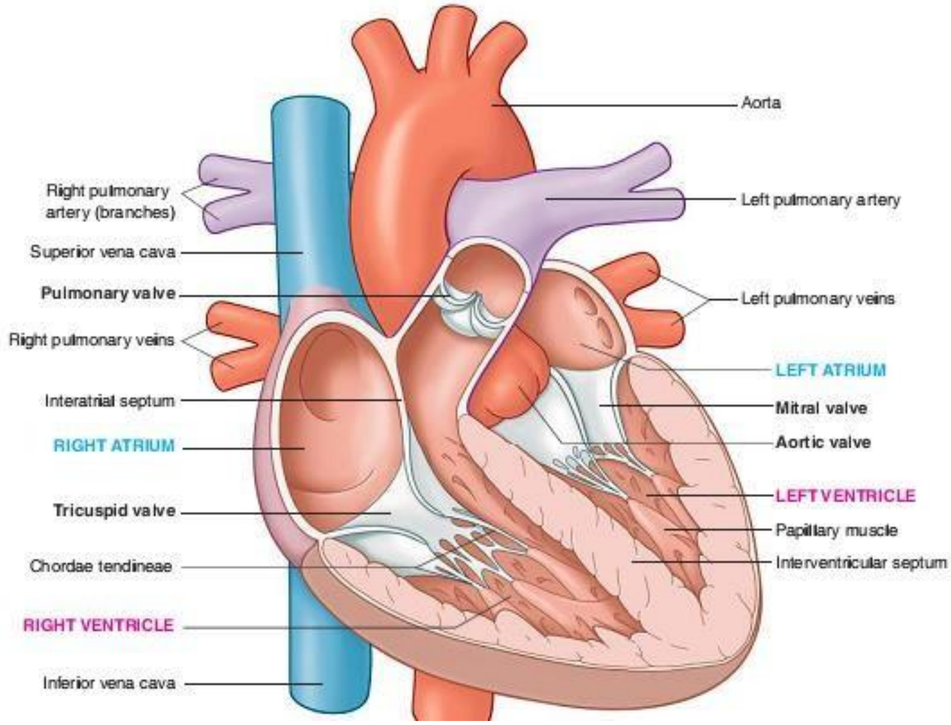
They include the:

A- Superior and inferior vena cava.

B- Pulmonary artery (which branches into a right and left pulmonary artery).

C- Four pulmonary veins (two for each lung).

D- Aorta.



Cardiac Conduction:

Cardiac muscle is unique in that it doesn't depend upon stimulation by extrinsic nerves to contract.

Rather; it contains special pacemaker cells that allow it to contract spontaneously, an ability called automaticity.

Also, because the heart beats regularly, it is said to have **rhythmicity**. (Although extrinsic nerves don't cause the heart to beat,

1- The nervous system.

2- Certain hormones.

Can affect the heart's rate and rhythm.

The electrical impulses generated by the heart follow a very specific route through the Myocardium.

Cardiac Output (CO):

Cardiac output (CO) refers to the amount of blood the heart pumps in 1 minute.

To determine cardiac output multiply the heart rate (HR) the number of times the heart beats in 1 minute by the stroke volume (SV) the amount of blood ejected with each heartbeat.

A typical resting heart rate is 75 beats per minute.

The heart ejects about 70 ml each time it beats. That's its **stroke volume**.

To determine cardiac output, multiply (75 × 70) = 5250 ml, or over 5 liters each minute. That is a typical cardiac put.

Cardiac output **increases with activity**, but the average resting cardiac output is between 5 and 6 liters per minute.

- If an individual's heart has a greater stroke volume (Such as the well-conditioned heart of an athlete), the heart would have to beat fewer times to maintain a cardiac output of 5 liters per minute. This explains why athletes tend to have slower pulse rates. Because cardiac output equals heart rate times stroke volume.
- Body tissues require continuous oxygen delivery which requires the sustained transport of oxygen to the tissues by systemic circulation of oxygenated blood at an adequate pressure from the left ventricle of the heart via the aorta and arteries.
- **Oxygen delivery (DO2 mL/min):** Is the resultant of blood flow (cardiac output CO) times the blood oxygen content (CaO2).

<u>Mathematically this is calculated as follows:</u>

- Oxygen delivery = cardiac output × arterial oxygen content. With a resting cardiac output of 5 L/min, a 'normal' oxygen delivery is around 1 L/min.
- The amount / percentage of the circulated oxygen consumed (VO2) per minute through metabolism varies depending on the activity level but at rest is circa 25% of the DO2.
- Physical exercise requires a higher than resting-level of oxygen consumption to support increased muscle activity.
- In the case of heart failure, actual CO maybe insufficient to support even simple activities of daily living; nor can it increase sufficiently to meet the higher metabolic demands stemming from even moderate exercise.

- Cardiac output is a global blood flow parameter of interest in hemodynamics, the study of the flow of blood.
- The factors affecting stroke volume and heart rate also affect cardiac output.

Heart Rate:

A person's heart rate, or pulse, is the number of times the heart beats each minute.

Newborn infants have heart rates of about 120 beats per minute.

Young adult females tend to have heart rates of 72 to 80 beats per minute;

Young adult males have heart rates of 64 to 72 beats per minute.

A persistent pulse rate slower than 60 beats per minute is called **bradycardia**. Although this commonly occurs during sleep or in athletes. A persistent, resting heart rate greater than 100 beats per minute is called **tachycardia**.

Lecture nine & ten:

BLOOD VESSELS

Arteries:

Arteries are high -pressure vessels that carry oxygenated blood from the Heart to the rest of the body, they have thick walls.

Arterioles:

Control blood flow and distribute blood in to the capillary beds. Their walls are composed primarily of smooth muscle. They are the major sites of controllable resistance in the systemic circulation.

Veins:

Are low-pressure vessels that return blood back to the heart via the Vena cava. They also act as expandable reservoirs. They passively relax or actively constrict under sympathetic adrenergic Stimulation.

Venules:

Are small veins that collect blood from the capillaries.

Physics of blood Flow:

All blood pumped by the **right side** of the heart passes through the pulmonary circulation to the **lungs** for O_2 pickup and CO_2 removal.

The blood pumped by the **left side** of the heart into the **systemic circulation** is distributed in various proportions to the systemic organs through a parallel arrangement of vessels that branch from the aorta (**Figure down**). **This arrangement ensures that all organs receive blood of the same composition**. The blood vessels transport and distribute blood pumped through them by the heart to meet the body's needs for:

1- O_2 and nutrient delivery.

2- Waste removal.

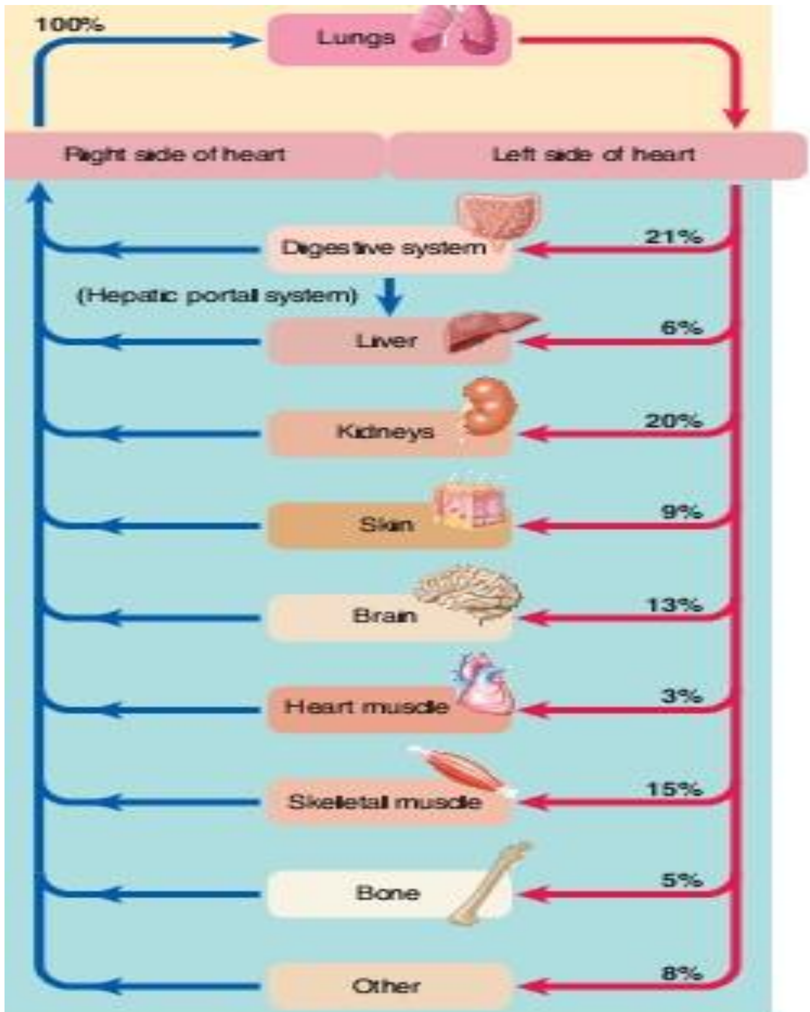
3- Hormonal signaling.

The highly elastic arteries:

A- Transport blood from the heart to the organs.

B- Serve as a pressure reservoir to continue driving blood forward when the heart is relaxing and filling.

The mean arterial blood pressure is closely regulated to ensure adequate blood delivery to the organs.



Distribution of cardiac output (CO) at rest:

Because reconditioning organs (**digestive organs, kidneys and skin**) receive blood flow in excess of their needs, **they can withstand temporary reductions in blood flow** much better than other organs can that do not have this extra margin of blood supply. **The brain in particular suffers irreparable damage when transiently deprived of blood supply**. After only **4 minutes without O_2**, permanent brain damage occurs. Therefore, constant delivery of adequate blood to the brain, which can least tolerate disrupted blood supply, is a high priority in the overall operation of the circulatory system.

Pressure Gradient:

It's the difference in pressure between the beginning and the end of a vessel.

Resistance:

Is a measure of the hindrance or opposition to blood flow through the vessel.

As resistance to flow increases, it is more difficult for blood to pass through the vessel.

Blood resistant:

Standard units of pressure. Blood pressure almost always is **measured in millimeters** of **mercury (mm Hg)** because the mercury manometer has been used as the standard reference for measuring pressure.

B**lood pressure**:

The force exerted by the blood against any unit area of the vessel wall.