CARDIOVASCULAR SYSTEM – THE HEART CIRCULATION

The heart is a reddish brown, hollow muscular organ about the size of one’s fist. It is conical in structure – the upper side is broad and is called base while the lower side is narrow and is called apex.

Location – Is situated between the two lungs in the thoracic cavity, the pointed apex is slightly tilted towards the left lung.

Protection – 1. Bones of the rib cage protect the heart well.

2. Pericardium is a two layered sac that protects the heart. The space between the two membranes is called the pericardial cavity.

3. Pericardial fluid is found in the pericardial cavity. It performs 3 functions
   - Protects the heart from any kind of mechanical injury and shock
   - Acts as a lubricant and reduces friction for the beating of the heart
   - Keeps the tissues of the heart moist
Muscles of the heart

1. Cardiac muscles form the walls of the heart. It is characterized by its ability to contract and relax rhythmically.

2. **Sino Atrial Node (SA node)** also called the **pacemaker** is a specialized region of muscle tissue found in the upper wall of the right atrium. It regulates the contraction of the auricles and stimulates the AV node viz. the heart beat originates in the SA Node.

3. **Atrio Ventricular Node (AVNode)** is present at the bottom of the right auricle/atrium. It receives an impulse from the SA node which regulates the contraction of the ventricles.

4. **Bundle of His** arises from the AV node and consists of a left and right branch which extends up to the apex of the heart. It receives impulse from the AV node and transmits it to the Purkinje Fibres.

5. **Purkinje Fibres** are the branches of the Bundle of His which spread and form a network throughout the walls of the ventricles.

Longitudinal section of the heart
Chambers of the heart

1. **The Atria or the auricles** are the upper or superior chambers of the heart. This chamber is divided into a **left and right auricle** by the **inter auricular septum**. The auricles are thinwalled as they only receive blood brought in by the veins and send it to the ventricles.

2. **The Ventricles** are the lower or inferior chambers of the heart. The **inter ventricular** septum separates it to form the **left and right ventricle**. They are thick walled and the left ventricle has the thickest wall as it has to push blood into the Aorta against the force of gravity with great pressure. The great arteries leave the ventricles to distribute blood to the lungs and the rest of the body.

Apertures and valves of the heart

The opening between the auricle and ventricle on the right side of the heart is the **right atrioventricular aperture** and on the left side is the **left atrioventricular aperture**.

The **valves of the heart** are muscular flaps which maintain a unidirectional flow of blood inside the heart and into the great blood vessels. The opening and closing of the valves is a result of the pressure difference created by the blood on either side of the valves.

The four valves of the heart

The **Cuspid valves or the atrio ventricular valves** – these valves guard the apertures and separate the auricles from the ventricles. They allow the blood to flow from the atria to the ventricles.

1. **The bicuspid valve or the mitral valve** is located at the left AV aperture and allows the blood to flow from the L. auricle to the L. ventricle and prevents it from going back into auricle. It is formed of two valves or cusps.

2. **The tricuspid valve** is located at the AV aperture on the right side of the heart and allows flow of blood from the L. Auricle into the L. ventricle. It is made of three flaps or cusps.

The pointed ends of the cuspid valves are attached to the inner walls of the ventricles which have conical projections called **papillary muscles** by fibrous chord like structures called **chordae tendinae**. Both these special structures keep the valves in position and prevent them from getting upturned.

The **Semi lunar valves** – these are half moon shaped valves or pocket shaped valves located at the origin of the arteries that leave the ventricles. When closed, these valves get filled with blood and prevent its back flow into the ventricles.

3. **Aortic semilunar valve** – three in number, pocket shaped and located at the opening of the aorta present in the left ventricle.
4. **Pulmonary semilunar valve** – three in number, pocket shaped and located at the opening of the pulmonary artery which arises from the right ventricle.

**Blood vessels entering and leaving the heart**

**Blood vessels entering the R. Auricle**

1. **Superior vena cava/anterior vena cava/ precaval** – Large vein that brings back deoxygenated blood from the head, neck, chest and arms (upper parts of the body). It opens in the anterior part of the R. Auricle.

2. **Inferior vena cava/posterior vena cava/ postcaval** – Large vein that brings back deoxygenated blood from the lower or posterior parts of the body viz. the trunk and the legs. It opens at the posterior part of the R. Auricle.

3. **Coronary sinus** - is an opening or aperture through which deoxygenated blood from the walls of the heart (collected by the cardiac veins) drain into the R. Auricle.

**Blood vessels entering the L. Auricle**

1. **Pulmonary veins** - oxygenated blood from the lungs is collected by four pulmonary veins (two from each lung). Each of them open into the L. Auricle by separate apertures.

**Blood vessel leaving the R. ventricle**

1. **Pulmonary trunk** – transports deoxygenated blood to the lungs for oxygenation. As the pulmonary trunk emerges from the heart, it branches into two, the right and left **Pulmonary Artery**, each going to the respective lung on its side.

**Blood vessel leaving the L. ventricle**

1. **Systemic Aorta** – is the largest blood vessel that supplies oxygenated blood to the whole body except the lungs.

As it emerges from the heart it arches to form the **Aortic arch** which gives off branches to the head and neck regions. It then continues down as the **Dorsal Aorta** supplying oxygenated blood to the rest of the body.

**A pair of coronary arteries** arises from the Aortic arch, near its base, as it emerges from the heart. The branches of these arteries supply oxygenated blood to the walls of the heart.
What is a Myocardial infarction?

Blockage of the coronary artery or any of its branches causes deadening of the cardiac muscles of that corresponding area. This leads to a heart attack and is called **myocardial infarction**. The pain in the chest experienced at this time is called **angina pectoris**.

What is coronary thrombosis?

Sometimes a blood clot is formed inside any of the vessels leading to the walls of the heart and thus obstructing bloodflow. This causes a heart attack.

**Blood flow through the heart**

The deoxygenated blood from the entire body is brought into the R. Auricle by the superior and inferior vena cava.

- Oxygenated blood from the lungs is brought into the L. Auricle by the Pulmonary veins.
- When the two auricles are full of blood, they contract and blood is pushed into the ventricles. At this time the AV valves open.
- When the two ventricles are full of blood they simultaneously begin to contract. The AV valves close and thus backflow of blood is prevented.
- From the R. ventricle, deoxygenated blood is pumped into the pulmonary trunk. The presence of the Pulmonary semilunar valves ensures that blood does not flow back into the R. Ventricle.
- From the L. Ventricle, oxygenated blood is pumped into the Systemic Aorta. The Aortic semilunar valves prevent the blood from flowing back into the L. Ventricle.
- In this way, deoxygenated blood is supplied to the lungs for oxygenation. Whereas, oxygenated blood is supplied to all parts of the body by the aorta.
**Cardiac cycle** – The series of events which occur during one complete beat of the heart is called the cardiac cycle. This consists of 3 phases –

1. **Auricular systole** – During this phase, the auricles contract and push the blood into ventricles. It is completed in 0.1-0.15 secs. In this phase, the AV valves are open and the Semilunar valves remain closed.

2. **Ventricular systole** - During this phase, the ventricles contract and push the blood into the Aorta and the Pulmonary trunk. It is completed in 0.3 secs. In this phase, the AV valves close and the Semilunar valves open.

3. **Joint diastole** - It extends for 0.4 secs during which all four chambers of the heart are relaxed.

**Average heart rate** - 72 times / minute

**Each cardiac cycle** - 0.8 seconds

**Definition of heart beat** - Time taken by one systole followed by an immediate diastole of the heart is called a heart beat.

**Heart sounds** - “Lubb” and “dup”

1. **Lubb** is the sound produced when the AV valves get closed sharply at the start of a ventricular systole.

2. **Dup** is the sound produced when at the beginning of a ventricular diastole the semilunar valves at the base of the aorta and pulmonary trunk close.

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<thead>
<tr>
<th>DIASTOLE</th>
<th>SYSTOLE</th>
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<td>1. This is the phase of rest or relaxation phase.</td>
<td>1. The heart muscle contracts during this phase.</td>
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<td>2. During a diastole, the heart chambers fill with blood.</td>
<td>2. In this phase, the auricles contract and send blood into the ventricles which in turn contract to push blood into the corresponding blood vessels.</td>
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<td>3. Atrial diastole- 0.7 to 0.76 secs</td>
<td>3. Atrial systole- 0.1 to 0.16 secs.</td>
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<tr>
<td>4. Ventricular diastole- 0.5 to 0.56 secs</td>
<td>4. Ventricular systole- 0.3 secs.</td>
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**BLOOD CIRCULATION**

In the human body, the blood passes through the heart twice before it completes one complete circulation throughout the body. For this reason, the blood circulation in the body is called **Double circulation**. It consists of two circulations -

1. **Pulmonary circulation**

The **Pulmonary trunk** arises from the **R. Ventricle** and divides into a **left and right pulmonary artery**. These blood vessels carry deoxygenated blood to the lungs for purification. The **Pulmonary veins** then transport the **oxygenated blood** from the lungs to the **L. Auricle**.

2. **Systemic circulation** – is the circulation of oxygenated blood from the **L. Ventricle** to the **R. Auricle** through the various body parts and systems.

The **Systemic Aorta** arises from the **L. Ventricle** and arches around the **R. Pulmonary artery**. This is called the **Aortic arch**. It then continues down through the thorax and abdomen as the **Dorsal Aorta**. Various branches of the aortic arch and dorsal aorta supply **oxygenated blood** to all **parts of the body**.

The deoxygenated blood from these parts is collected by various veins. These veins unite to form two very large veins called **superior and inferior vena cavae**. These two veins pour **deoxygenated blood** into the **R. Auricle**.

**PORTAL SYSTEM** – A vein that starts as capillaries and end as capillaries is called a **portal vein**.

All the portal veins which carry their contents into the liver (mainly from the gastro-intestinal tract) collectively constitute the **Hepatic portal system**.

This vein carries blood which is rich in nutrients absorbed from the gastro-intestinal tract to the liver. This is so, that the liver monitors the substances before they go into the general circulation.

The hepatic vein which leaves the liver joins the Inferior vena cava that carries back deoxygenated blood to the R.Auricle.
Pulmonary and Systemic circulation

Circulatory system in Human Body

Hepatic Portal System


3. Liver monitors blood content.

2. Nutrient molecules travel in hepatic portal vein to liver.

1. Small intestine absorbs products of digestion.
DEFINITIONS

1. PULSE:- The alternate expansion and elastic recoil of the wall of an artery with each systole and diastole of the left ventricle is called pulse.

The pulse can be felt in any artery that is near the surface of the body. The Radial artery at the wrist is most commonly used. Pulse rate is the same as the heart rate and averages about 70 – 90 beats per min.

Tachycardia – a rapid heart or pulse rate of over 100/min.

Bradycardia- A slow heart or pulse rate of below 60/min

2. BLOOD PRESSURE : -is the force of the blood against the walls of the arteries created by the heart’s pumping.

Normal blood pressure reading is 120/80 mm of Hg. This shows the higher systole over the lower diastole.

A sphygmomanometer is an instrument that measures blood pressure.

Electrocardiograph is a machine that records the impulses or electrical signals sent out by the pacemaker just before a heart beat. Such a record is an electrocardiogram (ECG).