

CIRCULATION

Introduction :- The blood circulation was discovered by William Harvey in 1628. Circulation is a process of continuous flow of fluids from one region to the another like blood, lymph, etc., Circulatory system (Cardio vascular system) helps in the transport of gases like O₂, CO₂, nutrients, hormones, minerals, vitamins and also carries the waste products from different tissues to the kidney for elimination.

There are two types of circulatory systems. Such as ;

1) **Open type of circulatory system** :- A system in which the blood flows (moves) from one region to another through the space.

Ex :- Leeches, Molluscs (Except class cephalopoda) & Arthropods.

2) **Closed type of circulatory system** :- A system in which the blood flows from one region to another region through the blood vessels like arteries, veins & capillaries.

Ex:- All vertebrates, cephalopods & most of Annelids.

Cardiology :- **“The study of heart & its diseases is called cardiology”**.

The circulatory system consists of three components like heart, blood, bloodvessels.

Gross anatomy of Human heart :

1) **HEART**:- The human heart is hollow, highly muscular pumping organ. It measures about 12cm. In length & 9 cm. In width in normal man. It weight about 250 to 300 gms. The size of the heart is of his or her own closed fist. Heart is located in the thoracic cavity, in between two lungs and above the diaphragm. Apex of the heart is slightly turned towards the left side.

Pericardium :- The heart is surrounded by the membrane called.

Pericardium :- In turn the pericardium is made up of two layers like an outer parietal pericardium (Fibrous) and an inner Visceral pericardium (Epicardium). **“The space is present between an outer parietal pericardial layer and an inner visceral pericardial layer is called pericardial space (Cavity)”**. The pericardial space is filled with the fluid called pericardial fluid. It gives free movement of the heart and protect from external shocks & injuries.

1) **Arteries** :- **“The blood vessels that carries the blood away from the heart is called arteries”**.

Or

The arteries are the blood vessels that carries the O₂ blood from heart to the various parts of the body except pulmonary veins.

- 2) **Veins** :- **“The blood vessels that carries the blood towards the heart is called veins”**. OR

The veins are the blood vessels that carries the CO₂ blood from different parts of the body to the heart for oxygenation except pulmonary veins.

- 3) **Capillaries** :- **“The capillaries are the fine blood vessels which connect between arteries and veins.”**

Wall of the human heart :-

The wall of the heart is made up of three layers. Such as follows ;

- 1) outer epicardium, 2) Middle myocardium 3) Inner endocardium.
- 1) **Epicardium** :- **“An outer most layer of the heart is called epicardium”**. It is a thin, transparent connective tissue.
- 2) **Myocardium** :- **“The middle layer of the heart is called myocardium”**. It is made up of **cardiac muscle** and **involuntary** in nature.
- 3) **Endocardium** :- **“An inner most layer of the heart is called endocardium”**. It is thin connective tissue lined by **endothelium**.

V.S. OF HUMAN HEART

The vertical section (V.S.) of human heart reveals the following parts. The heart is made up of **four chambers** like Right auricle (atrium), left auricle and left ventricle.

Atria or Auricles :- **“The upper chambers of the heart called auricles or atria.”**

Ventricles :- **“The lower chambers of the heart called ventricles.”**

The auricles are having thin walled and smaller than ventricles. **“The atria (right & left atrium) are separated by a layer of muscle called inter atrial septum”**. (Inter auricular septum). And **“The ventricles (right & left) are separated by a layer of muscle called inter ventricular septum.”**

1) **Chambers of the heart** :-

- i) **Right auricle** :- The right auricle **receives the deoxygenated blood** from the different parts of the body through the **superior venacava** (pre caval vein) and **inferior Vena Cava** (Post caval vein). The superior vena cava collecting the CO₂ blood from upper part of the body and inferior vena cava collecting the CO₂ blood from the lower part of the body. The **coronary sinus** collecting the CO₂ blood from the **heart** and opens into the right auricle.

The right and left auricles are separated by a layer of muscle called **inter atrial septum**.

- ii) **Left auricle** :- The left auricle receives the **oxygenated blood** from the lungs through the **pulmonary veins**.

- iii) **Right ventricle** :- The right ventricle receives the CO₂ blood from right auricle through the **right auriculo – ventricular aperture** guarded by **tricuspid valve**. The right and left ventricles are separated by a layer of muscle called **inter ventricular septum**. The right ventricle pumps the CO₂ blood into the lungs through the **pulmonary artery**.
- iv) **Left ventricle** :- The left ventricle receives the oxygenated blood from the left auricle through the **left auriculo Ventricular aperture** guarded by the **bicuspid value**. The left ventricle pumps or discharge the O₂ blood to the various parts of the body through the pulmonary artery.
- 2) **Great vessels of the heart** :- The different blood vessels are connected to the heart. Such as follows ;
- i) **Superior vena cava (pre caval veins)** :- The superior vena cava collecting the CO₂ blood from upper part of the body. & It opens into the right auricle.
- ii) **Inferior Venal Cava (Post caval vein)**:- It carries the CO₂ blood from lower parts of the body and it opens into the right auricle.
- iii) **Coronary sinus** :- Coronary sinns collecting the CO₂ blood from the wall of heart and it opens into the right atrium. Its opening is guarded by the besius value.
- iv) **Coronary arteries** :- It arises from the base of the aorta. It supplies the O₂ blood to the middle myocardium of the heart wall.
- v) **Pulmonary arteries** :- It arises from the right ventricle and carries the CO₂ blood to the lungs for the oxygenation (i.e. purification) of blood.
- vi) **Pulmonary veinus** :- Pulmonary veins carries the O₂ blood from the lungs into the left auricle.
- 3) **Valves of the heart** :-
- i) **Tricuspid value (Right atrio-ventricular value)** :- **“The right atrio-ventricular aperture is guarded by three triangular flaps called tricuspid value”**. Tricuspid valve is present in between **right auricle and right ventricle**. Tricuspid value prevents the reverse flow of blood from right ventricle to the right auricle.
- ii) **Bicuspid value (Mitral value or left atrio – ventricular aperture)** : **“The left atrio – ventricular aperture is guarded by two triangular flaps called bicuspid value”**. It is present in between **left auricle and left ventricle**. Bicuspid valve prevents the reverse flow of blood from left ventrice to the left auricle.

- iii) **Pulmonary semilunar valves** :- The pulmonary artery or pulmonary aorta arises from the right ventricle. The opening of the pulmonary artery is guarded by three semilunar valves called **pulmonary semi lunar valves**. It prevents the reverse flow of blood from pulmonary artery to the right ventricle.
- iv) **Aortic semi lunar valves** :- It arises from the left ventricle. The opening of the aorta is guarded by three semi lunar valves called aortic semi lunar valves. It prevents the reverse (backward) flow of blood from aorta into the left ventricle.

Aorta is the largest artery found in our body, and superior vena cava & inferior vena cava are the largest veins found in our body.

Lub :- “The lubb is a sound produced by the closing of tricuspid and bicuspid valves. It is a first sound.”

Dupp:- “The dupp is a sound produced by the closing of pulmonary semilunar valves and aortic semilunar valves. It is a second sound.

The inner wall of the ventricles are made up of pyramid like projections called **Papillary muscles**”. “The tricuspid and bicuspid valves are attached to the papillary muscles by fibrous thread like structures called chordae tendinae”.

Mechanism of working of the human heart :-

By the rhythmic contraction & relaxation of heart chambers, the heart pumps the blood to the different parts of the body. “The contraction of the heart chambers called **systole**” and the **relaxation** of the heart chambers called **diastole**.

Cardiac cycle (heart cycle) :- “The alternate rhythmic contraction and relaxation of auricles and ventricles followed by a period of pause called cardiac cycle”. OR

“The sequence of cyclical events occurs between a systole and diastole of the heart called cardiac cycle”.

During **atrial diastole**, the right atrium receives the CO₂ blood from different parts of the body through the **superior vena cava** and **inferior vena cava**. At the same time, the left atrium receives O₂ blood from the lungs through the **pulmonary veins**. Thus the two auricles get completely filled with blood. Hence the auricles are also called **receiving chambers**.

During **atrial systole** the right auricle pumps impure blood into the right ventricle. & left auricle pumps pure blood into the left ventricle. Due to the atrial systole the tricuspid & bicuspid valves are forced to allow the flow of blood into the respective ventricles.

During **ventricular systole**, the ventricles contract & pump the blood into the different parts of the body. Hence the ventricles are regarded as **pumping chambers**. When the ventricles contract the right & left atrioventricular apertures are kept **closed** by their **tricuspid & bicuspid valves** & **semilunar valves are kept open** to allow the flow of blood into the pulmonary aorta & aorta (left systemic arch). Thus the impure blood is carried by the pulmonary artery from right ventricle to the lungs for the purification of blood on the other hand the left ventricle pumps the O₂ blood to the various parts of the body through the aorta. The reverse flow of blood from ventricles to the auricles is prevented by the respective semi lunar valves.

Heart rate (HR) :- The number heart beats per minute. In normal man is 70 to 72 heart beats / minute.

Stroke volume (SV) :- **“The volume of blood pumped by the ventricle per heart beat is called stroke volume.**

Stroke volume is about 70ml / heart beat.

Cardiac output :- **“The volume or amount of blood pumped by the ventricles per minute is called cardiac output”.**

The cardiac output is calculated by using the following formula.

Cardiac output = Stroke volume x Heart rate

$$C O = S V \times H R$$

$$= 70\text{ml} \times 72$$

$$= 5,040\text{ml or } 5.0 \text{ litres/minute.}$$

Stethoscope :- **“The stethoscope is an instrument which is used to measure the number of heart beats”.**

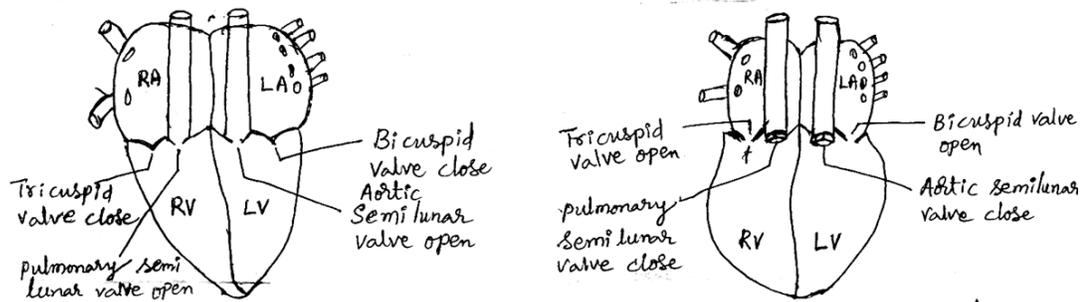


Fig:- Events during ventricular systole **Fig :- Events during atrial systole.**

The lub sound is a first heart sound produced by the closing of tricuspid and bicuspid valves. The dupp is a second heart sound produced by the closing of pulmonary semi-lunar & aortic semi-lunar valves.

Complete Double Circulation. :

Definition :- “The double circulation is a circulation in which the blood enters and leaves from the heart in two different circulatory pathways in a single ventricular systole”.

OR

At every heart beat, the right half of the heart receives & pumps CO_2 blood to the lungs and left half of the heart receives & pumps O_2 blood to the aorta. This type of circulation is called complete double circulation.

The human heart works like a double pump. Because the blood enters the heart twice before distributing to the different parts of the body. Here the Oxygenated & deoxygenated blood do not undergo mixing in the ventricles. Hence the name complete circulation.

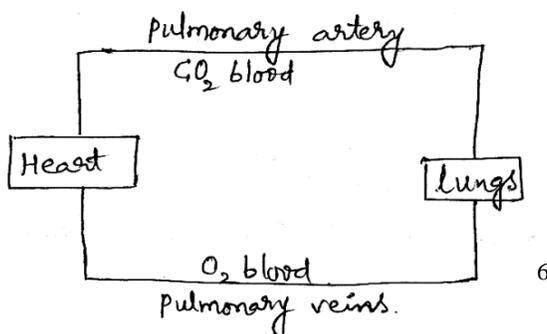
It involves two types of circulation. Such as follows;

- 1) **Pulmonary circulation:-** “Pulmonary circulation is the route in which the circulation of blood between heart and lungs”.

The right auricle receives the deoxygenated from the different parts of the body through the superior & inferior vena cava. The CO_2 blood is pumped by the right auricle to the right ventricle.

The pulmonary artery carrying the CO_2 blood from right ventricles to the lungs for the purification of blood. Then oxygenated blood is passes from lungs to the left auricle through the pulmonary veins.

The schematic representation of the pulmonary circulation is as follows ;

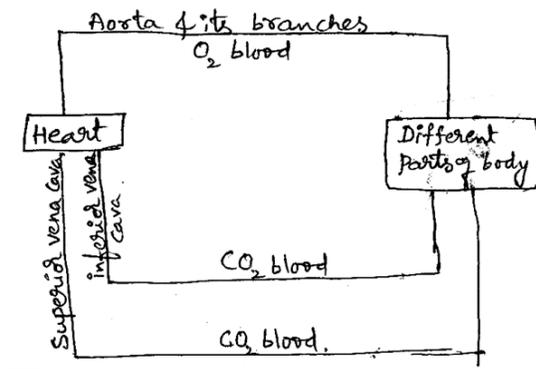


- 2) **Systemic circulation** :- **“The systemic circulation is the route in which circulation of blood between heart and different parts of the body”.**

The oxygenated blood is pumped from left auricle into the left ventricle. The left ventricle pumps the O_2 blood to the various parts of the body through the aorta during ventricular systole.

The right auricle (atrium) receives the impure or deoxygenated blood from different parts of the body through the superior & inferior vena cava.

The schematic representation of systemi circulation is represented as follows ;



- 3) **Coronary circulation** :- Coronary arteries arises from the base of the aorta. These arteries carries the pure blood to the muscles of the heart. The coronary sinus collecting the impure blood from the muscles of the heart and finally opens into the right atrium.

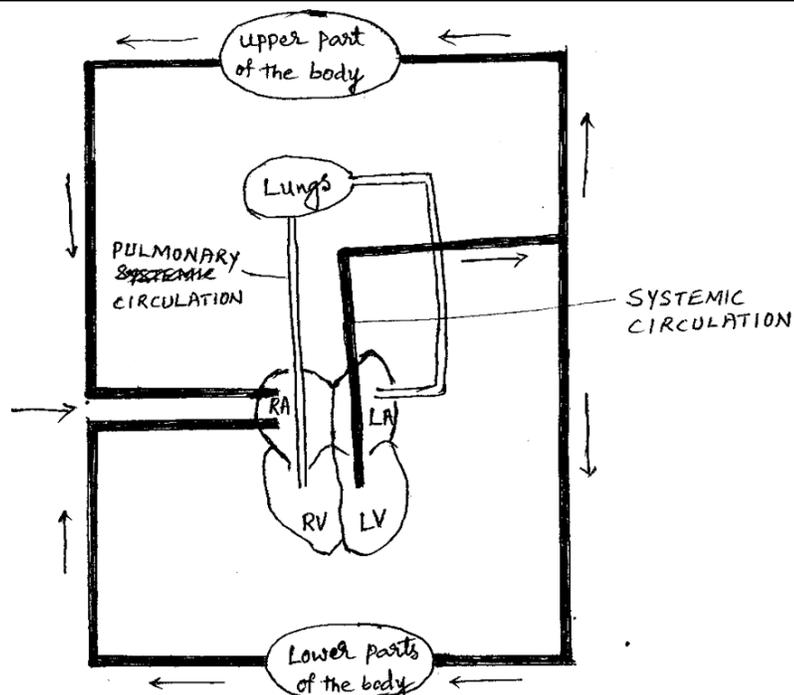
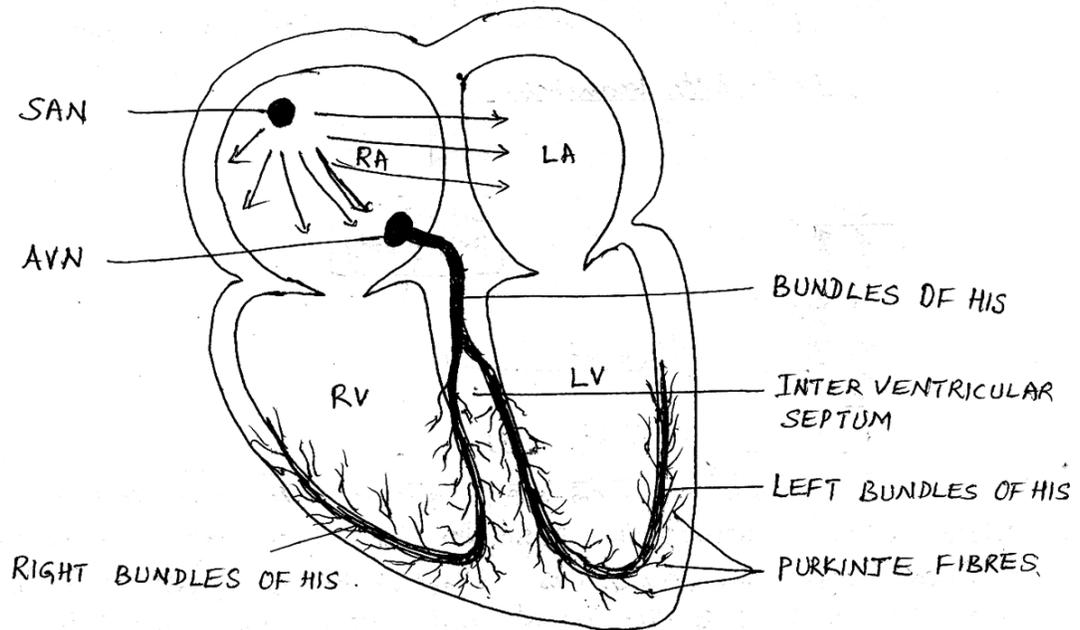


Fig:- SCHEMATIC REPRESENTATION OF COMPLETE DOUBLE CIRCULATION

ORIGIN & CONDUCTION OF HEART BEAT

The human heart is myogenic type. It consists of a specialized cardiac muscle fibres. The rhythmic contraction and relaxation of the heart occurs due to the presence of a specialized cardiac muscle fibres. It is responsible for the initiation & conduction of heart beat. i.e. It generates & transmits the impulses for the contraction & relaxation of the heart rhythmically. The origin and conduction of heart beat is associated with SAN, AVN, BUNDLES of his & purkinje fibres.



- 1) **SAN (Sinu – Atrial Node)** :- The SAN is a compact mass of specialized cardiac muscle. The SAN is situated in the right atrium just below the opening of the superior vena cava. SAN initiates the heart beat and set the pace **hence the name pace maker** i.e. **The SAN produces 70 to 80 signals / minute and each isgnal initiates a heart beat. Hence it is also known as a pace maker.** The SAN produces two pathways.
 - i) **atrial pathways** :- Which spread the impulses over the atria.
 - ii) **Internodal pathways** :- Which connect SAN to AVN.

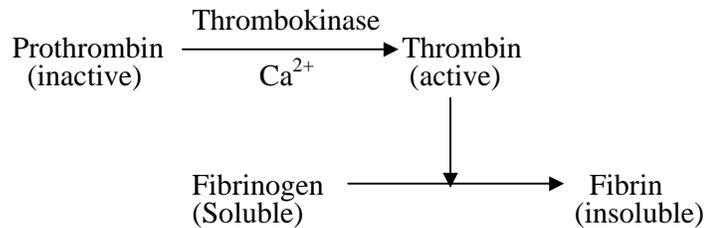
- 2) **AVN (Atrio – ventricular Node)** :- AVN is another compact mass of specialized cardiac muscle. It is situated in the inter atrial septum. AVN transmits the impulses towards the ventricles only. But AVN is under the control of SAN. i.e. AVN gets the stimulus from SAN.

- 3) **Bundles of His** :- A bundles of fibres arises from the AVN is called Bundles of His. It arises from AVN and runs downwards through the interventricular septum and divides it into two branches. i.e. right & left Bundles of His. They moves towards the right & left ventricles respectively.
- 4) **Purkinje fibres**:- The number of specialized cardiac muscle fibres arises from the right & left bundles of His are called purkinje fibres.

Mechanism of Blood clotting :-

According to the Best and Taylor's theory, the mechanism of blood clotting involves four substances, such as ;

- 1) **Prothrombin** (Produced by liver) 2) **Thromboplastin** (An enzyme produced by the damaged tissues) 3) Calcium ions (present in the blood plasma) and 4) Fibrinogen (a plasma protein).



The inactive prothrombin is converted into active thrombin in the by the thrombokinase enzyme in the presence of calciumions. The activated thrombin helps to convert the insoluble fibrinogen into soluble fibrin threads which is nothing but blood clot. The network of fibrin threads prevents the bleeding of blood.

Blood pressure (B P):- **“The pressure exerted by the out flowing of blood from the heart on the wall of the blood vessels (arteries, veins & capillaries) called blood pressure”**.

OR

“Blood pressure is defined as “the pressure exerted by the blood on the wall of the blood vessels particularly on the arteries”.

$$\text{Blood pressure} = \frac{\text{Systolic pressure}}{\text{Diastolic pressure}} \text{ or } \text{BP} = \frac{\text{SP}}{\text{DP}}$$

Normal Bp is $\frac{120}{80}$ mm Hg.

MM Hg = Milimeters of mercury.

Sphygmo manometer :- “ The sphygmomanometer is an instrument which is used to measure the blood pressure”.

Systolic pressure (SP) :- The highest arterial pressure in the arteries caused due to the ventricular systole at rest is called SP.

Diastolic pressure (DP) :- “The lowest arterial pressure in the arteries caused due to the ventricular diastole at rest is called DP”.

Pulse pressure :- “The differences between the systolic & diastolic pressure is called pulse pressure.”

Mean pressure :- An average of systolic pressure and diastolic pressure is called mean pressure.

Hypotension (Low B.P.) :- “The condition in which the blood pressure decreases below the normal level (lower limit) is called hypotension”.

Causes:- Hormonal imbalance, T.B., Cancer, Bleeding, Depression.

Effects :- Profuse sweating, heart burn, diarrhoea, vomiting, large urinary losses.

Preventive measures :- Reduce the body weight, Regular exercise, restriction of sodium intake, Avoid smoking, yoga, meditation may help to reduce hypotension.

Hypertension (High BP) :- “The condition in which, the blood pressure increases above the normal level (upper limit) is called hypertension”.

Causes:- High cholesterol, old age, fear anger, anxiety, nicotine, obesity, nephritis (Kidney disease) stress, High salt intake.

Effects:- Harm to the brain, Heart attack, stroke.

Arteriosclerosis:- “The hardening of the arterial wall due to the deposition of calcium salts are called arteriosclerosis”.

Atherosclerosis :- “The lumen of the blood vessels are thickened due to the deposition of cholesterol are called atherosclerosis”.

Disorders of the heart (Abnormalities of the heart)

1) **MYOCARDIAL INFARCTION** :- (Gr. Myos = Muscle, Cardia = heart, infarction = death)

Definition :- “The death of the myocardial tissue of the heart due to the inadequate supply of oxygenated blood is called myocardial infarction”. It is also known as **heart attack**”.

OR

“The death of cardiac muscles of the heart due to lack of O₂ blood supply is called myocardial infarction”.

Causes :-

- 1) **Atherosclerosis**:- (Hardening of the arteries due to the deposition of calcium salts called atherosclerosis).
- 2) **Arteriosclerosis**:- (The volume of the blood vessels are thickened due to the deposition of cholesterol is called arteriosclerosis)
- 3) **Thrombus or** clotting within the coronary artery. (The clotting of blood within an unbroken blood vessel called thrombosis).
- 4) **Smoking**
- 5) **Hypertension**(High BP) & Diabetis mellitus.

Symptoms :-

- 1) Angina pectoris or prolonged chest pain
- 2) Profuse sweating
- 3) Nausea
- 4) Shortness of breath
- 5) Anxiety & cough.

2) **CYANOSIS** (Gr. Kyanos = blue ; osis = condition)

Definition :- *“A baby with a bluish or dark purple colouration of the skin & tongue insufficient oxygenated blood in the systemic circulation is called cyanosis”.*

OR

“Cyanosis is a bluish or dark purple colouration of tissues, appearing due to the deficient oxygen in a persons blood or tissues”.

Cyanosis is easily seen in the areas where the skin, nailbeds, ear lobes, lips & fingers. [Cyanosis is also known as Tetralogy of Fallot'. Because it was discovered by E.L. Fallot].

Causes :- It is caused due to the four abnormalities of the heart

- 1) **Transposition of aorta** :- The aorta arises from the right ventricle instead of the left ventricle. Or receives the blood from both the ventricles.
- 2) **Pulmonary stenosis** :- The semilunar valves of the pulmonary artery stick to each other. Due to the pulmonary stenosis, the reverse flow of blood from pulmonary artery into the right ventricle.
- 3) **Ventricular septal defect (VSD)**:- The inter ventricular septal hole allows the flow of blood from right ventricle to the left ventricle
- 4) **Right ventricular hypertrophy (RVH)**:- *“The enlargement of the right ventricle called right ventricular hypertrophy”.*

Symptoms:-

- 1) Appearance of blue or dark purple colouration of tongue, lips, skin, nail beds.
- 2) Shortness of breath with increased heart beat.
- 3) Prolonged chest pain.
- 4) Numbness or tingling in the arms or legs.