Cardiovascular system

Introduction

Every tissue in our body needs a continuous and adequate supply of oxygen, nutrients and hormones, and the waste products generated need to be removed from the body continuously. Cardiovascular system acts as a transport system and blood acts as a medium to carry out these functions. Cardiovascular system is divided into two parts;

1) The circulatory system consisting of the heart, which acts as a pump and the blood vessels, through which the blood circulates.
2) The lymphatic system consisting of the lymph nodes and the lymph vessels, through which colorless lymph flows.

The circulatory system: Heart and blood vessels

The circulatory system consists of the heart and blood vessels. Heart is situated inside the thoracic cage and consists of four chamber, two atria and two ventricles. The heart pumps blood into two anatomically separate systems of blood vessels; the pulmonary circulation and the systemic circulation.

The right side of the heart pumps blood to the lungs (pulmonary circulation) .It involves the gaseous exchange of oxygen and carbon dioxide, i.e. oxygen enters the blood stream from the lungs and carbon dioxide leaves the blood stream and enters the lungs. The left side of the heart is involved in systemic circulation, wherein the heart pumps blood into the aorta and is supplied to the body through the different arterial branches of the aorta. There occurs exchange of nutrients and waste products, i.e. nutrients are extracted by the tissues and waste products are released into the blood stream.

The heart

Definition: Heart is a cone-shaped, hollow muscular organ, about 10cm in length, of approximately the size of the owner's fist and weighing about 225-50g in women and 300-40 g in men. It consists of four chambers, two atria (one right and one left) and two ventricles (one right and one left) Fig 2.1.

Position: The heart lies in the thoracic cavity and is situated in the space between two lungs (mediastinum). Heart is a little more towards the left side obliquely than the right side and has a base at the upper side and an apex at the lower side. The apex lies at the level of the 5^{th} inter-costal space, at a distance of 9cm from the midline on left side. The base of the heart extends up to the level of the 2^{nd} rib.

Diameters of the heart:

Base to apex diameter: 10-12 cm

Transverse diameter: about 9 cm

Anterior-posterior diameter: about 6 cm

Organs associated with the heart: The heart is enveloped by different organs on different sides and they are as under;

Inferiorly: The apex of the heart lies on the central tendon of the diaphragm.

Superiorly: superiorly heart is covered with the great blood vessels, i.e. the aorta, pulmonary veins, pulmonary artery and the superior vena cava.

Anteriorly: on the anterior side the heart has the sternum, ribs and intercostal muscles.

Posteriorly: the organs present on the posterior side of the heart include; the esophagus, trachea, bronchi, descending aorta, inferior vena cava and thoracic vertebrae.

Laterally: the lungs.

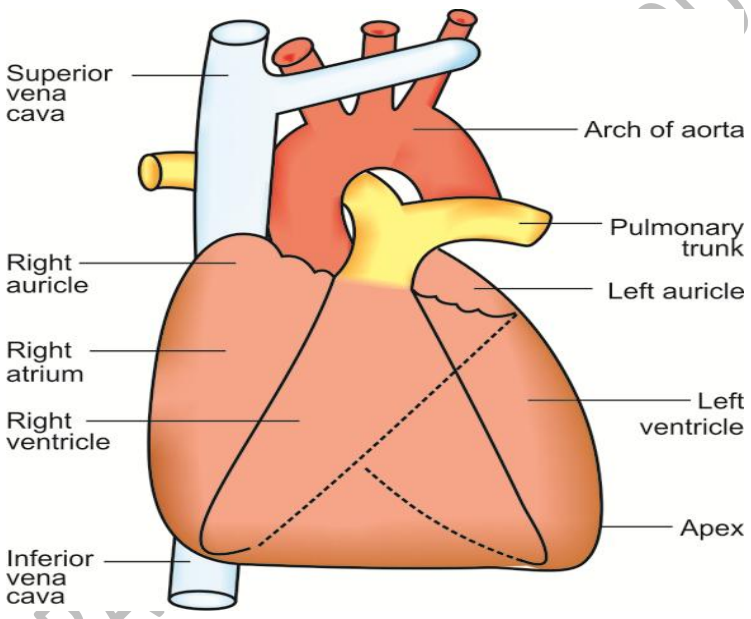

Fig.2.1.The Heart

Structure of the heart

The heart is composed of three layers of tissue, the pericardium, myocardium and endocardium.

Pericardium: the pericardium is made up of two sacs, an outer sac consisting of fibrous tissue and an inner layer consisting of a double layer of serous membrane. The fibrous sac is covered by the outer layer of the serous membrane (parietal pericardium) and the inner layer of the serous membrane(the visceral pericardium) is attached to the heart muscle. The serous membrane is made up of epithelial cells, which secret serous fluid into the space between the visceral and parietal pericardium. This serous fluid prevents the friction between them when the heart beats.

Myocardium: The myocardium of the heart is composed of a specialized cardiac muscle found only in the heart .It is not under the control of will but like skeletal muscles some cross-strips are seen microscopic examination .The arrangement of cells and their branches give cardiac muscle a special appearance of being a sheet of muscle rather than a large number of individual cells. As a result of this end-to-end connectivity ,impulse generated spreads from cell to cell via the brands and intercalated discs over the whole sheet of muscle ,causing contraction .The myocardium is thickest at the base and thinnest at the apex .This reflects the amount of work each chamber contributes towards the pumping of blood. Left ventricle having the greatest workload has thickest myocardium.

Endocardium: The chambers and the valves of the heart are lined by the endocardium, being a thin, smooth and glistening membrane it permits smooth flow of blood inside the heart. It is continuous with the endothelial lining of the blood vessels.

Interior of the heart(The chambers, septa and the valves)

Internally heart is divided into right and left side by inter atrial and inter ventricular septa (partitions consisting of myocardium and enveloped by endocardium) on upper and lower side respectively(Fig 2.2). The upper (atria) and lower (ventricles) parts of the heart are separated by a septum called as atreoventricular septum. The right side of the atreoventricular septum has a valve called as right atreoventricular valve or tricuspid valve (having three cusps) and left valve is called as left atreoventricular valve or mitral valve (having two cusps). The cusps or flaps are made of double flaps of endocardium and a little fibrous tissue.

The valves in the heart open and close as per the changes in pressure of the blood in the chambers(when pressure in the atria is more than that of ventricles) and shut down during ventricular contraction to prevent backflow of the blood into the atria.

The Right atrium: It is the right upper chamber of the heart and forms the right border of the heart. The internal wall of the right atrium has; (I) a smooth posterior part called as sinus venarum and (II) a rough anterior part called as muscular pectinati(muscular ridges). The two parts are separated externally by a groove, sulcus terminalis and internally by a crest, the crista terminalis. The wall of the right atrium contains sinoatrial node (SA node), the natural pacemaker of the heart, which is made up of special cardiac muscle fibres. The atreoventricular node(AV Node) is located in the atreoventricular septum.

The Right ventricle: It forms the largest part of the sternocostal surface, a small part of diaphragmatic surface and almost the entire inferior border of the heart. There are a number of irregular muscle bundles called as papillary muscles in the right ventricle, from which arise fibrous threads called as chordae tendineae.

The Left atrium: It contributes to the major part of the base of the heart. It has a conical projection called as auricle.

The left ventricle: It forms the apex of the heart, left border and the diaphragmatic surface. The left ventricle performs more work than the right ventricle, as a result the wall of the left ventricle is two times more thicker than the right ventricle.

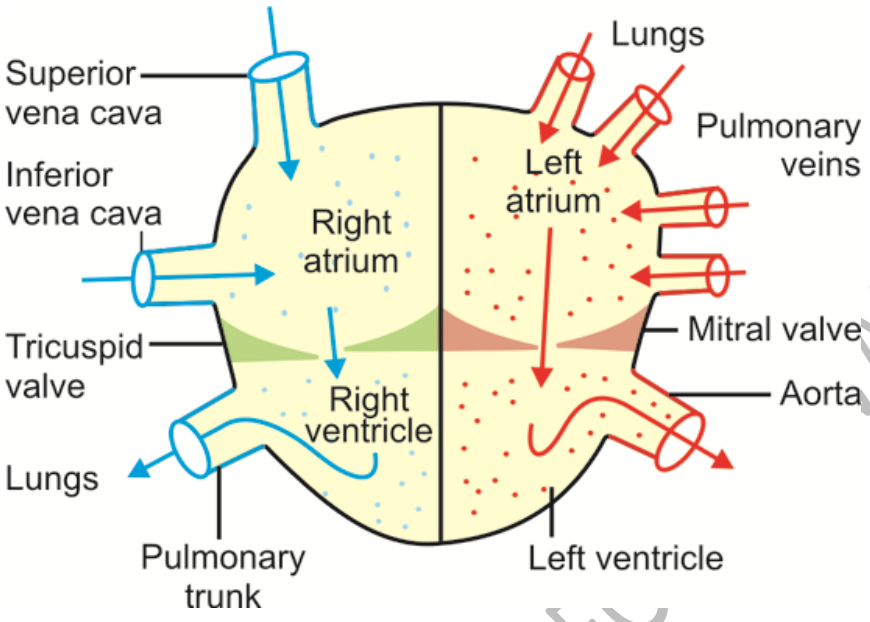

Fig.2.2 The heart with chambers

Borders of the heart (Fig. 2.3)

Upper border: it is formed mainly by the left atrium and partly by the right. It is overlapped by the ascending aorta and the pulmonary trunk.

Inferior border (Acute margin of the heart): It is formed mainly by the right ventricle and a very small portion by the left ventricle near the apex.

Right border: It is formed only by the right atrium.

Left border: It is formed mainly by the left ventricle and partly by the right.

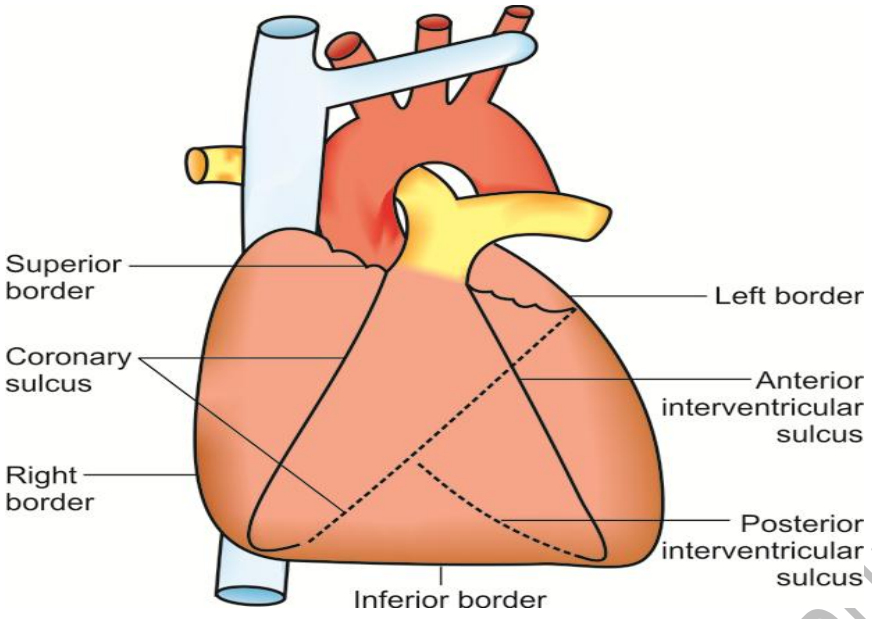

Fig 2.3 Borders of the heart

Blood and nerve supply to the heart

Atrial supply: the heart is supplied by the left and right coronary arteries , that branch from the aorta near the aortic valve. The heart receives about 5% of the total blood pumped by it. Although heart is a small organ but the amount of blood used by it highlights its importance to the body. A vast network of capillaries is formed by the coronary arteries throughout the heart(Fig 2.4)

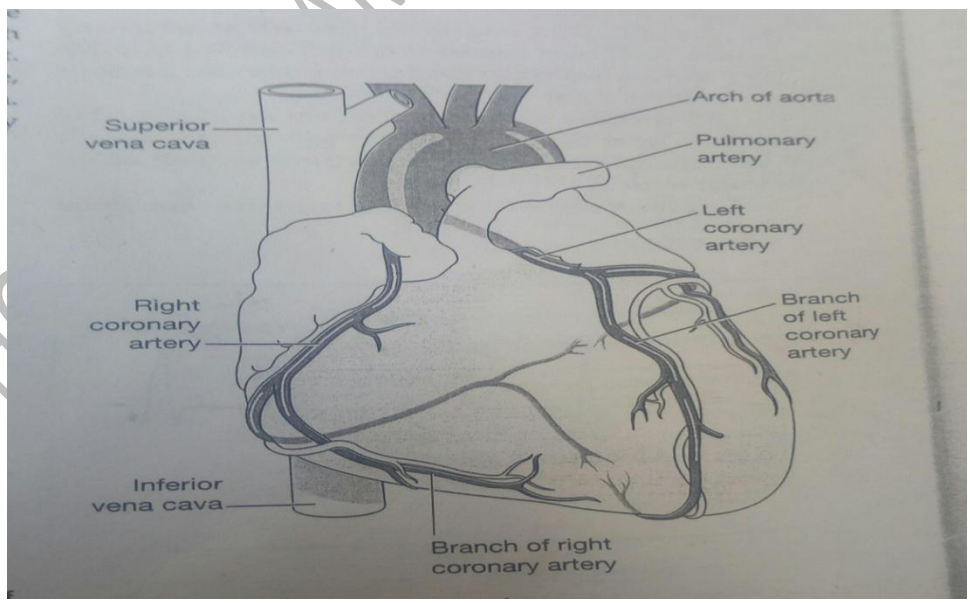

Fig 2.4 Atrial supply to the heart

Venous drainage: Several small veins join to form the coronary vein that receives most of the blood from the heart and opens into the right atrium, the remained blood passes directly into the heart chambers through little venous channels.

Nerve supply to the heart

The heart generates its own intrinsic impulses, but in addition to these impulses, the heart is influenced by autonomic nerve fibres consisting of parasympathetic and sympathetic nerves. The vagus nerve (parasympathetic) supplies the SA node, AV node and atrial muscle. The sympathetic nerves supply the SA node, AV node and the myocardium of atria and ventricles. Parasympathetic stimulation decreases the force and rate of the heartbeat while as sympathetic stimulation increases both

Course of blood through the heart (pulmonary and systemic circulation)

Systemic circulation: It is the type of circulation that involves exchange of oxygen, carbon dioxide, nutrients and waste products at the cell or tissue level through the capillaries. The detailed process of circulation is as under;

The heart pumps the blood from the left ventricle into the aorta, the aorta branches and re-branches, supplying blood to the different parts of the body. The arterial branches get re-branched to form arterioles and capillaries, the capillaries have a single layer of endothelial cells and allow the exchange of oxygen, carbon dioxide, nutrients and waste products at tissue level.

The capillaries are continuous with venules, which unite to form larger veins. The blood rich in carbon dioxide and waste products is drained into these venules and veins. Two larger veins carry the venous drainage from upper and lower parts of the body, the superior vena cava from the upper part and inferior vena cava from the lower part of the body. The deoxygenated blood carried by these two veins is finally drained into the right atrium, this completes the systemic circulation(Fig 2.5)

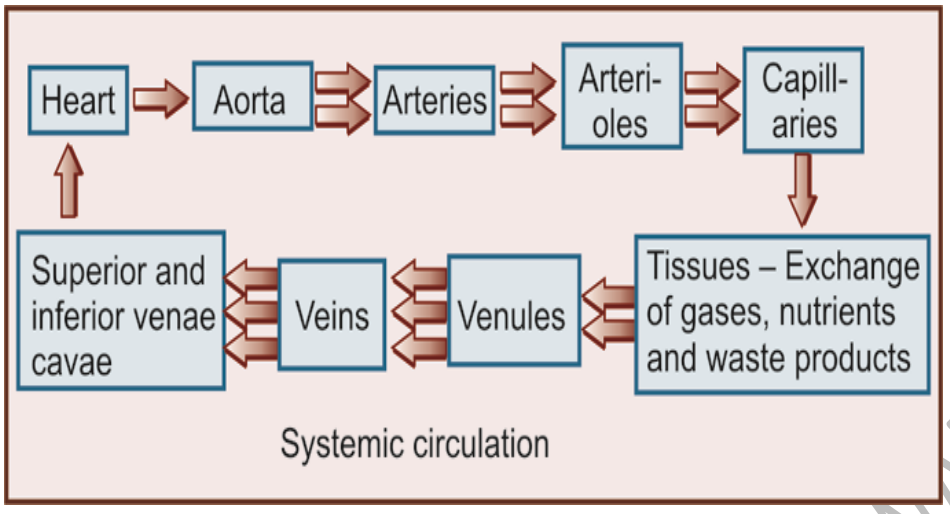

Fig 2.5 The systemic circulation

The pulmonary circulation: It is the type of circulation that involves the exchange of the oxygen and carbon dioxide at the lung capillaries. The deoxygenated blood in the right atrium is pumped into the right ventricle through the right atreoventricular valve (tricuspid valve), where from it is pumped into the pulmonary trunk and its branches (pulmonary arteries). The blood reaches the lungs through the pulmonary arteries and in the lungs there occurs the exchange of oxygen and carbon dioxide between the blood in the lung capillaries and the air in the alveoli through the alveolar-capillary membrane. The blood is thus enriched with the oxygen and carries through pulmonary veins (two from each lung) towards the left atrium of the heart. This blood is then pumped into left ventricle through the mitral valve . This completes the pulmonary circulation(Fig2.6).

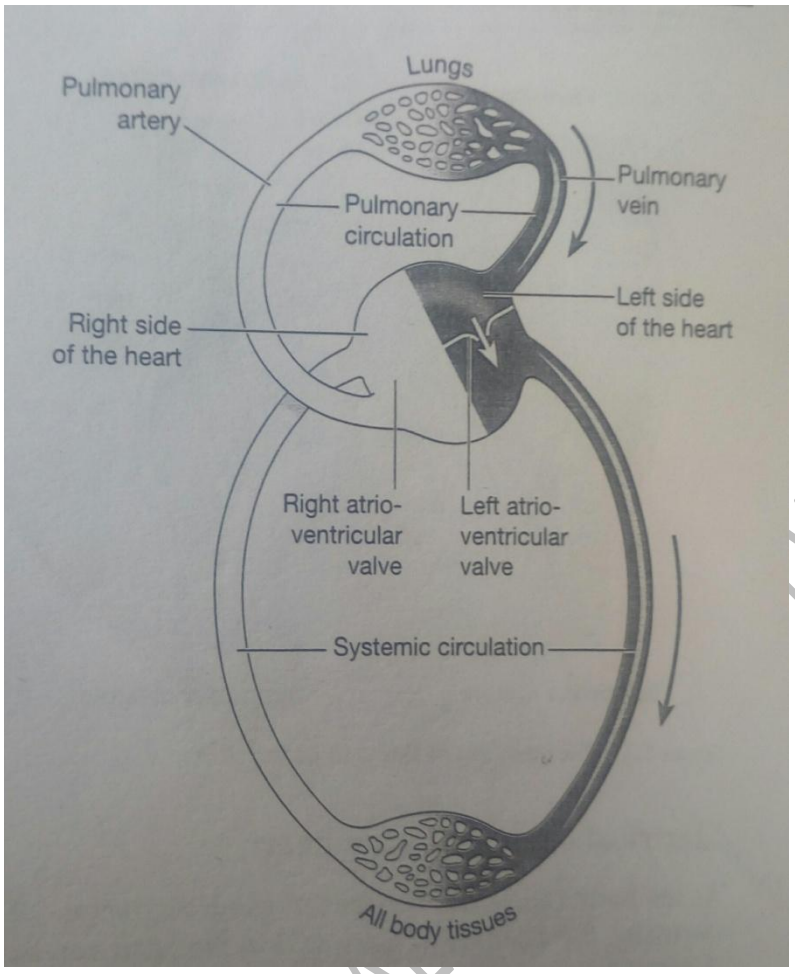

Fig 2.6 the systemic and pulmonary circulation

Conducting system of the heart

The cardiac muscles in the heart are automatically stimulated by the intrinsic property of the heart, therefore there is no need for any external stimulation, this property is known as the autorhythmicity of the heart. However this intrinsic property can get influenced by the external impulses generated by the brain and the circulating chemicals (e.g. hormones). There are some specialized cells in the myocardium of heart that initiate and conduct the intrinsic impulses and lead to the coordinated and synchronized contractions in the heart muscles. This whole conduction system of the heart consists of the following important structures(Fig 2.7):

Sinoatrial Node (SA node): It is a small mass of specialized neuromuscular cells, located in the right atrial wall, where the superior vena cava opens. It is called as the pacemaker of the heart because it initiates impulses more rapidly. Its firing leads to atrial contraction.

Atreoventricular node: It is a small mass of the neuromuscular tissue located in the wall of atrial septum near the atrioventricular valve. Normally the impulses generated from the SA node reach the AV node through the atria. A delay of 0.1 second takes place here, during which the electrical impulse takes its time to reach the walls of the ventricles and allows the atria to finish contracting and ventricles to start contracting. AV node acts as a secondary pacemaker if there is any problem with the SA node or with the transmission of the impulse.

Atrioventricular bundle (AV bundle or bundle of his): this is a mass of specialized fibres originating from AV node. The AV bundle crosses the fibrous ring that separates the atria and ventricles. At the upper end of the atrioventricular septum, the AV bundle bifurcates into right and left bundle branches. Each branch breaks up into fine fibres called as purkinje fibres. The AV bundle, bundle branches and the purkinje fibres convey electrical impulses from the AV node to the apex of the myocardium ,where the ventricular contraction begins and as a result blood is pumped into the pulmonary artery and the aorta.

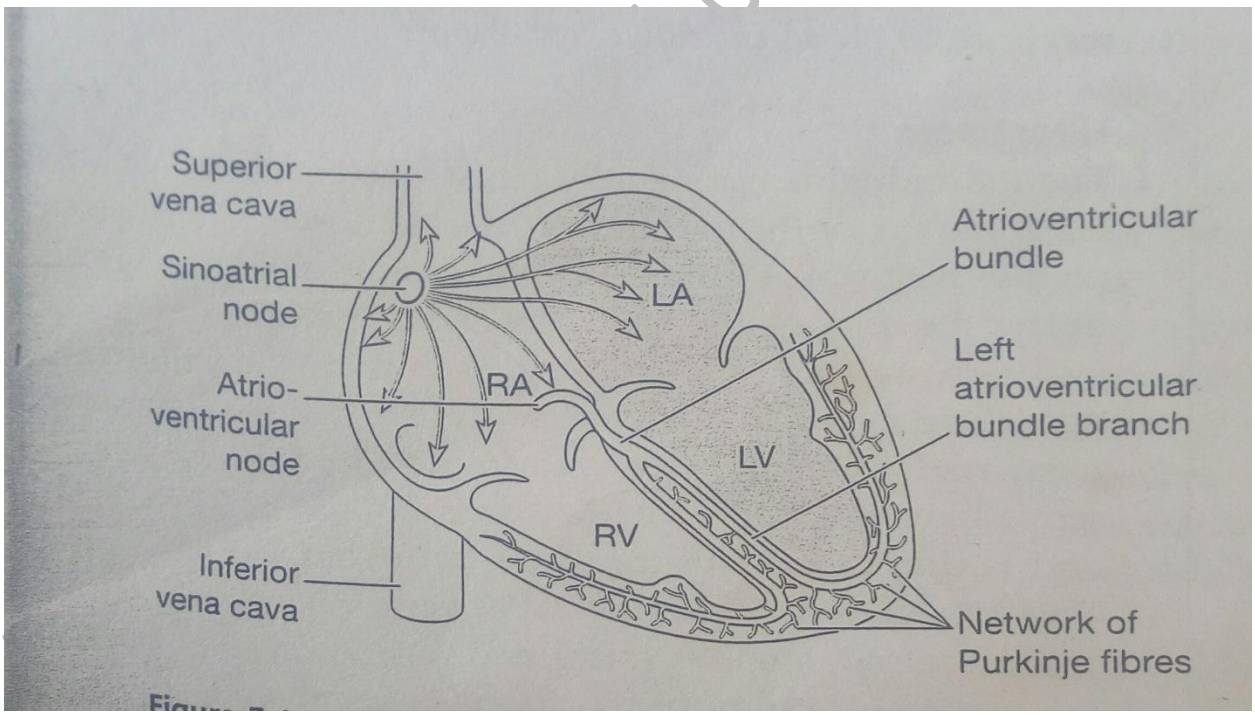

Fig 2.7 conduction system of the heart

Blood vessels of the heart

The heart pumps blood into the vessels that vary in size, structure and function. These vessels include: arteries, arterioles, capillaries, venules and veins. The heart pumps the blood into the arteries, the arteries divide and subdivide to form capillaries. The capillaries unite to form venules and finally the veins, which return blood to the heart. All blood vessels with lumina larger than the capillaries exhibit a common pattern of organization. The wall of each vessel contains 3 connective coats or tunica; 1) The tunica intima (innermost layer), 2) The tunica media(middle layer) and 3) The tunica adventitia (outer layer)(Fig 2.8).

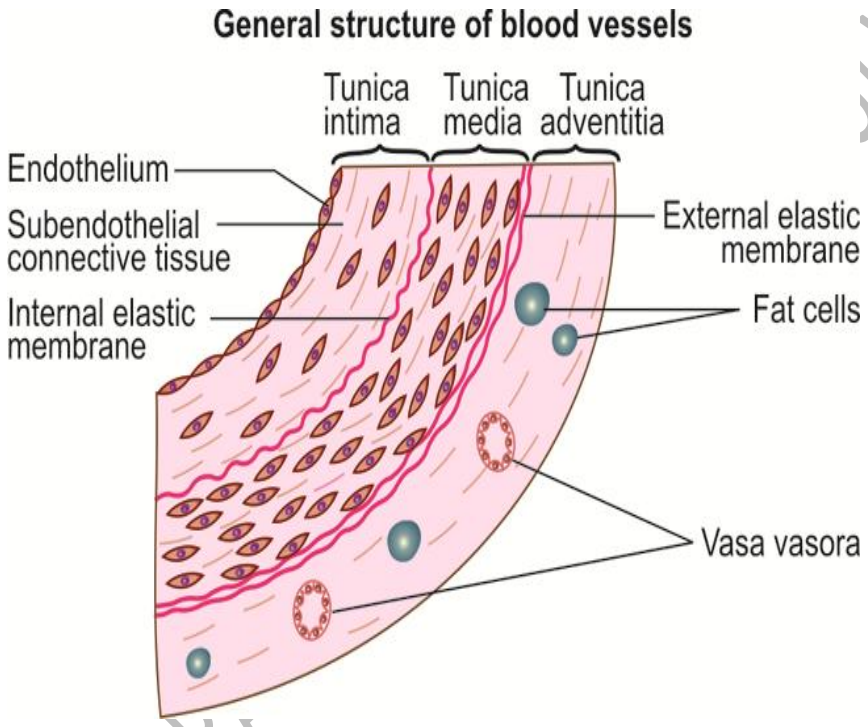

Fig 2.8 General structure of blood vessels

The major arteries and veins are discussed bellow;

The aorta

It is the largest artery of the body, which carries oxygenated blood from the left ventricle and distributes it to all parts of the body.

Parts of aorta:

1) The ascending aorta
2) The arch of aorta
3) The descending aorta(The thoracic aorta and the abdominal aorta)

The ascending aorta: It arises from the left ventricle and is about 5 cm long. It is enclosed in the pericardium. It arises at the level of 3rd costal cartilage and runs upwards, forwards and to the right. It becomes continuous with the arch of the aorta at the level of the sterna angle. The branches include the right and left coronary arteries that arise from the right and left aortic sinuses respectively.

The arch of the aorta: It is the continuation of the ascending aorta. It begins at the level of the sternal angle; runs upwards, backwards and to the left, arching over the root of the left lung. It ends at the lower border of the T4 vertebrae and becomes continuous with the descending thoracic aorta. Branches include(Fig. 2.9);

1) The brachiocephalic trunk, it divides into right common carotid and right subclavian arteries.
2) The left common carotid artery
3) The left subclavian artery
4) Occasionally, the thyroidea ima artery.

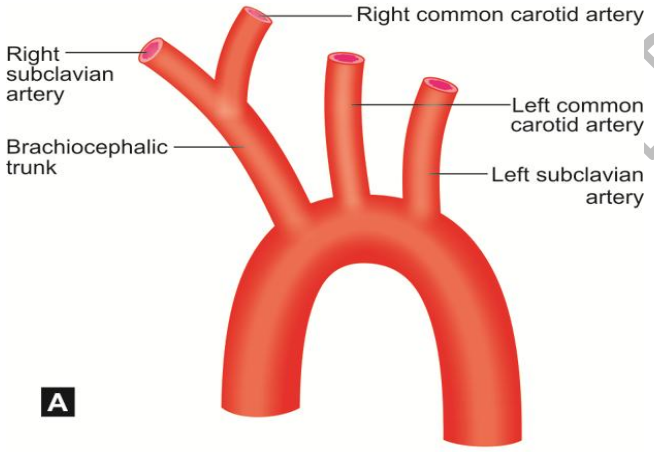

Fig 2.9 The arch of aorta

The brachiocephalic artery (or trunk): It arises behind the manubrium of the sternum from the convexity of the aortic arch. It is the first and largest branch of the aortic arch. It passes upwards, backwards and to the right, after crossing 5cm distance it divided into right subclavian artery and right common carotid artery.

The common carotid arteries: The right common carotid artery is a branch of the brachiocephalic trunk and the left common carotid artery is a direct branch of the arch of the aorta. The common carotid artery passes upwards, in the carotid sheath along with the internal jugular vein and the vagus nerve. At the level of the upper border of thyroid cartilage, it divides into 2 branches; the internal and external carotid arteries.

The external carotid artery: It is one of the terminal branches of the common carotid artery. It lies anterior to the internal carotid artery. It is the chief artery of supply to structures in the face and neck. It has further eight branches they are; superior thyroid, lingual, posterior auricular, facial , occipital, ascending pharyngeal, superficial temporal and maxillary.

The internal carotid artery: The internal carotid artery is one of the two terminal branches of the common carotid artery. It begins at the level of upper border of thyroid cartilage (opposite the disc between c3 and c4).**This is the principal artery of the brain and eye.**

The subclavian artery :It is the main artery of upper limb .The right subclavian artery is a branch of the brachiocephalic trunk and the left subclavian artery is a direct branch of the arc of the aorta .It passes over the first rib and grooves it .Then it passes behind the clavicle to enter the upper part of the axilla . At the outer border of the first rib, it continues as the axillary artery .The subclavian artery usually gives off branches including vertebral artery, internal thoracic artery , thyrocervical trunk, costocervical trunk(superior intercostal and deep cervical) and dorsal scapular artery. (Fig 3.1)

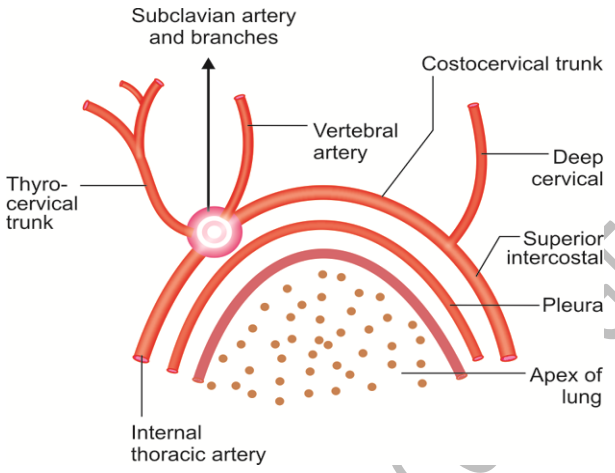

Fig 3.1 The subclavian artery

The axillary artery: This large vessel begins at the outer border of the 1st rib. It is the continuation of subclavian artery. The axillary artery ends at the lower border of teres major muscle; where it passes into the arm as the brachial artery. The axillary gives different branches from different parts they are given in the table 2.1 below;

Table 11.1: Parts and branches of axillary artery

Part	*Branches*
Part I	Superior thoracic artery
Part II	a. Thoracoacromial artery b. Lateral thoracic artery
Part III	a. Subscapular artery b. Anterior circumflex humeral artery c. Posterior circumflex humeral artery

Table 2.1

The brachial artery: This is the principal artery of the arm. It begins at the interior border of teres major as the continuation of axillary artery. In the cubital fossa, it ends opposite the neck of the radius. Under cover of the bicipital aponeurosis, the brachial artery divides into two terminal branches; the radial and ulnar artery. The branches include;

1) Muscular branches
2) The profunda brachii artery.
3) Nutrient artery to humerus.
4) Superior and inferior ulnar collateral arteries.

The radial artery: The radial artery begins in the cubital fossa opposite the neck of the radius. It is the smaller of the two terminal branches of the brachial artery(the other branch is the ulnar artery). The branches of the radial artery are; muscular branches, branches to the elbow joint , a branch to the superficial palmar arch and branches to the wrist.

The ulnar artery: It begins near the neck of the radius and is the larger of the two terminal branches of the brachial artery. It passes superficial to the flexor retinaculum and ends by forming the superficial palmar arch, with a branch of radial artery.

Palmar arches: There are two palmar arterial arches- the superficial palmar arch and the deep palmar arch. The superficial palmar arch is located distal to the deep palmar arch. It is formed mainly by the ulnar arch and is convex towards the digits. The deep palmar arch is formed mainly by the radial artery , is about a finger breadth proximal to the superficial palmar arch.

The descending aorta : The descending aorta, which is the continuation of the arch of the aorta, is divided into two parts: The thoracic part and the abdominal part(abdominal aorta).

The thoracic part: It is the continuation of the arch of the aorta. It lies in the posterior mediastinum. The descending thoracic aorta begins on the left side of the lower border of T4 vertebra. It descends with a slight inclination to the right and terminates at the lower border of the 12^{th} thoracic vertebra. It has a diameter of about 2cm.(Fig 3.2)

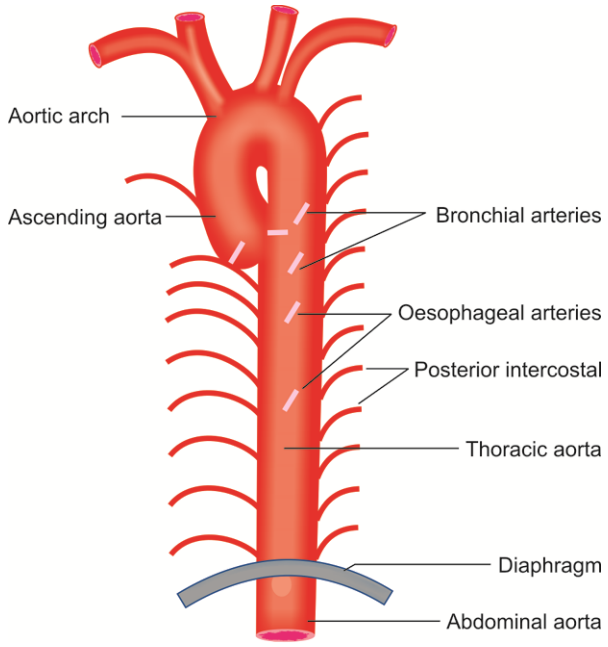

Fig 3.2 Thoracic aorta

The abdominal aorta: The abdominal aorta begins in the midline at the aortic opening of the diaphragm, opposite the body of T12 vertebra. It ends in front of the lower part of the body of L4 vertebra, by dividing into its two terminal branches, right and left common iliac arteries. The branches of abdominal aorta can be classified into the following groups; (fig 3.3)

1) Ventral branches: they supply the gut tube
2) Lateral branches
3) Dorsal branches
4) Terminal branches

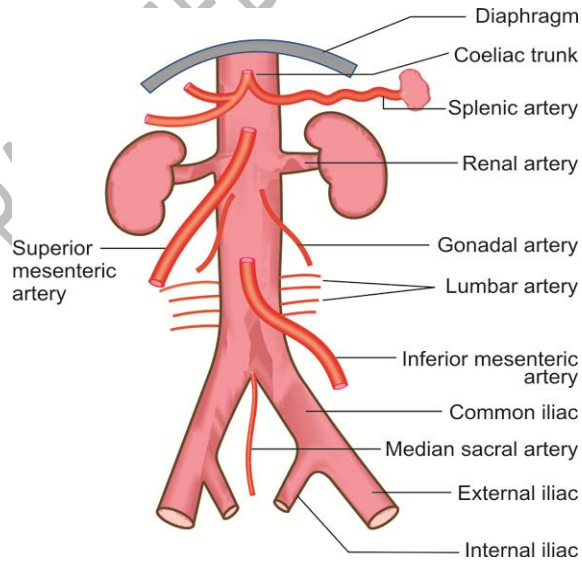

Fig 3.3 The abdominal aorta and its branches

The common iliac arteries: These are the terminal branches of the abdominal aorta, beginning at L4 vertebral level. The two common iliac arteries (right and left) pass downwards and laterally and end in front of the

sacroiliac joint ,by dividing into the external and internal iliac arteries. The external iliac artery is the larger of the two terminal branches of the common iliac artery. It starts in front of the sacroiliac joint, and then passes deep to the midinguinal point where it becomes the femoral artery. The internal iliac artery starts in front of the sacroiliac joint and runs to the upper border of the sciatic notch, where it divides into two divisions (anterior and posterior). It supplies almost all the pelvic viscera.

The femoral artery: This is the chief artery of the lower limb and is the continuation of the external iliac artery. It begins behind the inguinal ligament at the midinguinal point (midway between anterior superior iliac supine and pubic symphysis). It passes downwards first in the femoral triangle and then in the abductor canal. At the lower end of the abductor canal, it passes through an opening in the abductor magnus to continue as the popliteal artery

The Veins

Veins return blood to the heart from the tissues. Their walls are thinner than the arteries. Contracting skeletal muscles compress the veins, directing the blood towards the heart.

Veins of the abdomen: The inferior vena cava and the portal vein.

The inferior vena cava (IVC) f: it is the largest vein in the body (fig 3.4). The IVC returns blood from the lower limbs, most of the abdominal wall and the abdomino-pelvic viscera. It begins anterior to the L5 vertebra by the union of the two common iliac veins, inferior to the bifurcation of aorta. It oases through the vena caval opening in the diaphragm at the level of T8 vertebra. It then pierces the fibrous pericardium and enters the inferior part of the right atrium of the heart.

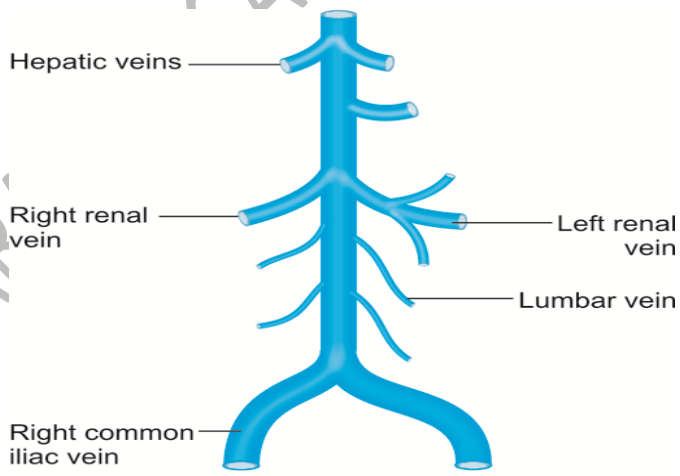

Fig 3.4 Inferior vena cava

The portal vein: The portal vein is the main channel of the portal system of veins. It starts in capillaries and ends in the venous sinusoids in liver. It has no valves. It collects blood from the abdominal part of the gastrointestinal tract, the gallbladder, the pancreas and carries it to the liver. In the liver it branches and re-branches to end in expanded capillaries or sinusoids. From the sinusoids, the blood is collected by hepatic veins, which drain into the inferior vena cava. It is formed by the union of the superior mesenteric vein and the splenic vein behind the neck of the pancreas, at the level of the L1. Its average length is 8.5 cm(Fig 3.5)

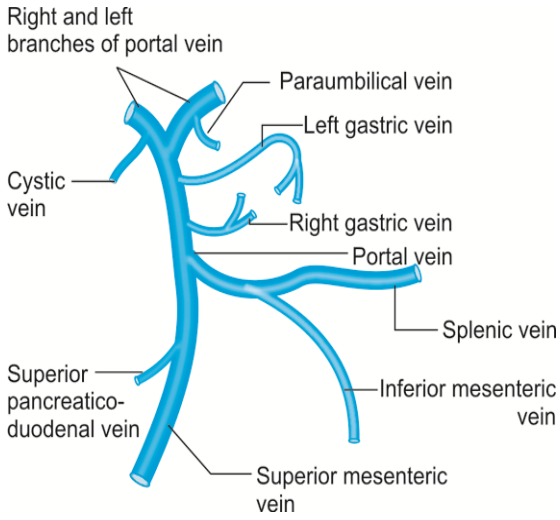

Fig 3.5Portal vein and tributaries

Communication between the portal and systemic veins – The Porto-systemic anastomoses

There are some areas , where the portal system of veins communicates with the systemic veins , they are as;

1) At the lower end of the esophagus: The venous plexus in the sub-mucosa of lower end of esophagus drains inferiorly into the left gastric vein ,which ends in portal vein and above into the azygous venous system , which inturn ends in the superior vena cava (systemic circulation)
2) Superficial veins of the anterior abdominal wall radiate from the umbilicus to drain into the axillary vein, saphenous vein or along the paraumbilical veins into the portal vein.
3) Sub mucous Venus plexus in the anal canal: These plexuses drain below into the inferior and middle rectal veins , which ultimately drain into the internal iliac and inferior vena cava(systemic veins) . Superiorly , the plexus is drained by the superior rectal vein , which continues as the inferior mesenteric vein and drains into the splenic vein(portal circulation).

The great saphenous vein or the long saphenous vein

It is the longest vein in the body. It begins as the continuation of the medial end of the dorsal venous arch of the foot; it passes upwards about 2.5 cm anterior to the medial malleolus and ascends along the medial surface of tibia to reach the knee. At the knee joint , the vein lies about the hand's breadth behind the patella, then it ascends along the medial side of the thigh to reach the saphenous opening. The vein passes through this opening, pierces the deep fascia and finally drains into the femoral vein.(Fig. 3.6))

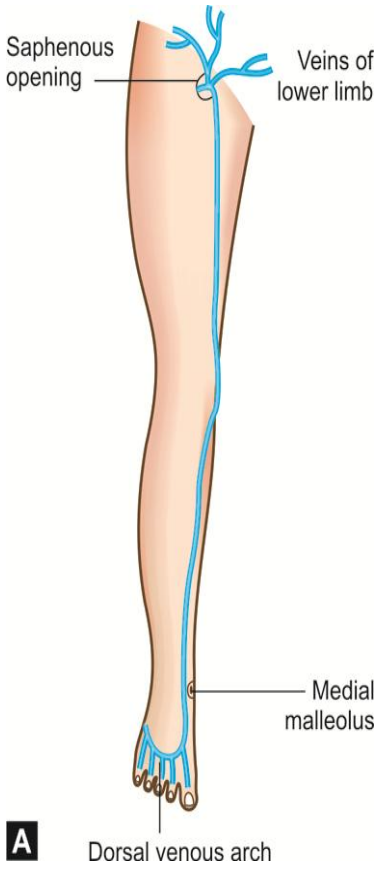

Fig 3.6 The great saphenous vein

Properties of the cardiac muscle:

The cardiac muscle has some unique characteristics, they are;

1) Contractility: By contraction of the cardiac muscles the heart pumps blood out of its chambers.
2) Conductivity: The cardiac muscle has a specialized conduction system through which the impulses for cardiac contraction are conveyed.
3) Rhythmicity: Cardiac muscle has an inherent property of rhythmic contractions. The cardiac contractions occur in a regular fashion. The two atria and ventricles contract alternatively.
4) Refractory period: During systole the heart does not respond to any stimuli, no matter how strong it is, this is called as the refractory period.

The cardiac cycle

The function of the heart is to maintain a constant circulation of blood throughout the body. The heart acts as a pump and its action consists of a series of events known as the cardiac cycle. During each heartbeat or cardiac cycle, the heart contracts and then relaxes. The period of contraction is called as systole and that of relaxation , as diastole(Fig 3.7)

The stages of the cardiac cycle

The normal number of cardiac cycles per minute ranges from 60 to 80. Taking74 as an example each cycle lasts about 0.8 0f a second and consists of:

- Atrial systole-contraction of the atria.
- Ventricular systole-contraction of the ventricles
- Complete cardiac diastole-relaxation of the atria and the ventricles.

The cycle of events occurs as follows:

1) To start with the superior vena cava and the inferior vena cava transport deoxygenated blood to right atrium and at the same time, the four pulmonary veins bring oxygenated blood into the left atrium.
2) This is followed by a contraction triggered by SA node, that spreads over the myocardium of both atria, emptying the atria and completing ventricular filling , i.e. **atrial systole (0.1 s).**
3) After that the AV node triggers its own electrical impulse, which quickly spreads to the ventricular muscle via the AV bundle, the bundle branches, and the purkinje fibres. This results in a wave of contraction which sweeps upwards from the apex of the heart and across the walls of both ventricles pumping the blood into the pulmonary artery and the aorta, i.e. **ventricular systole (0.3 s)**. The high pressure generated during the ventricular contraction is greater than that in the aorta and forces the atrioventricular valves to close, preventing backflow of blood into the aorta.
4) After contraction of the ventricles there is **complete cardiac diastole** (0.4 s), when atria and ventricles are relaxed. During this period the myocardium recovers in preparation for the next heartbeat, and the atria refill in preparation for the next cycle.

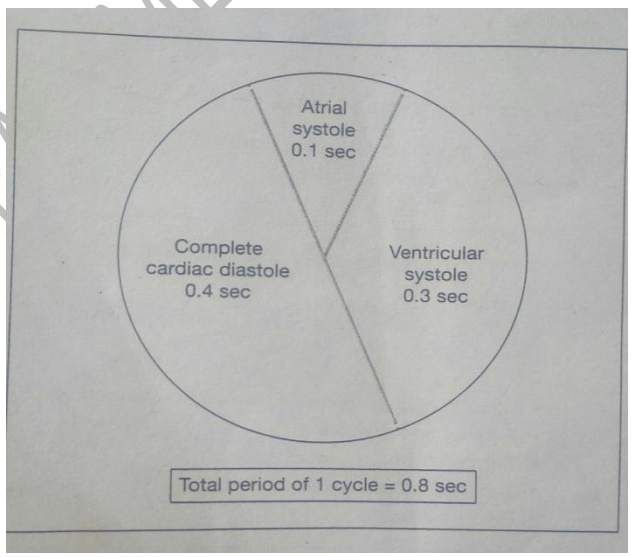

Fig 3.7 The Cardiac cycle

The heart sounds

An individual is not usually conscious of his heartbeat, but if the ear, or the diaphragm of a stethoscope, is placed on the chest wall a little below the left nipple and slightly near the midline the heartbeat can be heard. The are four heart sounds, each corresponds to a particular event in the cardiac cycle. The first two are most easily distinguished and can be heard with the stethoscope like , "LUP and DUB".

The first sound '**LUP'** is fairly loud and of long duration (0.1-0.17 s). It is due to the closure of the atrioventricular valves. This corresponds with the start of ventricular systole.

The second sound **'DUB'** is softer and of shorter duration (0.1-0.14 s). It is due to the closure of the aortic and pulmonary valves. This corresponds with atrial systole.

The heart rate

The heart rate determines the cardiac output and is measured in beats/ min. if heart rate rises the cardiac output also increases and if it falls cardiac output also decreases. The main factors affecting heart rate are outlined below:

Autonomic nervous system: The intrinsic rate at which the heart beats is a balance between the sympathetic and parasympathetic activity and this is the most important factor in determining the heart rate.

Circulating chemicals: Certain hormones like adrenaline, nor-adrenaline, thyroxin and some electrolytes, effect the heart rate.

Position: When the position is upright, the heart rate is usually faster than when lying down.

Exercise: It increases heart rate as active muscles need more blood than resting ones.

Emotional state: excitement, fear and anxiety leads to the increased heart rate.

Gender: Heart rate is faster in women than in men.

Age: heart rate is more in babies and adults than in old aged people.

Temperature: Temperature variations lead to variations in heart rate.

The pulse

The pulse is an alternate expansion (rise) and recoil (fall) of an artery as the wave of blood is forced through it during the contraction of the left ventricle. Pulse can be felt at any point where a superficial artery can be

pressed gently against a bone. When the left ventricle contracts, it forces about 60-80ml of blood through the already full aorta and the arteries. The walls of the arteries being elastic expand, as an added amount of blood is forced into them. The arteries relax as the wave of the blood passes, only to expand again with the next wave. This expansion and recoil of the arteries is the pulse and serves as an important indicator of the heart rate.

Characteristics of pulse

The characteristics of pulse are rate, rhythm, volume and tension.

Rate: Rate is defined as the number of pulse beats per minute. The normal rate in the resting adult is 60-100 per min. A pulse rate above 100/min is referred to be "tachycardia" and a rate below 60/min is referred to as bradycardia.

Rhythm: Rhythm refers to the regularity of beats. Normally the heart beats at regular intervals, when the interval varies, it is said to be irregular. The abnormal rhythm in the pulse is seen in the conditions like; arrhythmias, intermittent pulse, extra systoles, atrial fibrillation sinus arrhythmia etc.

Volume: Volume refers to the fullness of the artery. It is the force of the blood felt at each beat. If the arteries contain a normal volume of the blood , the pulse is said to be full or large in volume and if the volume of the blood is decreased the pulse will be weak, feeble or flickering.

Tension: It is the degree of compressibility. It is said to be high tension when the artery is difficult to compress and low tension when artery is easy to compress.

Sites of taking pulse (Fig 3.8)

Different sites for taking pulse are;

1) The radial artery in front of the wrist
2) Temporal artery over the temporal bone
3) Carotid artery at the sides of the neck
4) The brachial artery above the elbow and in the antecubital fossa(inner part of the elbow)
5) Femoral artery in the groin.
6) Popliteal artery in the popliteal fossa(back of the knee)
7) The dorsalis pedis artery on the foot
8) The posterior tibial artery behind the medial malleolus.

In infants the apical pulse is palpated to count the pulse rate.

Generally veins do not exhibit pulsation. The only vein that exhibits pulsation is Jugular Vein, which is nearer to the heart, called as the **jugular vein pulse (JVP).**

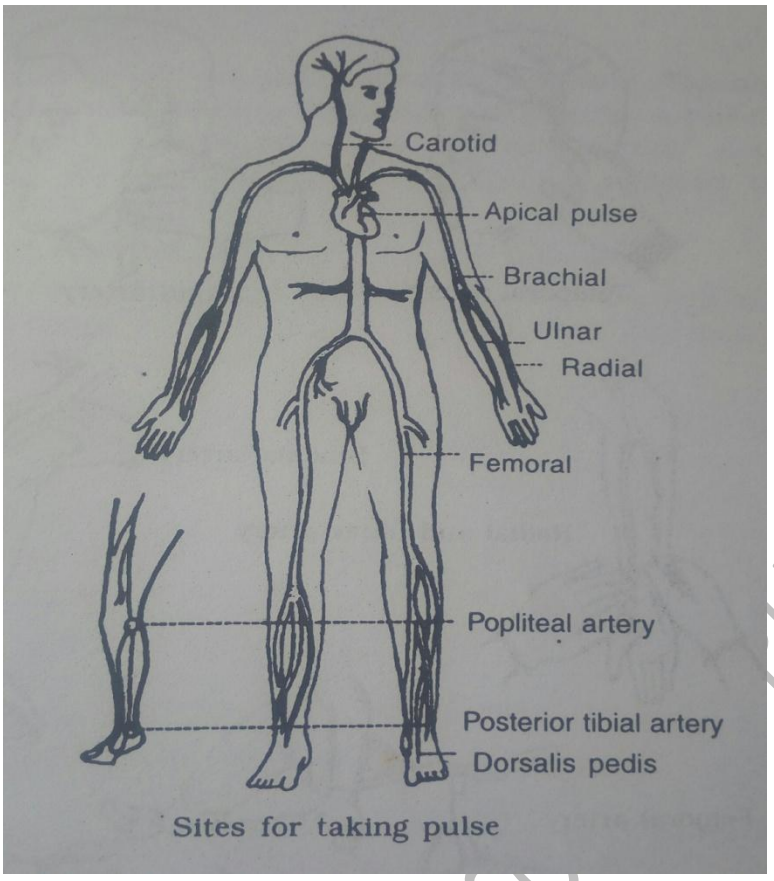

Fig 3.8 Diagram for sites of taking pulse

The blood pressure

Blood pressure is the force exerted by the blood on the walls of the blood vessels as it flows through them Systolic pressure is the highest degree of pressure exerted by the blood against the walls of the blood vessels during the ventricular systole when the left ventricle is forcing the blood into the aorta. Diastolic pressure is the lowest pressure that occurs when the heart is in its resting period just before the contraction of the left ventricle. The average blood pressure for the healthy adult is usually about 120/80 mm of Hg.

Factors causing variation in blood pressure

Age: Blood pressure is lower in children than adults. Pressure gradually increases until 45 to 50 years, after that it accelerates sharply.

Sex: There is no difference in B.P values between boys and girls until puberty. After that, females usually have a lower blood pressure than males of the same age until menopause when their pressure readings increases over males

Body build: B.P is higher in persons with over weight than in persons of same age with normal weight .Weight reduction usually decreases the blood pressure.

Race: Certain races e.g., Negroes will have higher B.P reading than other races.

Climate: Pressure norms are lower in tropical climates than temperate and highest in polar climates.

Time of the day: In all persons, B.P. is lowest in the early morning and then rises to a peak in the evening, and then it declines.

Exercise: Muscular exertion will raise the blood pressure.

Pain: Severe pain may cause temporary and marked increase in the blood pressure.

Emotion : Fear, worry, excitement and other emotional factors will raise the blood pressure to greater level .Blood pressure is more likely to be raised in persons who live in stressful urban environments or who have jobs with constant mental tension than in persons leading relaxed tranquil lives.

Drugs: The drugs such as amyl nitrate and nitroglycerin cause a decrease in the blood pressure .Certain drugs increase the blood pressure.

Disease condition: Diseases affecting the circulatory system and kidneys may increase the blood pressure .Disease that weaken the heart action may lower the blood pressure.

Hemorrhage: Hemorrhage causes a low blood pressure by decreasing the volume of blood in the blood vessels.

Instruments used in measuring the Blood Pressure

The standard instrument used to measure the blood pressure is called as a sphygmomanometer(Fig 3.9).There are two types of pressure manometers- mercury and aneroid. Both give accurate readings when they are functioning properly. The mercury manometer is used more commonly. It consists of a mercury manometer , cuff and hand pump.

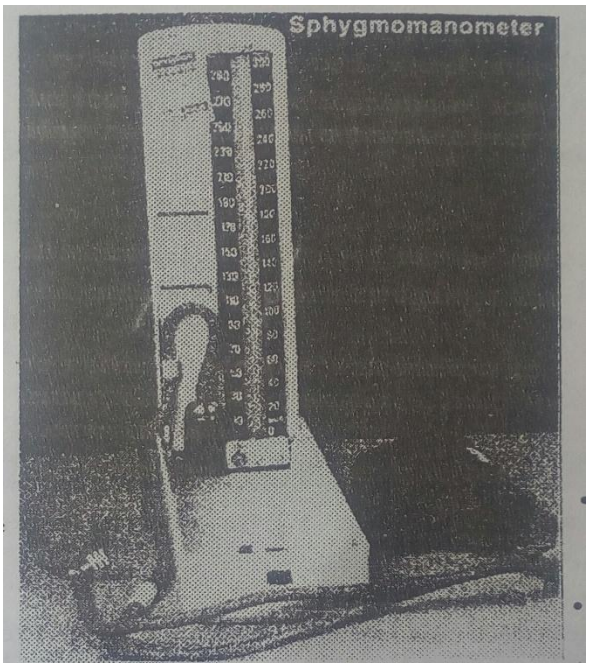

Fig 3.9 Diagram of sphygmomanometer.

Measurement of blood pressure

Preparation of the client :

Explain the procedure to the client to gain the confidence and cooperation of the client .

Place the client in a comfortable position either lying down with the arm resting on the bed or sitting with the arm supported on the table at the heart level.

Procedure:

1) Wash hands properly
2) Take the equipments to the bed side
3) Apply deflated cuff evenly with rubber bladder over the brachial artery, the lower edge being 2cm above the antecubital fossa. The two tubes turned towards the palm.
4) Palpate the brachial artery with finger tips and place the bell of the stethoscope on the brachial pulse.
5) Close the knob of the pump and pump air into the cuff until the sphygmomanometer reads 20mm above the level, where the radial pulsation disappears.
6) Open the knob slowly anticlockwise, note the reading on the manometer where the sound begins. This is the systolic pressure.
7) Continue to release the pressure slowly and note the point where the sound ceases. This is the diastolic pressure.
8) Allow the air to escape and mercury to fall zero.
9) Repeat the procedure after one minute, if any doubts are there.
10) Record the findings and reposition the client in the comfortable position.

Hypertension: It is blood pressure that is above normal. It is difficult to define the average normal blood pressure as it varies from one age group to other. The normal blood pressure in an adult is said to be 120/80 mmHg, with increasing age this value may also change, but the measurements above 140/90 mmHg is considered as higher than normal. A range of 40-50 normally exists between systolic and diastolic blood pressure.
Hypertension is described as essential (primary, idiopathic) or secondary to other diseases. Irrespective of the cause, hypertension commonly affects the kidneys.

Hypotension: It is a blood pressure below normal level. Low blood pressure usually occurs as a complication of other conditions, such as shock or Addison's disease, hemorrhage, MI , etc. Low blood pressure leads to inadequate blood supply to the brain. Depending on the cause, unconsciousness may be brief(fainting) or prolonged leading to even death.
Postural hypotension syncope(fainting): It is due to sudden fall of blood pressure on standing up quickly from a sitting or lying down position.

Shock: shock occurs when metabolic needs of the cells are not being met because of inadequate blood flow. In effect, there is a reduction in circulating blood volume, in blood pressure and in cardiac output. This cause tissue hypoxia, and inadequate supply of nutrients and the accumulation of waste products.
Cardiogenic shock: This occurs in acute heart disease when the damaged heart muscles cannot maintain an adequate cardiac output, e.g. in myocardial infarction.

The electrocardiogram (ECG)

It is the recording of electrical activity of the heart. Electrocardiograph is the instrument which is used to record the electrical current generated in the heart. By means of this instrument, the electrical current generated in the heart is conducted to remote parts of the body. The heart current can be recorded by connecting any two parts of the body with this instrument. The connections are called as leads. The ECG recordings are designed by letters P, Q, R, S, and T(Fig 4.1)
The wave P is caused by contraction of atria.
The wave Q, R and S are produced by the contraction of ventricles.
The wave T is produced by the relaxation of ventricles.
During diseases of the heart, theses waves are abnormal in shape and position.

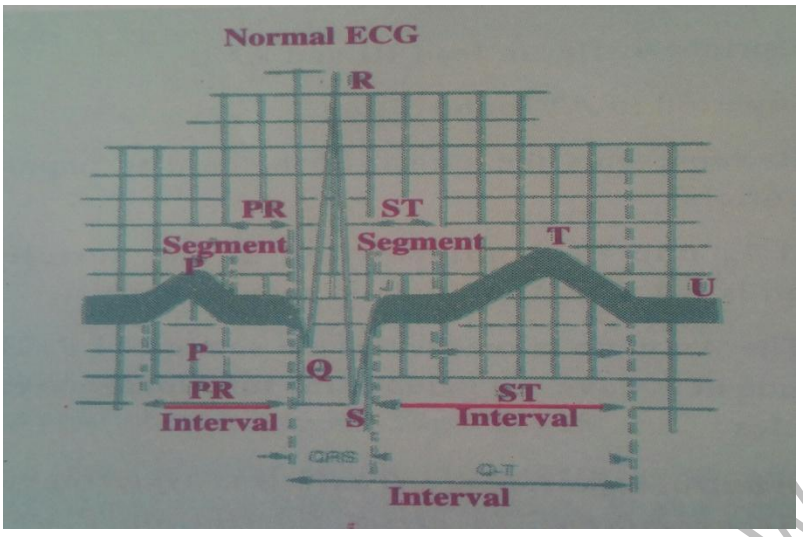

Fig 4.1The Normal ECG