Name of Unit	Cardiovascular System
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Learning Outcome of Module 05

LO	**Learning Outcome (LO)**	**Course Outcome Code**
LO1	To understand To explore anatomy and physiology heart	BP101.6
LO2	To understand anatomy of blood vessels and blood circulation.	BP101.6
LO3	To understand conduction system of heart and its regulation	BP101.6
LO4	To also focus on blood pressure and its regulation and ECG	BP101.6
LO5	To Know about disorders of blood	BP101.6

Table of Content

CARDIOVASULAR SYSTEM

Heart

INTRODUCTION

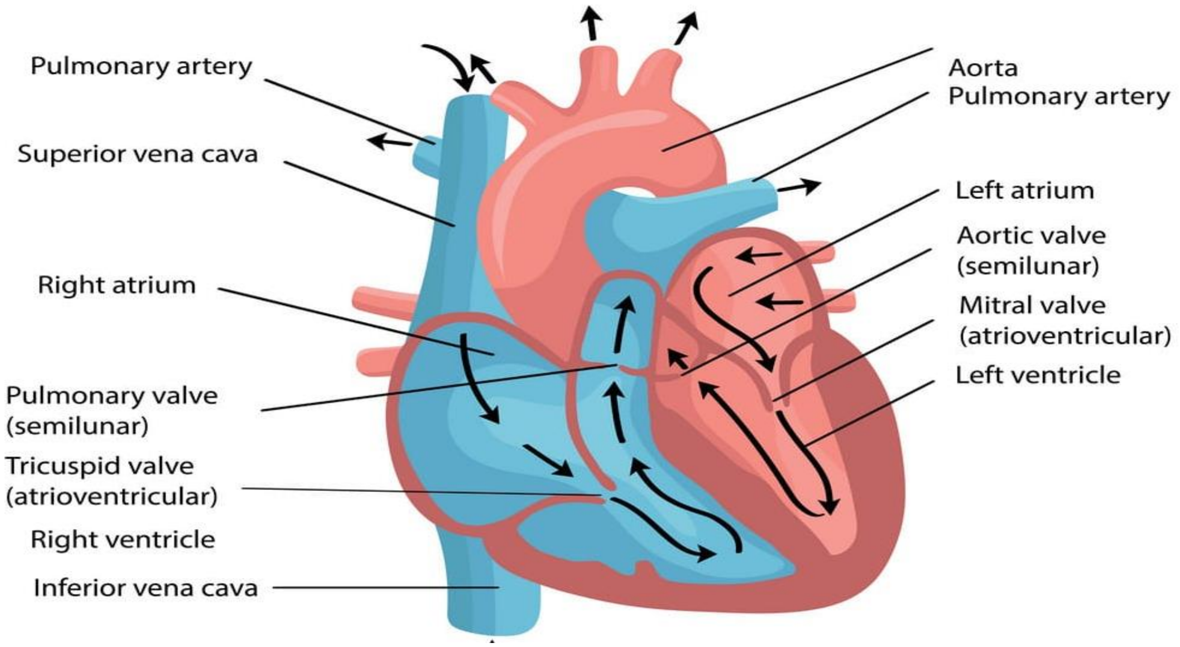
The human cardiovascular system comprises of the heart, blood vessels and blood supply. The components of the cardiovascular system supply vital oxygen, nutrients and hormones to tissues and remove carbon dioxide and metabolic waste products, It also plays an important role in stabilising body temperature and pH levels, as well as in maintains homeostasis.

Cardiology:

It is the branch of science which deals with the study of heart and the diseases associated with it.

ANATOMY OF THE HEART

The heart is a small structure, roughly the same size as that of a person's closed fist.The dimensions of heart is 12 cm long, 9 cm wide and 6 cm thick.The average weight is 250 g in adult females and 300 g in adult males. It rests on the diaphragm, near the middle of thoracic cavity. It lies in the mediastinum that extends from the sternum to the vertebral column the first rib to the diaphragm and between the lungs. About two third of the heart lies to the left of the midline. It consists of four chambers: two atria and two ventricles.



Internal structure of heart

Structure of Pericardium and Heart Wall:

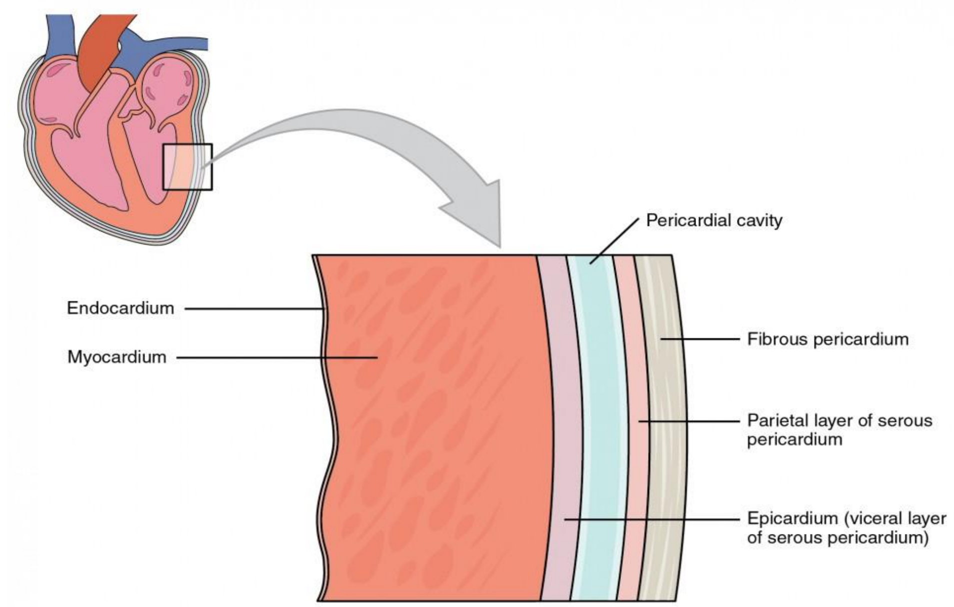
The membrane that surrounds and protects the heart is the pericardium. It confines the heart to its position, while allowing sufficient freedom of movements for contraction. It consists of two main parts.

Fibrous Pericardium:

It is composed of tough, inelastic, dense irregular connective tissue. The fibrous pericardium prevents overstretching of the heart, provides protection and holds the heart at particular position.

Serous Pericardium:

It is a thinner, more delicate membrane that forms a double layer around the heart. The outer parietal layer of serous pericardium also called as epicardium (external layer of heart wall). The space in between parietal and visceral layer is filled with pericardial fluid which is secreted by serous membrane itself. The space that contains the pericardial fluid called as pericardial cavity.



Structure of pericardium

Heart Wall:

The wall of heart consists of three layers.

Epicardium (External layer):

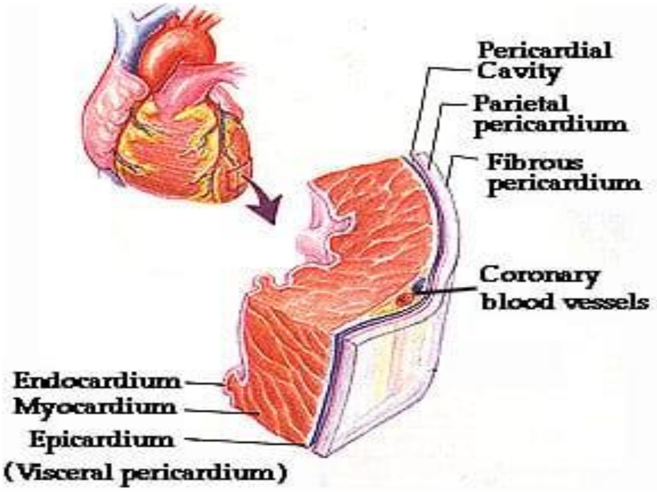
It is the outermost, thin, transparent layer of heart wall is also called as visceral layer of the serous pericardium. It is composed of delicate connective tissue that imparts smooth, slippery texture to the outermost surface of heart.

Myocardium (Middle layer):

It is middle layer made up of cardiac muscle tissue. This middle layer makes up the bulk of the heart and is responsible for pumping action.

Endocardium (Inner layer):

It is the inner layer of myocardium. It consists of thin layer of endothelial cells. It provides smooth lining for the chambers of heart and covers the valves of the heart. The endocardium continues with the endothelial lining of the large blood vessels attached to the heart.



Structure of heart wall

Chambers of the Heart:

The thickness of the walls of four chambers varies according to their functions. The atria are thin walled because they have to deliver blood into the ventricles. Right and left sides of the heart act as two separate pumps. The left side of heart has much larger work load than the right side of the heart. The left ventricle pumps blood to a great distance and at a high pressure to other parts of the body. Therefore, left ventricle works much harder than the right ventricle to maintain the same rate of blood flow. The muscular wall of left ventricle is two to four times as thick as wall of the right ventricle. Right ventricle pumps blood only to the lungs (pulmonary circulation), the left ventricle pumps blood to all other parts of the body (systemic circulation).

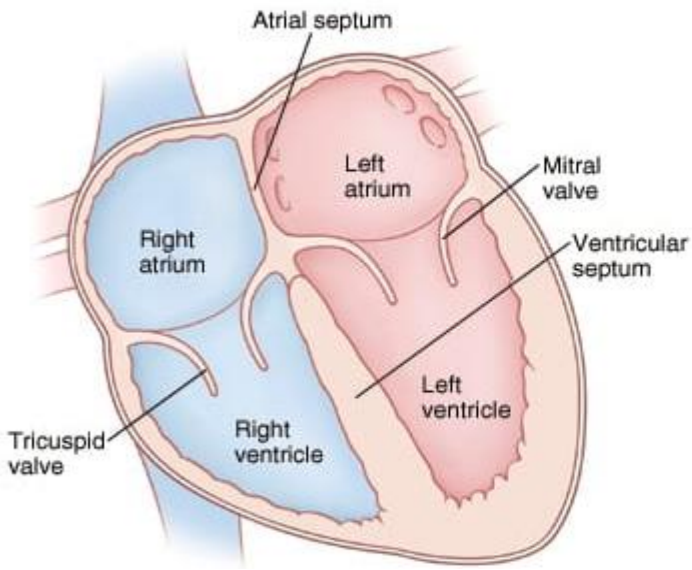
The heart has four chambers:

✓ **Two superior chambers**

Right atrium and Left atrium

✓ **Two inferior chambers**

Right ventricle and Left ventricle.



Chambers of heart

Right Atrium:

Externally, right atrium is roughly quadrangular in shape and can be divided into anterior part and posterior part. Superior vena cava present at the upper posterior part and inferior vena cava present at the lower posterior part. It has an appendage called auricle, which resembles a dog's ear.

Right Ventricle:

Externally, it is concave and forms a large part of heart. The wall of right ventricle varies greatly in thickness. It is much thinner than left ventricles. The wall of right ventricle is thickest at its atrial end and thinner towards the apex ventricle.

Left Atrium:

The wall of left atrium is thicker. It is smaller in shape than right atrium. It is roughly cuboidal in shape. The left auricle is longer, narrower and more curved than the right auricle. Four pulmonary veins open at the upper part of the left atrium. The auricle opens into the left atrioventricular orifice guarded by bicuspid valve (mitral valve).

Left Ventricle:

It functions as a powerful pump operating at the highest pressure and hence the walls are three times thicker as that of right ventricle. It is cone shaped, longer and narrower than right ventricle.

Externally, a groove known as coronary sulcus separates the atria from the ventricle. The anterior interventricular sulcus and posterior interventricular sulcus separates the right and left ventricles externally. Sulci contain coronary blood vessels and variable amount of fat. A wall known as the interventricular septum separates the two ventricles.

VALVES OF THE HEART

A heart valve normally allows blood flow in only one direction through the heart. As each chamber of heart contracts, it pushes a portion of blood into a ventricle or out of the heart through an artery. To prevent back flow of blood, the heart has valves. Valves are composed of dense connective tissue covered by endocardium. The four valves in the heart are:

✓ The two atrioventricular (AV) valves, which are between the atria and the ventricles, are the mitral valve and the tricuspid valve.

✓ The two semilunar (SL) valves, which are in the arteries leaving the heart, are the aortic valve and the pulmonary valve.

Atrioventricular valves (AV valves):

These are small valves that prevent backflow of blood from the ventricles into the atrium during systole. It lies between the atria and ventricles. It is composed of two types of valves, the tricuspid and bicuspid or mitral valve.

Tricuspid Valve:

The right AV valve between right atrium and right ventricle is called as tricuspid valve because it consists of three cusps (flaps).

✓ Septal valve

✓ Anterior cusp

✓ Posterior cusp

Bicuspid Valve:

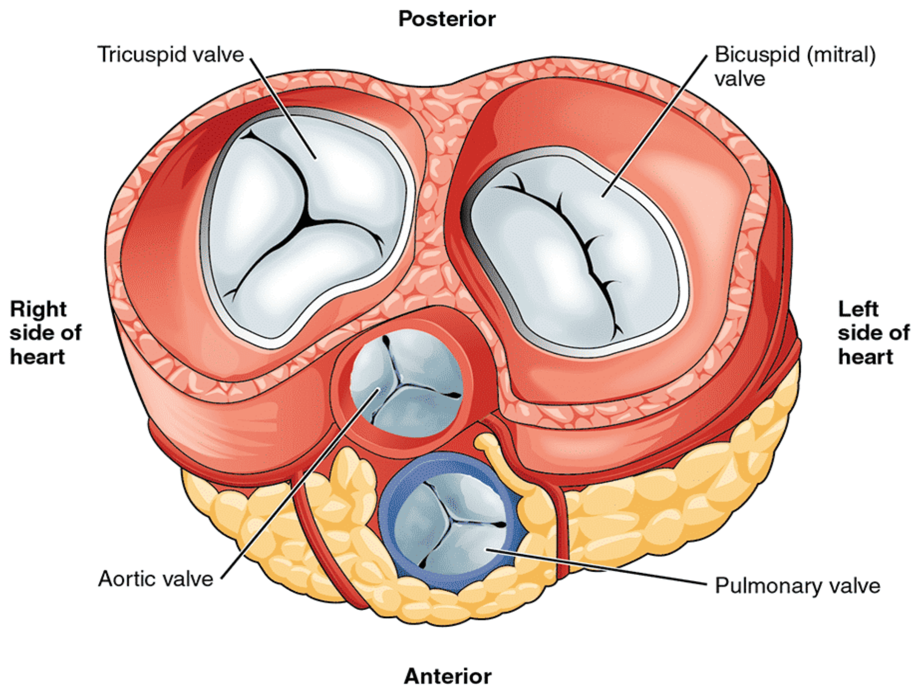
The left AV valve between left atrium and left ventricle is called as bicuspid valve because it consists of two cusps.It is also called as mitral valve. They open in one direction. Due to this arrangement, they prevent the back flow of blood from ventricles to the atria, during systole.

Semilunar Valves (SL. Valve):

These are located at the base of both the pulmonary trunk (pulmonary artery) and the aorta, the two arteries taking blood out of the ventricles. These valves permit blood to be forced into the arteries, but prevent backflow of blood from the arteries into the ventricles.

Pulmonary Semilunar Valve:

The pulmonary valve is the semilunar valve of the heart that lies between the right ventricle and the pulmonary artery. It has three cusps. The pulmonary valve opens in ventricular systole, when the pressure in the right ventricle rises above the pressure in the pulmonary artery. At the end of ventricular systole, when the pressure in the right ventricle falls rapidly, the pressure in the pulmonary artery closes the pulmonary valve.



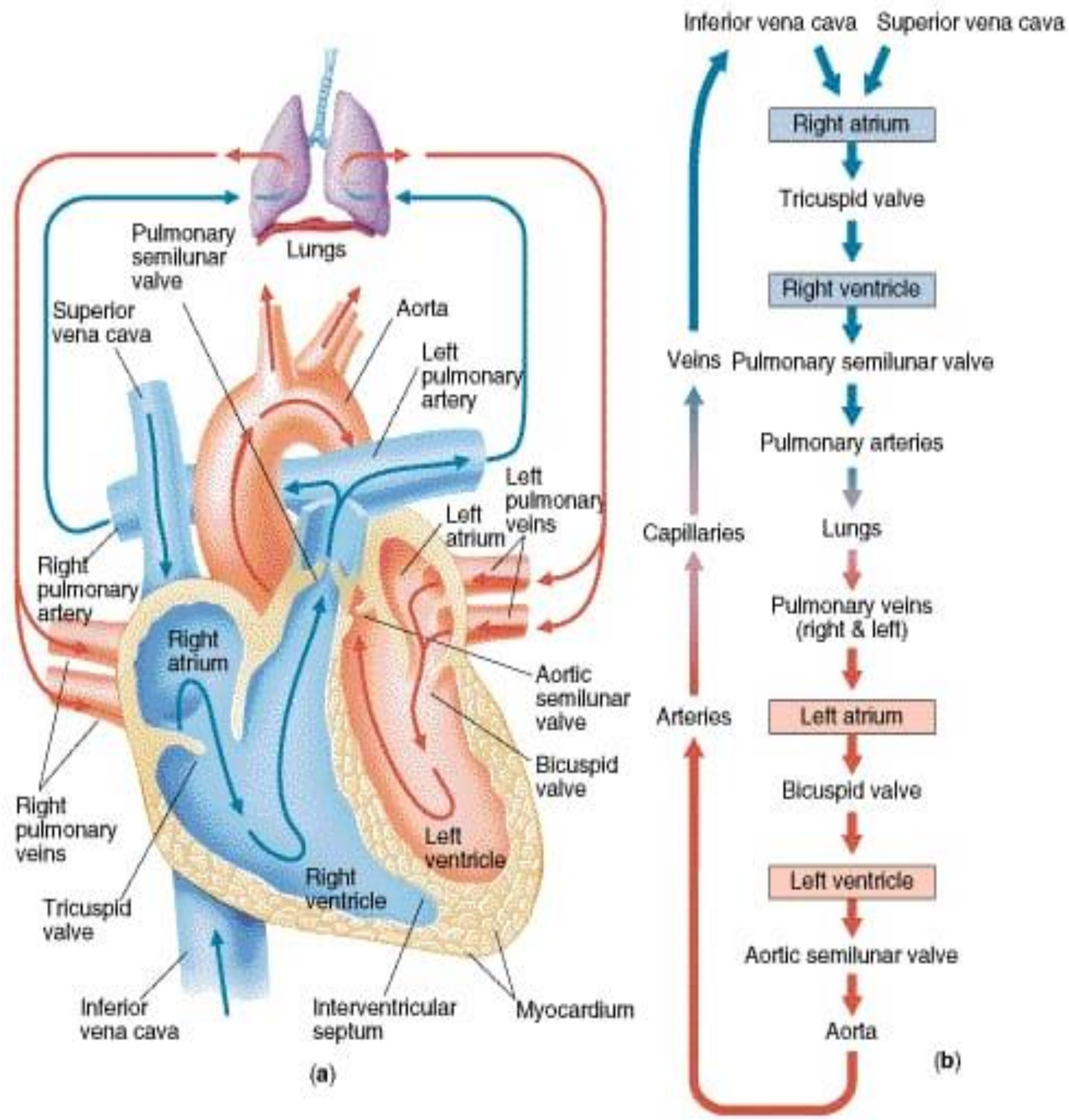
Valves of heart

Aortic Semilunar Valve:

The aortic valve lies between the left ventricle and the aorta. It has three cusps. During ventricular systole, pressure rises in the left ventricle. When the pressure in the left ventricle rises above the pressure in the aorta, the aortic valve opens, allowing blood to exit the left ventricle into the aorta. When ventricular systole ends, pressure in the left ventricle rapidly drops. When the pressure in the left ventricle decreases, the aortic pressure forces the aortic valve to close.

BLOOD FLOW THROUGH THE HEART

The left side of the heart is the pump for systemic circulation. It receives bright red, oxygen-rich blood from the lungs. The left ventricle ejects blood into the aorta. From the aorta the blood divides into smaller systemic arteries that carry it to all organs throughout the body, except for the air sacs alveoli of the lungs, which are supplied pulmonary circulation

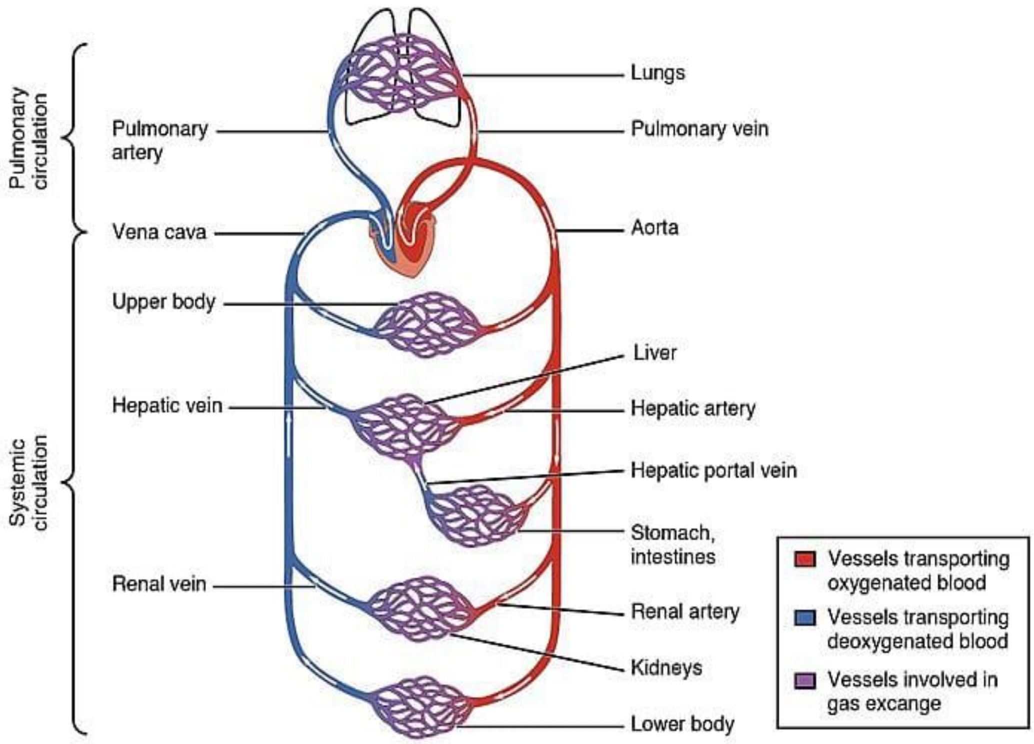


Blood flow through heart

In systemic tissues, arteries give rise to smaller diameter arterioles, which finally lead into extensive beds of systemic capillaries. The exchange of nutrients and gases occurs across the thin capillary walls. The blood unloads Oz (oxygen) and picks up CO2 (carbon dioxide). In most cases, blood flows through only one capillary and then enters a systemic venule. Venules carry deoxygenated blood away from tissues and merge to form larger systemic veins. Ultimately the blood flows back to the right atrium. The right side of the heart is the pump for pulmonary circulation. It receives all the dark red, deoxygenated blood returning from systemic circulation.

The blood ejected from the right ventricle flows into the pulmonary trunk, which branches into pulmonary arteries that carry blood to the right and left lungs. In pulmonary capillaries, blood unloads CO2, which is exhaled and picks up inhaled O2- Freshly oxygenated blood then flows into pulmonary veins and returns to the left atrium.

Systemic and Pulmonary Circulation:



Systemic and pulmonary circulation

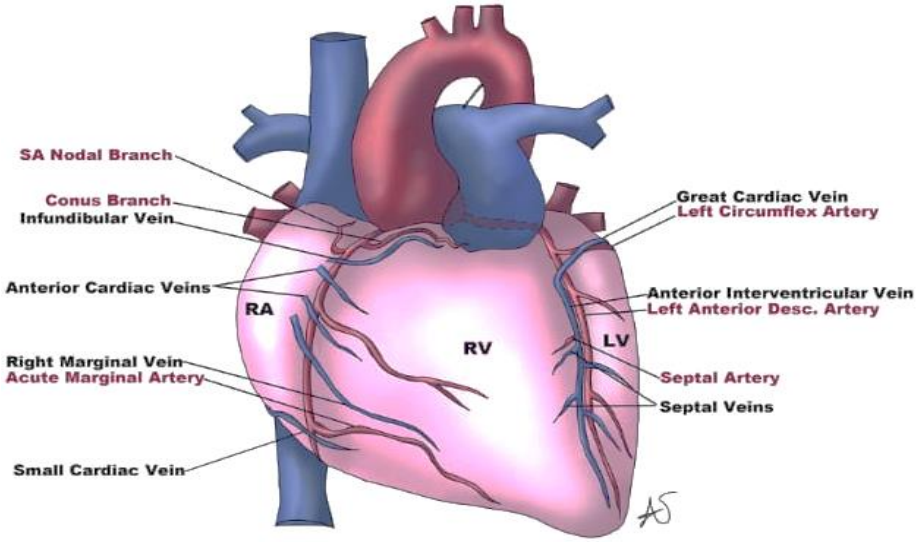
Coronary Circulation:

The heart tissue receives nourishment through the capillaries located in the heart. Serious heart damage may occur if the heart tissue (myocardium) does not receive normal supply of blood and oxygen. Coronary circulation refers to the movement of blood through the tissues of the heart. The myocardium has its own network of blood vessels, the coronary or cardiac circulation. The coronary arteries branch from the ascending aorta and encircle the heart like a crown encircles the head. While the heart is contracting, little blood flows in the coronary arteries as squeezed shut. When the heart relaxes, the high pressure of blood in the aorta propels blood through the coronary arteries, into capillaries, and then into coronary veins.

Coronary Arteries:

Two coronary arteries, the right and left coronary arteries, branch from the ascending aorta and supply oxygenated blood to the myocardium.

The left coronary artery passes inferior to the left auricle and divides into the anterior interventricular and circumflex branches. The anterior interventricular branch or left anterior descending (LAD) artery is in the anterior interventricular sulcus and supplies oxygenated blood to the walls of both ventricles. The circumflex branch lies in the coronary sulcus and distributes oxygenated blood to the walls of the left ventricle and left atrium. The right coronary artery supplies small branches to the right atrium. It continues inferior to the right auricle and ultimately divides into the posterior interventricular and marginal branches. The posterior interventricular branch follows the posterior interventricular sulcus and supplies the walls of the two ventricles with oxygenated blood. The marginal branch in the coronary sulcus transports oxygenated blood to the myocardium of the right ventricle.



Coronary arteries and Veins

Coronary Veins:

After blood passes through the arteries of the coronary circulation, it flows into capillaries, where it delivers oxygen and nutrients to the heart muscle and collects carbon dioxide and waste, and then enters into coronary veins. Most of the deoxygenated blood from the myocardium drains into a large vascular sinus in the coronary sulcus on the posterior surface of the heart, called the coronary sinus. The deoxygenated blood in the coronary sinus empties into the right atrium.

The principal veins carrying blood into the coronary sinus are as follows:

✓ Great cardiac vein in the anterior interventricular sulcus, which drains the areas of the heart supplied by the left coronary artery (left and right ventricles and left atrium).

✓ Middle cardiac vein in the posterior interventricular sulcus, which drains the areas supplied by the posterior interventricular branch of the right coronary artery (left and right ventricles).

✓ Small cardiac vein in the coronary sulcus, which drains the right atrium and right ventricle

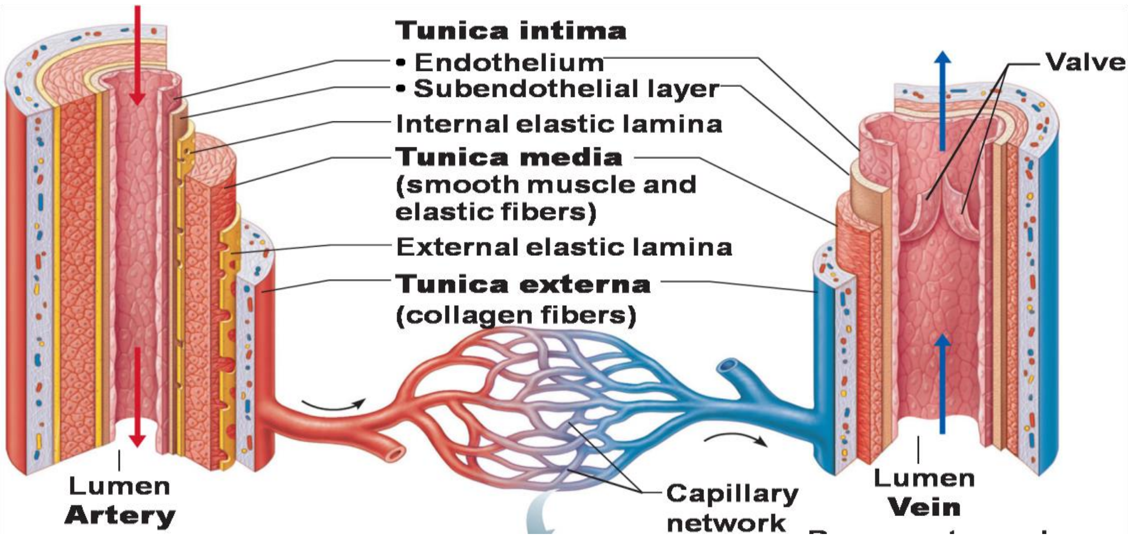
✓Anterior cardiac veins, which drains the right ventricle and open directly into the right atrium when blockage of a coronary artery deprives the heart muscle of oxygen.

BLOOD VESSELS

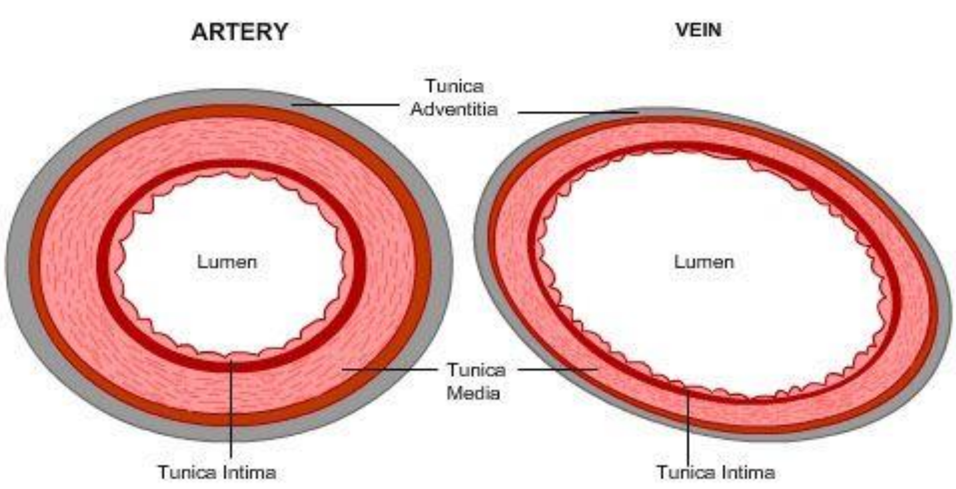
The heart pumps blood into vessels that vary in structure, size and function.

Five main types of blood vessels are;

✓ Arteries ✓ Arterioles ✓ Capillaries ✓ Venules ✓ Veins



Relationship between heart and different types of blood vessels



Structure of an artery and vein

Arteries:

Arteries are the blood vessels that carry blood vessels away from the heart to other organs. The wall of artery has three coats or tunics.

✓ **Tunica interna/intima:** It contains a lining of simple squamous epithelium called as endothelium, a basement membrane.

✓ **Tunica media:** It is thickest layer and it consists of elastic fibres and smooth muscle fibres that extend circularly around the lumen like a ring.

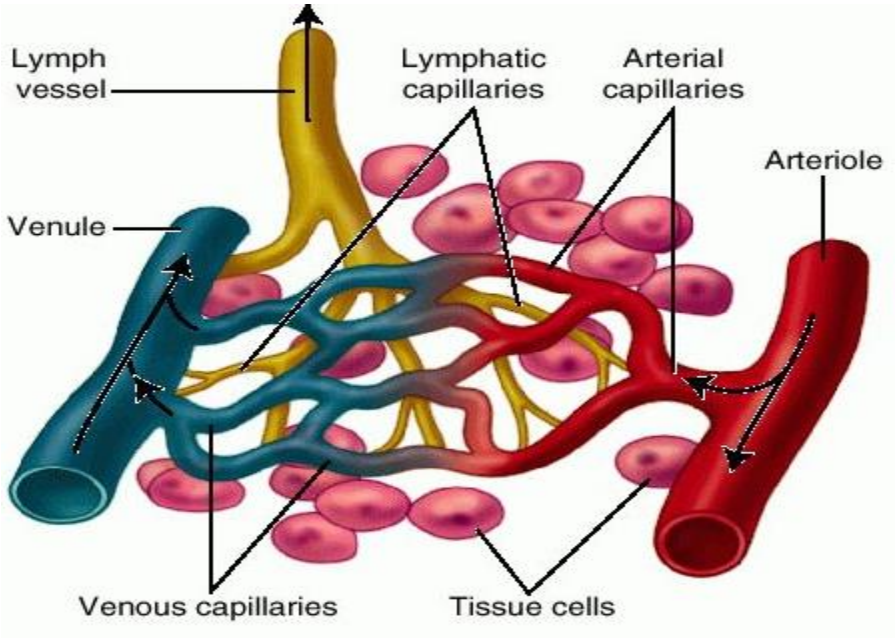
✓ **Tunica externa**: This outer layer or adventitia or outer layer made up of elastic and collagen fibres.

Arterioles

Larger arteries leave the heart and divide into medium sized muscular arteries. Medium sized arteries then divide into small arteries which in turn divide into still smaller arteries called as arterioles. An arteriole is very small ranging in diameter from 10 to 100 um. It delivers blood and regulates the flow of blood to capillaries.

Capillaries:

The smallest arterioles break up into a number of minute vessels called as capillaries. These are microscopic vessels that connect arterioles to venules. Its diameter is 4 to 10 micro meters. The flow of blood from arterioles to venules through capillaries is called the microcirculation They are the sites of nutrients and waste exchange between the blood and body cells.



Arteriole, capillaries and venue

Venules:

The groups of capillaries within a tissue reunite to form small veins called as venules. The smallest veins are called as venules. The diameter is 10 to 100 micro meters. They collect blood from capillaries and deliver it to vein.

Veins:

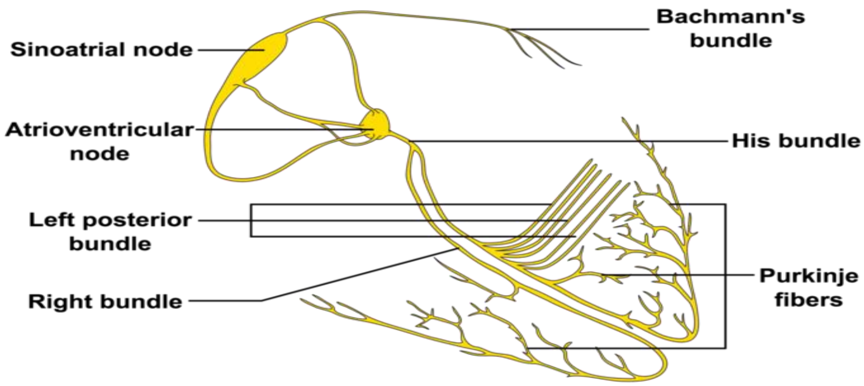
The veins are the blood vessels that convey blood from the tissues back to the heart. Its diameter ranges from 0.1 mm to greater than 1 mm. It consists of three coats as that of artery. They are thinner because there is less muscle and elastic tissue in tunica media. Veins carry blood at lower pressure than arteries.

CONDUCTING SYSTEM OF THE HEART

A special system is available in the heart which is responsible for the rhythmic contraction and conduction of impulses in the heart. The rate at which the heart conducts electrical impulses is called as the cardiac conduction

This system can be divided into five parts.

- ✓ SA node or Sino atrial node
- ✓ AV node or Atrioventricular node
- ✓ AV bundle or bundle of His
- ✓ Right and left bundle branches
- ✓ Conduction myofibrils (Purkinje fibres)



CONDUCTING SYSTEM OF THE HEART

SA Node:

Cardiac excitation begins in the SA node, located in the right atrial wall just below the opening of superior vena cava. The action potential from the SA node propagates throughout both the atrium. On receiving the action potential, the atrium undergoes contraction. Each SA node action potential travels throughout the heart via the conduction system.

AV Node:

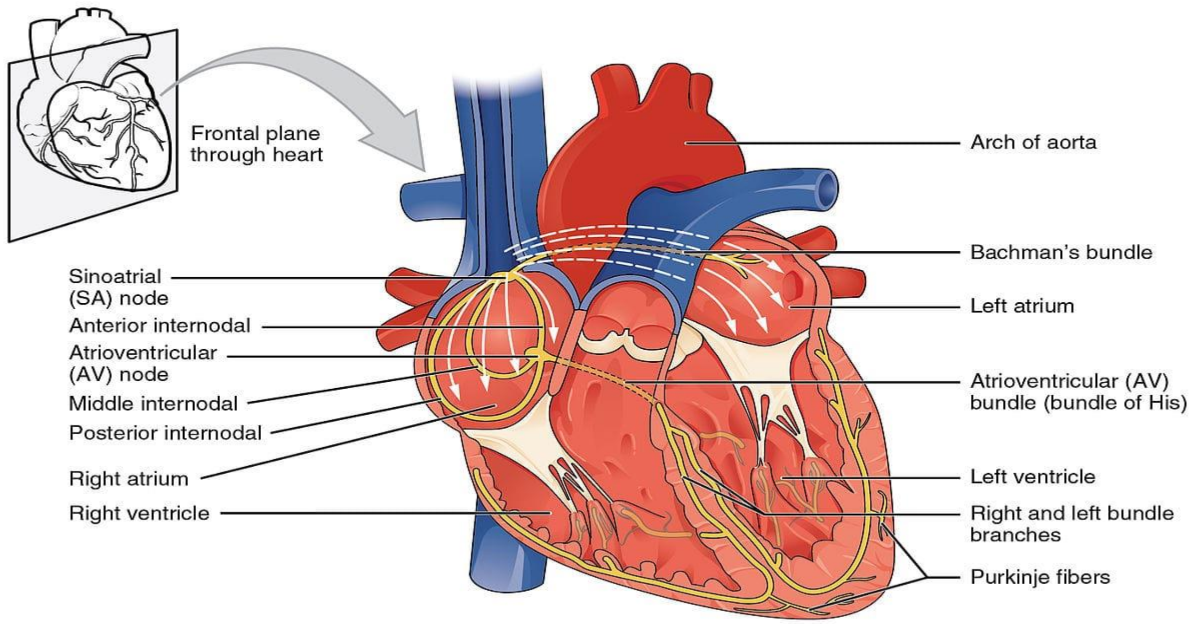
The atrioventricular (AV) node lies on the right side of the partition that divides the atria, at the bottom of the right atrium. There is a brief delay when the impulses from the SA node reaches the AV node. During this period, the atria contract and empty their contents. Once the atria are empty of blood, the valves between the atria and ventricles close. The atria begin to refill and the electrical stimulus passes through the AV node and Bundle of his into the Bundle branches and Purkinje fibres.

AV Bundle (Bundle of His):

The Bundle of His connects with the distal part of the compact AV node and penetrates the membranous septum. From the AV node, the action potential enters the bundle of His, the only electrical connection between atria and ventricle. This bundle of fibres branches off into two bundles and the impulses are carried down the center of the heart to the left and right ventricles.

Right and Left Bundle Branches:

The bundle branches originate at the superior margin of the muscular interventricular septum, immediately below the membranous septum.After travelling along the AV bundle, the action potential then enters both the right and left bundle branches that runs through the interventricular septum towards the apex of the heart



Conducting system of heart

Purkinje Fibres:

These fibres are less concentrated at the base of the ventricle and the papillary muscle tips. The Purkinje fibres connect with the ends of the bundle branches to form interweaving networks on the endocardial surface of both ventricles. They penetrate only the inner third of the endocardium. They transmit the cardiac impulses almost simultaneously to the entire right and left ventricular endocardium.

CARDIAC OUTPUT

It is the volume of blood ejected from the left ventricle (or the right ventricle) into the aorta (or pulmonary trunk) each minute.

Cardiac output equals the stroke volume (SV), the volume of blood ejected by the ventricle during each contraction, multiplied by the heart rate (HR), the number of heart beats per minute:

CO = SV X HR

(mL/min.) (mL/beat) (beats/min.)

In a typical resting adult male, stroke volume averages 70 ml/beat, and heart rate is about 75 beats/min. Thus, average cardiac output is

CO = 70 mL/beat x 75 beats/min

= 5250 mL/min.

= 5.25 L/min.

This volume is close to the total blood volume, which is an about 5 liters in an adult male.

HEART SOUND

Auscultation is the act of listening to heart sounds with the help of stethoscope. The sound of heart beat comes primarily from blood turbulence caused by the closing of heart valves. During each cardiac cycle, there are four heart sounds, but in a normal heart only the first and second heart sounds (S1and S2) are loud enough to be heard through a stethoscope.

S1: It is caused by blood turbulence associated with closure of the AV valves soon after the ventricular systole begins. It is called as lubb sound, it is louder and longer than the second sound.

S2: It is caused by blood turbulence associated with closure of the semilunar valves at the beginning of ventricular diastole. It is called as dupp sound which is shorter than and not as loud as S1.

S3: It is a faint sound associated with blood turbulence during rapid ventricular filling.

S4: It is another faint sound caused due to blood turbulence during atrial systole.

CARDIAC CYCLE

The events occurring in the heart from the beginning of one heart beat to the beginning of other heart beat is called as cardiac cycle. In a normal cardiac cycle, the two atria contracts while the two ventricles relax. Then, the two ventricles contract and the two atria undergo relaxation. The term systole refers to the phase of contraction while diastole refers to the phase of relaxation. A cardiac cycle consists of systole and diastole of both the atria plus systole and diastole of both the ventricles.

A cardiac cycle is divided into three phases:

✓ Phase of ventricular filling

✓ Phase of relaxation period

✓ Phase of ventricular contraction

Phase of Ventricular Filling:

During ventricular relaxation, large amount of blood collects in the atria, as the AV valve are closed. This increases the pressure in the atria and AV valves get opens and semilunar valves are closed. So, the blood flows rapidly into the ventricles. The initial 1/3th time of ventricular filling is called as period of rapid ventricular filling. A small amount of blood flows into the ventricles.

P-wave on ECG indicated atrial depolarization. During the phase of ventricular filling, the AV valves are open and semilunar valves are closed.

Phase of Ventricular Contraction:

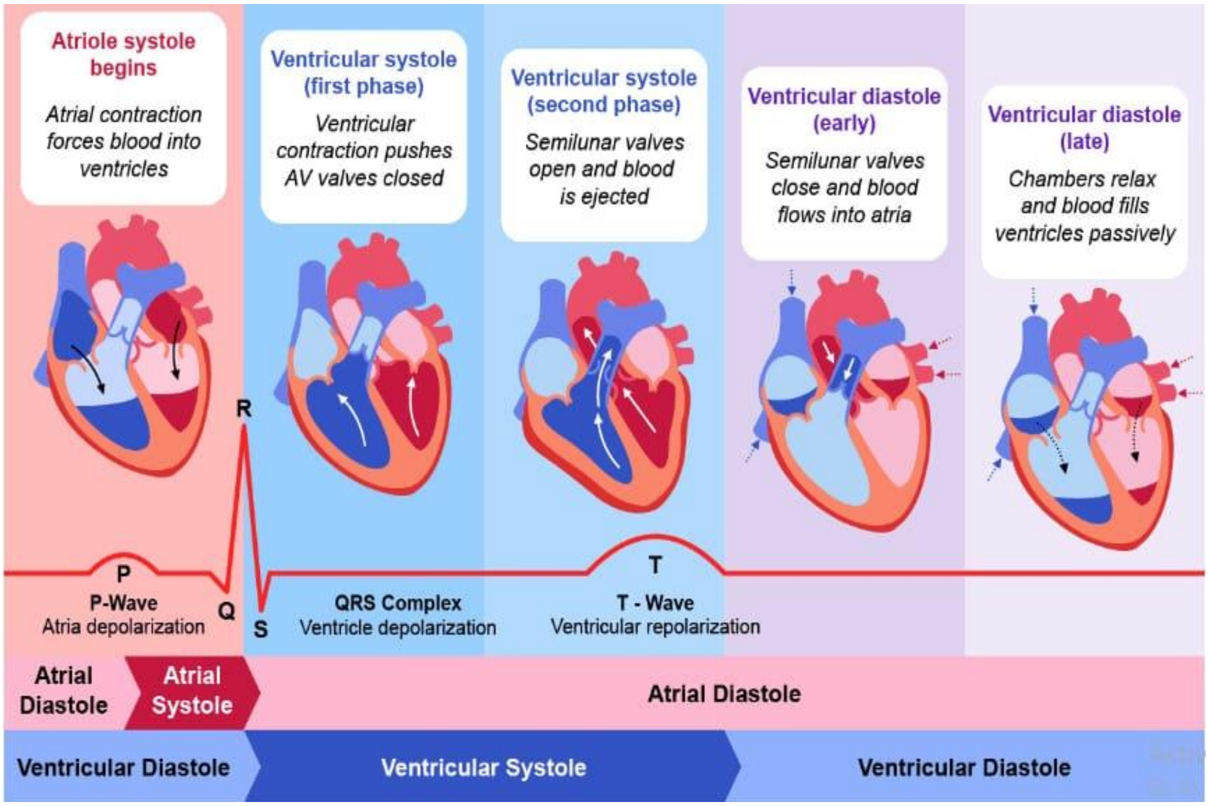
The QRS complex of EGC represents the depolarization of ventricles which begins at the apex of ventricles, as the action potential is carried from AV node to the apex. Immediately after ventricular filling the pressure inside the ventricles rise suddenly. This rise in pressure tries to push blood back to the atria and due to this AV valves get closed. At this particular junction, the AV valves and semilunar valves are closed and the volume inside the ventricles does not change called as period of iso-volumetric contraction.

Period of Ventricular Ejection:

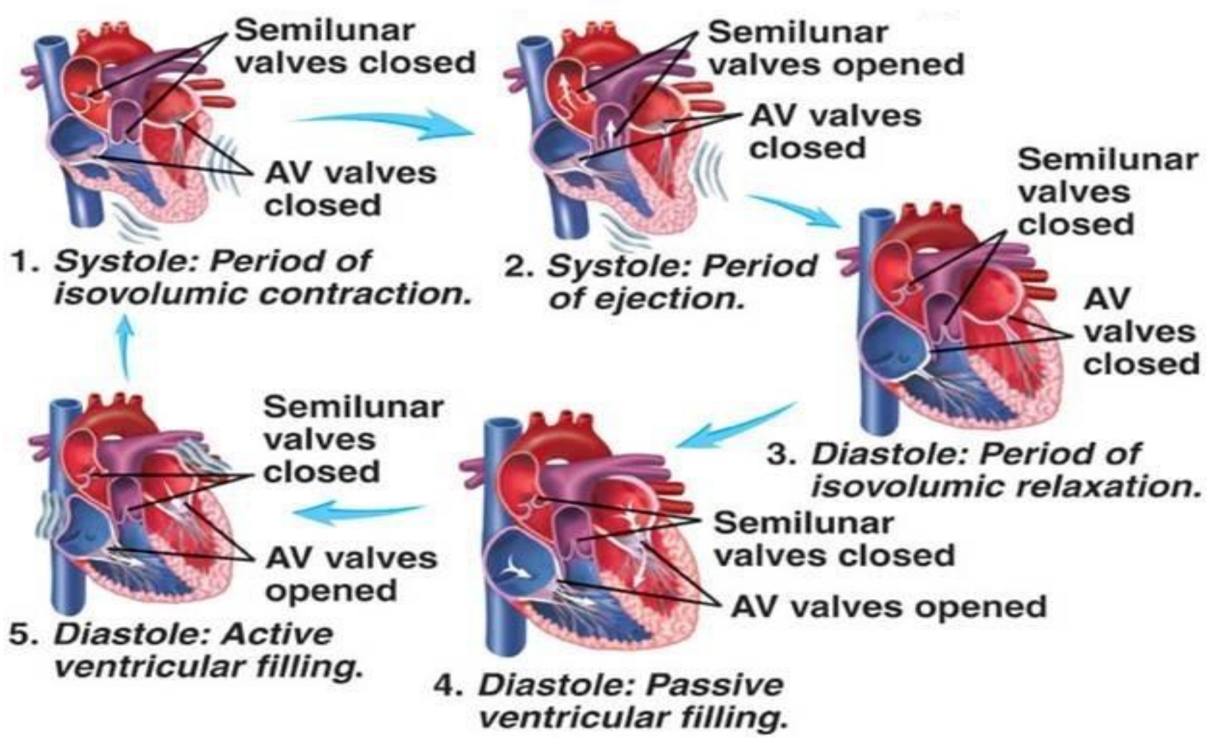
As ventricles further starts contracting the pressure inside rises sharply. When the pressure rises above the aortic pressure and pulmonary trunk pressure SL valve opens. As the semilunar valve opens blood ejected out of the ventricles. This period is called as ventricular ejection. About 70% of blood emptied during the first one third of ventricular ejection period is called as period of rapid ventricular ejection. After this ventricular pressure falls, the period of ventricular relaxation is repeated.

Phase of Ventricular Relaxation:

Ventricles starts to relax at the end of heart beat. At this particular point all the chambers of heart relax. This is represented by T wave on ECG. As the ventricles starts relaxing, pressure inside the ventricles drops suddenly. This drop in pressure leads to back flow of blood from the pulmonary trunk and aorta. This forceful back flow of blood closes the semilunar valve valves suddenly. This pressure produces a bump called as dicrotic wave. At this particular point both the SL valves and AV valves are closed. Due to this the ventricular volume does not change and this period is called as iso-volumetric relaxation. With the further relaxation of ventricles there is further fall in pressure inside the ventricles. When this ventricular pressure drops below the atrial pressure, AV valves open and ventricular filling begins.



Events in cardiac cycle



Events in cardiac cycle

BLOOD PRESSURE (BP)

Blood pressure is lateral pressure excreted by blood on the vessels walls while flowing through it.

Systolic BP: It refers to phase of ventricular contraction.

Diastolic BP: It refers to phase of ventricles relaxation.

Normal = 120/80 mm Hg.

Pressure in blood vessels decreases as the distance from the heart increases.

It is essential to record both the diastolic and systolic BP because it gives information regarding status of working heart. BP varies from various physiological parameters like age, sex, exercise, posture, and sleep, emotions, etc. The various methods for determination of blood pressure are as follows:

✓ Oscillatory method

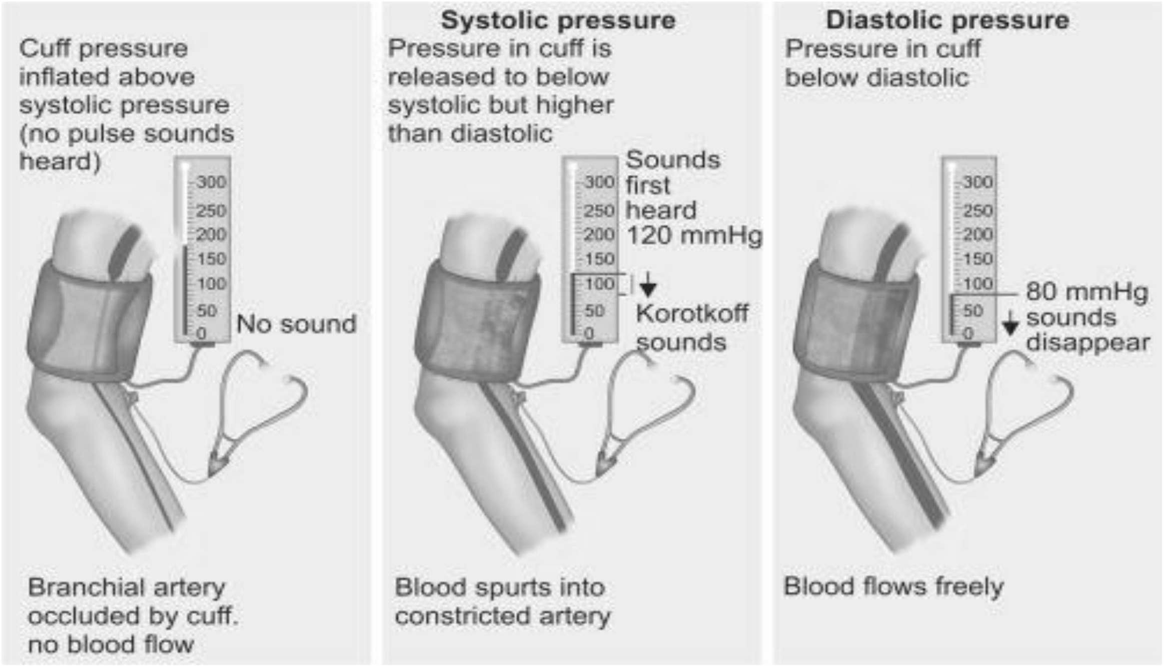
Palpatory method

✓ Auscultatory method

Ouscultatory Method:

It is the most commonly used method for measurement of blood pressure. Initially the cuff is inflated to a level higher than the systolic pressure. Thus, the artery is completely compressed, there is no blood flow, and no sounds are heard. The cuff pressure is slowly decreased. At the point where the systolic pressure exceeds the cuff pressure, the Korotkoff sounds are first heard and blood passes in turbulent flow through the partially constricted artery. Korotkoff sounds will continue to be heard as the cuff pressure is further lowered. However, when the cuff pressure reaches diastolic pressure, the sounds disappear. Now at all points in time during the cardiac cycle, the blood pressure is greater than the cuff pressure, and the artery remains open.

Sphygmomanometer & Stethoscope



Auscultatory method

Factors affecting on Blood Pressure:

Age: Blood pressure increases as you get older.

Gender: Men tend to have higher blood pressure than women.

Stress: It can cause increased blood pressure.

Diet: Salt and saturated fats can increase blood pressure.

Exercise: Lack of physical activity increases blood pressure.

Control of Blood Pressure:

Blood pressure is controlled by two ways:

✓ Short-term control, on a moment-to-moment basis, which mainly involves the baroreceptor reflex, chemoreceptor and circulating hormones.

✓ Long term control, which involves regulation of blood volume by the kidneys and the renin-angiotensin-aldosterone system.

Regulation of Blood Pressure:

Neural Regulation of blood Pressure: The nervous system regulates blood pressure via two types of reflexes: baroreceptor reflexes and chemoreceptor reflexes. The cardiovascular center (CVC) is a collection of interconnected neurons in the brain and is situated within the medulla and pons. The CVC receives, integrates and co-ordinates inputs from:

✓ Baroreceptors (pressure receptors)

✓ Chemoreceptor

✓ Higher centers in the brain.

Baroreceptors:

Baroreceptors, pressure-sensitive sensory receptors, are located in the aorta, internal carotid arteries (arteries in the neck that supply blood to the brain), and other large arteries in the neck and chest. They send impulses to the cardiovascular center to help regulate blood pressure. When blood pressure falls, the baroreceptors are stretched less, and they send nerve impulses at a slower rate to the cardiovascular center. In response, the CV center increases stimulation of the heart. Also secretion of epinephrine and norepinephrine by the adrenal medulla is increased. As the heart beats faster and more forcefully, and as systemic vascular resistance increases, cardiac output and systemic vascular resistance rise, and blood pressure increase to the normal level.

Conversely, when an increase in pressure is detected, the baroreceptors send impulses at a faster rate. The CV center responds by decreasing stimulation of heart. The resulting decreases in heart rate and force of contraction reduce the cardiac output. These are nerve endings sensitive to pressure changes (stretch) within the vessel, situated in the arch of aorta and in the carotid sinuses.

Rise in B.P. in aortic arch and carotid sinuses

↓

Stimulation of Baroreceptors

↓

Increasing their input to the CVC

↓

Increases parasympathetic nerve activity to heart

↓

Decreases heart rate and decreases force of contraction

↓

Vasodilation

↓

Fall in systemic blood pressure conversely,

Fall in BP in aortic arch and carotid sinuses

↓

Deactivation of baroreceptors

↓

Decreasing their output to CVC

↓

Increases sympathetic nerve activity to heart

↓

Increases heart rate and increases force of contraction

↓

Vasoconstriction

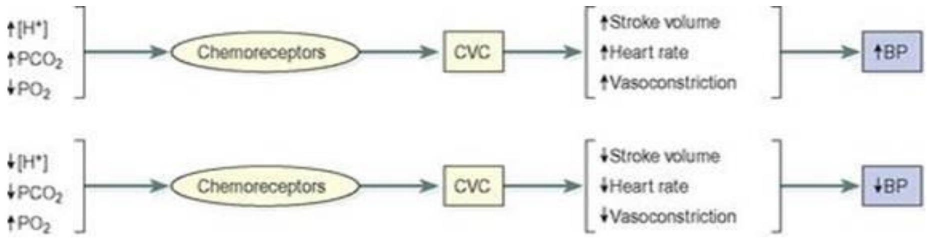
↓

Increase in systemic blood pressure

Baroreceptor control of blood pressure is called as Baroreceptor reflex.

Chemoreceptor:

Chemoreceptors are sensory receptors that monitor the chemical composition of blood. These are located close to the baroreceptors. These chemoreceptors detect changes in blood level of O_2, CO_2, and H+. Hypoxia (lowered O_2 availability), acidosis (an increase in H+ concentration), or hypercapnia (excess CO_2) stimulates the chemoreceptors to send impulses to the cardiovascular center. In response, the CV center increases sympathetic stimulation to arterioles and veins, producing vasoconstriction and an increase in blood pressure. These chemoreceptors also provide input to the respiratory center in the brain stem to adjust the rate of breathing. These are nerve endings situated in the carotid and aortic bodies. They are primarily involved in control of respiration. They are sensitive to changes in the levels of carbon dioxide, oxygen and the acidity of the blood (pH). Their input to the CVC influences its output only when severe disruption of respiratory function occurs or when arterial BP falls to less than 80 mmHg.



Stimulation of chemoreceptor and arterial blood

Hormonal Regulation of BP:

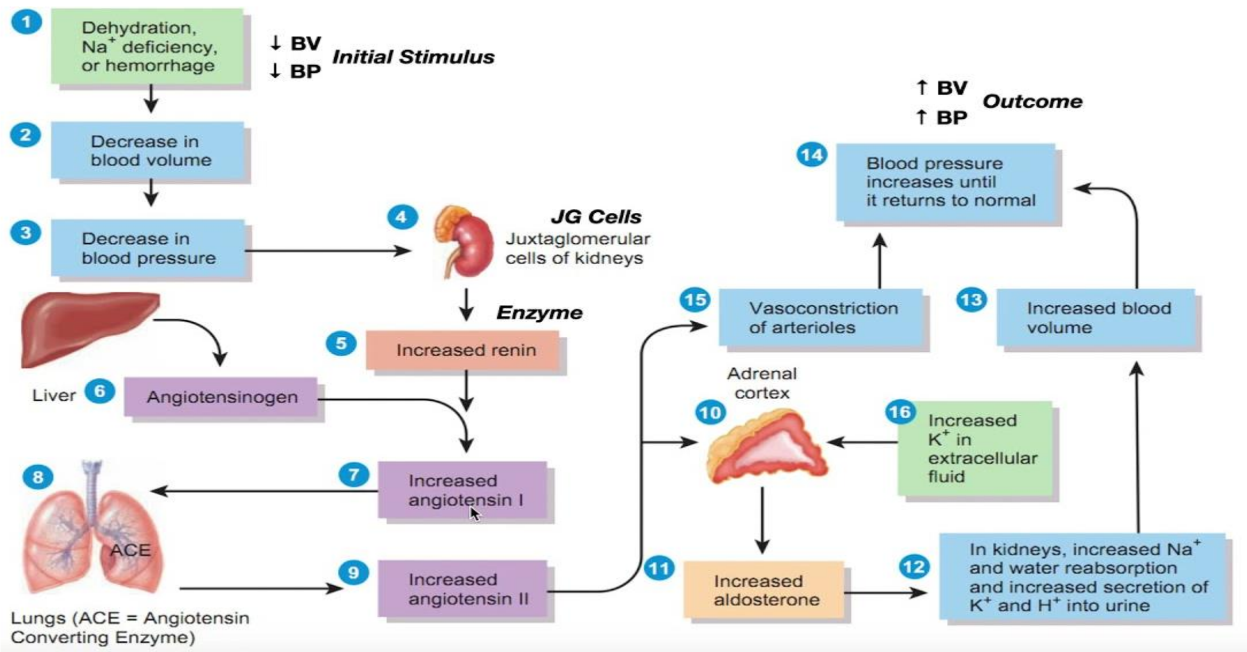
Epinephrine and Nor-epinephrine: In response to sympathetic stimulation, the adrenal medulla releases epinephrine and nor-epinephrine. These changes increases the cardiac output by increase in the heart rate and force of contraction.

Antidiuretic hormone (ADH): It is produced by hypothalamus and released from the posterior pituitary in response to dehydration or decrease in blood volume. ADH causes vasoconstriction which increases blood pressure. Hence, it is also called as vasopressin.

Atrial natriuretic peptide (ANP): It is released by the cells in the atria of the heart. ANP lowers blood pressure by causing vasodilation and by promoting the loss of salt and water in the urine which reduces blood volume.

RENIN-ANGIOTENSIN-ALDOSTERONE (RAA) SYSTEM

Stimuli that initiate the renin-angiotensin-aldosterone pathway include dehydration, Na^+ deficiency, or hemorrhage. These conditions cause a decrease in the blood volume. Decreased blood volume leads to decreased blood pressure. Lowered blood pressure stimulates certain cells of the kidneys, called juxtaglomerular cells, to secrete the enzyme renin. The level of renin in the blood increases. Renin converts angiotensinogen, a plasma protein produced by the liver, into angiotensin I. Blood containing increased levels of angiotensin I circulate in the body. As blood flows through capillaries, particularly those of the lungs, the enzyme angiotensin-converting enzyme (ACE) converts angiotensin I into the hormone angiotensin II. Blood level of angiotensin II increases. Angiotensin II stimulates the adrenal cortex to secrete aldosterone. Blood containing increased levels of aldosterone circulates to the kidneys. In the kidneys, aldosterone increases the reabsorption of Na^+ and water so that less is lost in the urine. Aldosterone also stimulates the kidneys to increase secretion of K and H^+ into the urine. With increased water reabsorption by the kidneys, blood volume increases. As blood volume increases, the blood pressure increases to normal. Angiotensin II also stimulates contraction of smooth muscle in the walls of arterioles. The resulting vasoconstriction of the arterioles increases blood pressure and thus helps raise blood pressure to normal. Besides angiotensin II, a second stimulator of aldosterone secretion is an increase in the K^+ concentration of blood (or interstitial fluid). A decrease in the blood K^+ level has the opposite effect.



Renin-angiotensin-aldosterone (RAA) system

AUTO-REGULATION OF BLOOD PRESSURE

The ability of a tissue to automatically adjust its blood flow to match its metabolic demands as auto-regulation.

Two general types of stimuli cause auto regulatory changes in blood flow.

(a) Physical change: Warming promotes vasodilation and cooling causes vasoconstriction.

(b) Vasodilating and vasoconstricting chemicals: Several types of cells such as WBC, platelets, smooth muscle fibres, macrophages, and endothelial cells release a wide variety of chemicals that alters blood vessels diameter. Vasodilating chemicals released by metabolically active tissue cells include K", H, lactic acid and adenosine (From ATP). Important vasodilator released by endothelial cell is Nitric Oxide named as Endothelium Derived Relaxation Factor (EDRF).

ELECTROCARDIOGRAM (ECG)

Conduction of action potential through heart generates electrical currents that can be detected at the surface of the body. A recording of the electrical changes that accompany each cardiac cycle is called as electrocardiogram. The instrument used to record the change is called as an electrocardiograph. It consists of three waves:

P wave

QRS wave

T wave

P Wave:

It is small upward wave. It represents atrial depolarization which spreads from SA node throughout both atria.

QRS Wave:

The complex represents three separate waves:

- ✓ Q wave
- ✓ R wave
- ✓ S wave

The complex begins with the downward deflection of Q wave, continues as a large, upright, triangular deflection of R wave and ends as a downward deflection of S wave. The QRS complex represents the ventricular depolarization.

T Wave:

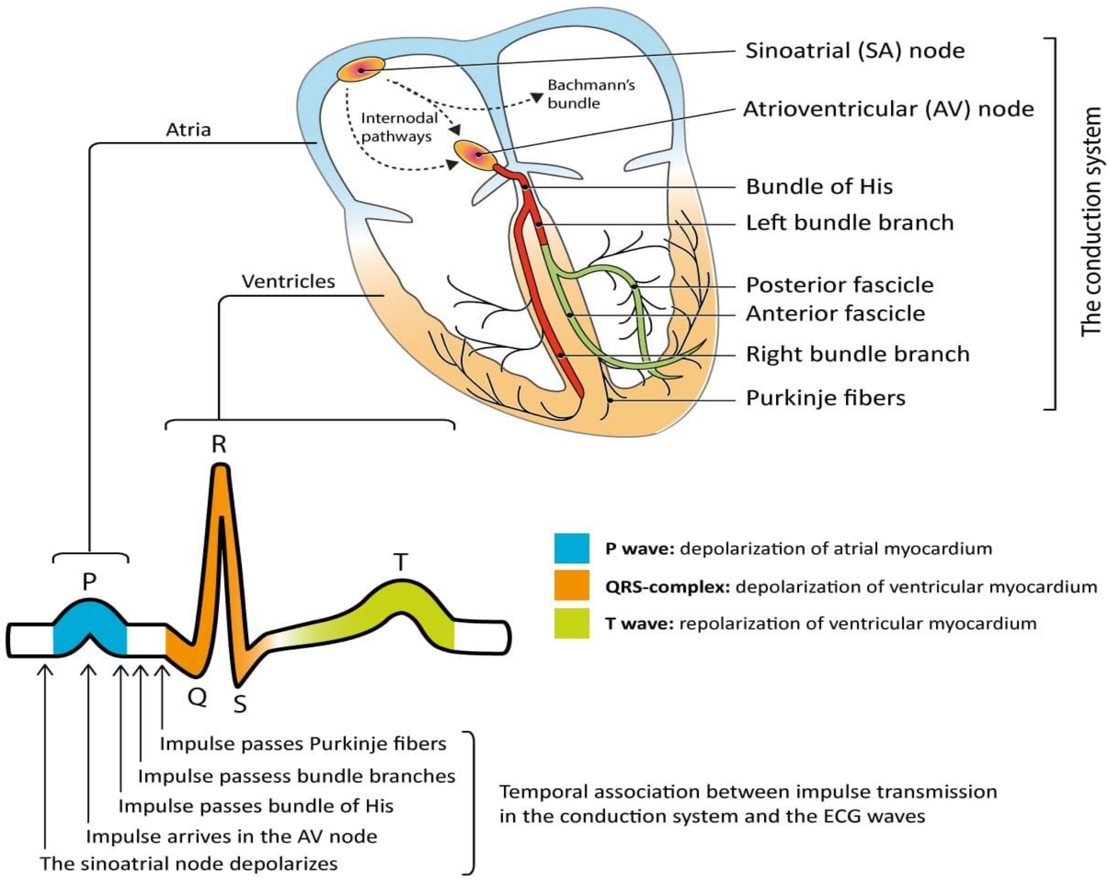
Third wave dome shaped upward deflection called as T wave. It represents ventricular repolarisation. The T wave is small and more spread out than the QRS complex because repolarisation occurs slower than the depolarisation.

***PQ or PR Interval*:**

The duration between beginning of P wave and the beginning of QRS wave is called as PQ interval. It is also called as PR interval because the Q wave is frequently absent. It is interval between beginning of contraction of atria and beginning of contraction of ventricles.

QT Interval:

The time from the beginning of S-wave and end of T-wave called as ST segment. ST wave segment represents ventricular contraction. During reading of an ECG, the size and timing of the waves is carefully noted. Following conclusions can be made with the altered ECG notes:



***Larger P wave*:** It indicates enlargement of atrium.

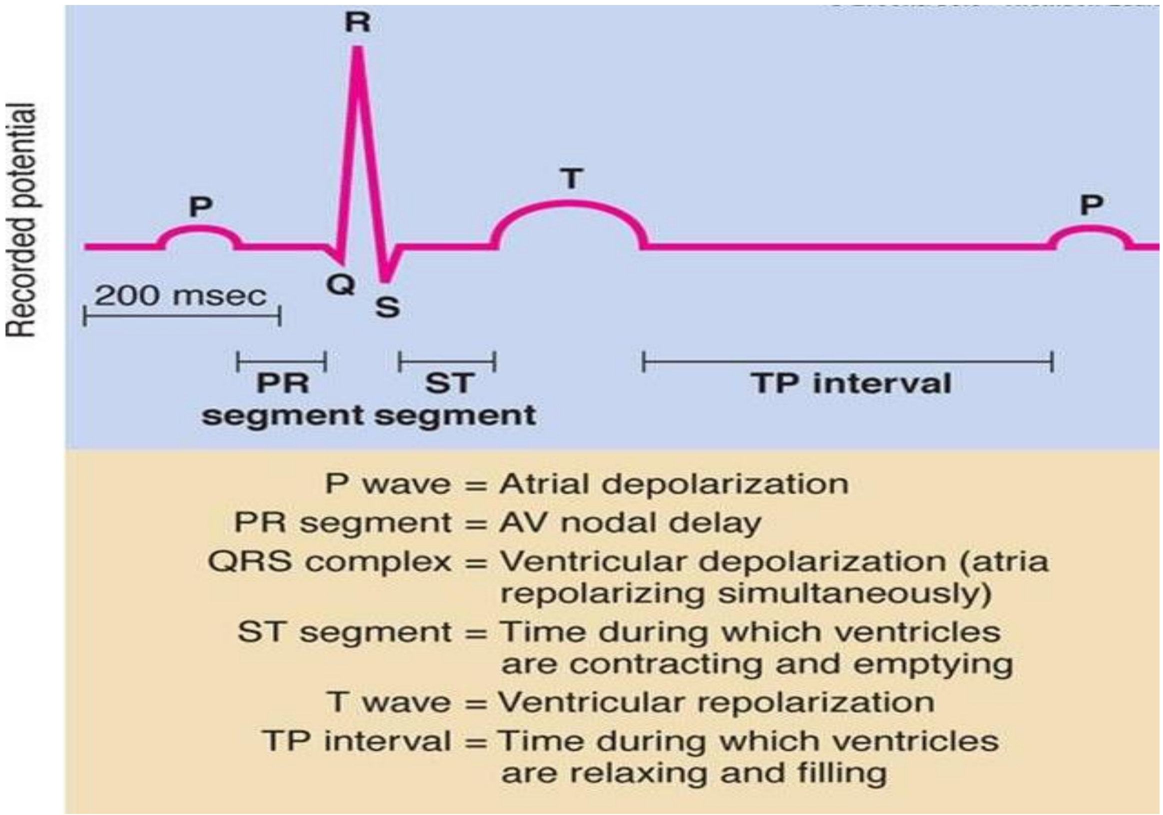
Enlarged Q wave: It indicates myocardial infarction.

Enlarged R wave: It indicates enlargement of ventricles.

Flatter T wave: It indicates insufficient oxygen supply to myocardium.

Larger PQ interval: It indicates formation of scar tissue in heart due to coronary artery disease or rheumatic fever.

Larger ST segment: It indicates acute myocardial infraction when elevated above the baseline and insufficient oxygen supply to heart muscle when depressed below the base line.



Disorders of Heart

1. **Myocardial ischemia:** It is a condition of reduced blood flow to the myocardium caused by partial obstruction of blood flow in the coronary arteries (*ische*-_to obstruct; -*emia*_in the blood). Usually, ischemia causes hypoxia (reduced oxygen supply), which may weaken cells without killing them. ***Angina pectoris*** which literally means "strangled chest," is a severe pain that usually accompanies myocardial ischemia. The pain associated with angina pectoris is often referred to the neck, chin, or down the left arm to the elbow. **Silent myocardial ischemia,** ischemic episodes without pain, is particularly dangerous because the person has no forewarning of an impending heart attack.

2. **Myocardial Infarction:** A complete obstruction to blood flow in a coronary artery may result in a myocardial infarction (in-FARK-shun), or MI, commonly called a *heart attack*. *Infarction* means the death of an area of tissue because of interrupted blood supply. Because the heart tissue distal to the obstruction dies and is replaced by noncontractile scar tissue, the heart muscle loses some of its strength. Depending on the size and location of the infarcted (dead) area, an infarction may disrupt the conduction system of the heart and cause sudden death by triggering ventricular fibrillation.

3. **In congestive heart failure (CHF),** there is a loss of pumping efficiency by the heart. Causes of CHF include coronary artery disease, congenital defects, long-term high blood pressure (which increases the afterload), myocardial infarctions (regions of dead heart tissue due to a previous heart attack), and valve disorders. As the pump becomes less effective, more blood remains in the ventricles at the end of each cycle, and gradually the end-diastolic volume (preload) increases. Initially, increased preload may promote increased force of contraction (the Frank–Starling law of the heart), but as the preload increases further, the heart is overstretched and contracts less forcefully.

4. **Coronary artery disease (CAD)** results from the effects of the accumulation of atherosclerotic plaques in coronary arteries, which leads to a reduction in blood flow to the myocardium. Some individuals have no signs or symptoms; others experience angina pectoris (chest pain), and still others suffer heart attacks. People who possess combinations of certain risk factors are more likely to develop CAD. *Risk factors* include smoking, high blood pressure, diabetes, high cholesterol levels, obesity, sedentary lifestyle, and a family history of CAD

5. Development of Atherosclerotic Plaques: Thickening of the walls of arteries and loss of elasticity are the main characteristics of a group of diseases called **arteriosclerosis** (*sclero-* _ hardening). One form of arteriosclerosis is **atherosclerosis**, a progressive disease characterized by the formation in the walls of large and medium-sized arteries of lesions called **atherosclerotic plaques.** It occurs due to deposition of low density lipoprotein in arteries.

6. Arrhythmias: The usual rhythm of heartbeats, established by the SA node, is called **normal sinus rhythm.** The term **arrhythmia** or **dysrhythmia** refers to an abnormal rhythm as a result of a defect in the conduction system of the heart. The heart may beat irregularly, too quickly, or too slowly. Symptoms include chest pain, shortness of breath, lightheadedness, dizziness, and fainting. Arrhythmias may be caused by factors that stimulate the heart such as stress, caffeine, alcohol, nicotine, cocaine, and certain drugs that contain caffeine or other stimulants. Arrhythmias may also be caused by a congenital defect, coronary artery disease, myocardial infarction, hypertension, defective heart valves, rheumatic heart disease, hyperthyroidism, and potassium deficiency. Arrhythmias are categorized by their speed, rhythm, and origination of the problem.

7. Bradycardia (*brady-* slow) refers to a slow heart rate (below 50 beats per minute); **Tachycardia** (*tachy-* quick) refers to a rapid heart rate (over 100 beats per minute); and **Fibrillation** refers to rapid, uncoordinated heartbeats.

Arrhythmias that begin in the atria are called **supraventricular** or **atrial arrhythmias;** those that originate in the ventricles are called **ventricular arrhythmias.**

8. Hyprertension: Rise in the blood pressure is known as Hypertension. It is the most common disorder affecting the heart and blood vessels and is the major cause of heart failure, kidney disease, and stroke.

Category	*Systolic (mmHg)*	*Diastolic (mmHg)*
Normal	Less than 120	Less than 80
Prehypertension	120–139	80–89
Stage 1 hypertension	140–159	90–99
Stage 2 Hypertension	Greater than 160	Greater than 100

Types and Causes of Hypertension: Hypertension is of two types:

Primary hypertension: In this type of hypertension, the cause for rise in blood pressure is not known.

Secondary hypertension: In this type, hypertension has an identifiable underlying cause. Several disorders cause secondary hypertension including

Obstruction of renal blood flow: or disorders that damage renal tissue may cause the kidneys to release excessive amounts of renin into the blood. The resulting high level of angiotensin II causes vasoconstriction, thus increasing systemic vascular resistance.

Hypersecretion of aldosterone stimulates excess reabsorption of salt and water by the kidneys, which increases the volume of body fluids.

Hypersecretion of epinephrine and norepinephrine increase heart rate and contractility and increase systemic vascular resistance.

Question Bank

1. Draw labeled diagram of heart and explain covering layer of heart.

2. Write short note on systemic and pulmonary circulation with diagram

3. Describe the conduction system of heart.

4. Differentiate artery and vein.

5. How cardiac muscle generates an action potential.

6. Write a brief note on ECG and its significance with the pictorial presentation.

7. Write a brief note on cardiac cycle.

8. Discuss about regulation of heart rate.

9. Define blood pressure and mention its regulation.