#### **!!JAY AMBE!!**

# 6. CARDIOVASCULAR SYSTEM EART

## PREPARED BY

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## CARDIOVASCULAR SYSTEM

#### **INTRODUCTION:**

Cardiovascular is the system which includes the study of the heart, blood vessels and blood. These system is some time known as circularly system because it circulate or transport the nutrients, oxygen, carbon dioxide and essential molecules from environment to cells and cells to environment. It is involuntary in nature and gives continuous work. The heart propelling or impelling blood around 100,000 km of blood vessels and it pumps 14000 liters blood in day and 10 million liters in year.

#### **LOCATION OF HEART:**

- Cone shaped heart is relatively small, about the same size of closed fist of person.
- It is 12 cm (5 in.) long, 9 cm (3.5 in.) wide and 6 cm (2.5 in.) thick.
- In an adult, average weight of heart is 300gm.
- The heart consist four chambers:
  - a) Two atria or atrium
  - **b**) Two ventricles
- It is located near to the middle of thoracic cavity in the mediastinum (the space between the lungs) and it rest on to the diaphragm.
- About two third of the mass of the heart lies to the left of the body's midline.
- Pointed end portion which is formed by the tip of left ventricle is known as apex and opposite to apex the wide superior and posterior margin is known as base.



![](_page_2_Figure_1.jpeg)

#### **INTERIOR OF THE HEART:**

 The heart is divided in to right and left side by partition known as the septum which is made up by myocardium covered by epithelium

![](_page_3_Figure_3.jpeg)

- Heart consists of four chambers;
- i) Two atria:
  - The two superior chambers are known as right atrium and left atrium.
    - The posterior wall of the atrium is smooth surface while the anterior wall of the atrium is rough surface.
  - On the surface of the atrium is wrinkle pouch like structure is known as auricle because it resemble like dog ear.

#### ii) Two ventricles

- The two inferior are known as right ventricle and left ventricles.
- On the surface of heart grooves like structures known as coronary sulcus which separate the atria to ventricle.
- The thickness of the wall of the four chambers varies according to their function.
  - **Example:** The wall of the atria is thin and it pumps blood in to ventricles & the ventricle wall is thick in which right ventricle pumps blood in to lungs and left ventricle pumps blood in to aorta so the work load on left ventricle is high because of that the wall of left ventricle is two to four times thicker than right ventricle.

#### b) Valve of the heart:

- In the heart blood passes from various compartment and finally it enter in to the artery.
- During these circulations for the prevention of back flow of blood there is special type of structure in heart which is known as valve.
- These special types of structures or valves are composed by dense connective tissue which is covered by endocardium.
- Valves are opened and closed in response to the contraction or relaxation of heart.

![](_page_4_Figure_1.jpeg)

#### a) Atrioventricular valves (AV valve):

- Its names indicate the location of valves that means these valves located between the atria and ventricle or it moves blood from atrium to ventricle..
- Inner surface of the ventricle contain the papillary muscles which is connected with the end or tip part of valve.
- Blood moves atrium to ventricle when the pressure in to the ventricle is lower than the atrium that time valves get opened and papillary muscles are in relaxed condition.
- When the AV valve is open the point end of the valve project in to the ventricle.
- So pressure in to the ventricle get increased at a same time ventricles start to contraction due to this contraction blood produce pressure on to the cups of valve and they move upward until their edge meet and close the opening.
- During the ventricle contraction blood may not goes from ventricle to atrium because valve have special type of opening and closing structure and during the closing time papillary muscles are also contracted so it prevents the back flow of blood from ventricles to atrium.
- It is mainly subdivided in to two types:

#### i) Tricuspid Valves:

- This valve located between the right atrium and right ventricle.
- It consist three cups that's why it is known as tricuspid valves.

#### ii) Bicuspid Valves (mitral valve):

- This valve located between the left atrium and left ventricle.
- It consist two cups so it is known as bicuspid valves also known as mitral valve.

Ventricle

![](_page_5_Figure_15.jpeg)

2 As ventricles fill, atrioventricular valve flaps hang limply into ventricles

③Atria contract, forcing additional blood into ventricles

(a)

- Ventricles contract, forcing blood against atrioventricular valve cusps
- 2 Atrioventricular valves close

③ Papillary muscles contract and chordae tendineae tighten, preventing valve flaps from everting into atria

![](_page_5_Picture_22.jpeg)

![](_page_5_Picture_23.jpeg)

Direction of

blood flow

Atrium

Cusp of atrioventricular

Chordae tendineae

Papillary

muscle

valve

Atrioventricular valve closed

Atrioventricular valve open

![](_page_5_Picture_25.jpeg)

#### **b) Semilunar Valves:**

- These valves consist three Semilunar (half moon like) cups.
- It is further subdivided in to:
- i) Pulmonary Semilunar valve:
  - It passes the blood from right ventricle to lungs during opening stage.

#### ii) Aortic Semilunar valve:

• It passes the blood from left ventricle to aorta during opening condition.

![](_page_6_Picture_8.jpeg)

As ventricles relax and intraventricular pressure falls, blood flows back from arteries, filling the cusps of semilunar valves and forcing them to close

Semilunar valve closed

## CIRCULATRY SYSTEM OF BLOOD THROUGH HEART:

#### 1) Pulmonary circulation:

 In the body system cells receive O<sub>2</sub> from blood and give CO<sub>2</sub> in to blood so blood become deoxygenate.

(b)

- These Deoxygenated blood by the help of Superior venacava, Inferior venacava and coronary sinus transfer in to the right atrium.
- Right atrium flow this deoxygenated blood in to right ventricle with the help of tricuspid valves.
- Right ventricle pumps blood in to pulmonary trunk via pulmonary Semilunar valve.
- The pulmonary trunk divided in to right pulmonary artery and left pulmonary artery, the right pulmonary artery gives blood to right lungs and left pulmonary artery gives blood to left lungs.

#### 2) Systemic Circulation:

- In the lungs blood become oxygenated means it gain O<sub>2</sub> and loss CO<sub>2</sub>.
- Now, the oxygenated blood returns in to heart through pulmonary veins.
- Then pulmonary veins pass blood in to left atrium which pumps blood in to left ventricle with the help of bicuspid valve.
- Then, left ventricle through blood enters in to a with the help a ortic valve.
- Finally, bloods flows in systemic circulation from aorta and reach near to each and every cells of the body and gives O<sub>2</sub> and take CO<sub>2</sub>.
- Again the deoxygenated blood flow trough pulmonary circulation.

![](_page_6_Picture_25.jpeg)

![](_page_7_Figure_1.jpeg)

- The anterior interventricular branch or left anterior descending (LAD) arteries enter in to the anterior interventricular sulcus and supplies oxygenated blood to the walls of both ventricles and the interventricular septum.
- The circumflex branch lies in the coronary sulcus and distributes oxygenated blood to the walls of the left ventricle and left atrium.

#### ii) The right coronary artery:

- The right coronary arteries branches supply blood to the right atrium.
- It continues inferior to the right auricle and divided in to the posterior interventricular and marginal branches.
- The posterior interventricular branches enter in to the posterior interventricular sulcus and supply the oxygenated blood in to two ventricles and the interventricular septum.
- The marginal branch in the coronary sulcus transports oxygenated blood to the myocardium of the right ventricle.

![](_page_8_Figure_0.jpeg)

![](_page_9_Figure_0.jpeg)

#### **HEART CONDUCTION SYSTEM:**

![](_page_10_Figure_2.jpeg)

- The Sinoatrial node (SAN), located within the wall of the right atrium (RA) just inferior to the opening of the superior vena cava, normally generates electrical impulses (Action Potential) that are carried by special conducting tissue of both atria to the atrioventricular node (AVN).
- Upon reaching the AVN, located between the atria and ventricles, the electrical impulse is relayed down conducting tissue (Bundle of HIS) that branches into pathways that supply the right and left ventricles. These paths are called the right bundle branch (RBBB) and left bundle branch (LBBB) respectively that course through the interventricular septum towards the apex of the heart. The left bundle branch further divides into two sub branches (called fascicles).
- Finally, large diameter conduction myofibers (Purkinje Fibers) passes electrical current to the apex of the ventricular myocardium and then upward to the remainder of the ventricular myocardium.

SA-node→ AV-node→ AV bundle→ Right & Left Bundle braches→ Purkinje fibers

![](_page_11_Picture_1.jpeg)

- Electrical impulses generated in the SAN cause the right and left atria to contract first. Depolarization (heart muscle contraction caused by electrical stimulation) occurs nearly simultaneously in the right and left ventricles 1-2 tenths of a second after atrial depolarization. The entire sequence of depolarization, from beginning to end (for one heart beat), takes 2-3 tenths of a second.
- All heart cells muscle and conducting tissue are capable of generating electrical impulses that can trigger the heart to beat. Under normal circumstances all parts of the heart conducting system can conduct over 140-200 signals (and corresponding heart beats) per minute.
- The SAN is known as the "heart's pacemaker" because electrical impulses are normally generated here. At rest the SAN usually produces 60-70 signals a minute. It is the SAN that increases its' rate due to stimuli such as exercise, stimulant drugs, or fever.
- Should the SAN fail to produce impulses the AVN can take over. The resting rate of the AVN is slower, generating 40-60 beats a minute. The AVN and remaining parts of the conducting system are less capable of increasing heart rate due to stimuli previously mentioned than the SAN.
- The Bundle of HIS can generate 30-40 signals a minute. Ventricular muscle cells may generate 20-30 signals a minute.
- Heart rates below 35-40 beats a minute for a prolonged period usually cause problems due to not enough blood flow to vital organs.
- Problems with signal conduction, due to disease or abnormalities of the conducting system, can occur anyplace along the heart's conduction pathway. Abnormally conducted signals, resulting in alterations of the heart's normal beating, are called arrhythmias or dysrrythmia.
- By analyzing an EKG a doctor is often able to tell if there are problems with specific parts of the conducting system or if certain areas of heart muscle may be injured.

#### **ELECTROCARDIOGRAPHY:**

- Electrocardiography (ECG or EKG from the German *Elektrokardiogramm*) is a transthoracic interpretation of the electrical activity of the heart over time captured and externally recorded by skin electrodes.
- It is a noninvasive recording produced by an electrocardiographic device.
- The ECG works mostly by detecting and amplifying the tiny electrical changes on the skin that are caused when the heart muscle "depolarizes" during each heart beat.
- At rest, each heart muscle cell has a charge across its outer wall, or cell membrane. Reducing this charge towards zero is called de-polarization, which activates the mechanisms in the cell that cause it to contract.
- During each heartbeat a healthy heart will have an orderly progression of a wave of depolarization that is triggered by the cells in the sinoatrial\_node, spreads out through the atrium, passes through "intrinsic conduction pathways" and then spreads all over the ventricles. This is detected as tiny rises and falls in the voltage between two electrodes placed either side of the heart which is displayed as a wavy line either on a screen or on paper. This display indicates the overall rhythm of the heart and weaknesses in different parts of the heart muscle.
- Usually more than 2 electrodes are used and they can be combined into a number of pairs. (For example: Left arm (LA), right arm (RA) and left leg (LL) electrodes form the pairs: LA+RA, LA+LL, RA+LL) The output from each pair is known as a lead. Each lead is said to look at the heart from a different angle.
- Different types of ECGs can be referred to by the number of leads that are recorded, for example 3-lead, 5-lead or 12-lead ECGs (sometimes simply "a 12-lead").
- A 12-lead ECG is one in which 12 different electrical signals are recorded at approximately the same time and will often be used as a one-off recording of an ECG, typically printed out as a paper copy. 3- and 5-lead ECGs tend to be monitored continuously and viewed only on the screen of an appropriate monitoring device, for example during an operation or whilst being transported in an ambulance.

There may, or may not be any permanent record of a 3- or 5-lead ECG depending on the equipment used.

#### **Placement of electrodes:**

Ten electrodes are used for a 12-lead ECG. The electrodes usually consist of a conducting gel, embedded in the middle of a self-adhesive pad onto which cables clip. Sometimes the gel also forms the adhesive. They are labeled and placed on the patient's body as follows:

![](_page_12_Picture_13.jpeg)

Electrode	Electrode placement
label (in	
the USA)	
RA	On the right arm, avoiding bony prominences.
LA	In the same location that RA was placed, but on the left arm this time.
RL	On the right leg, avoiding bony prominences.
LL	In the same location that RL was placed, but on the left leg this time.
$\mathbf{V}_1$	In the <i>fourth</i> intercostal space (between ribs 4 & 5) just to the <i>right</i> of
	the sternum (breastbone).
$\mathbf{V}_2$	In the <i>fourth</i> intercostal space (between ribs 4 & 5) just to the <i>left</i> of the
	sternum.
$V_3$	Between leads V <sub>2</sub> and V <sub>4</sub> .
$V_4$	In the fifth intercostal space (between ribs 5 & 6) in the mid-clavicular
	line (the imaginary line that extends down from the midpoint of the
	clavicle (collarbone)).
$V_5$	Horizontally even with V4, but in the anterior axillary line. (The anterior
	axillary line is the imaginary line that runs down from the point midway
	between the middle of the clavicle and the lateral end of the clavicle; the
	lateral end of the collarbone is the end closer to the arm.)
$\mathbf{V}_{6}$	Horizontally even with $V_4$ and $V_5$ in the midaxillary line. (The
	midaxillary line is the imaginary line that extends down from the middle
	of the patient's armpit.)

### > Waves and intervals:

A typical ECG tracing of the cardiac cycle (heartbeat) consists of a P wave, a QRS complex, a T wave, and a U wave which is normally visible in 50 to 75% of ECGs. The baseline voltage of the electrocardiogram is known as the *isoelectric line*. Typically the isoelectric line is measured as the portion of the tracing following the T wave and preceding the next P wave.

![](_page_13_Figure_4.jpeg)

Feature	Description	Duration
RR interval	The interval between an R wave and the next R wave is the	0.6 to
	inverse of the heart rate. Normal resting heart rate is between 50 and 100 bpm	1.2s
P wave	During normal atrial depolarization, the main electrical vector is directed from the SA node towards the AV node, and spreads from the right atrium to the left atrium. This turns into the P wave on the ECG	80ms
PR interval	The PR interval is measured from the beginning of the P wave to the beginning of the QRS complex. The PR interval reflects the time the electrical impulse takes to travel from the sinus node through the AV node and entering the ventricles. The PR interval is therefore a good estimate of AV node function.	120 to 200ms
PR segment	The PR segment connects the P wave and the QRS complex. This coincides with the electrical conduction from the AV node to the bundle of His to the bundle branches and then to the Purkinje Fibers. This electrical activity does not produce a contraction directly and is merely traveling down towards the ventricles and this shows up flat on the ECG. The PR interval is more clinically relevant.	50 to 120ms
QRS complex	The QRS complex reflects the rapid depolarization of the right and left ventricles. They have a large muscle mass compared to the atria and so the QRS complex usually has a much larger amplitude than the P-wave.	80 to 120ms
J-point	The point at which the QRS complex finishes and the ST segment begins. Used to measure the degree of ST elevation or depression present.	N/A
ST segment	The ST segment connects the QRS complex and the T wave. The ST segment represents the period when the ventricles are depolarized. It is isoelectric.	80 to 120ms
T wave	The T wave represents the repolarization (or recovery) of the ventricles. The interval from the beginning of the QRS complex to the apex of the T wave is referred to as the <i>absolute refractory period</i> . The last half of the T wave is referred to as the <i>relative refractory period</i> (or vulnerable period).	160ms
ST interval	The ST interval is measured from the J point to the end of the T wave.	320ms
QT interval	The QT interval is measured from the beginning of the QRS complex to the end of the T wave. A prolonged QT interval is a risk factor for ventricular tachyarrhythmias and sudden death. It varies with heart rate and for clinical relevance requires a correction for this, giving the QTc.	300 to 430ms
U wave	The U wave is not always seen. It is typically low amplitude, and, by definition, follows the T wave.	
J wave	The J wave, elevated J-Point or Osborn Wave appears as a late delta wave following the QRS or as a small secondary R wave. It is considered pathognomic of hypothermia or hypocalcemia.	

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Shortened QT interval	Hypercalcemia, some drugs, certain genetic abnormalities.
Prolonged QT interval	Hypocalcemia, some drugs, certain genetic abnormalities.
Elevated ST segment	Myocardial infraction
Depressed ST segment	The heart muscles receive insufficient oxygen
Prolonged PQ intervals	<b>Coronary artery disease, Rheumatic fever and Scar tissue may</b> be form in the heart.
Flattened or inverted T Waves	Coronary ischemia, left ventricular hypertrophy, digoxin effect, some drugs.
Hyper acute T Waves	Possibly the first manifestation of acute myocardial infarction.
<b>Prominent U Waves</b>	Hypokalemia.
Larger P Wave	Indicate enlargement of an Atrium, as may occur in mitral stenosis in which blood back up in to the left atrium.
Enlarge Q Wave	Indicates myocardium infrection.
Enlarge R Wave	Indicates enlarged ventricles

Some pathological entities which can be seen on the ECG:

• The ECG cannot reliably measure the pumping ability of the heart, for which ultrasound-based (echocardiography) or nuclear medicine tests are used. It is possible to be in cardiac arrest with a normal ECG signal (a condition known as pulseless electrical activity).

#### **CARDIAC CYCLES:**

#### "A cardiac cycle include all the events associated within one heart beat"

- The normal heart beats in healthy adult is 75 beats/min and cardiac cycle last for 0.8 sec.
- In the cardiac cycle due to the pressure changes atria and ventricles alternately contract and relax, and blood flows from areas of higher blood pressure to areas of lower blood pressure.
- The term systole is used for the contraction and diastole used for the relaxation.
- In a normal cardiac cycle, the two atria contract while the two ventricles relax. Then, while the two ventricle contract, the two atria relax.
- Cardiac cycle is described by the following phase:

#### 1) Atrial systole

- In this phase Atrial contraction is begins which is last about 0.1 sec at same time ventricle are relaxed.
- So, the Right and Left AV valves are open and Atria send blood into the relaxed ventricles.
- Atrial systole pushes 25 ml of blood in to ventricles which already contain 105 ml blood so at the end of atrial systole means end of ventricle diastole Ventricles contain maximum blood volume which is 130 ml known as end-diastolic volume (EDV).
- In the ECG or EKG it is noted as P wave.

#### 2. Ventricular systole:

- In this phase ventricles begin contraction which is last for 0.3 sec.
- Pressure in ventricles rises due to contraction and shut the AV valves which is heard by "Lubb" Sound.
- For about 0.05 sec all four valve are closed which is known as isovolumetric contraction.
- Ventricular contraction pushes blood out of the ventricles and opens the both Semilunar valve and ejected 70 ml blood in to aorta and same amount of blood in to pulmonary trunk by respectively left and right ventricles so the 60 ml of blood remains in the each ventricle out of 130 ml.
- This is known as ventricular ejection which last for 0.25 sec

#### Ventricular systole = isovolumetric contraction + ventricular ejection

- =(0.05)+(0.25)
- = 0.3 sec.
- The blood volume in the Ventricles at the end of ventricle systole is 60 ml known as end-systolic volume (ESV).
- The blood ejection per beat from each ventricle is known as stroke volume.

#### **Stroke volume = EDV – ESV**

- = 130 ml 60 ml
- = 70 ml
- It is noted as QRS wave in ECG or EKG.

#### **3. Ventricular Diastole or Relaxation period:**

- In this phase both ventricles and atria are in relaxation.
- Relaxation which is last for 0.4 sec.
- Pressure in the ventricles drops so blood in the Pulmonary Trunk and aorta
- backflows closing the Semilunar Valves.
- This is heard by "Dubb" sound.
- In this period, ventricular pressure is higher than atrial pressure hence all heart valves are closed again and this period is known as isovolumetric.
- It is noted as T wave in ECG or EKG.
- Again the AV valves open and fill up the ventricle and complete the one Cardiac cycle.

![](_page_17_Figure_1.jpeg)

- Means the cardiac out put volume is close to the total blood volume, which is about 5 liters in the typical adult male. The entire blood volume thus flows through the pulmonary and systemic circulations about once a minute.
- When the demand of oxygen is increase or decrease, cardiac output changes to meet the need by increasing or decreasing the stroke volume and heart rate.
- For example during the mild exercise demand of oxygen is increase so the stroke volume may increase to 100 ml/beat and heart rate to 100 beats/min. cardiac output then would be 10 liters/min.

#### Factor affecting on Stroke volume:

- Three important factors regulate the stroke volume in different circumstances and ensure that the left and right ventricles pump equal volume of blood.
- i) Preload:
  - The blood supply to the ventricle is often referred to as **preload**. Technically, the definition of preload is the volume or pressure in the ventricle at the end of diastole or refers as end-diastolic volume.
  - According to Frank-Starling law of the heart, more the heart is filling during diastole, the greater the force of contraction during systole.
  - The duration of ventricular diastole and venous pressure are the two key factors that determine EDV.
  - When the heart rate is increase, the duration of diastole is shorter so it takes smaller filling times means smaller EDV.
  - On the other hand, when venous pressure increase, a greater volume of blood is forced into the ventricles and the EDV is increased.

For example:

- When heart rate exceeds about 160 beats/min, stroke volumes usually decrease. At such rapid heart rate decrease the ventricular filling time so decrease the EDV and thus the preload is lower.
- People, who have slow resting heart rate, usually have large stroke volumes because filling time is prolonged and preload thus is larger.

#### ii) Contractility:

- The second factor that influences stroke volume is myocardial contractility, which is the strength of contraction at any given preload.
- Increases the contractility are called positive inotropic agents and decreases the contractility are called negative inotropic agents.
- Thus, for a constant preload, stroke volume is larger when positive inotropic agent is present and it promotes the forceful contraction.

#### iii) Afterload:

• The resistance to the ejection of blood by the ventricle is called **afterload**.

#### For example:

 In the atherosclerosis condition arteries are narrowed so they resist the blood flow from ventricles to out of heart and it decrease the stroke volume, and more blood remains in the ventricles at the end of systole.

![](_page_19_Figure_0.jpeg)

Sympathetic stimulation

- Increase the Epinephrine (E) and Non Epinephrine (NE) level
- Causes ventricles to contract with more force and increases ejection fraction and decreases ESV and increase the stroke volume.

Parasympathetic activity

- Increases the Acetylcholine (Ach) released by vagus nerves
- Reduces force of cardiac contractions

## **IMPORTANT QUESTIONS:**

- 1. Draw the neat and labeled diagram of heart.
- 2. Write short note on layer and wall of heart.
- 3. Write short note on cardiac cycle.
- 4. Explain the blood circulation through the heart/Circulatory systems.
- 5. Write short note on ECG.
- 6. Write short note on cardiac output.
- 7. Explain the valve of heart.

## <u>A serious person can never be innocent, and one</u> <u>who is innocent can never be serious.</u>

![](_page_19_Picture_16.jpeg)