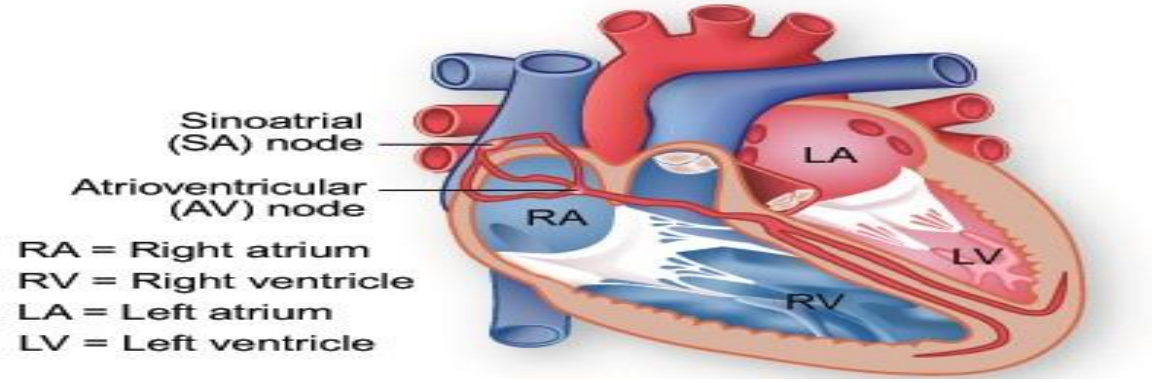
L32 Electrical Signals from the Heart

The heart muscle

The heart is an organ comprised of mostly muscle, which divided into four chambers. These are the right atrium, the right ventricle and the left atrium and the left ventricle.



The human heart

. It pumps blood, when the chamber receives the order (electrical impulse), it contracts and pushes the blood out of the chamber. Valves help the heart make sure that blood only flows in one direction.

Electrical Signals from the Heart-

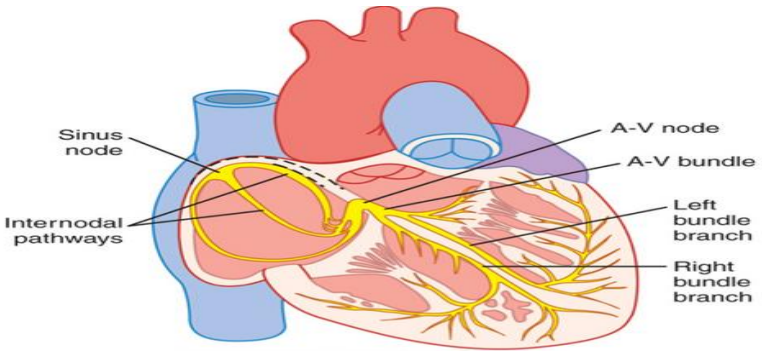
The Electrocardiogram (ECG)

The rhythmical action of the heart is controlled by an electrical signal initiated by spontaneous stimulation of special muscle cells located in the right atrium, these cell make up the sinoatrial (SA) node , or the pacemaker.

They produce roughly 60-100 action potentials every minute. This action potential passes along the cell membrane causing the cell to contract, therefore the activity of the SAN results in a resting heart rate of roughly 60-100 beats per minute.

Pacemakers of the Heart

- **SA Node - Dominant pacemaker with an intrinsic rate of 60 - 100 beats/minute.**
- **AV Node - Back-up pacemaker with an intrinsic rate of 40 - 60 beats/minute.**
- **Ventricular cells - Back-up pacemaker with an intrinsic rate of 20 - 45 bpm.**



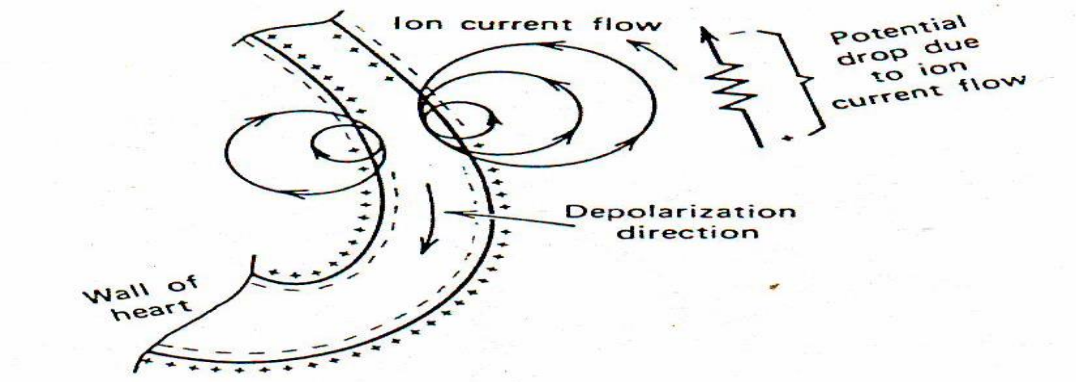
- **The SA node fires at regular intervals about 72 times per minute.**

- **The rate of firing can be increased or decreased by nerves external to the heart that respond to the blood demand of the body as well as to other stimuli.**
- **The electrical signal from the SA node initiates the depolarization of the nerves and muscles of atria, causing the atria to contract and pump blood into ventricles.**

- **Repolarization of the atria follows.**
- **The electrical signal then passes into the atria ventricular (AV) node which initiates the depolarization of the RV and LV, causing them to contract and force blood into the pulmonary and general circulations**
- **The ventricle nerves and muscles then repolarize and the sequence begins again.**
- **In short, the electrical conduction in the heart allows the impulse that to generate by the sinoatrial node (SA node) of the heart to propagated and stimulate the heart muscle. This allows efficient contraction of the heart, thereby allowing blood to be pumped throughout the body.**

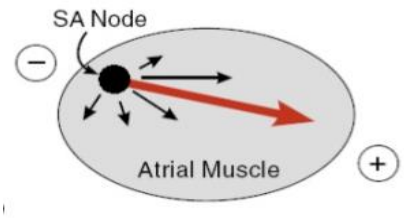
- **The nerves and muscles of the heart can be regarded as sources of electricity enclosed in an electrical conductor .**
- **The record of the heart's potential on the skin is called the electrocardiogram (ECG)**

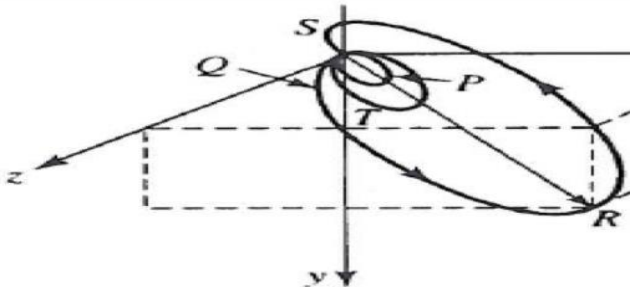
The action potential in heart



Schematic of an action potential moving down the wall of the heart. Some of the ion current ,(indicated by the circles) , passes through the torso, (indicated by the resistor). The potential on the chest wall is due to current flow through the resistance of the torso.

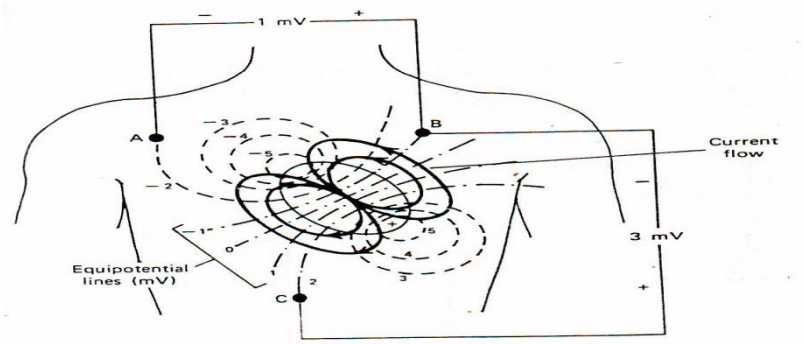
- **The form of the potential lines is the same as that obtained from an electric dipole.**
- **The equipotential lines at other time in the heart's cycle can also be represented by electric dipole: however, the dipoles for different moments in the cycle would differ in size and orientation.**



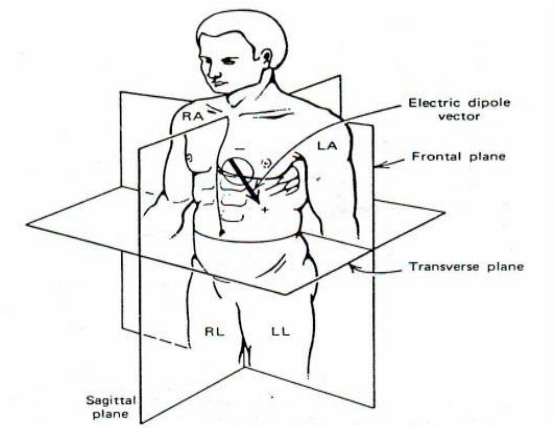


The potential distribution on the chest

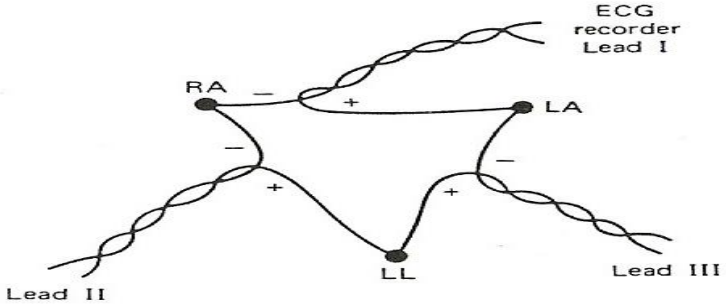
- **The potential distribution on the chest at the moment when the ventricles are one-half depolarized shown in the figure below**
- **Electrodes located at A, B , and C would indicate the potentials at that moment.**
- **The form of the potential lines is the same as that obtained from an electric dipole**



- **The three electrocardiographic planes and an electric dipole vector, RA , LA , RL and LL indicate electrode locations on the right and left arms and legs**



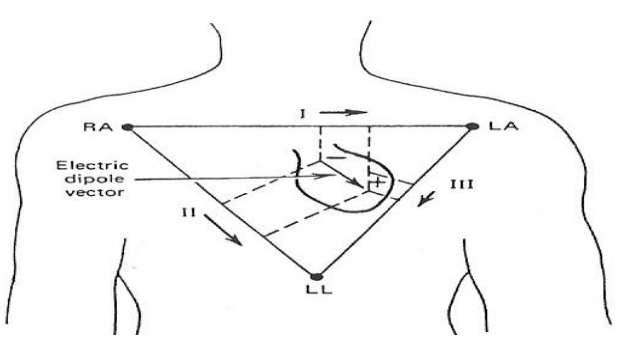
Three electrocardiographic planes
Frontal plane ,Transverse plane ,Sagittal plane



The surface electrodes for obtaining the ECG are the most commonly located on the : Right arm RA , Left arm LA , & Left leg LL

The electrical connections for Leads,(the standard limb leads).

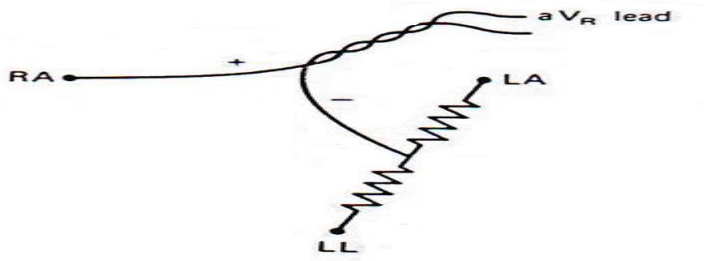
Lead name	Negative electrode (i.e. "start")	Positive electrode (i.e. "stop")
Lead I	Right arm	Left arm
Lead II	Right arm	Left leg
Lead III	Left arm	Left leg



The potential between any two gives the relative amplitude and direction of the electric dipole vector in the frontal plane

The electric dipole of the heart

- **The electric dipole of the heart projected on the frontal plane.**
- **For electrical purposes the three electrodes (RA , LA , and LL) can be thought of as the points of a triangle , the Einthoven triangle.**
- **The potential in Lead I at any moment is proportional to the projection of the dipole vector on the line RA-LA;**
- **The potentials in Lead II and III are proportional to the projections on the other sides of the triangle.**
- **An augmented lead is obtained by placing a pair of resistors between two of the electrodes.**
- **The center of the resistor pair is used as one of the connection and the remaining electrode is used as the second connection.**



The arrangement for the aVR augmented lead is shown.