ELECTROCARDIOGRAPH

Bioelectric signals and their characteristics

Biolelectric signal	Frequency range (Hz)	Voltage range (µV)	Electrodes used	Origin
Electrocardiogram	0.05 to 100	10 to 5000 covers fetal range	Surface electrodes are used with jelly, paste or cream. Needle electrode are less noisy	Heart muscles
Electroencephalogram	0.1 to 100	2 to 200	Surface and needle electrode	Neuronal activity of the brain
Cerebral potentials (intracranially recorded)	Pulse duration 0.6ms to 0.1s	10 to 100000	Deep needle electrodes	Cerebrum of the brain
Electromyogram	5 to 2000	20 to 5000	Surface or needle electrodes	Skin muscles
Electrogastrogram	0.05 – 0.2	10 – 350	Surface electrodes	Peristaltic movements of the gastrointestinal tract
Electroretinogram	0.01 to 200	0.5 – 1000	Corneal electrodes	Retina of the eye
Electrooculogram	0.1 to 100	10 to 3500	Miniature surface electrodes	Corneal-retinal potential variations

- Electrocardiography :
  - the study of electrical activity of the heart muscles.
  - **Electrocardiogram** → record of ECG pattern
  - Reflects rhythmic electrical depolarisation and repolarisation of the myocardium (contraction of atria and ventricles)
  - The shape , time interval and amplitude of the ECG give details of the state of the heart.
- Heart structure
  - 4 chambers → 2 atria + 2 ventricles
  - Impure blood → venacava →

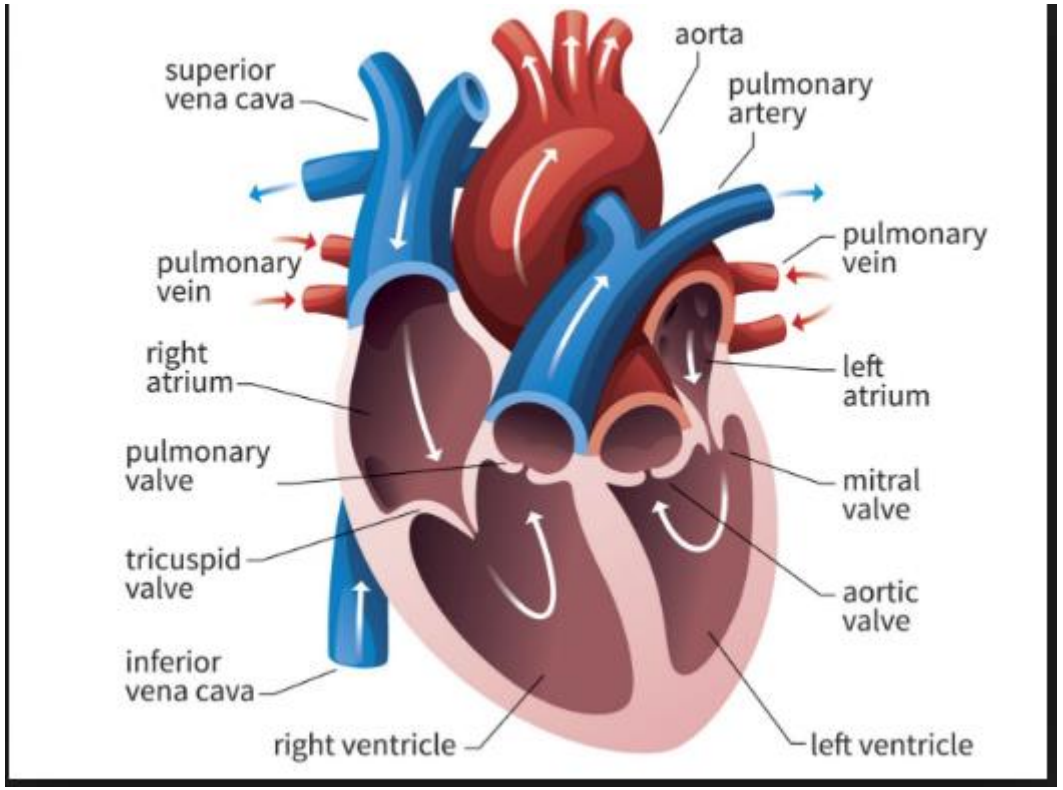
  → right atrium → right ventricle

  →Pulmonary artery → lungs (purification)

  → pure blood → pulmonary vein →

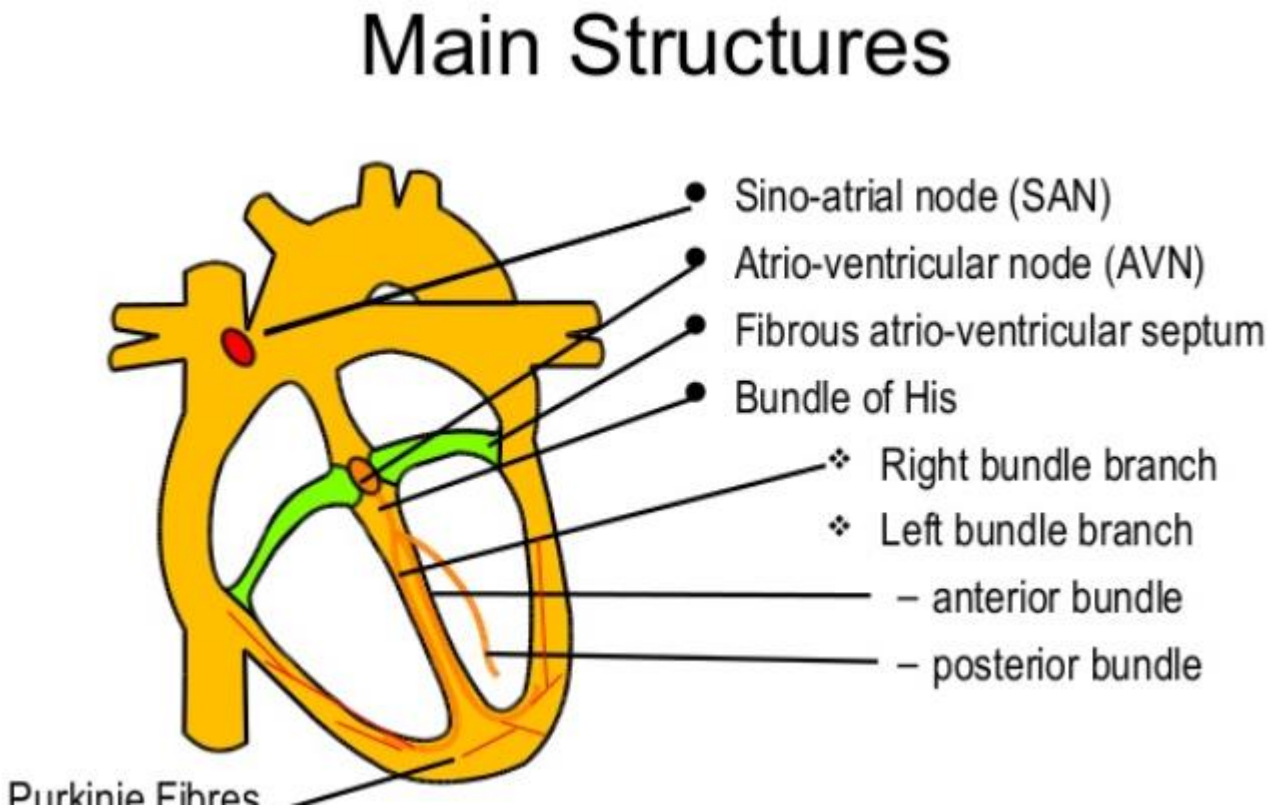
  →Left atria → left ventricle → aorta →

  →All parts of the body

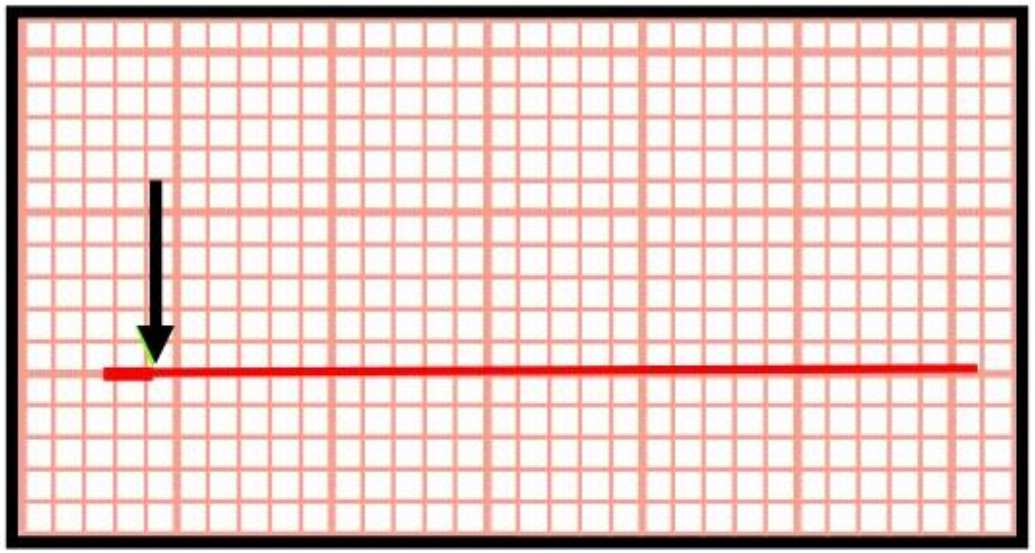


Origin of cardiac action potential

- SA Node (natural pacemaker) (0.04sec)
- AV Node (delay line) (0.11sec)
- The bundle of his
- Purkinjie fibers

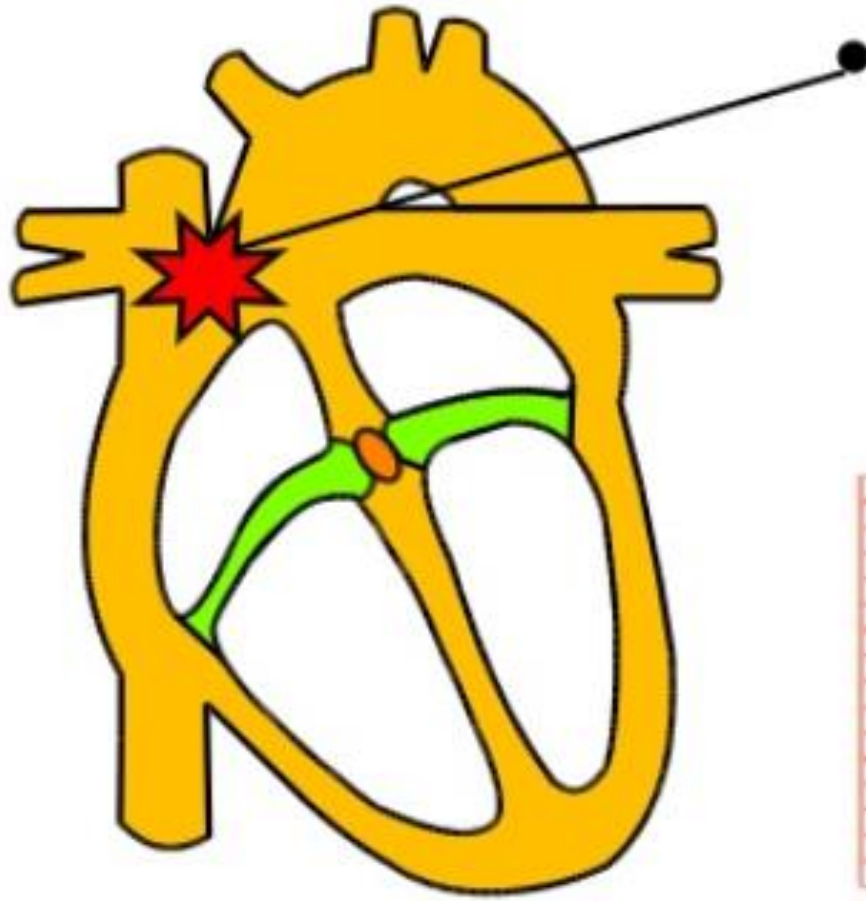


The Iso Electrical Line

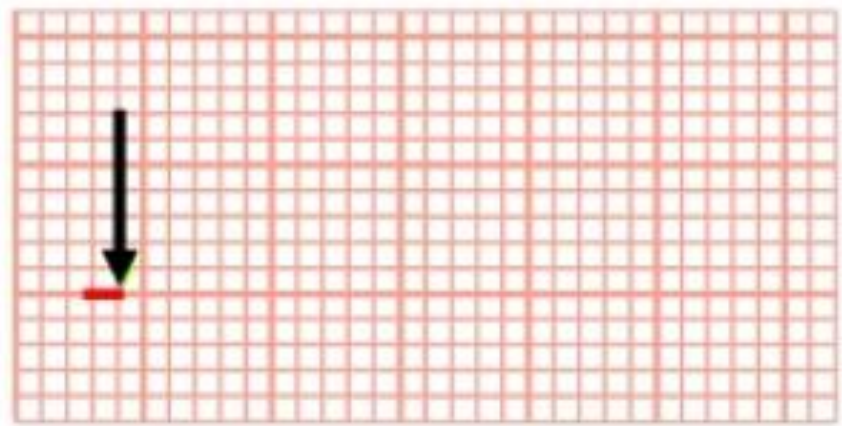


This represents the resting potential of the heart. The electrical events of the cardiac cycle will be represented by deflections away from this line.

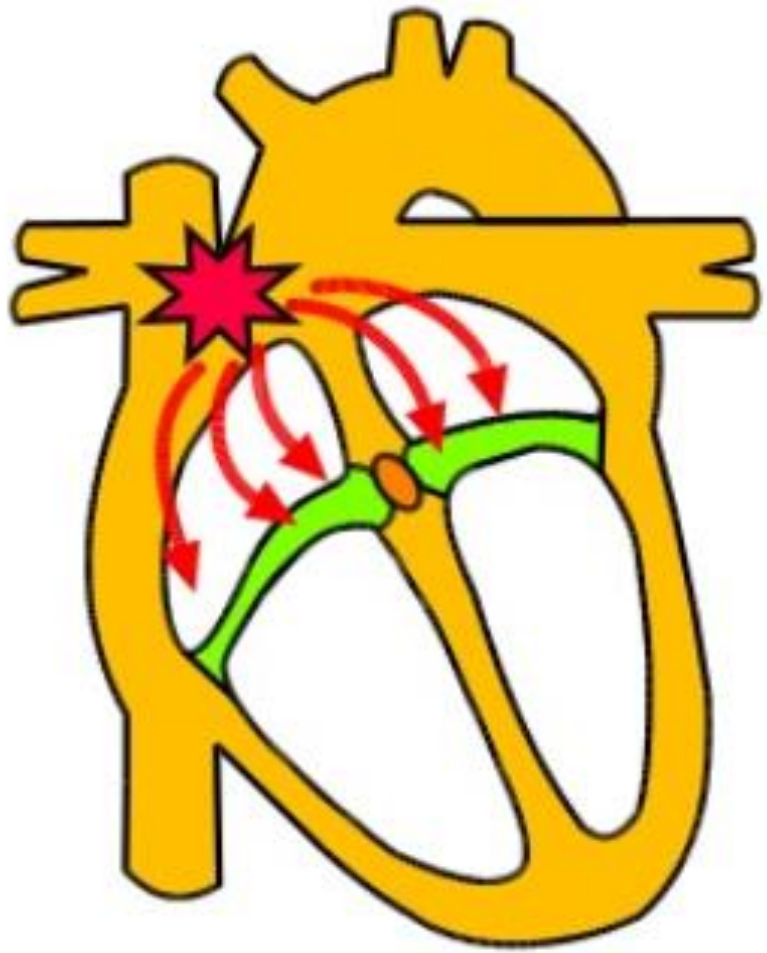
SAN Depolarisation End of Iso Electrical Line



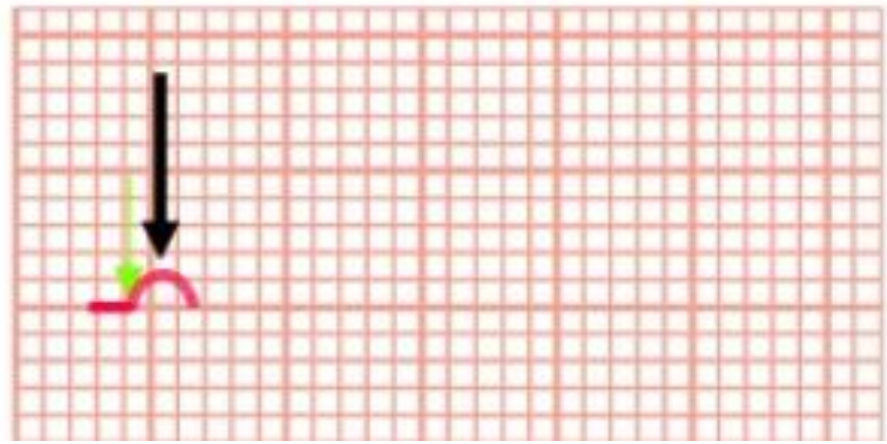
The events of the cardiac cycle are initiated by depolarisation of the sino-atrial node



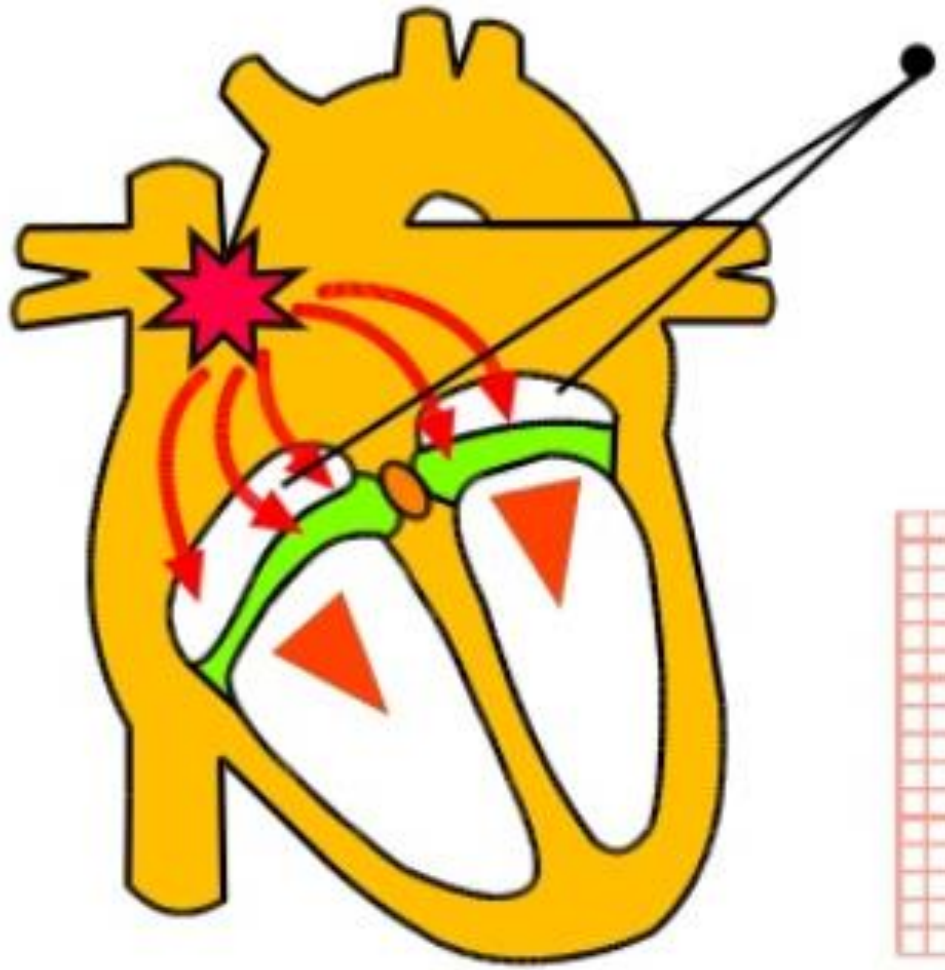
Atrial Depolarsiation (P Wave)



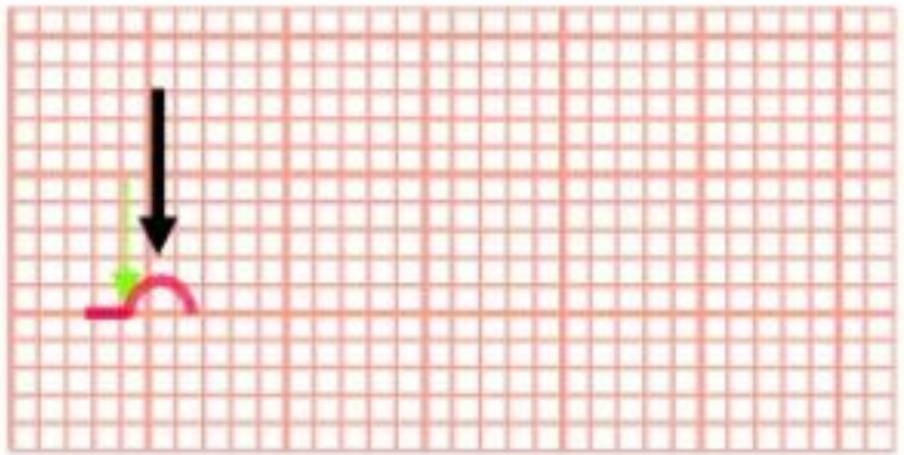
- The wave of electrical depolarisation is conducted through the cardiac muscle of both atria



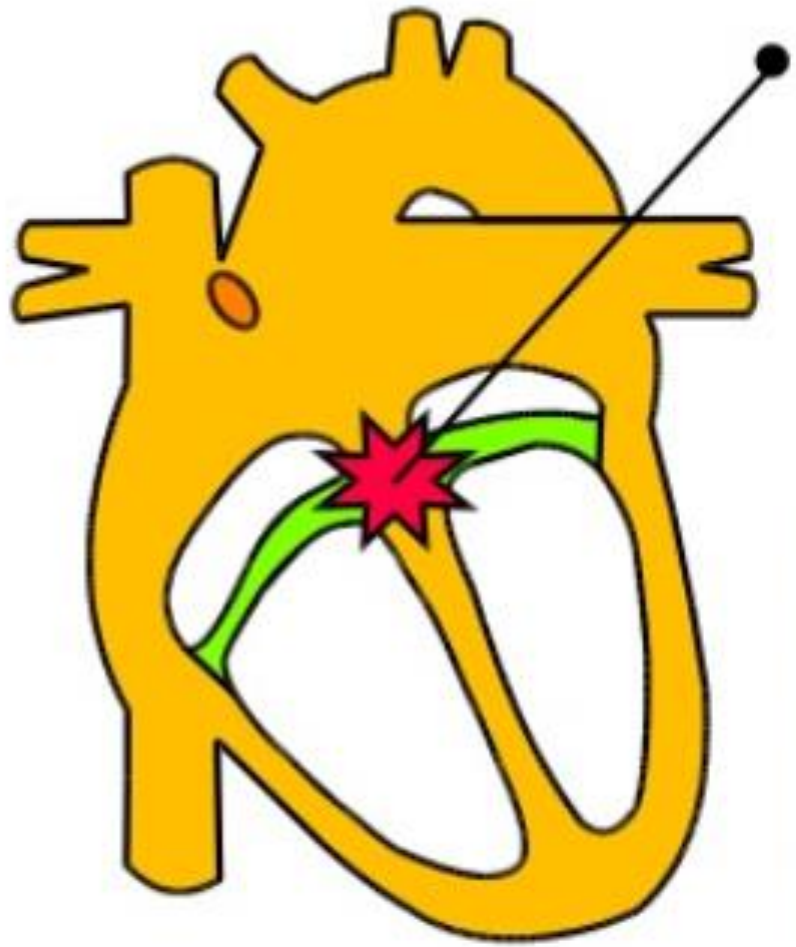
Atrial Contraction (P Wave)



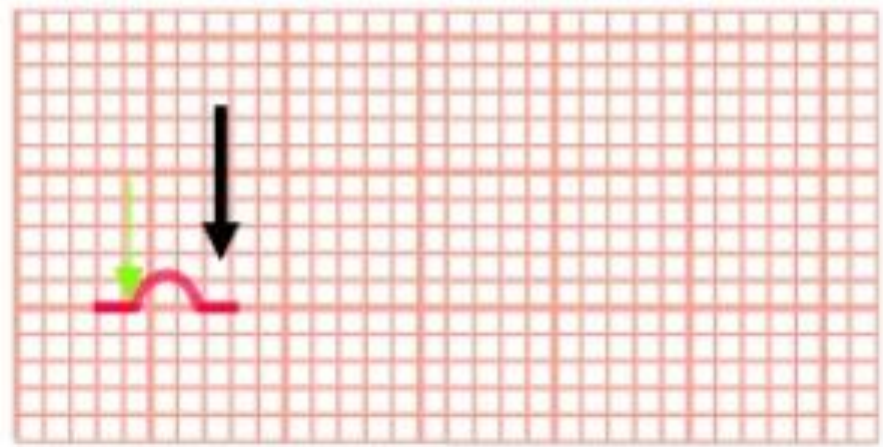
The depolarising wave causes contraction of the atria pushing blood into the ventricles



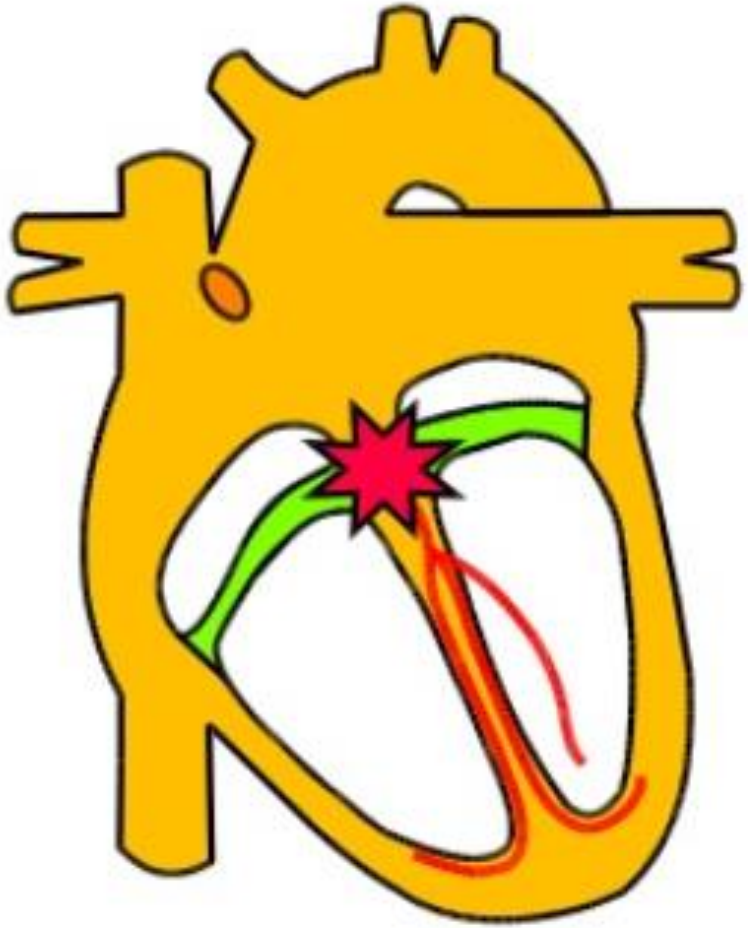
AVN depolarisation (PR Interval)



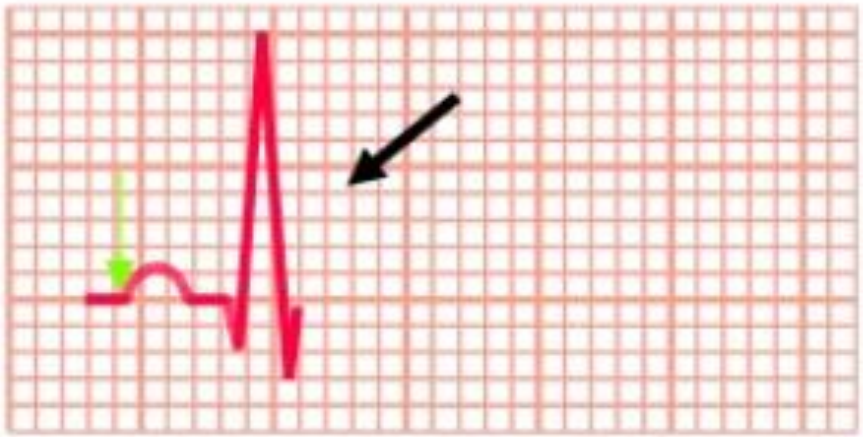
The wave of depolarisation reaches the atrio-venticular node which depolarises and conducts, but slows the wave



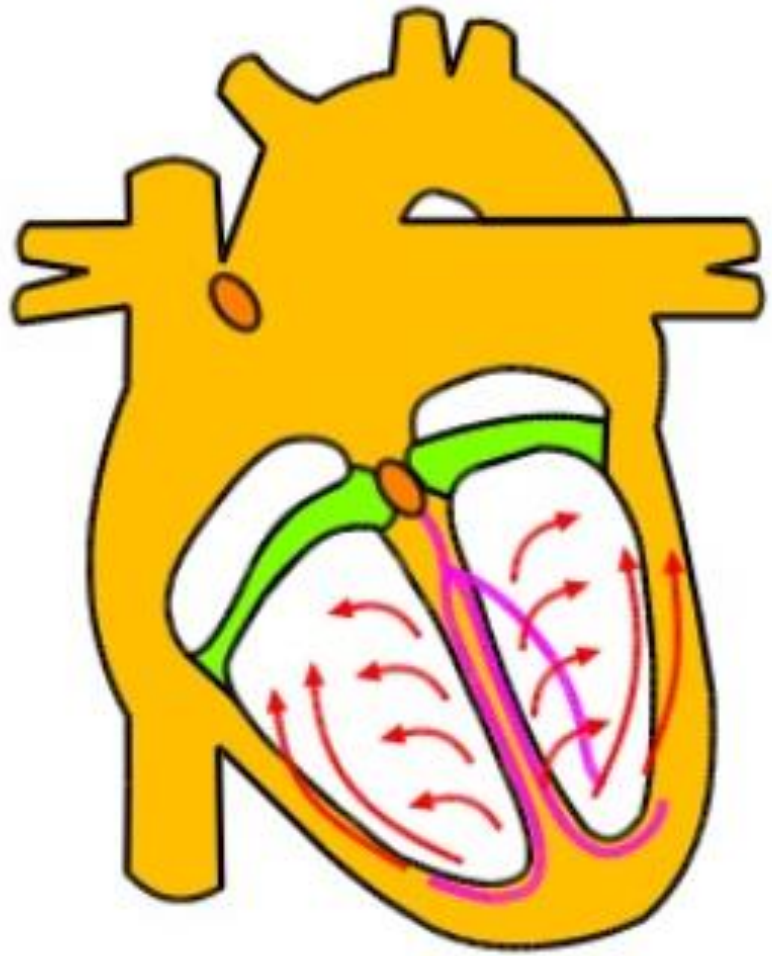
Specialised conducting tissue (QRS Complex)



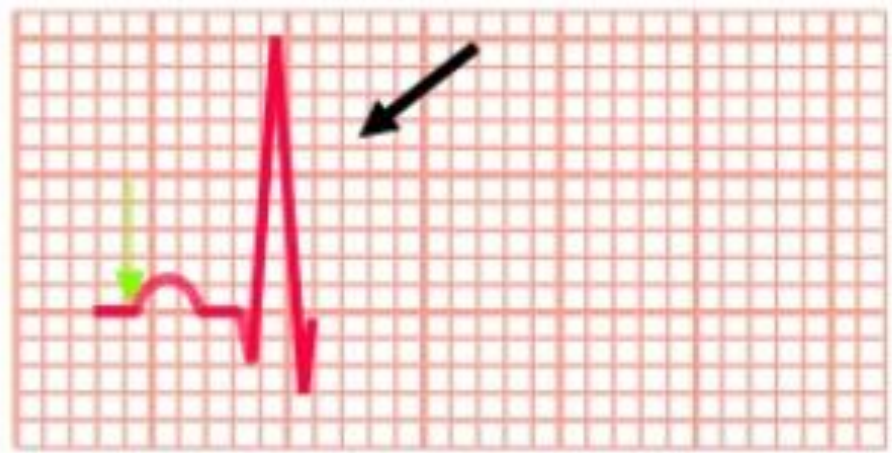
- The AVN conducts the depolarisation to the Bundle of His



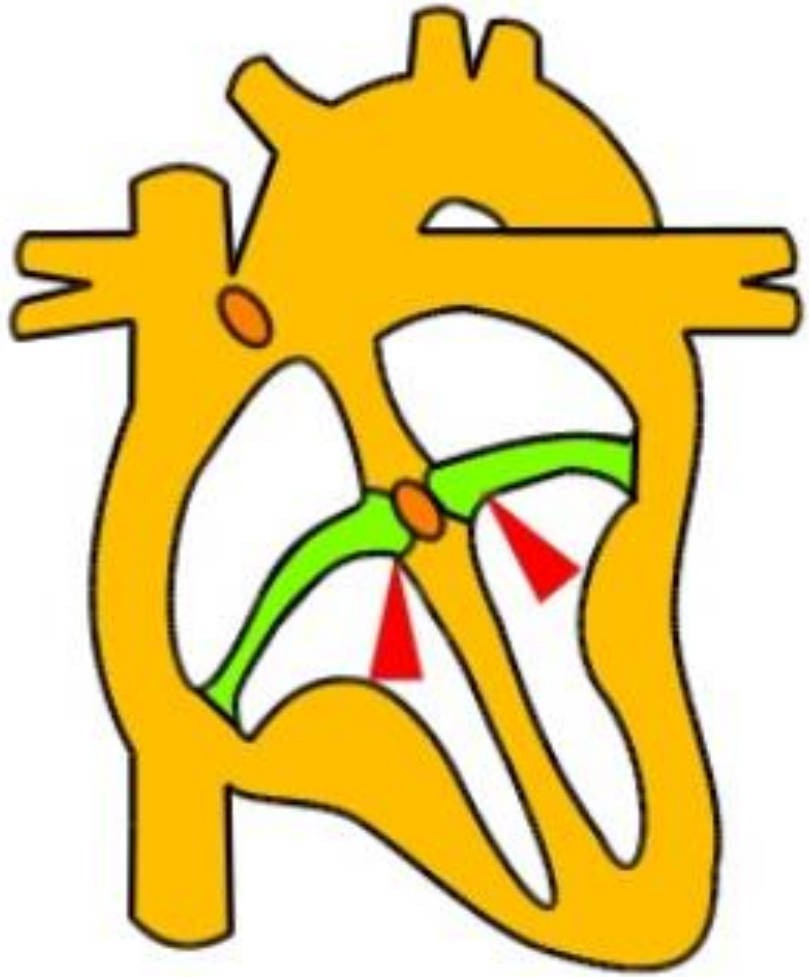
Ventricular depolarisation (QRS Complex)



- The wave of depolarisation quickly moves through the specialised conducting tissue

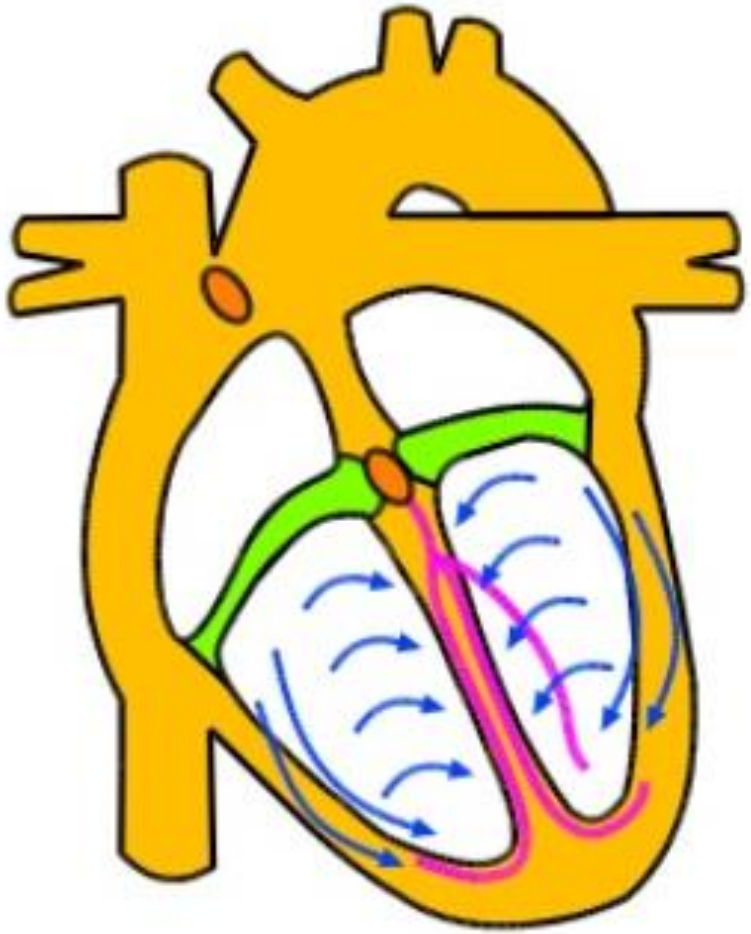


Ventricular contraction (QRS Complex)

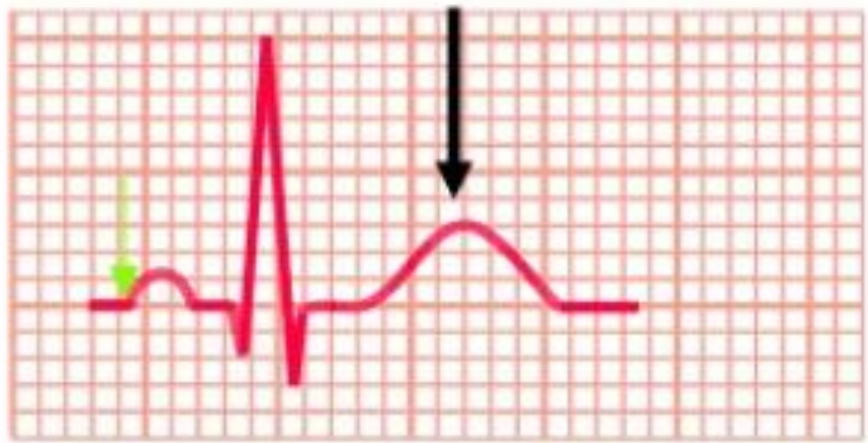


- The co-ordinated, synchronised depolarisation produces an effective contraction of both ventricles

Ventricular Repolarisation (T Wave)



- After depolarisation and contraction the ventricle repolarise, returning to the resting potential.



	Origin	Amplitude mV	Duration sec
P wave	Atrial depolarisation or contraction	0.25	0.12 to 0.22 (P-R interval)
R wave (QRS)	Repolarisation of the atria and depolarisation of the ventricles	1.60	0.07 to 0.1
T Wave	Ventricular repolarisation	0.1 to 0.5	0.05 to 0.15 (ST interval)
S-T interval	Ventricular contraction		
U wave	Slow repolarisation of the intraventricular (purkinjie fibers) system	< 0.1	0.2 (T-U interval)

ECG lead configuration

- Electric potential generated by the heart appear through the body and appear on its body surface.
- The potential difference is determined by placing pair of electrodes on the body and measuring the voltage between them.
- A pair of electrodes, or combination of several electrodes through a resistive network that gives an equivalent pair, is referred to as a **lead.**
- More than one lead must be recorded to describe the hearts electrical activity completely

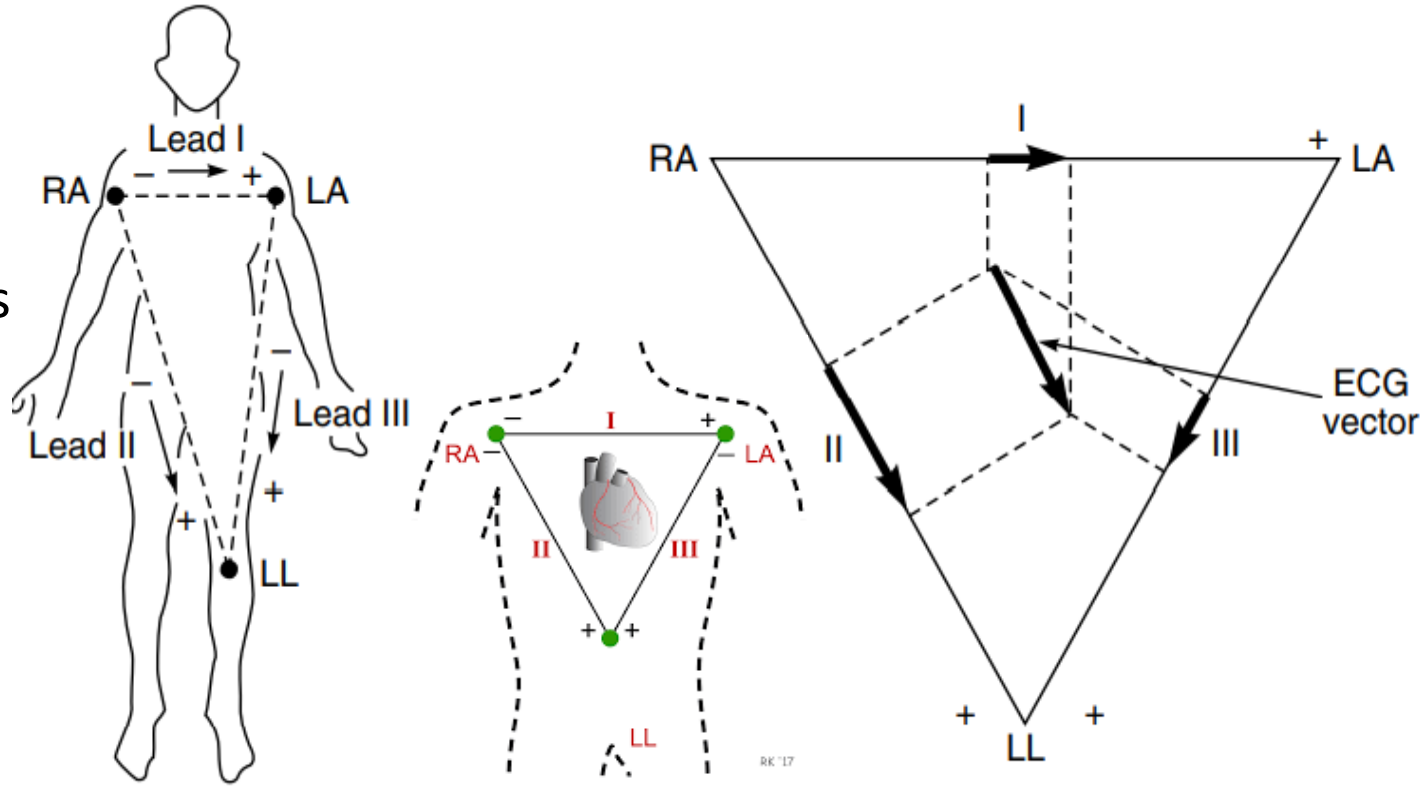
Three types of electrode lead system (12 lead system)

- limb leads or standard leads (3) → **Bipolar**
- Augumented unipolar leads (3)
- Chest leads or pericardial leads (6)

} **Unipolar**

Bipolar Limb/Standard Leads – lead I, II,III

- Potential are tapped from 4 location of our body→ right arm, left arm, right leg and left leg.
- Right leg → ground and reference electrodes
- Einthoven postulated, the frontal plane representation of the electrical axis of the heart is 2 D vector.
- Eithoven also made the assumption that the heart is near the center of an equilateral triangle , the apexes of which are the right and left shoulders and the crotch.
- The point of this triangle represents the electrode position of the three limb leads.
- This triangle is called Einthoven triangle.



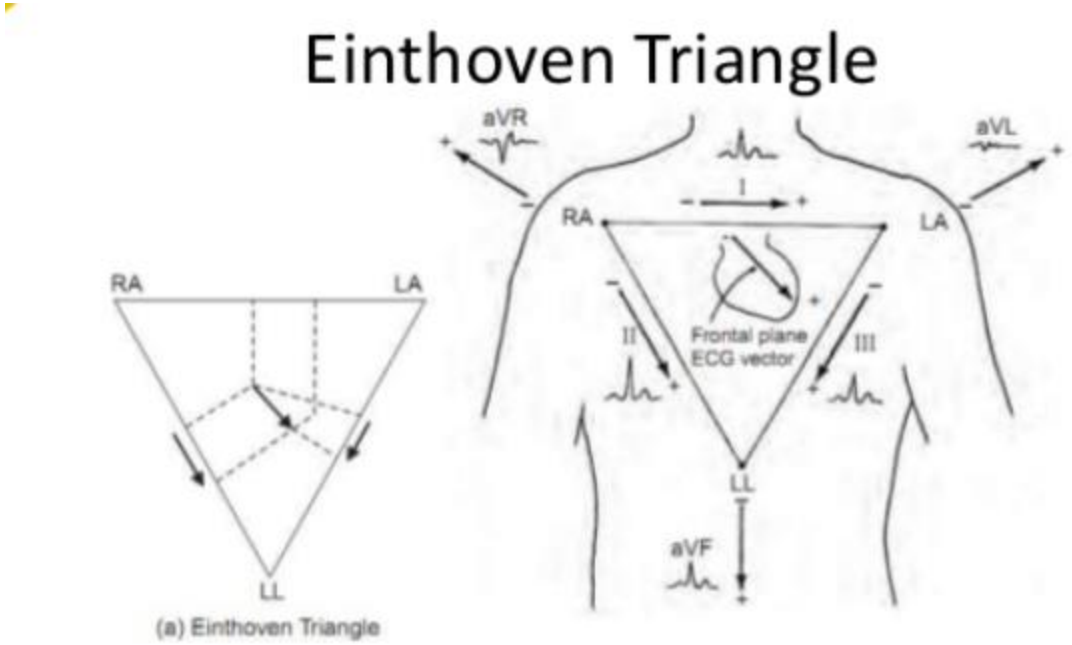
➤ **Fig. 5.5** *The Einthoven triangle for defining ECG leads*

The vector sum of the frontal plane Cardiac Vector at any instant onto the three axes of the Einthoven Triangle will be zero.

- Lead 1: Potential between the Right Arm (RA) and the Left Arm (LA)
- Lead 2: Potential between the Right Arm and the Left Leg
- Lead 3: Potential between the Left Arm and the Left Leg

- Lead I – gives voltage V_I, the voltage drop between left arm (LA) to right arm (RA).
- Lead II – gives voltage V_{II}, the voltage drop between left leg (LL) to right arm (RA).
- Lead III– gives voltage V_{III}, the voltage drop between left leg (LL) to left arm (LA).

- $V_I + V_{II} + V_{III} = 0$
- $V_{II} = V_I + V_{III}$



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- Lead 1: Potential between the Right Arm (RA) and the Left Arm (LA)
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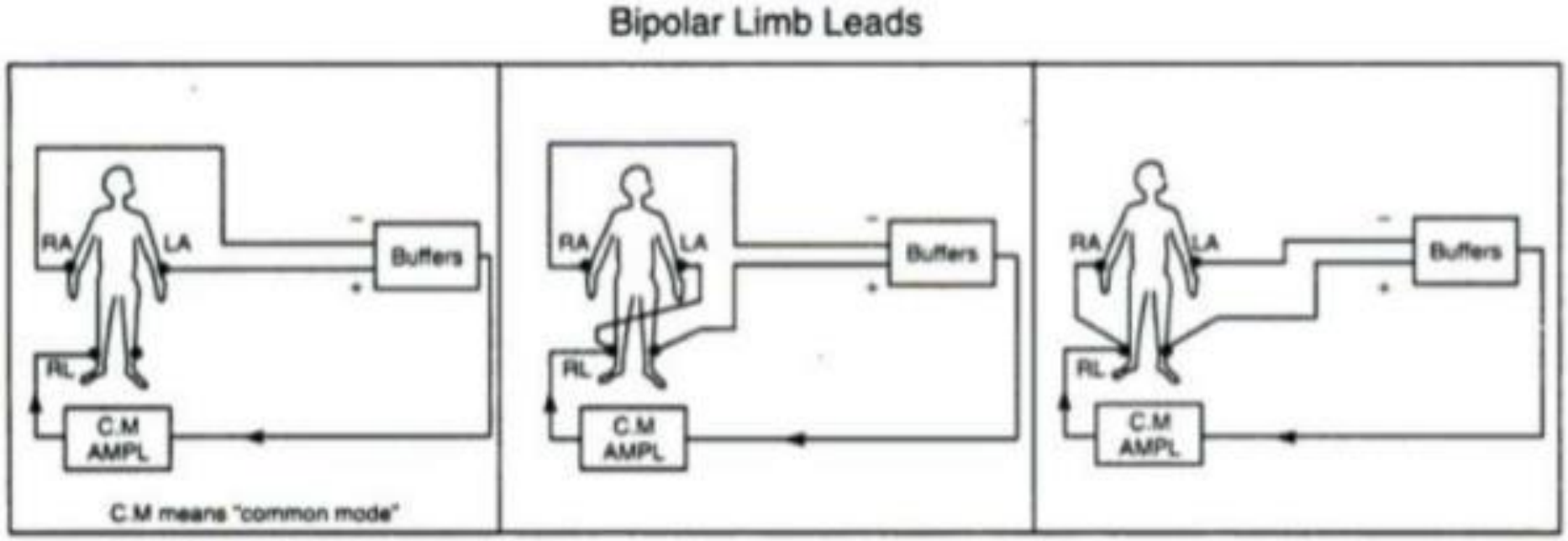
- Lead 3: Potential between the Left Arm and the Left Leg

12 Lead ECG System



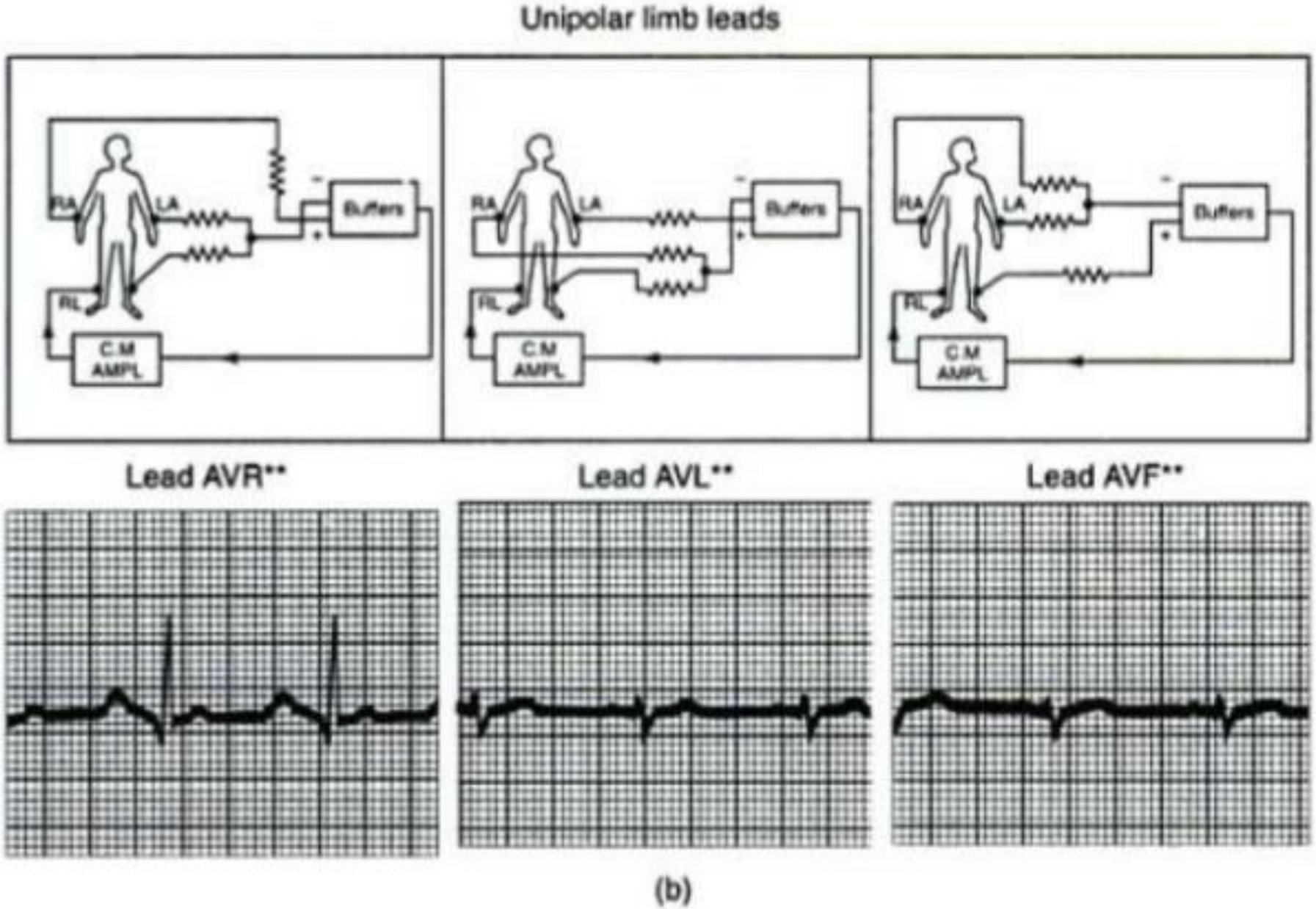
Unipolar electrodes

- Unipolar – Single electrode
  - Limb leads : two limb leads are tied together and recorded wrt to third limb AVR,AVL,AVF
  - Precordial leads : heart action on the chest at six different positions.

Augumented unipolar limb electrodes (AVL,AVR,AVF)

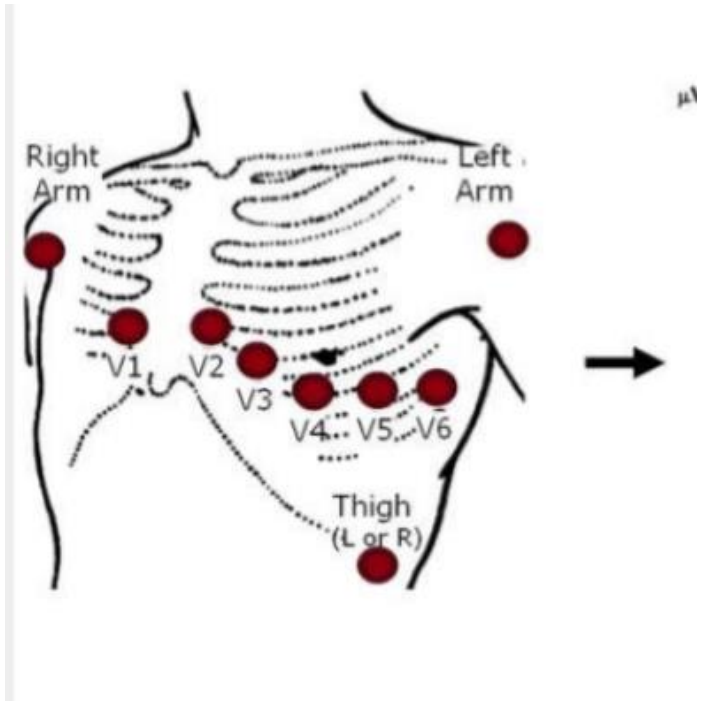
- introduced by Wilson
- a small increase in the ECG voltage can be realized.

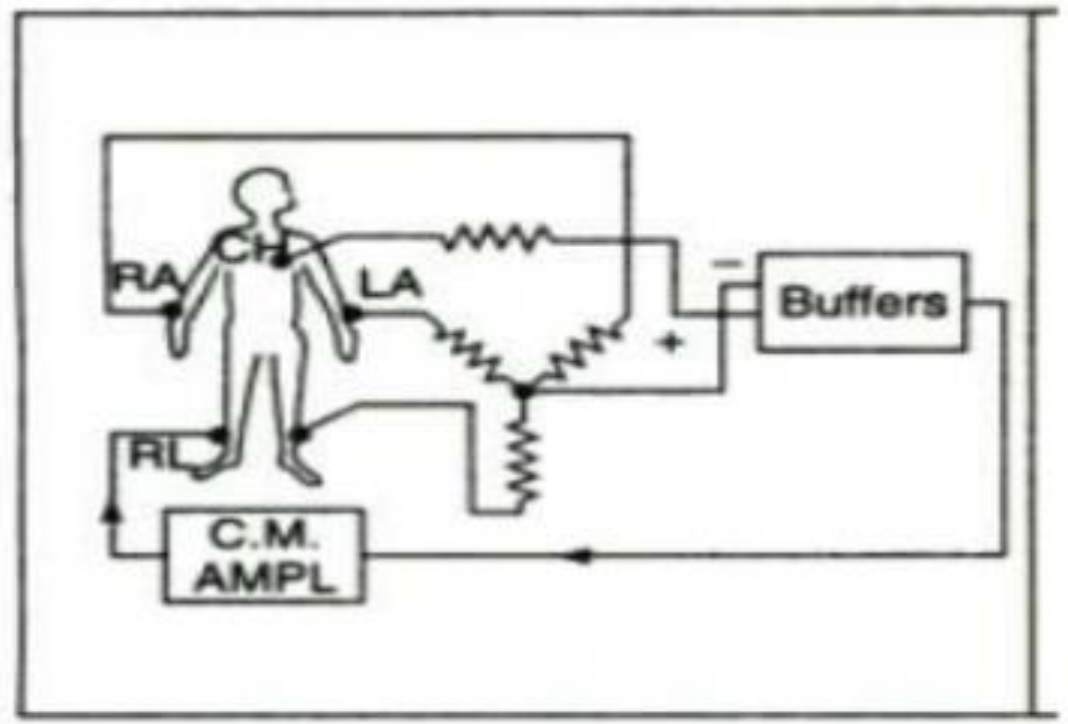
12 Lead ECG System



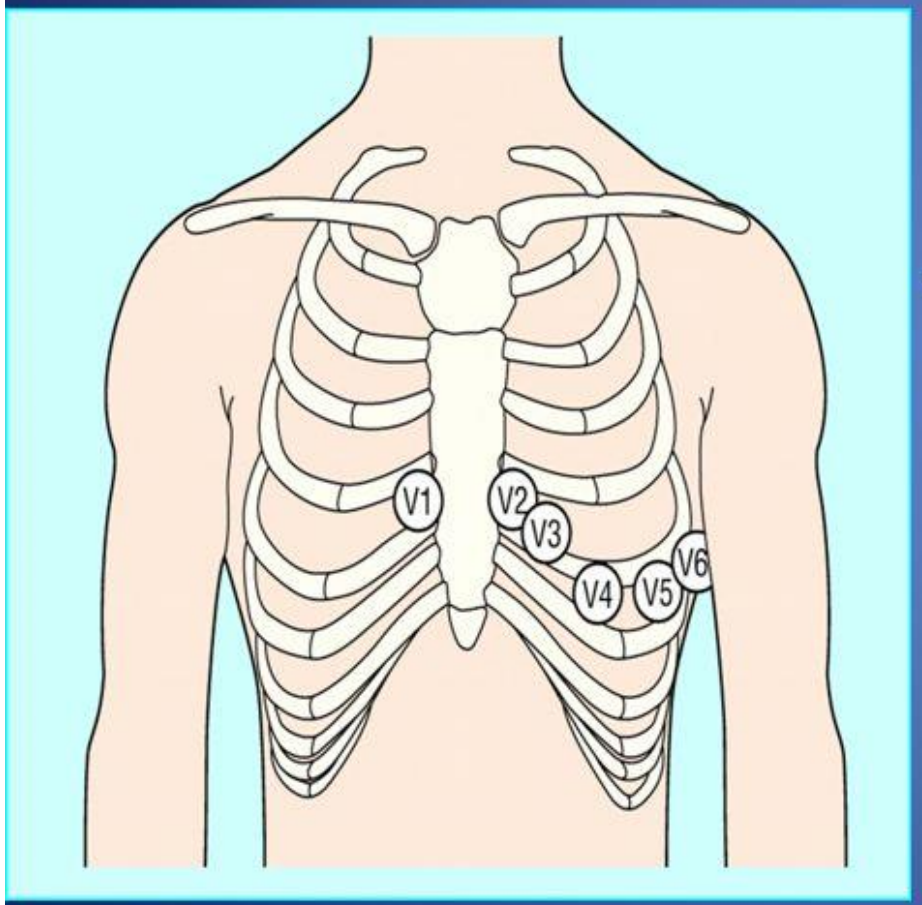
Unipolar chest leads (V1, V2,V3,V4,V5,V6)

- Active electrode → chest electrodes (placed on 6 different position close to the heart)
- Reference electrode → connecting 3 large resistance to left arm, right arm, left leg.
- This lead system is also called Wilson system



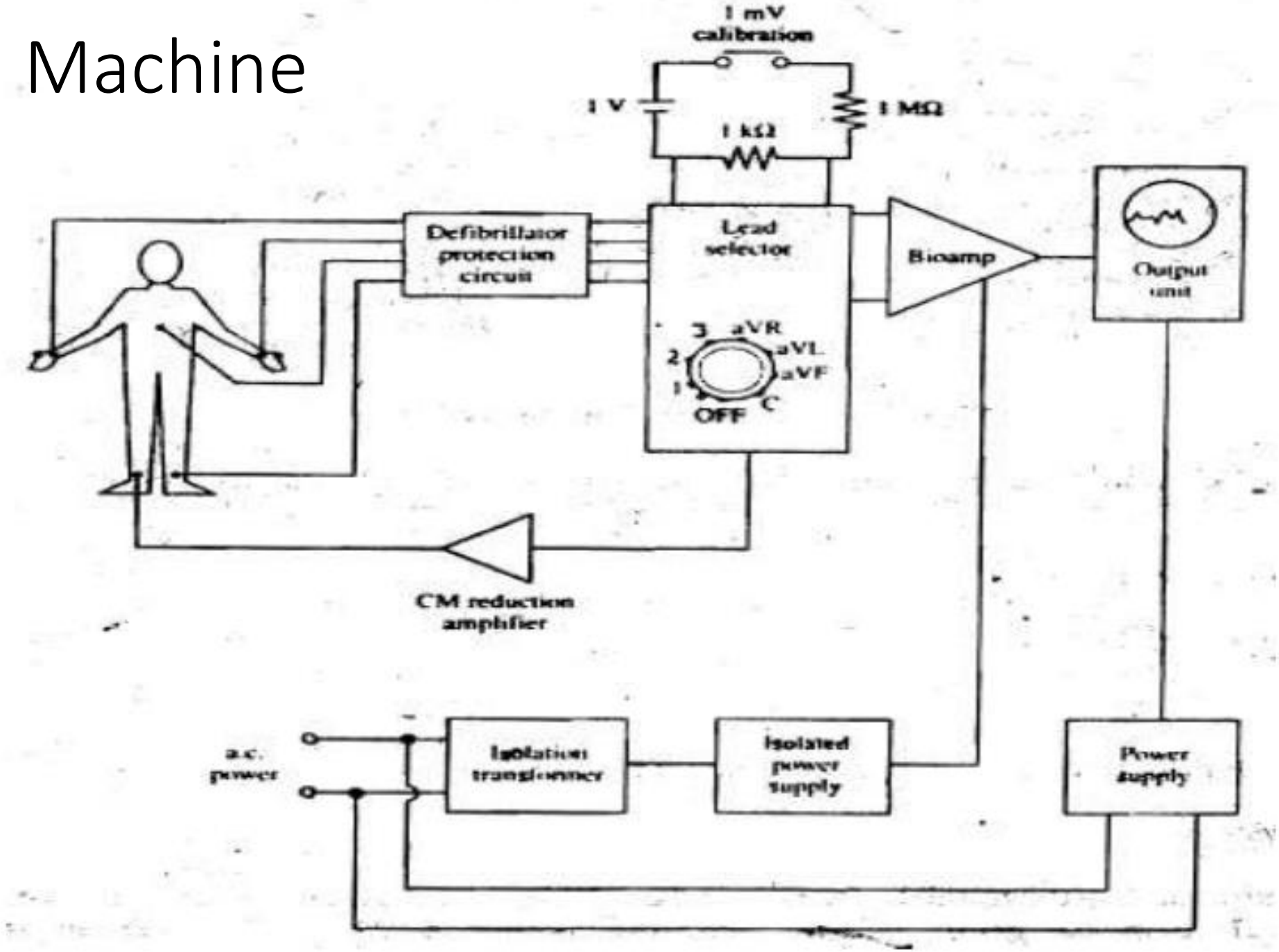


Chest Lead Electrode Position.



V1 – fourth intercostal space at the right sternal edge
V2 – Fourth intercostal space at the left sternal edge
V3 – Midway between V2 and V4.
V4 – Fifth intercostal space in the mid-clavicular line
V5 – Left anterior axillary line at the same horizontal level as V4
V6 – Left mid-axillary line at the same horizontal level as V4 and V5

ECG Machine


1 mV calibration
1 V
1 MΩ
1 kΩ
Defibrillator protection circuit
Lead selector
Bioamp
Output unit
3
aVR
2
aVL
aVF
1
OFF
C
CM reduction amplifier
a.c. power
Isolation transformer
Isolated power supply
Power supply

ECG Transducer(Recording set up)

- Defibrillation and protection circuit:-
  - Patient is connected to this circuit through different connecting cables.
  - Contains buffer amplifier and over voltage protection circuit.
  - Over voltage occur when ECG is used in conjunction with the radiofrequency diathermy units.
  - Over voltage protection circuit includes resistors and neon lamps so as to avoid the entrance of excess of voltage.
- Lead Selector Switch:-
  - Used to feed the input voltage from the appropriate electrode to the preamplifier.

ECG Transducer(Recording set up)

- Calibrator:-
  - Push button closed, standardization of 1mV is introduced to pre amplifier.
- BioAmplifier:-
  - Consists of a pre amplifier, power amplifier
- Auxiliary Amplifier(CM Reduction Amplifier):-
  - To reduce interference
- Isolated Power supply:-
  - To power the bio amplifier
- Output unit:-
  - Cathode Ray Oscilloscope or a paper chart recorder