ECG

ECG

- Electrocardiography -- recording of the electrical activities of heart.
- Electrocardiograph – instrument
- Electrocardiogram – record obtained.

- Conducting system of heart
- SA node --→ AV node -→ internodal tracts →

  Bundle of His with Rt & Lt branches -→ purkinje fibres

William Einthovan ---- Father of modern ECG

- Body acts as a volume conductor
- Body fluids –good conductors of electrolytes
  (it contains ions & electrolytes)

- During generation of cardiac impulse in SAN,
  electrical currents are produced in the heart.
- Electric currents spread through conducting system, working myocardial fibres and spread through entire body and also reach on body surface
- From body surface these electrical events can be picked up by placing suitable electrodes

- **ECG** --- A record of the sum **total** of the electrical events in the heart during cardiac cycle obtained from the body surface

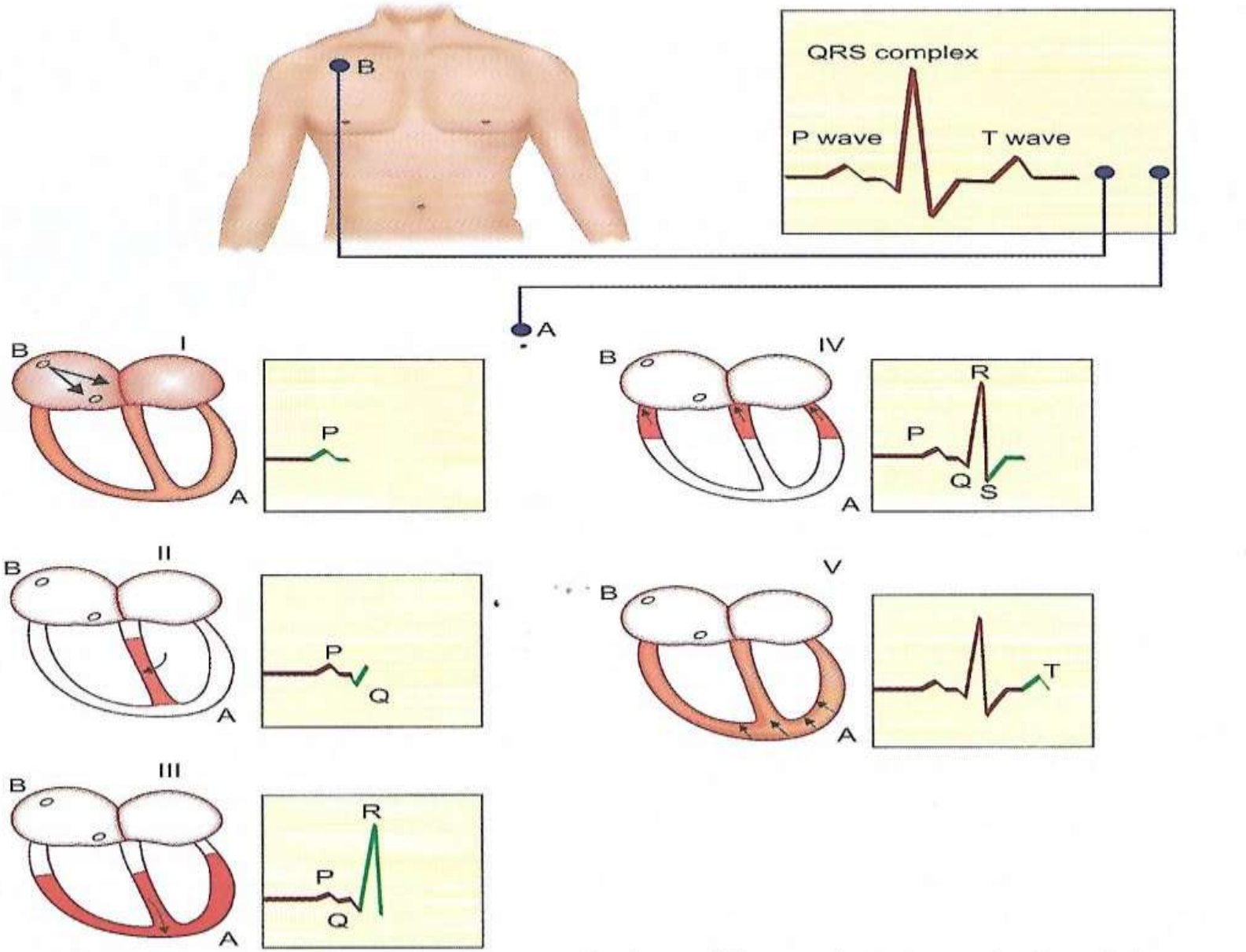
- **Sir William Einthoven** --- father of modern ECG
- ECG can be recorded --- on CRO

  --- on a graph paper.

- Speed of electrocardiograph -- 25 mm / sec

  ecg paper – on X axis – time, 1mm = .04 sec

  on Y axis -- voltage , 1mm = .1 mv



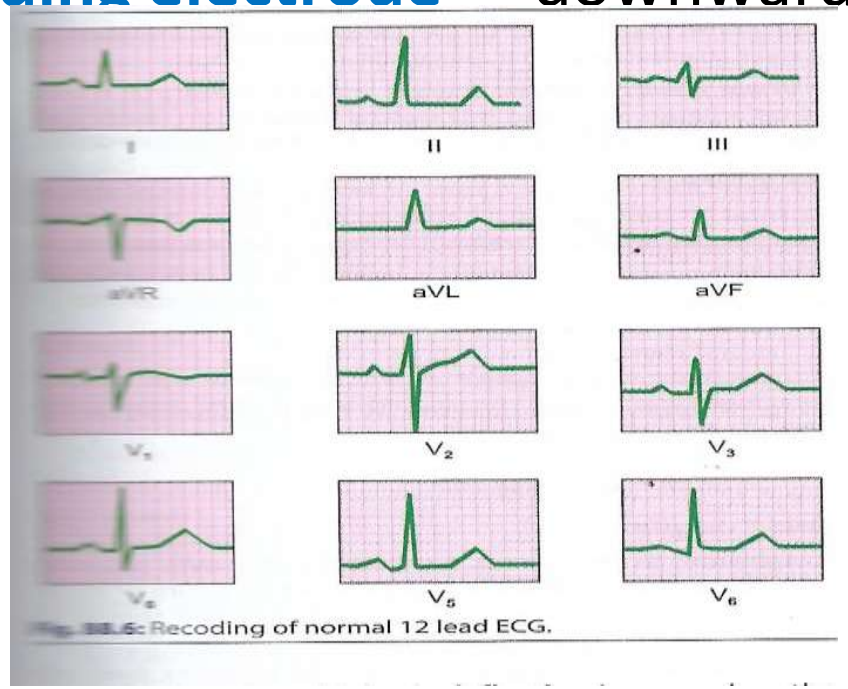
ECG recording by connecting electrodes that record voltage difference between point B on right arm ar

- Waves of ECG - due to depol and repolarization, not due to contra.

  (ie , recording electrical activity, not mechanical activity)

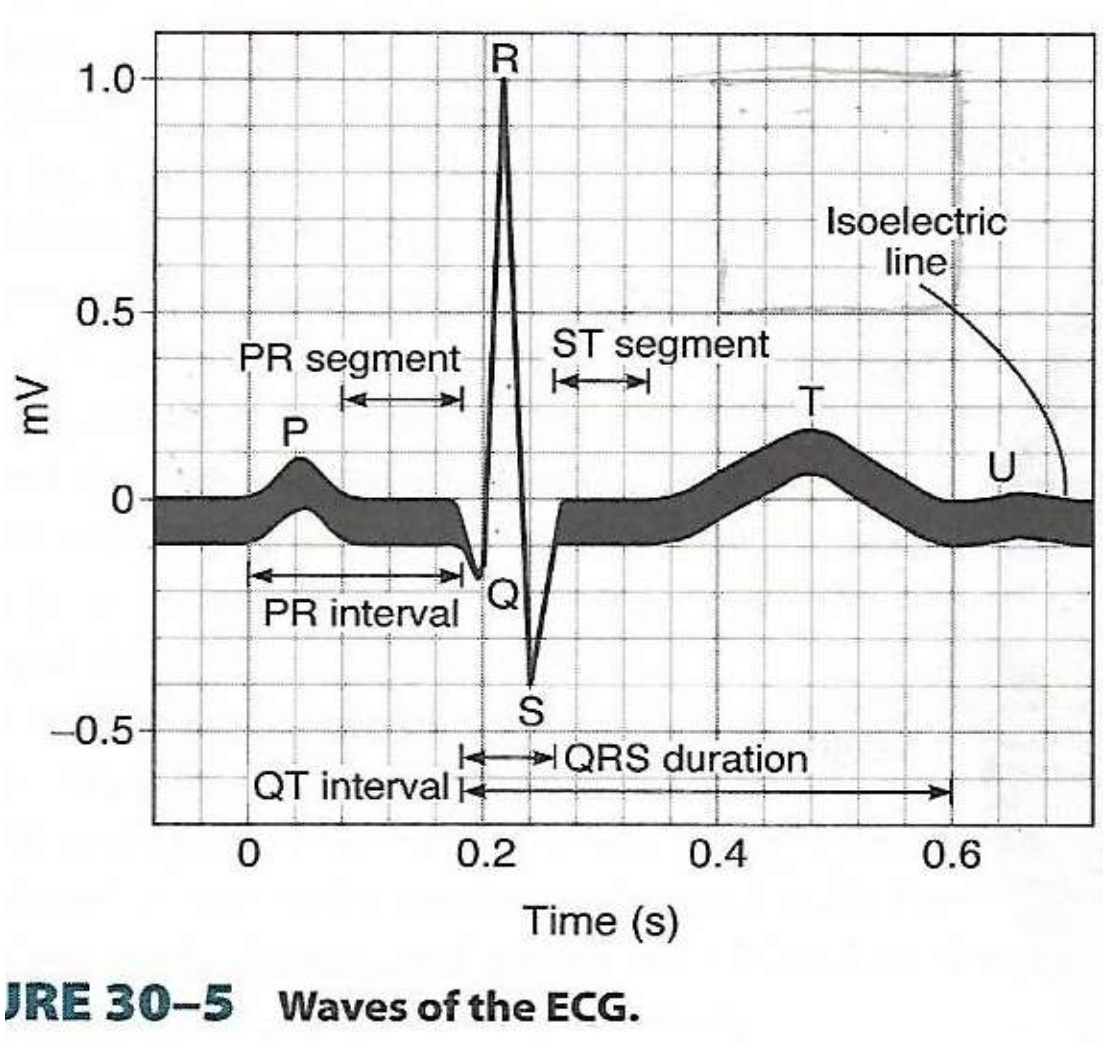
- When depol wave **moves towards recording electrode** (exploring electrode) -upward deflection -- **+ve** wave obtained

- When depol moves **away from the recording electrode** - downward -- deflection **-ve** wave obtained

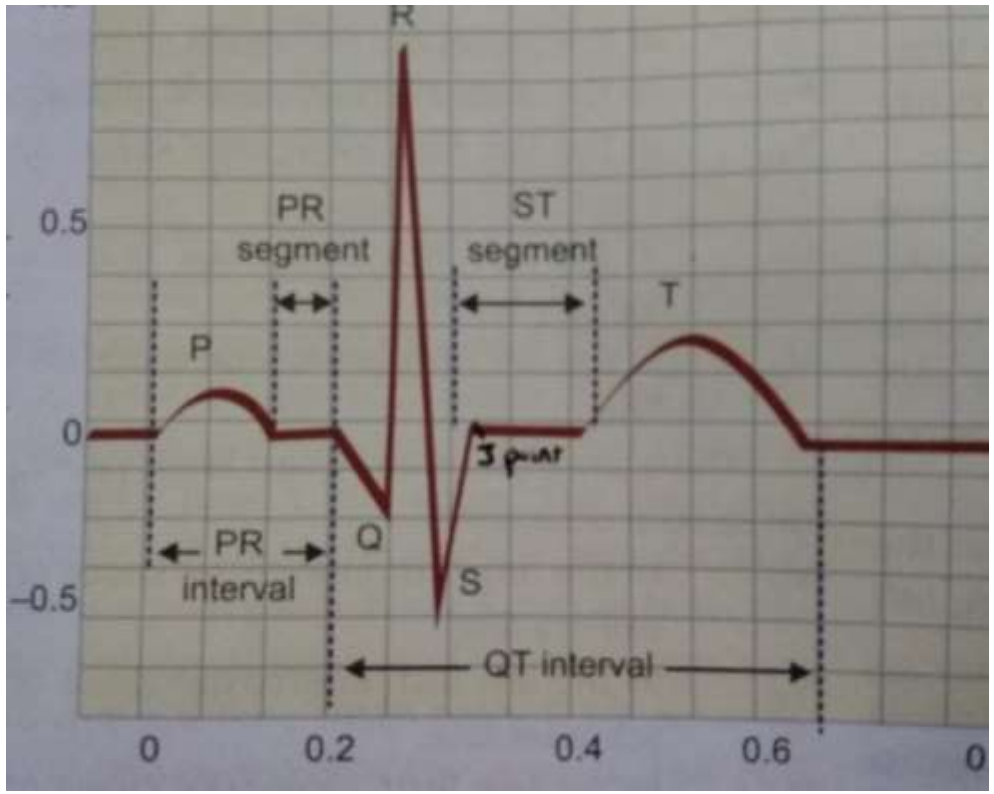


Recoding of normal 12 lead ECG.

Normal ECG -----(Lead II)



JRE 30–5 **Waves of the ECG.**



- Normal ECG has --waves -- P, QRS complex, T

  -segments--- PQ/PR segment, ST segment

  - intervals----PR interval, QT interval,

  RR interval

- **P wave**

  +ve deflection

  Duration = .08 - .1 sec

  Amplitude 0.1 to .3 mv

- ---due to atrial depolarization

- Magnitude of p --- a guide to the functional activity of atria.
- In mitral stenosis – left atrium is hypertrophied & P wave becomes larger & prolonged
- In atrial fibrillation – p wave absent
- In atrial ectopic ---- inverted p wave

QRS complex

- **--- due to ventricular depol**

- (-atrial repolarization is masked by ventr depol)

Consists of 3 waves—Q, R, S

Duration .08 ms -- .12 ms

Amplitude 1 – 3 mv (top of R → S)

Q –due to depol of interventricular septum from left to right

R – depol of apex of both ventricles

S – depol of basal part of vent

Clinical significance-

Deep Q wave (>.2mv) –is a sign of MI

Tall R wave (>1.3 mv) seen in vent hypertrophy

QRS duration > .12 sec – heart block

T wave

- -represents vent repol.
- Wider – because repol is slower
- Duration 0.15 -- 0.3 sec, amplitude 0.1 – 0.3 mv

- **Clinical significance**
- Inverted T wave -- important sign of MI
- Tall & peaked T wave -- hyperkalaemia (increased K+)

- **U wave** --- rarely seen
- due to repol of papillary muscles
- **Prominent in hypokalaemia**

Segments

Isoelectric lines in b/w the waves

PR segment

ST segment

PR segment (PQ segment)

Space b/w end of P wave & beginning of QRS complex

Duration .04 --0.1 sec

--depol of AVN , bundle of His & bundle branch

- **ST segment**
- period b/w --end of QRS complex & beginning of T wave

  " " end of vent depol to the beginning of vent. repol
- Duration 0.04 –0.08 sec
- **Clinical significance**
- In MI --- ST seg is elevation
- In myocardial ischemia– ST seg depressed

- **J point**
- Point b/w end of S wave and beginning of ST segment
- Point of zero voltage
- Helps in assessing ST seg elevation

- **Intervals**
- -- include waves and segments

- **PR interval**
- Interval from beginning of P wave to the beginning of Q or R wave
- Time b/w onset of atrial depol and onset of vent depol
- Atrial depol + conduction time in bundle of His
- P wave + PQ segment
- normal duration **.12 --- .20sec**
- If PR int > .2 – indicates AV conduction block

- **QT interval**

- Interval from beginning of Q wave to the end of T wave
- --vent. Depol & vent. repol
- Nl duration 0.40 -- 0.43 sec
- QT int – **shortened in hyperkalaemia**

- **PP interval**
- interval b/w peaks of 2 successive P waves

- **RR interval**
- Interval b/w 2 successive R waves
- Normal duration = **0.8 sec**
- **for calculating heart rate**
- HR = 60 / RR int. in **sec**
- = 60 / 0.8 = 75 / min

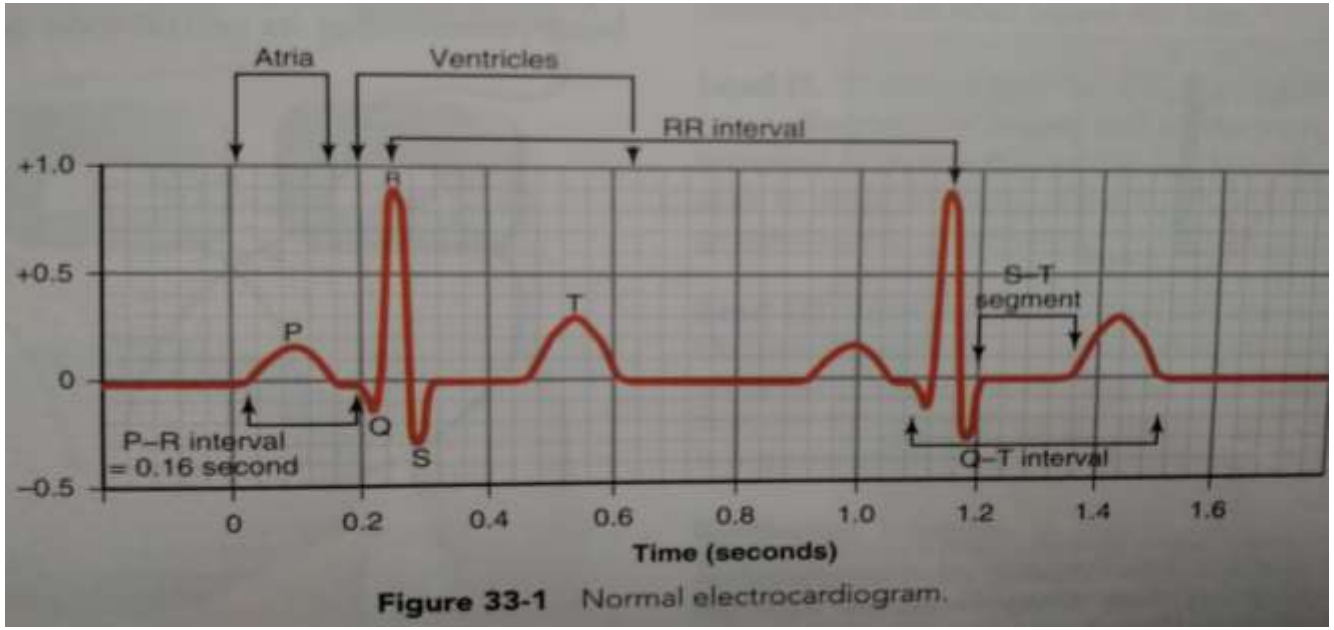


Figure 33-1 Normal electrocardiogram.

Other method

- H R = 1500 / RR int. in **mm**

ECG --- 2nd class

Recording of ECG

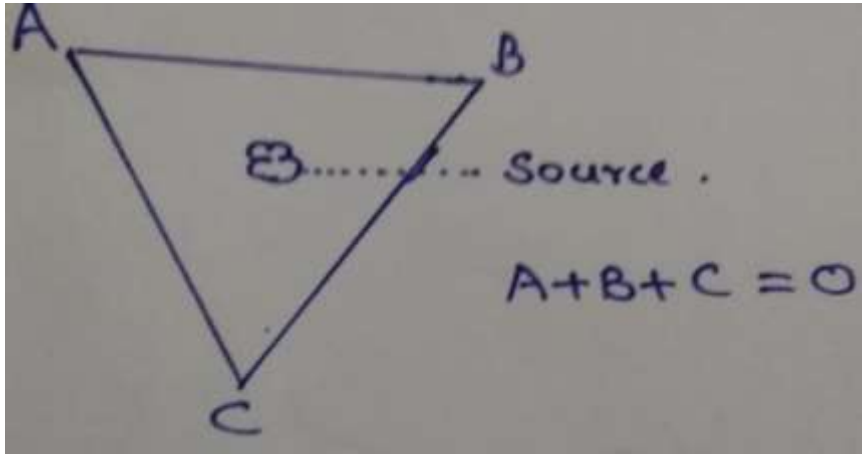
The basis of ECG recording is formed by postulates of **William Einthovan**

Postulates

1) Body acts as a volume conductor & heart acts as a current source.

Heart is a dipole situated in the centre of volume conductor.

- 2) In any volume conductor, if an equilateral triangle is drawn with electric source at the centre, the sum of the potentials at the 3 apices of the triangle is equal to 0 at any time .



3) **Einthovan's triangle**

- William Einthovan approximated an equilateral triangle in the body with heart at the centre , and triangle is formed by the points where the left arm, right arm and left leg join with the trunk. This is Einthovan's triangle .

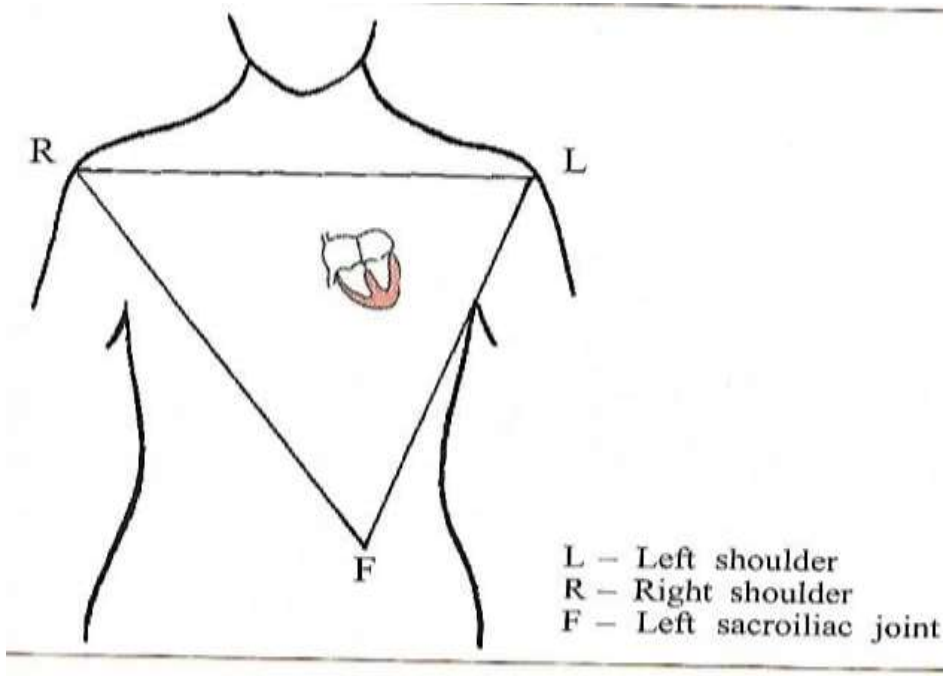


Fig. 6.56. *Einthoven's triangle.*

- 4) The 3 limbs (Lt arm , Lt leg & Rt arm) are considered as extensions of this volume conductor so that electrodes can be placed anywhere on the limbs . It will not make any difference to the ECG pattern.

- Fig

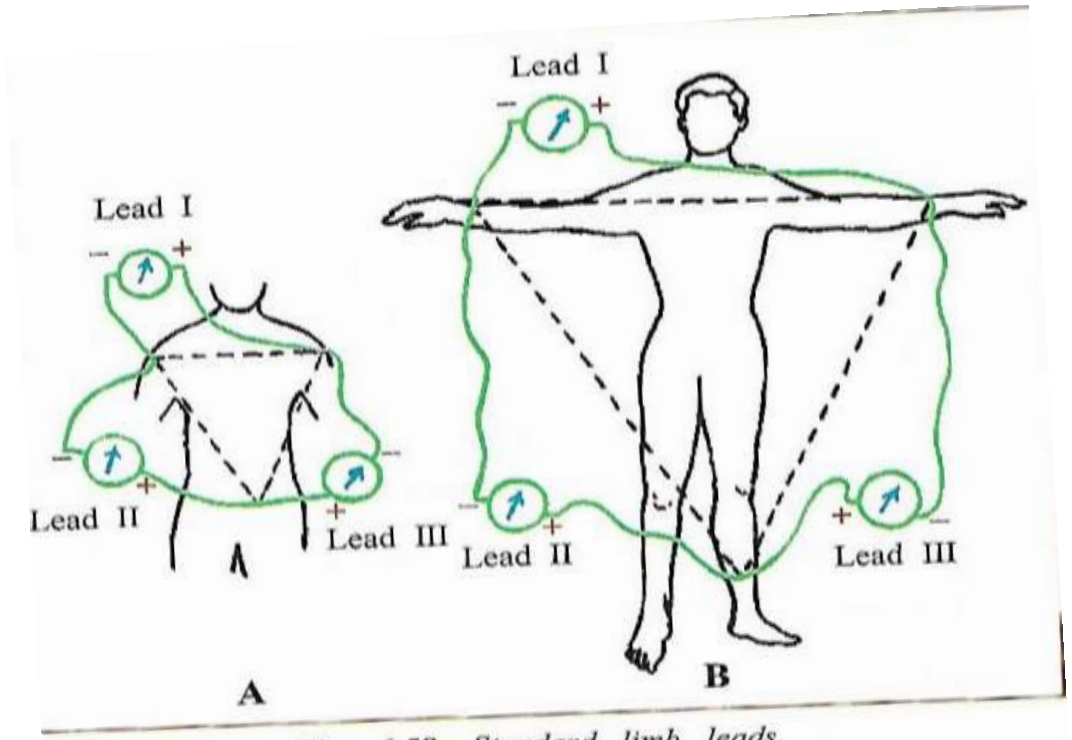


Fig. 6.58. *Standard limb leads.*

t does not matter where the electrodes are placed but these must be equidistant in between them and also from the heart.

ECG LEADS

- Leads - electrodes which can pick up electrical activities from the body surface.
- They are placed on the body surface & connected to the ECG machine for measuring p.d b/w 2 points .
- **Leads – 2 types**
- **Bipolar leads**
- **Unipolar leads**

- **Bipolar leads**

* Both electrodes are active (both can pick up electrical activity)

One is connected to the +ve and other is connected to –ve terminal of ECG machine

* Bipolar leads measure the p.d b/w 2 points

- **Unipolar leads**
- Here 1 electrode is **active.**

  It is the recording electrode or **exploring electrode** .
- It is connected to the +ve terminal of ECGraph
- The other electrode is **inactive** -- **indifferent electrode,** it is kept at 0 pot
- Unipolar leads measure the **absolute pot at** a point
- ----------

Leads ----- total 12

---- Bipolar limb leads 3 -LI , LII, LIII

----- Augmented unipolar limb leads – 3 - aVR , aVL, aVF

------ Unipolar chest leads – 6 - V1 , V2, V3, V4, V5, V6

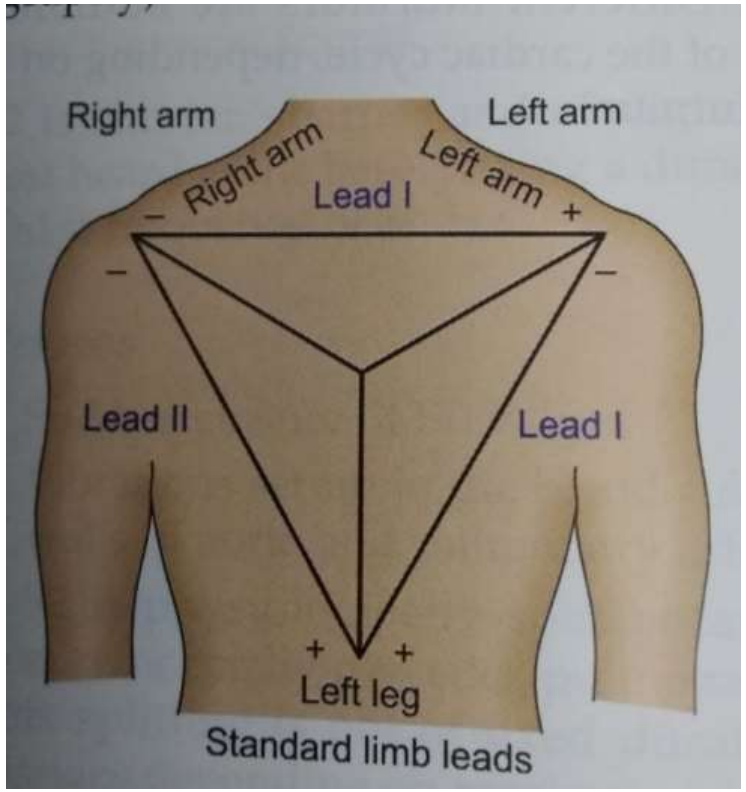
Bipolar Limb Leads

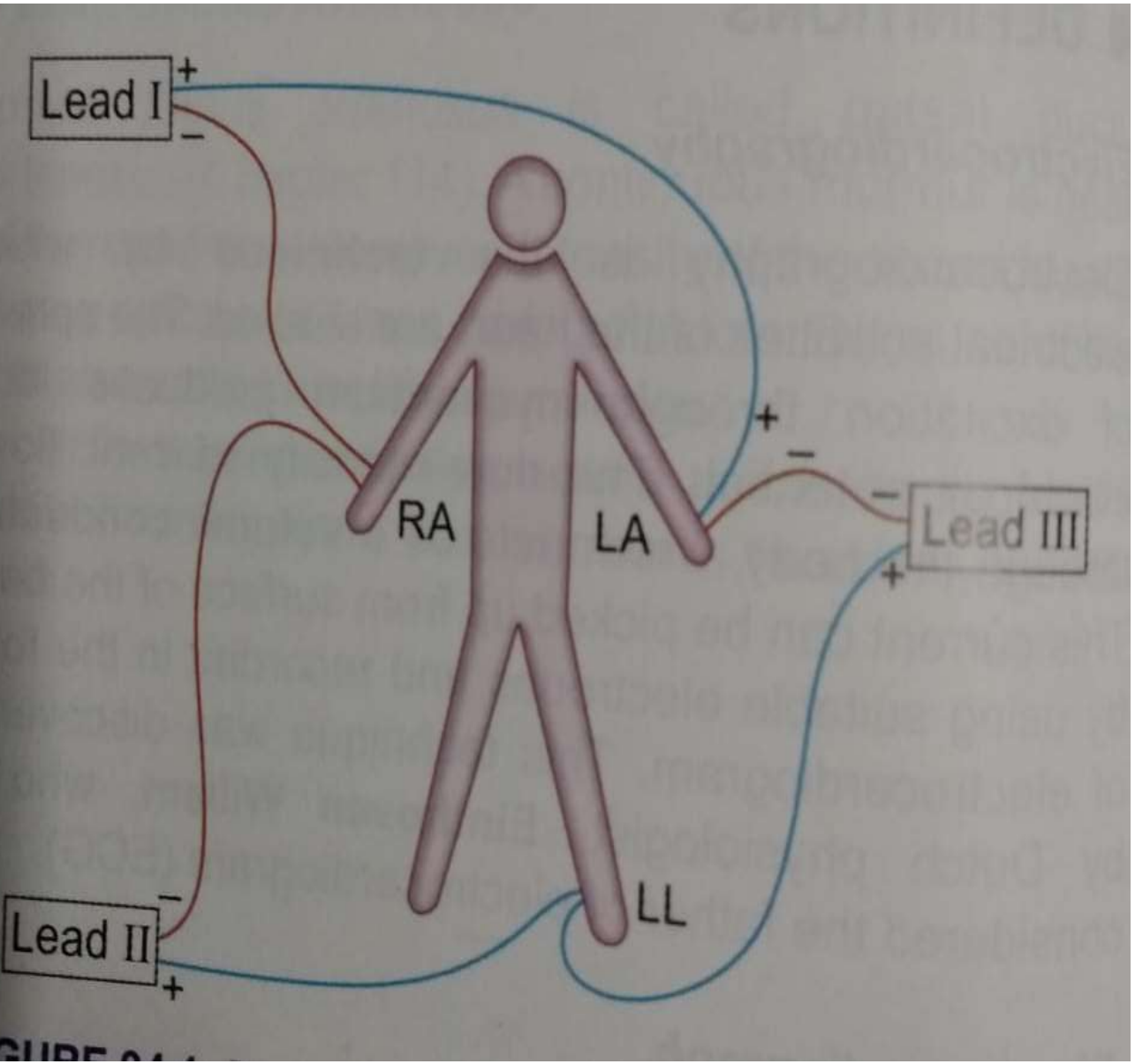
- 2 electrtodes- both are active.
- They measure the p.d b/w 2 points.
- Bipolar limb leads are designated as LI, LII, & LIII
- electrodes are connected to the Lt arm(LA), Rt arm (RA), & Lt foot (LF)

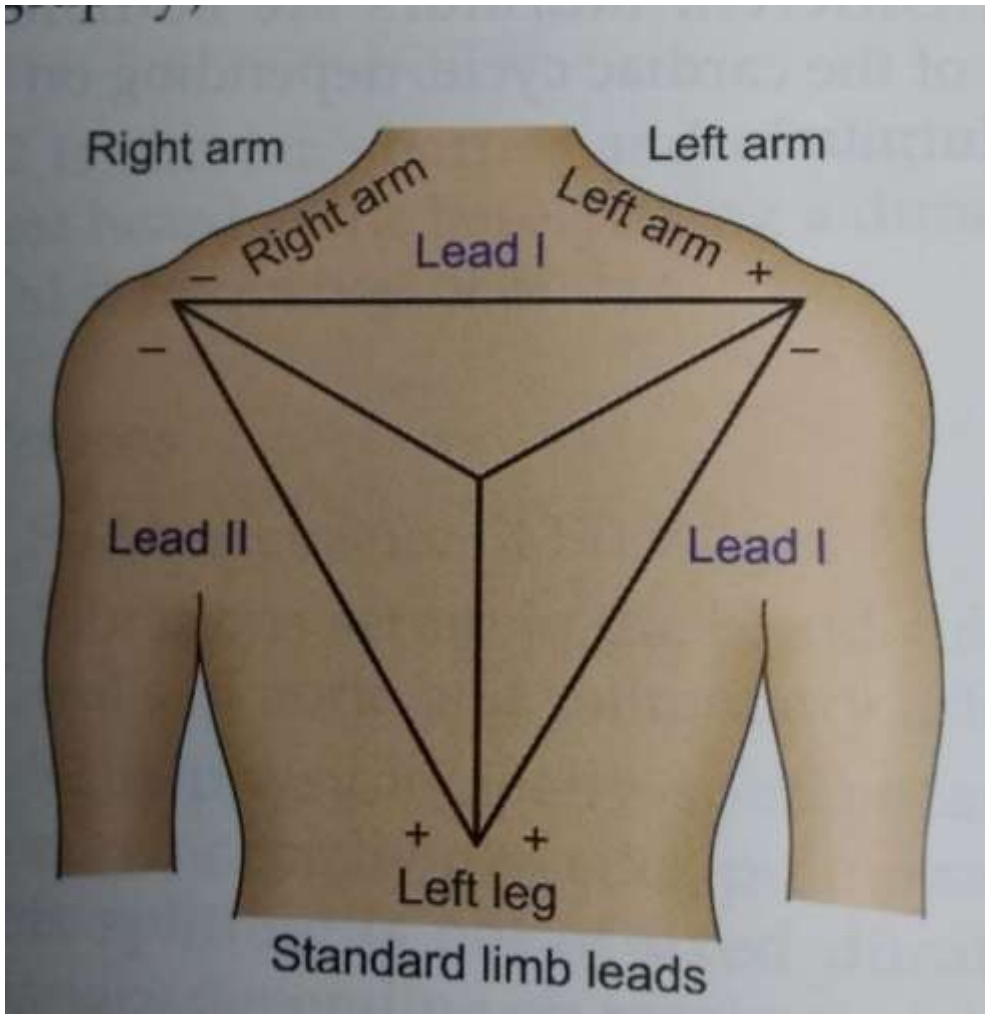
LI---- measures the p.d b/w LA & RA (LA +ve

LII--- measures the p.d b/w RA & LF (LF +ve)

LIII--- measures the p.d b/w LA & LF (LF +ve)




Lead I
+
–
RA
LA
+
–
–
Lead III
+
–
Lead II
+
LL

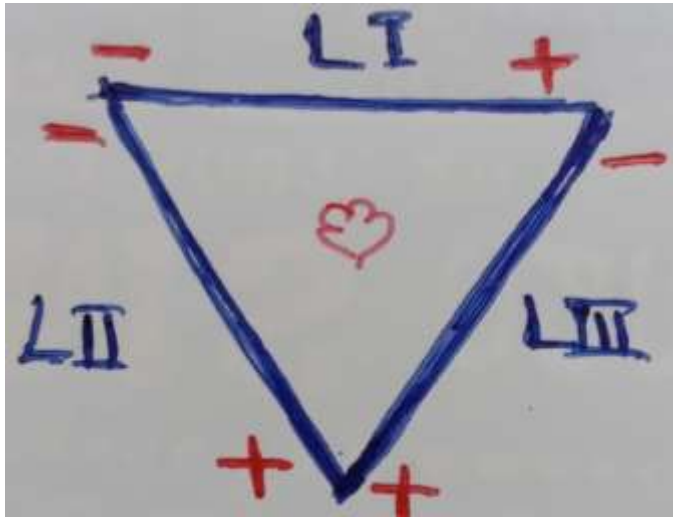

Right arm
Left arm
Right arm
Lead I
Left arm
–
+
–
–
Lead II
Lead I
+
+
Left leg
Standard limb leads

Einthovans Law

The 3 bipolar limb leads represents a closed circuit.

According to **Kirchoff's law** (closed circuit law), the algebraic sum of the potentials sequentially recorded in a closed circuit is **0**

- Ie **LI + LII + LIII = 0**



But Einthovan reversed the polarity of LII

in order to get +ve waves in all 3 bipolar leads.

Eq becomes

LI - LII + LIII = 0 or LI + LIII = LII

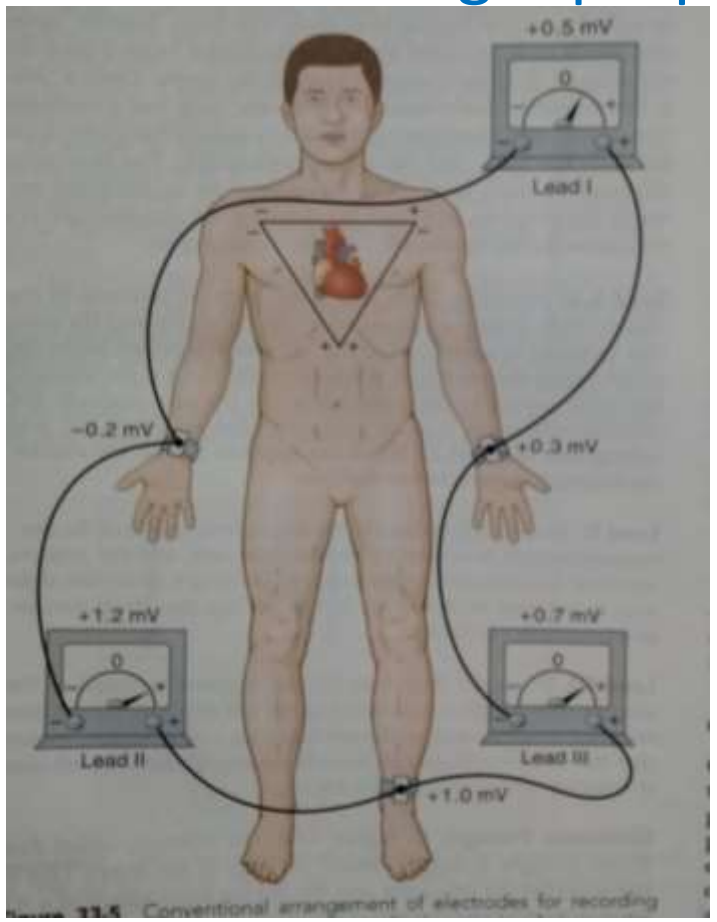
So if the electrical pot of any 2 standard bipolar limb leads at any instant are known, the pot of 3rd lead can be calculated by using the eq **LI+ LIII =LII** . This is known as **Einthovans Law**

- Electrodes are placed just above the wrist on the arms & just above the ankles on the leg.

-electrodes – gel is applied – to decrease resistance and to get proper contact with skin

Earthing –RL --for the electrical protection of the patient and to eliminate electrical interference in the recordings.

RL --- from right leg



Unipolar leads

- It records the absolute potential at a point

- Exploring electrode is connected to +ve terminal
- Indifferent electrode -→ zero pot --- -ve terminal

- Unipolar leads --- different types

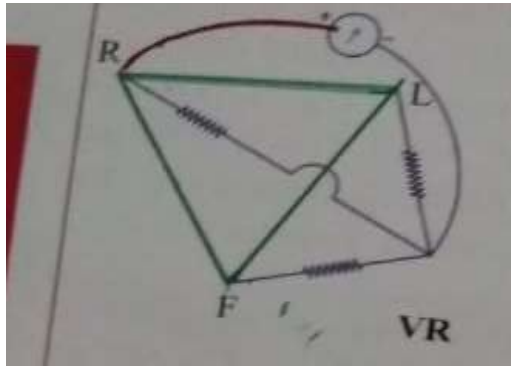
- Unipolar limb leads--- VR, VL, VF

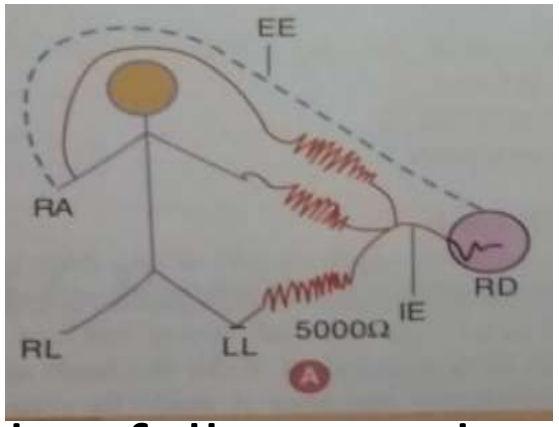
- Unipolar chest leads—V1, V2 , V3 , V4, V5, V6

- Unipolar limb leads –include VR, VL, VF (now they are not used - they are changed into aVR, aVL, aVF)

here active electrode is placed over one limb eg

- VL – active electrode on Lt arm – measures - pot at Lt arm
- VF – " Lt Foot - " pot at LT foot
- VR— " Rt arm - " pot at Rt arm



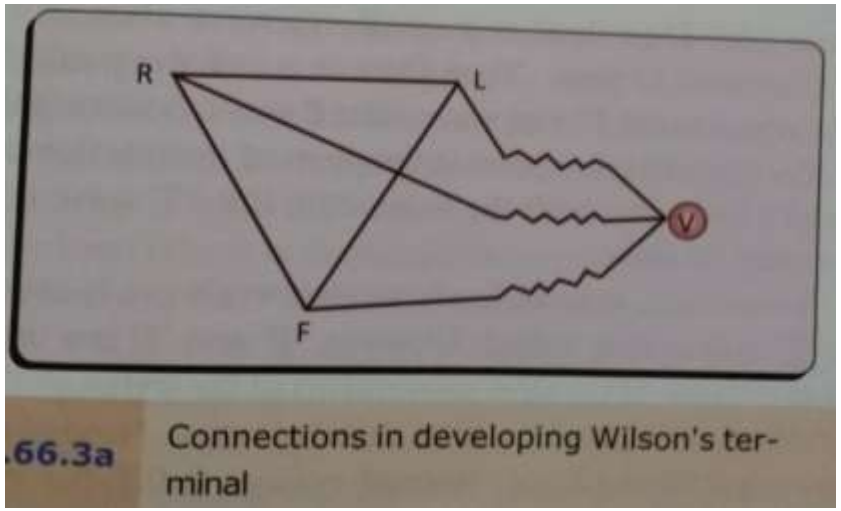


- Indifferent electrode is obtained as follows and connected to –ve terminal of ECGraph

- In a volume conductor , the sum of potentials at the apices of an equilateral triangle with current source at the centre is **0**

(2nd postulate)

- Indifferent electrode is made by connecting the three limbs rt arm, Lt arm & Lt foot each through a high resistance of 5000 ohm to a common terminal . Pot at that point is 0
- This common terminal is called **Wilsons' central terminal (WCT)**



66.3a Connections in developing Wilson's terminal

- Exploring electrode is placed on one limb and the indifferent electrode is connected to WCT
- Here the magnitude of recording is small
- **Gold berger** modified the unipolar limb leads– pot can be amplified
- **augmented**—50% greater

Thus unipolar limb leads ---→ **augmented** unipolar limb leads

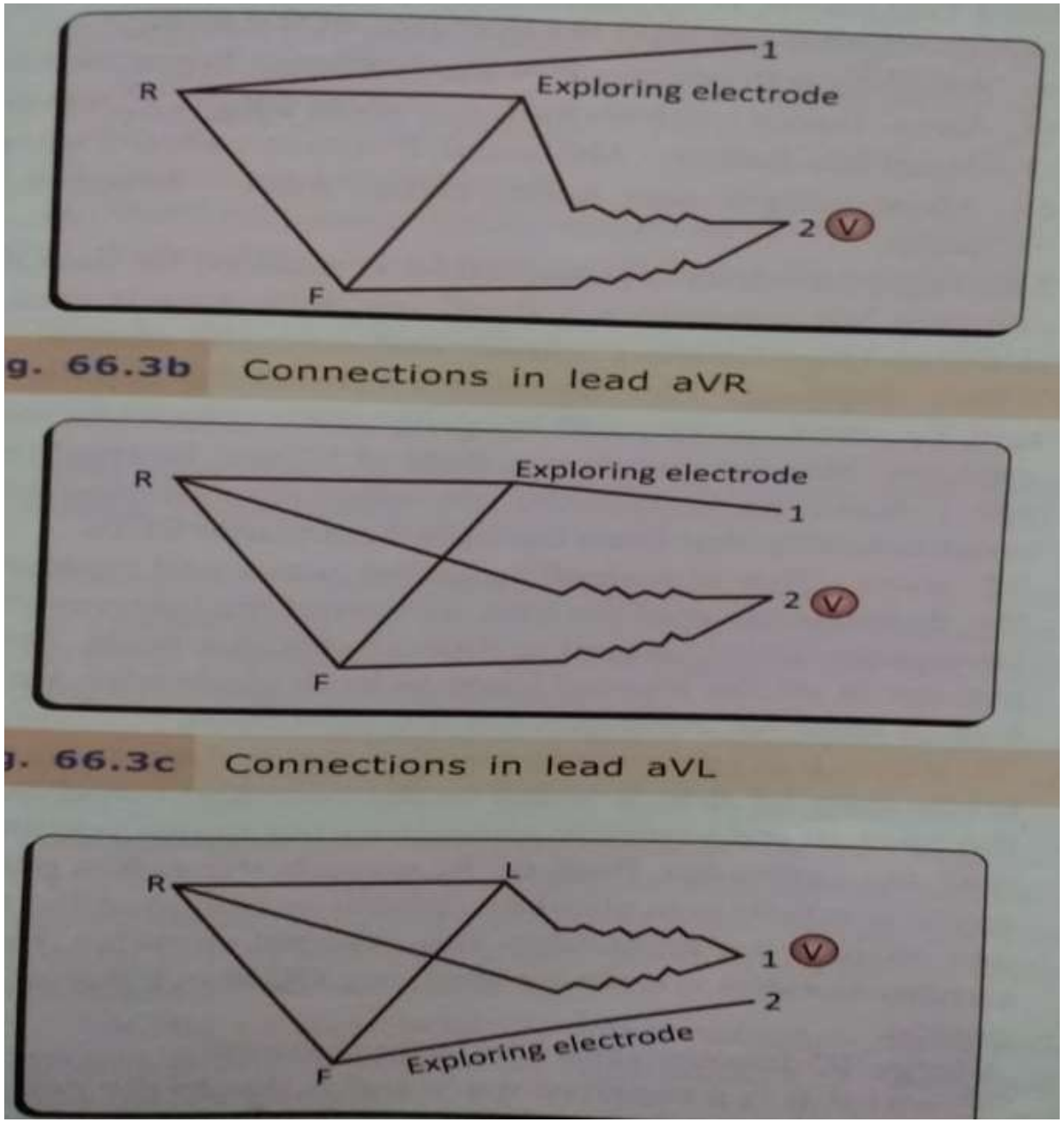
- **Augmented limb leads ---- aVR, aVL, aVF**
- Here active electrode is from one of the limbs and

indifferent electrode is obtained by connecting the other 2 limbs to WCT through 5000 ohm resistance each

- Eg aVR – active electrode is from RA and indifferent electrode is from LA & LF

- aVR = 3/2 VR , aVL = 3/2 VL , aVF = 3/2 VF

aVR, aVL, aVF


1
R
Exploring electrode
2
V
F
g. 66.3b Connections in lead aVR
R
Exploring electrode
1
2
V
F
. 66.3c Connections in lead aVL
R
L
1
V
2
F
Exploring electrode

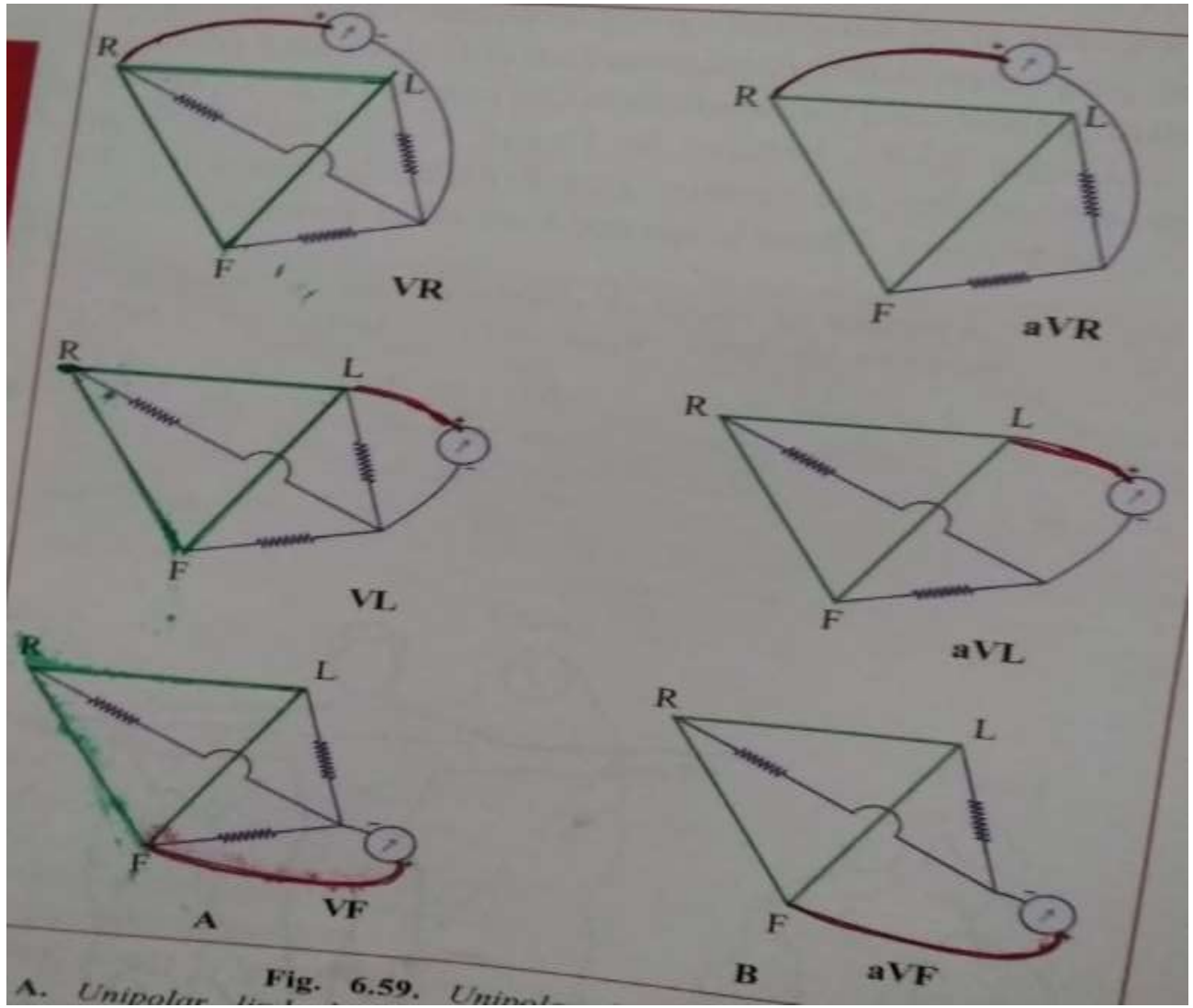
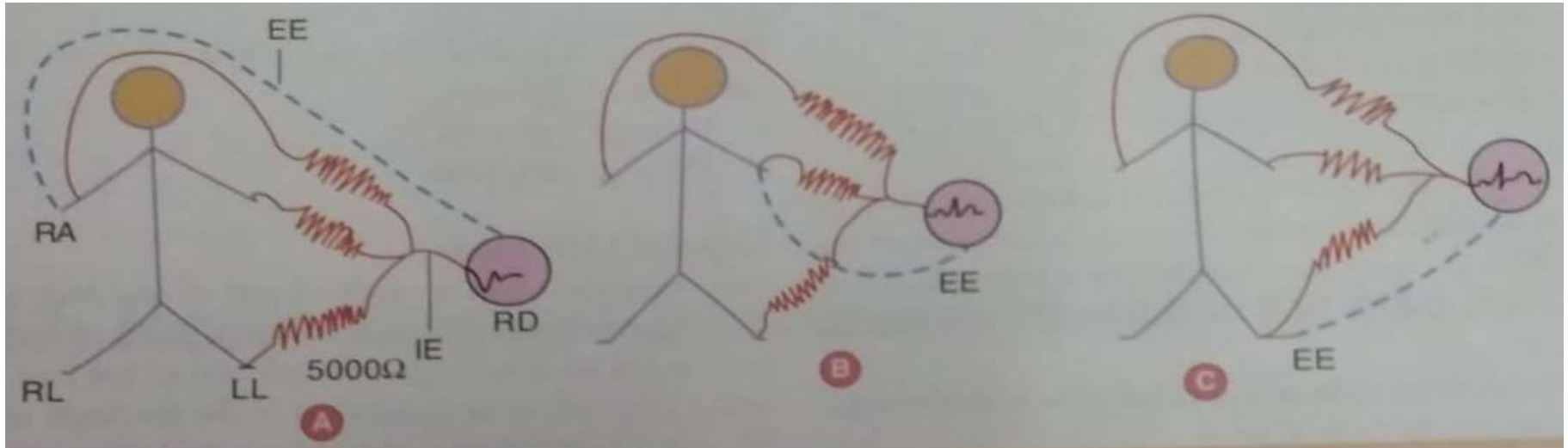
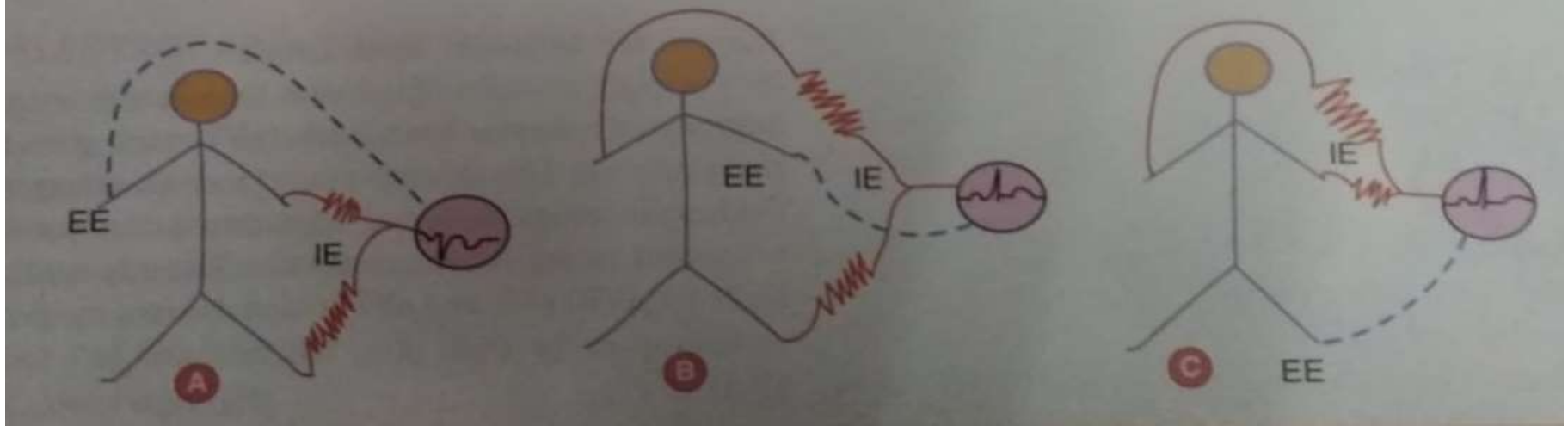


Fig. 6.59. *Unipolar*



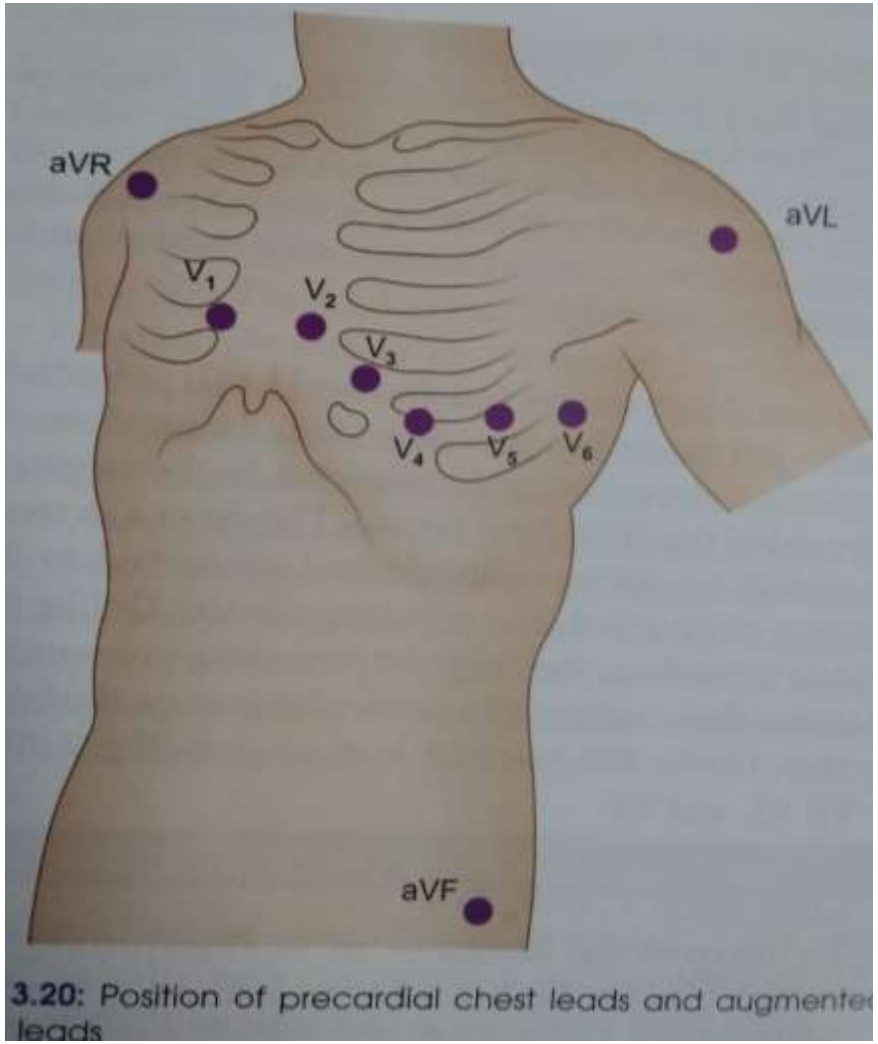
17.2 Unipolar limb leads. (A) VR; (B) VL; (C) VF. EE - Exploring electrode, IE - Indifferent elect
RD - Recording device, RA - Right arm, LA - Left arm, RL - right leg, LL - Left leg.



Unipolar chest leads

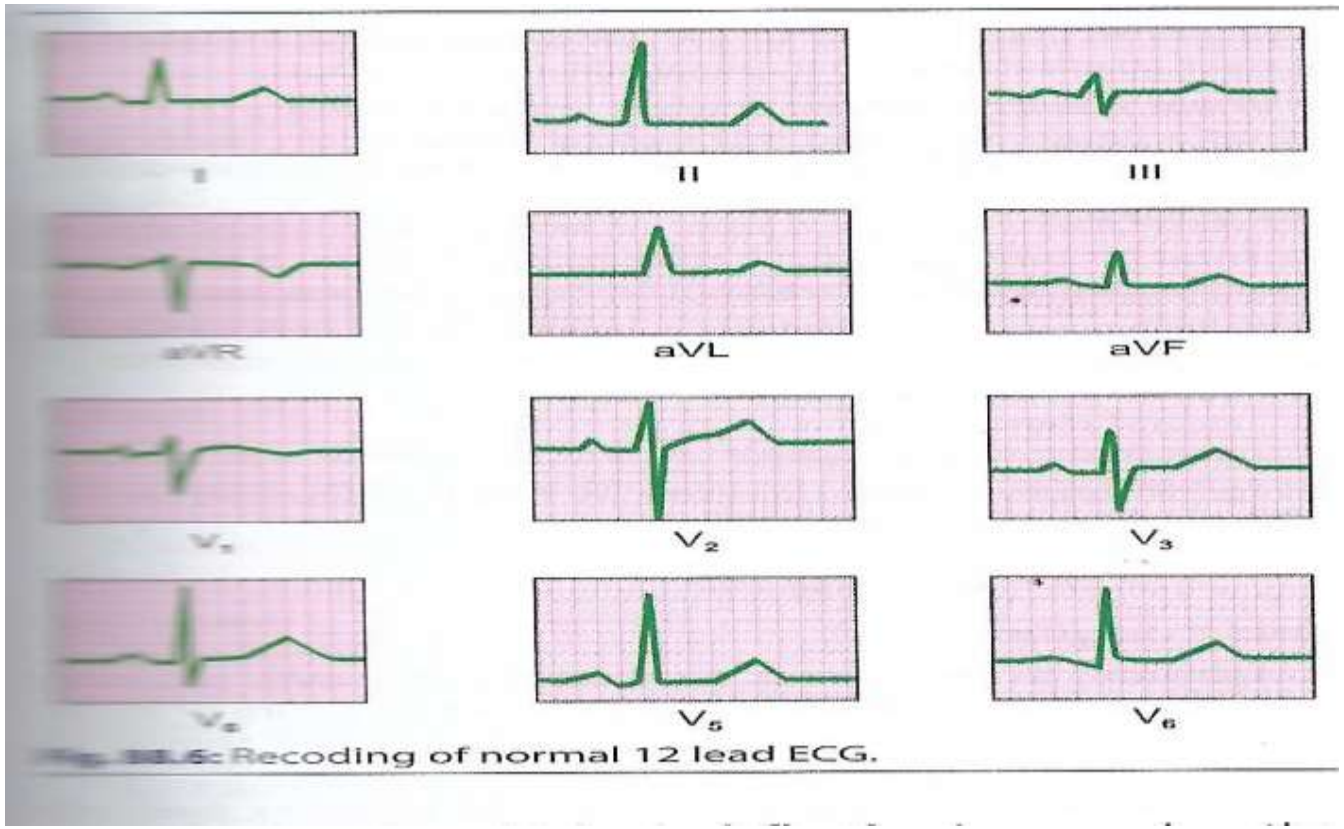
- Chest leads give a greater magnitude of potential as the electrode is near the heart.
- The exploring electrode is placed on different positions on the chest to get multiple leads.
- Indifferent electrode is placed on WCT
- Positions of aVR,aVL ,aVF & chest leads are as follows

- V1 -4th intercostal space to the rt of sternum
- V2-4th ICS to the left of sternum
- V3 - midway b/w V2 & V4
- V4 - 5th Lt ICS in midclavicular line
- V5 -5th Lt ICS in anterior axillary line
- V6 –5th Lt ICS in mid axillary line

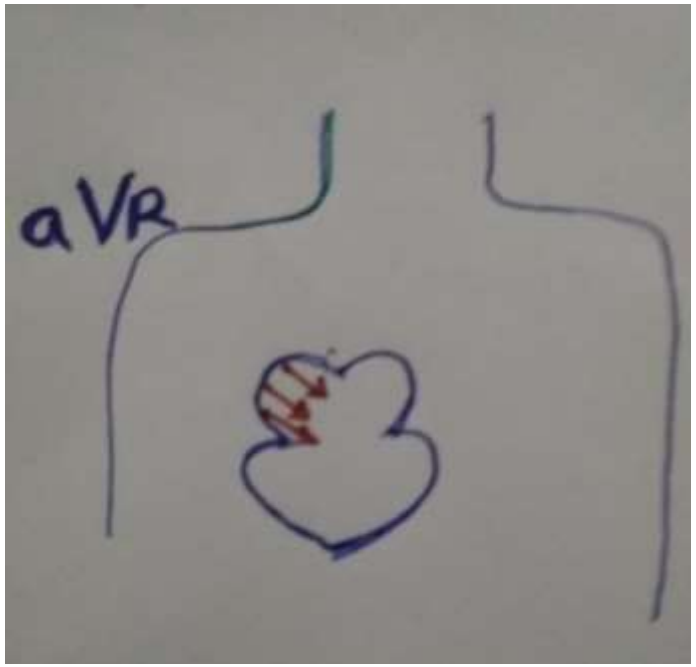


3.20: Position of precardial chest leads and augmente leads

- Only in aVR – all waves are –ve
- Expl electrode is in the rt arm & depol wave from SAN is moving **away from** the expl electrode ie, to the left.



Recoding of normal 12 lead ECG.



Recording of ECG - procedure

- The subject lies in a supine position with the chest bare
- Limb leads and chest leads are connected to the subject
- Earthing is done

- speed of machine 25 mm/sec .

- Recording is done on ECG paper with the help of a heated stylus.

- When current passes through the stylus, it gets heated and it melts the wax of wax coated paper,

standardisation

It is by applying 1mv of current – we should get 10 mm height and ends are at right angles to each other

- Heart rate calculation
- Speed of ecg machine = 25 mm/sec
- Duration of 1 ecg = RR interval
- Distance moved by paper in 1 minute =25 X 60 = 1500
- H R = 1500 / RR int in mm

- **ECG** -3rd class

Clinical applications of ECG

- Abnormal ECG pattern are significant in the diagnosis of different pathological conditions like

- 1 Injury – ischemia or death of myocardial tissues --MI

- 2 disorders of cardiac rhythm- arrythmias

- 3 conduction defect -- heart block

- 4 changes in the ionic composition of blood

- Use of ECG in the diagnosis of Arrythmias
- Cardiac arrhythmias--- it is a disturbance in the heart rate or rhythm

Causes 1) disorders of impulse production

2) disorders of impulse conduction

1) Disorders of impulse production –sinus tachycardia-}SAN pacemaker

sinus bradycardia --} " "

sinus arrhythmia----} " "

ectopic / abnormal pacemaker---pacemaker other than SAN

- 2) disorders of impulse conduction ---conduction block = heart block

------ accelerated AV conduction

- **Conduction block** - SAN Block

- AVN Block---incomplete HB-1st degree HB

--2nd degree HB

--wenke back phenome

---complete HB

--BB Block

Accelerated AV conduction -- Wolf Parkinsons White syndrome

(WPW syndrome)

- Normal impulse production at SAN

normal sinus rhythm = 70 / min

- **Sinus Tachycardia**

  increased impulse production, HR > 100 / min

  (seen in fever, exercise, anxiety etc)

- **ECG** – normal with short RR interval

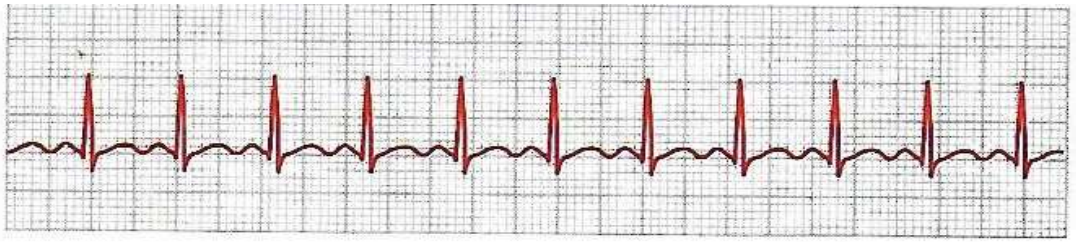


Figure 34-1 Sinus tachycardia (lead I).

Sinus bradycardia.

Decreased HR--- HR < 60 / min

(seen in athlets)

ECG –normal with prolonged RR int.

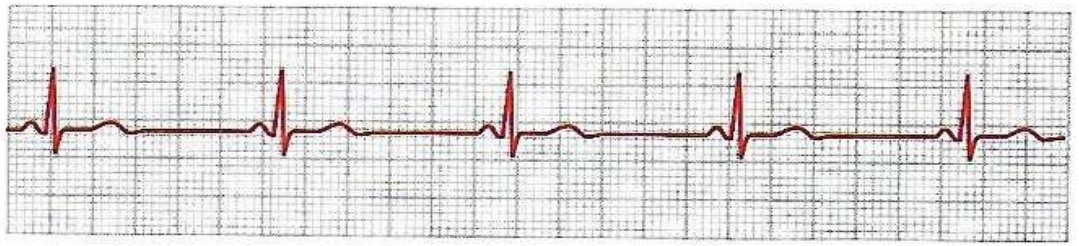


Figure 34-2 Sinus bradycardia (lead III).

- Sick sinus syndrome
- Diseases affecting SAN – cause marked bradycardia., along with dizziness & syncope (unconsciousness)
- Treatment – artificial pacemaker

- **Sinus Arrythmia**
- H R changes with different phases of resp.
- During inspiration – HR increased
- During expiration – HR decreased.
- ECG – Nl , RR int varies according to HR

- **Ectopic pacemaker**

in pathological conditions – parts of conducting system other than SAN –produce impulses. –**ectopic focus or ectopic pacemaker**

- Abnormal beat comes earlier than normal expected beat – extrasystole, or premature beat
- Ectopic focus –--- **AVnode, bundle of His, Purkinje system, atria, -. vent**
- If it discharges at a rate higher than that of SAN---paroxysmal tachycardia or atrial flutter.
- Ectopic focus in atrium– 150- 200 / min – atrial tachycardia
- If HR > 200 /min --- atrial flutter.
- If atrial rate > 300 / min – atrial fibrillation

- **Conduction block**
- Defect in transmission of impulses generated in SAN

  Block can occur anywhere
- SAN block
- Impulses from SAN are blocked from entering the atrial muscle.
- Whole heart beat is lost
- Then AVN becomes pacemaker –heart starts functioning

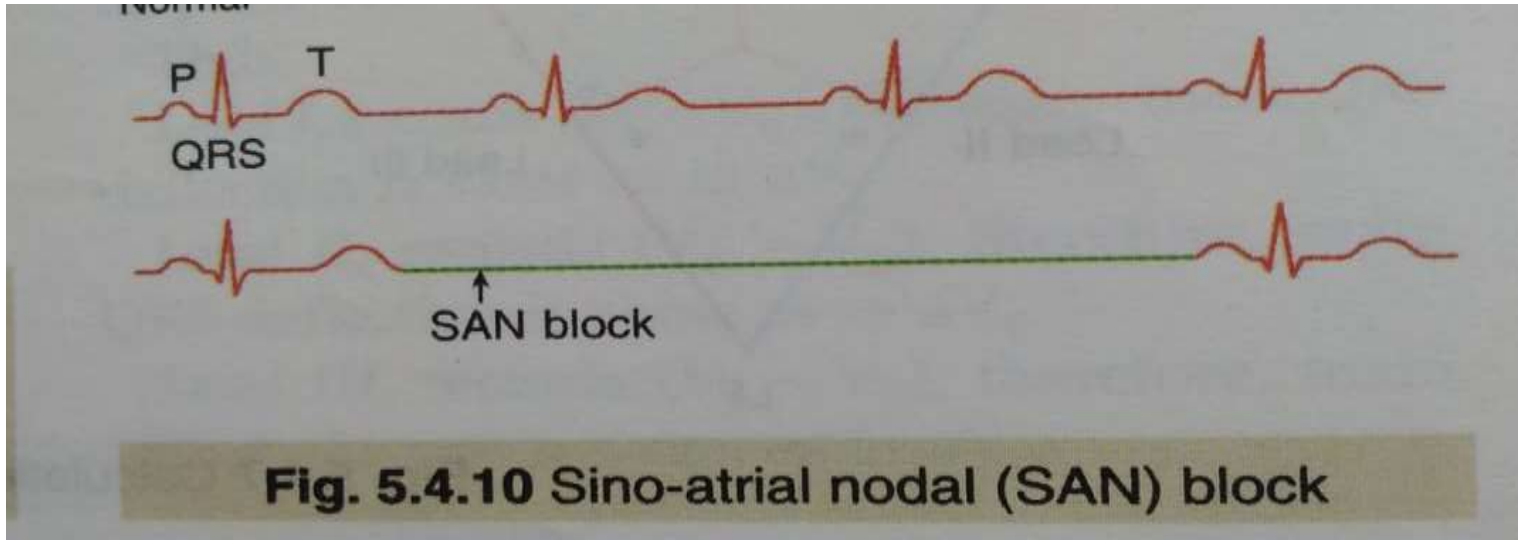


Fig. 5.4.10 Sino-atrial nodal (SAN) block

- **Atrioventricular block**

--Defect in transmission of impulses from atria to ventricle

--Incomplete HB

--Partial disturbance of conduction b/w atria and vent—first degree

- second degree

First degree HB- all atrial impulses reach vent.

Increased delay in AVN ---slow conduction --- PR int prolongs

Atria : vent = 1:1

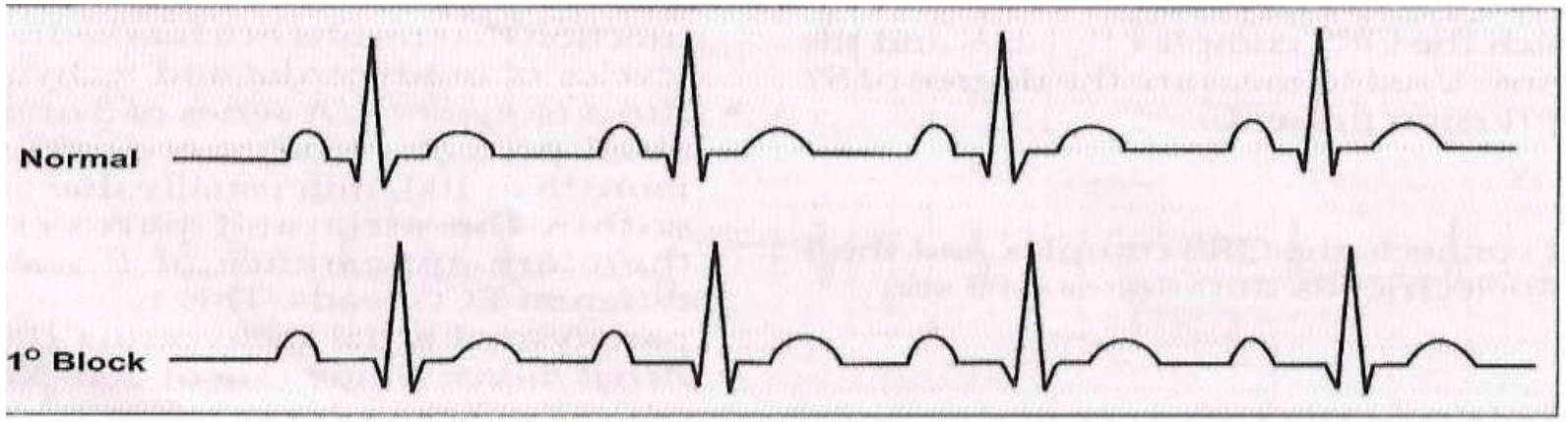


Fig. 6.23: First-degree AV nodal block

- **Second degree HB**

--- all atrial impulses are not conducted to vent .

-After 2 or 3 atrial contraction , 1 vent contr occurs.

- Atrial rate : vent rate = 2:1 , 3 : 1

- ECG – vent beat QRST missing
- 2:1 – after 2 atrial contr – I vent contr
- 3:1 - after 3 atrial contr – 1 vent contr

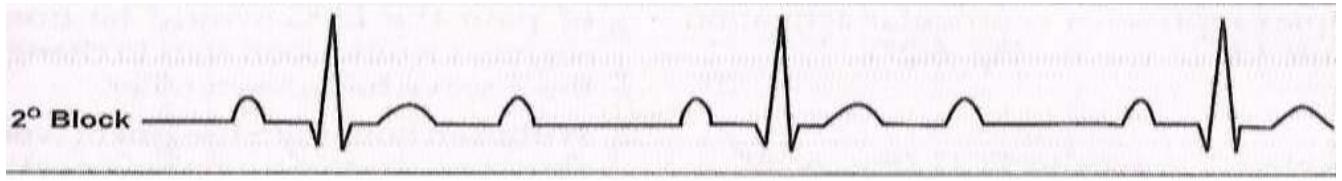


Fig. 6.24: Second-degree AV nodal block

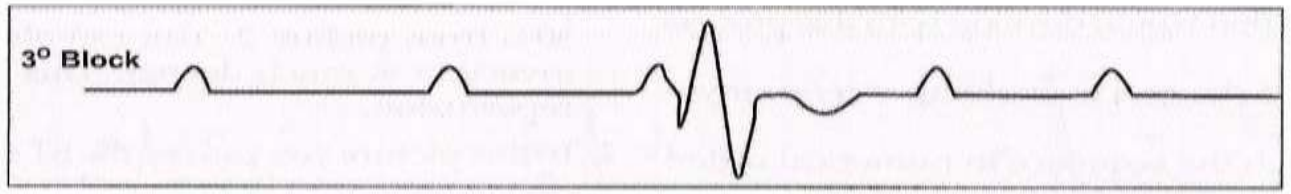
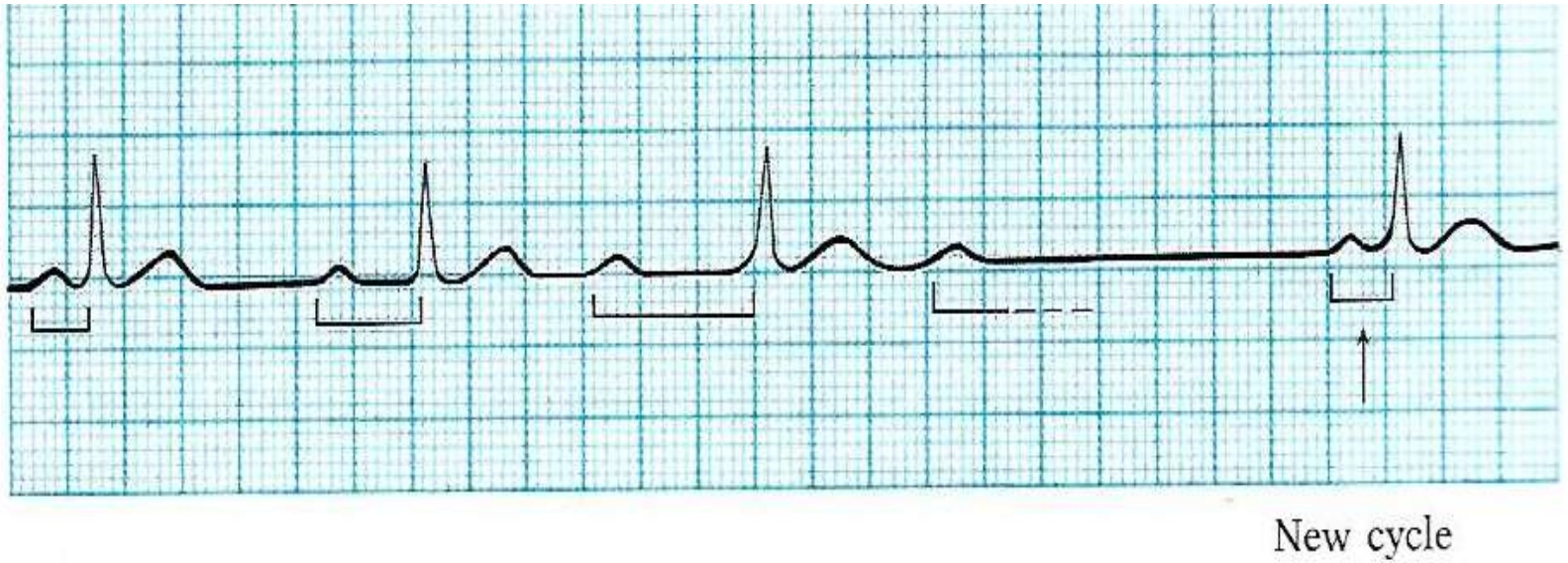


Fig. 6.25: Third-degree AV nodal block

- **Wenkebach phenomenon-**-- gradual prolongation of PR int with every successive beat and then one QRS complex is dropped, then again normal pattern with prolongation of PR int .. The cycle is repeated .



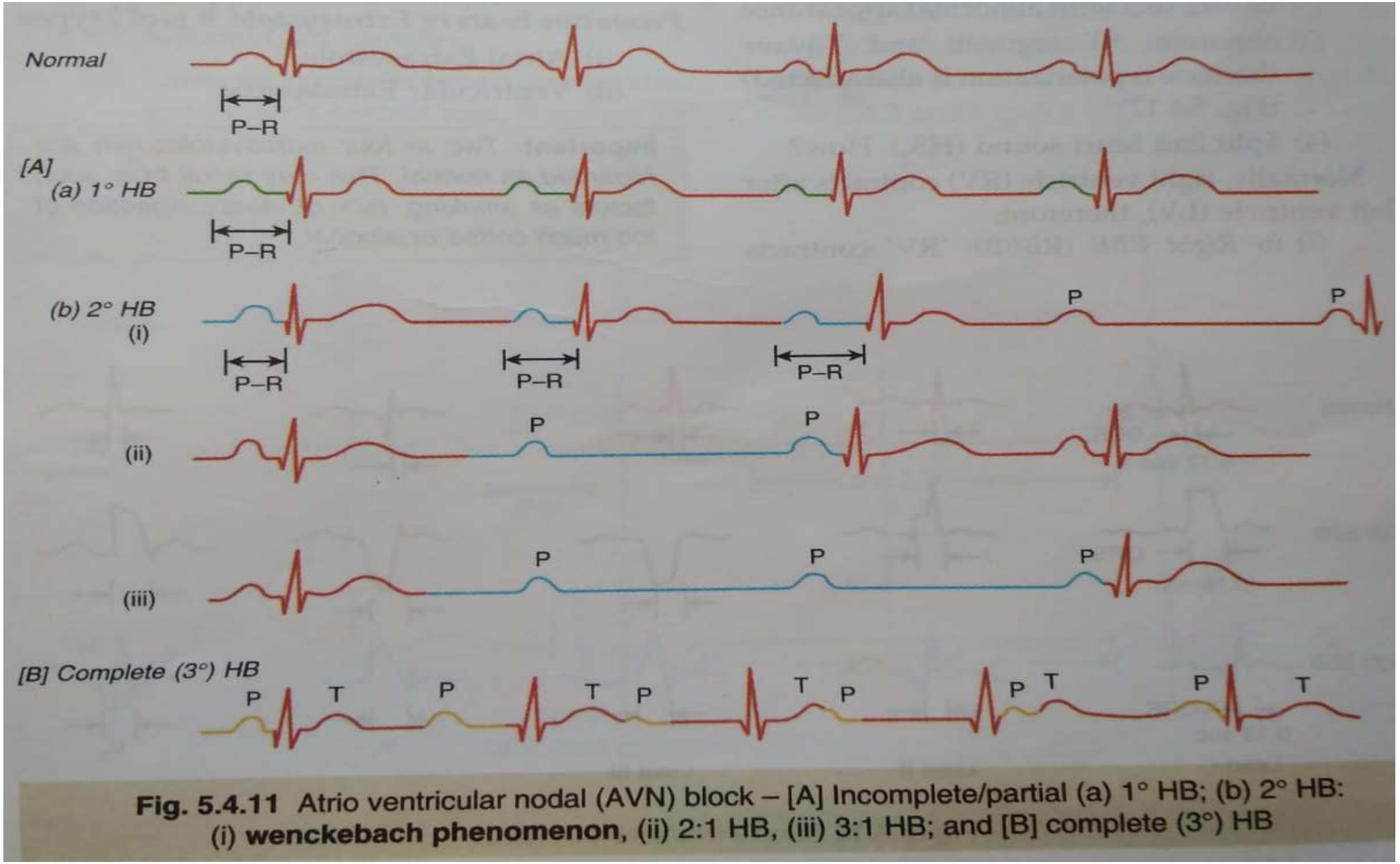


Fig. 5.4.11 Atrio ventricular nodal (AVN) block – [A] Incomplete/partial (a) 1° HB; (b) 2° HB: (i) **wenckebach phenomenon**, (ii) 2:1 HB, (iii) 3:1 HB; and [B] complete (3°) HB

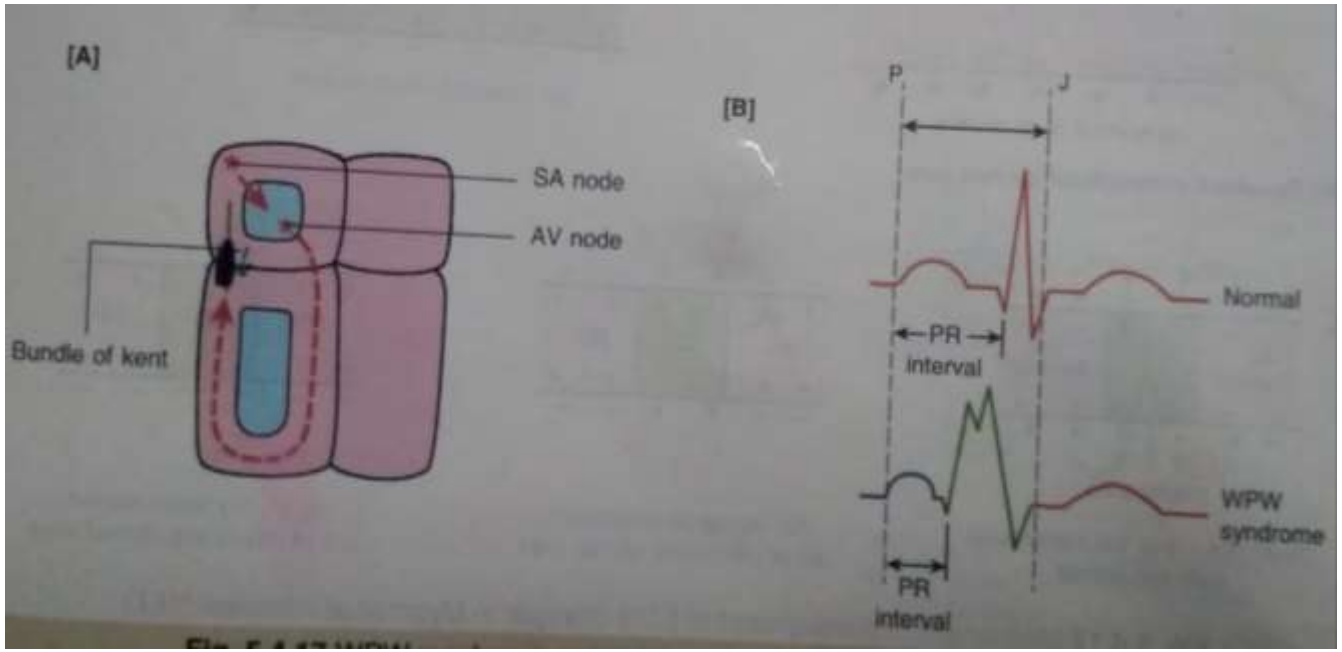
- **Complete HB or 3rd degree HB**
- Complete interruption of conduction b/w atria & vent
- atria and vent beat at different rates,
- vent beat with its own rhythm ----Idioventricular rhythm (ivr)

- 15 – 40 / min (ivr) – inefficient pumping of heart ---cerebral ischemia—fainting –**Stokes Adams syndrome**– if it exceeds 1or 2 min – loss of consciousness, convulsions -- death

- Treatment -- artificial pacemaker

- **Accelerated AV conduction**
- Normally the conducting pathway b/w Atria and Ventricle is AVN
- People with WPW syndrome have an additional nodal tissue called **Bundle of Kent** –connect atria and ventricle

It conducts impulses faster than AVN & bundle of His to one ventricle therefore - One vent excites earlier than other



- Bundle branch block
- Block of one of the branches of bundle of His

- In Rt Bundle branch block—block in Rt branch
  - Lt " " - block in Lt branch

  -------- one ventricle is excited early

- In Rt BBB, Lt vent contracts earlier than Rt vent
- In Lt BBB, Rt vent " " Lt vent

Changes in ECG due to ionic changes in blood

- Electrical activities of heart depends upon distribution of ions
- If there is any change in ionic conc, it will affect ECG
- **K+**
- Normal ECF [K+] = 4 – 5.5 meq/ L

- Hyperkalemia increased K+ in ECF
- **ECG** -- --- QRS complex is prolong
- T wave – tall and peaked – due to altered repol of myocadial cells

- Hypokalemia

- Decrease in [K+] in ECF
- **ECG**
- PR int prolongation
- ST segment depression
- T wave inversion
- Prominent U wave

- **Na+** -

- normal conc in serum 135 – 145 m eq/ L

- decrease in conc –reduces electrical activity

- ECG -- low voltage waves

Ca+

- Hypocalcemia –decrease in [Ca 2+) in ecf
- ECG – duration of ST seg and QT interval are prolonged.
- Hyper calcemia increase in Ca2+
- ECG – decrease duration ST seg and QT interval

Myocardial Ischemia

- When coronary blood flow decreases due to atherosclerosis or any other reason – causes deficiency of blood and Oxygen
- ECG -- ST seg --- depression
- -- T wave inversion

- **Myocardial Infarction**
- When Myocardial ischemia ------severe -→ M I
- **ECG – ST seg elevation**
- **T wave inversion**
- **-- deep Q wave**

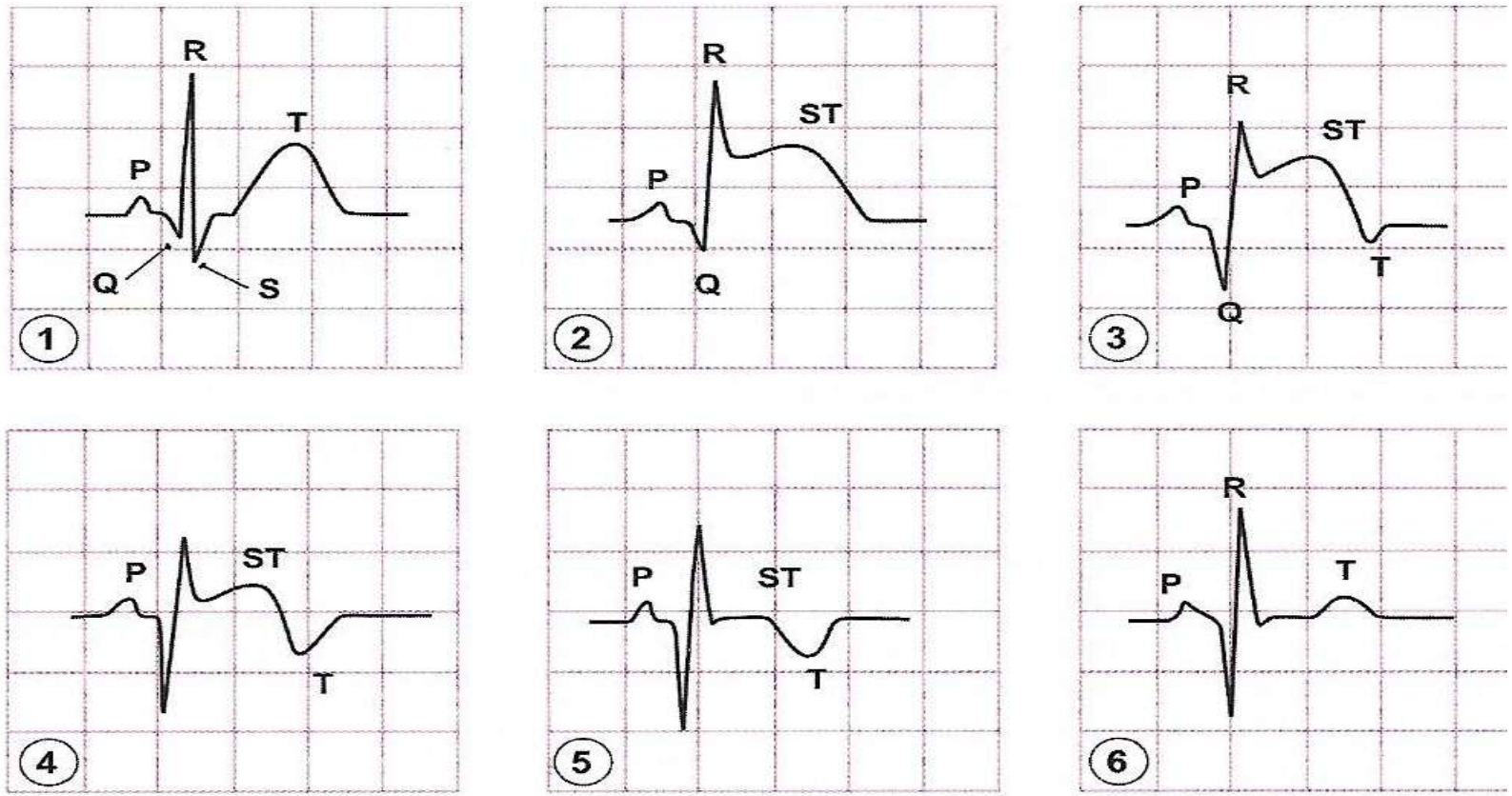


Fig. 6.29: Sequence of ECG changes in myocardial infarction

- End end end