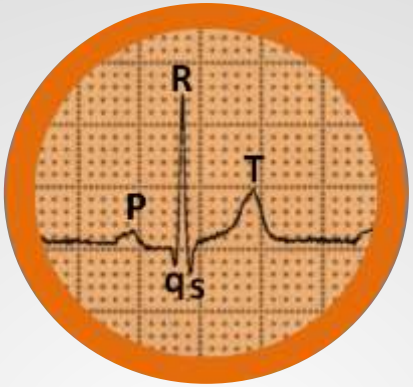
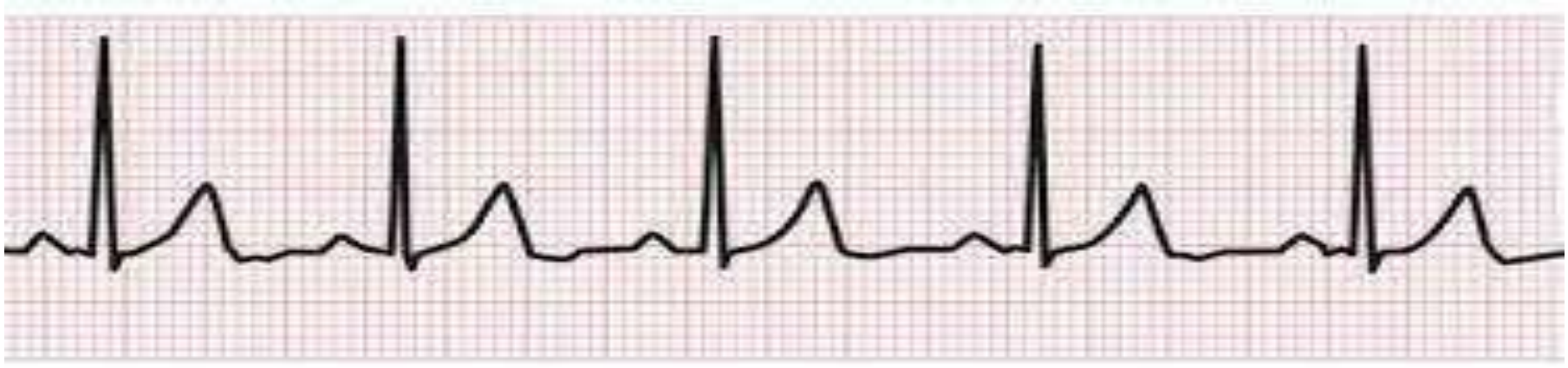


ECG Analysis Made Simple

DR. D.P Khaitan

M.D (Medicine) F.C.G.P(IND) F.I.A.M.S (Medicine) FICP FICCMD FIACM



ESSENTIALS :

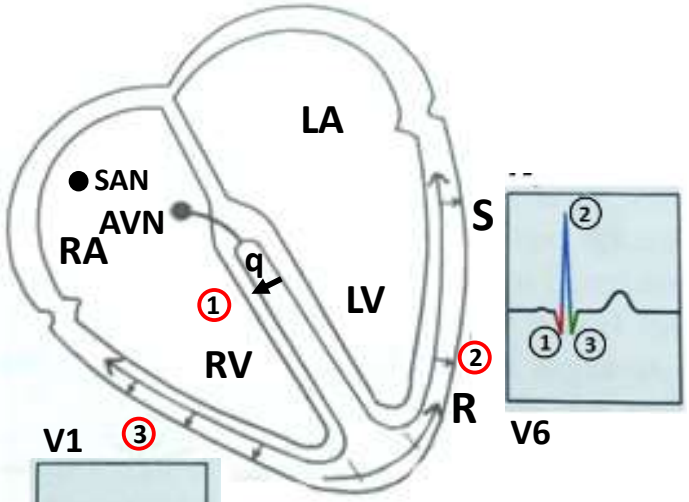
- **ECG interpretation is a knowledge based skill**

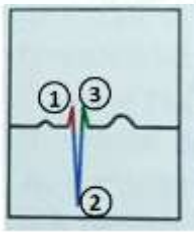
3A

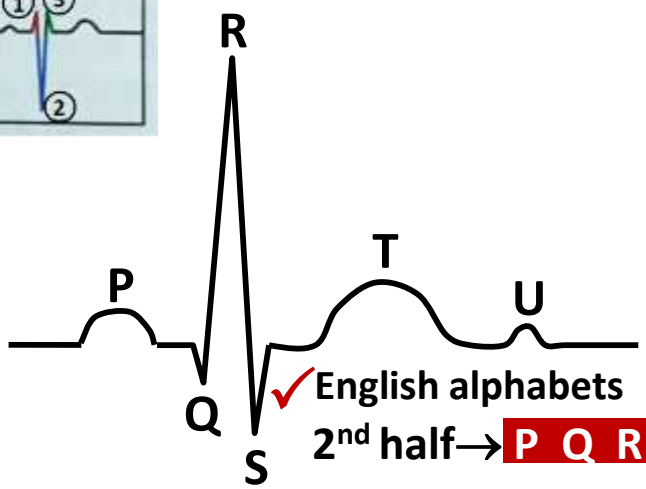
- **A concept of normal ECG and abnormal ECGs based on a basic book with special emphasis on illustrated ECGs explanation**
- **A regular revision**
- **A step-by-step methodical approach in collaboration with the clinical history**

Normal ECG

- Positive wave towards the flow of current
- Negative wave away from the flow of current







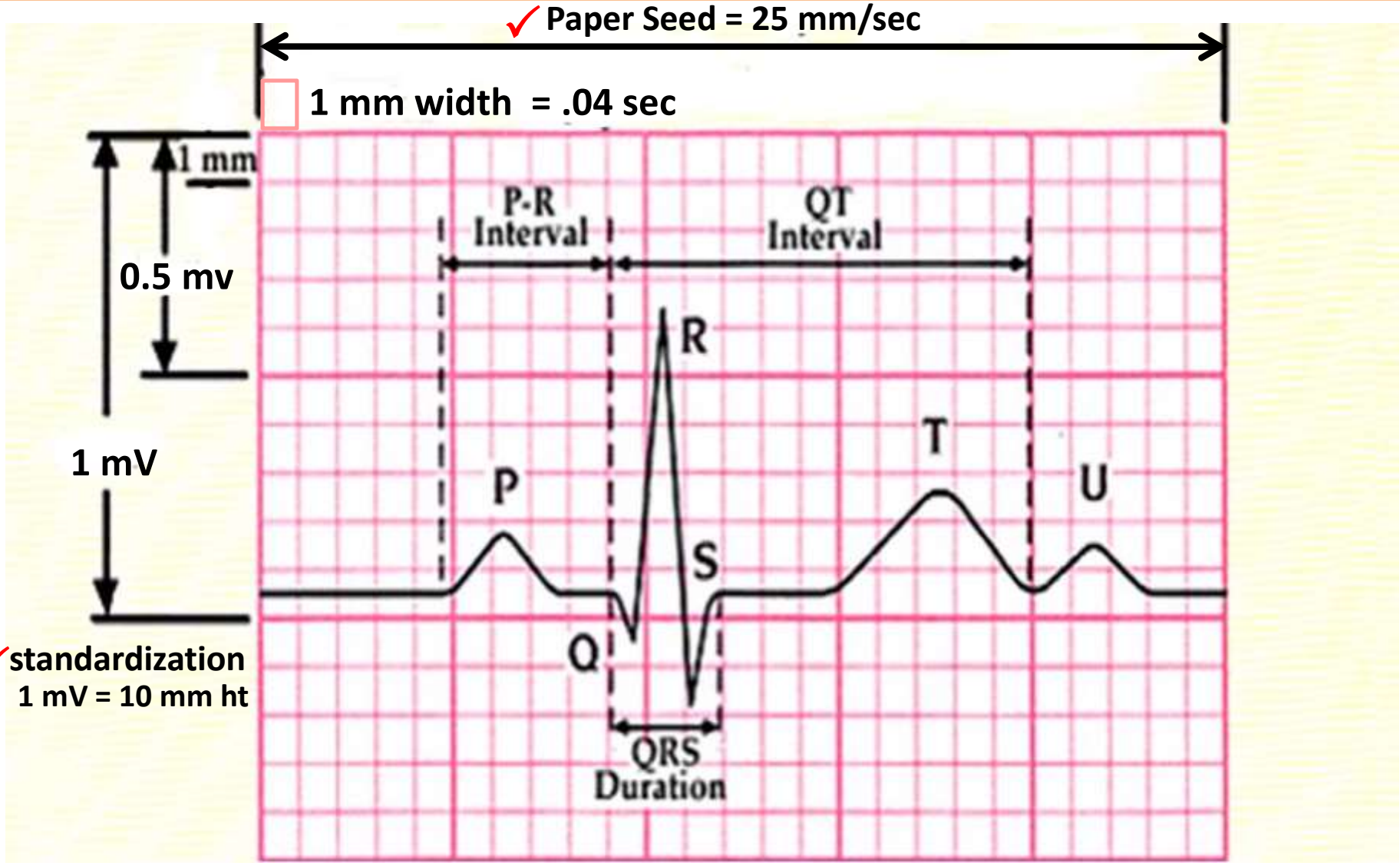
English alphabets

2nd half → P Q R S T U

11 Steps interpretation of ECG

1. A Bird's eye view
2. Heart rate (A rate – V rate)
3. Rhythm
4. Electrical axis
5. P-wave
6. PR interval
7. QRS morphology
8. ST segment
9. T changes
10. QTc interval
11. U wave

Step 1 : A Bird's Eye View



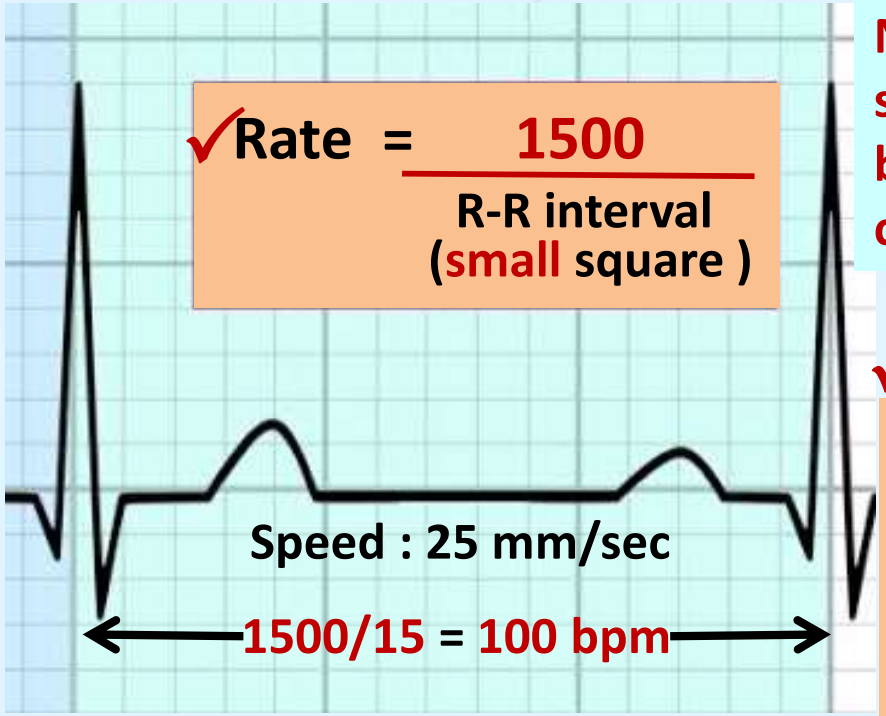
✓ **NB** : Any gross abnormality on ECG : Rhythm regular or irregular , Tachycardia /Bradycardia , Low voltage /Poor R-wave progression , etc.

Step 2 : Heart rate (A rate – V rate)

1 sec = 25 small sq
60 sec (1 min) =
25x60 = 1500 small sq

When the **rhythm is regular**

A

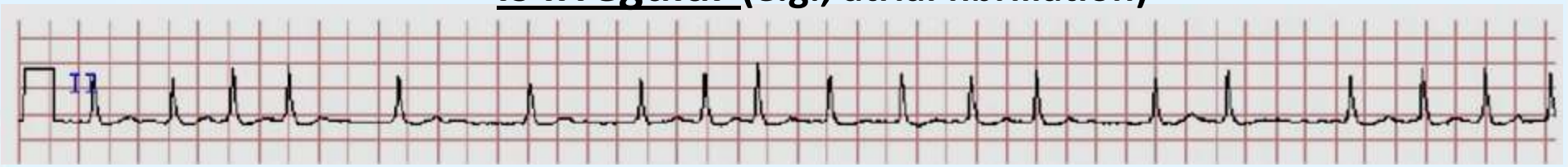


Number of small squares in between two corresponding RR

✓A practical approach

- < 3 big squares = Tachycardia
  > 5 big squares = Bradycardia
- Accurate rate calculation by the given formula

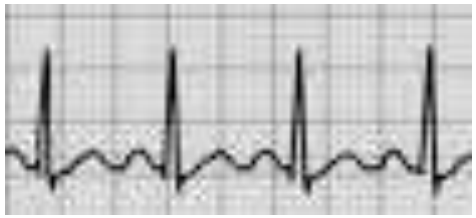
✓ **B** Count QRS in 10 sec , i.e. in 50 large squares X 6 when **rhythm is irregular** (e.g., atrial fibrillation)



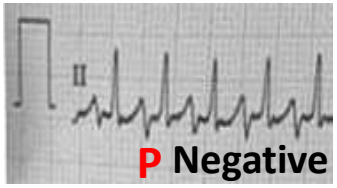
Step 3 : Rhythm

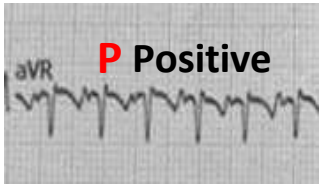
Tachy-rhythm

Sinus Tachycardia



Atrial Tachycardia





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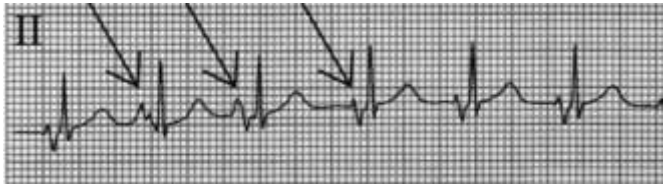
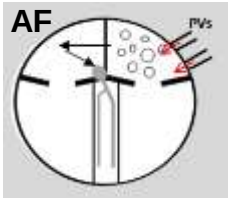
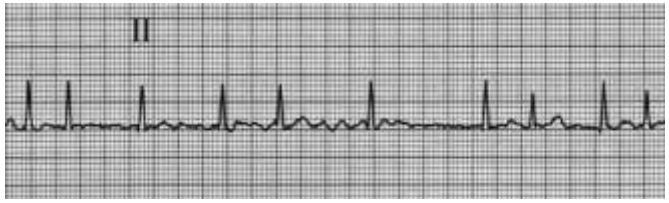
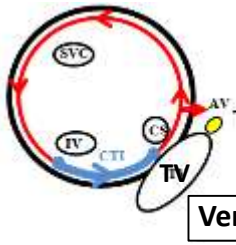
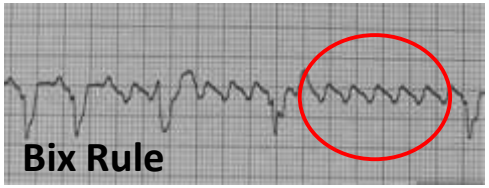




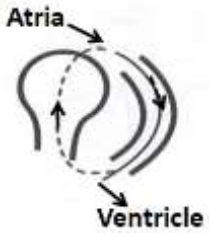


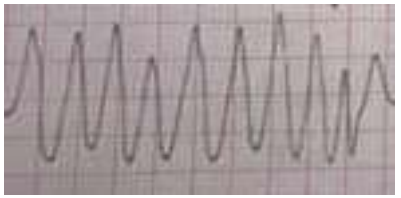


Atrial flutter : cavo-tricuspid Isthmus circuit

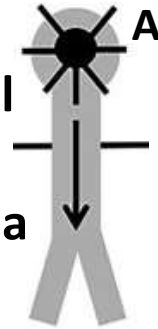


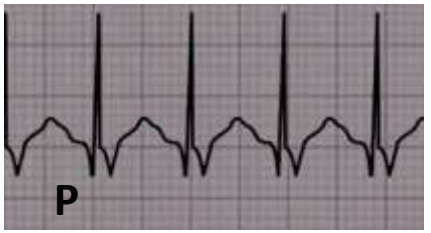
Pre-exciatation AF



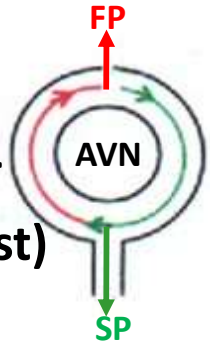


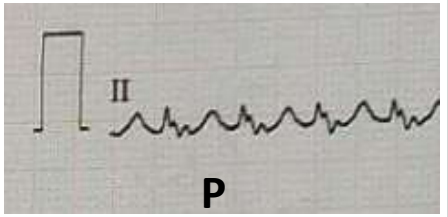
Junctional Ectopic tachycardia



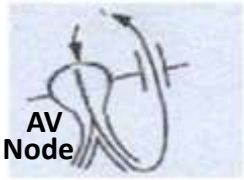


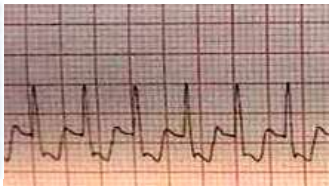
AVNRT (Slow-Fast)





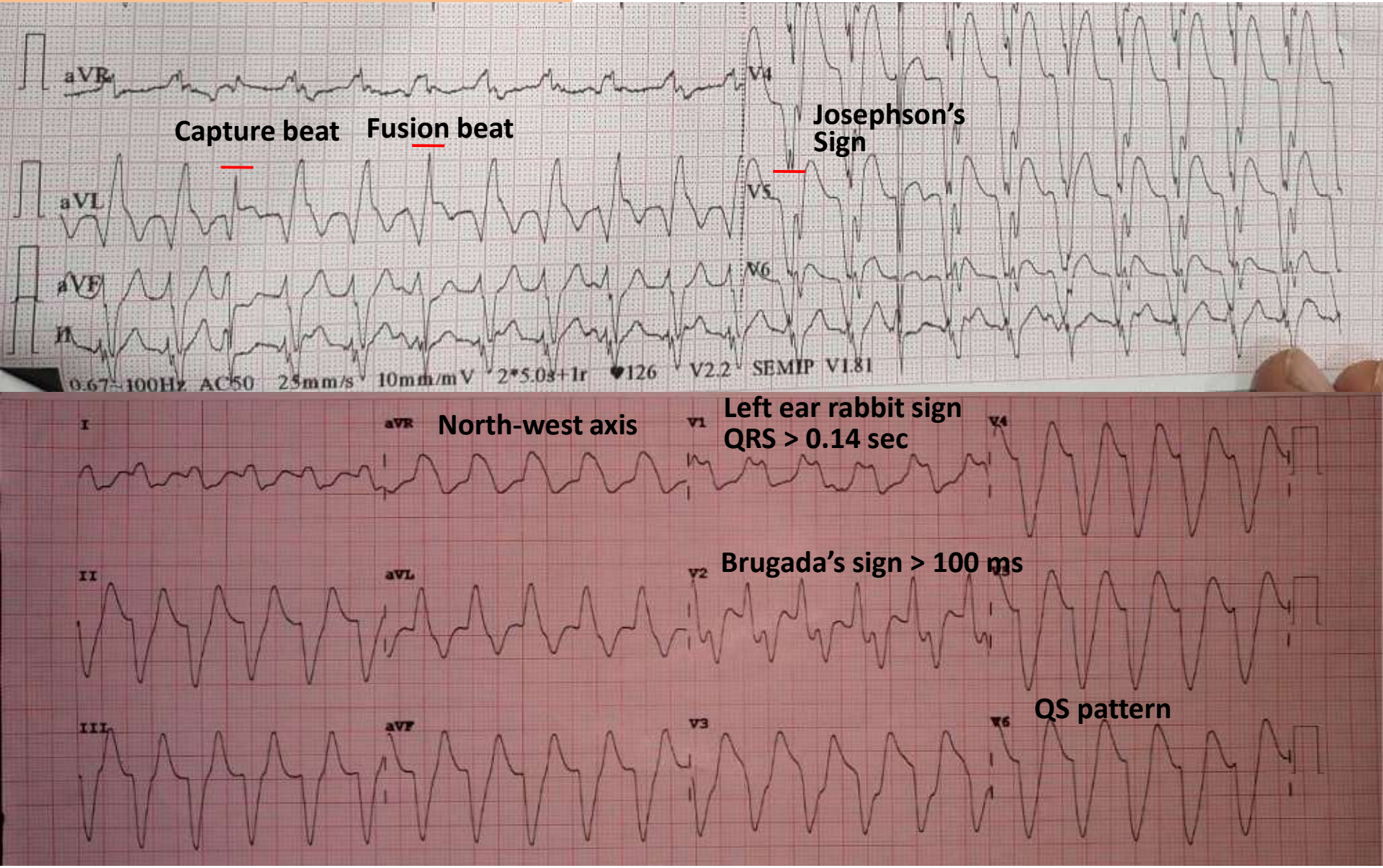
AV orthodromic





Ventricular tachycardia - VT

AV dissociation with faster ventricular rate or ventricular origin



NB : +Ve or –Ve concordance throughout the chest lead , i.e. with leads V1-6 so entirely positive (R) or entirely negative (QRS complexes) , with no RS complexes seen

Brugada Algorithm for VT

Step 1 Absence of RS complexes in all precordial leads

- Yes → VT
- → **Step 2** R to S interval > 100 msec in 1 precordial lead

Step 2

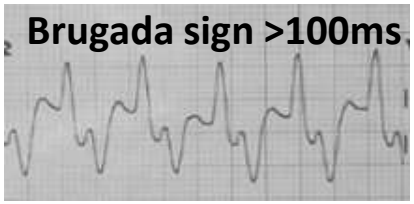
- Yes → VT
- → **Step 3** More QRS complexes than P waves (AV dissociation)

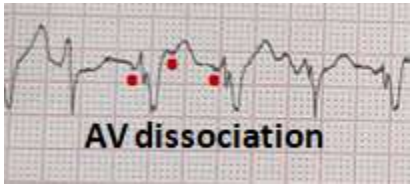
Step 3

- Yes → VT
- → **Step 4** Morphologic criteria for VT present in V1-V6

Step 4

- Yes → VT
- → SVT with aberrant conduction

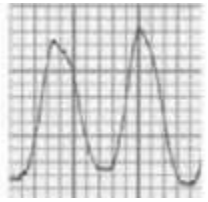




Vereckei aVR Algorithm

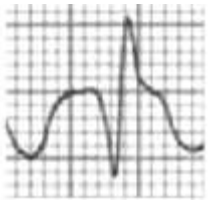
Initial dominant R wave

Step 1



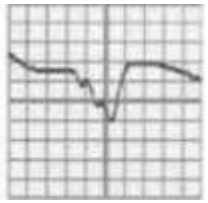
Initial r or q wave > 40 ms

Step 2



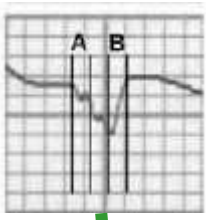
Notched downstroke of negative QRS

Step 3



V(i)/V(t)≤1

Step 4



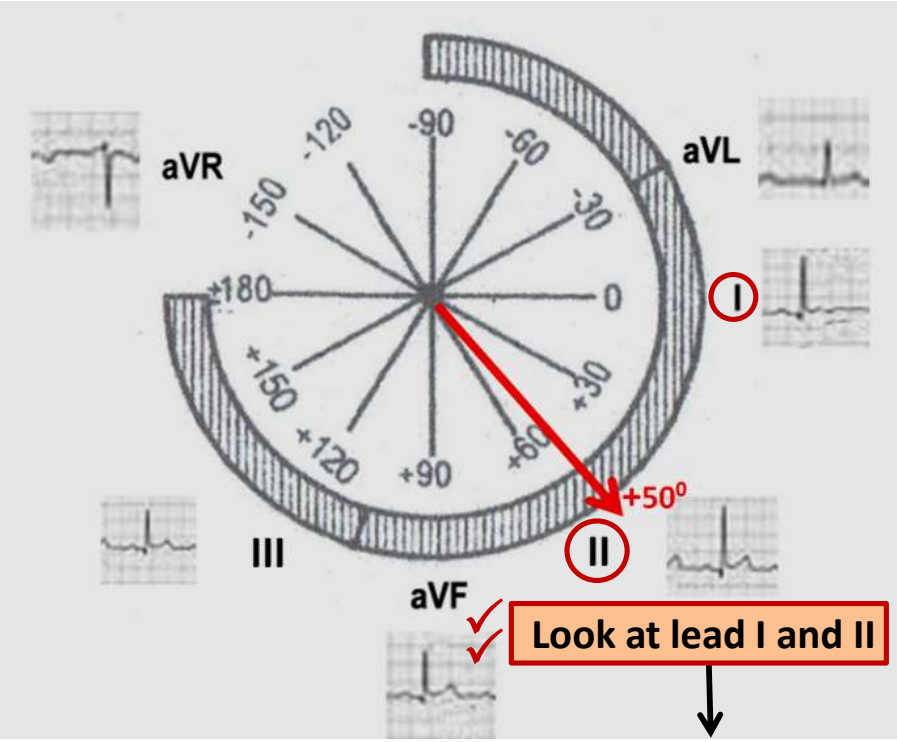
Any +Ve sequential step suggests VT

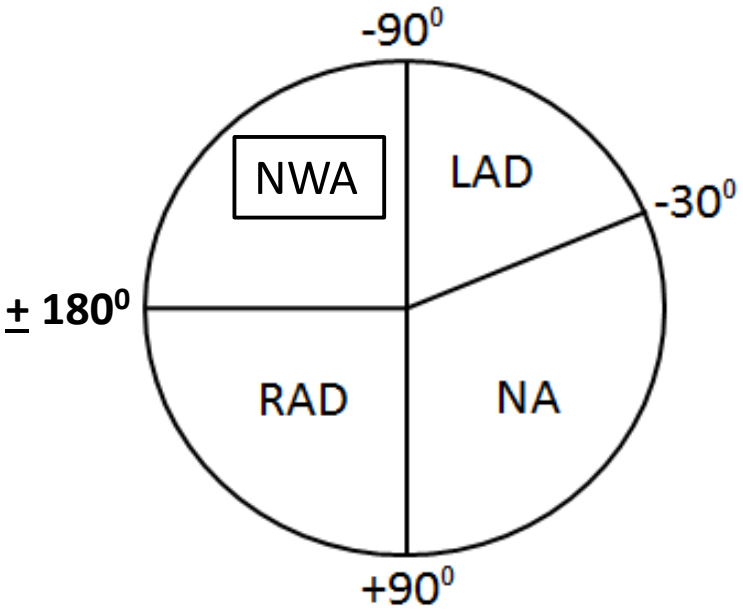
VT

Vi= Voltage change in first 40 ms of QRS

Vt = Voltage change in last 40 ms of QRS

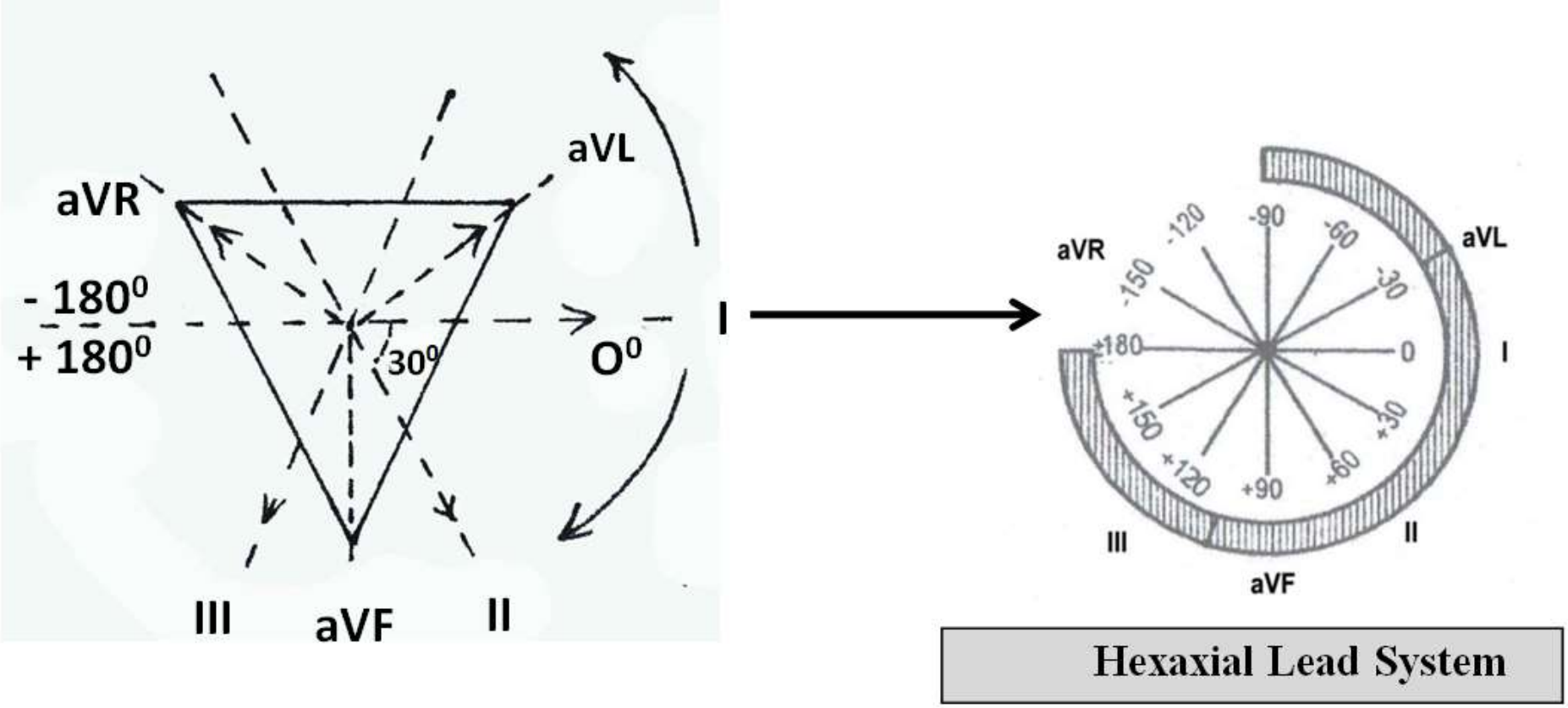
Step 4 : Electrical Axis (Frontal plane)





QRS Positive in leads I and II	Normal Axis	-30^0 to $+90^0$
QRS complex is positive in lead I but negative in lead II	Left Axis Deviation	-30^0 to -90^0
QRS Negative in lead I but positive in lead II	Right Axis Deviation	$+90^0$ to $+180^0$

A Geometrical model of Hexaxial lead system

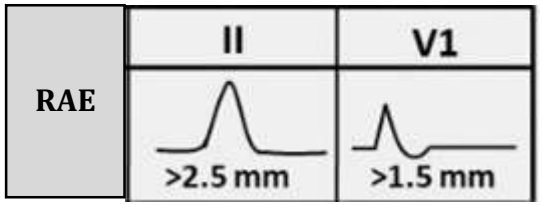


Rule of 90^0 : Any exploring lead placed within a range of 90^0 in respect to cardiac vector records positive deflection , at 90^0 equiphasic deflection or no deflection and beyond 90^0 negative deflection

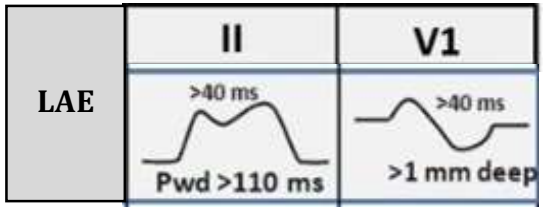
Step 5 : P-wave

- P wave pattern usually best seen in lead II
- Inverted P-waves in inferior leads (II, III & aVF) suggest retrograde activation of the atria :
  - AV nodal rhythm
  - Low left atrial site
  - AVNRT or AVRT
- Inverted P wave wave in standard lead I :
  - Incorrect electrode placement (in between right arm and left arm)
  - Mirror image dextrocardia

- RAE

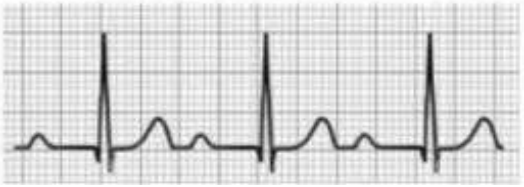


- LAE

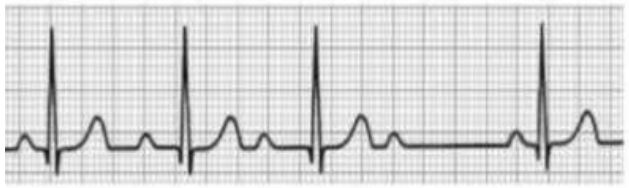


Step 6 : PR interval (0.12 to 0.20 Sec)

- PR > : constant or gradual prolongation till QRS drop

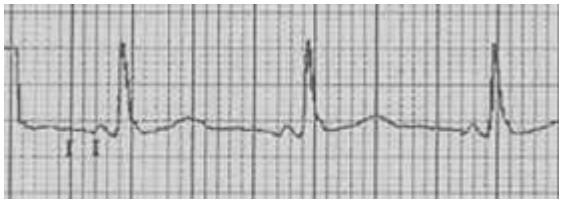


First degree AV block



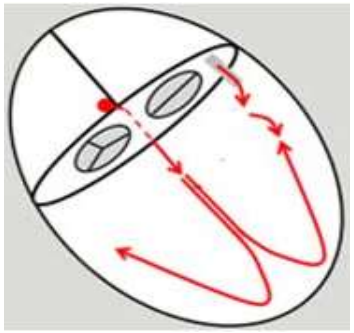
Second degree – Mobitz type I

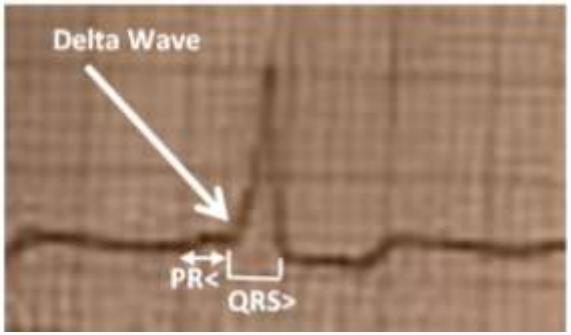
- Shortened PR interval , LGL syndrome or WPW pattern



LGL syndrome

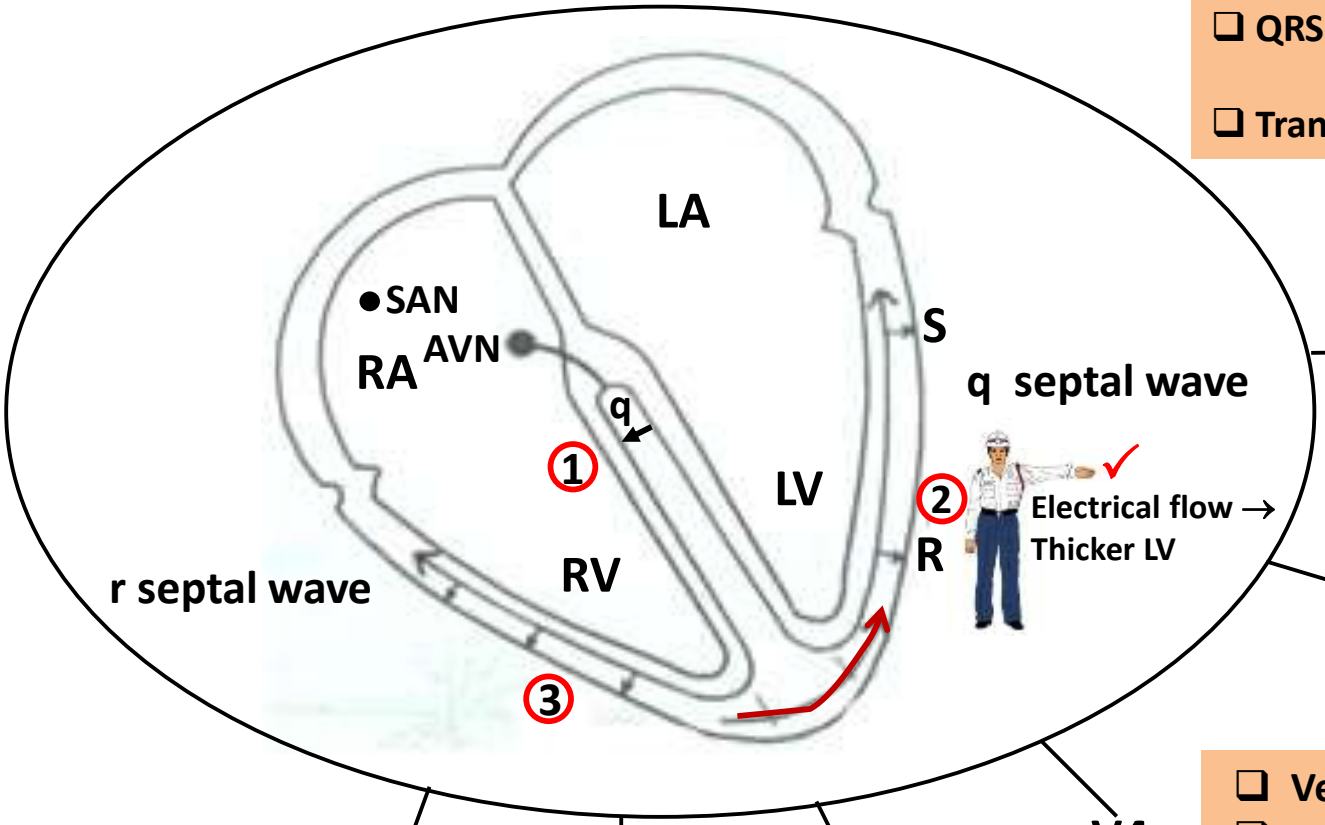
- WPW pattern



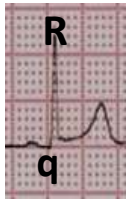


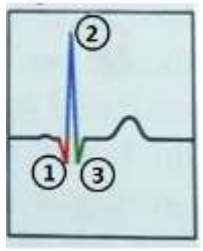
Step 7 : QRS (on horizonatal plane) morphology

- QRS voltage < 5 mm in limb leads
  <10 mm in chest leads
- Transition zone & R-wave progression

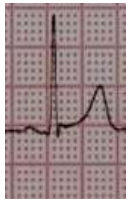


V6



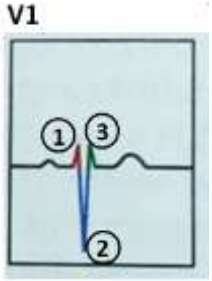


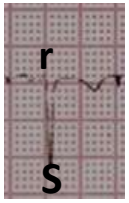
V5

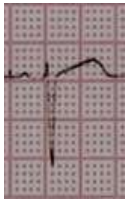


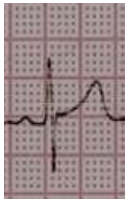
V5 , V6 = L. Ventricle

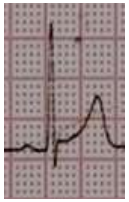
V1 V2 V3 V4









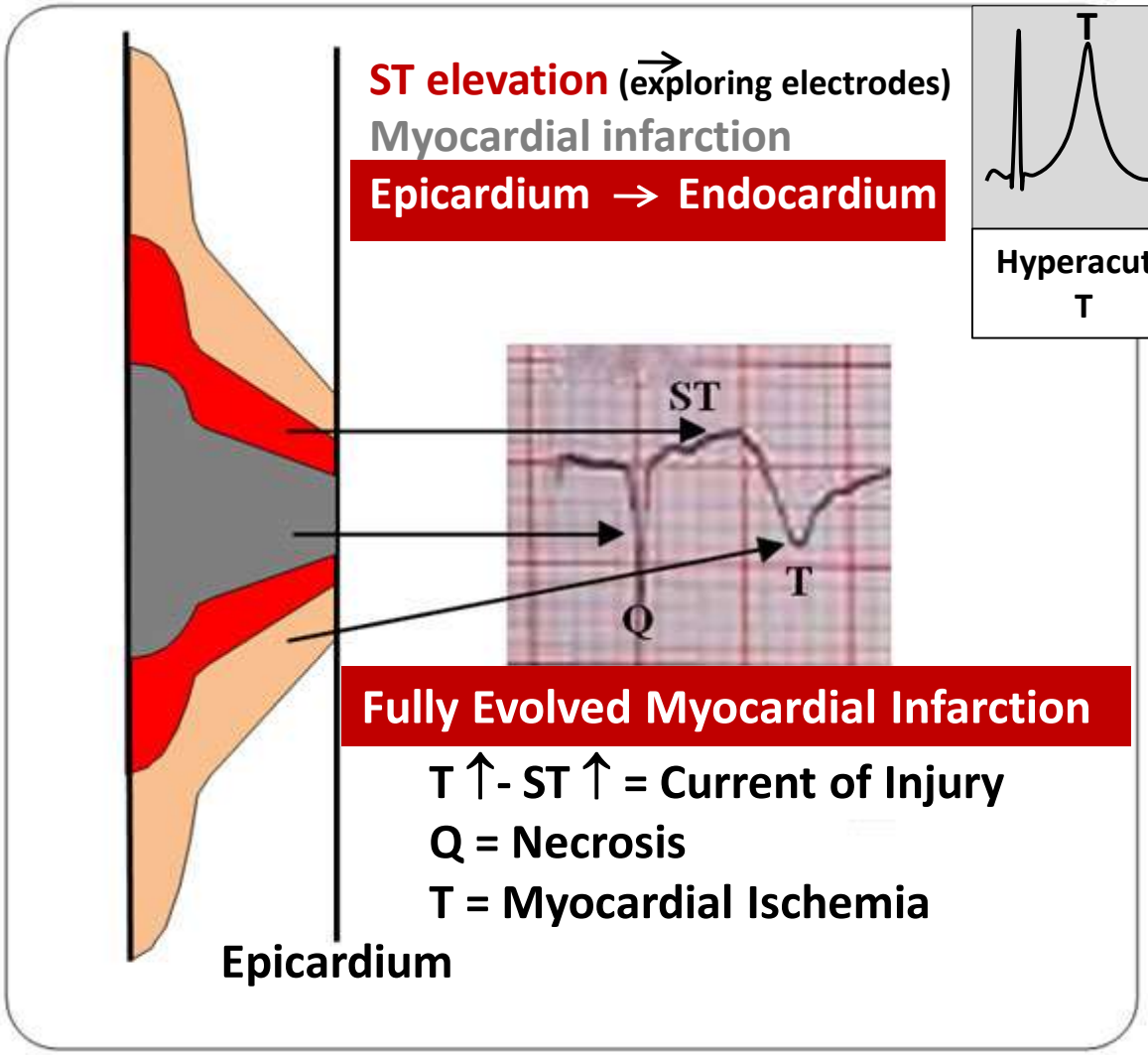


V1 -V2 = R. Ventricle

Transitional zone

- Ventricular dominance : RVH/LVH
- In bundle branch block (limb leads) : no simulataneous ventricular activation but one after the other (Biphasic R)
  - RBBB with RV pattern dominance
  - LBBB with LV pattern dominance
- Pathological Q wave : dead / inert myocardium

Diagnostic Approach to STEMI



T	1 R ST ↑	2 R ↓ T ↓ Q ST ↑	3 R Q ST T ↓
Hyperacute T	mts-few hrs ✓	few hrs-few days ✓	few days – few weeks

Fully Evolved Myocardial Infarction

T ↑- ST ↑ = Current of Injury

Q = Necrosis

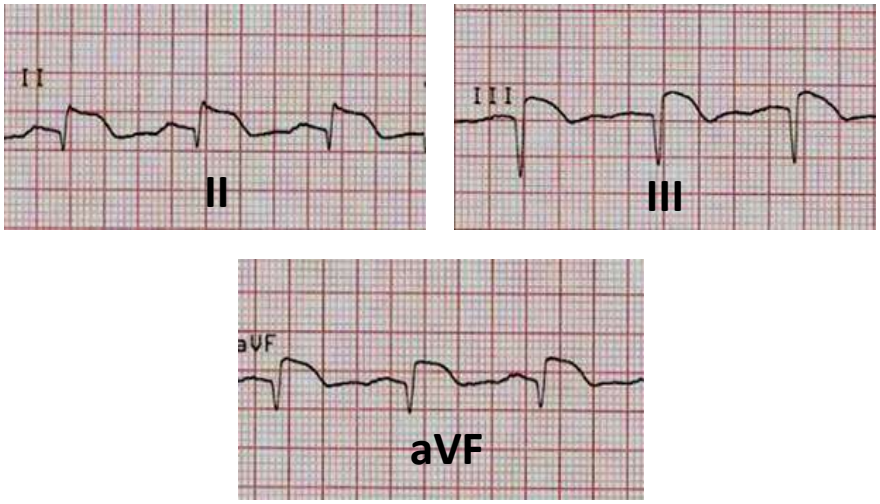
T = Myocardial Ischemia

New ST-segment elevation at J-point in at least two anatomical continuous leads of ≥ 2 mm in a male or ≥ 1.5 mm in a female over leads V2-V3 and/or at least 1 mm in other continuous leads or limb leads

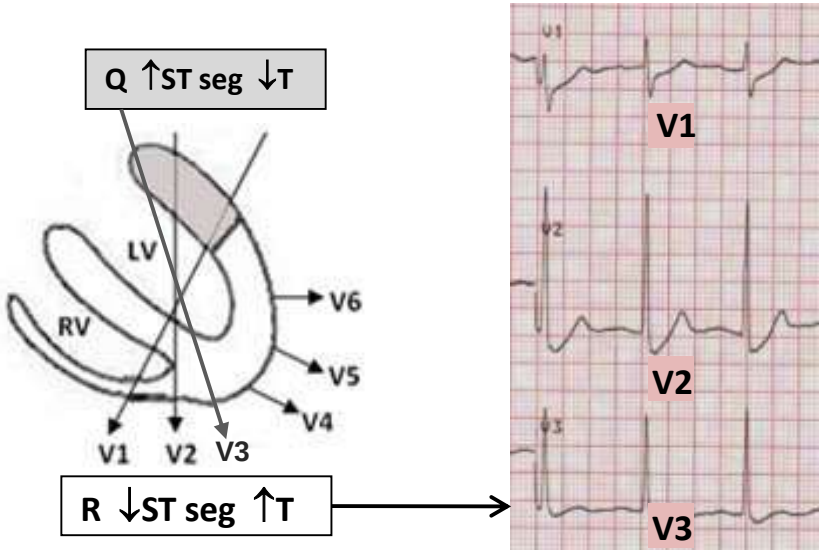
(other ↑ST causes excluded)

A wide Q wave (>0.04 sec) that exceeds 25% of the R wave in the leads with necrosis.

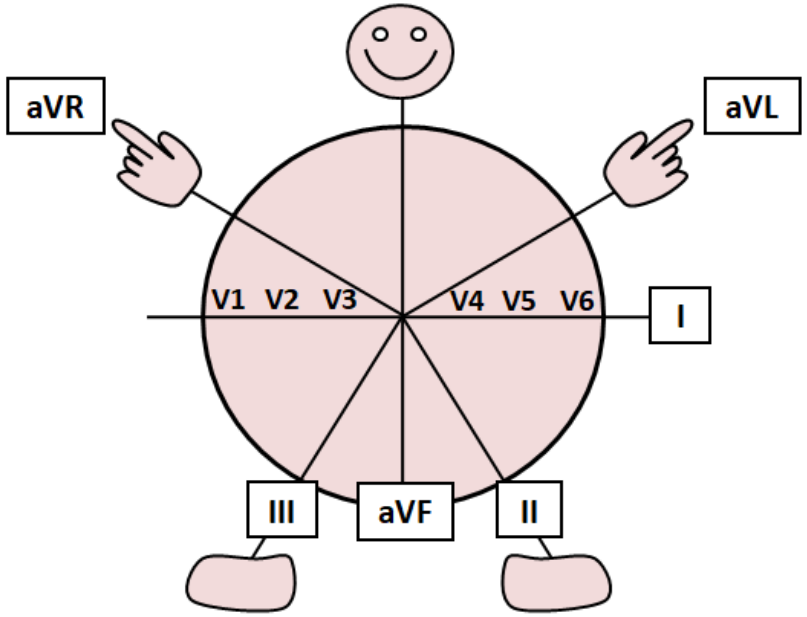
STEMI pattern on ECG



Inferior STEMI



Posterior wall MI



Reciprocal change is defined as ST-segment depression ≥ 1 mm in at least 2 leads in a single anatomic segment , occurring onto the contralateral side , as a mirror-image effect of ST-segment elevation associated with STEMI.

This supports the diagnosis of STEMI with specificity and positive predictive value of 93%.

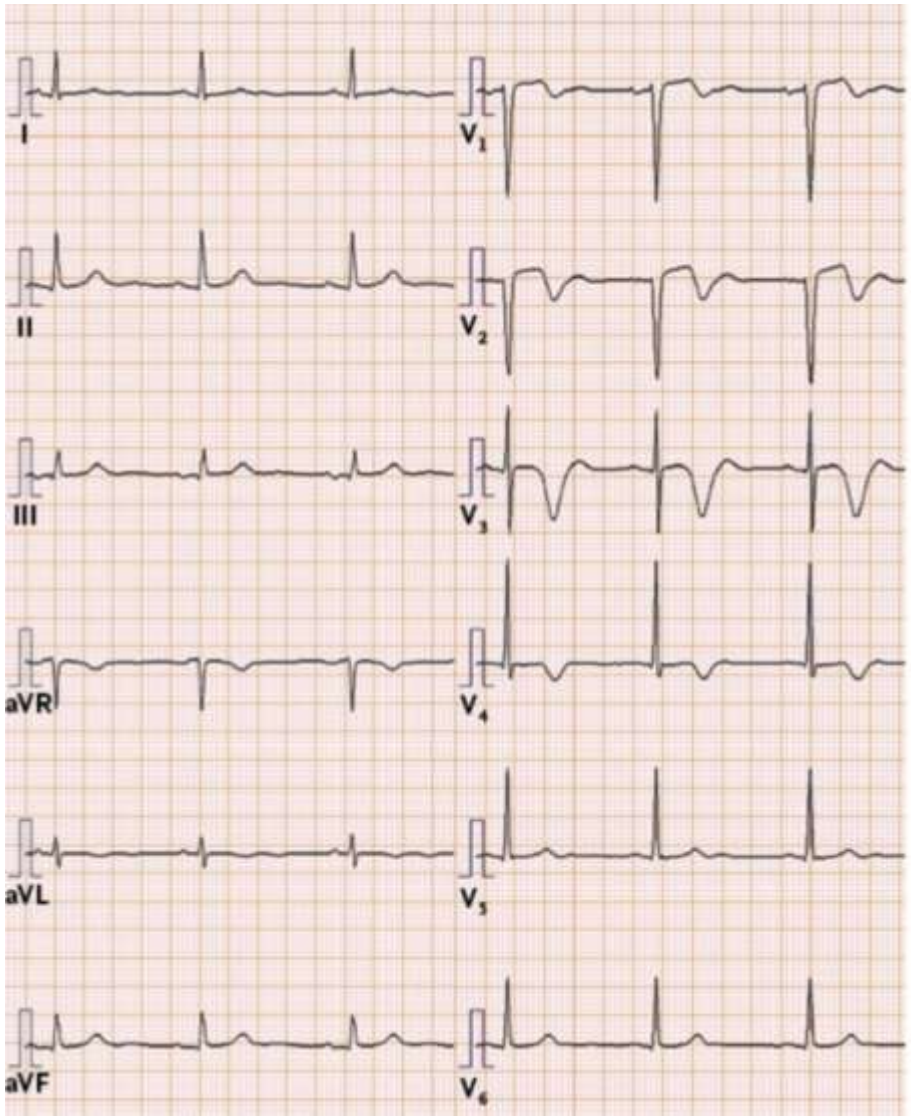
An approach to recognize sites of occlusion in CAD

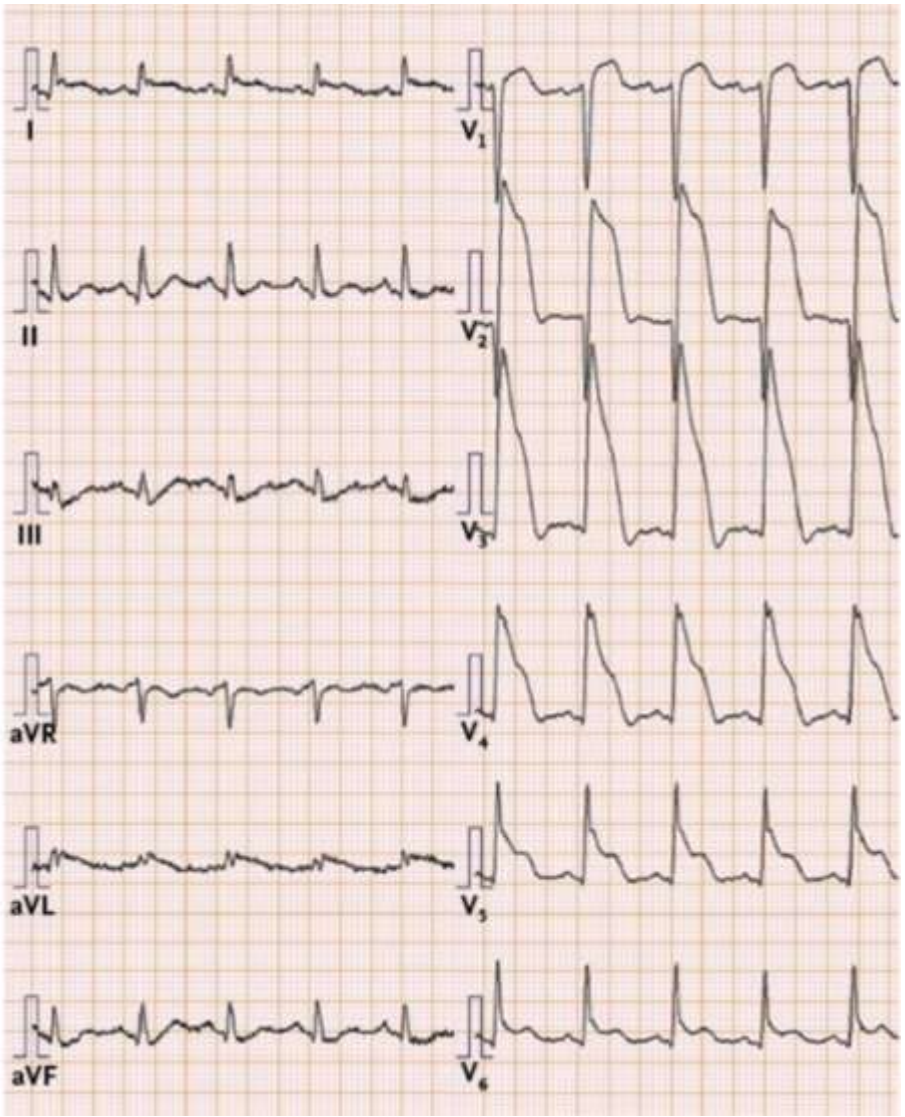
I	aVR	V1	V4
II	aVL	V2	V5
III	aVF	V3	V6

- ❑ **LMCA (subtotal occlusion)**
  Widespread ST depression with ST elevation in aVR $\geq$ 1 mm
- ❑ **Proximal LAD**
  - Before septal and diagonal branches : ST↑ in V1-6 $\pm$ aVL (1) (qRBBB possible) with ST elevation in lead V1 > aVR
  - Proximal to septal branches : ST↑ in V1-3
- ❑ **Pre D1 occlusion**
  ST↑ in I , aVL , +/- V2
- ❑ **Mid LAD**
  ST↑ in V2-6 (reciprocal depression in I , aVL)
- ❑ **Distal LAD**
  ST↑ in V5-6 (reciprocal depression in I , aVL)

- ❑ **RCA STEMI**
  ST↑ in III>II + ST↑ in V1 and ST↓ in V2
- ❑ **LCX STEMI**
  ST↑ in II>III , aVL , I , V5-6
- ❑ **Posterior wall MI**
  Reciprocal changes in V1 V2 V3 : R ↓ST Seg ↑T

Wellens' syndrome ⟶ anterior STEMI

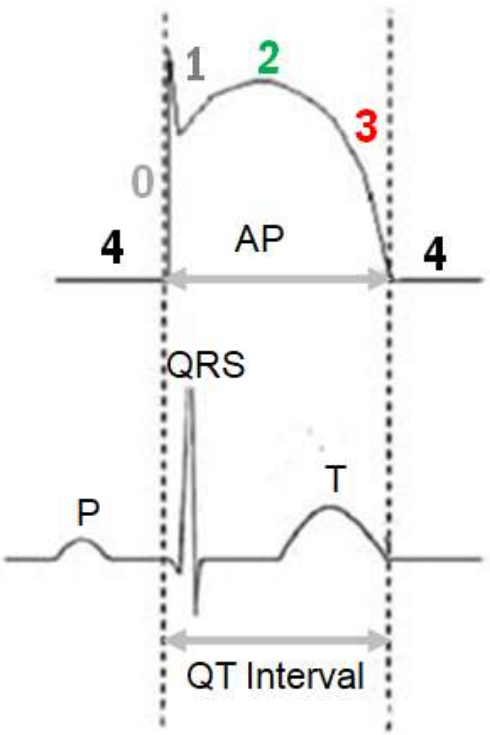


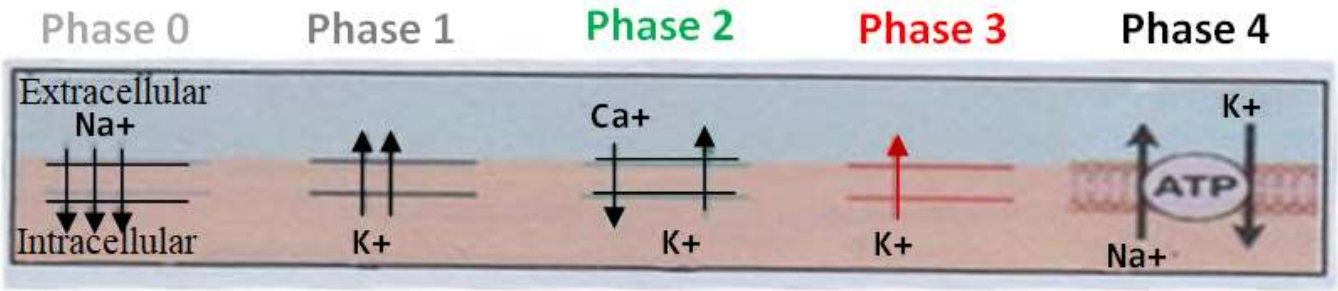


A Wellens' Syndrome ⟶ **B Anterior STEMI with ''Shark Fin'' sign formed by fusion of QRS , ST-seg and T wave**

(this pattern present in pain-free period)

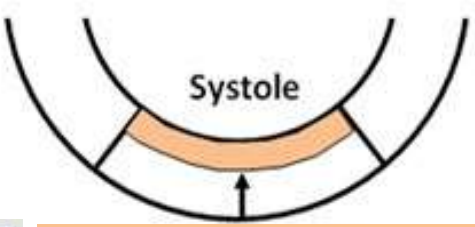
Step 8 : ST segment - Phase 2





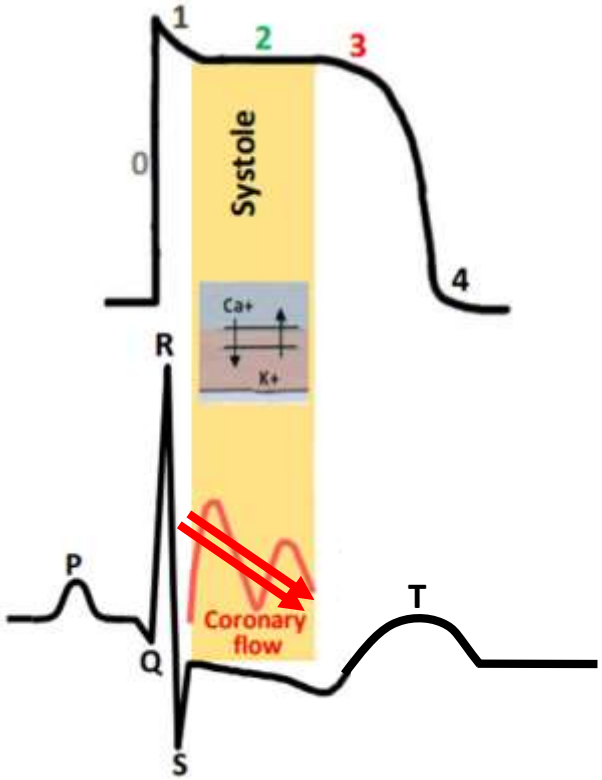
- Coronary aretery disease is suggested by horizontal plane or down sloping ST segment
- The strain pattern – depressed convex – upward ST segment with inverted T-wave
- Digitalis effect : a mirror image correction mark shape of the ST segment
- Hyperacute phase of myocardial infarction and prinzmetal's angina is reflected by slope eelvation of the ST segment associated with the Tall and widened T -wave

ST↓ in myocardial ischemia



Subendocardial Injury

- The flow of current is away from the exploring electrode (Potential difference)
- ST segment depression

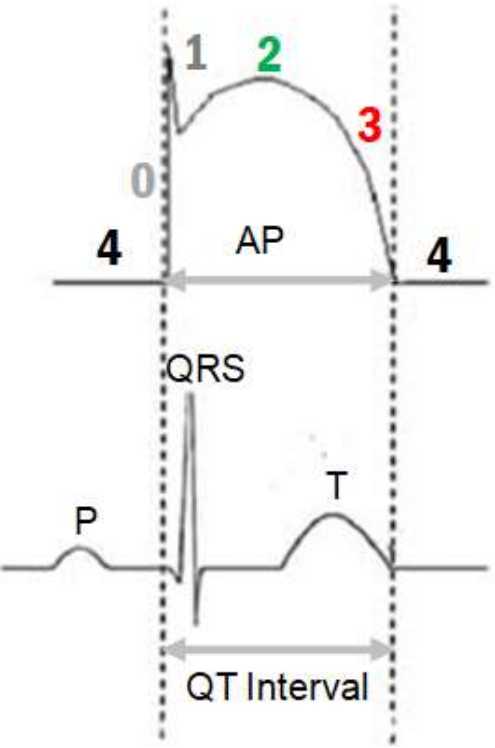


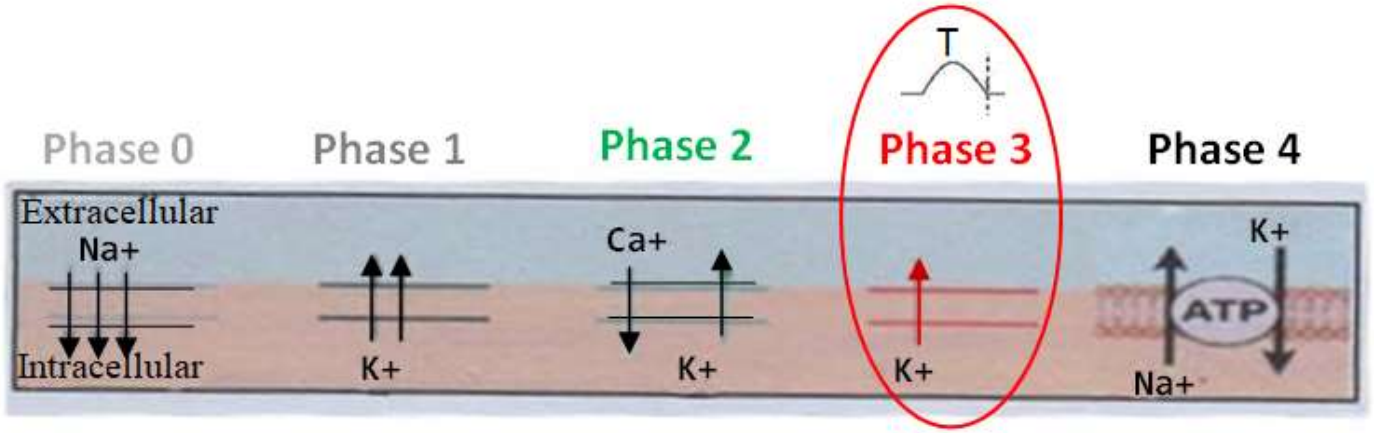
Downsloping ST segment depression

Horizontal or downsloping ST segment depression

- ≥ 0.5 mm ≥ 2 in two contiguous leads myocardial ischemia
- ST depression ≥ 1 mm a worse prognosis.
- ST depression ≥ 2 mm in ≥ 3 leads possibility of Non-ST elevation myocardial infarction (NSTEMI) ± T inversions or flat T

Step 9 : T –wave – Phase 3





- Low or inverted T waves in most leads may be associated with coronary heart disease
- Low or inverted T waves associated with generalized low voltage of the QRS complex suggest pericardial effusion or myxoedema.
- Tall , peaked T waves in the precordial leads may be due to :
  - ST elevation MI (broad based hyperacute T-wave)
  - de Winter T-wave
  - Early repolarization syndrome

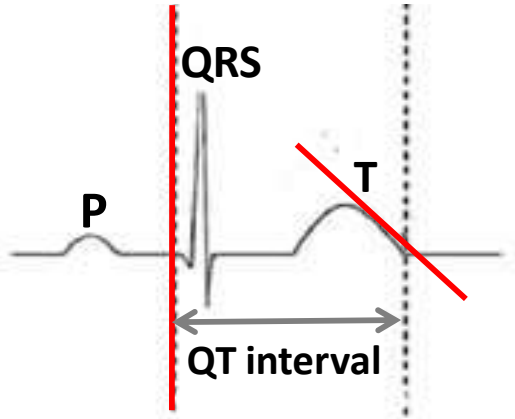
  - Hyperkalaemia (narrow based Tall T-wave)

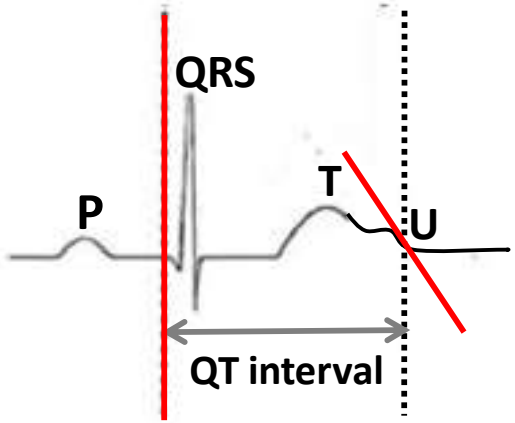
Step 10 : QTc interval

❑ QTc estimation (use scientific calculator)

https://play.google.com/store/apps/details?id=com.scientificCalculator

- Bazett formula : QT / √RR (useful with HR 60-100 bpm)
- Framingham formula : QT + 0.154 (1-RR) (At heart rate outside of the range 60-100 bpm)
- A useful rule of thumb is that a normal QT is less than half the preceding PR interval





❑ Normal QTc values

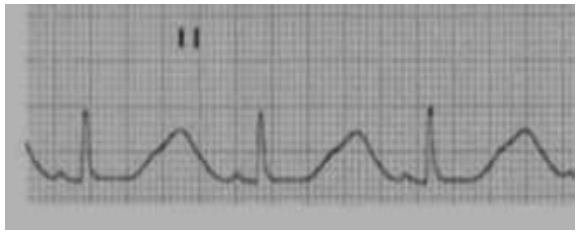
- QTc prolonged if > 440 ms in male or > 460 ms in women
- QTc is abnormally short if < 350 ms
- QTc > 500 ms is illustrated with an increased risk of Torsades de pointes

QTc (continued)

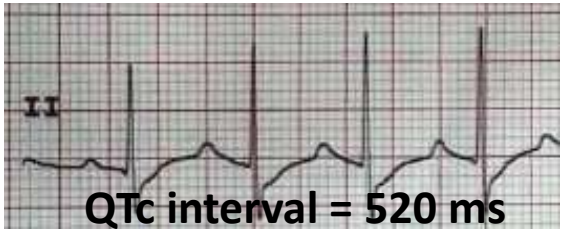
- Prolonged QTc in hypokalemia , hypocalcaemia , myocardial disease , congenital long QT syndrome

  Shortened QT interval : In Hyperkalemia , Hypercalcaemia , Vagotonia , Digoxin toxicity , congential short QT syndrome

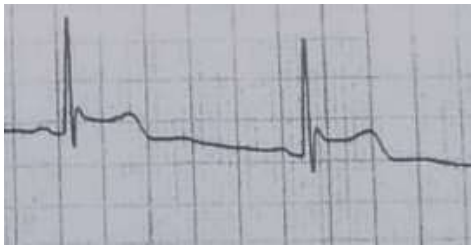
- Illustration by ECGs



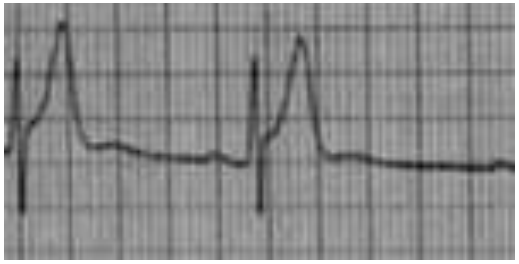
Prolonged QT by rule of thumb



Hypokalemia (A young male with Quadriparesis and respiratory arrest)



Hypercalcaemia : with 340 ms with virtual absence of ST segment and a widening of T-wave



Congenital short QT syndrome

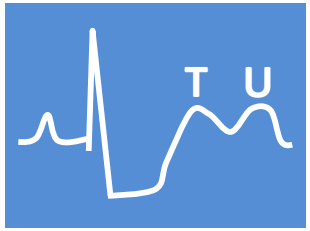
- QT and QTc intervals respectively : 0.32 and 0.32 ms both are equal and unchanged.
- Tall / peaked T , best seen over precordial leads V1-V4.

Step 11 : U wave

- A predominant U wave in the midprecordial leads – V3 to V5 – commonly due to hypokalemia
- An inverted U wave in standard leads leads I and II and leads and V6 is usually due to one of the following :
  - Coronary heart disease
  - Hypertensive heart disease

- Normally Synchronized repolarization of cardiac myocytes and Purkinje fibres
- In hypokalemia dichotomized repolarization : delayed and prolonged repolarization through purkinje fibres → T-U complex
  fusion of T with U → QT prolongation

Prominent U wave



- ST depression
- Fusion of T with U

Concluding remark

Again to remind

ESSENTIALS :

- **ECG interpretation is a knowledge based skill**

3A

- **A concept of normal ECG and abnormal ECGs based on a basic book with special emphasis on illustrated ECGs explanation**
- **A regular revision**
- **A step-by-step methodical approach in collaboration with the clinical history**


Thanks