ECG - basics

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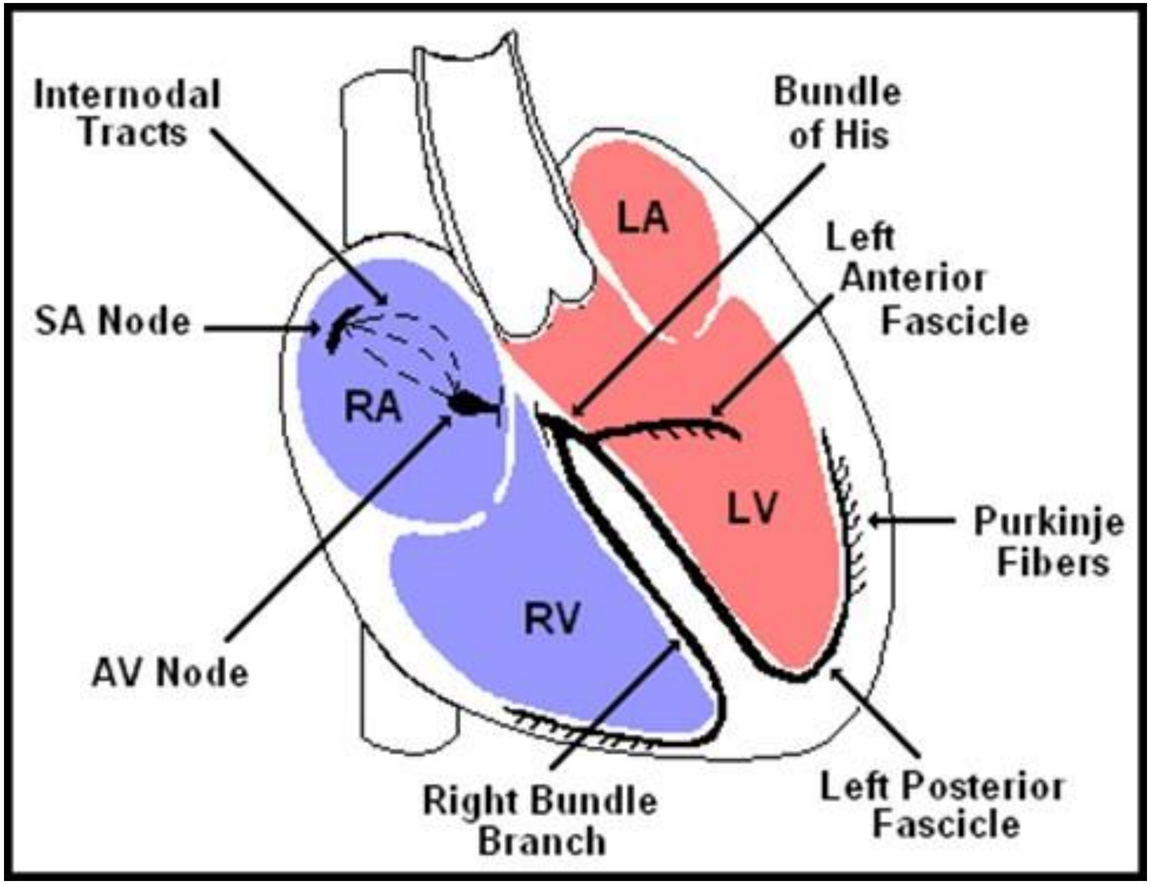
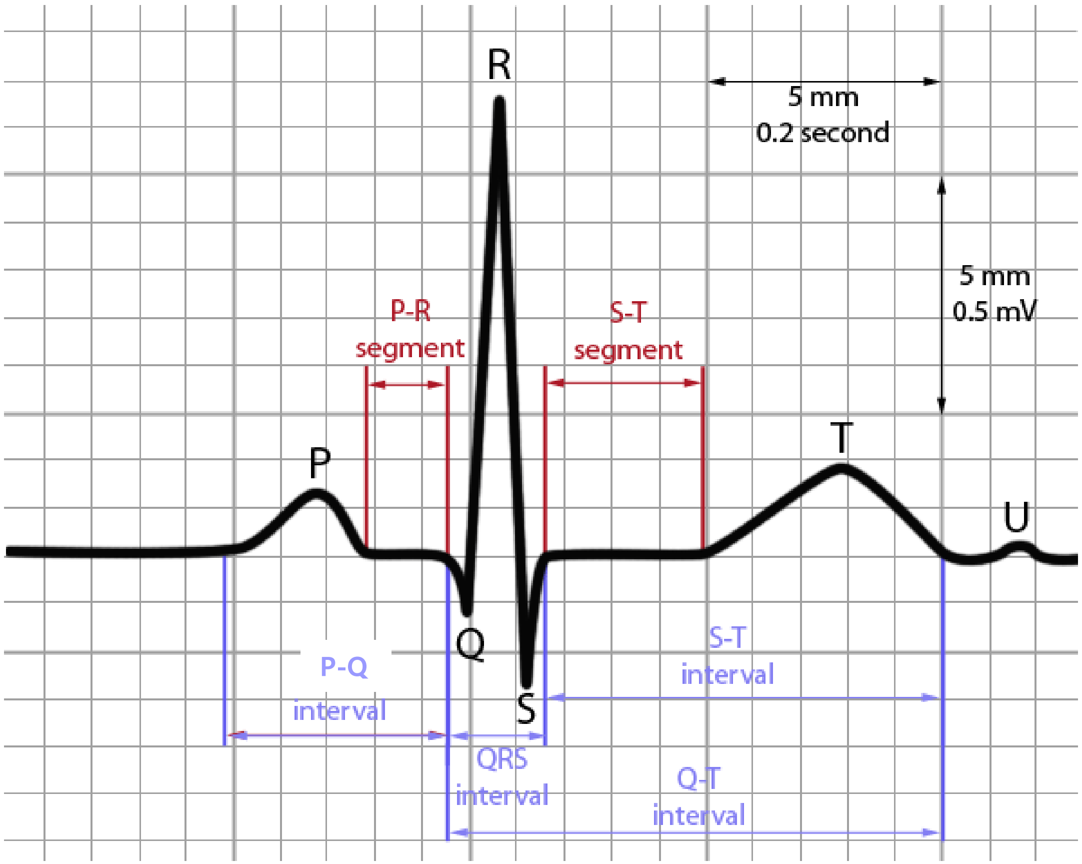
ECG

- The electrocardiogram (ECG) is a representation of the electrical events of the cardiac cycle
- Normal Conduction System



ECG

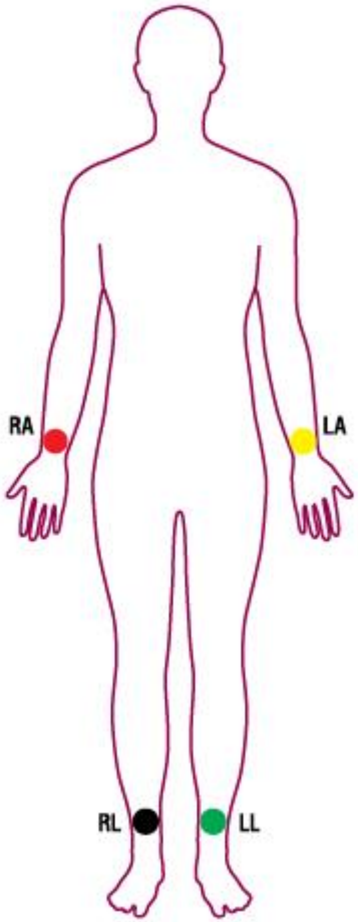


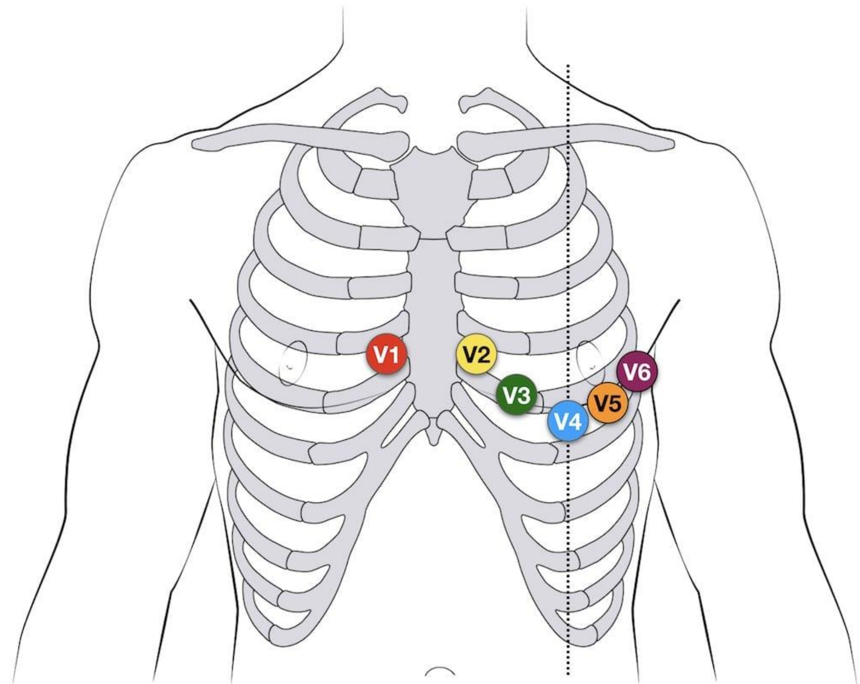
- P wave = atrial depolarisation
- PQ Interval
  = impulse from atria to ventricles
- QRS complex
  = ventricular depolarisation
- ST segment = isoelectric
  - part of repolarisation
- T wave = same direction as QRS
  – ventricular repolarisation
- QT = onset of depolarisation to the completion of the ventricles

ECG- electrodes position

- ECG device has 10 electrodes – 4 limb electrodes

  \- 6 precordial electrodes
- electrodes sense the electrical vector of the myocardium- that creates ECG curve

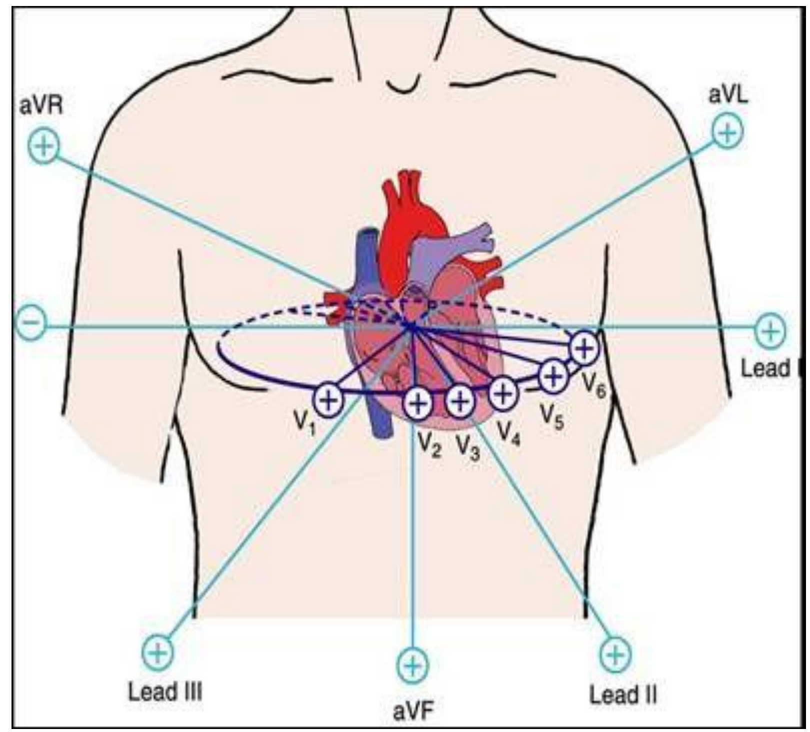


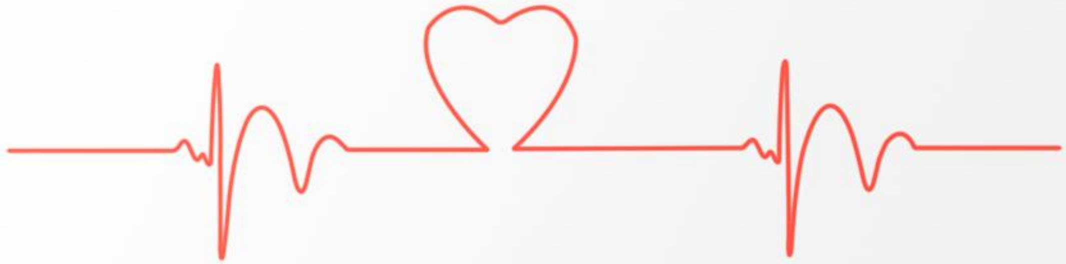


ECG- leads

- **Standard ECG has 12 leads:**
  - **Standard (bipolar) leads- I, II, III**
  - **Augmented (unipolar) leads – aVR, aVL, aVF**
  - **Precordial (unipolar) leads- V1-V6**

anterior wall	V1-V6
anteroseptal wall	V1-V3
inferior wall	II, III,aVF
lateral wall	I, aVL, V5, V6





How to read ECG?

Rhythm

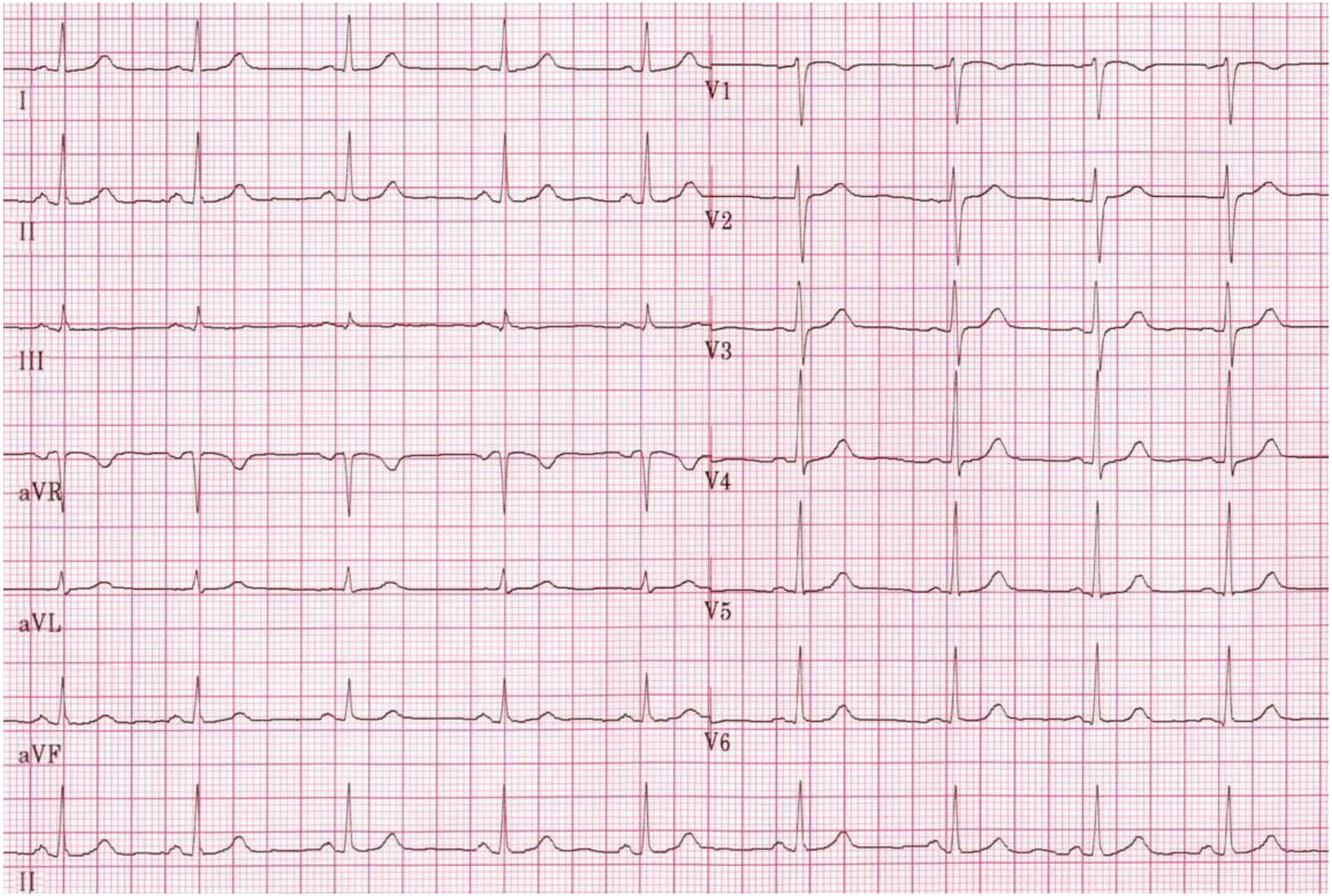
- **the sinus node (SA)** - in the right atrium is the fastest physiological pacemaker

- SA generates an electrical impulse →
- surrounding cells of the right atrium depolarize →
- the depolarization wave spreads to the cells of the left atrium →
- the AV node → the bundle of His → to the ventricles through the Purkinje fibers

- **criteria for normal sinus rhythm**:

  - The **P wave** precedes **every QRS complex**
  - is **positive in I and II**
  - maximum height is 2.5 mm in II and/or III
  - The rhythm is sinus, action is regular, varies slightly while breathing
  - The frequency ranges between 60 and 100 beats per minute

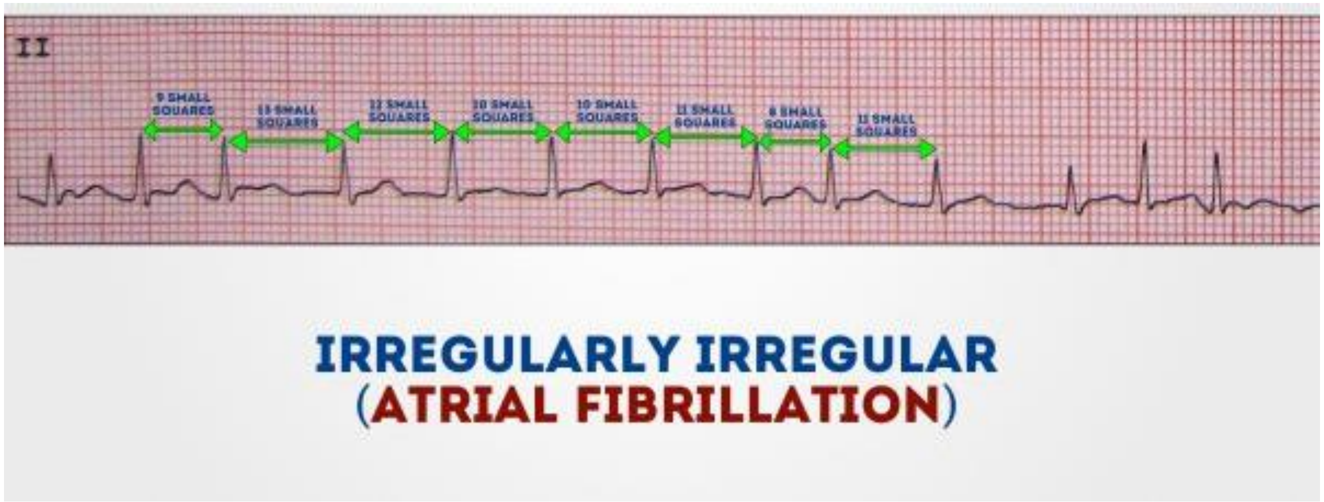
- normal sinus rhytm



Action and Rhythm

- **Action is** regulare- regularity of the waves
- distance between two R waves- (RR interval) is constant and regular
- if RR interval is not constant, action is irregular

- **Rhythm**: **sinus / non sinus**
  - P wave is absent in atrial fibrillation, junctional or ventricular rhythm
  - variable morphologies of P waves in a single ECG lead is suggestive of an ectopic pacemaker rhythm (wandering pacemaker or multifocal atrial tachycardia)

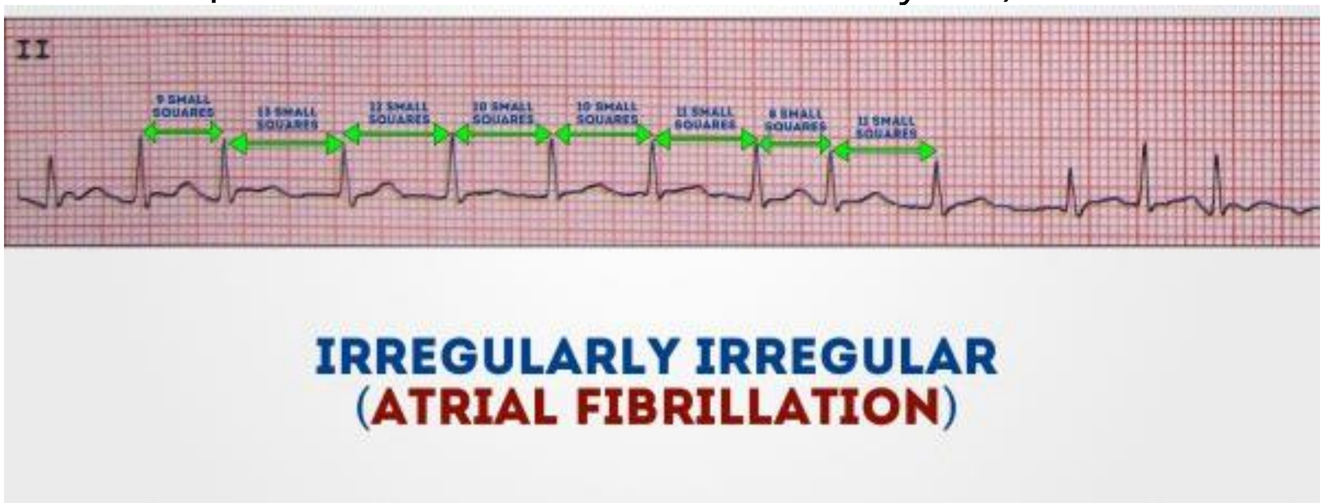


Action

- ➢ Irregular action can be either:
- ▪ **regularly irregular** (i.e. a recurrent pattern of irregularity)
- ▪ **irregularly irregular** (i.e. completely disorganised)

➢ mark out several consecutive R-R intervals on a piece of paper, then move them along the rhythm strip to check if the subsequent intervals are similar

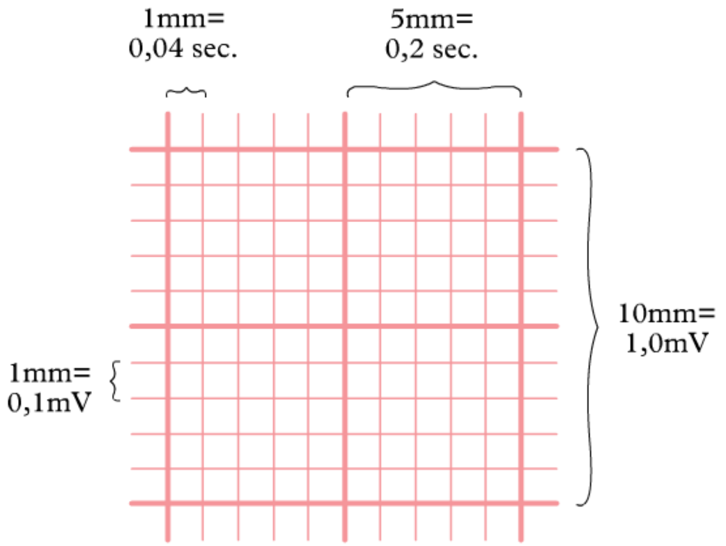
➢ if you are suspicious that there is atrioventricular block (AV block), map out the atrial rate and the ventricular rhythm separately
(i.e. mark the P waves and R waves)- PQ interval, if QRS complexes are missing or if there is complete dissociation between the two cycles)



Rate

- normal heart rate is between 60 and 100 beats per minutes
- **bradycardia** - heart rate less than 60´
- **tachycardia** - heart rate larger than 100´

- small and large squares in an ECG paper – speed rate 25mm/s

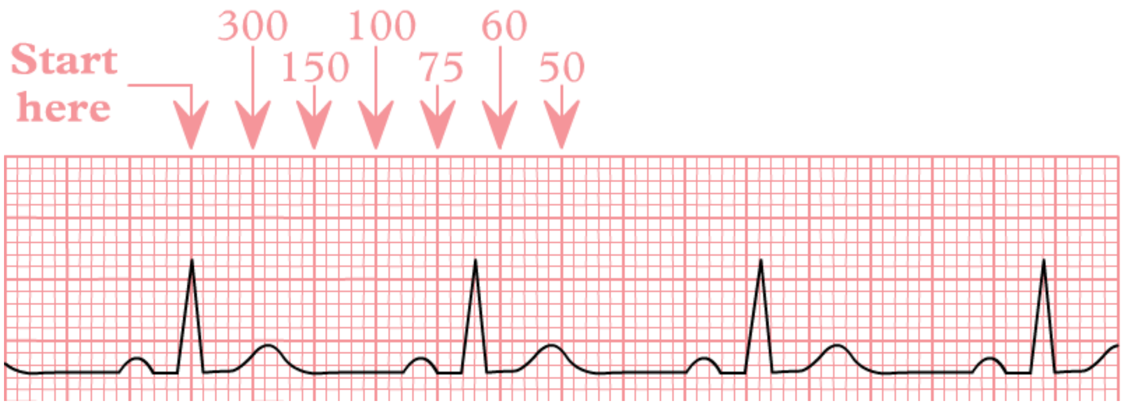


Rate

- to determine the heart rate one of these methods can be used:

1. **counting the squares:** use the sequence 300-150-100-75-60-50-43-37
   - ✓ count from the first QRS complex
     the first thick line is 300, the next thick line 150 etc.

   - ✓ stop the sequence at the next QRS complex (when the second QRS complex is between two lines, take the mean of the two numbers from the sequence)



2. Use the ECG ruler – the most easy

Rate

- **3.** if the ECG paper runs at 25 mm/sec through the ECG printer use the formula:

$$\underset{\text{(beats/min)}}{\textbf{Heart rate}} = \frac{(25\ \text{mm/sec} \times 60\ \text{sec/min})}{\text{number of squares}} = \frac{1500}{\text{number of squares}}$$

- **<u>4. if regular rhythm</u>** is present, use the following method:
  - count the number of large squares within one R-R interval and
  - divide 300 by number of squares

Heart rate= 300 : number of large squares in one R-R interval

300 : 4= 75

Heart rate: 75 beats/min

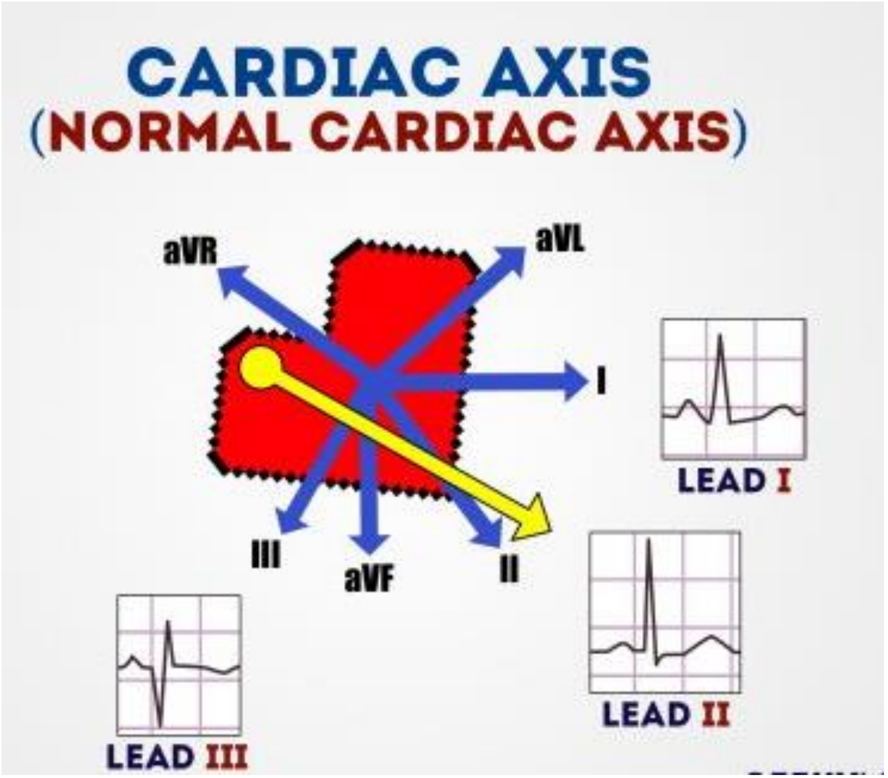
Cardiac axis

- describes the overall **direction of electrical spread** within the heart
- the depolarization wave begins in the right atrium and spread to the left and right ventricle
- the **shapes of the QRS complex in leads I, II and III** are used to estimate the **cardiac axis**
- when the **depolarization** is directed **towards the lead**, the ECG recording in that lead will show **positive deflection**
- when the depolarization is directed **away from the lead**, the ECG recording in that lead will show **negative deflection**

Cardiac axis-normal

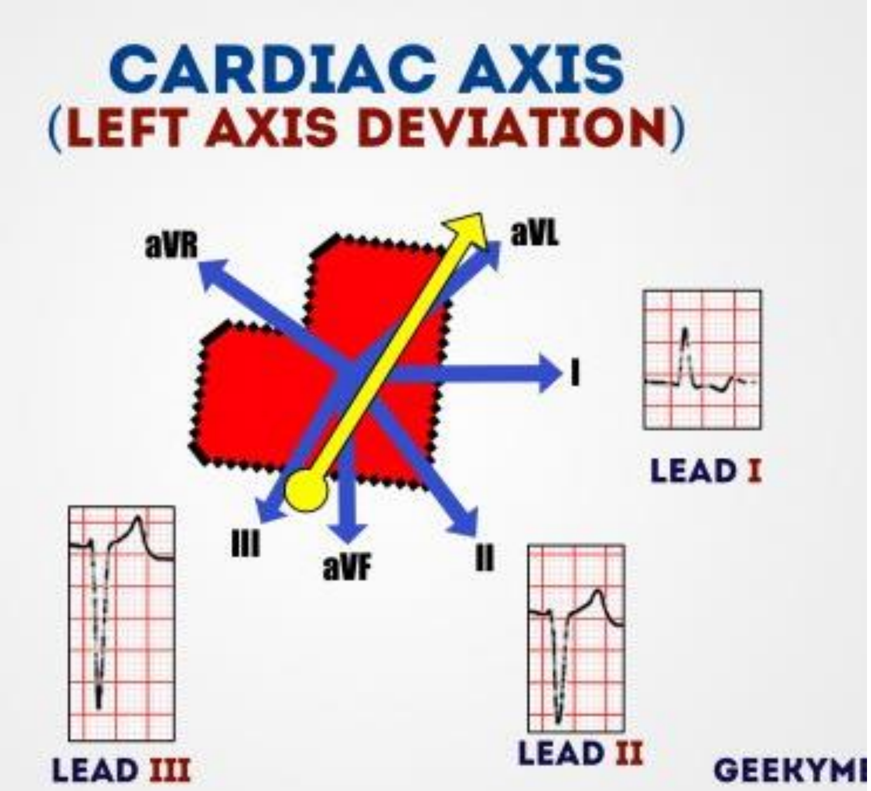
- the normal cardiac axis lies between -30 and +90 degrees

- **lead II** - the **highest positive deflection** compared to leads I and III.



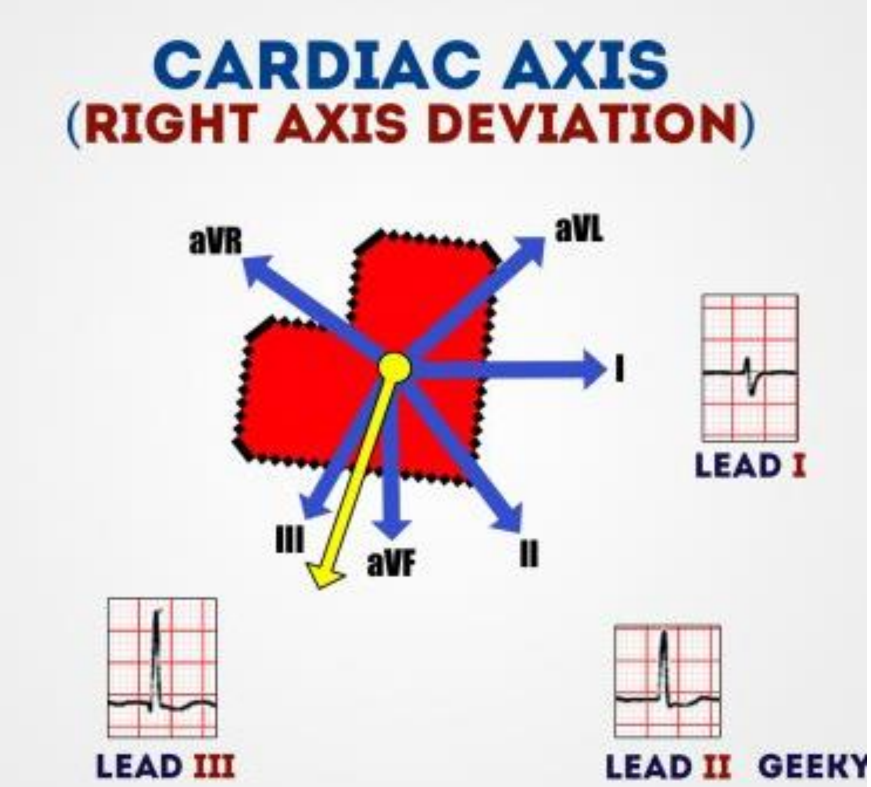
Cardiac axis left /right deviation

- lead I - the highest positive deflection
- leads II and III are negative



- lead III -the highest positive deflection
- right ventricular hypertrophy

  (i.e. pulmonary hypertension, COPD)



PQ Interval

- **Measurement**:

  from the beginning of the P wave to the beginning of the QRS complex

- reflects the time of travel of the electrical impulse from the SA to the AV node (reaching the ventricles)

- a good appraisal of AV node function

- normal duration: between 120 - 200 ms

Prolong PQ Interval

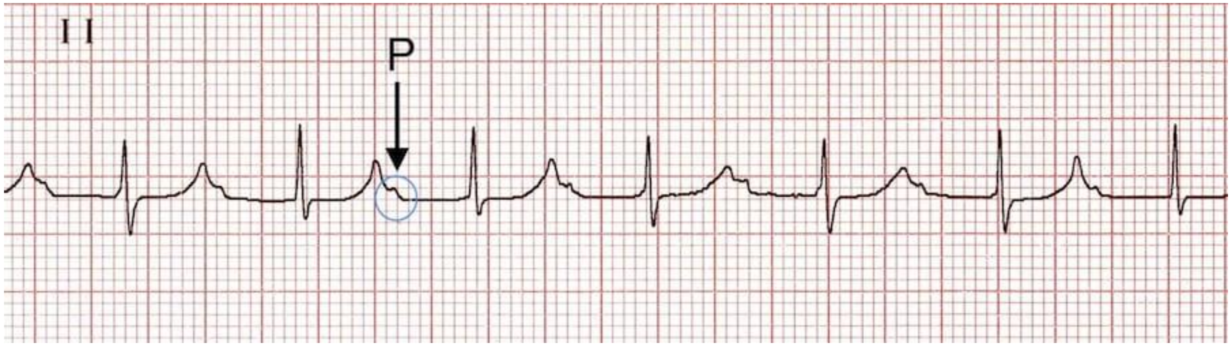
First-degree heart block (AV block)

PQ interval > 0.2 seconds (200 ms)

= suggests the presence of atrioventricular delay (AV block)

- **First-degree heart block (AV block):**

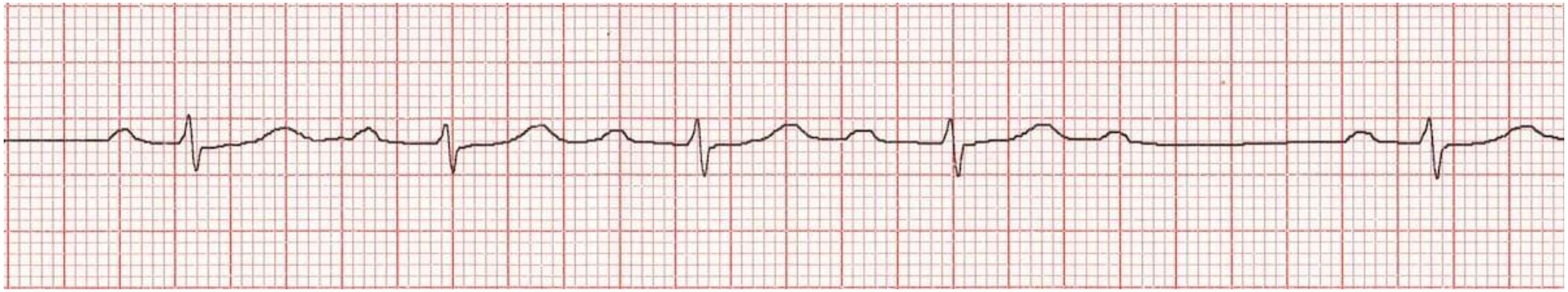
  a fixed prolonged PQ interval (>200 ms)



Second-degree AV block (type 1)

Mobitz type 1 (Wenckebach phenomenon)

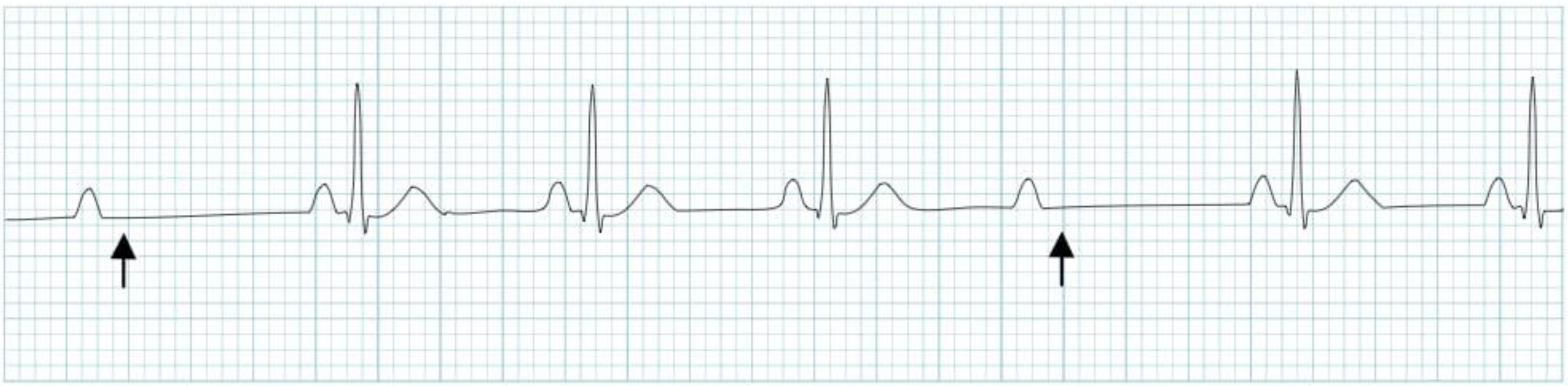
- **progressive prolongation of the PQ interval until the atrial impulse is not conducted and the QRS complex is dropped**
- AV nodal conduction resumes with the next beat and the sequence of progressive PQ interval prolongation and the eventual dropping of a QRS complex repeats itself



Second-degree AV block (type 2)=Mobitz type 2

- a consistent PQ interval duration with intermittently dropped QRS complexes due to a failure of conduction

- the intermittent dropping of the QRS complexes typically follows a repeating cycle of every 3rd (3:1 block) or 4th (4:1 block) P wave



Third-degree AV block

(complete heart block)

- no electrical communication between the atria and ventricles

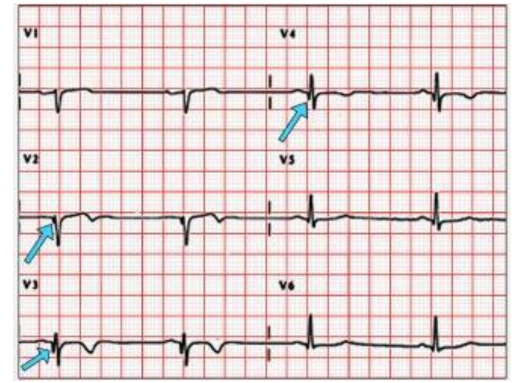
  (complete failure of conduction)

- the presence of P waves and QRS complexes, but no association between them
- atria and ventricles operate independently
- cardiac function is maintained by a junctional or ventricular pacemaker

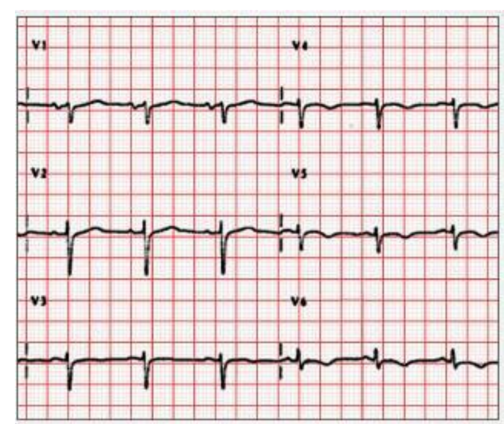
- atrial rate: 100 bpm
- **ventricular rate: 40 bpm: syncope, Morgan- Adams´s-Stock syndrome**
- the two rates are independent; no evidence that any of the atrial impulses are conducted to the ventricles

QRS complex

- Q-waves:
- pathological Q wave is >25% the size of the R wave that follows it or >2mm in height and >40ms in width



- R and S waves:
- assess the R wave progression across the chest leads
  (from small in V1 to large in V6)
- transition from S > R wave to R > S wave should occur in V3 or V4
- poor progression can be a sign of previous MI)

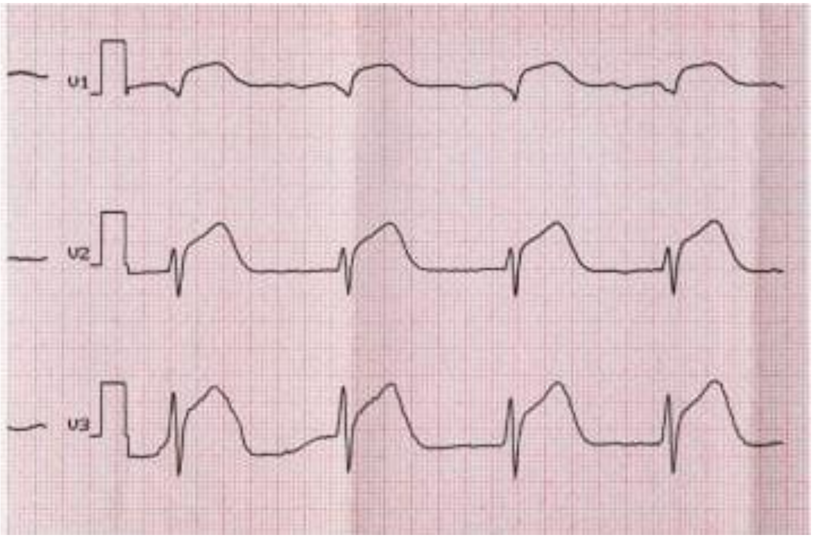


ST segment

- in a healthy individual, it should be in an isoelectric line (neither elevated nor depressed)

- **ST-elevation** is significant when it is greater than 1 mm (1 small square) in 2 or more contiguous limb leads or >2mm in 2 or more chest leads

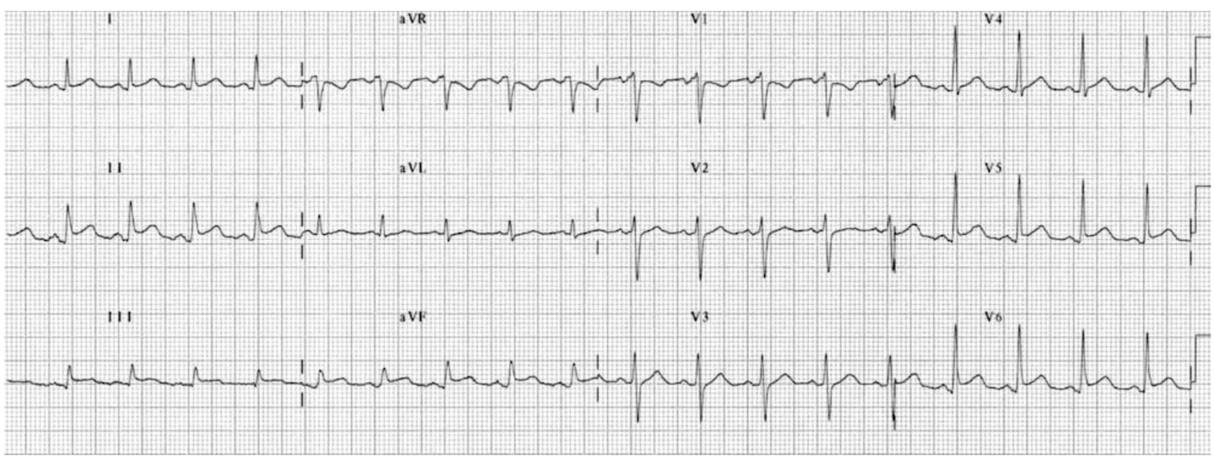
- acute myocardial infarction



- this ECG shows anterior myocardial infarction

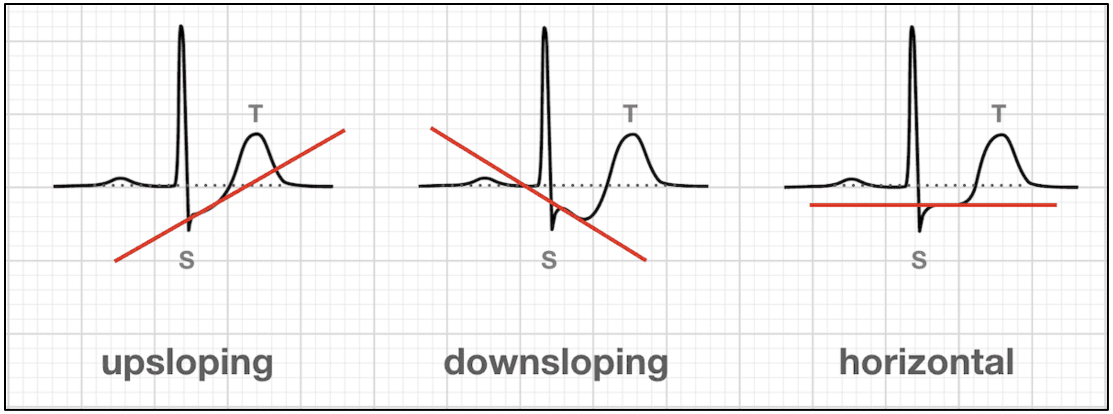
ST segment elevation

- Acute myocardial infarction
- Coronary vasospasm (Printzmetal's angina)
- Pericarditis
- Benign early repolarization
- Left bundle branch block
- Left ventricular hypertrophy
- Ventricular aneurysm
- Brugada syndrome
- Ventricular paced rhythm
- Raised intracranial pressure
- Takotsubo Cardiomyopathy
- Acute pericarditis- concave "saddleback" ST elevation in leads I, II, III, aVF,V5-6



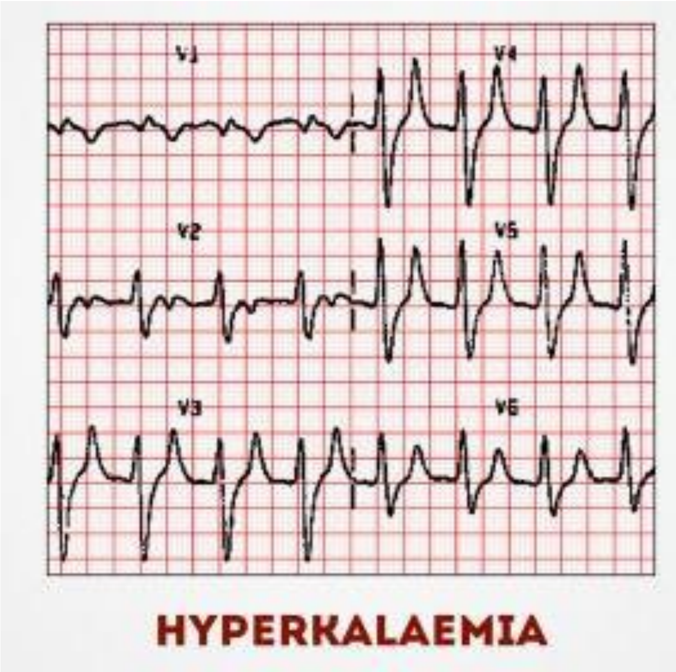
ST depression

- **≥ 0.5 mm in ≥ 2 contiguous leads** indicates **myocardial ischaemia**
- Myocardial ischaemia / NSTEMI
- Reciprocal change in STEMIPosterior MI
- Digoxin effect
- Hypokalaemia
- Supraventricular tachycardia
- Right branch block
- Right ventricular hypertrophy
- Left branch block
- Left ventricular hypertrophy
- pacemaker rhythm
- ST depression can be either **upsloping, downsloping, or horizontal**



T waves

- represent **repolarisation of the ventricles**
- T waves are considered **tall** if they are **>5mm in the limb leads**
  >10mm in the chest leads
- can be associated with:
  - **Hyperkalaemia ("tall tented T waves")**
  - **Hyperacute STEMI**



T waves

- **Inverted T waves**

T waves are normally inverted in V1 and in lead III

- in other leads are a nonspecific sign of a wide variety of conditions:

  - ❑ **Ischaemia**
  - ❑ **Bundle branch blocks (V4-6 in LBBB and V1-V3 in RBBB)**
  - ❑ **Pulmonary embolism**
  - ❑ **Left ventricular hypertrophy (in the lateral leads)**
  - ❑ **Hypertrophic cardiomyopathy (widespread)**

- **biphasic T waves** - have two peaks

  - ischaemia
  - hypokalaemia

- **flattened T waves** are a non-specific sign

  - ischaemia
  - electrolyte imbalance

U waves

- not a common finding
- >0.5mm deflection after the T wave best seen in V2 or V3
- they become larger in the bradycardia
  - ✓ **electrolyte imbalances**
  - ✓ **hypothermia**
  - ✓ **secondary to antiarrhythmic therapy**
  - ✓ **(digoxin, procainamide or amiodarone)**