THE ELECTROCARDIOGRAPHY ECG

BY

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Objectives

To understand and record normal electrocardiogram

Definition

- ECG = electro + cardio + graphy.

- Is the process of recording the electrical activity of the heart over a period of time using electrodes placed over chest wall

- The algebraic sum of all the electrical potentials of the heart recorded from the body surface

Equipment

- ECG recording machine (electrocardiograph).
- ECG graph paper.
- Disposable ECG electrodes.
- Alcohol swabs and gauze.

ECG

Function of the ECG

- Assessment of the electrical and muscular function of the heart
- Detection of heart rate
- Detection of heart rhythm
- Detection of the heart's orientation
- Presence of ischemia or infarction in the heart along with its location and extent
- Detection of electrolytes imbalance (hypocalcaemia and hypercalcemia)
- Detection of drug toxicity

Before recording

- The subject should be supine and relaxed.
- The temperature of the room should be neutral.
- Sweating and muscle movements should be avoided so as to minimize artifacts.

Leads of ECG

- A lead is a pair of electrodes joined together to record the potential difference between the two electrodes.

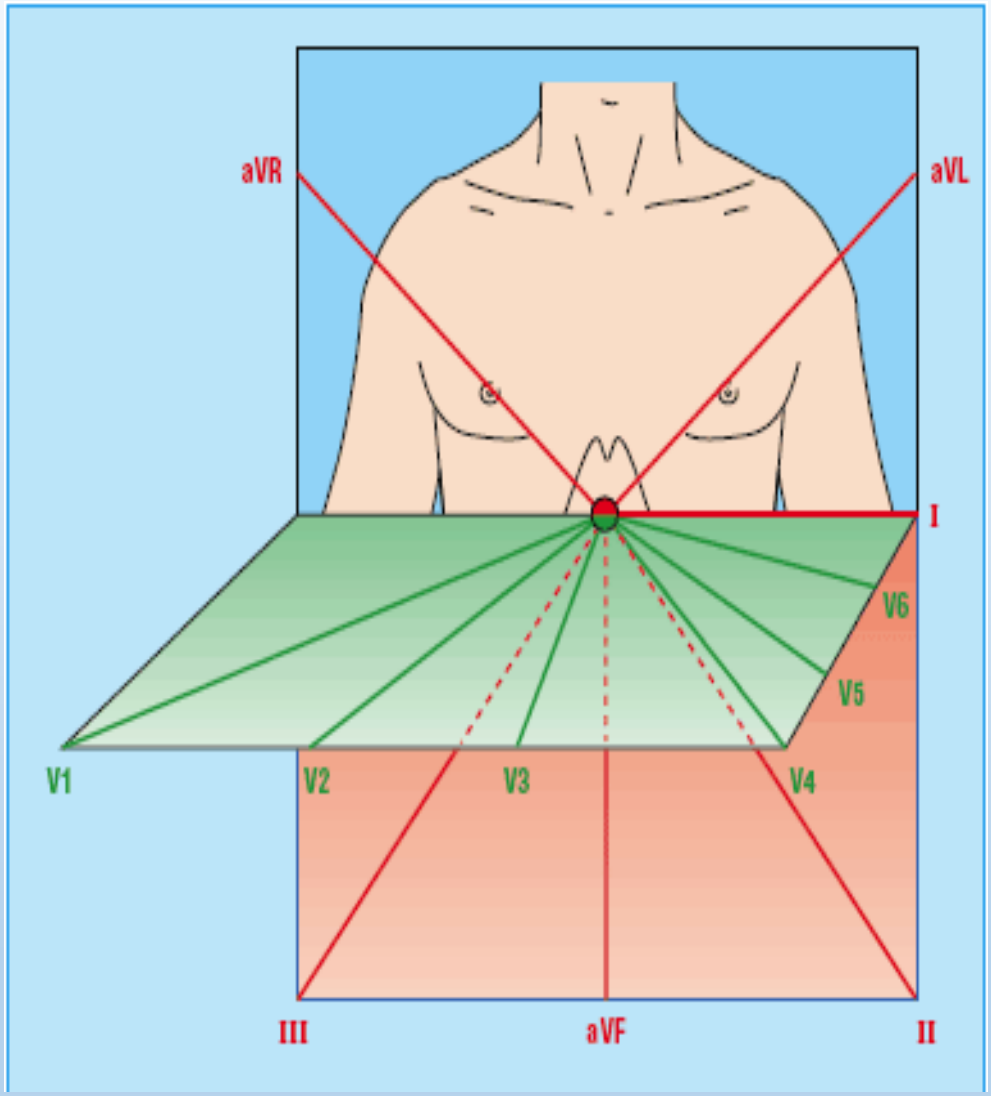
- Each lead looks at heart from a different angle so as to locate an abnormality in the heart that can be detected by ECG.

- A bipolar lead records the potential difference between two active electrodes

- Unipolar lead records the potential of one active electrode as compared to the other inactive electrodes, as it provides resistance to the inactive electrodes making their potential zero.

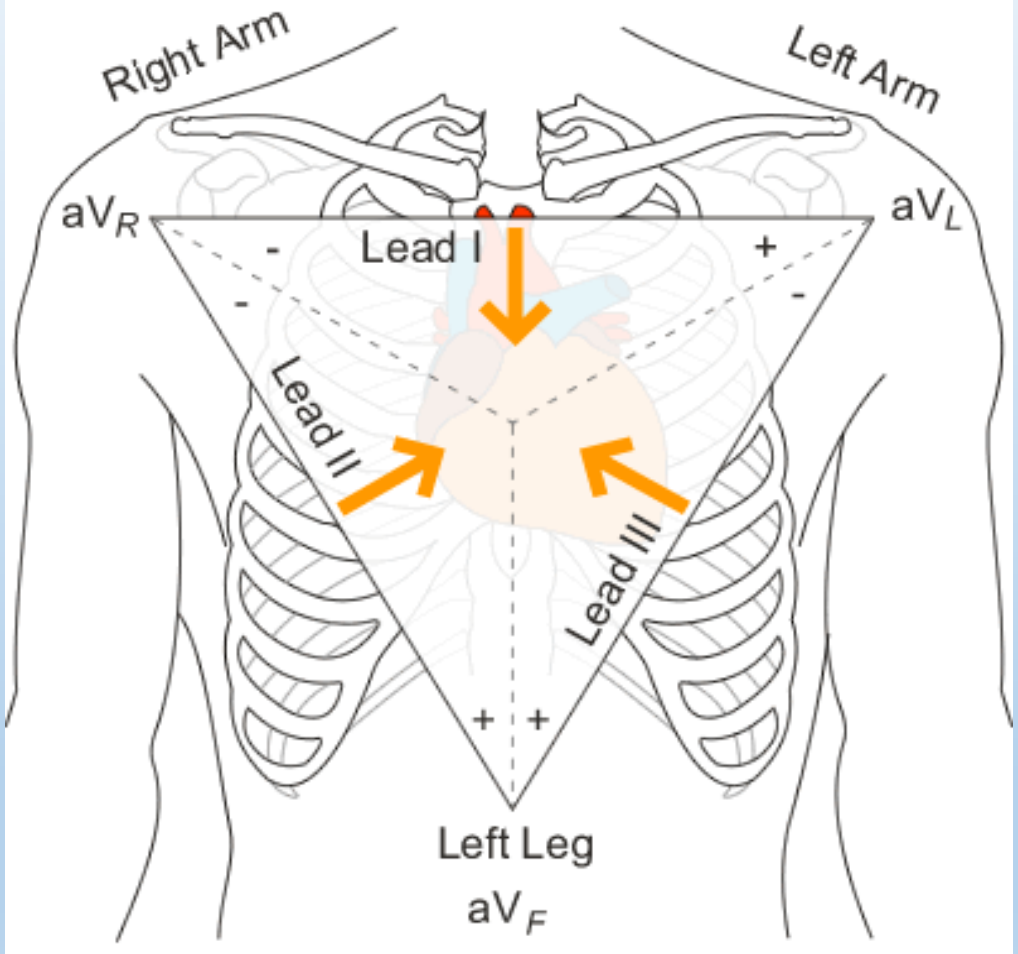
- There are 12 standard leads to record ECG.
- Out of 12 leads, 6 are limb leads and 6 are chest leads:
  - 3 bipolar limb leads (Leads I, II and III)
  - 3 Unipolar limb leads (aVR, aVL and aVF),
  - 6 Unipolar chest leads

- Lead = view
- 12 views of the heart:
  - **From the frontal plane:**
    - Limb leads.
    - Augmented limb leads.
  - **From the horizontal plane:**
    - Chest leads.

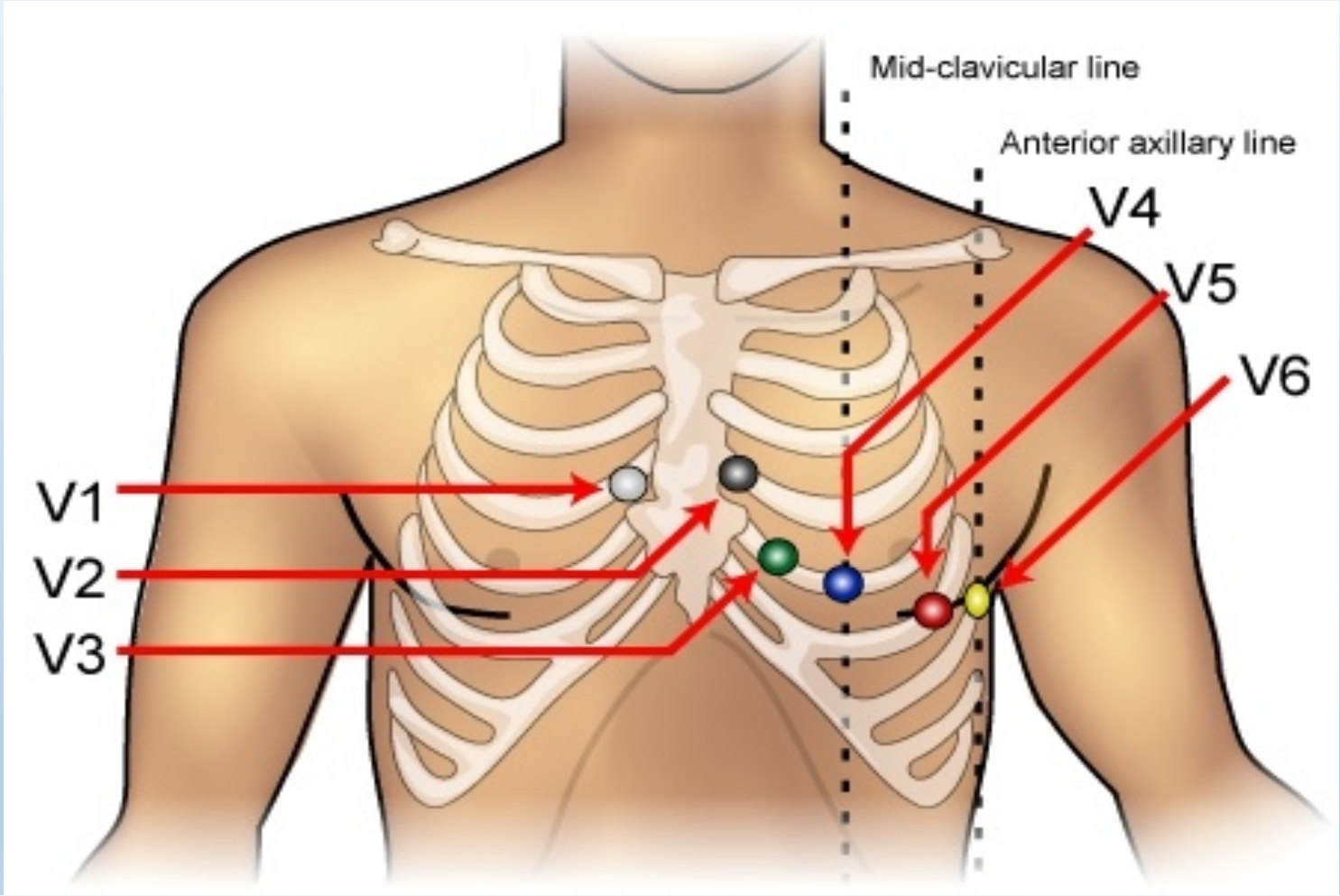


Types of leads	Limb Leads	Chest Leads
Bipolar	I, II, III Standard limb leads	
Unipolar	aVR, aVL, aVF	V1- V6

Einthoven's triangle



Chest Leads



Chest Leads

V1 - placed in the 4th intercostal space, right of the sternum

V2 - placed in the 4th intercostal space, left of the sternum

V3 - placed between V2 and V4

V4 - placed in the 5th intercostal space and the mid-clavicular line.

V5 - placed in the anterior axillary line horizontal to V4.

V6 - placed in the mid-axillary line horizontal to V5.

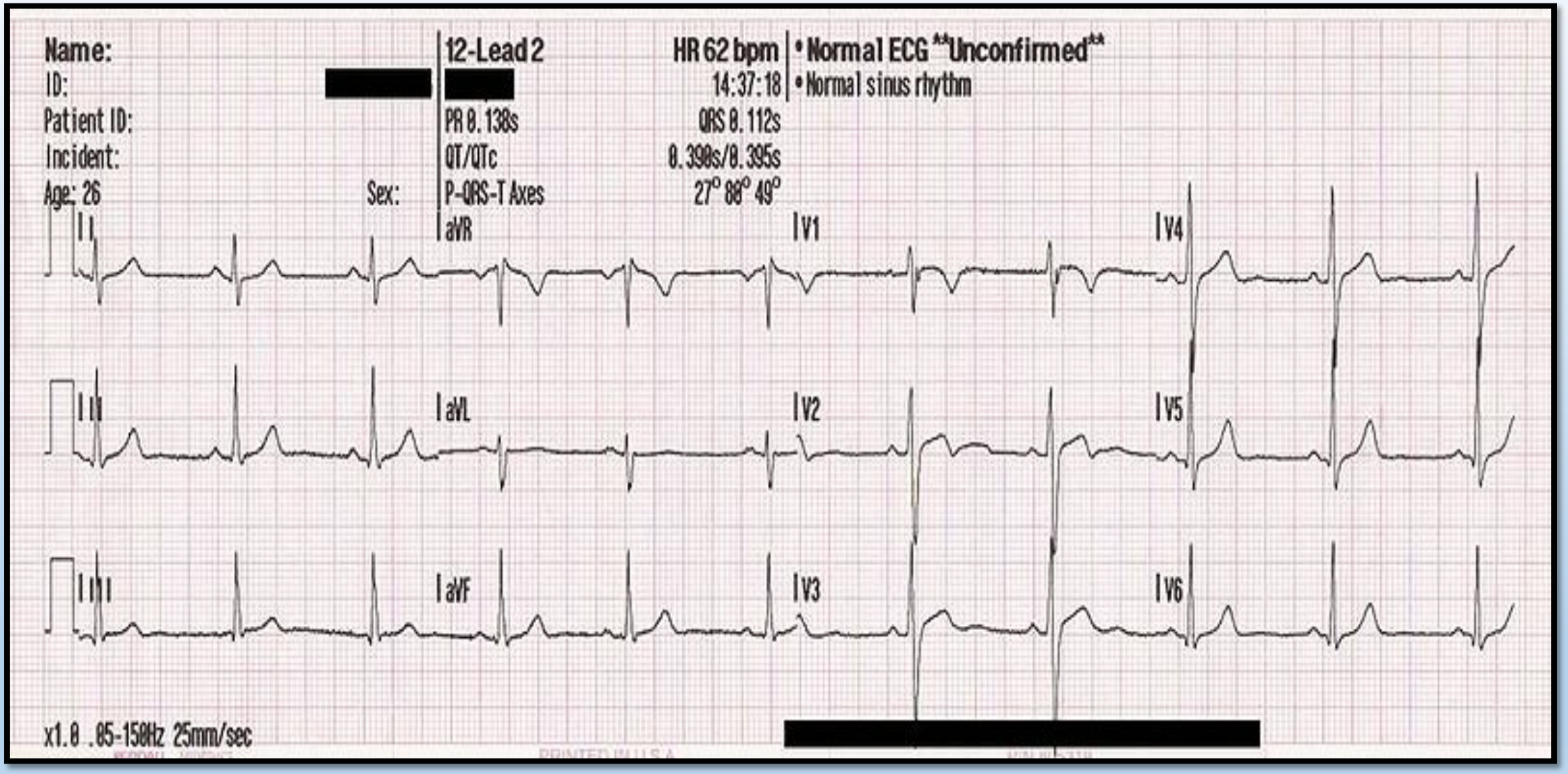
Procedure

1. Ask a student volunteer to lie on their back on the examination bed with arms by their side.
2. Expose the volunteer appropriately (exposing chest and ankles).
3. Make sure that the skin over the precordium is dry, hairless and oil-free to ensure that electrodes stick nicely on the skin. If not, the skin can be cleaned with an alcohol swab and dried using gauze.
4. Place 10 electrodes on the skin surface, and connect them correctly with the wires of the machine. When placing the electrodes avoid pressing hard on the center of the electrode to avoid gel from spilling to the edge reducing conductivity.
5. Ask the subject to relax and start recording the ECG.

ECG trace

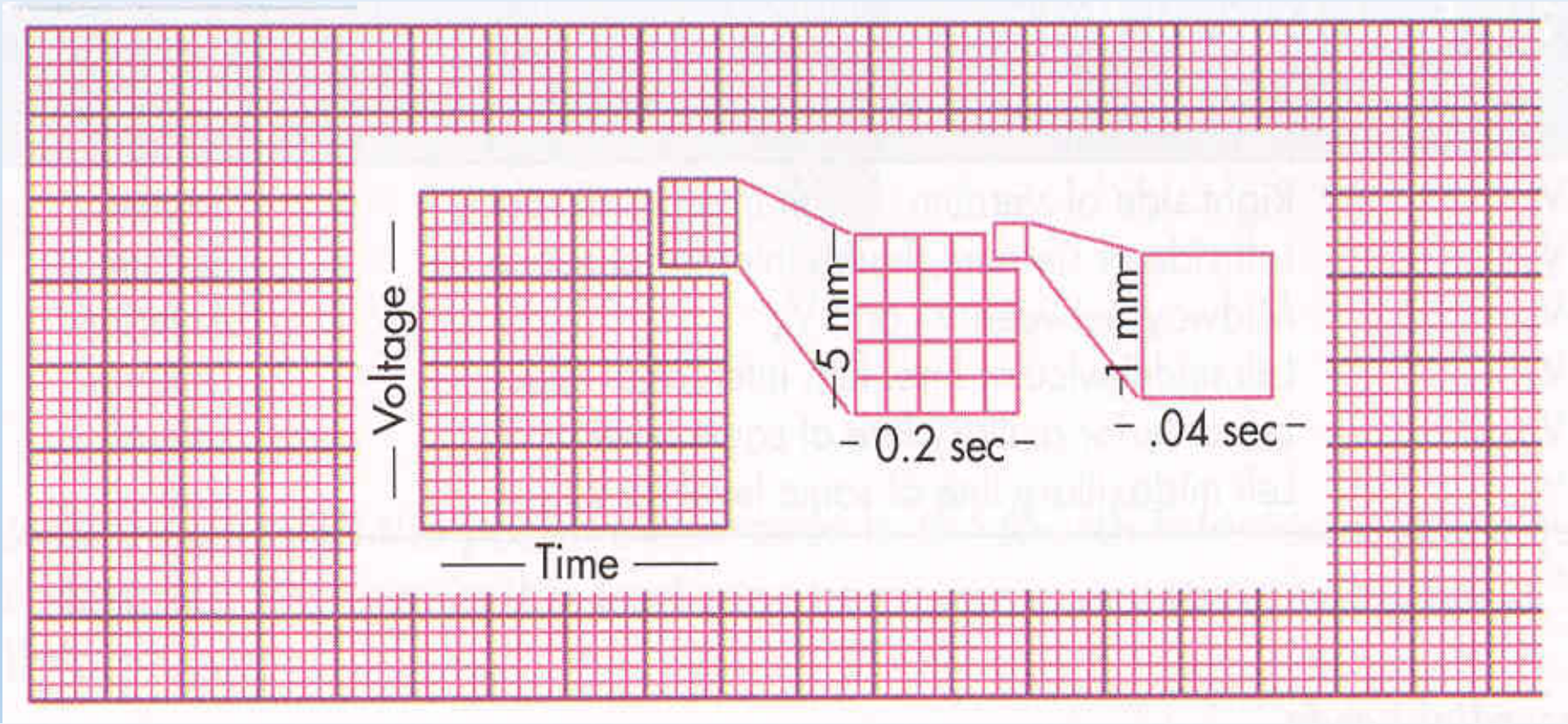
An ECG trace will be recorded. Analyze the trace for the following parameters:

- Calculate the heart rate of the subject.
- Comment on the rhythm of the heart.
- Name the waves and intervals and calculate their duration.
- Calculate the cardiac axis.

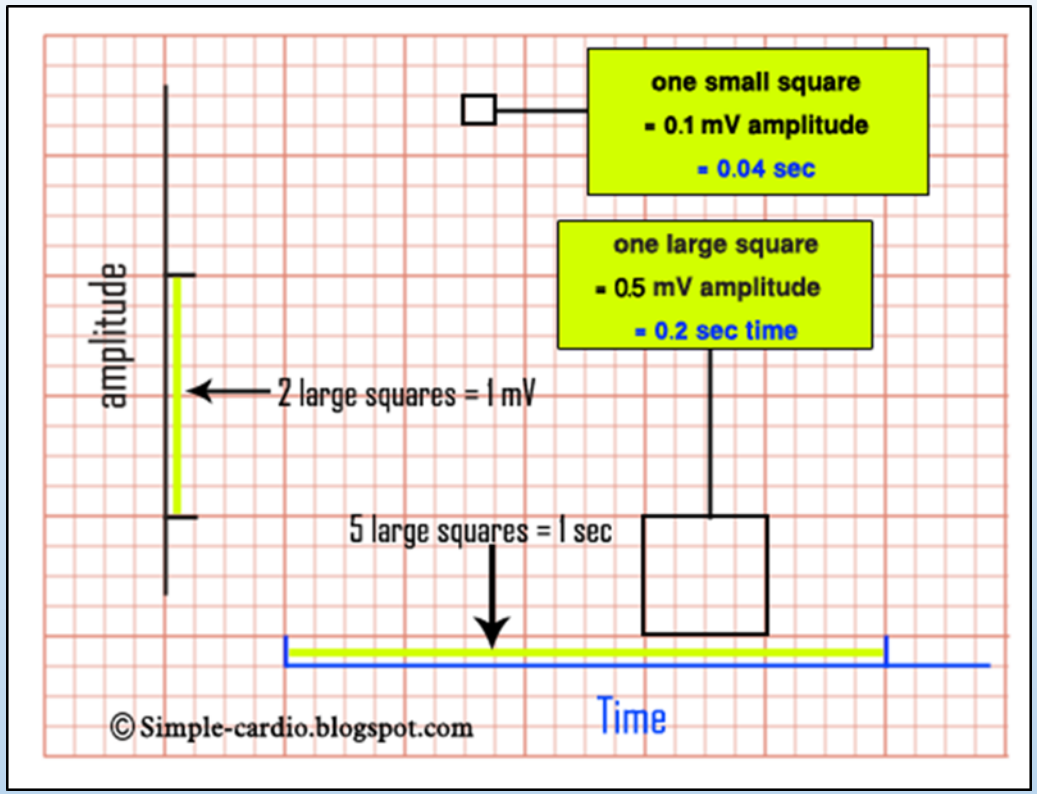

Name:
ID:
Patient ID:
Incident:
Age: 26
Sex:
12-Lead 2
PR 0.138s
QT/QTc
P-QRS-T Axes
HR 62 bpm
14:37:18
QRS 0.112s
0.398s/0.395s
27° 86° 49°
• Normal ECG **Unconfirmed**
• Normal sinus rhythm
I
II
III
aVR
aVL
aVF
V1
V2
V3
V4
V5
V6
x1.0 .05-150Hz 25mm/sec

ECG Paper calibration

Calibration of 25 mm/sec



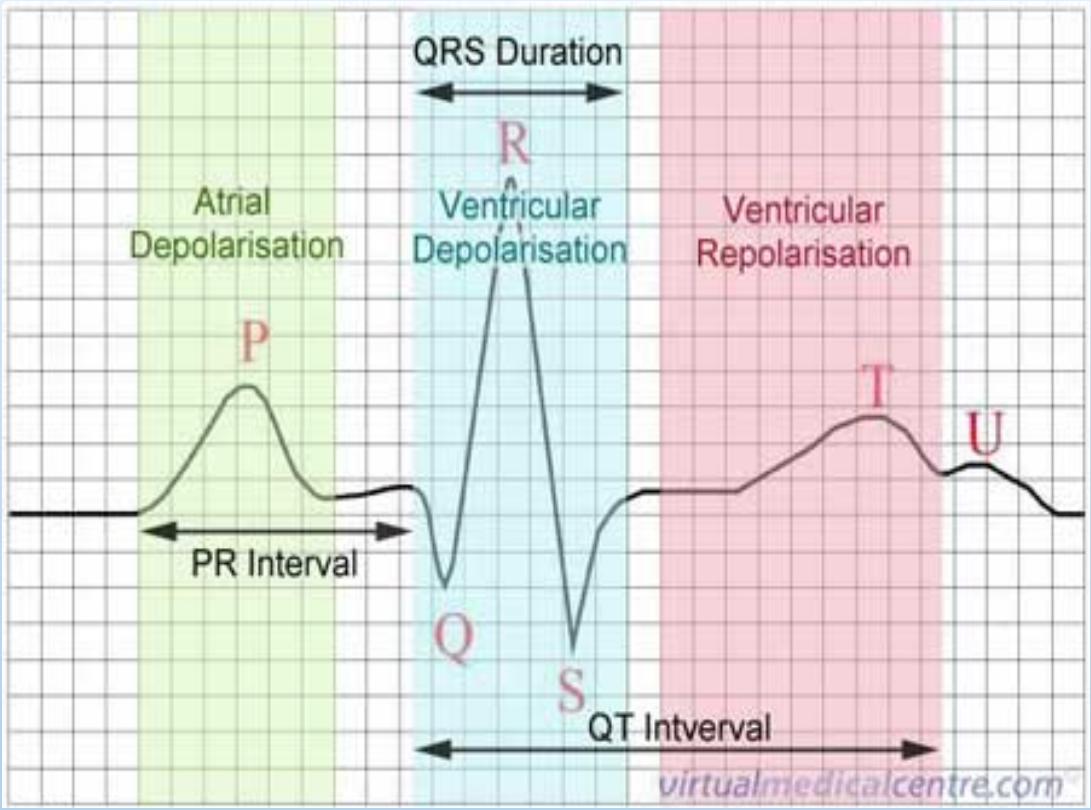
ECG paper calibration



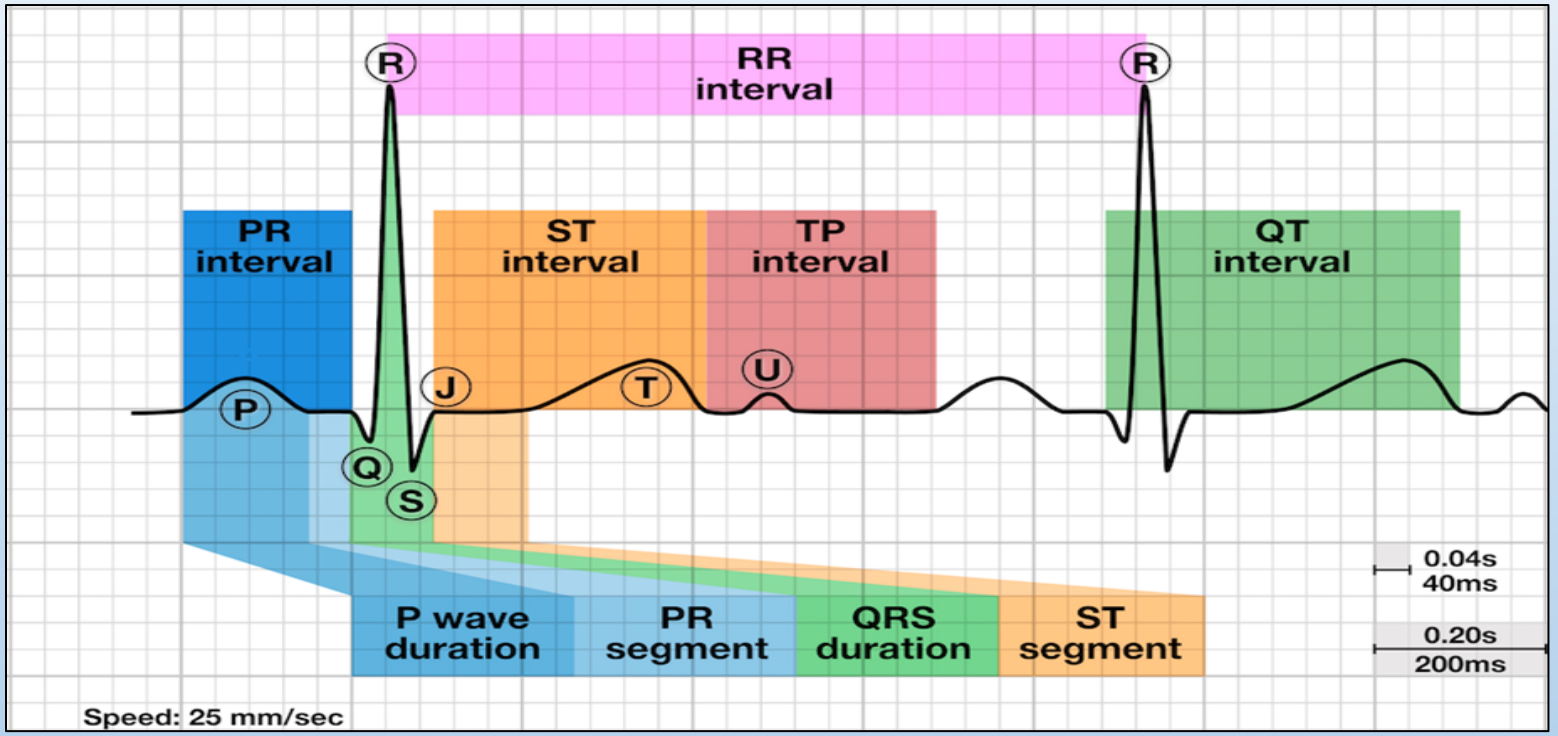
The ECG is recorded on graph paper divided into large and small squares (boxes). Each small box is 1mm in length. Five small boxes make one large box. The horizontal axis denotes time (seconds) while the vertical axis denotes voltage (mv). The paper runs at a standard speed of 25mm/sec. This means that horizontally each small box=0.04 seconds while the large box=0.2 seconds. Vertically, 10mm=1mv.

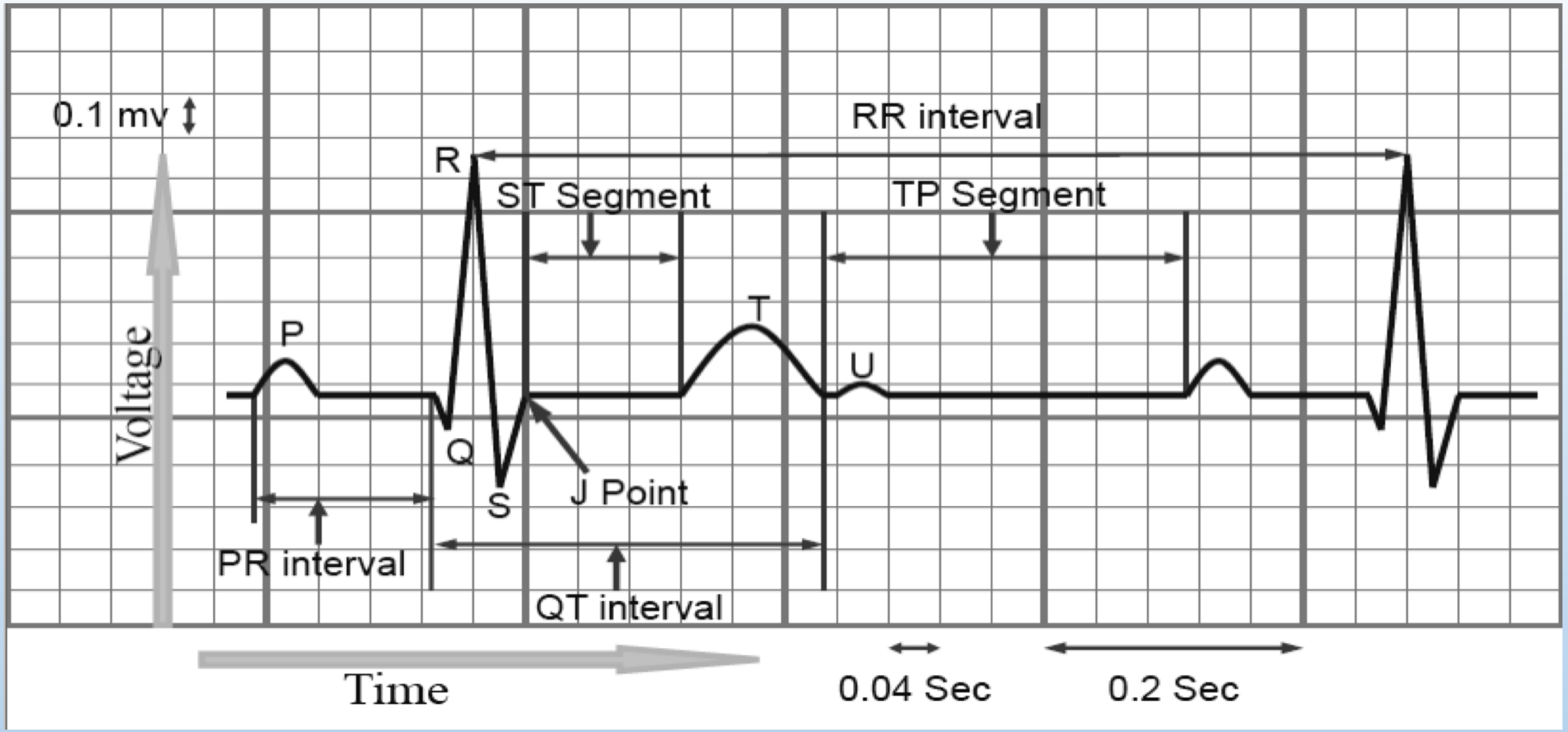
ECG Waves

ECG wave	Physiologic phenomenon
P wave	Atrial depolarization
QRS complex	Ventricular depolarization
T wave	Ventricular repolarization
U wave	Papillary muscle repolarization



ECG waves and intervals




0.1 mv
RR interval
R
ST Segment
TP Segment
T
P
U
Voltage
Q
S
J Point
PR interval
QT interval
Time
0.04 Sec
0.2 Sec

Interval	Measurement	Normal duration/characteristics	Abnormalities
PR interval	From beginning of P wave to beginning of Q (R) wave	0.12-0.2 seconds (3-5 small squares)	Prolonged in 1st degree heart block, Digitalis toxicity
QRS complex	From beginning of Q wave to the end of the S wave	Not more than 0.12 seconds (3 small squares)	Prolonged QRS in cases of Rt & Lt BBB
QT interval	From beginning of Q wave to the end of T wave	0.35-0.43 seconds (9-11 small squares)	Prolonged in cases of hypocalcaemia and Shortened in cases of hypercalcemia
ST interval	From end of S wave to the end of the T wave	0.28-0.36 seconds (7-9 small squares)	
ST segment	From the end of the S wave to the beginning of the T wave	Normally isoelectric	ST segment elevation or depression can be seen in myocardial damage (ischemia or infarction)

Determination of the heart rhythm

-The heart rhythm refers to the regularity with which the heart beats.

- Heart rhythm can be determined by observing the R-R intervals on the strip recording of the ECG.

- If the heart beats regularly(R-R interval have the same duration) the rhythm is said to be normal.

- If the heart beats irregularly (R-R interval have different duration) it is called arrhythmia.

Sinus Arrhythmia

Is a physiological arrhythmia as the heart beats faster during inspiration and slower during expiration, due to the different firing rate of SA node during inspiration and expiration.

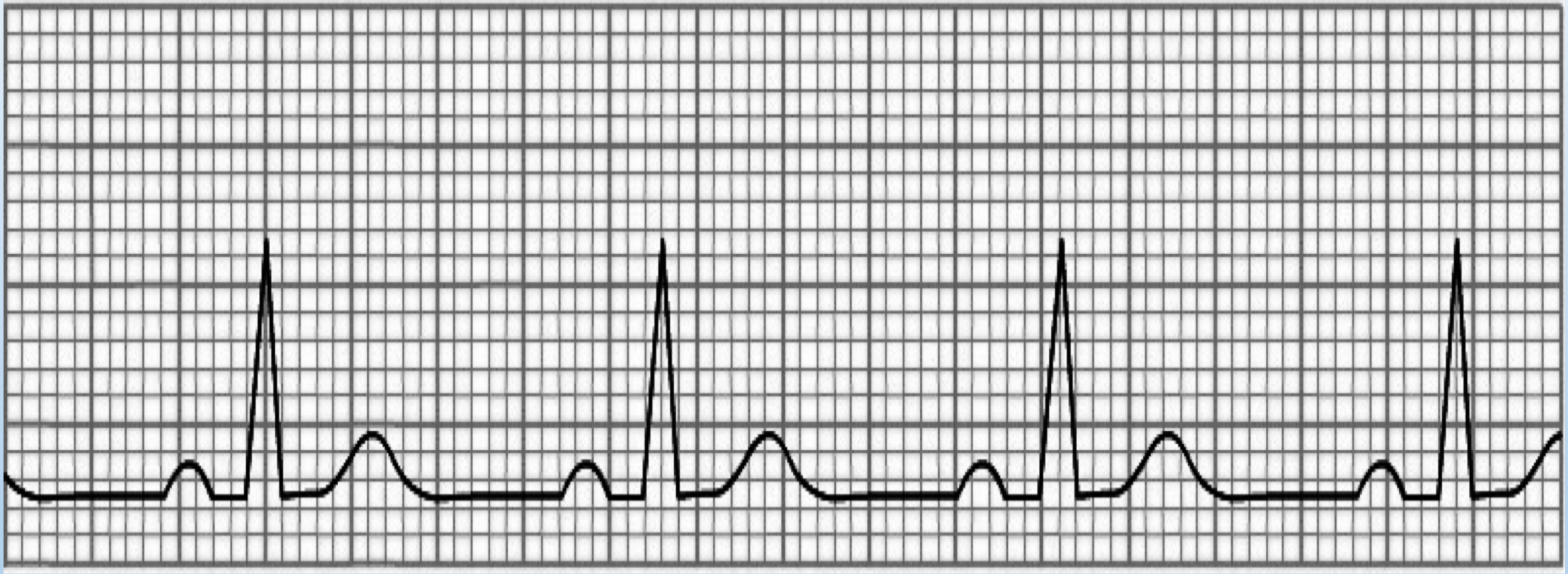
Heart rate calculation
Regular heart rate

- Heart Rate $= \dfrac{1500}{\text{Number of small squares between R} - \text{R}}$

- Or = $\dfrac{300}{\text{Number of large squares between R} - \text{R}}$

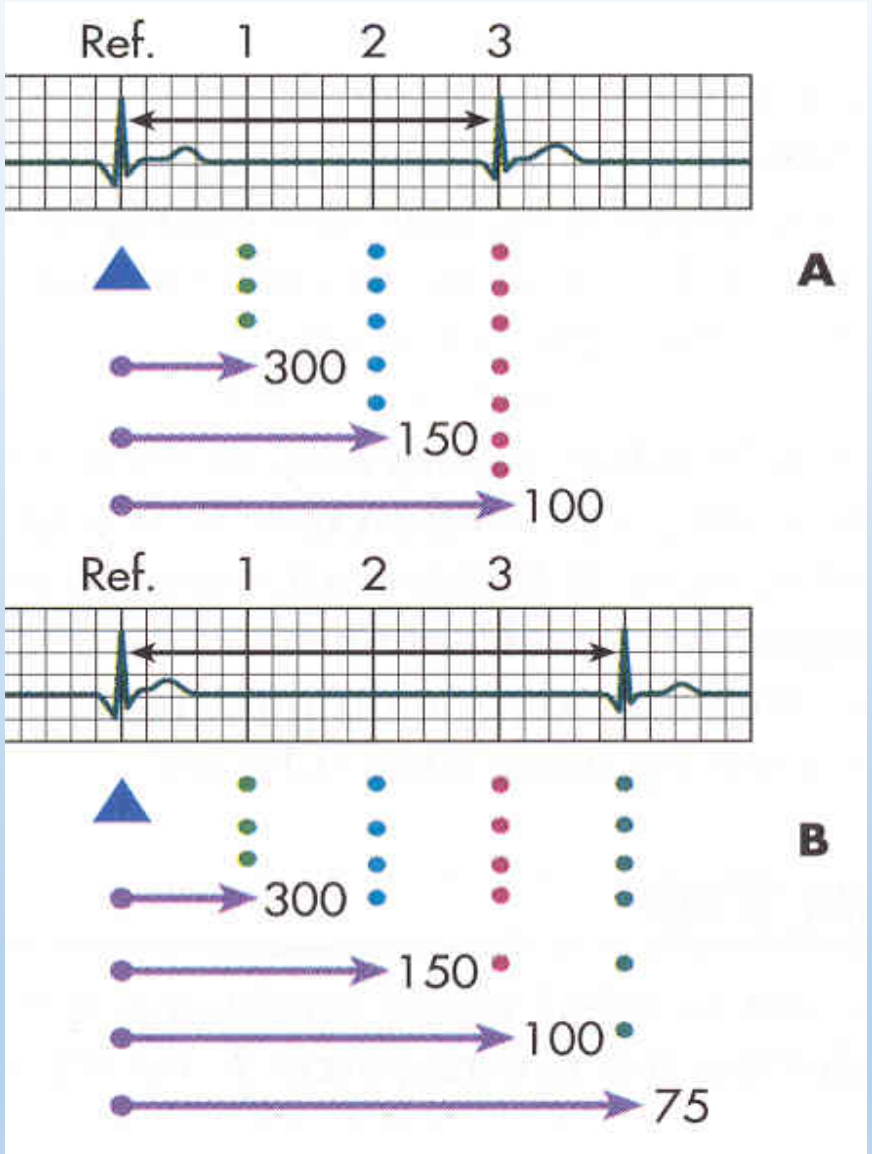
- The normal range of heart rate is between 60 – 100 beats/min.
- **Tachycardia :** heart rate $>$ 100 beats / min
- **Bradycardia :** heart rate $<$ 60 beats / min

Regular heart rate



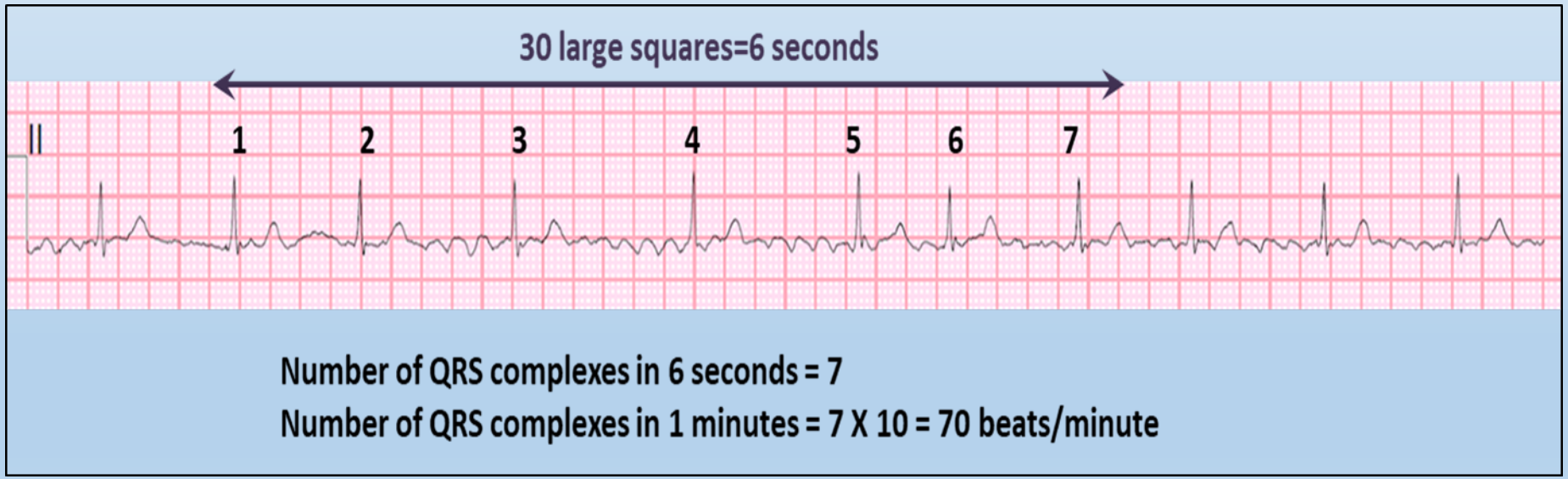
THE RULE OF 1500

No of boxes	Rate
1	300
2	150
3	100
4	75
5	60


Ref.
1
2
3
A
300
150
100
Ref.
1
2
3
B
300
150
100
75

Irregular heart rhythm

In case of Irregular heart rhythm , heart rate can be calculated by first, counting the number of QRS complexes in 30 large squares (which equals the number of QRS complexes in 6 seconds). Then multiply the number of QRS complexes counted in 6 seconds by 10 to get the number of QRS complexes in one minute.



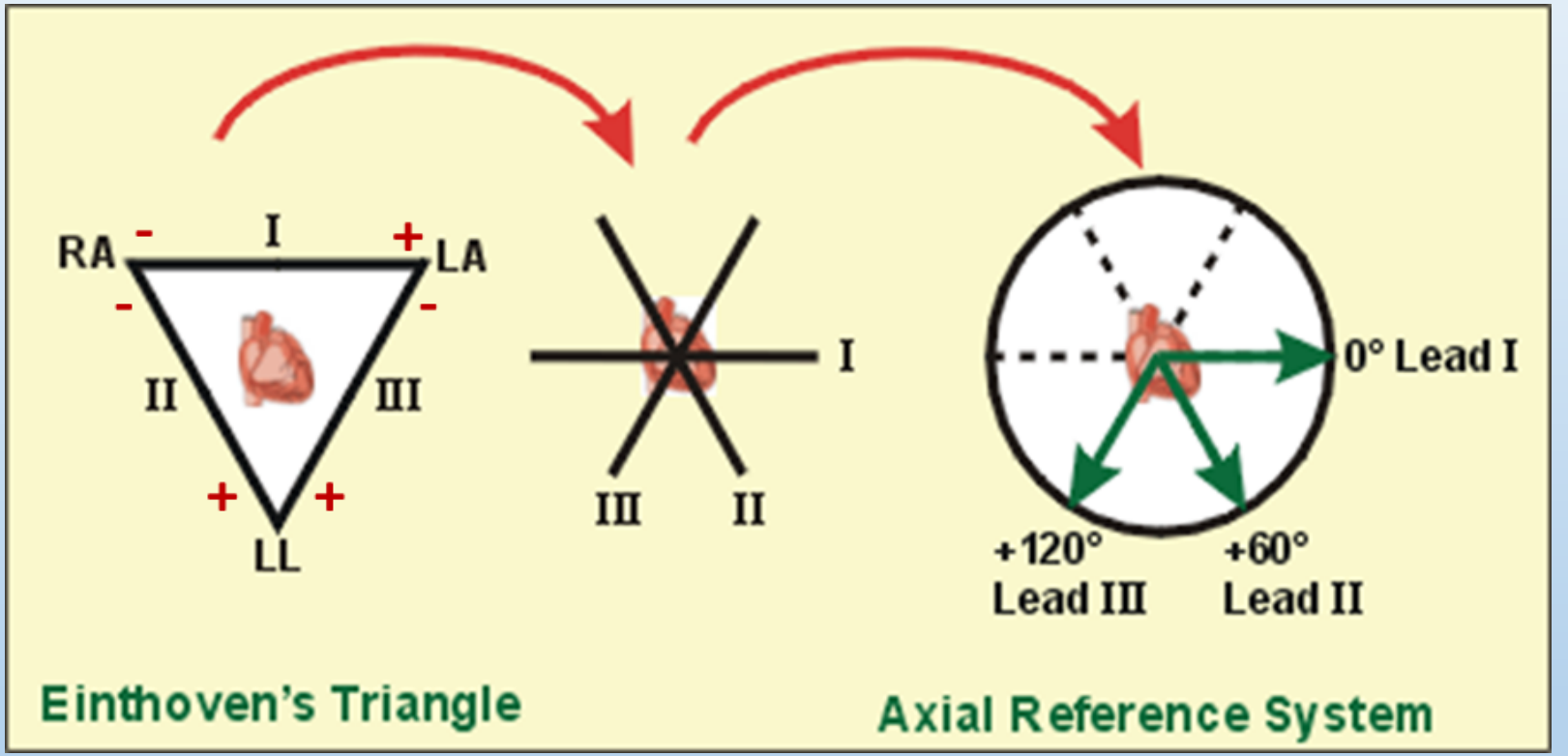
Cardiac axis

Definition:

It is the average direction of the current flow in the heart during a cardiac cycle.

- It is expressed as an angle and is measured in degrees.
- The depolarization wave normally spreads through the ventricles in a direction from base of the heart to its apex. If limb leads are superimposed on each other, lead one will be looking at the heart from the left at an angle of 0^0. This horizontal line is considered the reference or zero point. Any deviation below that line is expressed as a positive number whereas deviations above the line are expressed as negative numbers. As such, lead II is considered to be looking at the heart at an angle of $+60^0$ while lead III looks at the heart at $+120^0$.

Cardiac axis



Cardiac axis

The normal cardiac axis:

- lies between -30^{o} to 90^{o}.

left axis deviation (LAD):

- Deviation of the cardiac axis to the left (between -30^{o} to -90^{o}) in obese people, at the end of deep expiration and due to some pathological conditions (LBBB)

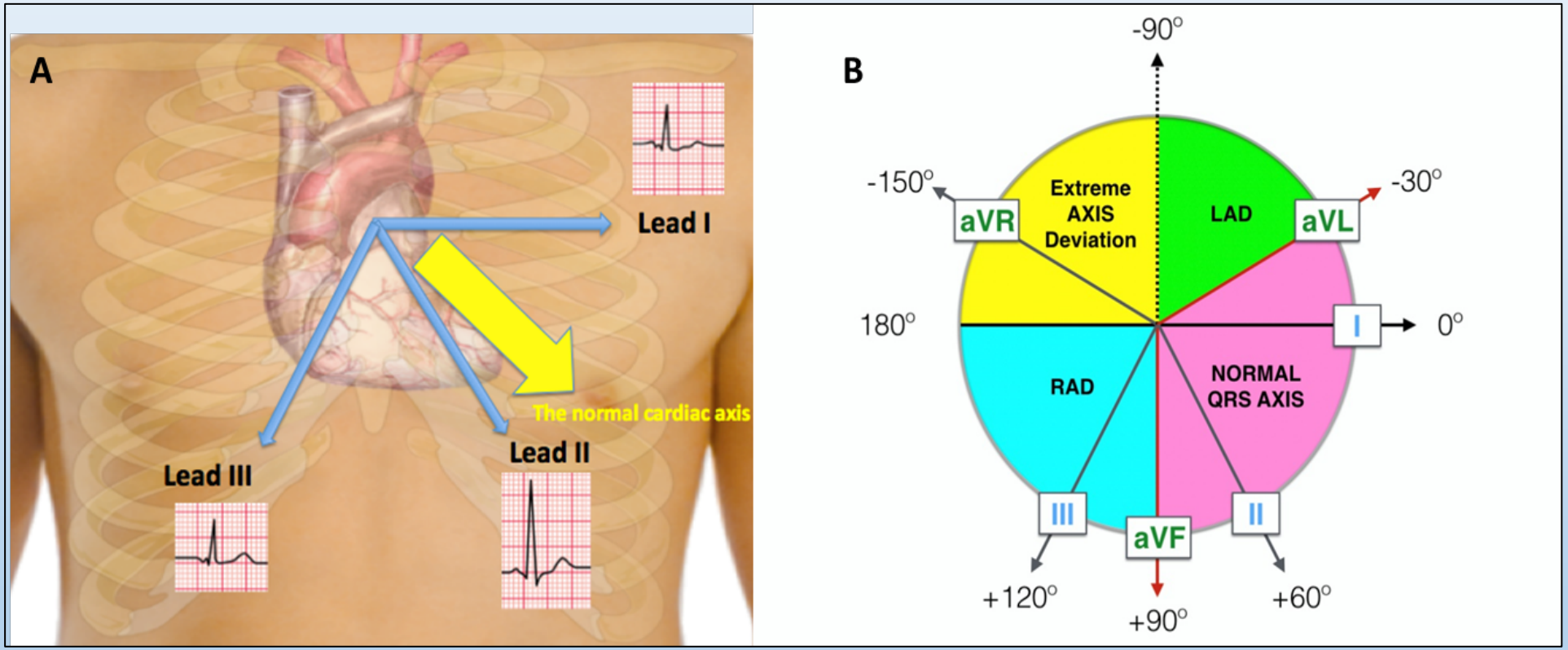
Right axis deviation (RAD):

- Deviation of the cardiac axis to the right (90^{o} to 180^{o}) at the end of deep inspiration ,in tall people and due to some pathological conditions (RBBB, right ventricular hypertrophy)

Extreme or right /left axis deviation:

- Beyond the above values

Cardiac axis



Determination of the cardiac axis

Accurate method

Use two limb leads, namely leads I and III. Looking at the QRS complexes in these leads, calculate the overall size and polarity of the QRS complex in each by subtracting the depth of S wave from the height of the R wave. Construct a vector diagram and draw arrows that represent the sum of size and polarity for each lead on the diagram. The cardiac axis lies between the two arrows. Drop a perpendicular line from the tip of each arrow. The point at which the two perpendicular lines meet, constitute the tip of the cardiac axis. Draw a line from that point to zero point and this will be the cardiac axis.

N.B. the height of the R wave and the depth of the S wave are both measured starting from the isoelectric line.

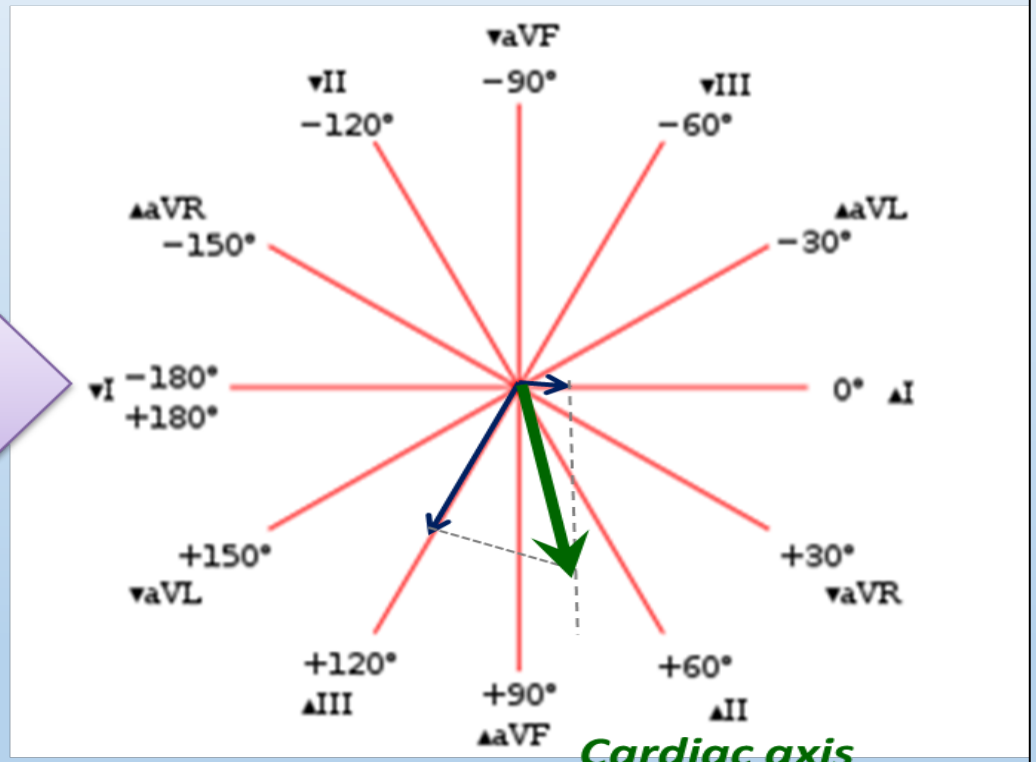
Step 1
Look at leads I & III

Step 2
Calculate the average size and polarity of QRS complex in each

Step 3
Plot on the hexaxial reference system

R wave = +5
S wave = -4
Their sum= +1

R wave = +12
S wave = -1
Their sum= +11



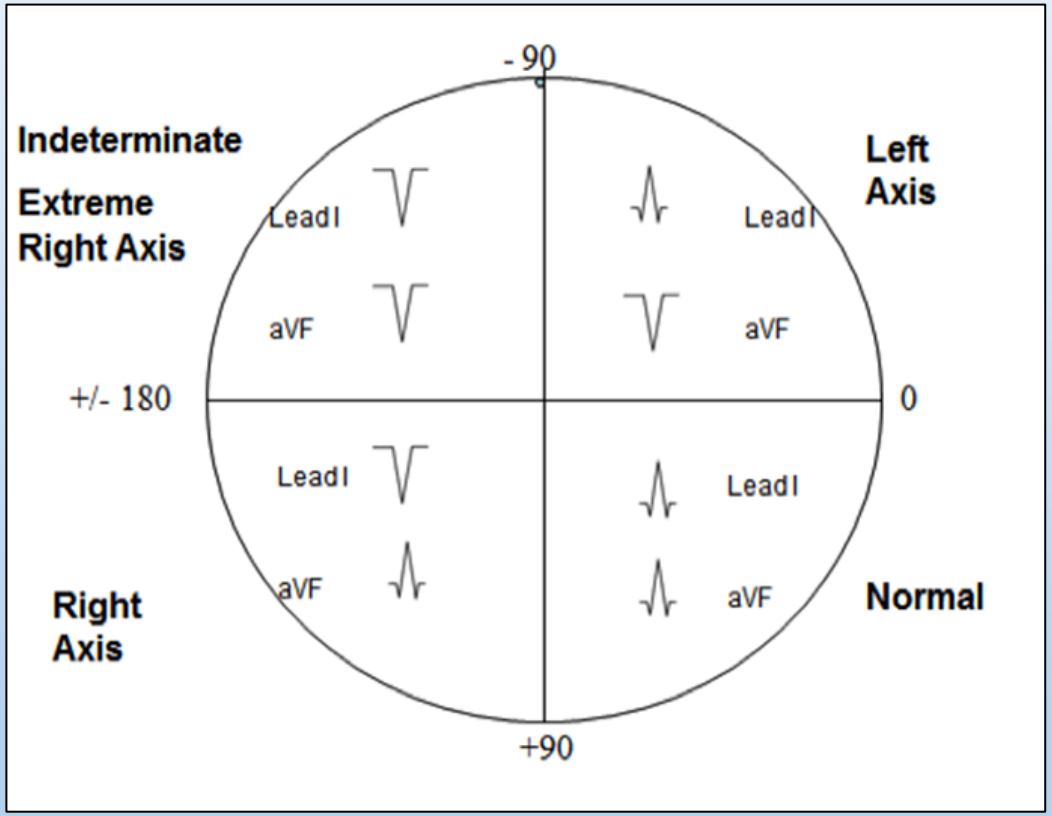
Quick & easy method (Rule of thumb)

Is by applying the “rule of thumb” on the direction of QRS complex in leads I and III/aVF of the ECG

- If the QRS complex is predominantly positive in both leads I and III, then the cardiac axis is normal.

- If the QRS complex is predominantly positive in lead I and predominantly negative in lead III, this means left axis deviation.
- If the QRS complex is predominantly negative in lead I and predominantly positive in lead III, this means right axis deviation.

Rule of thumb



THANK YOU