ELECTROCARDIOGRAM (ECG)

Basic ECG recording, reporting and interpretation.

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Topic Outline

1. Introduction to ECG
2. Overview of a cardiac cycle
3. Conduction system of the heart
4. ECG interpretations steps
5. Conclusion

INTRODUCTION TO ECG

- ECG/EKG measures the heart's **electrical activity** as waveforms. An EKG uses electrodes attached to the skin to detect electric currents moving through the **heart**. These signals are transmitted to produce a record of **cardiac activity.**
- The electrical activity of the heart starts in the 'internal pacemaker', which is called the **sinoatrial node**. This is in the right atrium.
- Abnormalities in the electrical activity of the heart can result in abnormal conduction or rhythms where the heart may go **too quickly**, **too slowly**, or beat irregularly.

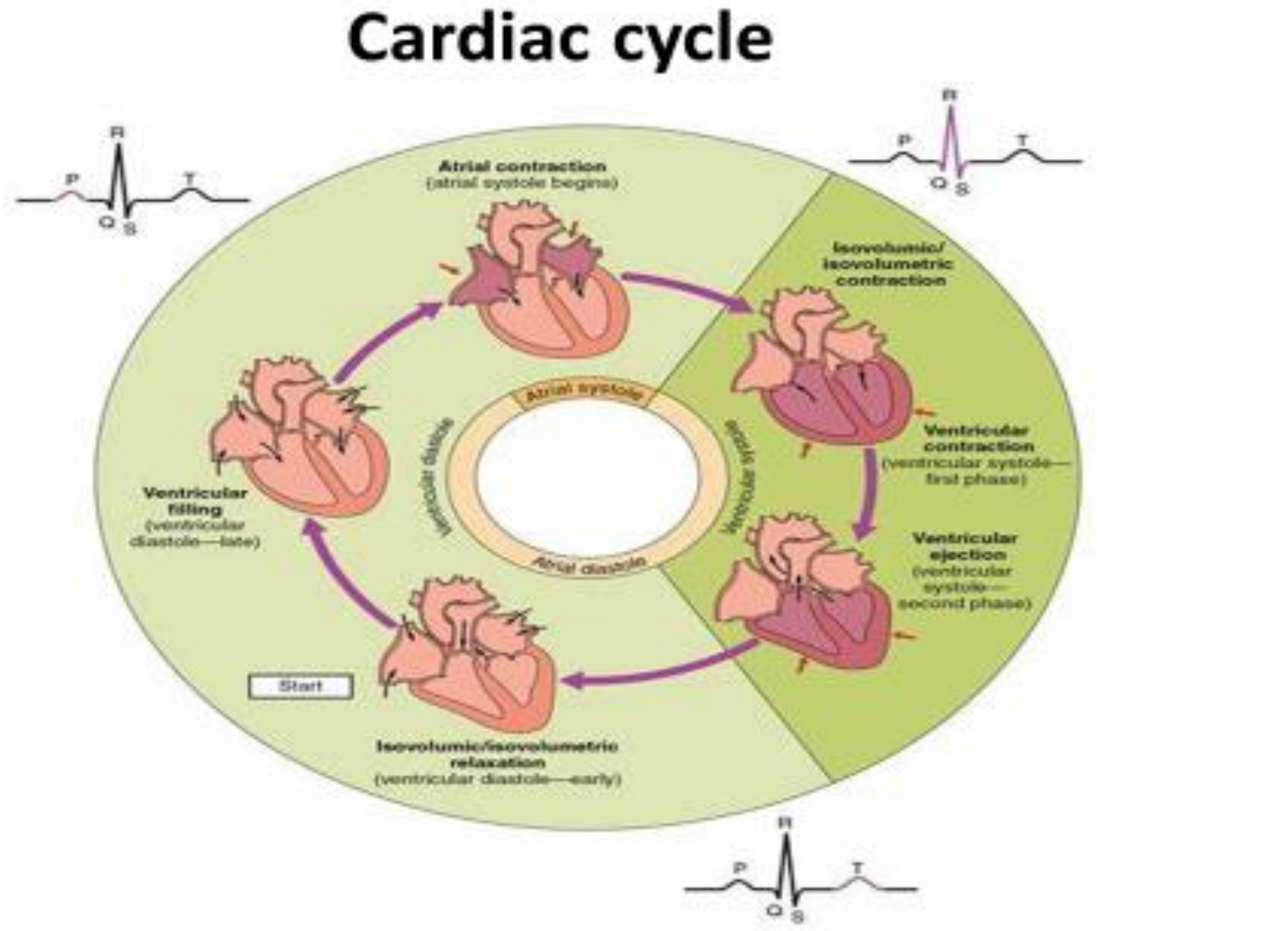
Introduction..

- It is the graphical recording of electrical conduction in the heart over a period of time (usually 10 sec), using **electrodes** placed over the skin.
- In conventional 12 lead ECG, a total **10 electrodes are placed: 6 over the chest and one on each limb.**
- The overall magnitude of electrical activity of heart is measured from 12 different angles or **"leads".**
- The graph of voltage versus time produced is called Electrocardiogram.

CARDIAC CYCLE

- The cardiac cycle refers to the sequence of events that occur in the heart during **one complete heartbeat**. It involves two main phases: **systole and diastole**.
- **Diastole**: During this phase, the heart muscles **relax,** allowing the chambers to fill with blood.
- **Systole** is the phase of the cardiac cycle during which the heart muscle **contracts**, pumping blood out of the chambers. It consists of two main parts: **atrial systole and ventricular systole**.

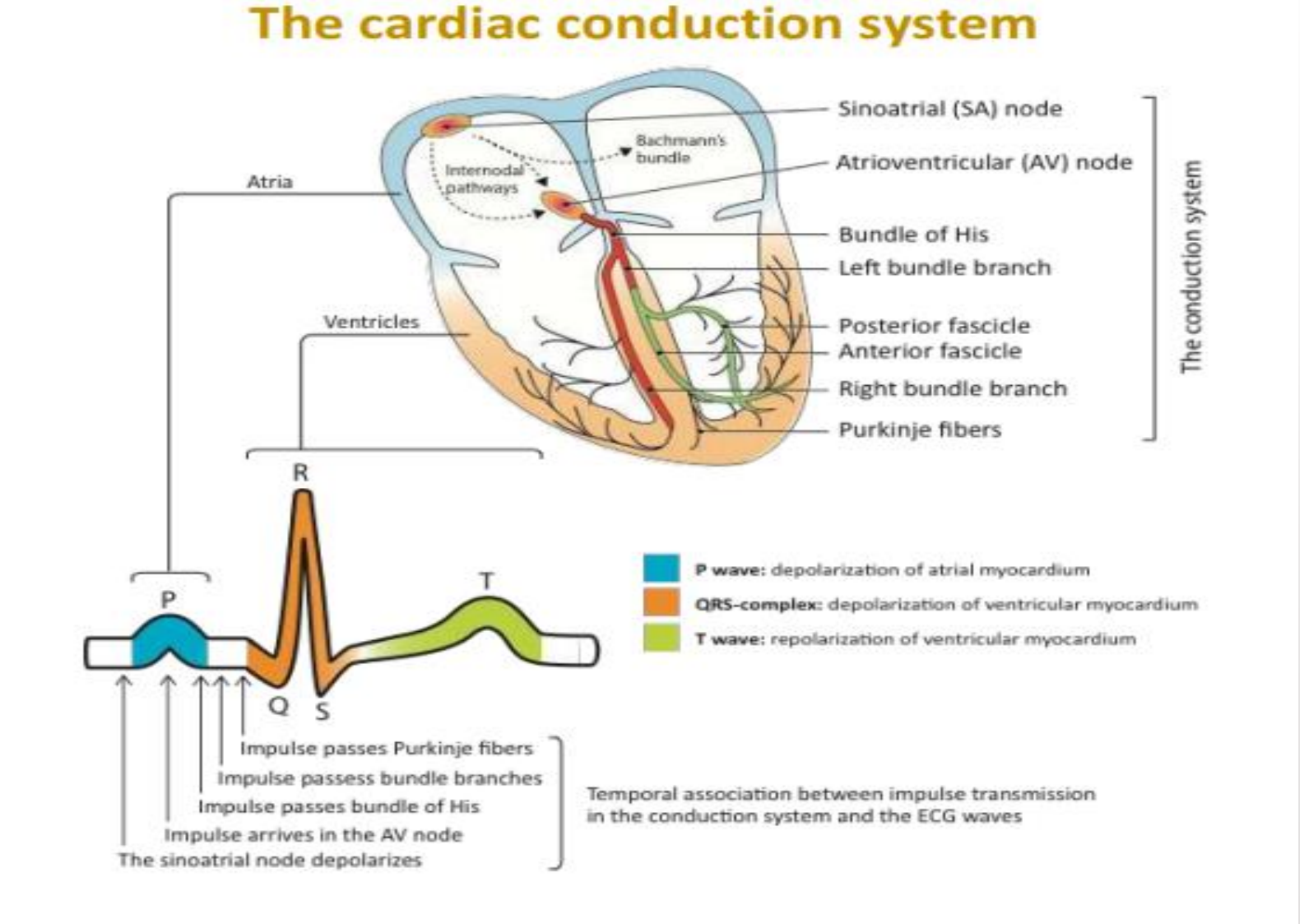
CARDIAC CYCLE



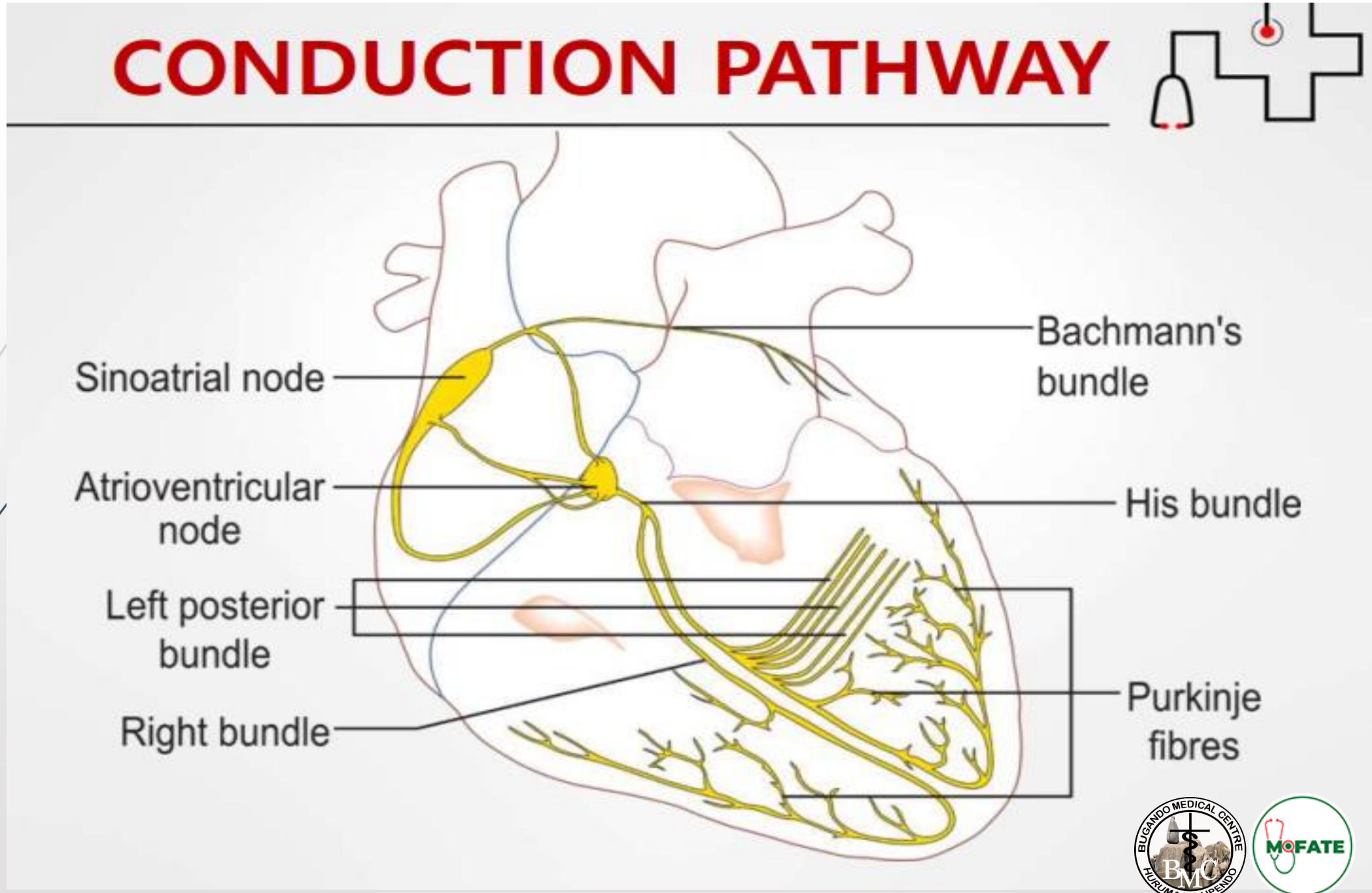
Cardiac cycle….

- 1 cardiac cycle takes **0.8 seconds**, so in 60 seconds (1 min) it will be 600/8=75 cardiac cycles/minute.
- Therefore there are **75 cardiac cycles** per minute
- Thus, 60-100 beats/ min

Conduction system of the heart

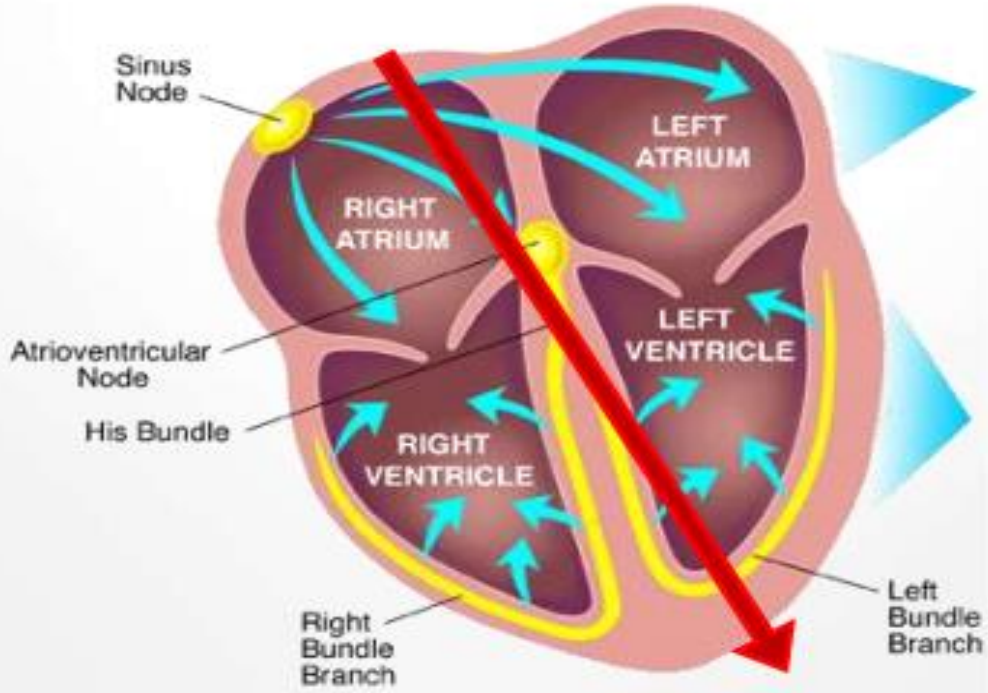


CONDUCTION PATHWAY

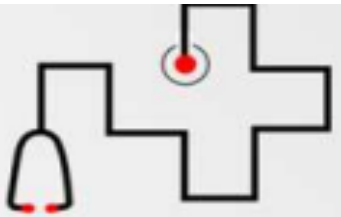


AXIS OF THE HEART

- The **electrical axis of the heart** is the mean direction of the action potentials traveling through the conductive system of the heart.



WAVEFORMS

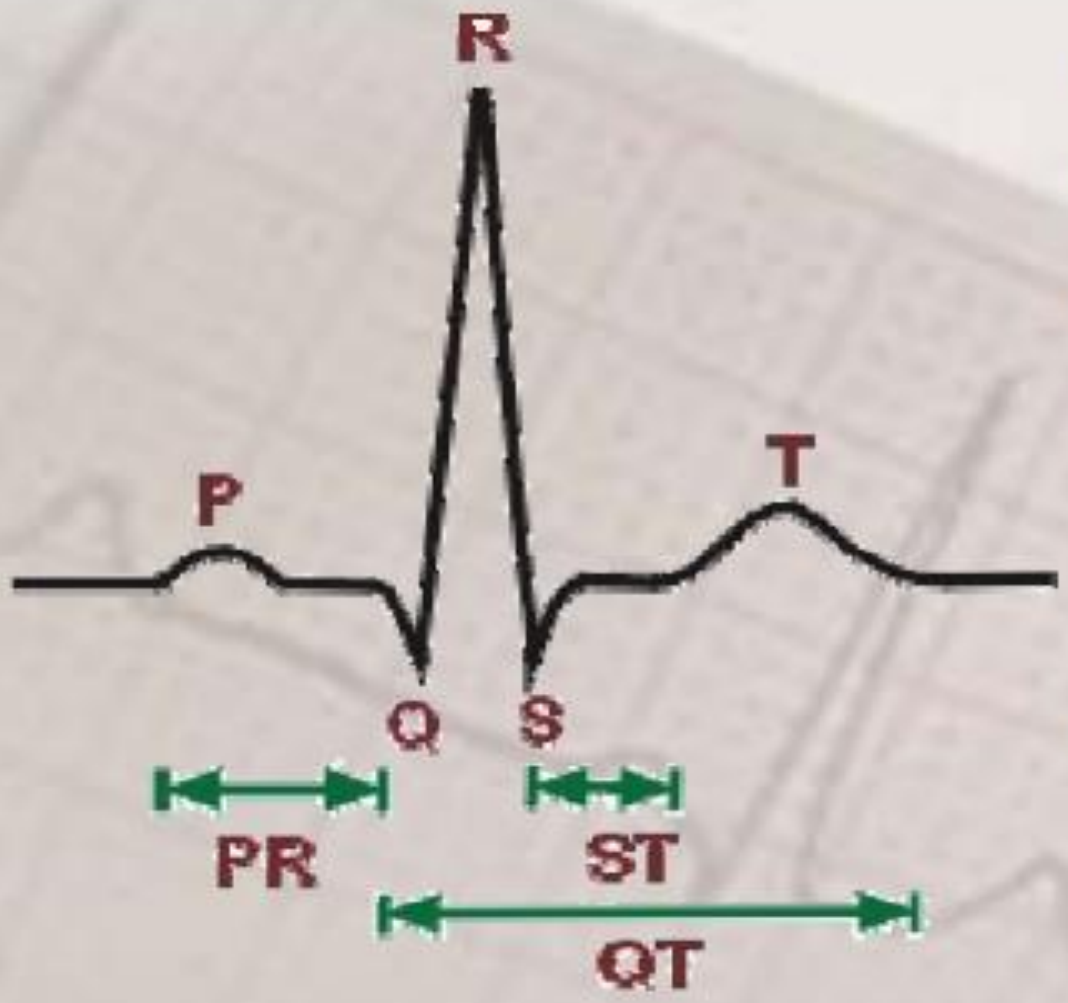


- Contraction of any muscle is associated with electrical changes called **depolarization**.
- This is followed by its relaxation, which is associated with the reversal of these changes called **repolarization**.
- These electrical changes will produce waveforms on the ECG. i.e. P-QRS-T waves.
- No electrical changes will produce an flat **isoelectric baseline** on the ECG.

PACEMAKERS

- **Sinoatrial "SA" Node**
  - Dominant pacemaker
  - Intrinsic rate of 60 - 100 beats/minute.
- **Atrioventricular "AV" Node**
  - Back-up pacemaker
  - Intrinsic rate of 40 - 60 beats/minute.
- **Ventricular cells**
  - Back-up pacemaker
  - Intrinsic rate of 20 - 45 beats/minute.

Conduction Pathways



P wave = atrial depolarisation.

PR Interval = impulse from atria to ventricles.

QRS complex = ventricular depolarisation.

ST segment = isoelectric - part of repolarisation.

T wave = usually same direction as QRS - ventricular repolarisation.

QT Interval = This interval spans the onset of depolarisation to the completion of repolarization of the ventricles.

USES OF ECG

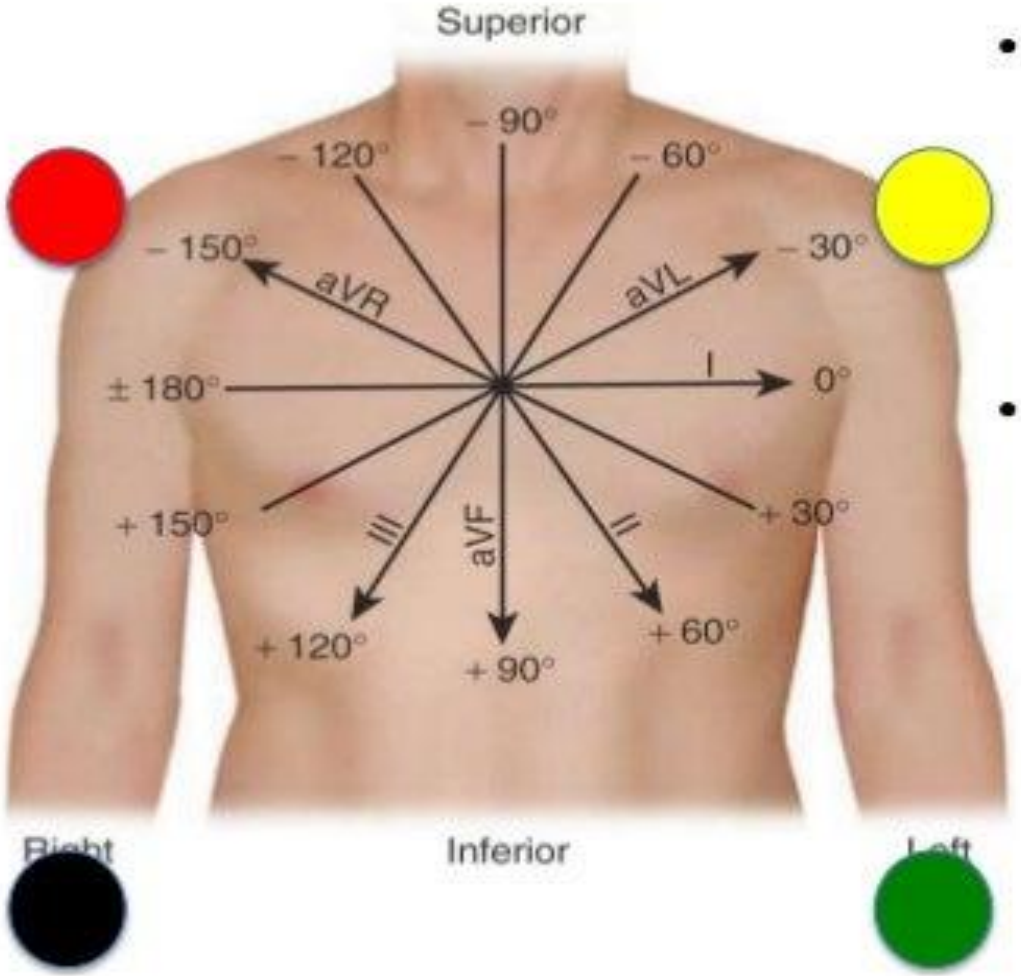
It is used to detect:

- Rate and rhythm disorders
- Conduction problems
- Myocardial ischemia
- Myocardial infarcts
- Chamber dilation
- Chamber hypertrophy
- Inflammation i.e. pericarditis
- Electrolyte disturbances
- Drug toxicity
- Other: pulmonary embolism

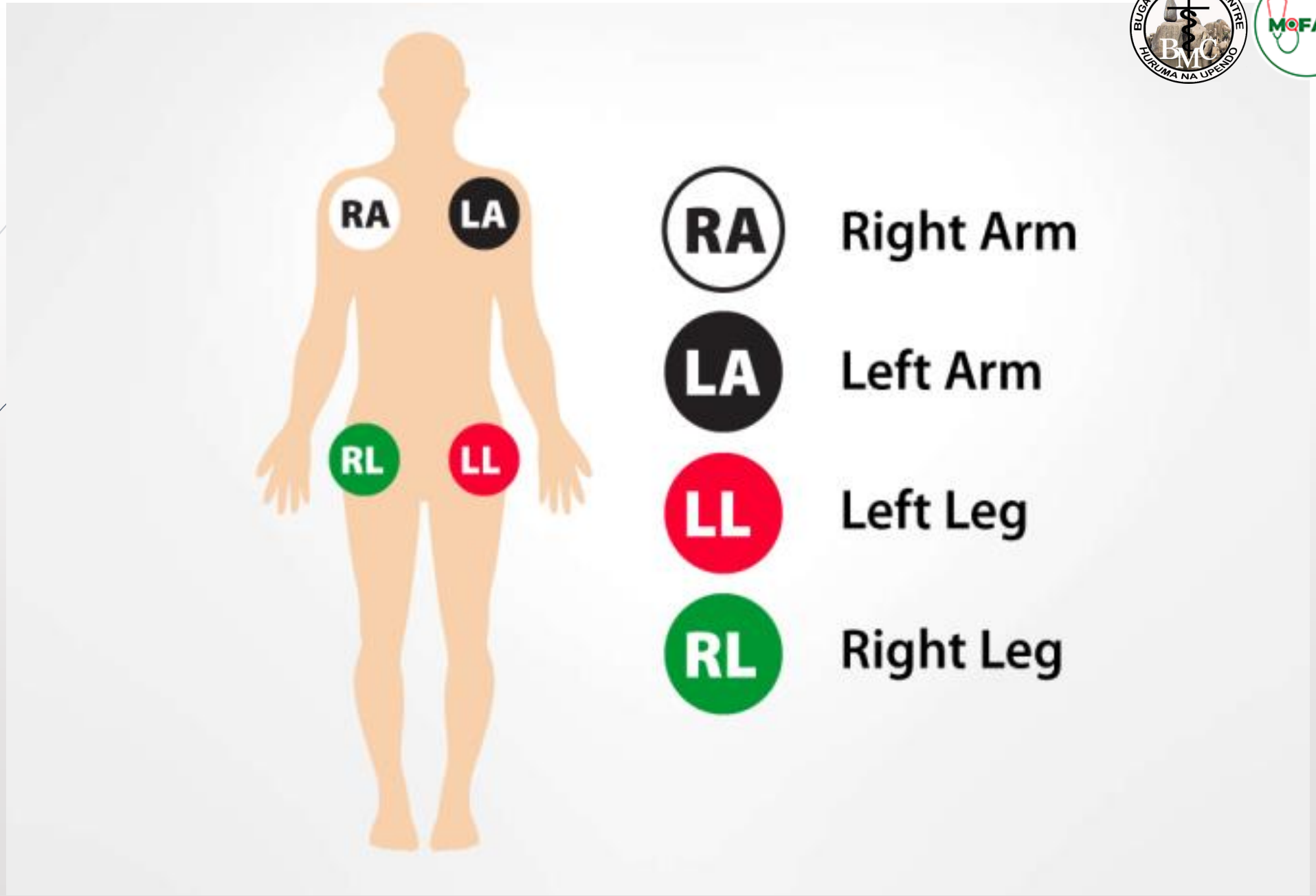
ELECTRODES AND ECG LEADS

- There are four limb leads. Place the **red** lead on the **right arm**, proximal to the wrist; the **yellow** lead on the **left arm**, proximal to the wrist; the **green** lead on the **left leg**, proximal to the ankle; and the **black** lead on the **right leg**, proximal to the ankle. The electrodes placed on the limbs give rise to the **unipolar and bipolar leads.**

How to attach the leads



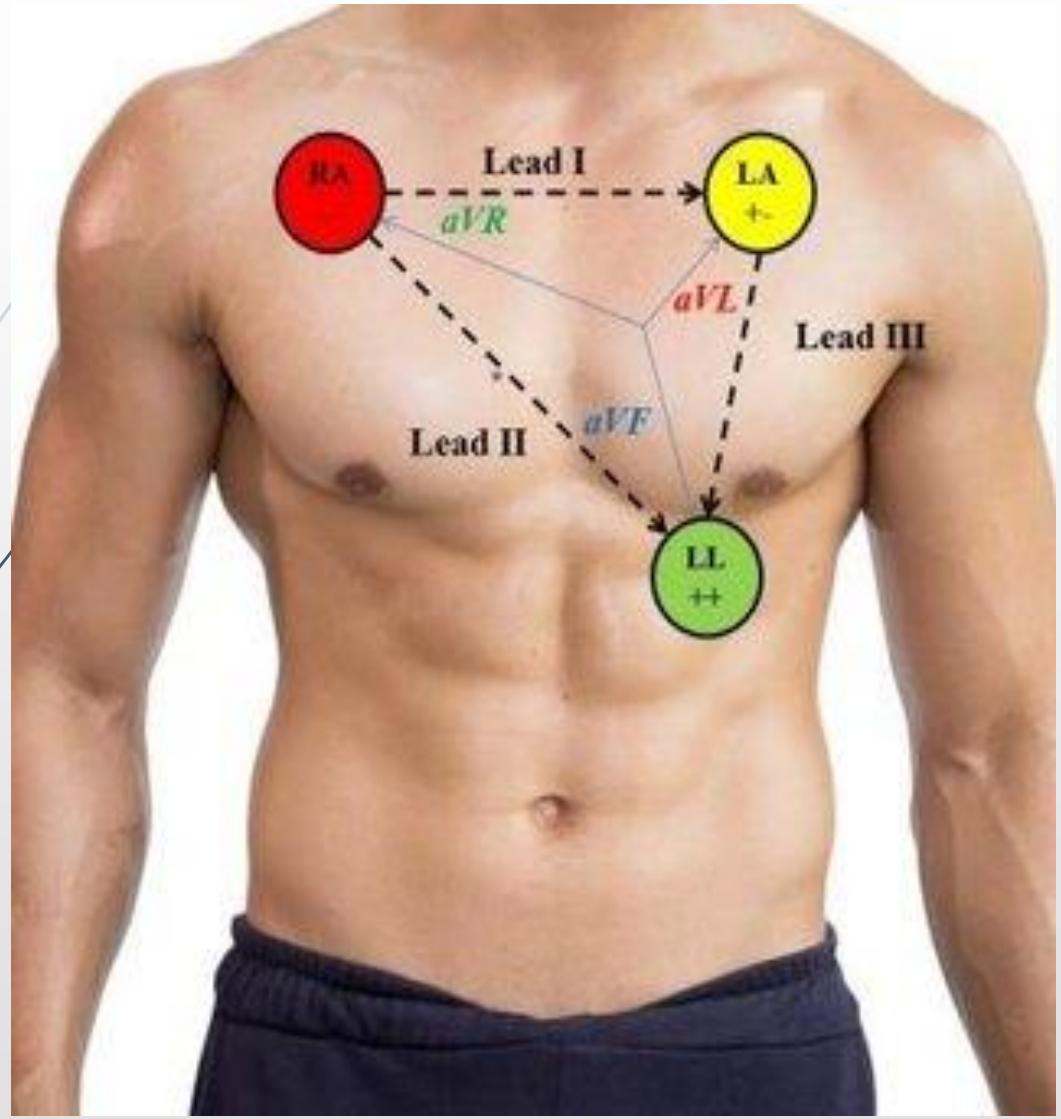
- Limb leads
  - Black-right ankle
  - Red-right arm
  - Yellow-left arm
  - Green-left ankle
- Chest leads
  - V1-4th ICS, RPSB
  - V2-4th ICS, LPSB
  - V3-between V2 and V4
  - V4-5th ICS, LMCL
  - V5-5th ICS, LAAL
  - V6-5th ICS, LMAL


RA
LA
RL
LL
RA
Right Arm
LA
Left Arm
LL
Left Leg
RL
Right Leg

CHEST ELECTRODES

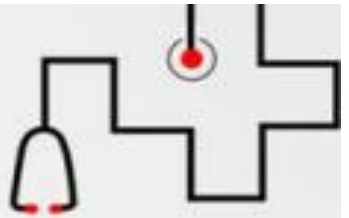
Chest Electrode Placement	
V1	4th ICS, right of sternum
V2	4th ICS, left of sternum
V3	Between V2 and V4
V4	5th ICS, in left mid clavicular line
V5	Same height as V4, in left anterior axillary line
V6	Same height as V4, in left mid axillary line

LEADS



- 3 limb leads
  - **I** - (+LA and -RA)
  - **II** - (+LL and -RA) also called 'sinus lead'
  - **III** - (+LL and -LA)
- 3 augmented limb leads:
  - **aVR** - (+RA and average of LA & LL)
  - **aVL** - (+LA and average of RA & LL)
  - **aVF** - (+LL and average of RA & LA)
- 6 Chest leads:
  - **V1, V2, V3, V4, V5, V6** (have +ve electrodes of same name)
  - Negative electrode is **WCT** (Wilson's central terminus), an average of the three limb electrodes (RA, LA, LL)
- Other Chest leads:
  - Posterior chest leads: **V7, V8, V9**
  - Right chest leads: **V3R, V4R, V5R**

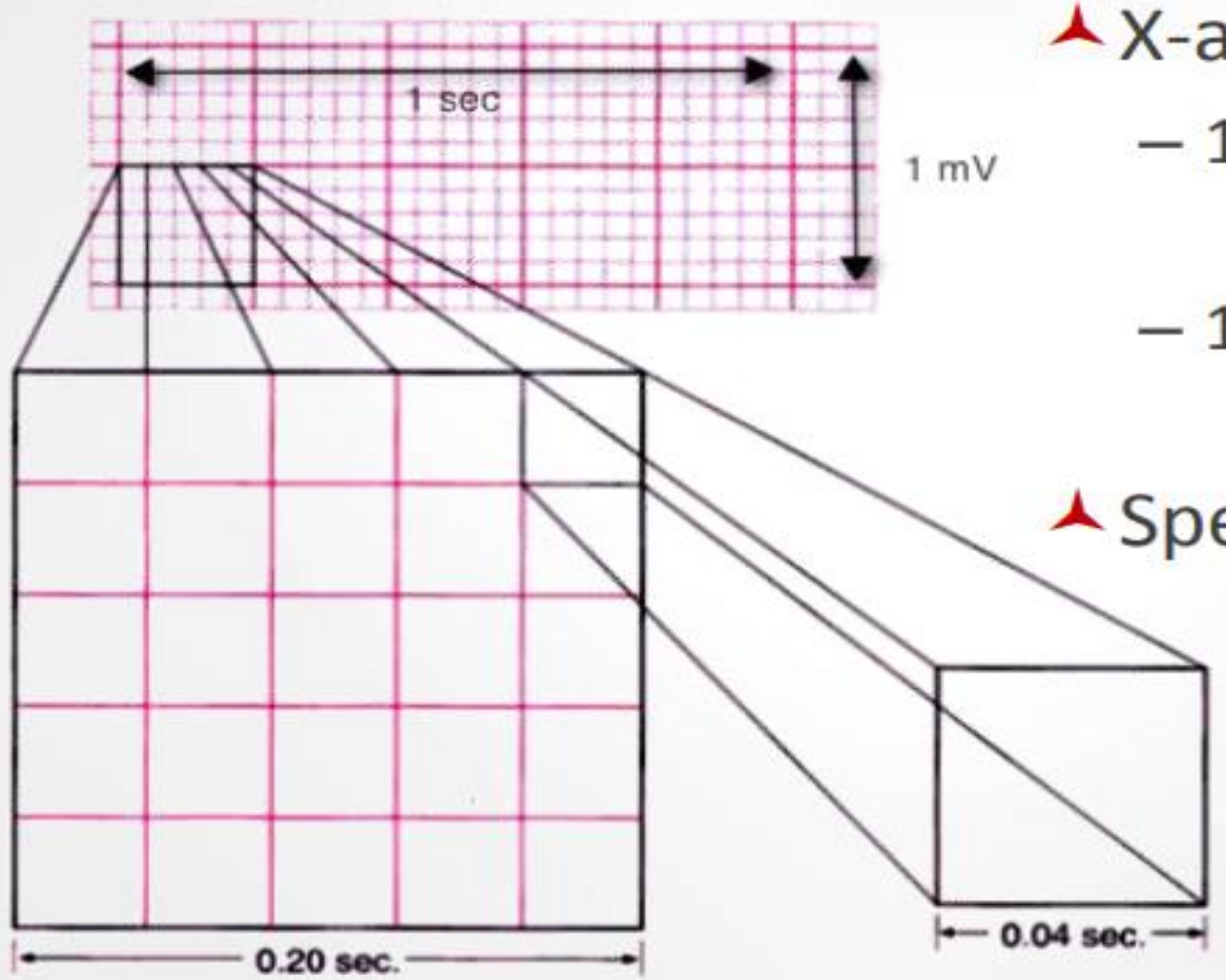
LEAD PERSPECTIVES



I Lateral	aVR	V1 Septal	V4 Anterior
II Inferior	aVL Lateral	V2 Septal	V5 Lateral
III Inferior	aVF Inferior	V3 Anterior	V6 Lateral

EMS12Lead.com

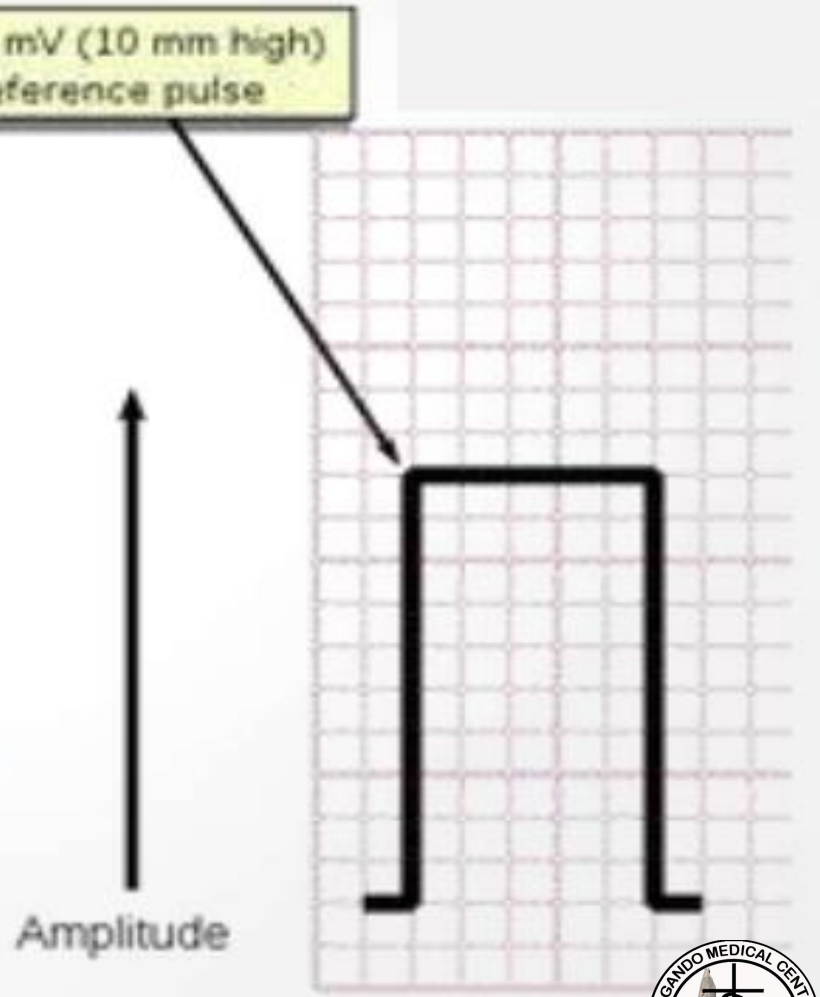
SPEED CALIBRATION



- X-axis → time
  - 1 small square
    - 40 ms (**0.04** sec)
  - 1 large square
    - 200 ms (**0.2** sec)
- Speed: 25 mm/sec

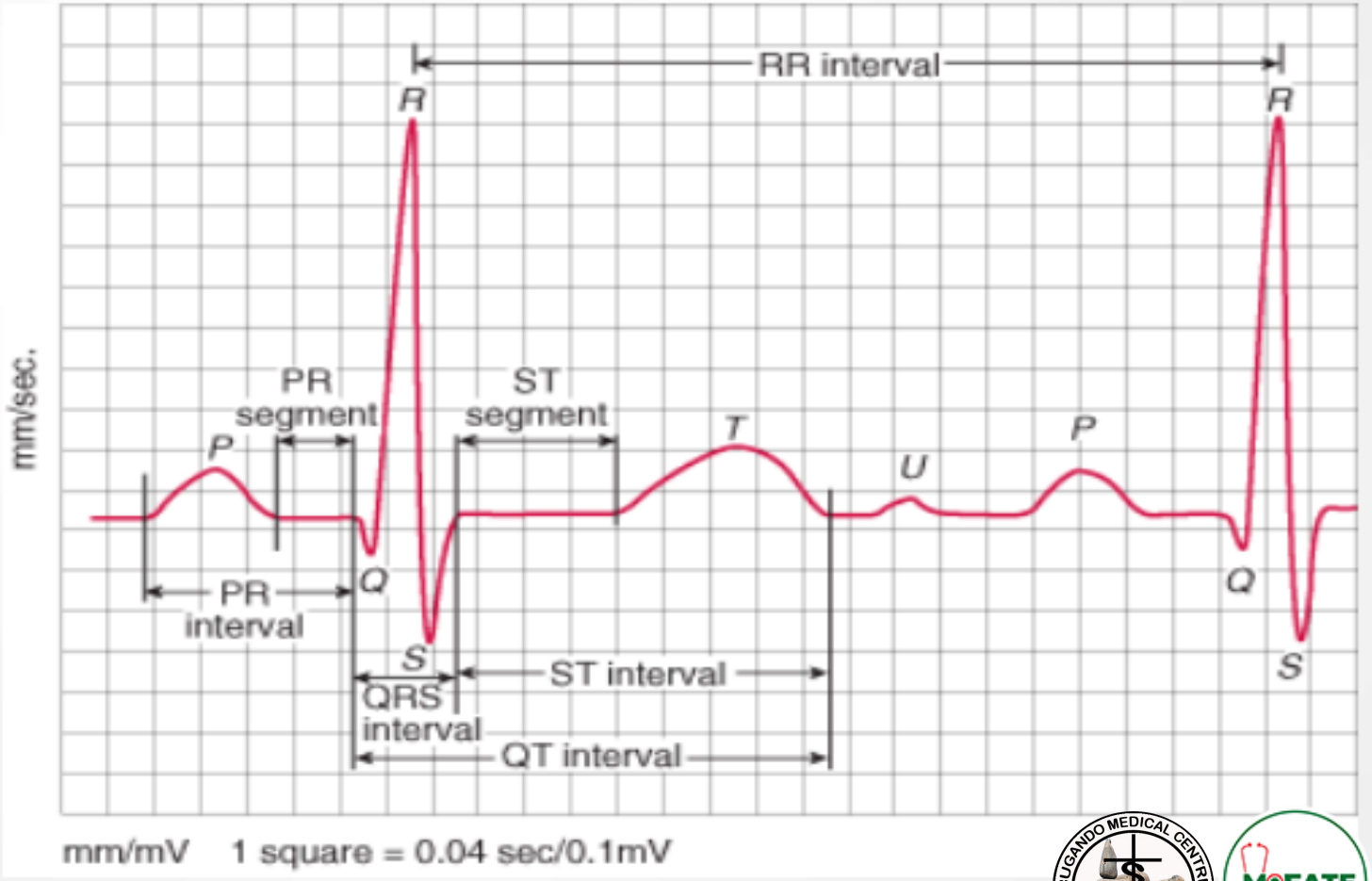
VOLTAGE CALIBRATION

- Y axis → voltage
  - 1 large square
    → **0.5** mV
  - 2 large squares
    → **1.0** mV
  - Therefore, 1 mV produces deviation of 2 large squares (10 mm)

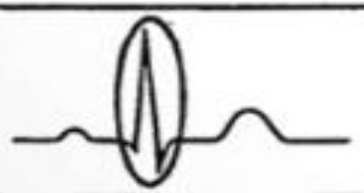


ECG COMPLEX

- Waveforms
  - P wave
  - QRS complex
  - T wave
  - U wave
- Segments
  - PR segment
  - ST segment
- Intervals
  - PR interval
  - QT interval
  - RR interval



ECG COMPLEX

Electrical Activity	Graphic Depiction	Associated Pattern
Atrial Depolarization		P Wave
Delay at AV Node		PR Segment
Ventricular Depolarization		QRS Complex
Ventricular Repolarization		T Wave
No electrical activity		Isoelectric Line

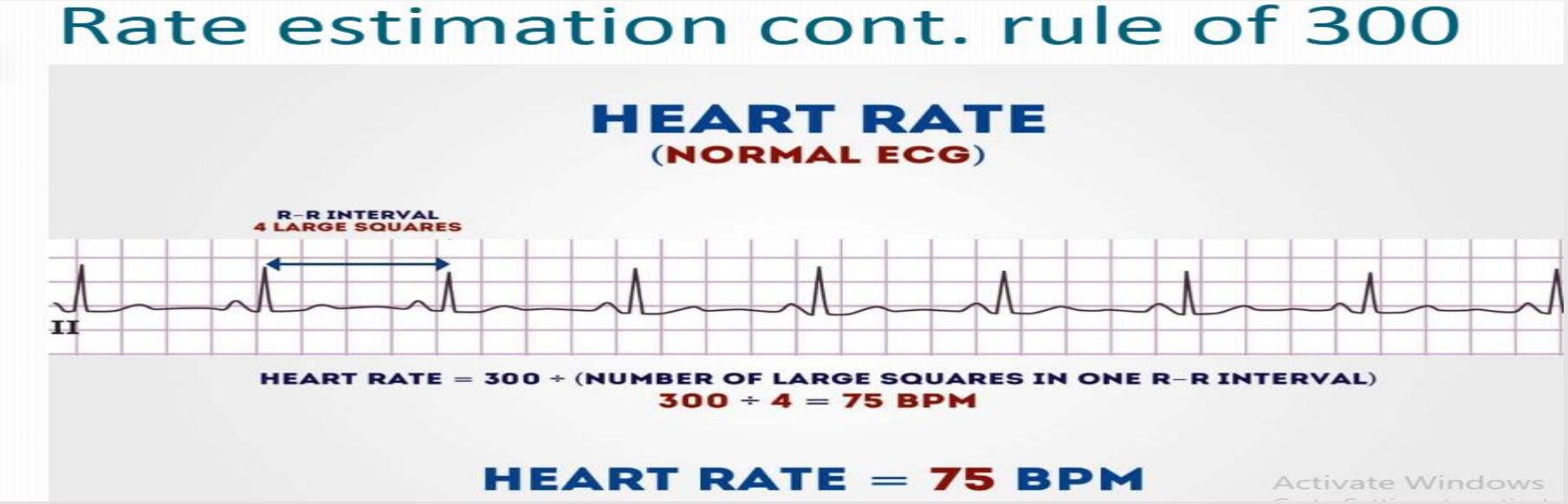
ECG interpretations

Interpreting an ECG (electrocardiogram) involves a systematic approach to ensure accuracy and thoroughness. Here are the general steps:

1. **Confirm Patient Details**: Verify the patient's name, date of birth, and the date and time the ECG was performed.
2. **Check Calibration**: Ensure the ECG is calibrated correctly (usually 25mm/s and 10mm/1mV)

ECG interpretations…

3. **Determine Heart Rate:** Calculate the heart rate by counting the number of **large squares** in one R-R interval and **dividing 300** by this number for **regular rhythms**. For **irregular rhythms**, count the number of complexes in a 10-second strip and **multiply by 6**



ECG interpretations…

What if the rhythm is irregular?...

The first method of calculating the heart rate doesn't work when the R-R interval differs significantly throughout the ECG and therefore another method is required

- Count the number of complexes on the rhythm strip (each rhythm strip is 10seconds long)
- Multiply the number of complexes by 6 (giving you the average number of complexes in 1 minute)
- e.g. 10 complexes on a **rhythm strip X 6** = 60 beats per minute

If the rate is < 60 bpm the patient is **bradycardic.**

If the rate is > 100 bpm the patient is **tachycardic**

ECG interpretations…

4. Assess Heart Rhythm: Determine if the rhythm is **regular or irregular**. Regular rhythms have consistent intervals, while irregular rhythms do not.

-If the rate is regular and a P wave precedes every QRS complex then the rhythm can be described as **sinus rhythm.**

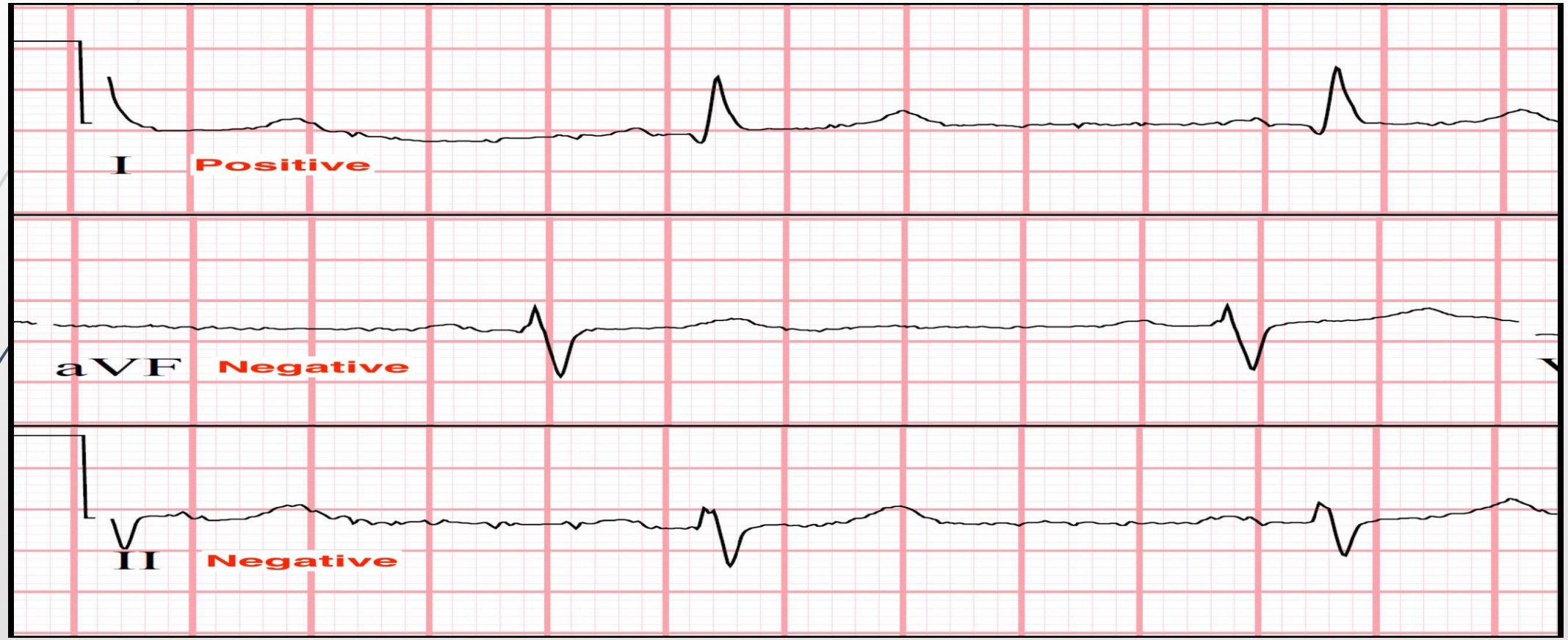
ECG interpretations…

5. Cardiac Axis

Cardiac axis gives us an idea of the direction of the electrical flow through the heart muscle.

- The easiest way to evaluate this is by looking at leads I and aVF.
- If the QRS complexes are positive in both then there is **no axis deviation.**
- If the QRS complex in lead I is negative and aVF is positive, then there is **right axis deviation**.
- If the QRS complex in lead I is positive and aVF is negative then there is **left axis deviation.**

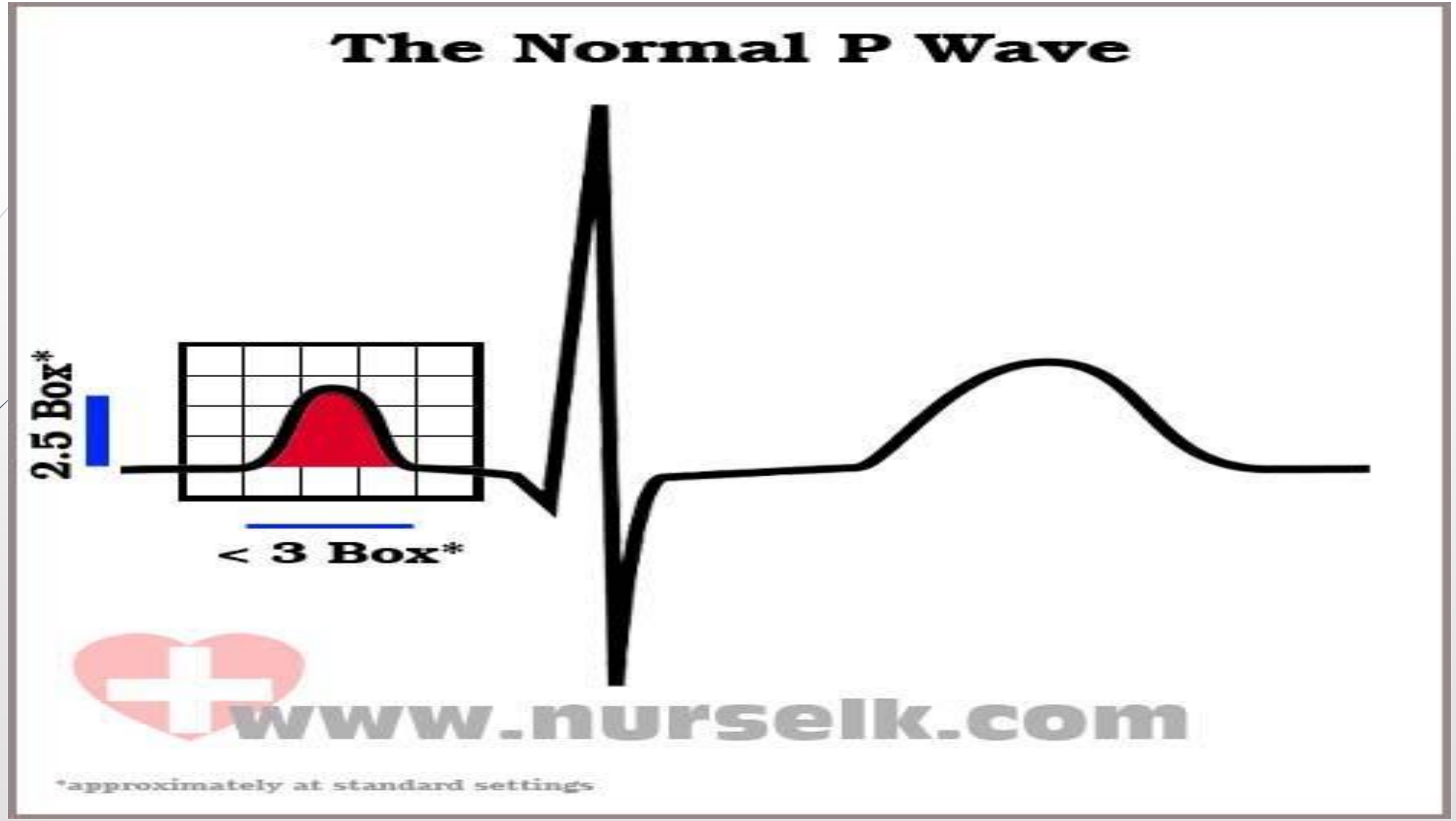
Axis deviation…



ECG interpretation…

6. Evaluate the P Wave

- Check for normal morphology, duration (≤120 ms), and amplitude (≤2.5 mm).
- Look for signs of **atrial enlargement.**


The Normal P Wave
2.5 Box*
< 3 Box*
www.nurselk.com
*approximately at standard settings

ECG interpretation…

7. Intervals

i.PR Interval = impulse from atria to ventricles to ventricles

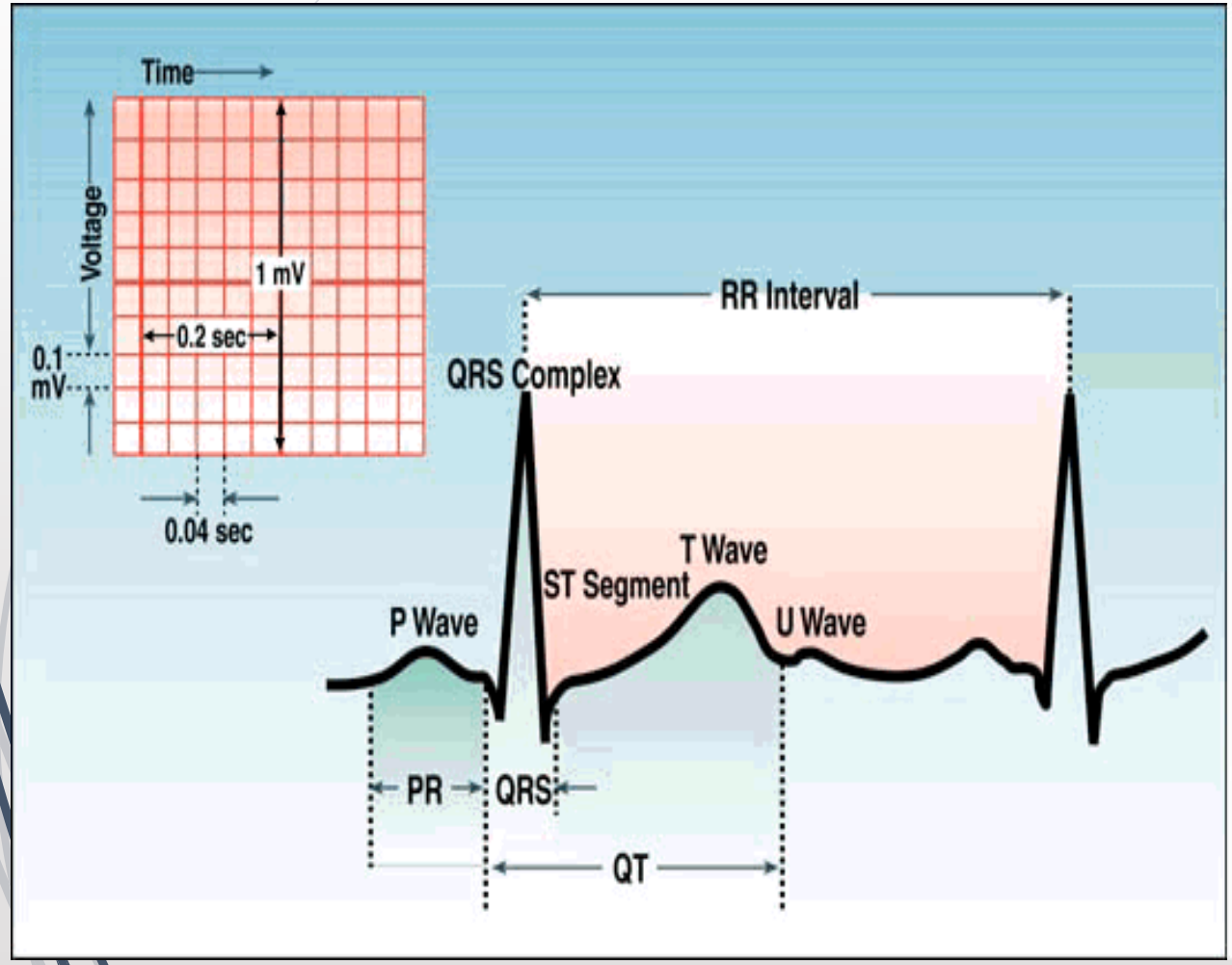
- **Measure PR Interval (Normal: 120–200 ms)**
- Normal PR interval **is 3-5 small boxes**
- Short PR (<120 ms) may indicate pre-excitation (e.g., WPW syndrome).
- Prolonged PR (>200 ms) suggests first-degree AV block.

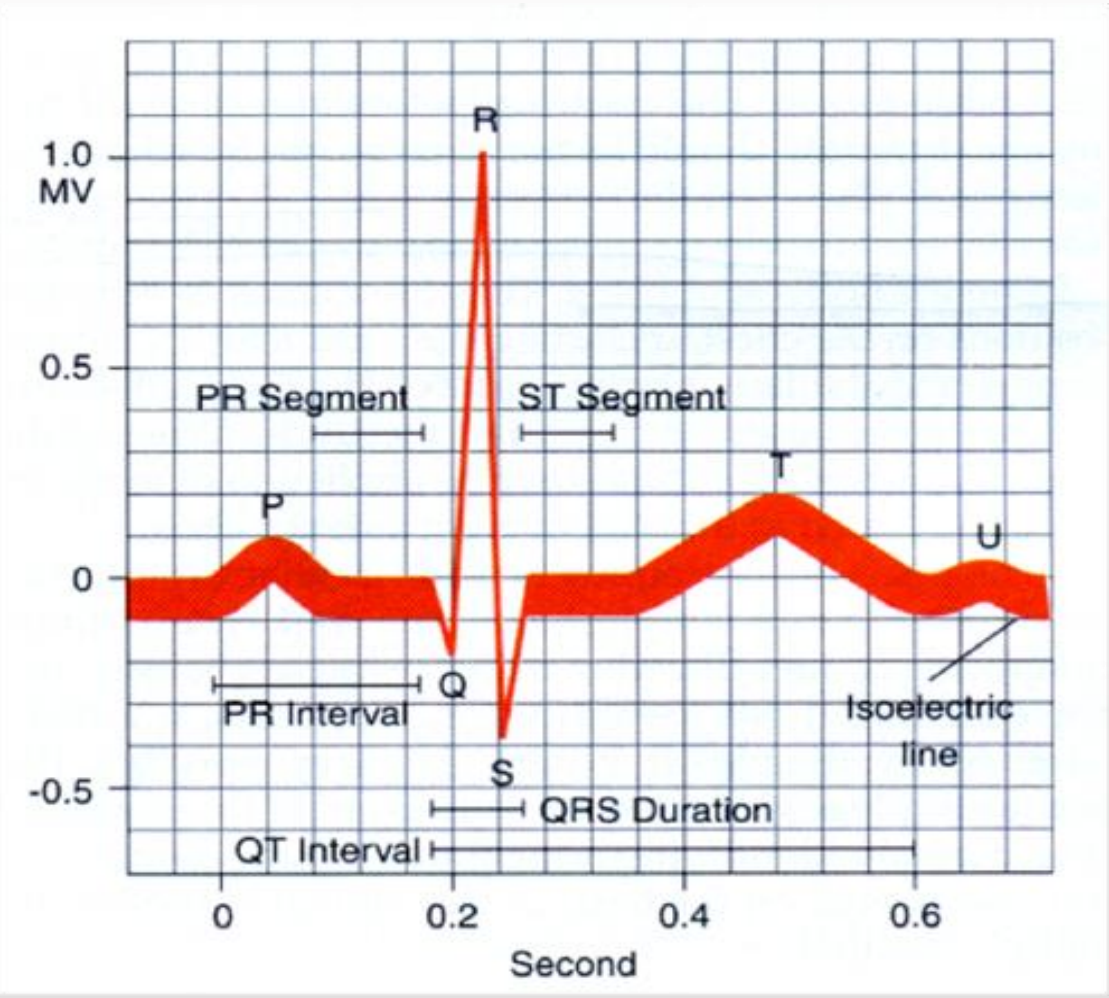
Intervals…

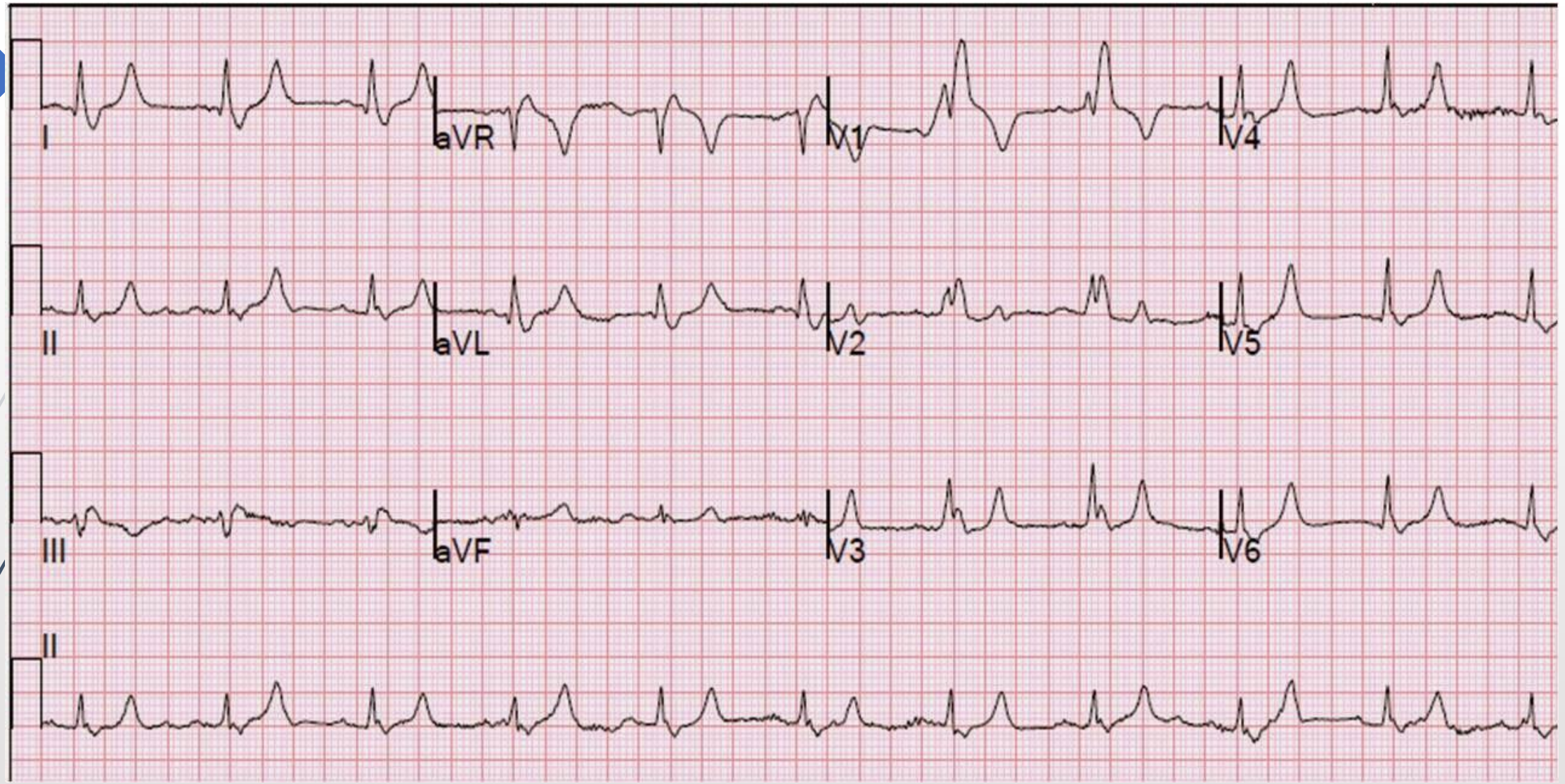
8. Assess the QRS Complex

- **Normal duration:** ≤120 ms.
- **Wide QRS (>120 ms):** Consider bundle branch block (BBB), ventricular rhythm, or pre-excitation.
- Check QRS morphology for ventricular hypertrophy, infarction, or conduction abnormalities.

Intervals…


Time
Voltage
1 mV
0.2 sec
0.1 mV
0.04 sec
RR Interval
QRS Complex
T Wave
ST Segment
P Wave
U Wave
PR
QRS
QT


1.0 MV
0.5
0
-0.5
R
PR Segment
ST Segment
T
P
U
Q
PR Interval
Isoelectric line
S
QRS Duration
QT Interval
0
0.2
0.4
0.6
Second


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

Segments…

Evaluate the ST Segment

- **ST elevation:** Suggests acute myocardial infarction (STEMI).
- **ST depression:** Indicates ischemia or strain.

ST Segment Elevation

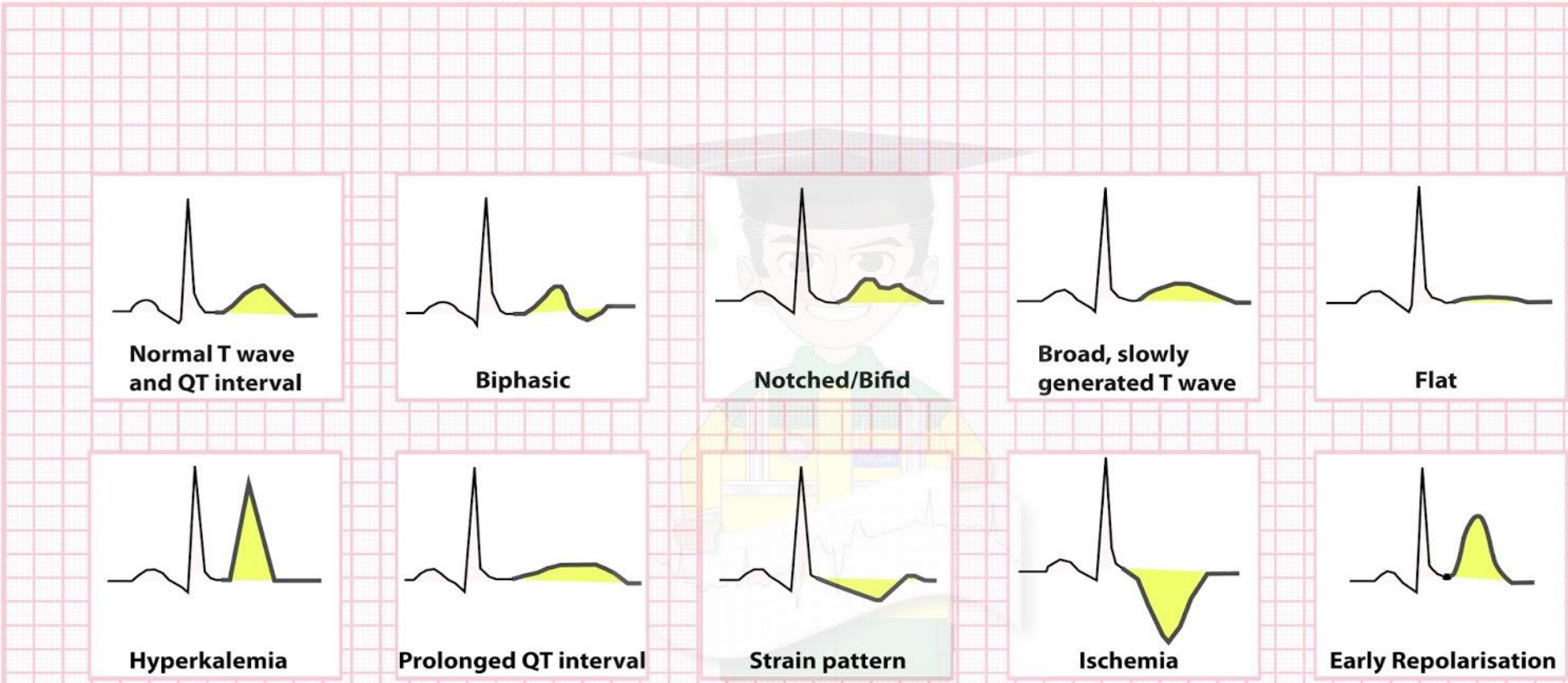
ST depression

ECG interpretation…

9. Examine the T Wave

- Inversion may suggest **ischemia, strain, or electrolyte imbalances.**
- Tall, peaked T waves may indicate **hyperkalemia**.

Types of T wave Morphologies

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REFERENCES

Cardiovascular Care and British Association of Cardiovascular Prevention and Rehabilitation can be accessed through this website:

1. http://www.bcs.com British Heart Foundation:
2. http://www.bhf.org.uk British Heart Foundation statistics website:
3. http://www.heartstats.org British Heart Valve Society:
4. http://www.bhvs.org.uk Cardiomyopathy UK:
5. http://www.cardiomyopathy.org