Interpretation of ECG

By

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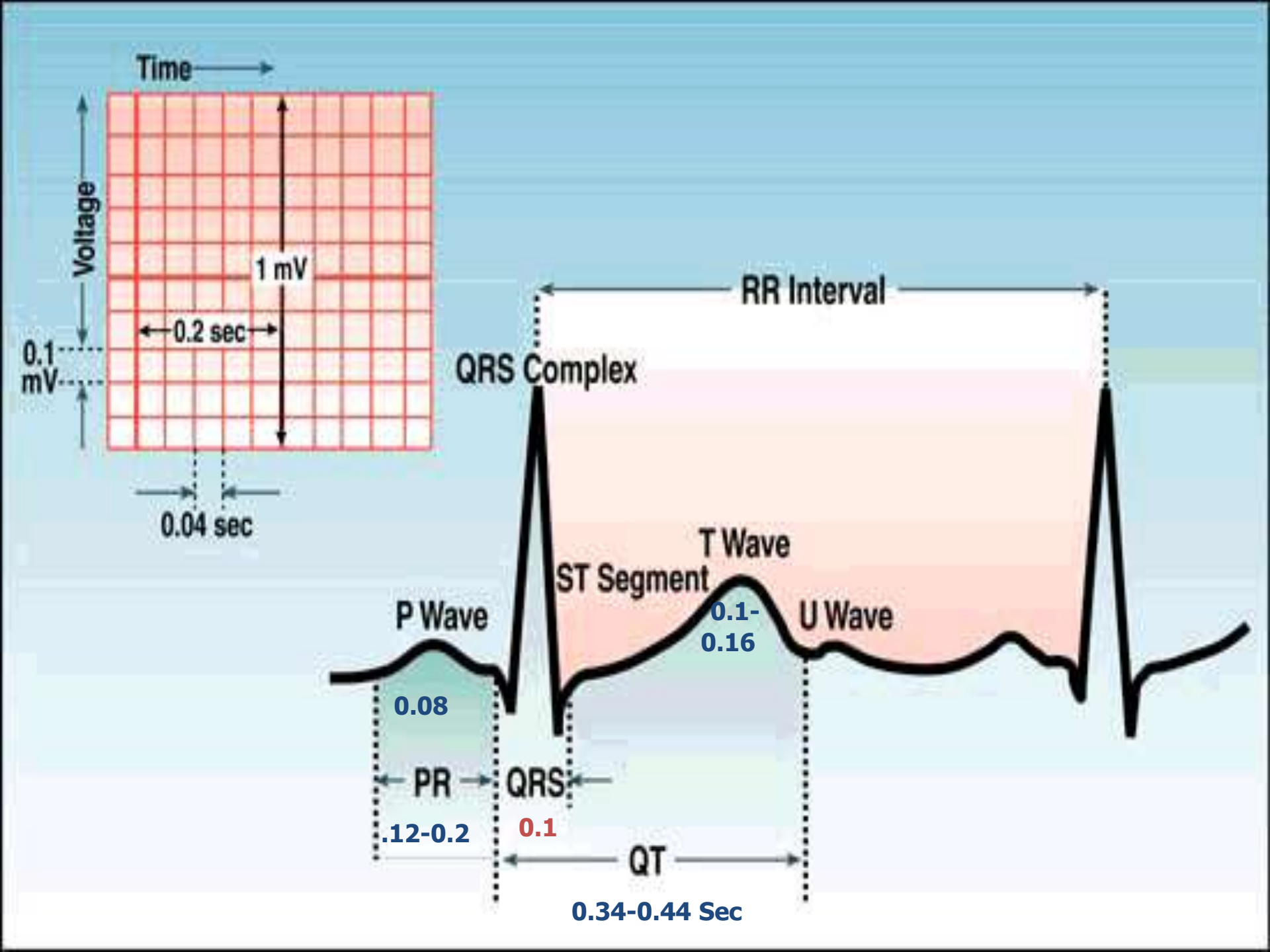
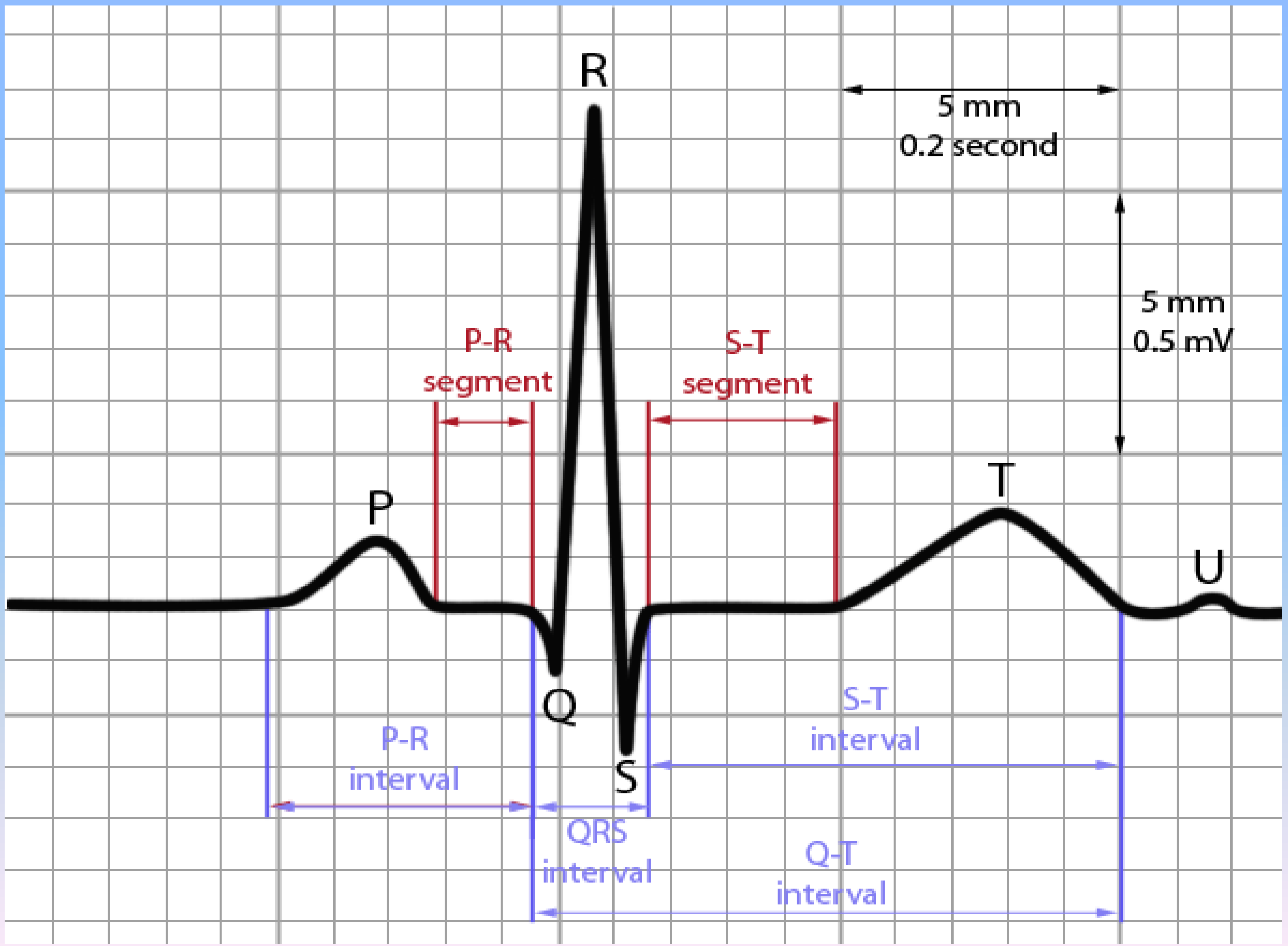
Learning Objectives

- To calculate the timings of ECG waves, segments and intervals
- How to calculate the heart rate
- Clinical significance of each part of ECG in different conditions

Interpreting the ECG

- Check
  - Name
  - DoB
  - Time and date
  - Indication e.g. “chest pain” or “routine pre-op”
  - Any previous or subsequent ECGs
  - Is it part of a serial ECG sequence? In which case it may be numbered
- Calibration
- Rate
- Rhythm
- Axis
- Elements of the tracing in each lead


Time
Voltage
1 mV
0.2 sec
0.1 mV
0.04 sec
RR Interval
QRS Complex
T Wave
ST Segment
P Wave
0.1-0.16
U Wave
0.08
PR
QRS
.12-0.2
0.1
QT
0.34-0.44 Sec


R
5 mm
0.2 second
5 mm
0.5 mV
P-R
segment
S-T
segment
P
T
U
Q
S
P-R
interval
S-T
interval
QRS
interval
Q-T
interval

PARTS OF ECG

1. **WAVES**

   P- =0.08 Sec

   QRS Comp:=0.1 Sec

   T- =0.1-0.16 Sec

2. **INTERVALS**

   P-R = 0.12-0.2 Sec

   Q-T =0.3-0.4 Sec

3. **SEGMENTS**

   PQ SEGMENT

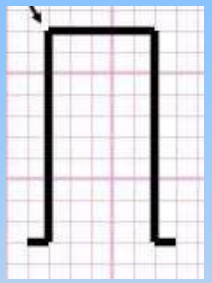
   ST SEGMENT

Calibration

Check that your ECG is calibrated correctly

Height

- 10mm = 1mV
- Look for a reference pulse which should be the rectangular looking wave somewhere near the left of the paper. It should be 10mm (10 small squares) tall



Paper speed

- 25mm/s
- 25 mm (25 small squares / 5 large squares) equals one second

Rate

- If the heart rate is regular
  - Count the number of large squares between R waves
    - i.e. the RR interval in large squares
    - Rate = $\frac{300}{RR}$

e.g. RR = 4 large squares

300/4 = 75 beats per minute

Rate

If the rhythm is irregular (see next slide on rhythm to check whether your rhythm is regular or not) it may be better to estimate the rate using the rhythm strip at the bottom of the ECG (usually lead II)

The rhythm strip is usually 25cm long (250mm i.e. 10 seconds)

If you count the number of R waves on that strip and multiple by 6 you will get the rate

Rhythm

Is the rhythm regular?

- The easiest way to tell is to take a sheet of paper and line up one edge with the tips of the R waves on the rhythm strip.
- Mark off on the paper the positions of 3 or 4 R wave tips
- Move the paper along the rhythm strip so that your first mark lines up with another R wave tip
- See if the subsequent R wave tips line up with the subsequent marks on your paper
- If they do line up, the rhythm is regular. If not, the rhythm is irregular

Rhythm

Sinus Rhythm

- Definition — Cardiac impulse originates from the sinus node. Every QRS must be preceded by a P wave.

- (This does not mean that every P wave must be followed by a QRS – such as in 2nd degree heart block where some P waves are not followed by a QRS, however every QRS is preceded by a P wave and the rhythm originates in the sinus node, hence it is a sinus rhythm. It could be said that it is not a *normal* sinus rhythm)

Rhythm

Sinus arrhythmia

- There is a change in heart rate depending on the phase of respiration
- Q. If a person with sinus arrhythmia inspires, what happens to their heart rate?
- A. The heart rate speeds up. This is because on inspiration there is a decrease in intrathoracic pressure, this leads to an increased venous return to the right atrium. Increased stretching of the right atrium sets off a brainstem reflex (Bainbridge's reflex) that leads to sympathetic activation of the heart, hence it speeds up)
- This physiological phenomenon is more apparent in children and young adults

Rhythm

Sinus bradycardia

- Rhythm originates in the sinus node
- Rate of less than 60 beats per minute

Sinus tachycardia

- Rhythm originates in the sinus node
- Rate of greater than 100 beats per minute

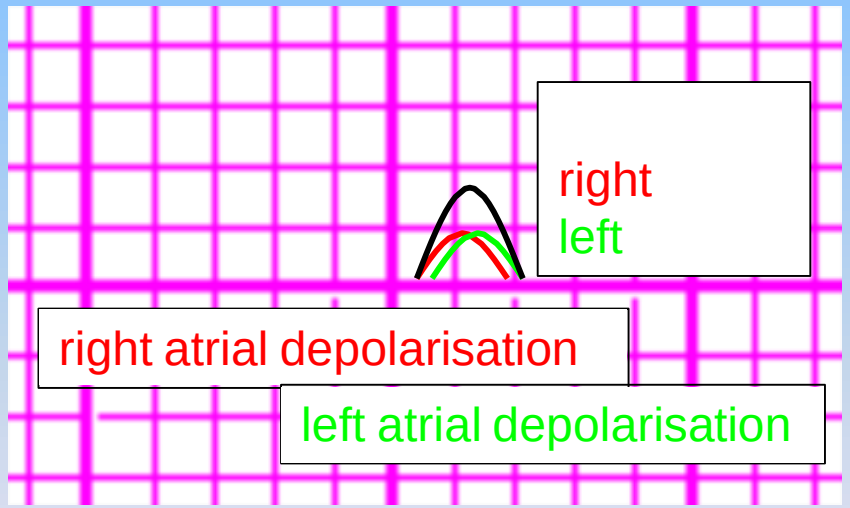
The P wave

The P wave represents atrial depolarisation

It can be thought of as being made up of two separate waves due to right atrial depolarisation and left atrial depolarisation.

Which occurs first?

Right atrial depolarisation



The P wave

Dimensions

- No hard and fast rules

Height

- a P wave over 2.5mm should arouse suspicion

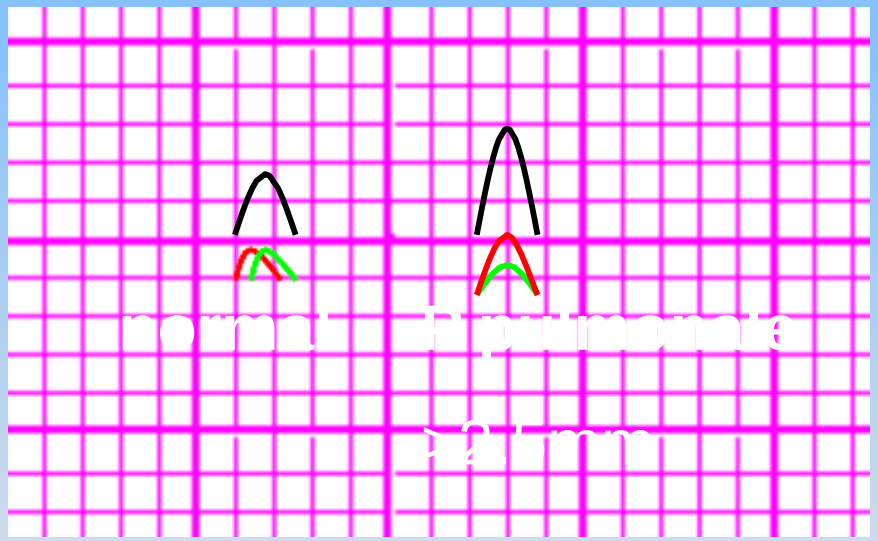
Length

- a P wave longer than 0.08s (2 small squares) should arouse suspicion

The P wave

Height

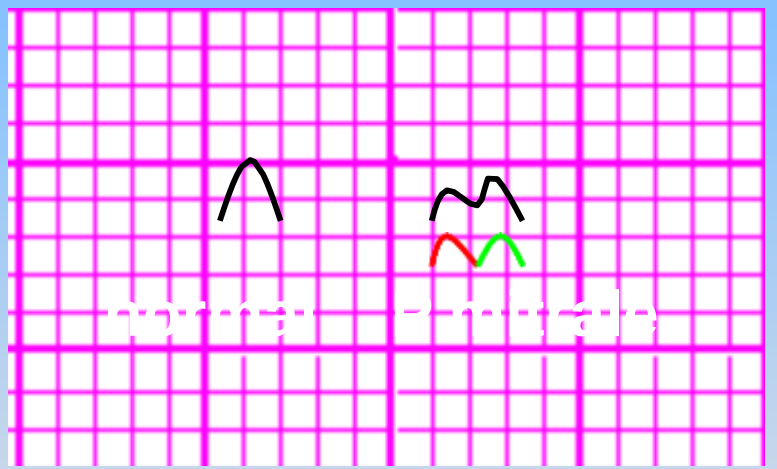
- A tall P wave (over 2.5mm) can be called *P pulmonale*
- Occurs due to R atrial hypertrophy
- Causes include:
  - pulmonary hypertension,
  - pulmonary stenosis
  - tricuspid stenosis



The P wave

Length

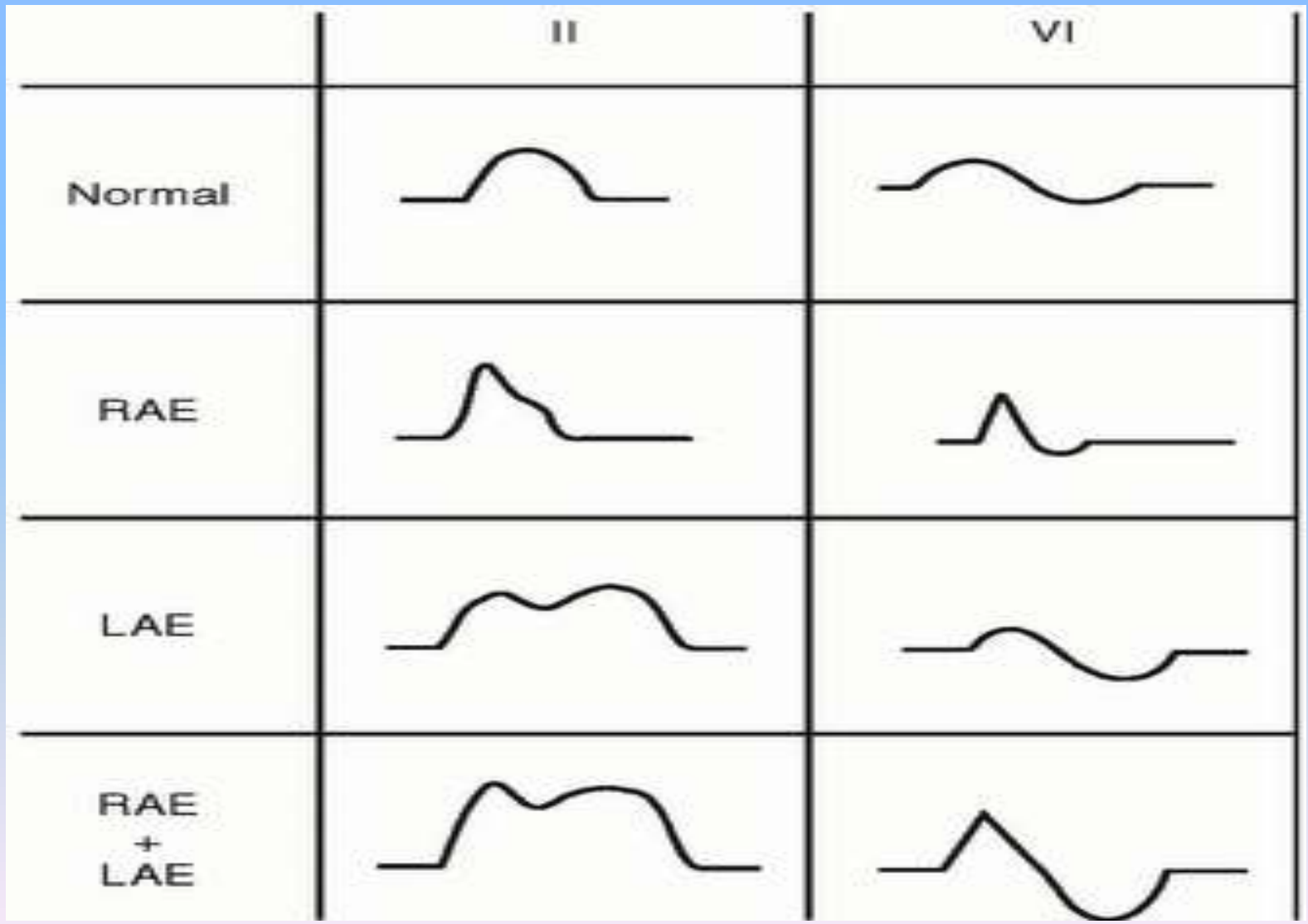
- A P wave with a length >0.08 seconds (2 small squares) and a bifid shape is called *P mitrale*



- It is caused by left atrial hypertrophy and delayed left atrial depolarisation

- Causes include:
  - Mitral valve disease
  - LVH

P wave



Tall P wave

Fig. 3 ECG shows sinus rhythm with tall, peaked P waves.

The PR interval

- The PR interval is measured between the start of the P wave to the start of the QRS complex

- (therefore if there is a Q wave before the R wave the PR interval is measured from the start of the P wave to the start of the *Q* wave, not the start of the R wave)

The PR interval

- The PR interval corresponds to the time period between depolarisation of the atria and ventricular depolarisation.

- A normal PR interval is between 0.12 and 0.2 seconds (3-5 small squares)

The PR interval

- If the PR interval is short (less than 3 small squares) it may signify that there is an accessory electrical pathway between the atria and the ventricles, hence the ventricles depolarise early giving a short PR interval.

- One example of this is **Wolff-Parkinson-White** syndrome where the accessory pathway is called the bundle of Kent. See next slide for an animation to explain this

The PR interval

- If the PR interval is long (>5 small squares or 0.2s):
- If there is a constant long PR interval 1st degree heart block is present
- First degree heart block is a longer than normal delay in conduction at the AV node

The PR interval

- If the PR interval looks as though it is widening every beat and then a QRS complex is missing, there is 2nd degree heart block, Mobitz type I. The lengthening of the PR interval in subsequent beats is known as the Wenckebach phenomenon
- (remember (w)one, Wenckebach, widens)

- If the PR interval is constant but then there is a missed QRS complex then there is 2nd degree heart block, Mobitz type II

The PR interval

- If there is no discernable relationship between the P waves and the QRS complexes, then 3rd degree heart block is present

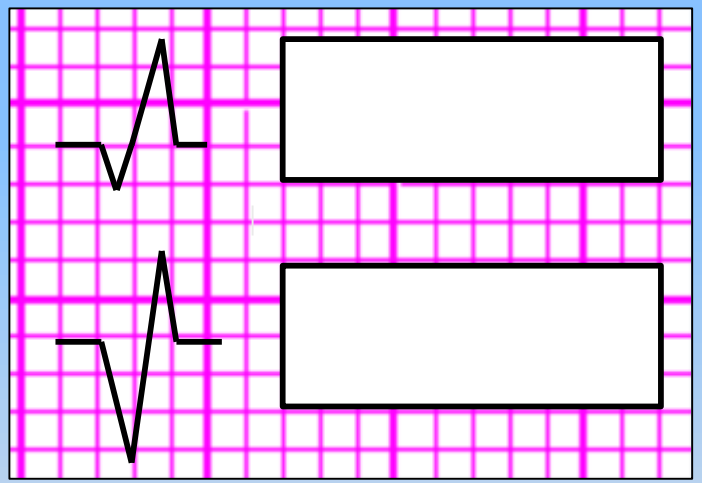
The Q wave

Are there any pathological Q waves?

- A Q wave can be pathological if it is:
  - Deeper than 2 small squares (0.2mV)

  and/or
  - Wider than 1 small square (0.04s)

  and/or
  - In a lead other than III or one of the leads that look at the heart from the left (I, II, aVL, V5 and V6) where small Qs (i.e. not meeting the criteria above) can be normal



The QRS height

- If the complexes in the chest leads look very tall, consider left ventricular hypertrophy (LVH)

- If the depth of the S wave in V_1 added to the height of the R wave in V_6 comes to more than 35mm, LVH is present

Criteria of LVH

- **Cornell criteria:**

Add the R wave in aVL and the S wave in V3. If the sum is greater than 28 millimeters in males or greater than 20 mm in females, LVH is present.

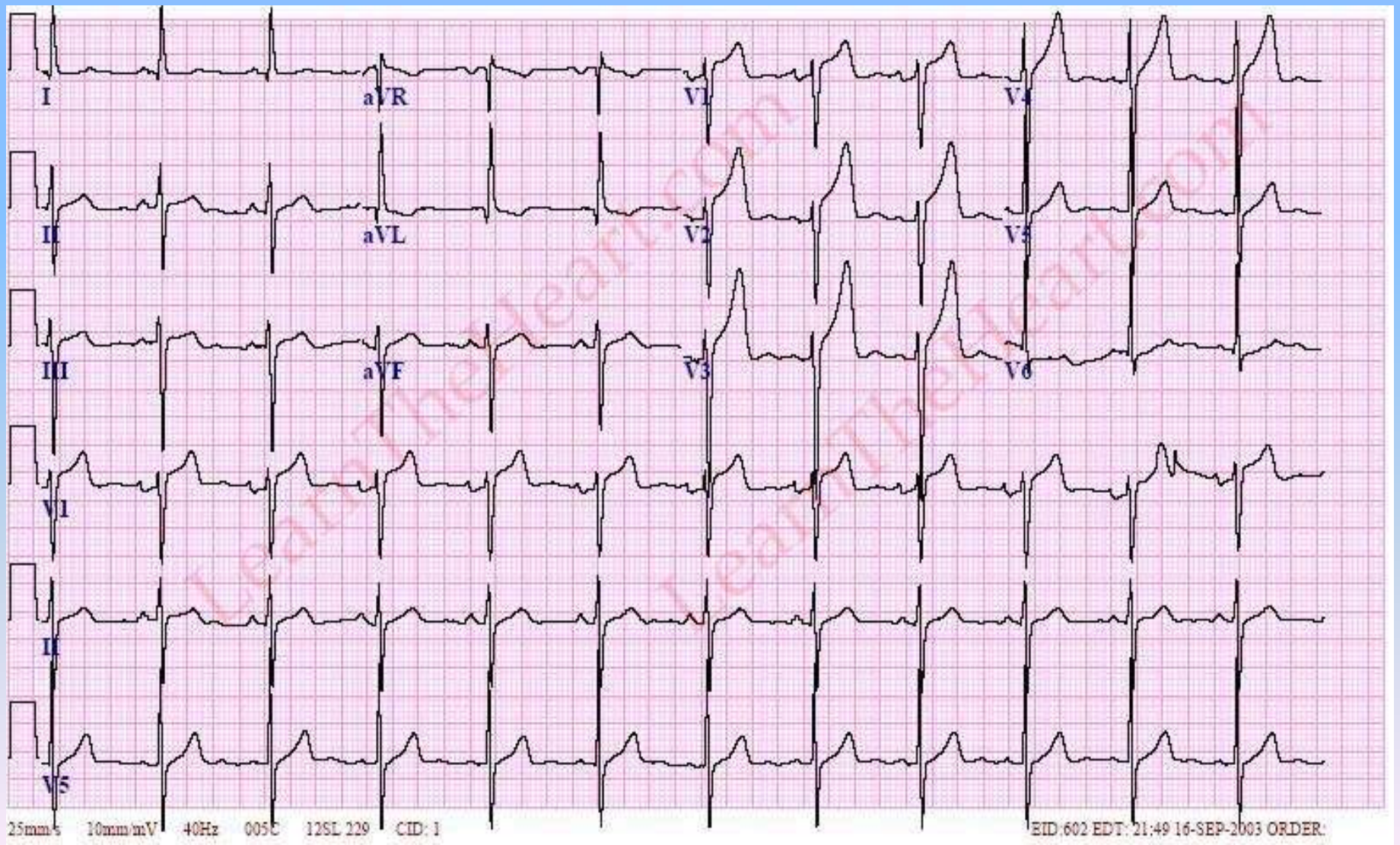
- **Modified Cornell Criteria:**

Examine the R wave in aVL. If the R wave is greater than 12 mm in amplitude, LVH is present.

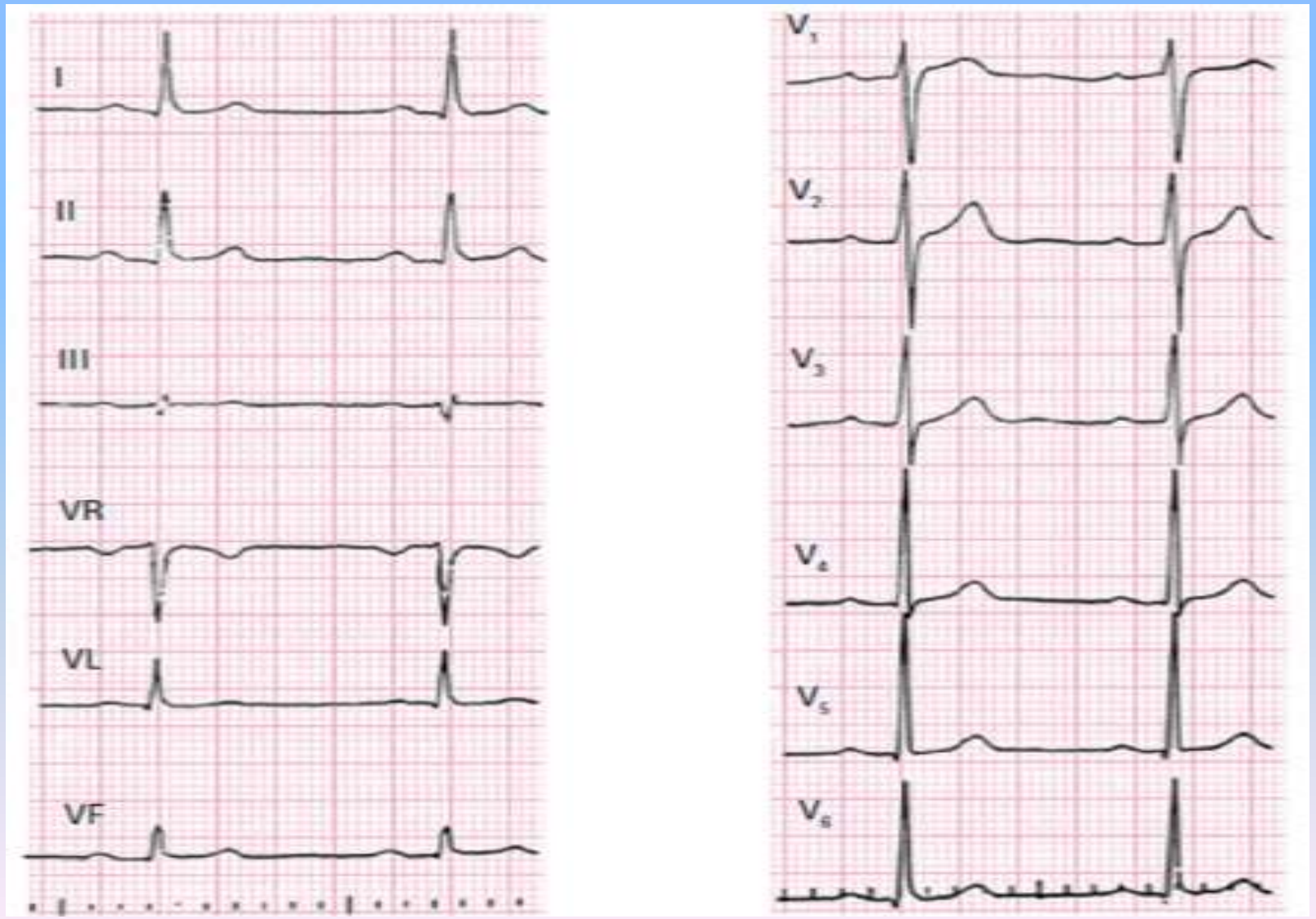
Sokolow-Lyon Criteria:

- Add the S wave in V1 plus the R wave in V5 or V6. If the sum is greater than 35 mm, LVH is present.

Left Ventricular Hypertrophy




V1
V2
V3
V4
V5
V6
normal ST-segment elevation
early-repolarization pattern
normal variant
normal ST-segment elevation and normal variants
ECGPEDIA.ORG

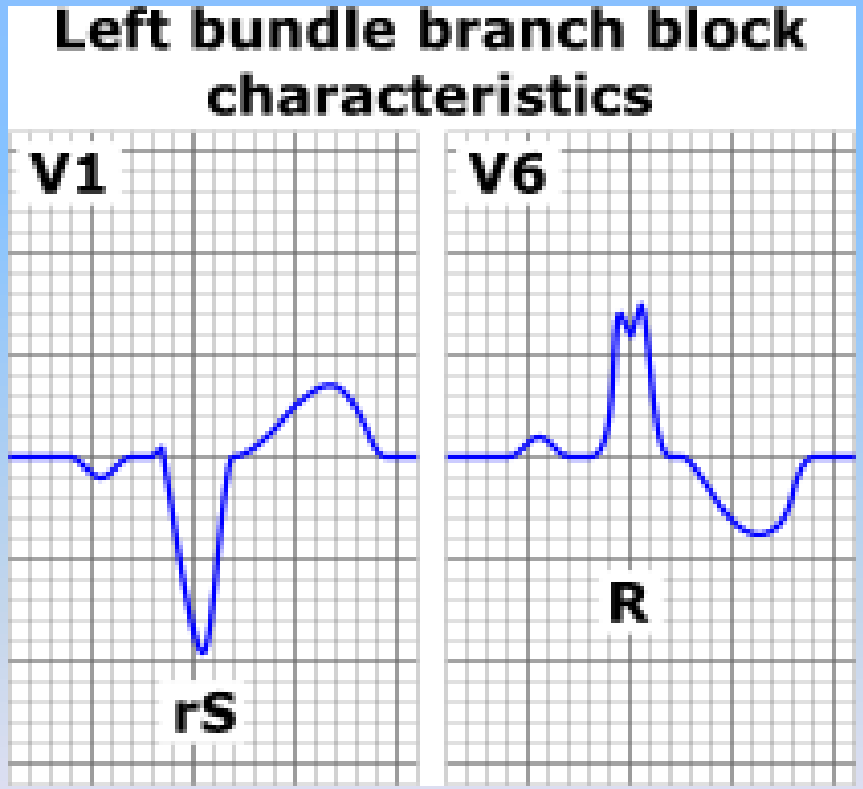

I
II
III
VR
VL
VF
V1
V2
V3
V4
V5
V6

QRS width

- The width of the QRS complex should be less than 0.12 seconds (3 small squares)
- Some texts say less than 0.10 seconds (2.5 small squares)
- If the QRS is wider than this, it suggests a ventricular conduction problem – usually right or left bundle branch block (RBBB or LBBB)

Broad and bizarre QRS complex

LBBB

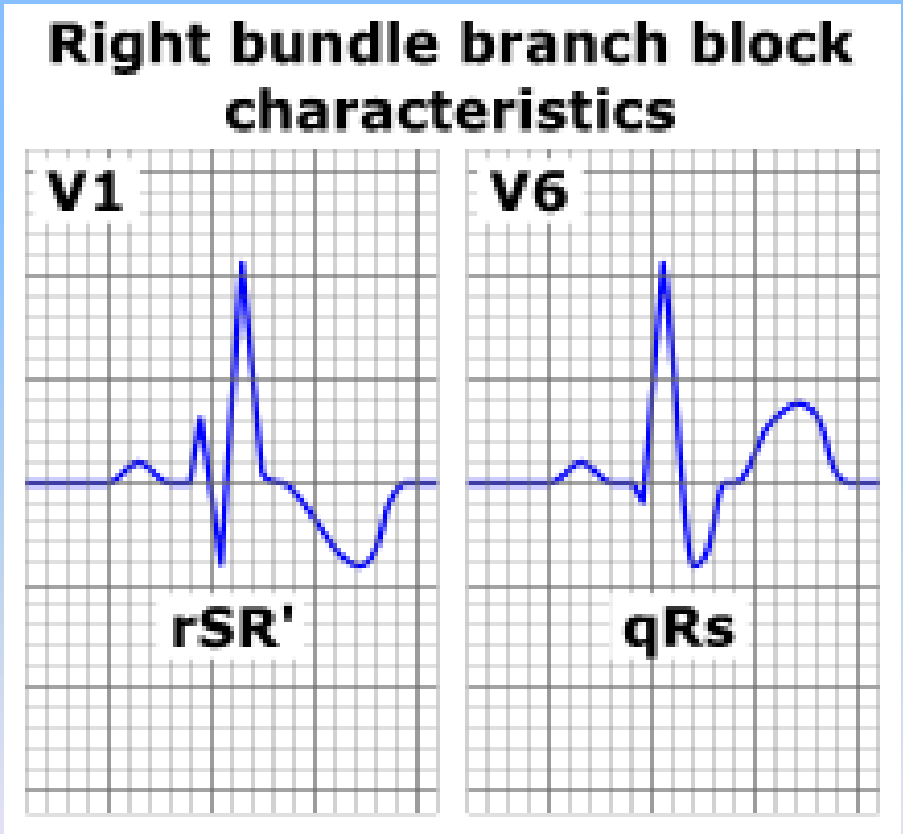


- If left bundle branch block is present, the QRS complex may look like a ‘W’ in V_1 and/or an ‘M’ shape in V_6.
- New onset LBBB with chest pain consider Myocardial infarction
- Not possible to interpret the ST segment.

RBBB

- It is also called RSR pattern
- If right bundle branch block is present, there may be an ‘M’ in V1 and/or a ‘W’ in V6.

- Can occur in healthy people with normal QRS width – partial RBBB



QRS width

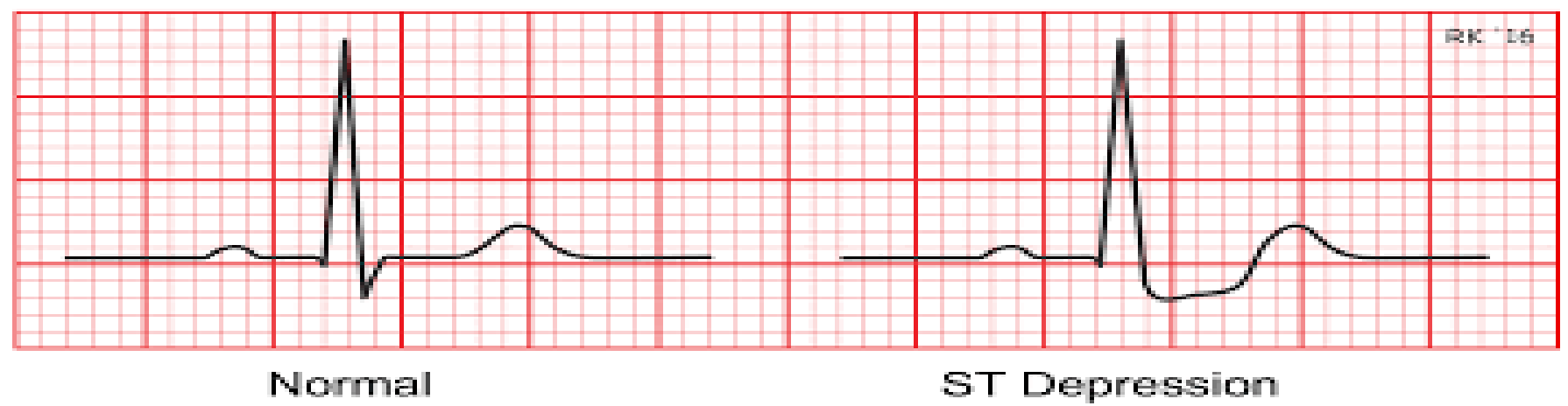
It is useful to look at leads V_1 and V_6

- LBBB and RBBB can be remembered by the mnemonic:
- **WiLLiaM** **MaRRoW**
- Bundle branch block is caused either by infarction or fibrosis (related to the ageing process)

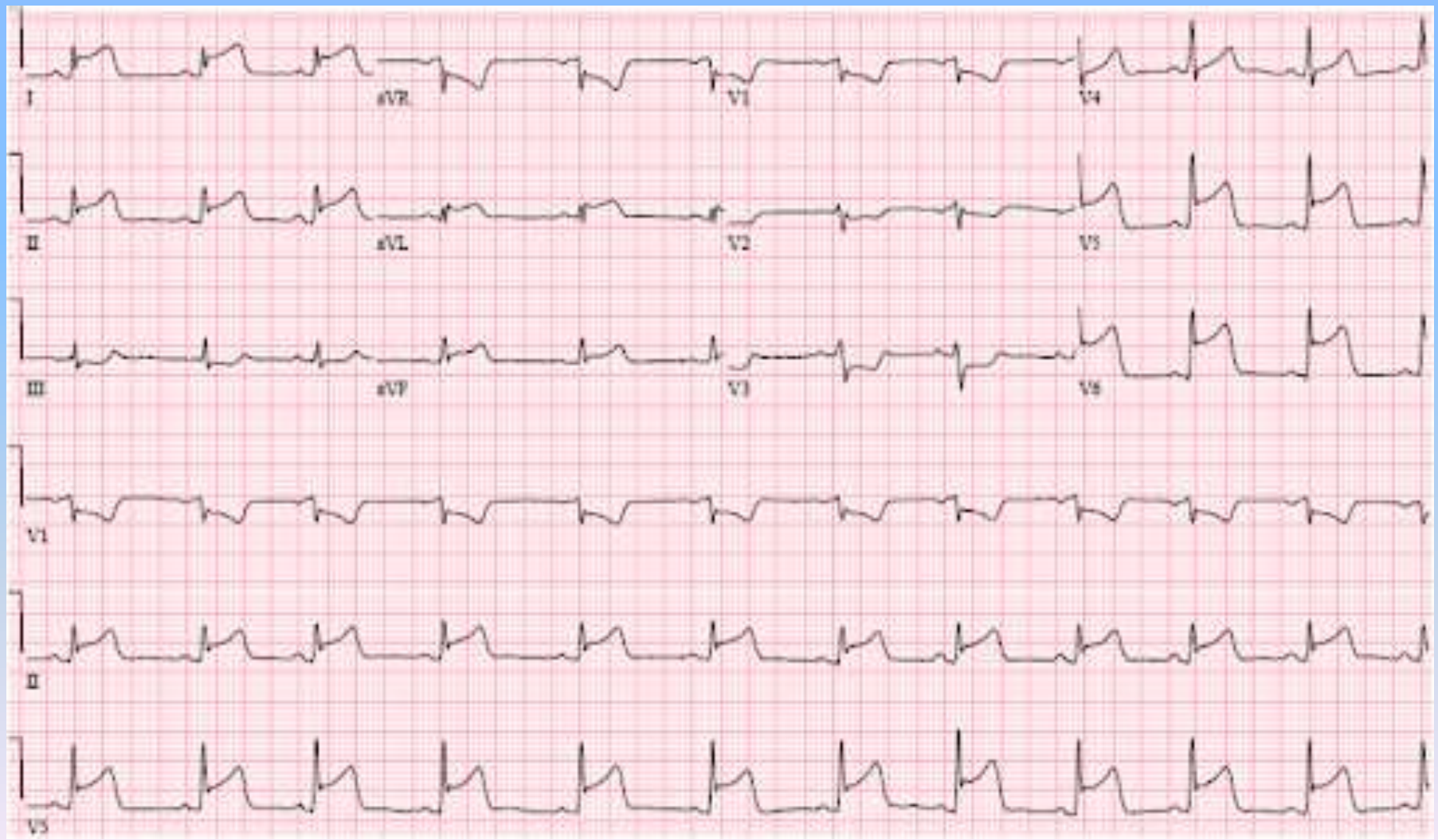
The ST segment

- The ST segment should sit on the isoelectric line
- It is abnormal if there is planar (i.e. flat) elevation or depression of the ST segment
- Planar ST elevation can represent an MI or Prinzmetal's (vasospastic) angina
- Planar ST depression can represent ischaemia

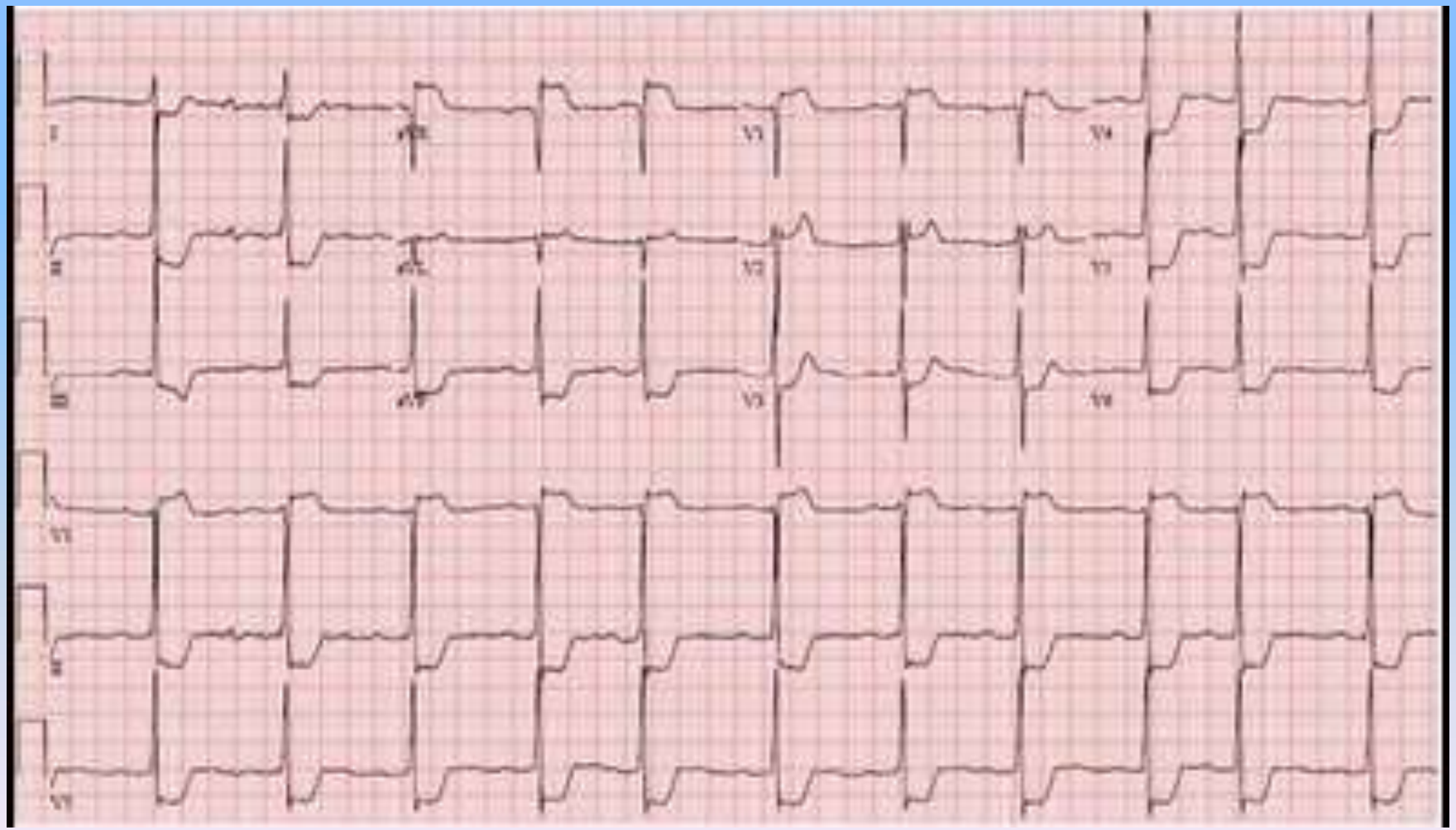
ST segment depression



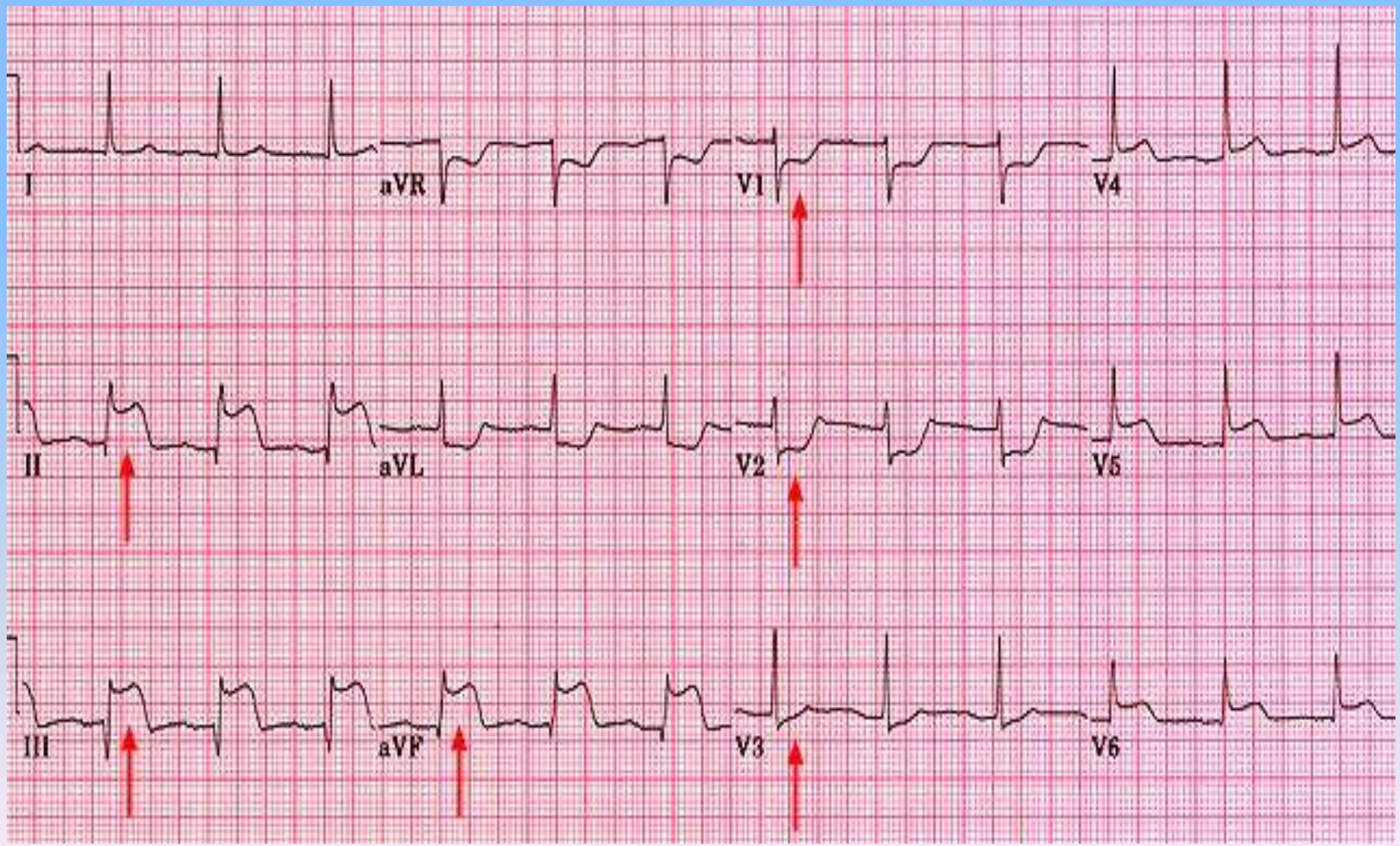
ST segment ?



ST Segment ?



ST Segment



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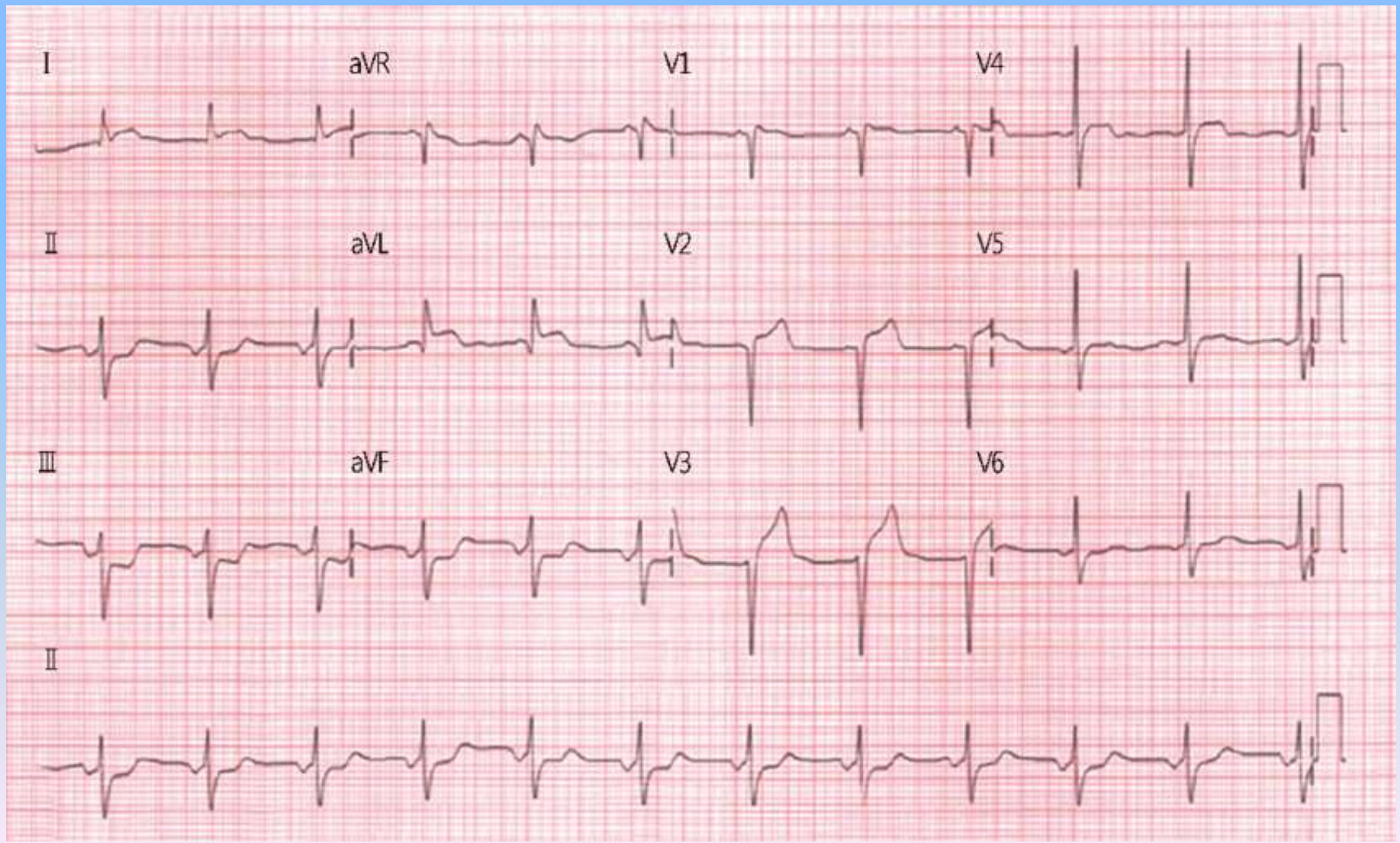
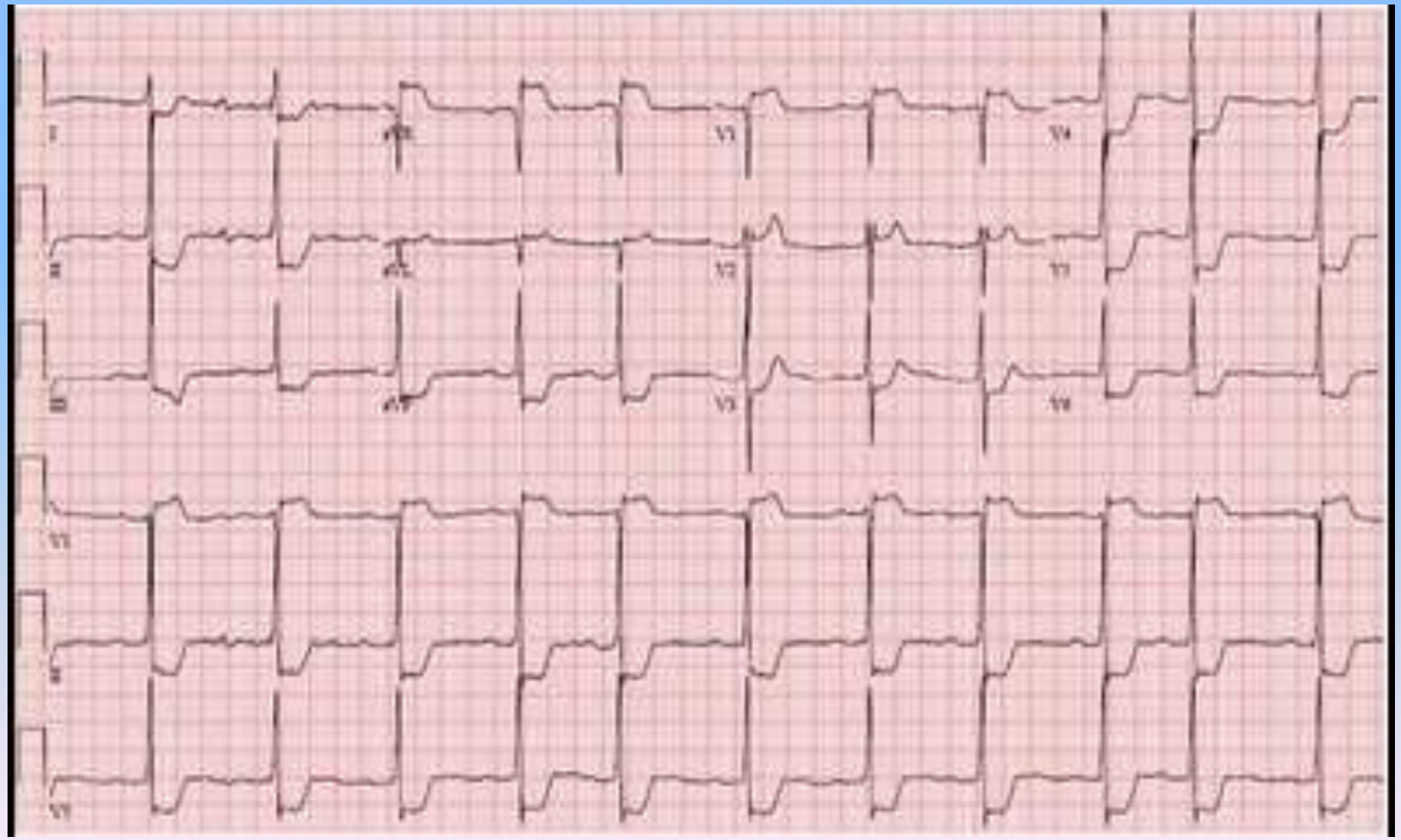

I
aVR
V1
V4
II
aVL
V2
V5
III
aVF
V3
V6
II

?



Myocardial infarction

- Within hours:
  - T wave may become peaked
  - ST segment may begin to rise
- Within 24 hours:
  - T wave inverts (may or may not persist)
  - ST elevation begins to resolve
  - If a left ventricular aneurysm forms, ST elevation may persist
- Within a few days:
  - pathological Q waves can form and usually persist

Myocardial infarction

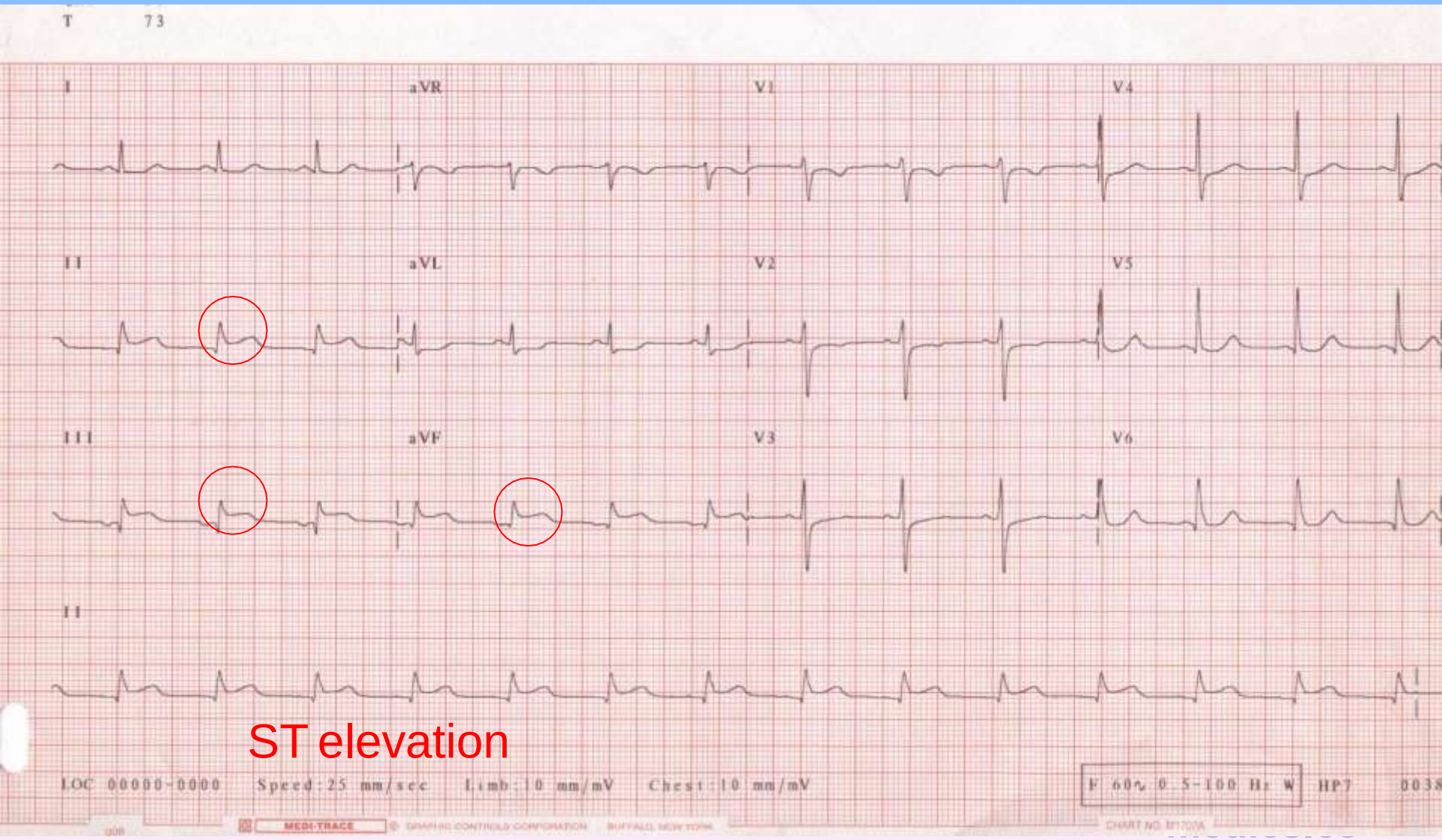
- The leads affected determine the site of the infarct

- Inferior II, III, aVF
- Anteroseptal V1-V4
- Anterolateral V4-V6, I, aVL
- Posterior Tall wide R and ST⇓n V1 and V2

Acute Anterior MI

ST elevation

Inferior MI

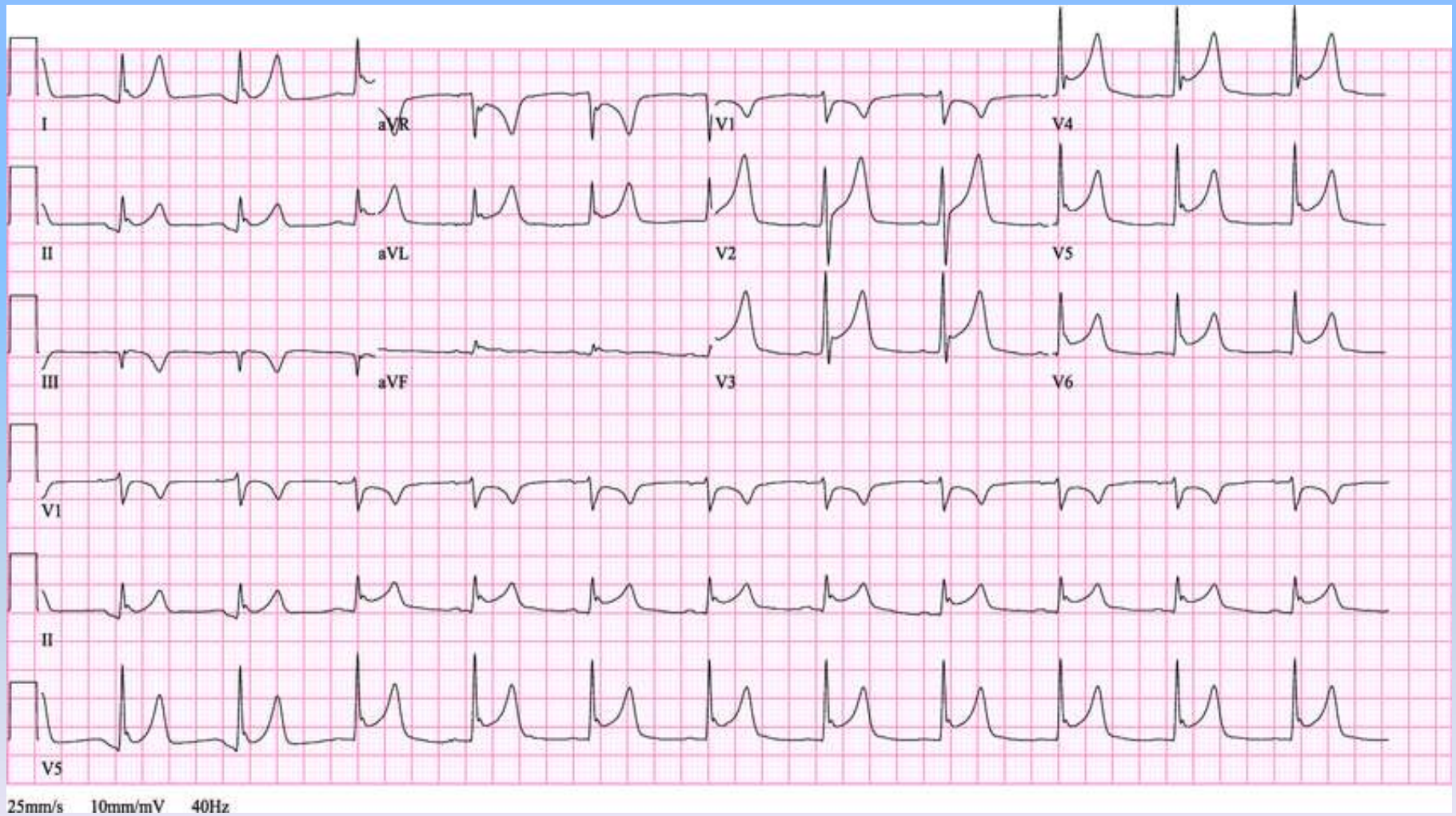

T 73
I
aVR
V1
V4
II
aVL
V2
V5
III
aVF
V3
V6
II
ST elevation
LOC 00000-0000
Speed: 25 mm/sec
Limb: 10 mm/mV
Chest: 10 mm/mV
F 60∿ 0.5-100 Hz W
HP7
MEDI-TRACE

The ST segment

- If the ST segment is elevated but slanted, it may not be significant

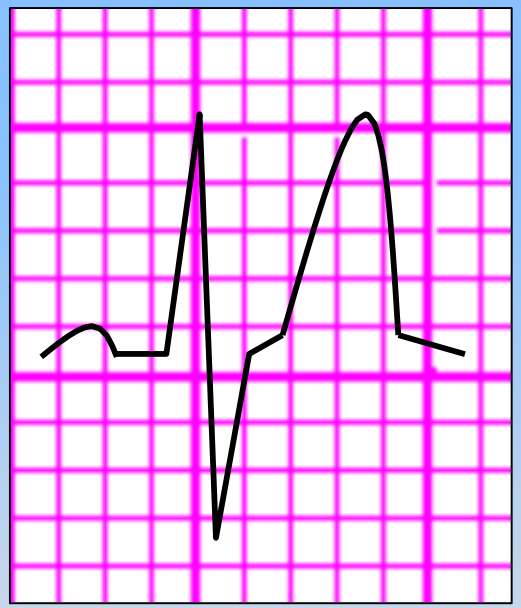
- If there are raised ST segments in most of the leads, it may indicate pericarditis – especially if the ST segments are saddle shaped. There can also be PR segment depression

Pericarditis



The T wave

- Are the T waves too tall?
  - No definite rule for height
  - T wave generally shouldn't be taller than half the size of the preceding QRS
  - Causes:
    - Hyperkalaemia
    - Acute myocardial infarction



The T wave

- If the T wave is flat, it may indicate hypokalaemia
- If the T wave is inverted it may indicate ischaemia

The QT interval

- The QT interval is measured from the *start* of the QRS complex to the *end* of the T wave.

- The QT interval varies with heart rate
- As the heart rate gets faster, the QT interval gets shorter

- It is possible to correct the QT interval with respect to rate by using the following formula:
  - $QTc = QT/\sqrt{RR}$ (QTc = corrected QT)

The QT interval

- The normal range for QTc is 0.38-0.42
- A short QTc may indicate hypercalcaemia
- A long QTc has many causes
- Long QTc increases the risk of developing an arrhythmia

The U wave

- U waves occur after the T wave and are often difficult to see
- They are thought to be due to repolarisation of the atrial septum
- Prominent U waves can be a sign of hypokalaemia, hyperthyroidism

Elements of the tracing

P wave

- Magnitude and shape,
- e.g. P pulmonale, P mitrale

PR interval (start of P to start of QRS)

- Normal 3-5 small squares, 0.12-0.2s

Pathological Q waves?

QRS complex

- Magnitude, duration and shape
- ≤ 3 small squares or 0.12s duration

ST segment

- Should be isoelectric

T wave

- Magnitude and direction

QT interval (Start QRS to end of T)

- Normally < 2 big squares or 0.4s at 60bpm
- Corrected to 60bpm
- (QTc) = $QT/\sqrt{RR_{interval}}$


THANK
YOU