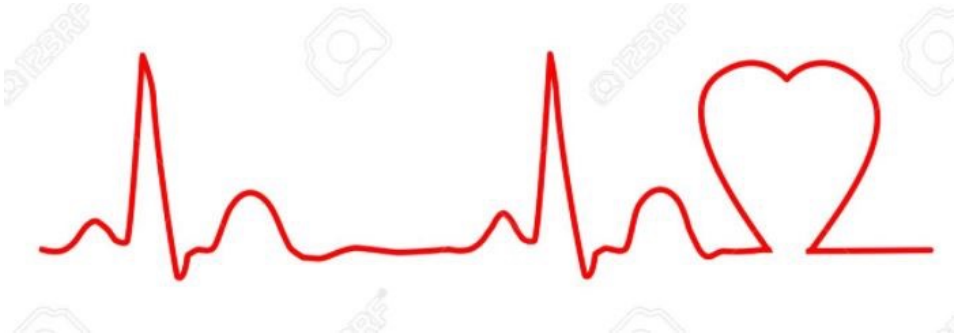
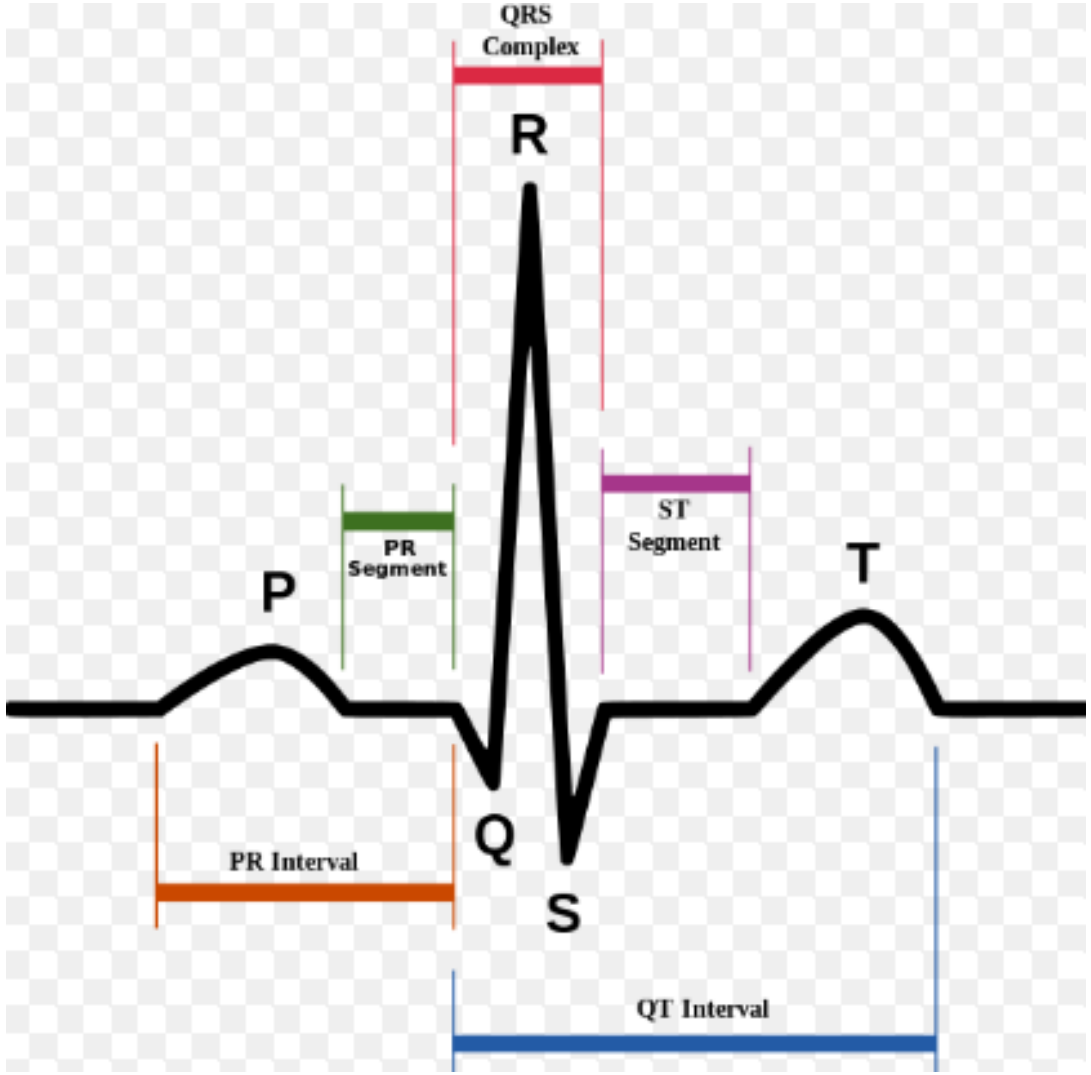
Introduction to ECGs and their interpretation

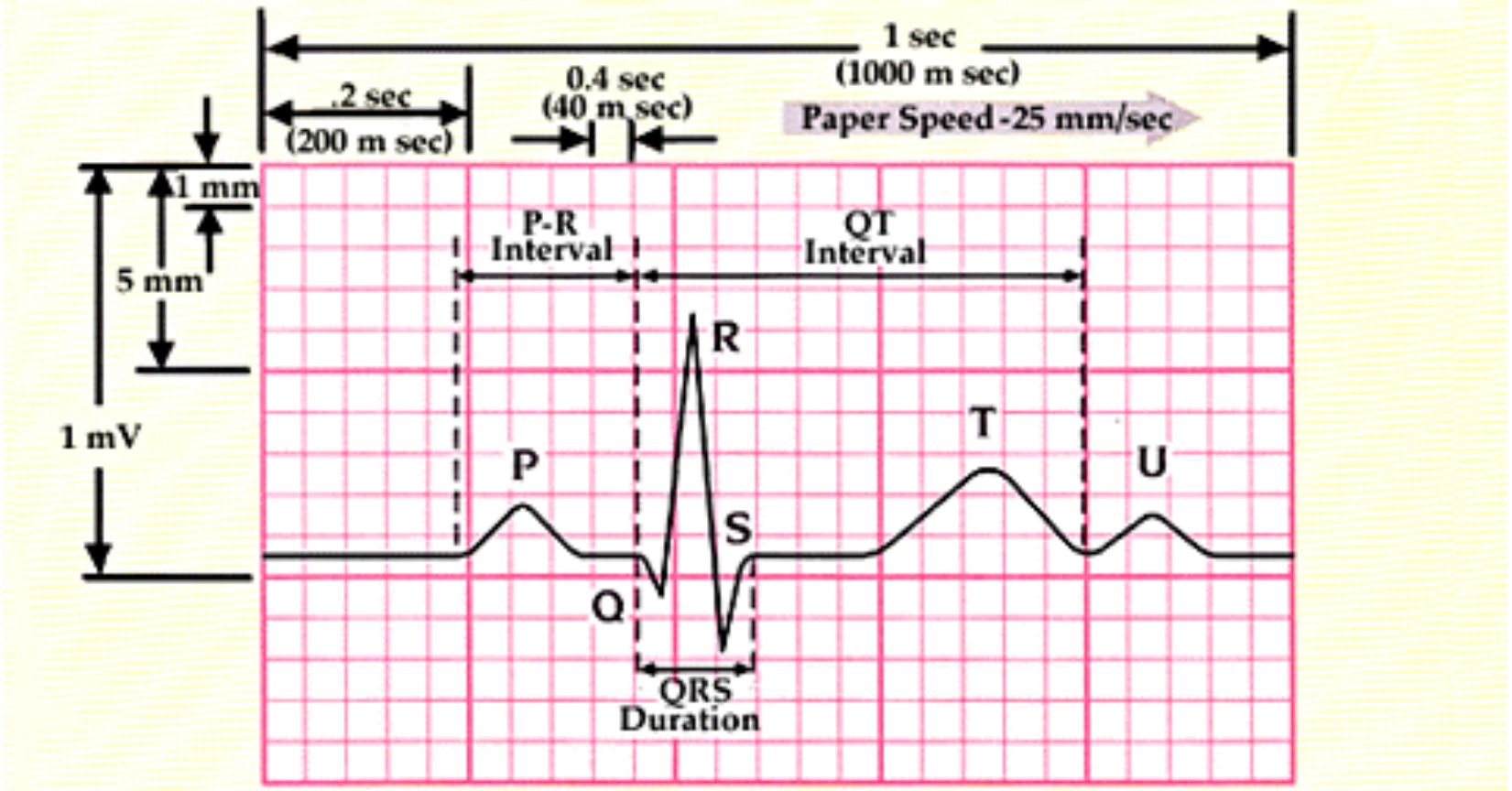


Learning Objectives for ECG Interpretation

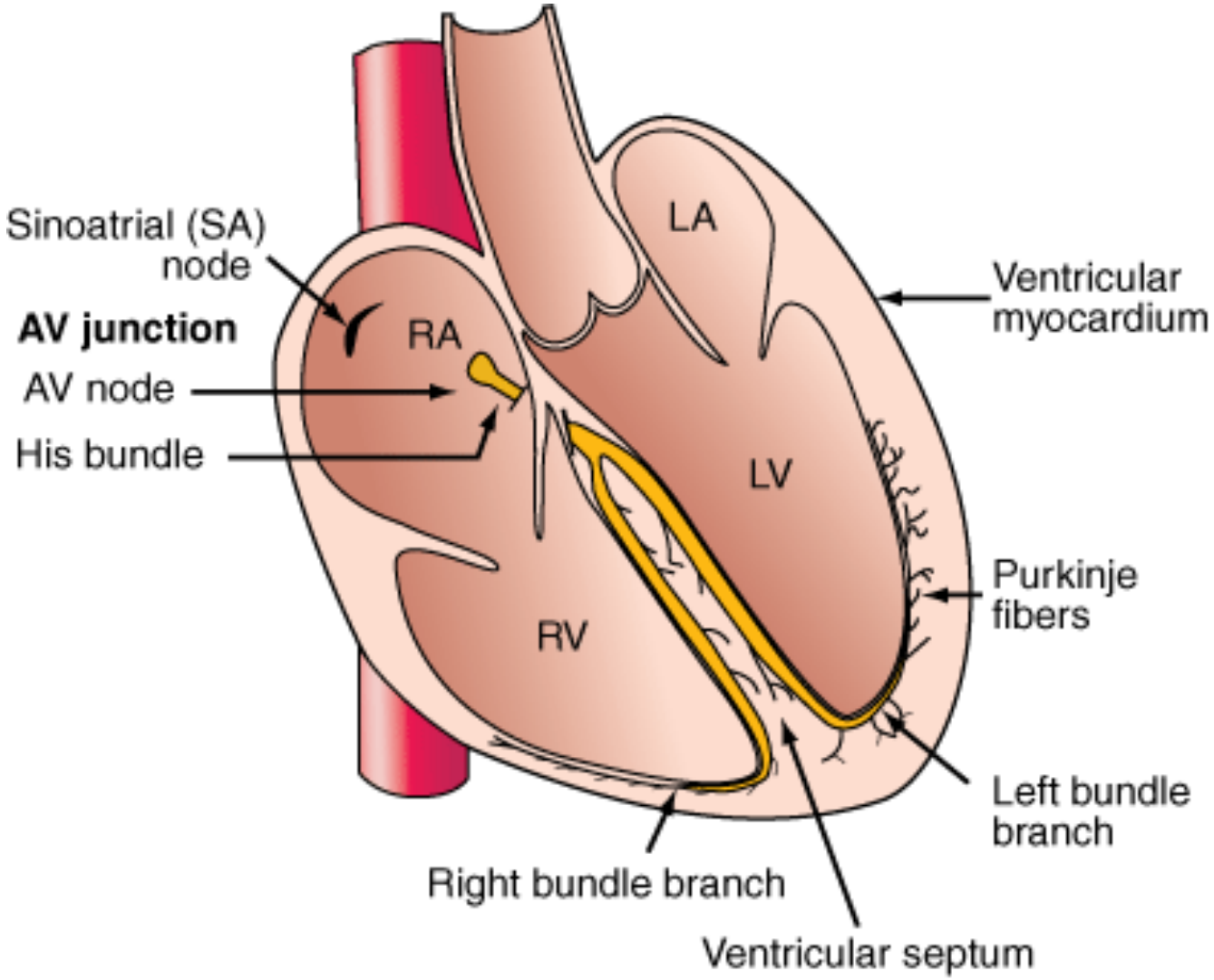
- Understand the electrophysiology of a normal ECG
- Having a systematic method to interpret ECGs including measuring the rate, rhythm and axis, measuring intervals and looking at ST segment for infarction
- Being able to detect AV heart block
- Being able to detect life threatening arrhythmias
- Being able to detect ischaemia and a myocardial infarction

Normal ECG trace



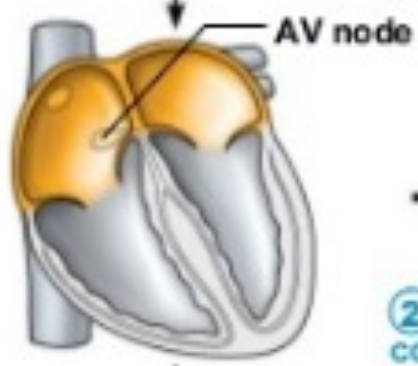


- Y axis=voltage, 1 mm (small box) = 0.1 mV
- X axis=time, 1 mm (small box) = 0.04 seconds

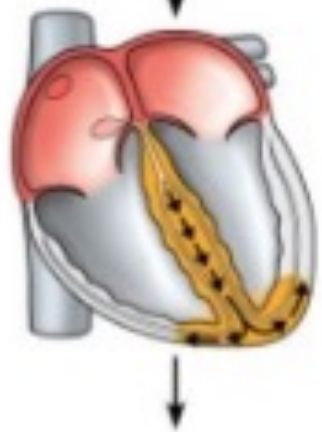


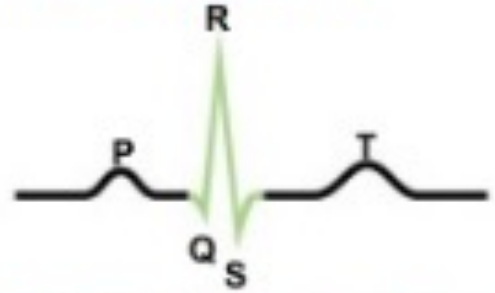
Source: Fauci AS, Kasper DL, Braunwald E, Hauser SL, Longo DL, Jameson JL, Loscalzo J: *Harrison's Principles of Internal Medicine*, 17th Edition: http://www.accessmedicine.com

① Atrial depolarization, initiated by the SA node, causes the P wave.

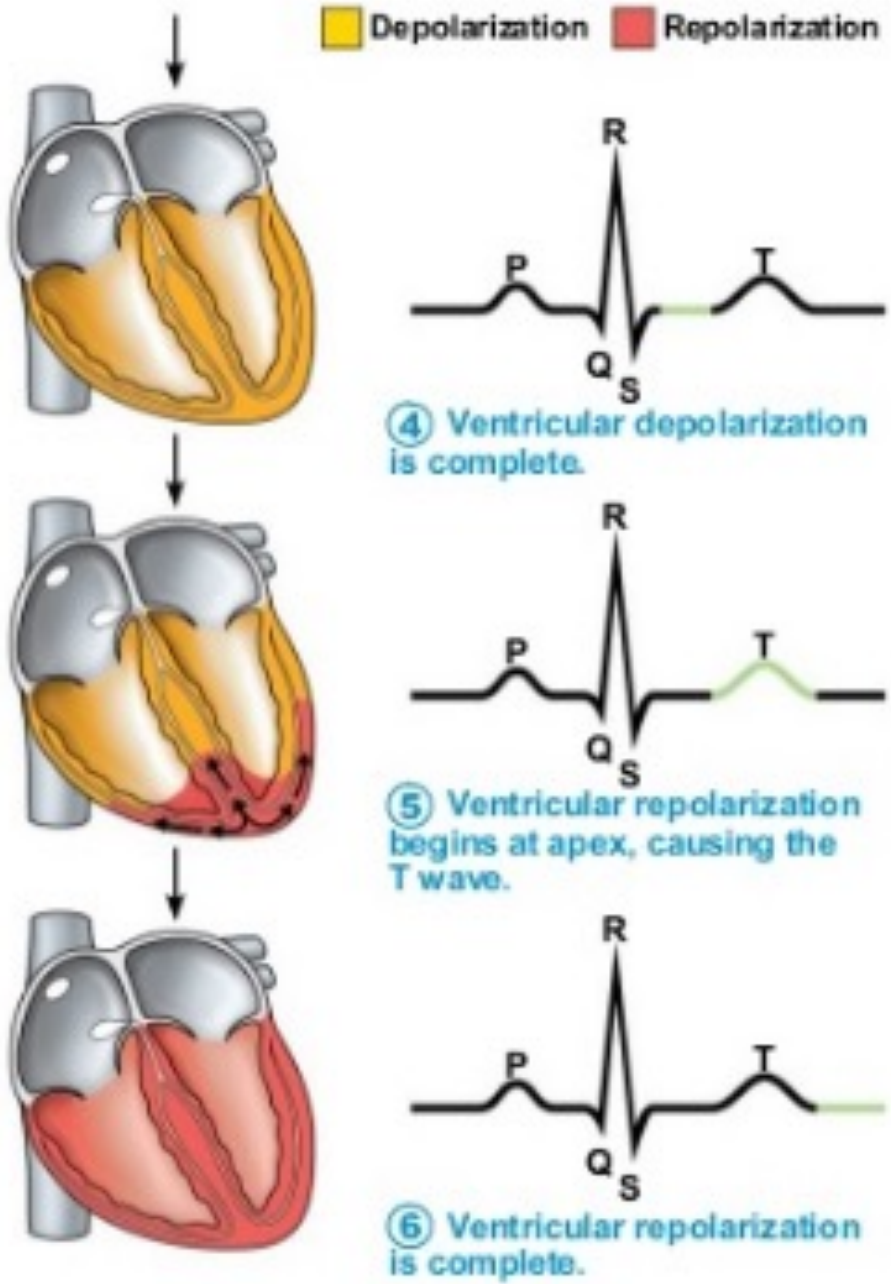


② With atrial depolarization complete, the impulse is delayed at the AV node.





③ Ventricular depolarization begins at apex, causing the QRS complex. Atrial repolarization occurs.


Depolarization
Repolarization
R
P
T
Q
S
④ Ventricular depolarization is complete.
R
P
T
Q
S
⑤ Ventricular repolarization begins at apex, causing the T wave.
R
P
T
Q
S
⑥ Ventricular repolarization is complete.

Summary

- P wave relates to atrial depolarisation

(normal time length 0.12 sec = 3 small squares on ECG trace)

- QRS complex relates to ventricular depolarisation

(normal time length 0.12sec = 3 small squares on ECG trace)

- T wave relates to ventricular repolarisation

(no strict criteria for width but need to look at ST segment for changes – myocardial ischaemia or infarction)

- PR interval (measured from beginning of P wave to beginning of QRS complex) should be between 0.12-0.21 sec (equivalent to 3-5 small squares).

  Represents time taken for atrial depolarisation and pass message to ventricles (involves SA node, atrial tissue and AV node)

Stepwise Approach to looking at an ECG

1) Check patient's ID and age

2) Check rate – normal, fast (tachycardia) or slow (bradycardia)?

Calculate the heart rate by dividing 300 by the number of big boxes between R waves

3) Check rhythm – sinus or not?

Sinus rhythm has a P wave followed by a QRS complex and every QRS complex has a preceding P wave

4) Check axis – normal or not?

If the QRS in Leads I and aVF are positive, the axis is normal

5) Check Intervals – long or short?

- PR interval — prolonged in heart blocks, short in Wolff Parkinson White (WPW)
- QRS interval — prolonged and wide - ventricular bundle branch block
- QT interval — prolonged with certain drugs – potentially dangerous

6) Check for ischaemia or infarction?

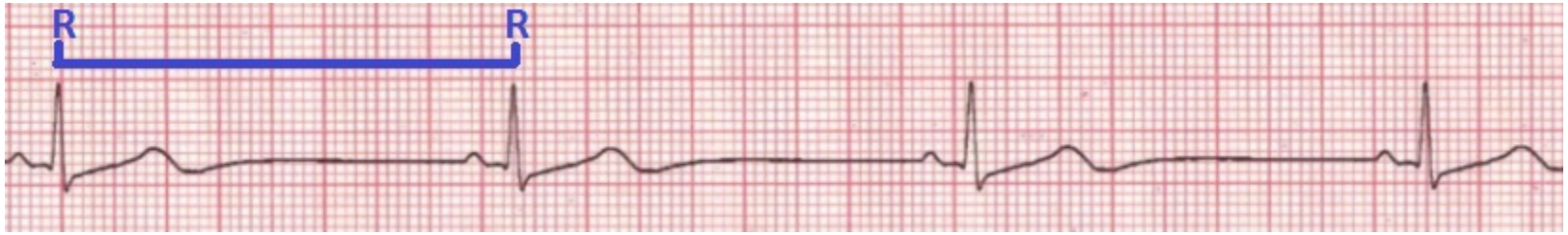
ST segment depression or elevation, Q waves or T wave inversion

7) Check for left ventricular hypertrophy

Step 2 - Check the rate

- **Check rate – normal, fast (tachycardia) or slow (bradycardia)?**

Calculate the heart rate by dividing 300 by the number of big boxes between R waves



R – R wave is 8.5 big boxes

Rate = 300 / number of big boxes

Rate = 300 / 8.5 = 35 beats per minute

1a. What is the rate in this ECG?

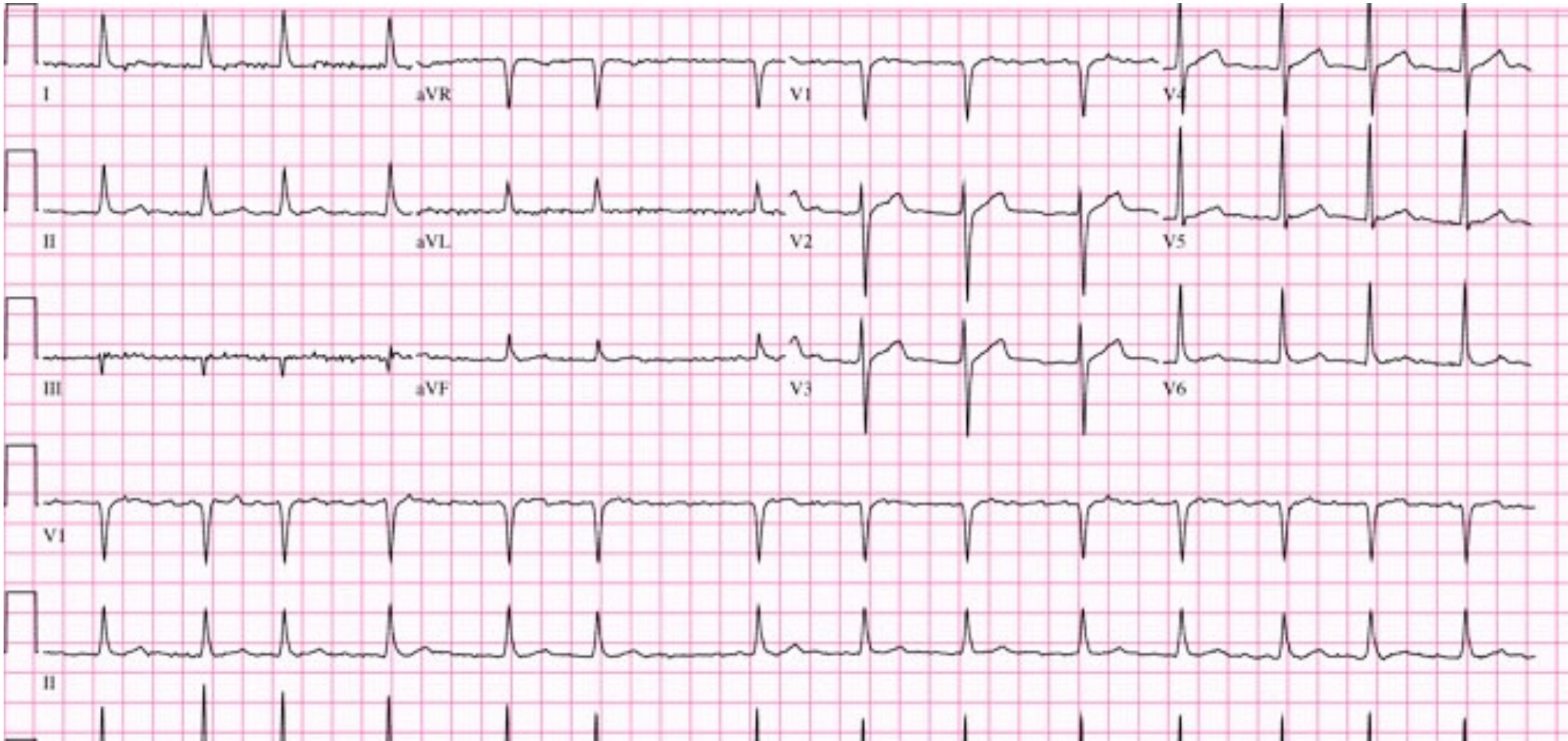
1b. What arrhythmia does this often signify?

2a. What is the rate in this ECG?
2b. What do you need to check clinically?

Step 3 – Check the rhythm

3a) Is this sinus rhythm?

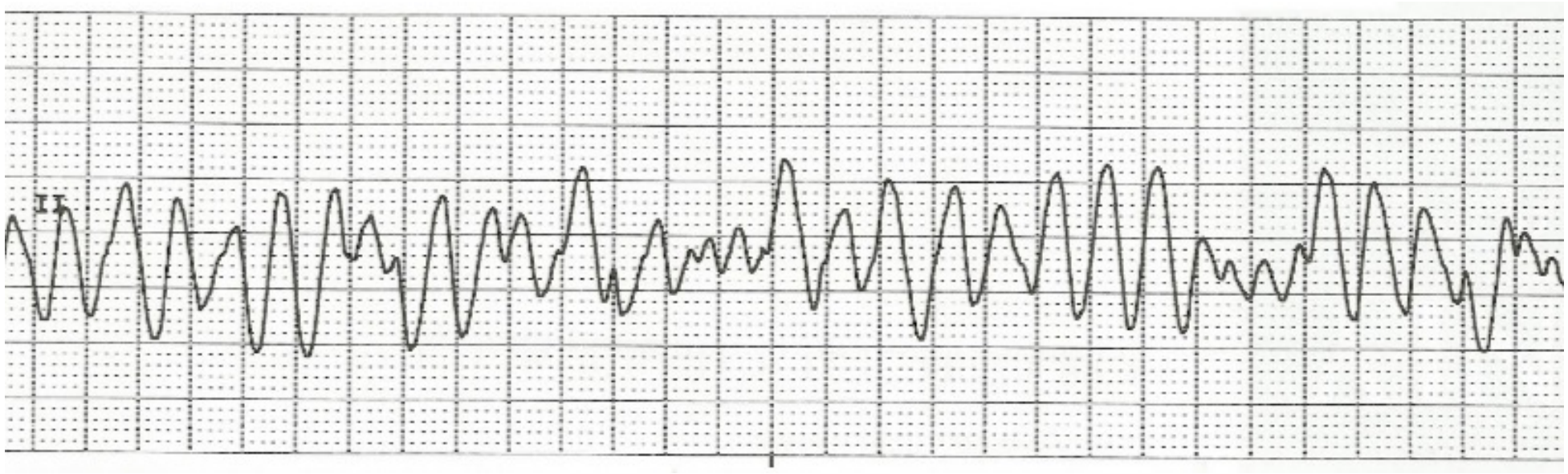
3b) If not what is it?



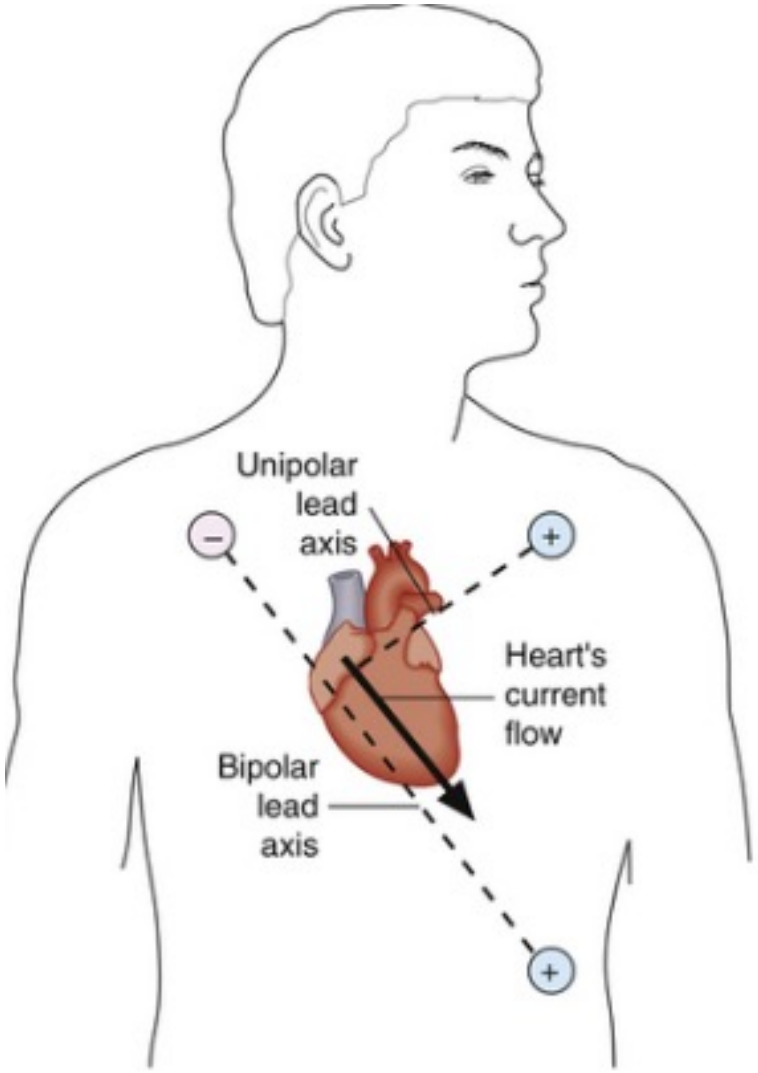
Premature ventricular ectopic

Sinus rhythm has a P wave followed by a QRS complex and every QRS complex has a preceding P wave

4a) What does this ECG show?
4b) What would you do if you saw this ECG in the clinical situation?

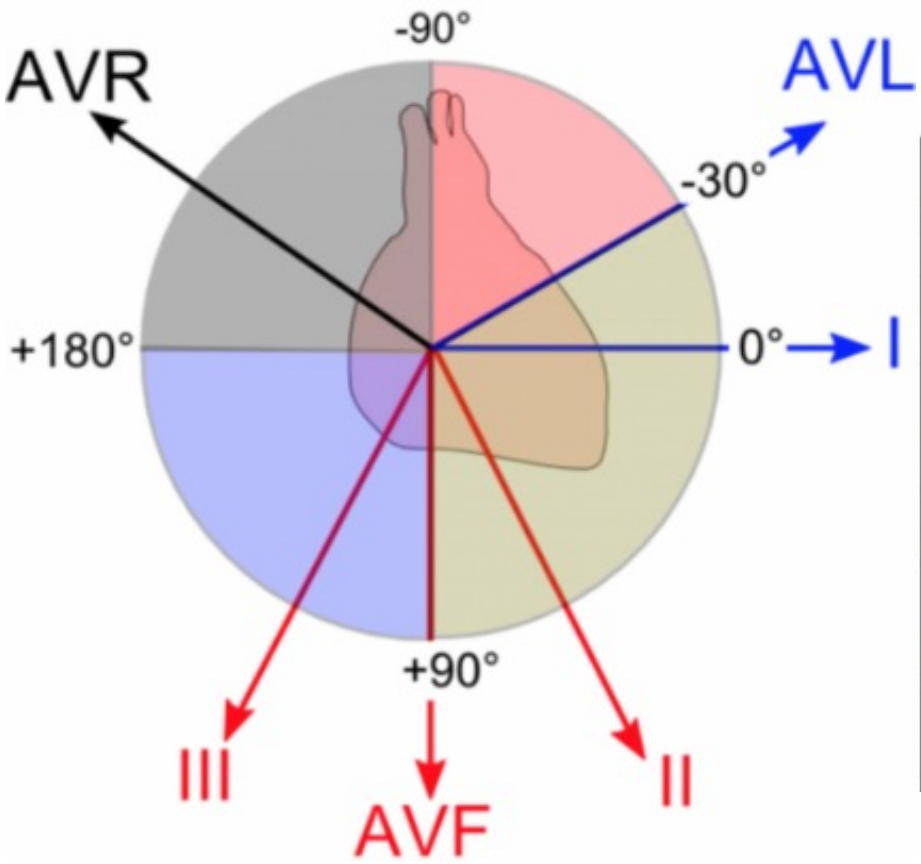


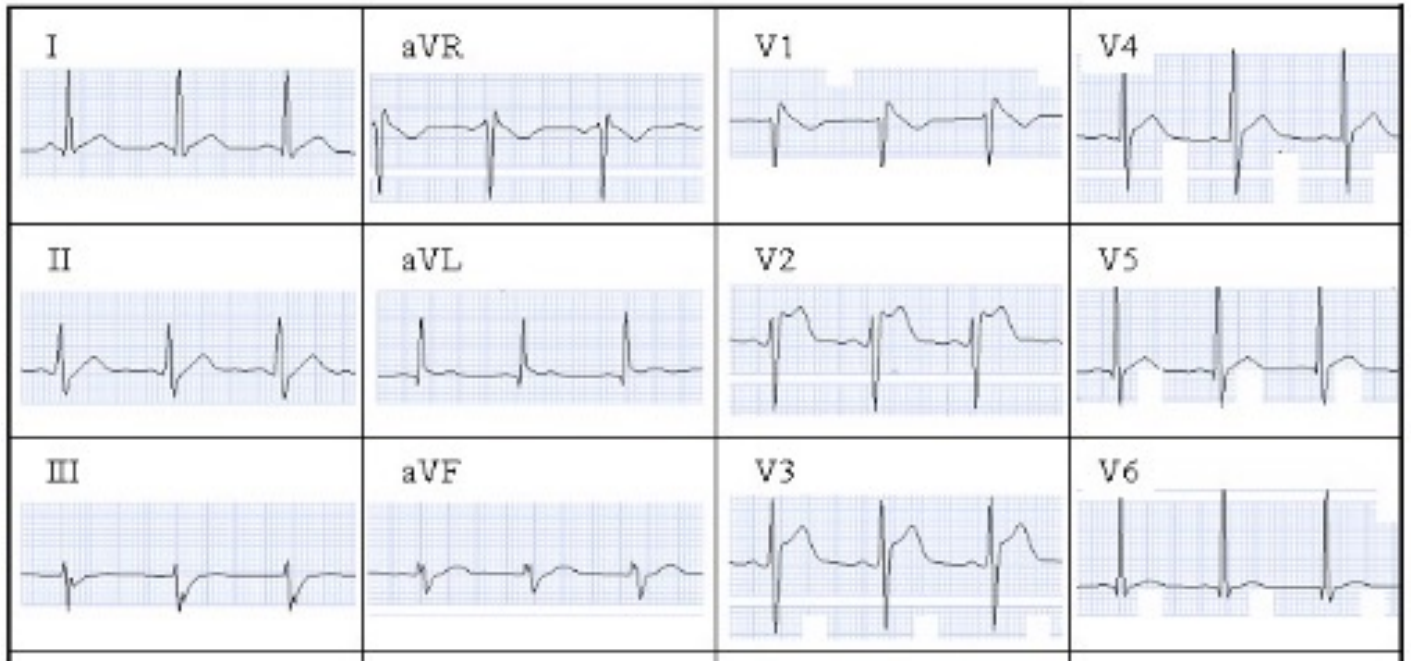
Step 4 – What is the axis?



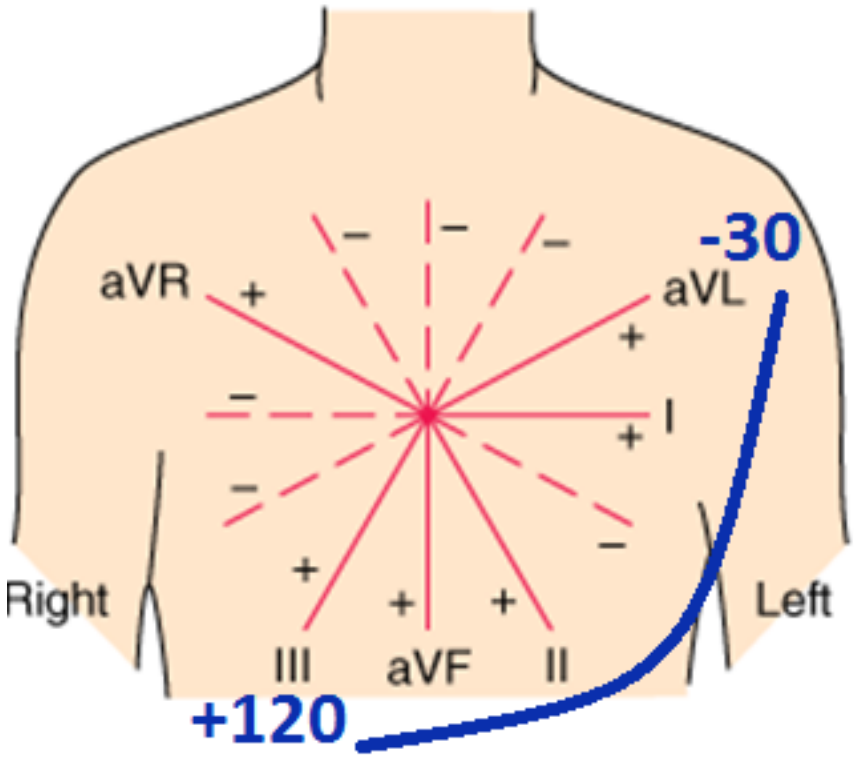

DON'T PANIC
I'm a towel

You need a 12 lead ECG to work out the axis



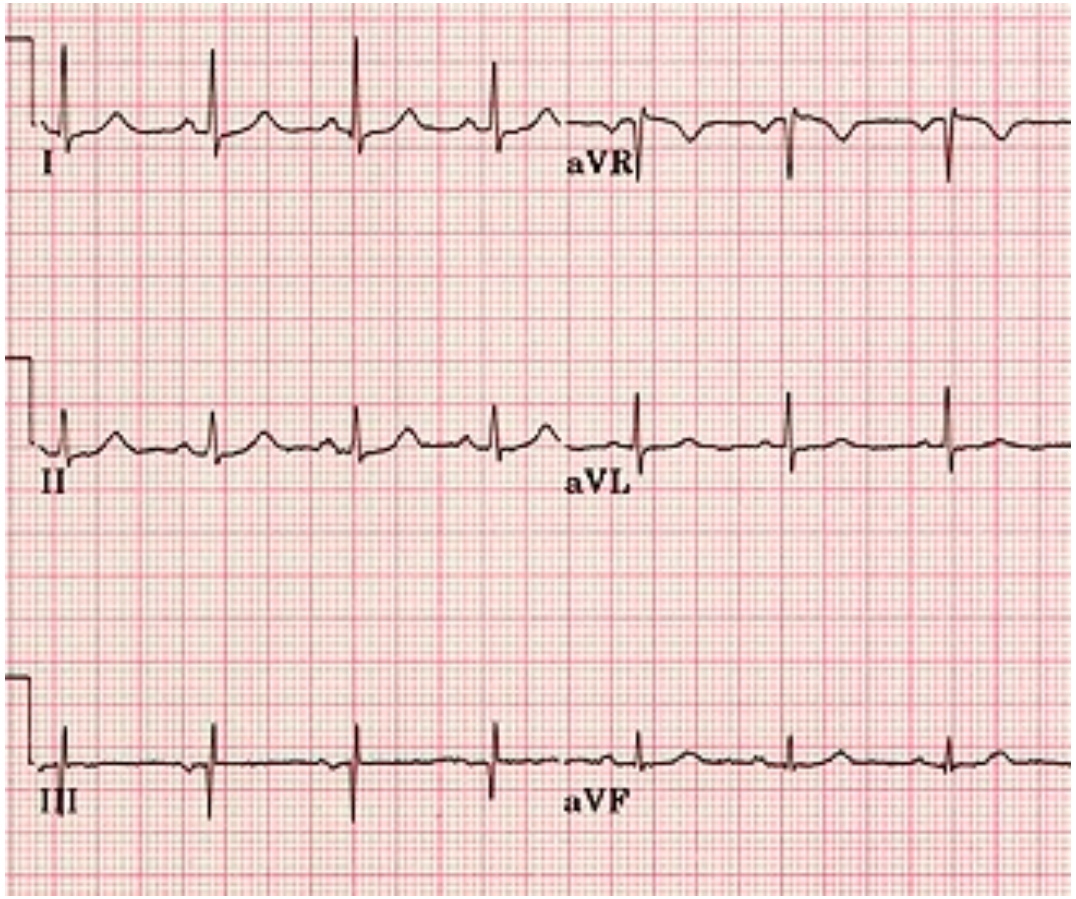


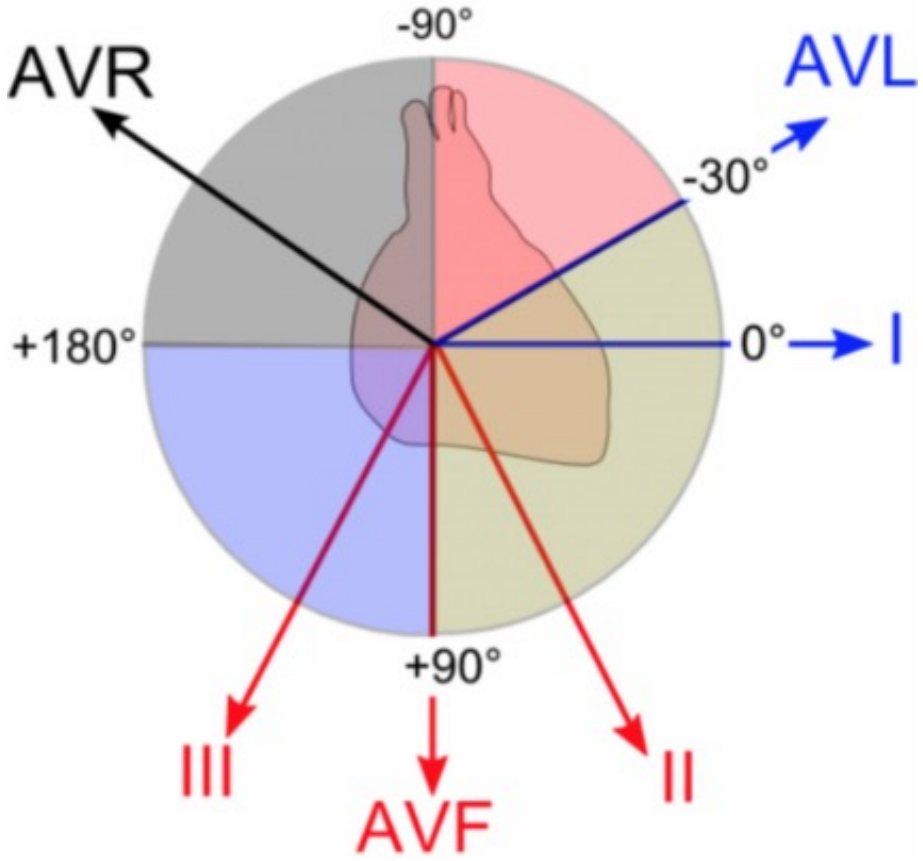
What is a normal axis?



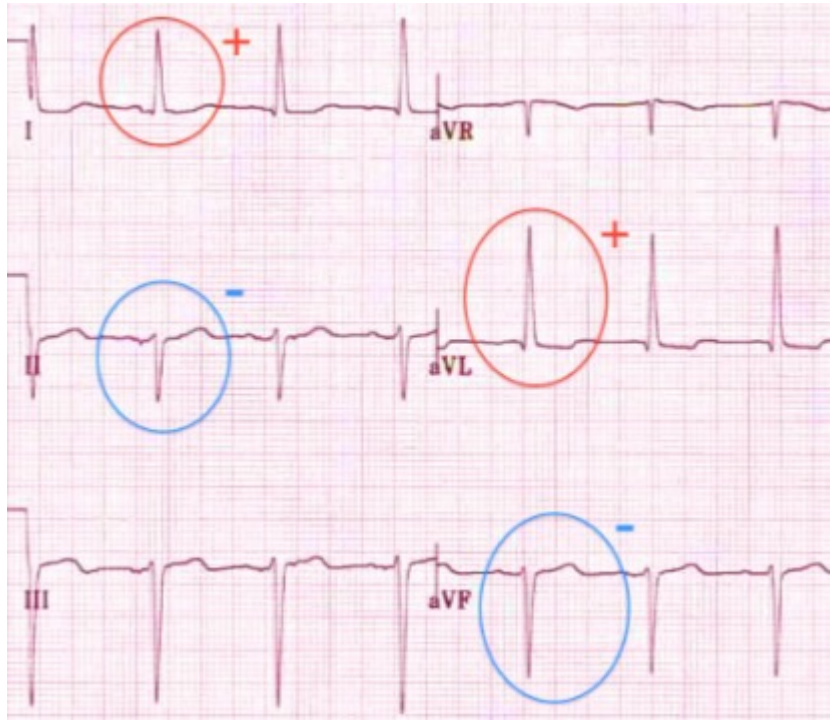
- Normal is anything from -30 to 110°
- If the QRS in Leads I and aVF are positive, the axis is normal

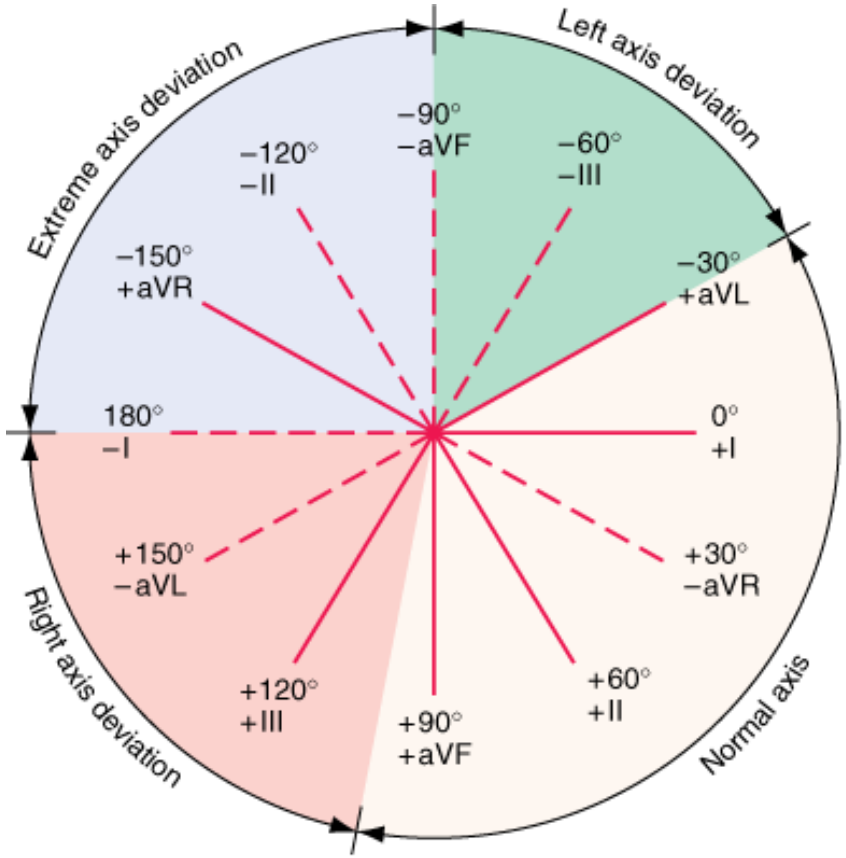
Quick look at axis use Leads I, II and III – where is the QRS complex more positive?





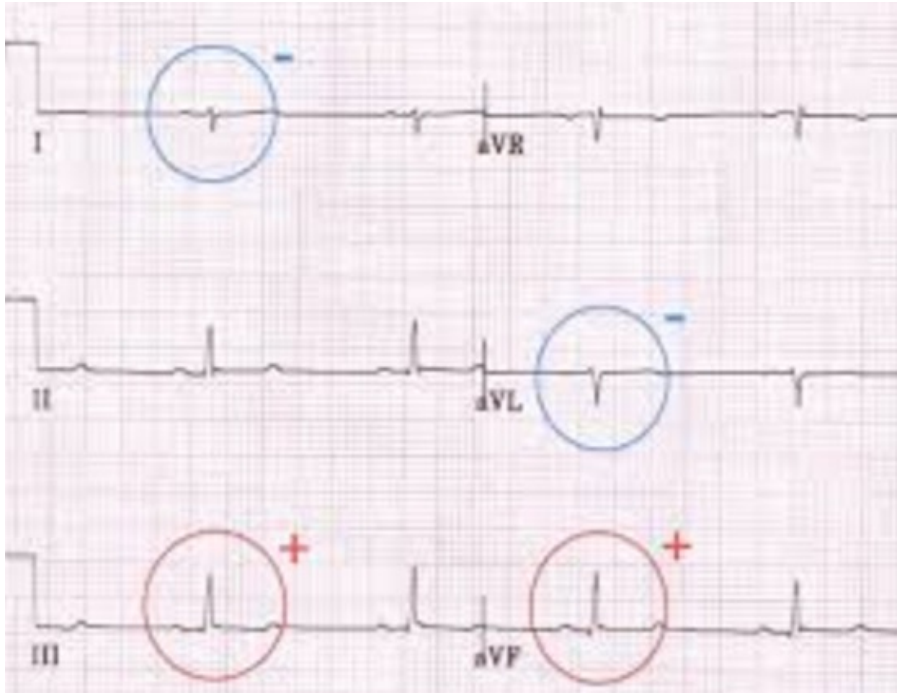
Left Axis Deviation

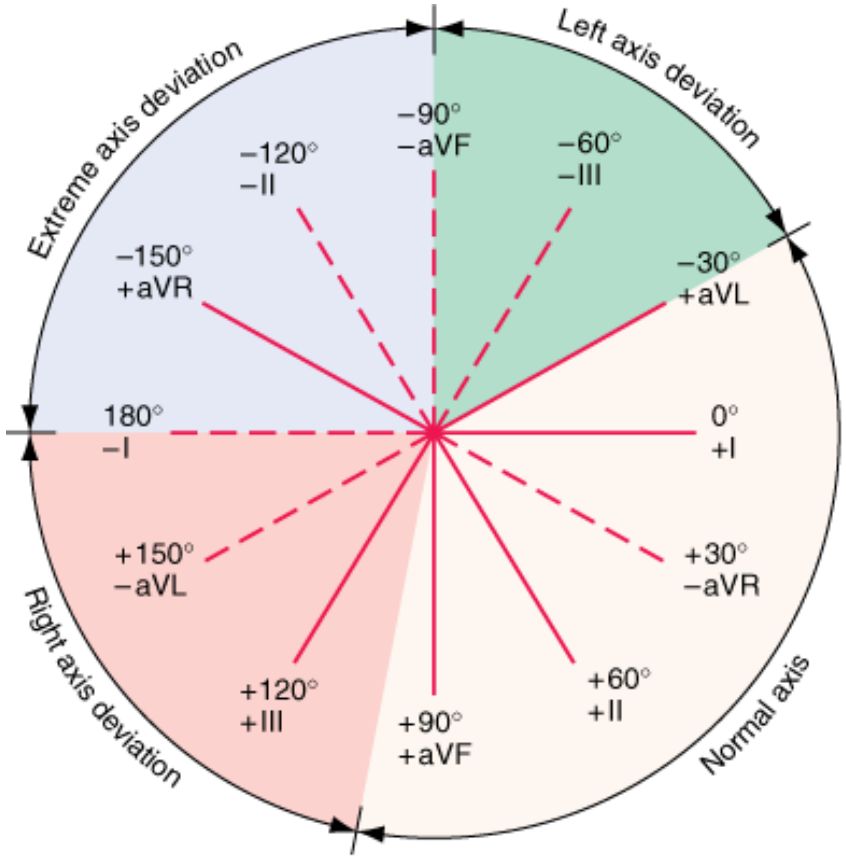




Source: Fauci AS, Kasper DL, Braunwald E, Hauser SL, Longo DL, Jameson JL, Loscalzo J: *Harrison's Principles of Internal Medicine*, 17th Edition: http://www.accessmedicine.com

Right Axis Deviation





Source: Fauci AS, Kasper DL, Braunwald E, Hauser SL, Longo DL, Jameson JL, Loscalzo J: *Harrison's Principles of Internal Medicine*, 17th Edition: http://www.accessmedicine.com

Causes of axis deviation

Left Axis Deviation

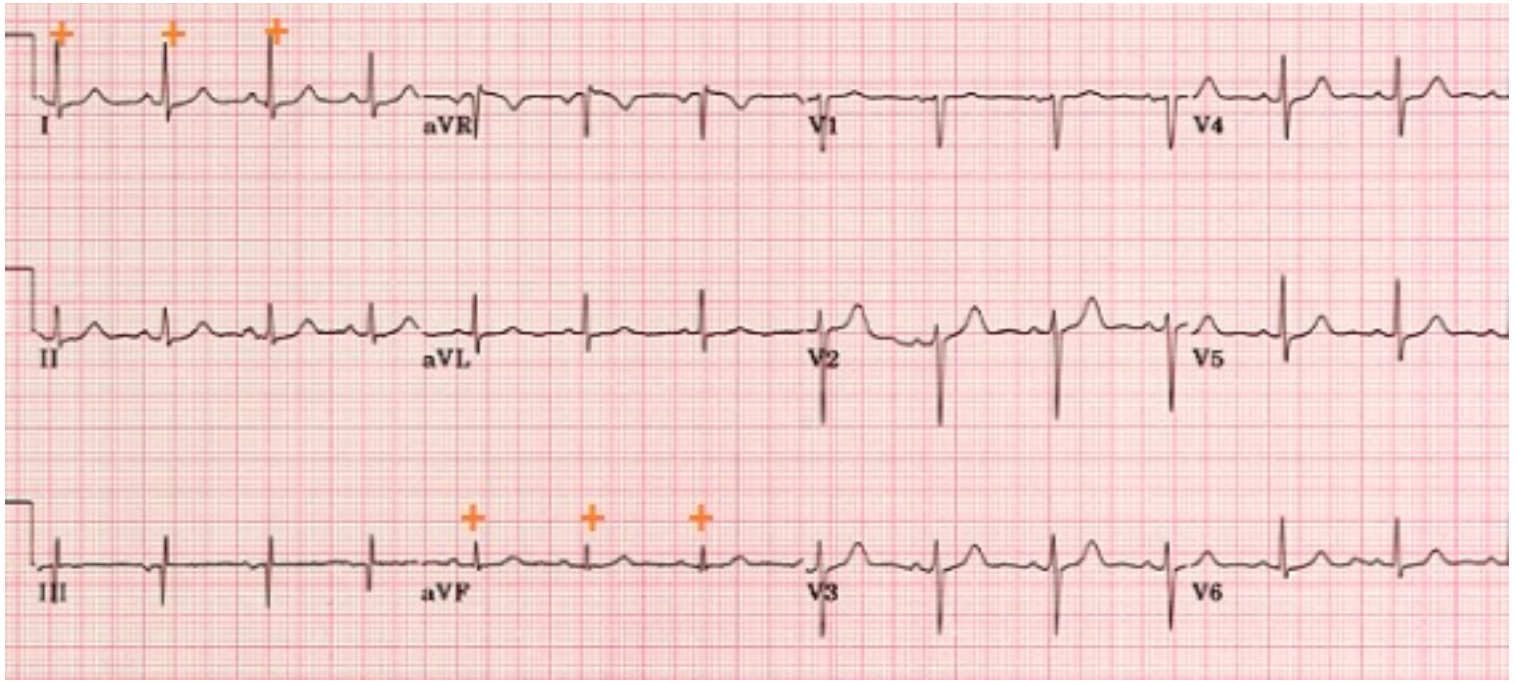
- Normal variation
- Left ventricular hypertrophy (LVH)
- Mechanical shift e.g. ascites, abdominal tumour, pregnancy…
- Left anterior hemiblock
- Left Bundle Branch Block (LBBB)
- Wolff Parkinson White (WPW)
- Hyperkalaemia

Right Axis Deviation

- Arrhythmias
- Right Ventricular Hypertrophy
- Mechanical shifts e.g. COPD
- Pulmonary Embolus
- Left posterior hemiblock
- Right Bundle Branch Block (RBBB)
- WPW

Summary of axis

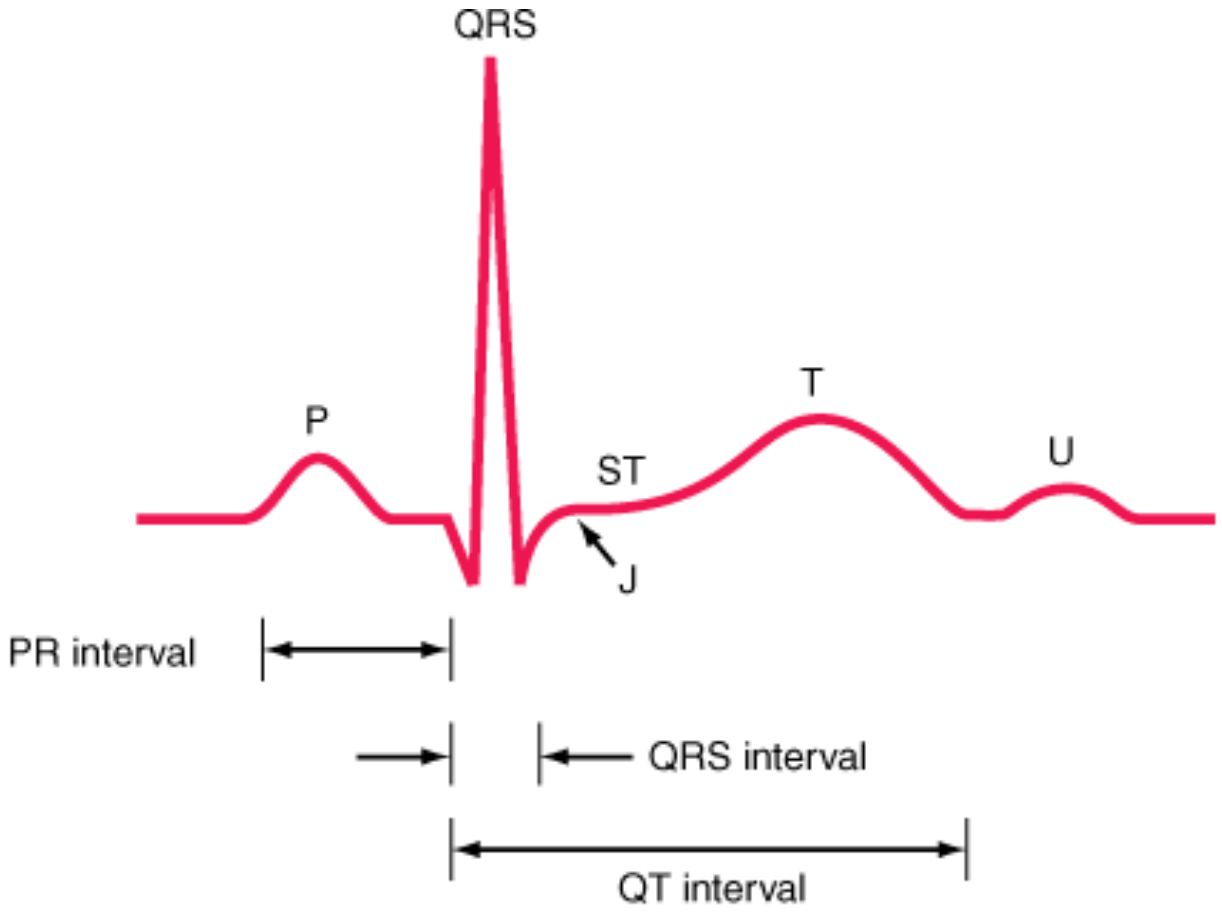
If the QRS complex in Leads I and aVF are positive, the axis is normal



If Lead I is positive and aVF negative it is likely Left Axis Deviation

If Lead I is negative and aVF positive it is likely Right Axis Deviation

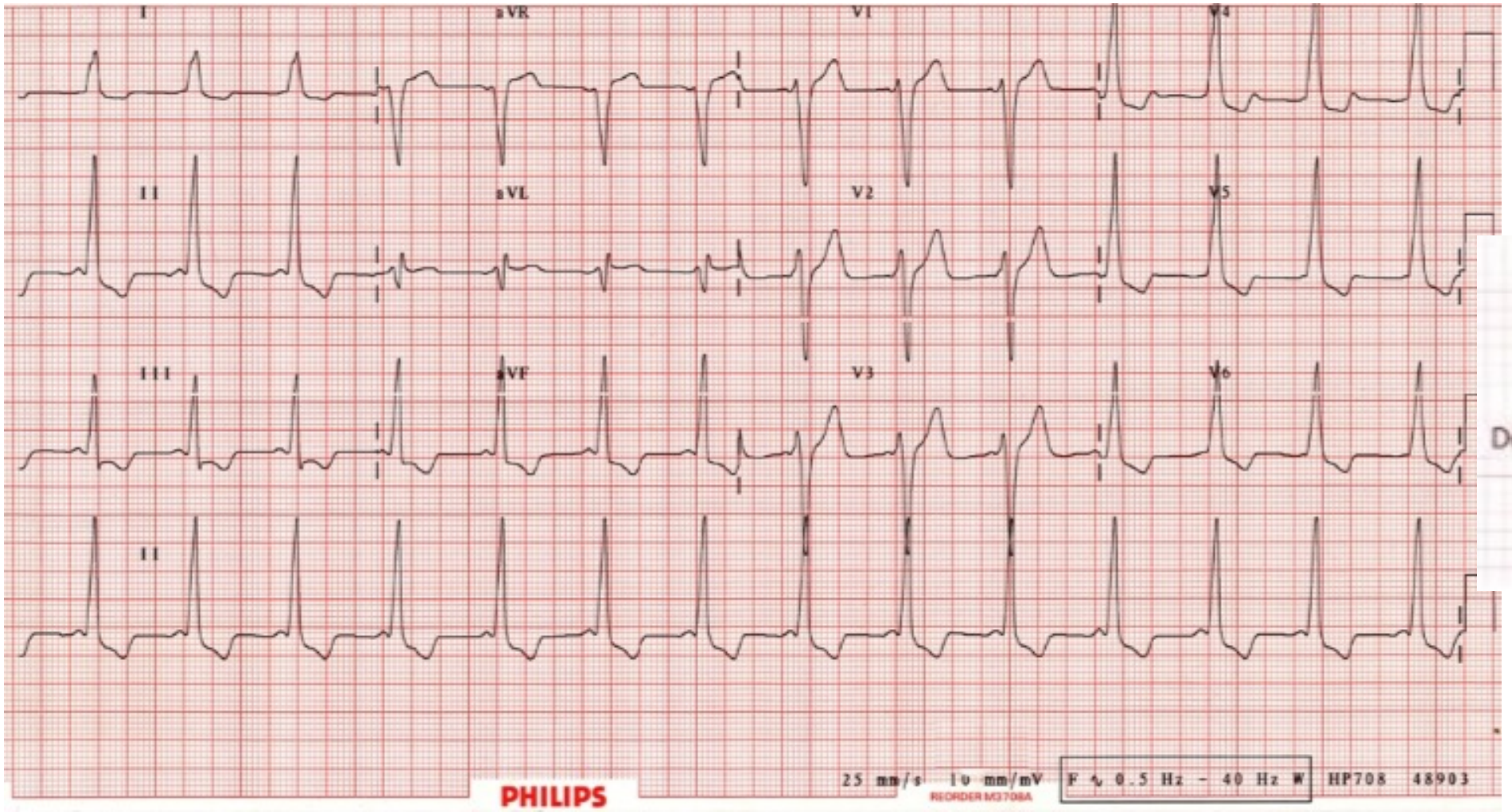
Step 5 – Check intervals

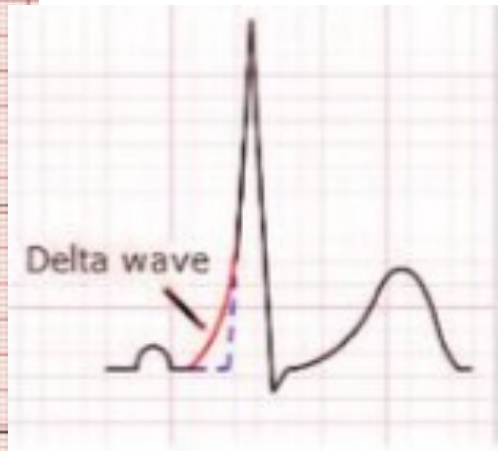


Source: Fauci AS, Kasper DL, Braunwald E, Hauser SL, Longo DL, Jameson JL, Loscalzo J: *Harrison's Principles of Internal Medicine*, 17th Edition: http://www.accessmedicine.com

- **PR interval of 0.12-0.20 sec (3-5 small squares) is normal**
- **QRS interval less than 0.10-0.12sec (2.5-3 squares) is normal**
- **QT interval less than half the R-R rate is grossly normal (depends on heart rate) – less than 0.445 sec (11 small squares) is normal**

Short PR interval – Wolf-Parkinson White





Prolonged PR interval – AV heart block

- 1st degree AV block = PR>0.20s, no variation

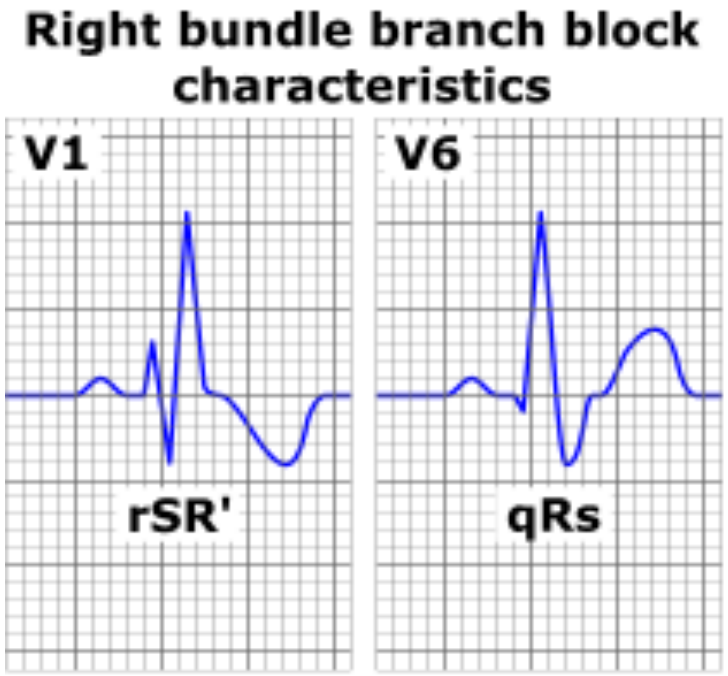
- 2nd degree AV block (Mobitz I) = progressive lengthening of PR with eventual dropped QRS

Prolonged PR interval - Heart Block

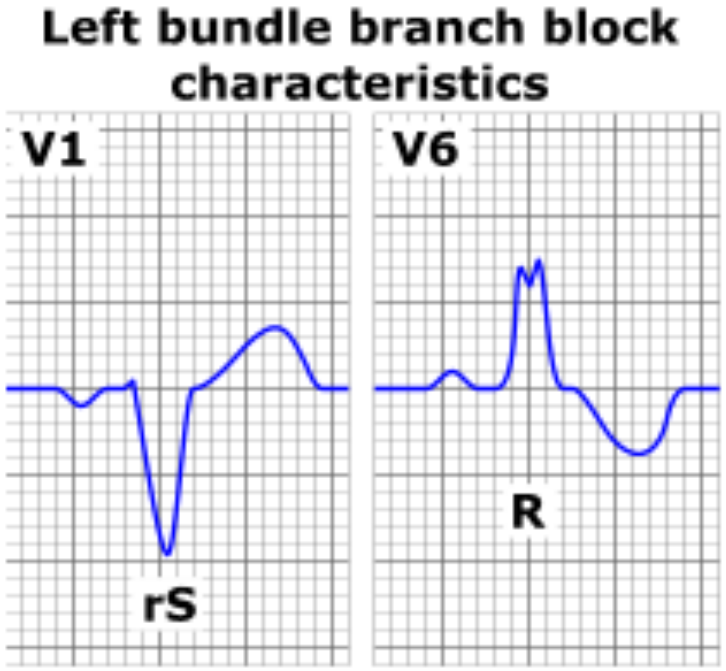
- 2nd degree AV heart block (Mobitz II) = fixed PR with dropped QRS

- 3rd degree AV heart block = complete dissociation of P and QRS

QRS interval prolonged

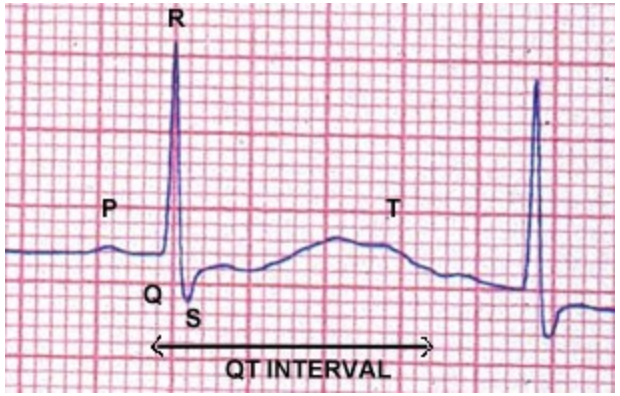


Normal variant, IHD, right ventricular hypertrophy, PE, congenital disease e.g. VSD



IHD, MI, hypertension, dilated cardiomyopathy, aortic stenosis, Lenegre disease, hyperkalaemia, digoxin toxicity

Prolonged QT interval

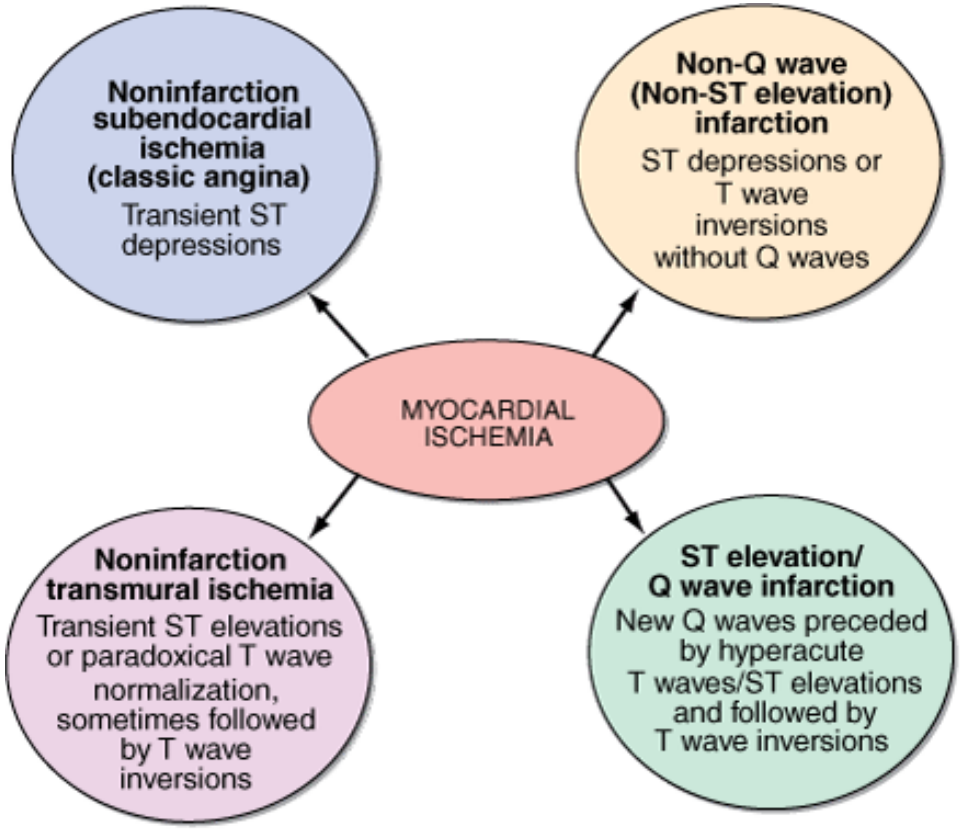


If QT is grossly more than half the R-R distance
it is abnormal
Risk factor for faints, blackouts and sudden death

<u>Common drugs that cause QT prolongation</u>

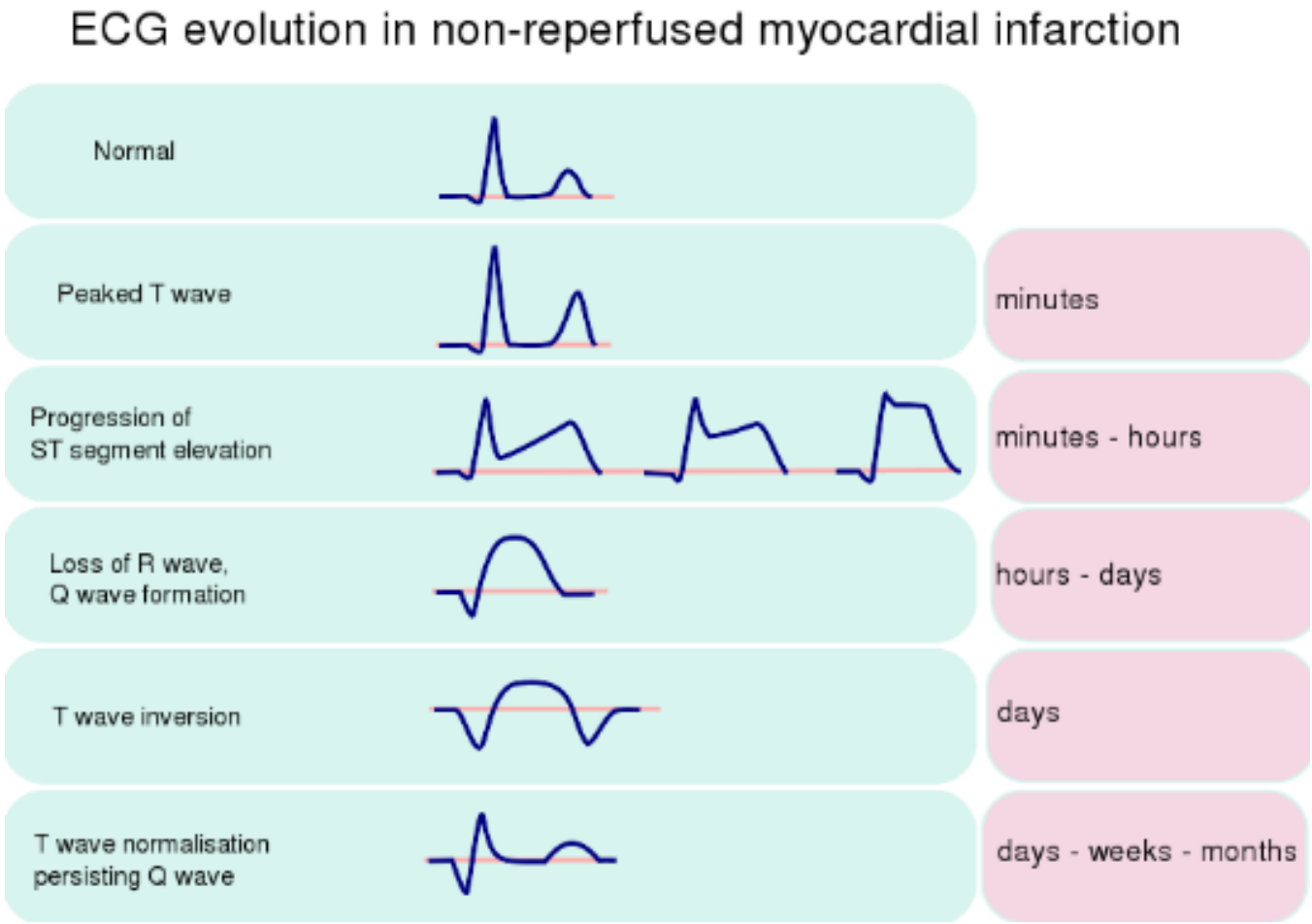
- Some antihistamines e.g. loratadine, terfinadine
- Some antibiotics e.g. erythromycin, clarithromycin, chloroquine
- Tricyclic antidepressants e.g. amitriptyline, imipramine
- Other antidepressants e.g. venlaflaxine, citalopram, escitalopram
- Antipsychotics e.g. quetiapine, haloperidol, olanzapine

Step 6 – Review ST segment – ischaemia or not?

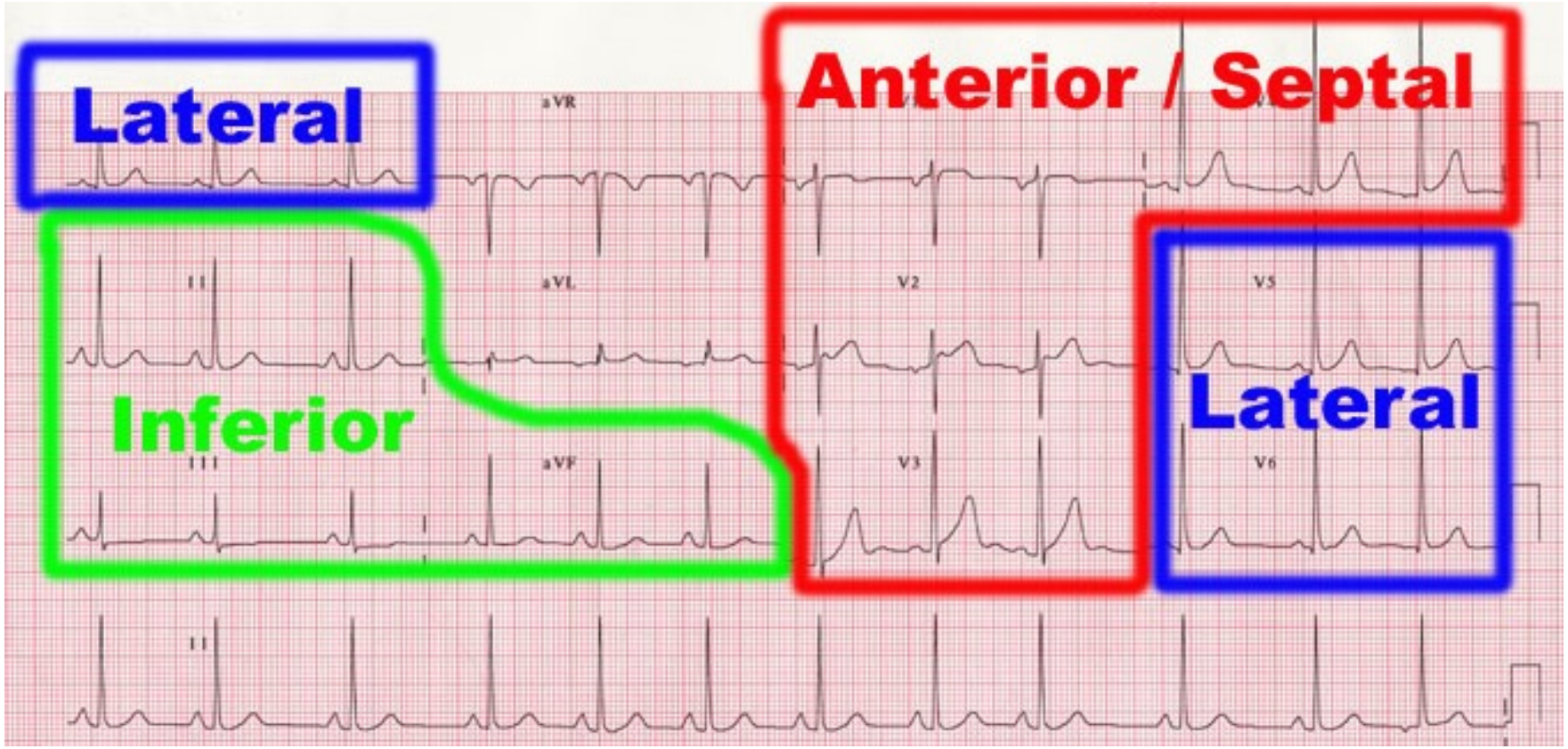


Source: Fauci AS, Kasper DL, Braunwald E, Hauser SL, Longo DL, Jameson JL, Loscalzo J: *Harrison's Principles of Internal Medicine*, 17th Edition: http://www.accessmedicine.com

Classical natural progression of MI on ECG

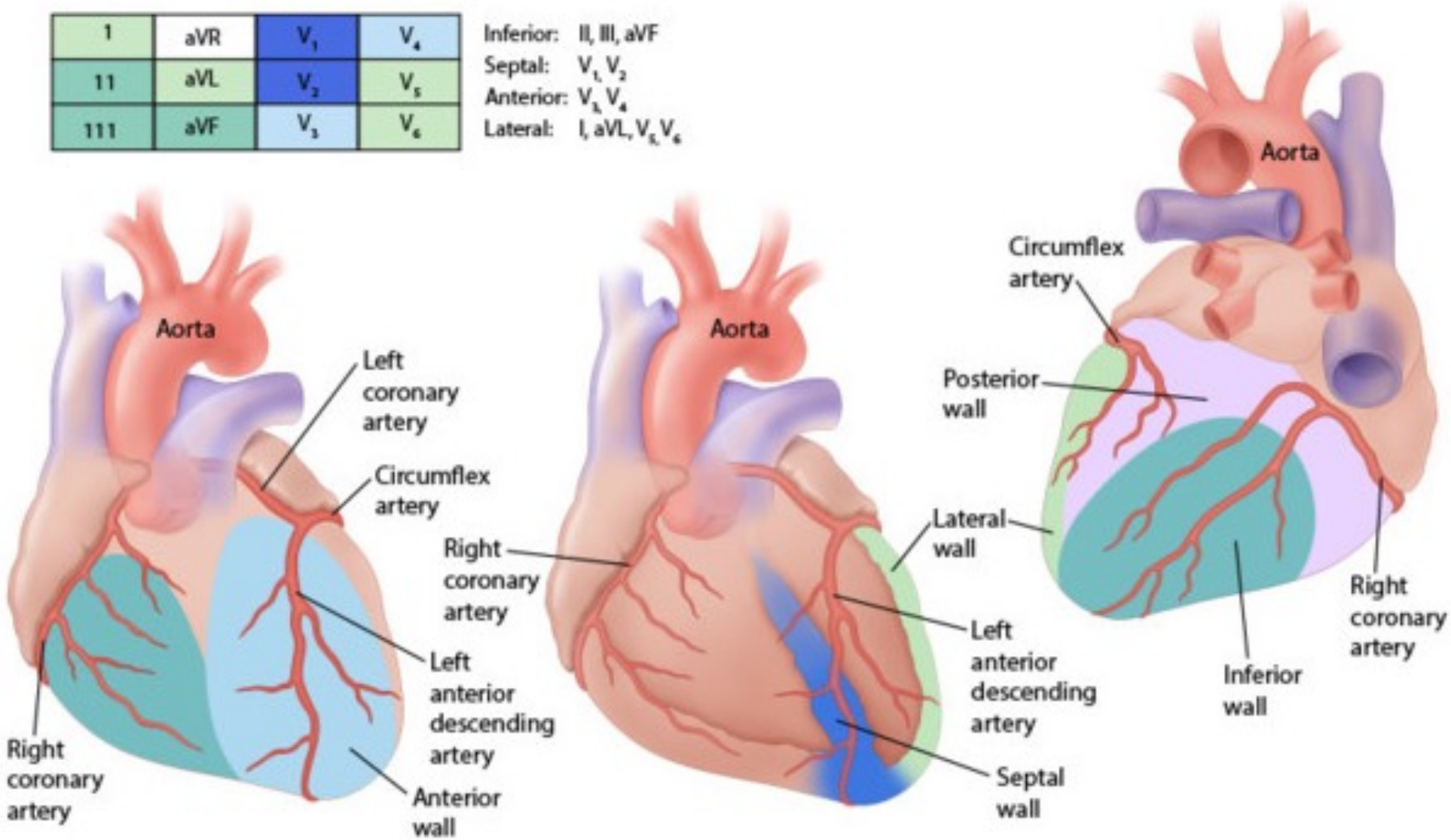


Which leads relate to which part of the heart?

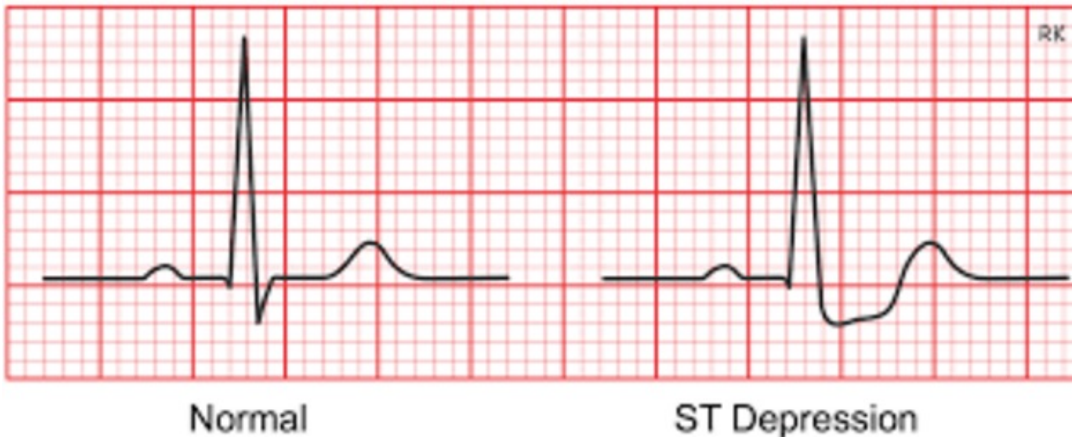


1	aVR	V_1	V_4
11	aVL	V_2	V_5
111	aVF	V_3	V_6

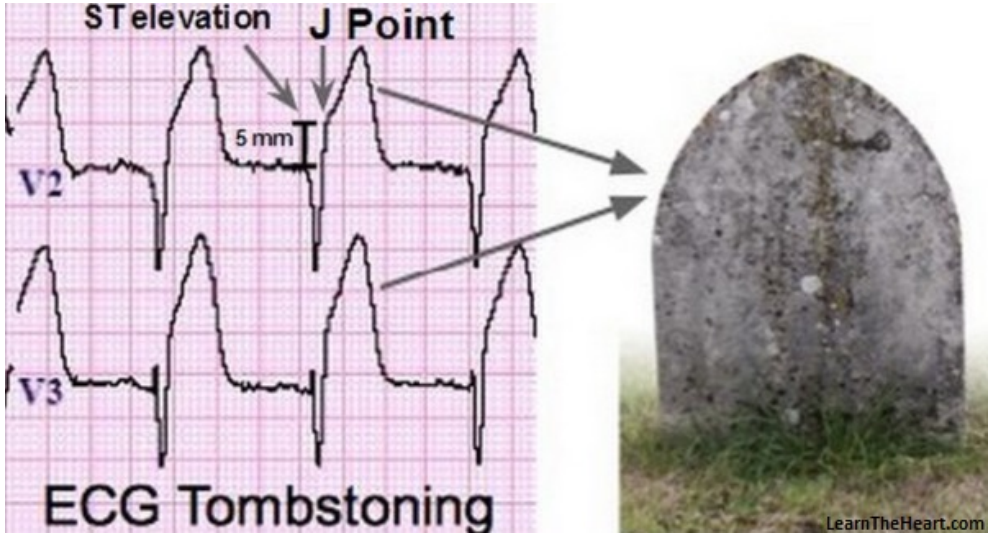
Inferior: II, III, aVF
Septal: V_1, V_2
Anterior: V_3, V_4
Lateral: I, aVL, V_5, V_6



ST segment changes



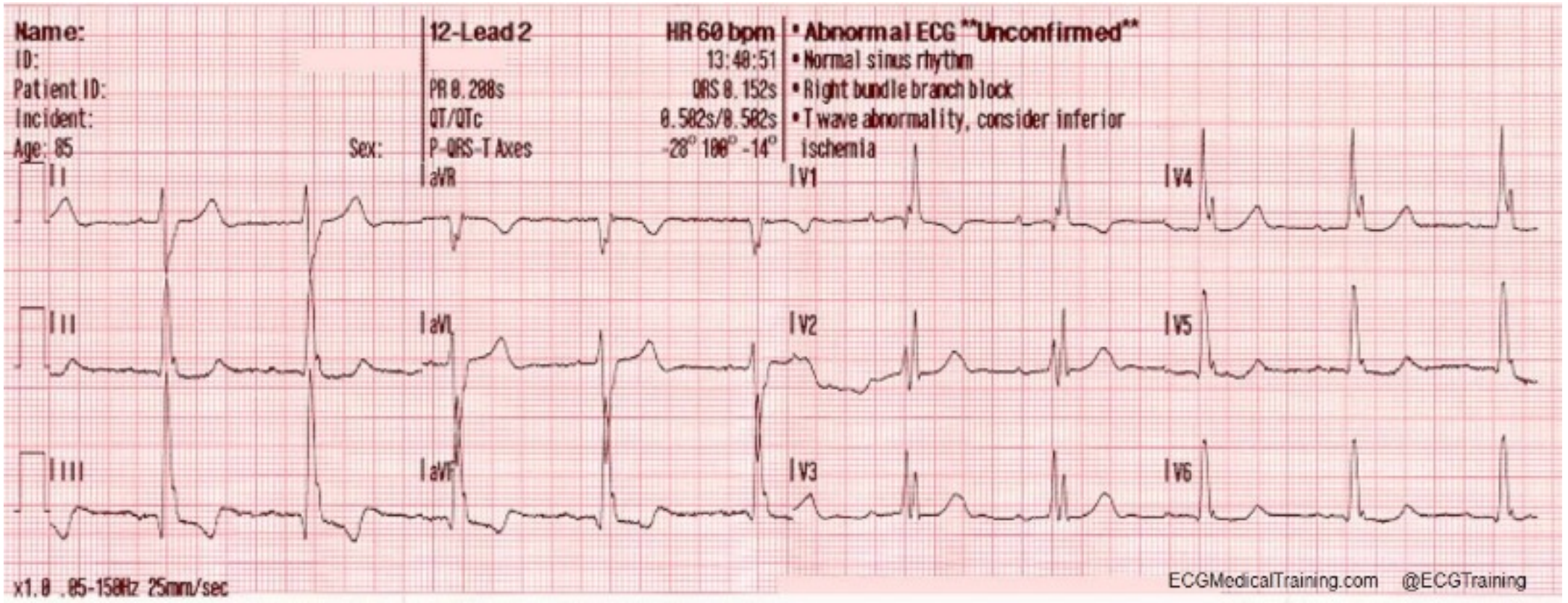
ST depression occurs in myocardial ischaemia or Non-ST Elevation MI (non-STEMI)



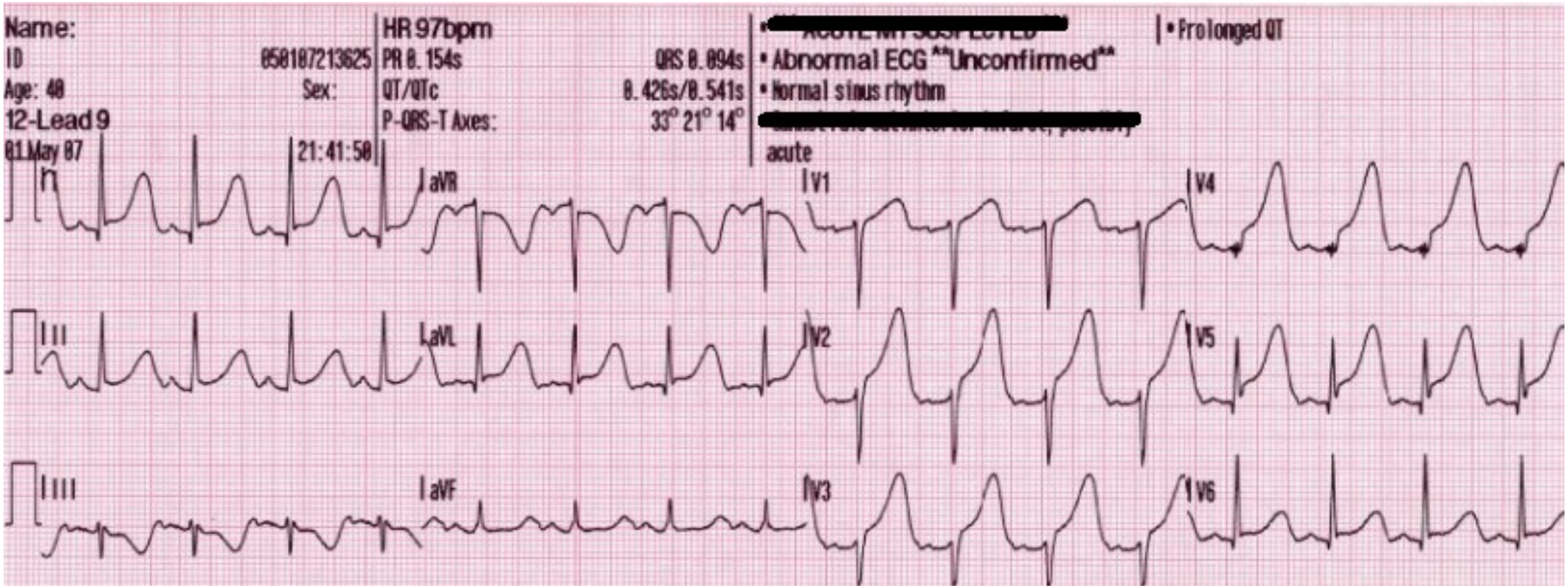
Criteria for ST Elevation MI (STEMI)

- Increase of 0.1mV (1 small squares) in ***two*** subsequent leads II, III, aVF or I, aVL
- Increase of 0.2mV (2 small squares) in ***two*** subsequent leads V2-V6
- New LBBB

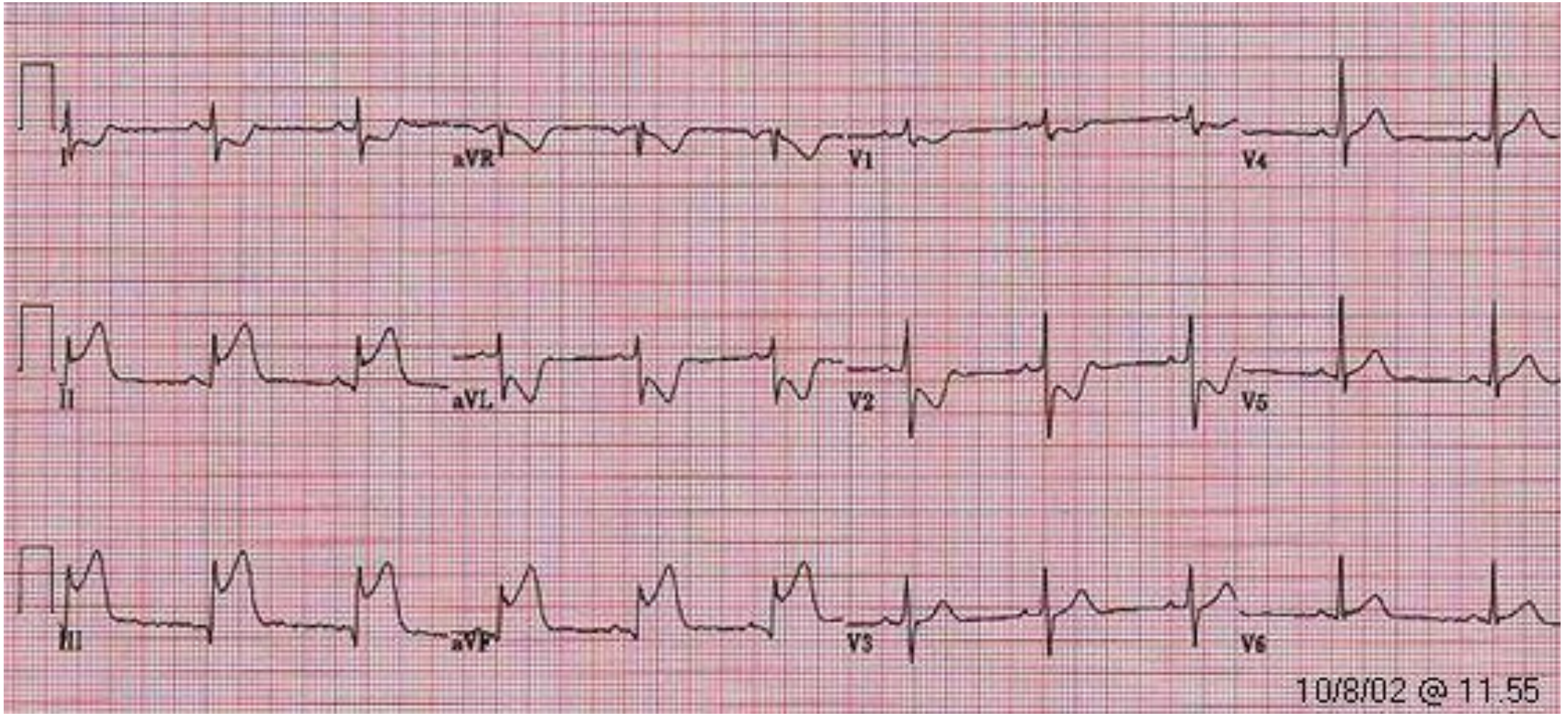
5) Which leads show myocardial ischaemia?



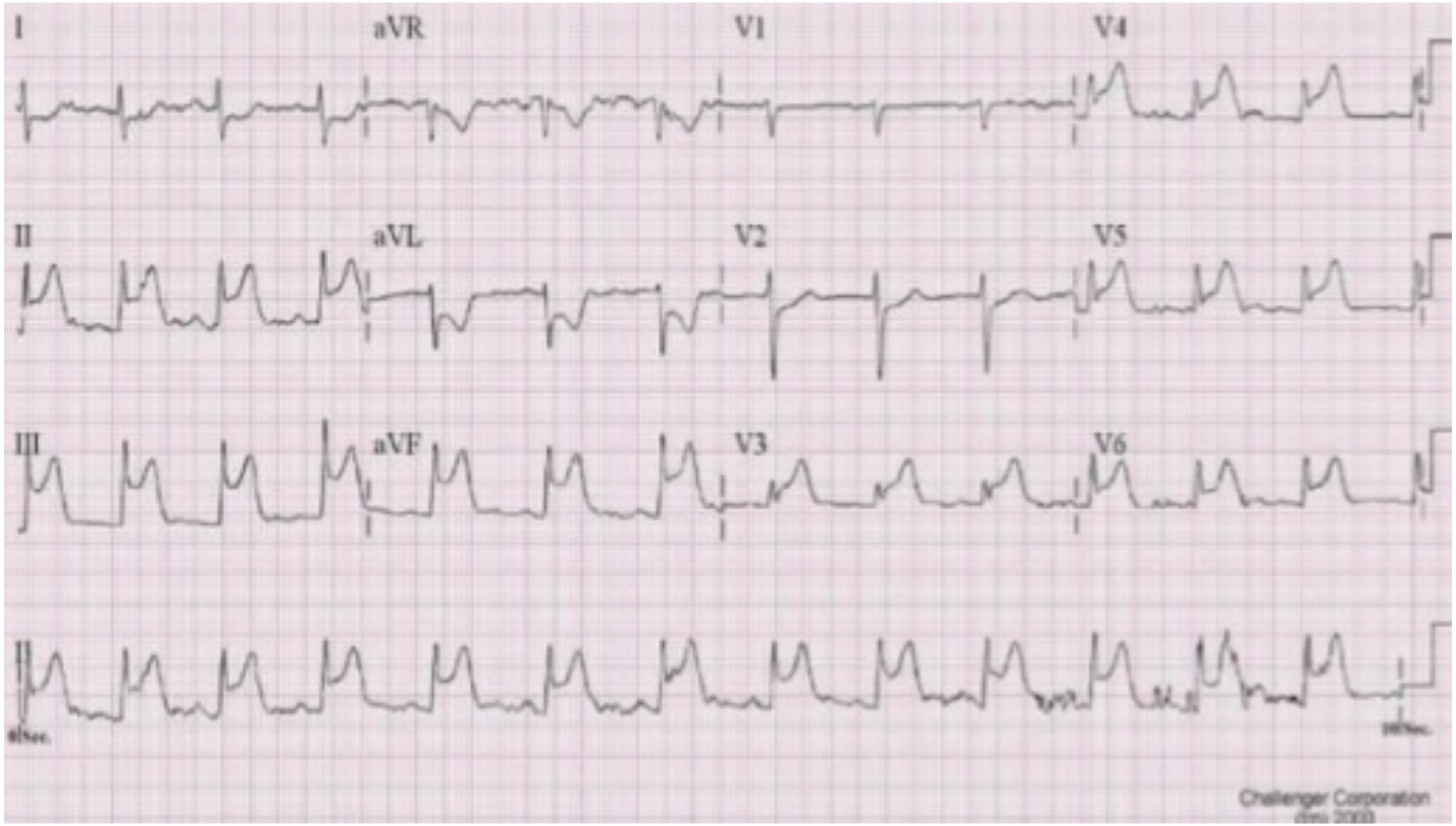
6a) In which leads do you suspect an acute MI?
6b) Which coronary artery does this correspond to?



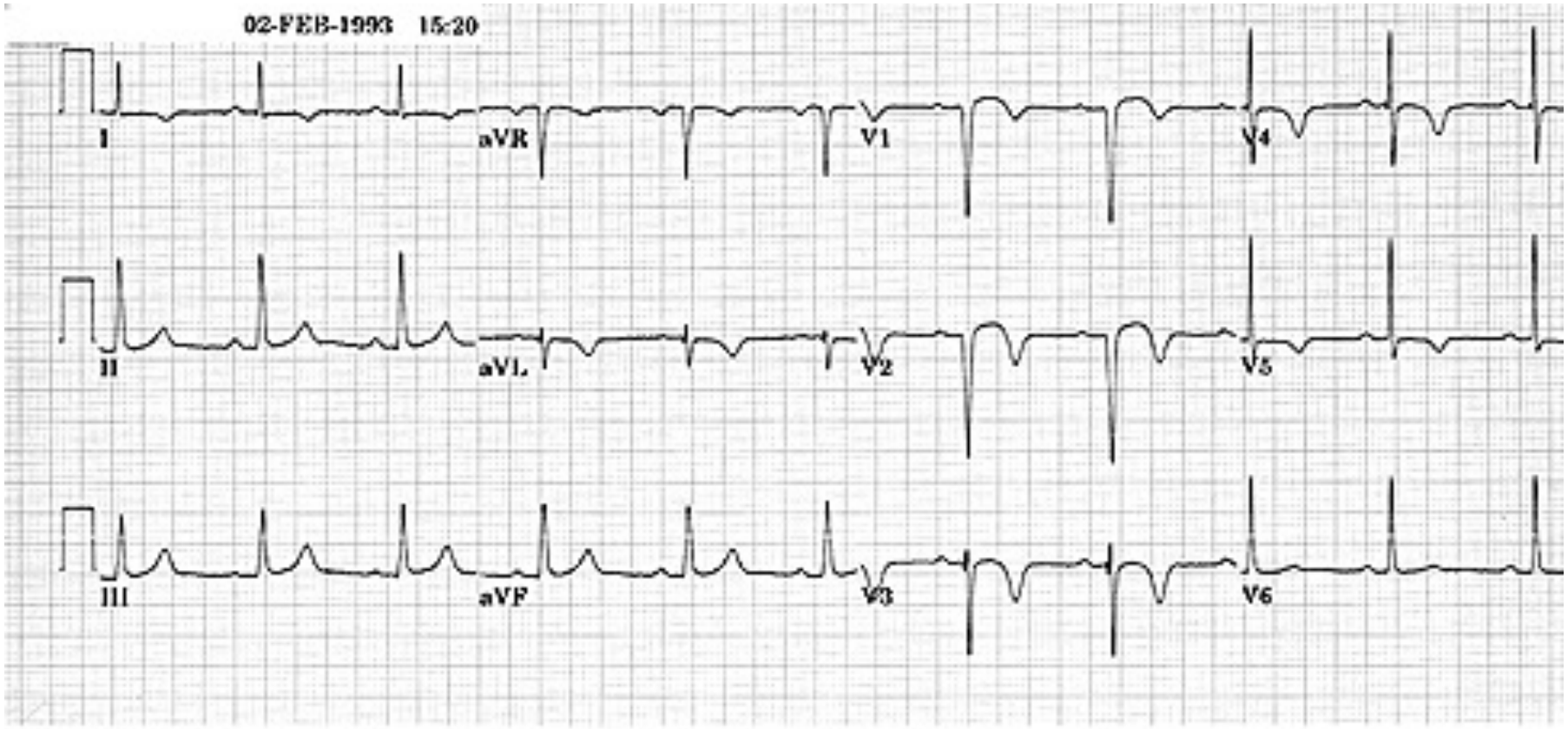
7a) In which leads do you suspect an acute MI?
7b) Which coronary artery does this correspond to?



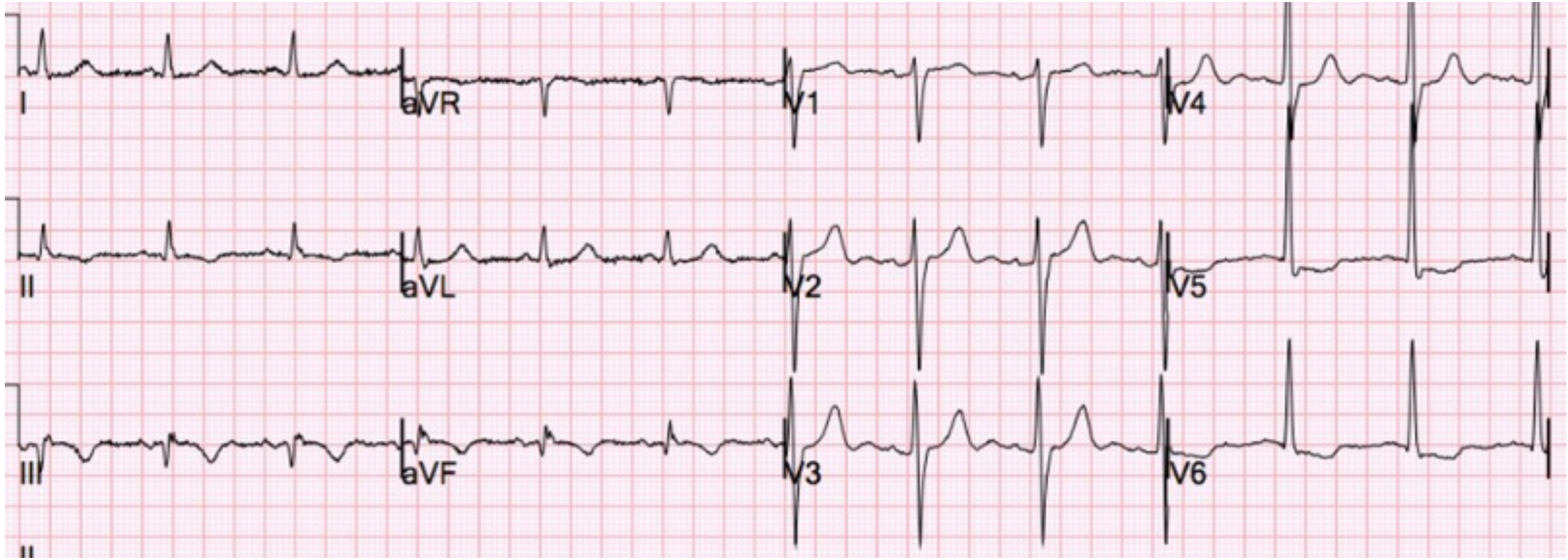
8) Where is this ST Elevated MI (STEMI) located?



This is an ECG of a patient who has been on the Coronary Care Unit for 3 days
9) Where did he have his myocardial infarction?



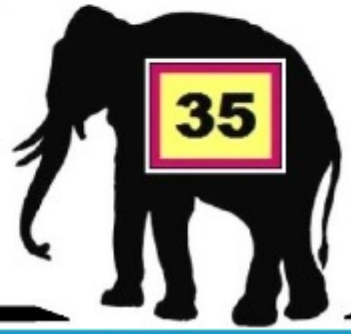
10) What does this ECG show?

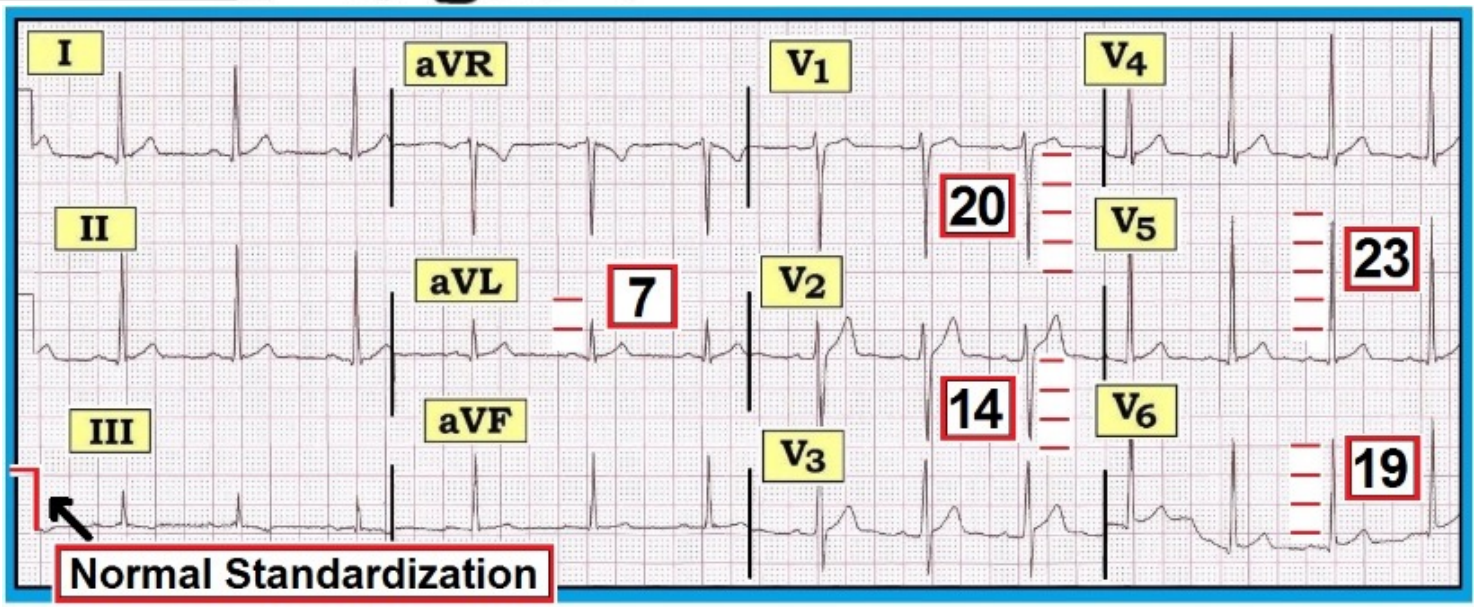


Step 7 – Left Ventricular Hypertrophy (for your info only)

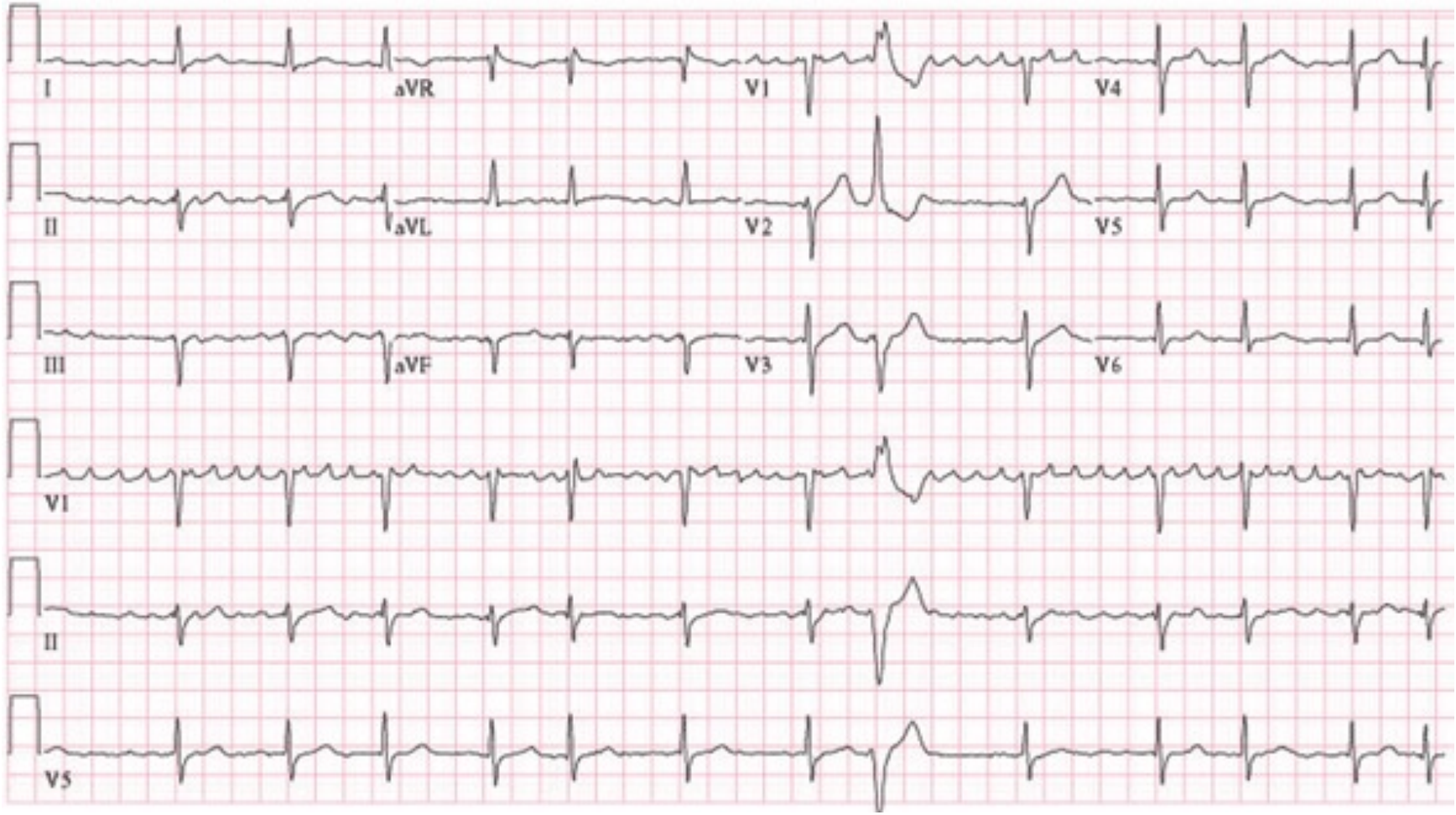
Simplified Criteria for Diagnosing **LVH**

1. Deepest S wave in lead V_1 *or* V_2,
   plus tallest R wave in lead V_5 *or* V_6 ≥ **35**.
   — *and/or* — R in lead aVL ≥ **12**.
2. Patient ≥ **35** years old.
3. Left ventricular (LV) "***strain***".

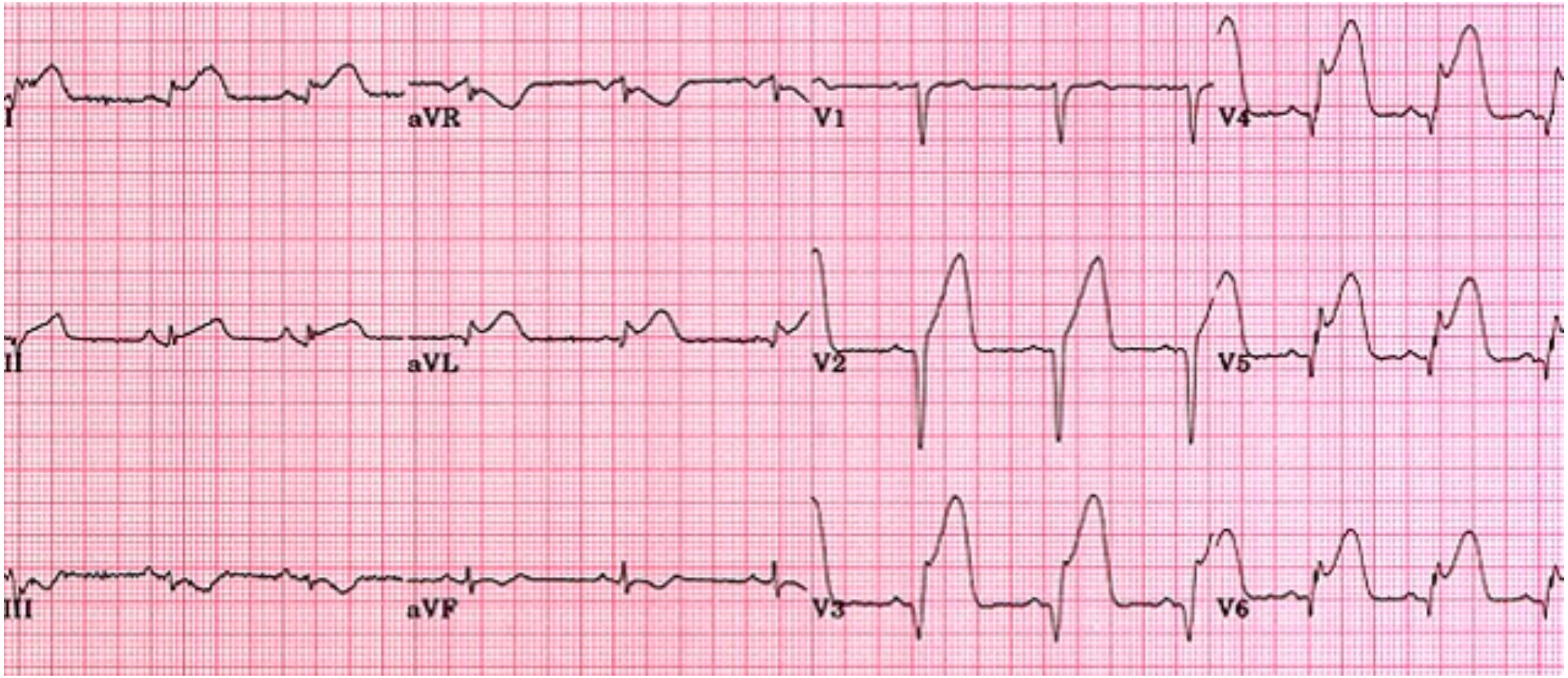




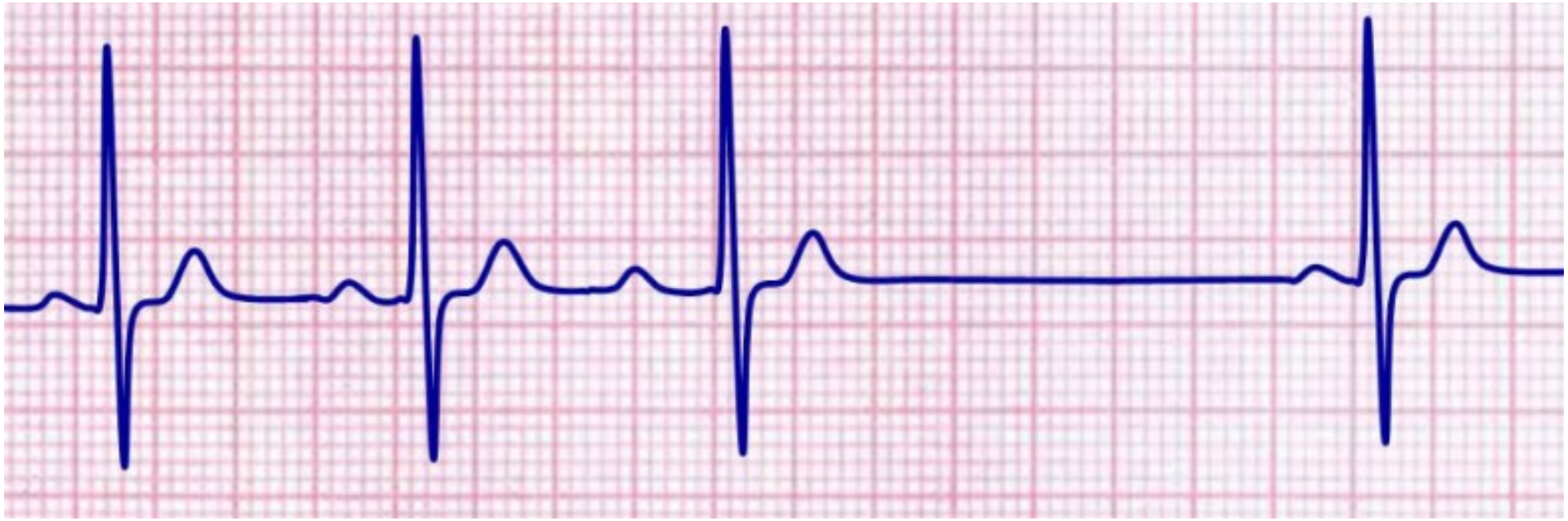
ECG Mini-Quiz Qu 11 – New onset of hypertension and you check the pulse and then request an ECG



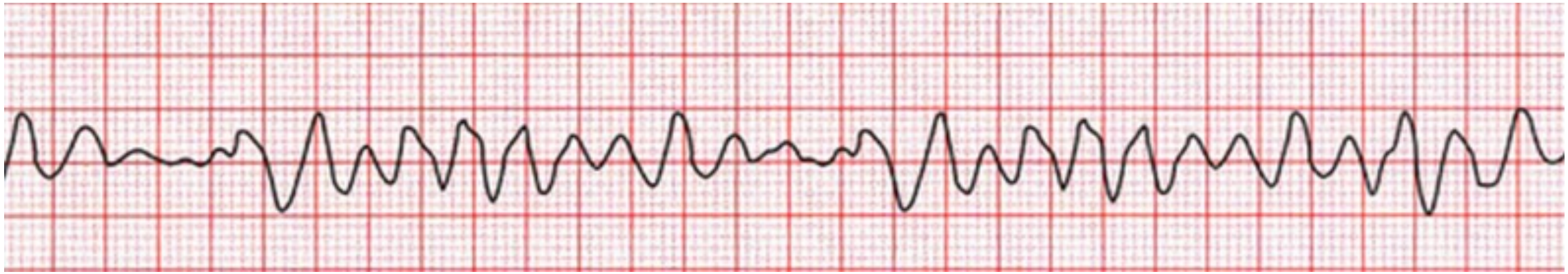
ECG Qu 12



ECG Qu 13 - 64 year old man with episodes of dizziness



ECG Qu 14



Answers to ECG questions

1a) 300/2 *(R-R – 2 big squares)* - 150 beats per minute

1b) Atrial flutter – 2:1

2a) 300/1.5 (1.5 big squares) – 200 beats per minute

2b) These are wide QRS complexes signifying Ventricular Tachycardia – the first thing you need to do is check for a pulse. Is this pulseless VT or pulse VT?

3a) No as there are no distinct `p' waves and the R-R length varies

3b) This is atrial fibrillation – irregularly irregular pattern. You can mark the R waves using a piece of paper and move it along the rhythm strip to test this. Lead II is usually the best lead to look at for rhythm

4a) Ventricular fibrillation – polymorphic wide QRS complexes

4b) Call for help, call 911 if outside and start CPR. Use a defibrillator as soon as possible

5) Inferior leads III and aVF show ST depression – this is what you may find in an angina attack or if you put someone on a treadmill test. It can also be part of a non-STEMI myocardial infarction too (refer back to initial slide on ST segment checks)!

6a) Anterior leads V2- V6

6b) LAD – Left anterior descending coronary artery

7a) Inferior leads II, III and aVF

7b) Right coronary artery

8) Inferolateral MI - inferior leads II, III and aVF, and lateral leads V4-V6

9) Anterior MI – Q waves prominent V1-V3 and T waves inversion V1 – V6

10) Q waves in leads III, aVF, flattened T wave lead II and T wave inversion in leads III, aVF – old inferior MI

11) Atrial fibrillation

12) Anterolateral MI

13) 2nd degree heart block (Mobitz Type I) AV heart block

14) Ventricular Fibrillation

Extra reading and resources

- Student BMJ articles on ECG interpretation – `Mind your P's and Q's, `Bradycardia', `Tachycardia'
- ECG interpretation practice:

  www.ecg-quiz.com/ecg-quiz/mini-test-quiz/
- The ECG Made Easy – John Hampton
- BMJ learning - Online Learning Modules