KG INTERPRETATION: FOCUS ON ACUTE CORONARY SYNDROMES

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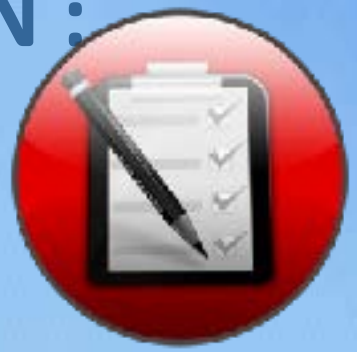
PRESENTATION CONTENT

- EKG IN MYOCARDIAL INFARCTION : THEORY



- ELECTROCARDIOGRAPHY IN MYOCARDIAL INFARCTION: PRACTICE

ECG

Chief diagnostic tool to identify

- Ischemia
- Injury
- Infarction

To understand EKG ischemic changes you must know coronary circulation ! ! !

Universal definition of myocardial infarction

Excluding myocardial infarction associated with revascularization procedures

- **Detection of rise and/or fall of cardiac biomarker values (preferably troponin) with at least one value above the 99th percentile of the upper reference limit and with at least one of the following:**
  - Symptoms of ischaemia;
  - New or presumably new significant ST-T changes or new LBBB;
  - Development of pathological Q waves in the ECG;
  - Imaging evidence of new loss of viable myocardium, or new regional wall motion abnormality;
  - Identification of an intracoronary thrombus by angiography or autopsy.
- **Cardiac death with symptoms suggestive of myocardial ischaemia, and presumably new ECG changes or new LBBB, but death occurring before blood cardiac biomarkers values are released or before cardiacbiomarker values would be increased.**
- **Stent thrombosis associated with MI when detected by coronary angiography or autopsy in the setting of myocardial ischaemia and with a rise and/or fall of cardiac biomarker values with at least one value above the 99th percentile URL.**

ECG = electrocardiogram; LBBB = left bundle branch block.

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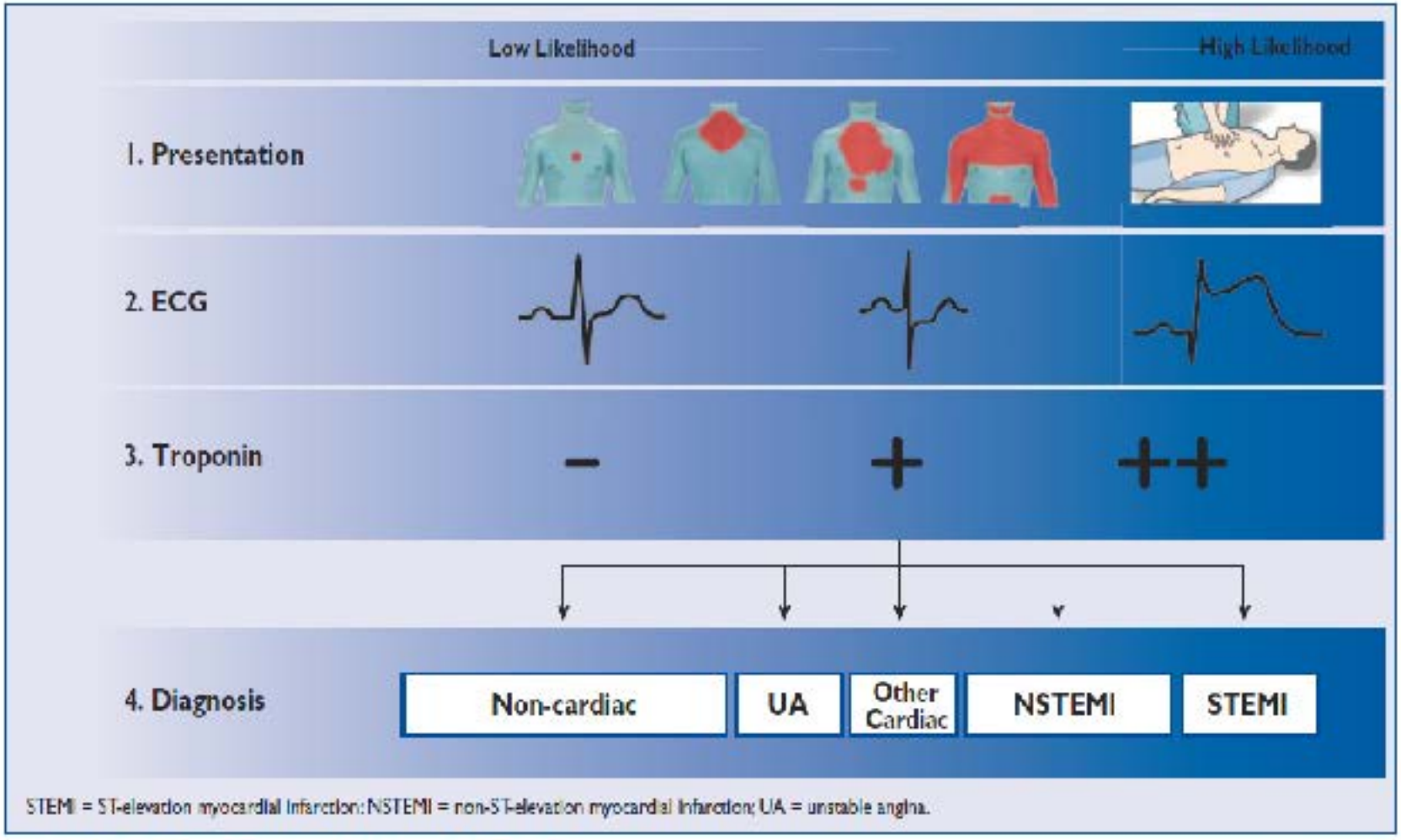
doi:10.1093/eurheartj/ehs215

Diagnosis


Low Likelihood
High Likelihood
1. Presentation
2. ECG
3. Troponin
−
+
++
4. Diagnosis
Non-cardiac
UA
Other Cardiac
NSTEMI
STEMI
STEMI = ST-elevation myocardial infarction; NSTEMI = non-ST-elevation myocardial infarction; UA = unstable angina.

Recommendation for initial diagnosis

	Class	Level
A 12-lead ECG must be obtained as soon as possible at the point of FMC, with a target delay of ≤ 10 min.	I	B
ECG monitoring must be initiated as soon as possiblein all patients with suspected STEMI.	I	B
Blood sampling for serum markers is recommended routinely in the acute phase but one should not wait for the results before initiating reperfusion treatment.	I	C
The use of additional posterior chest wall leads (V7–V9 ≥ 0.05 mV) in patients with high suspicion of infero-basal myocardial infarction (circumflex occlusion) should be considered.	IIa	C
Echocardiography may assist in making the diagnosis in uncertain cases but should not delay transfer for angiography.	IIb	C

ECG = electrocardiogram, FMC = first medical contacts, STEMI = ST segment elevation myocardial infarction.

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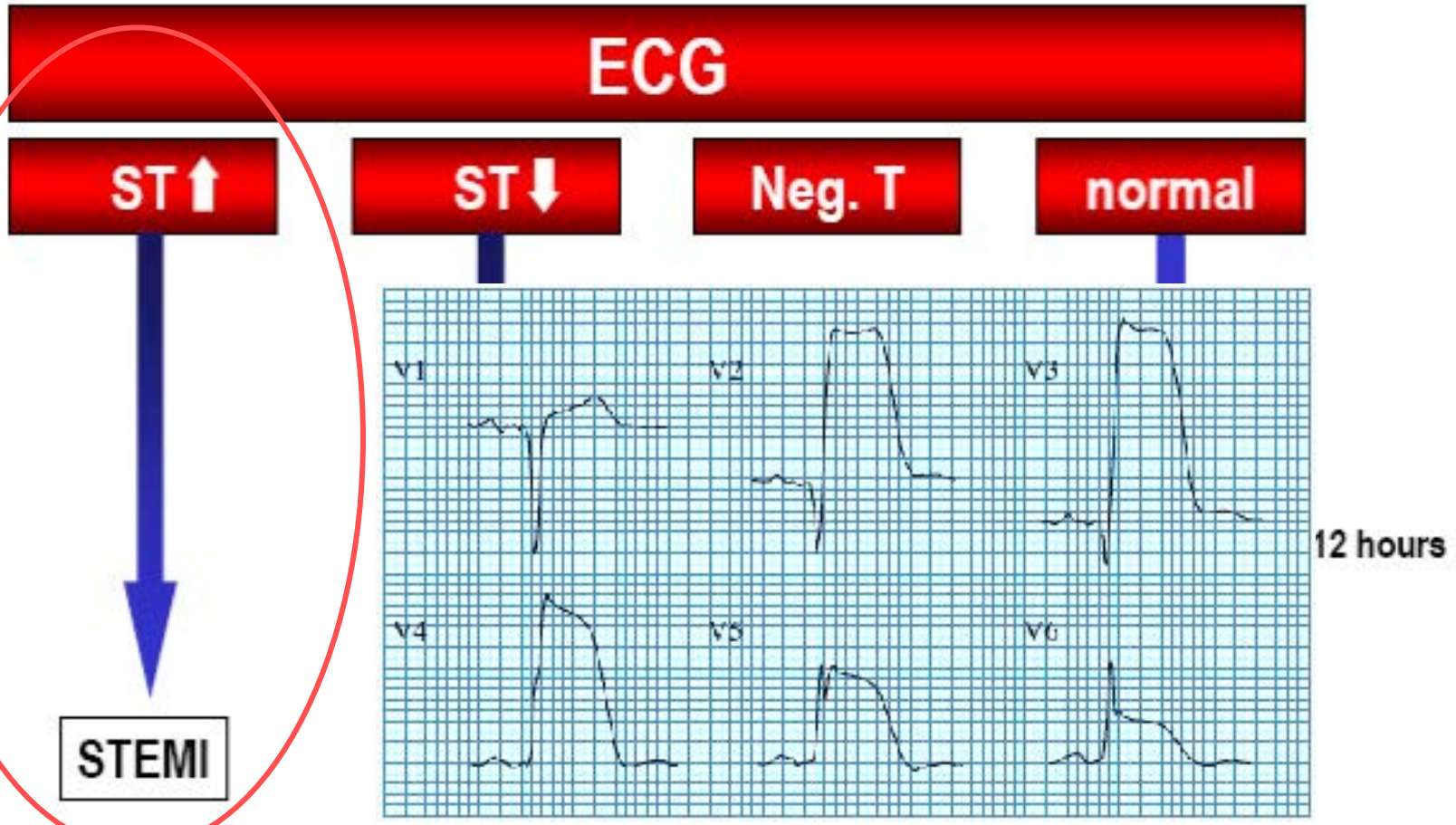
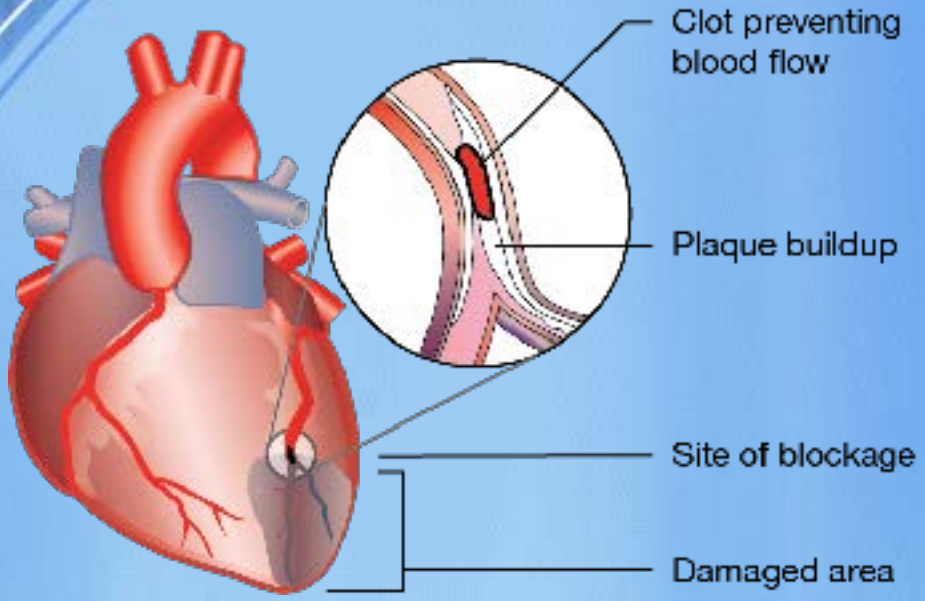
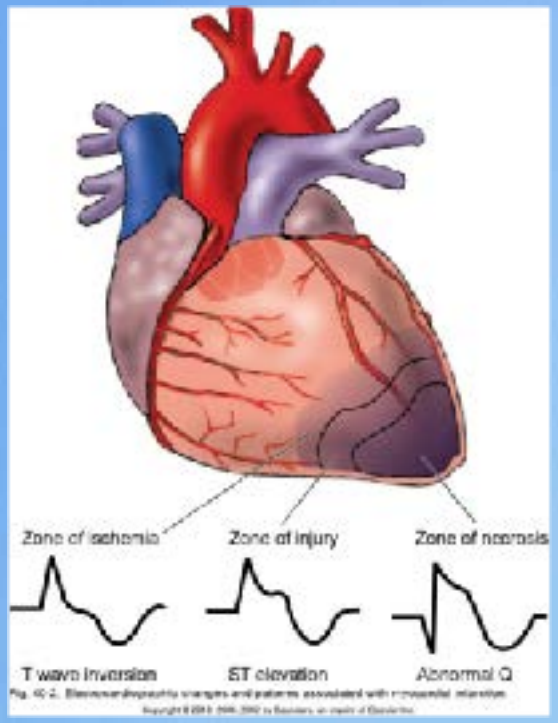
ACS
Initial Decision-making Algorithm

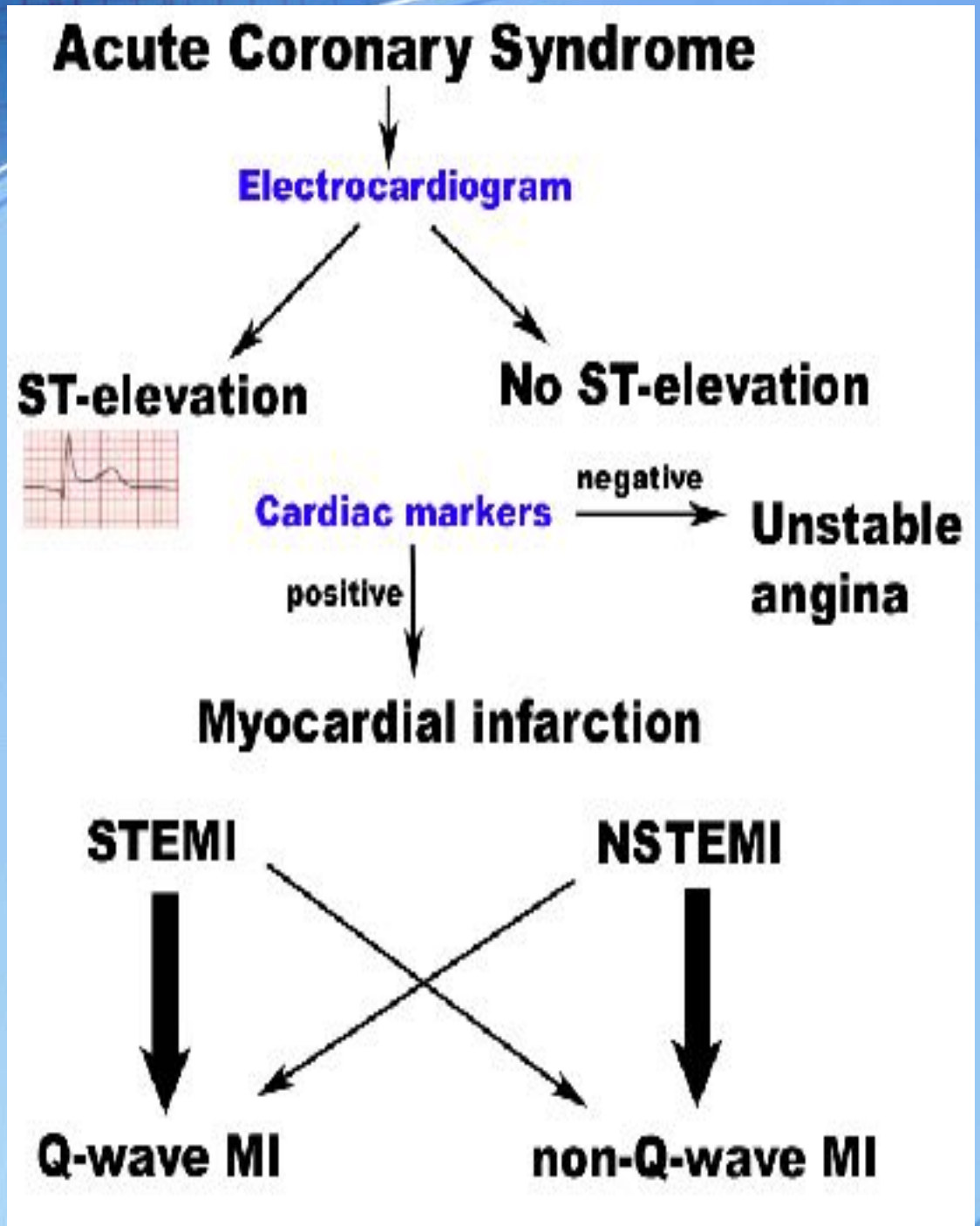



Clot preventing blood flow
Plaque buildup
Site of blockage
Damaged area

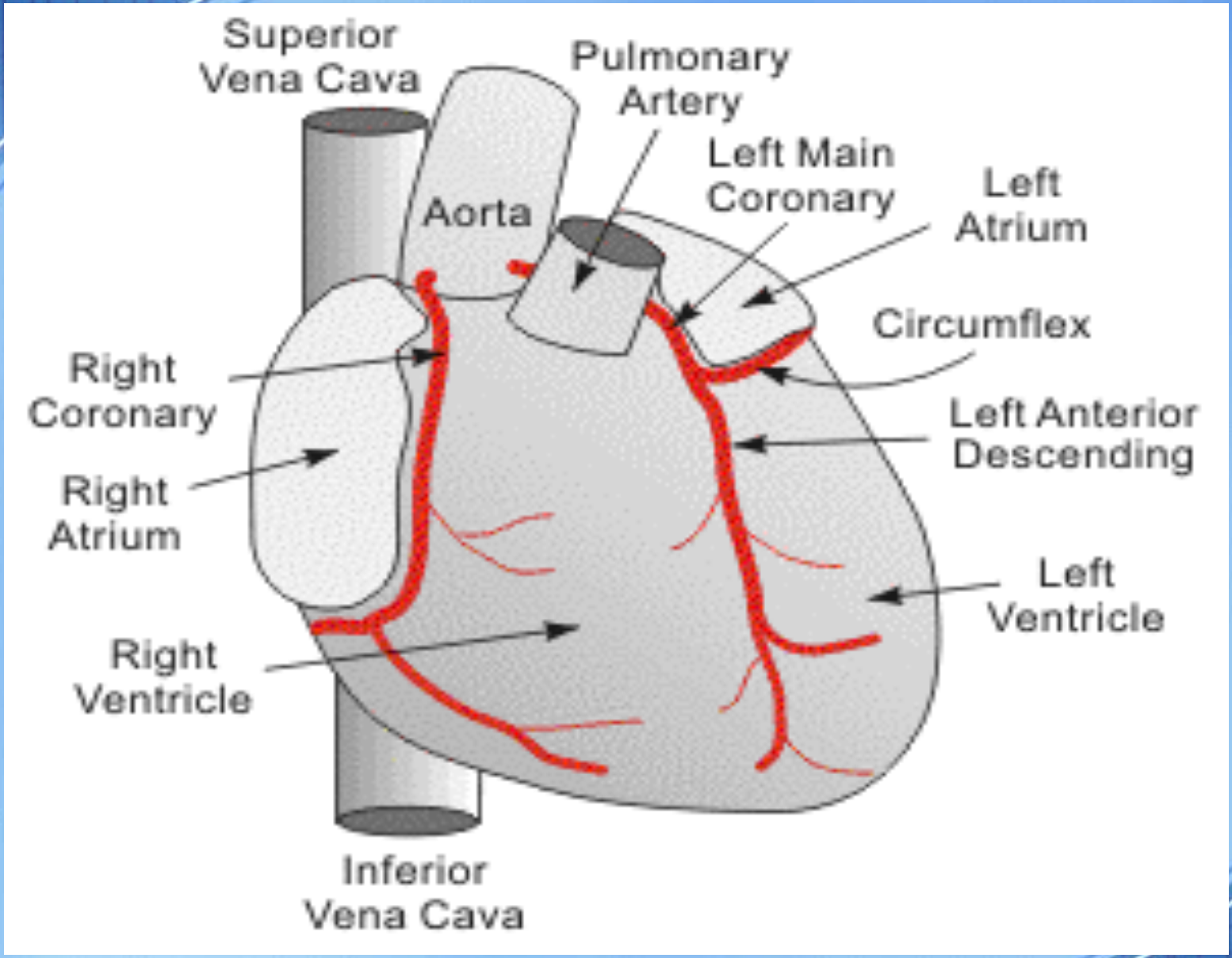

Zone of ischemia
Zone of injury
Zone of necrosis
T wave inversion
ST elevation
Abnormal Q

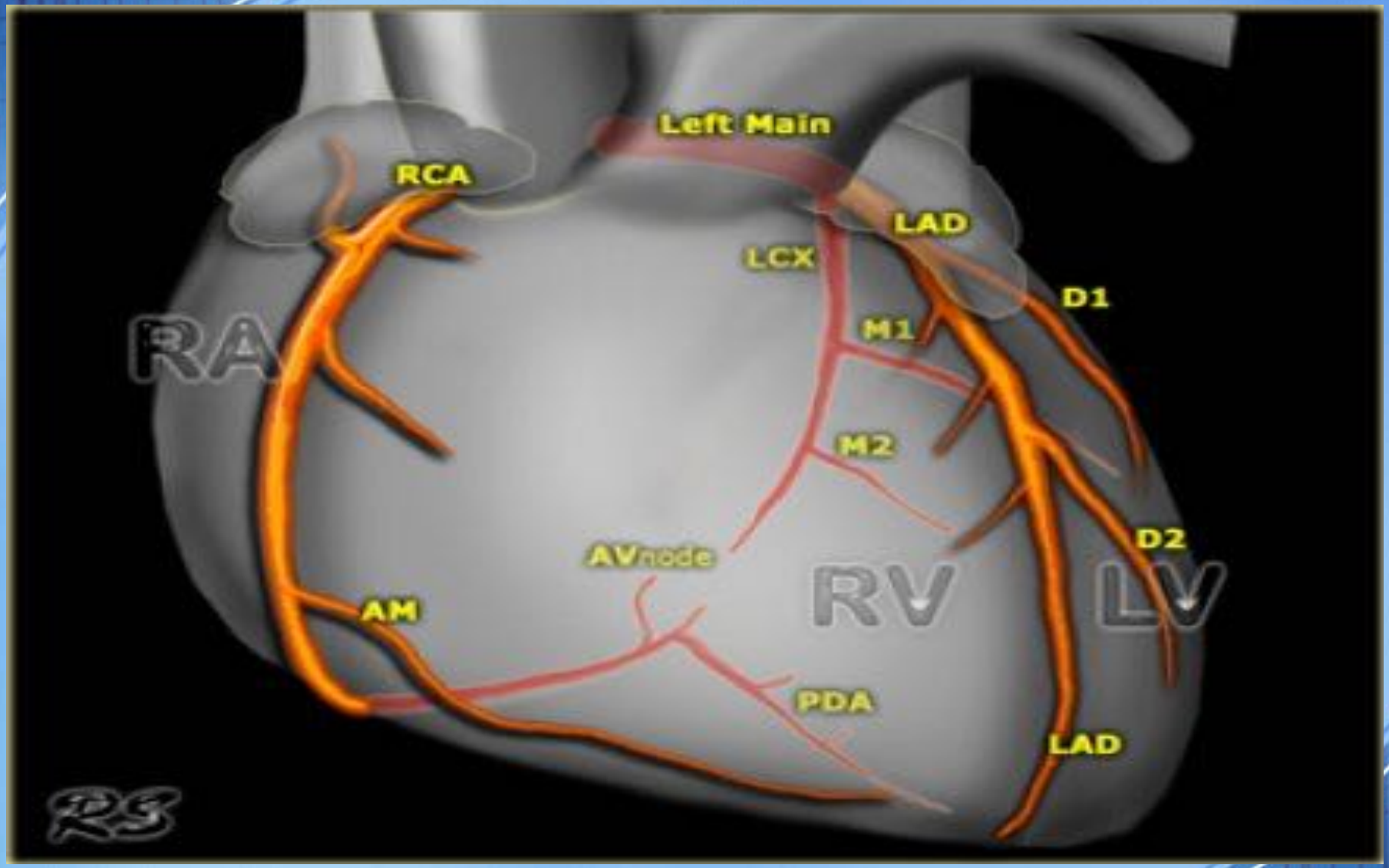
Based on ECG and cardiac enzymes, ACS is classified into:

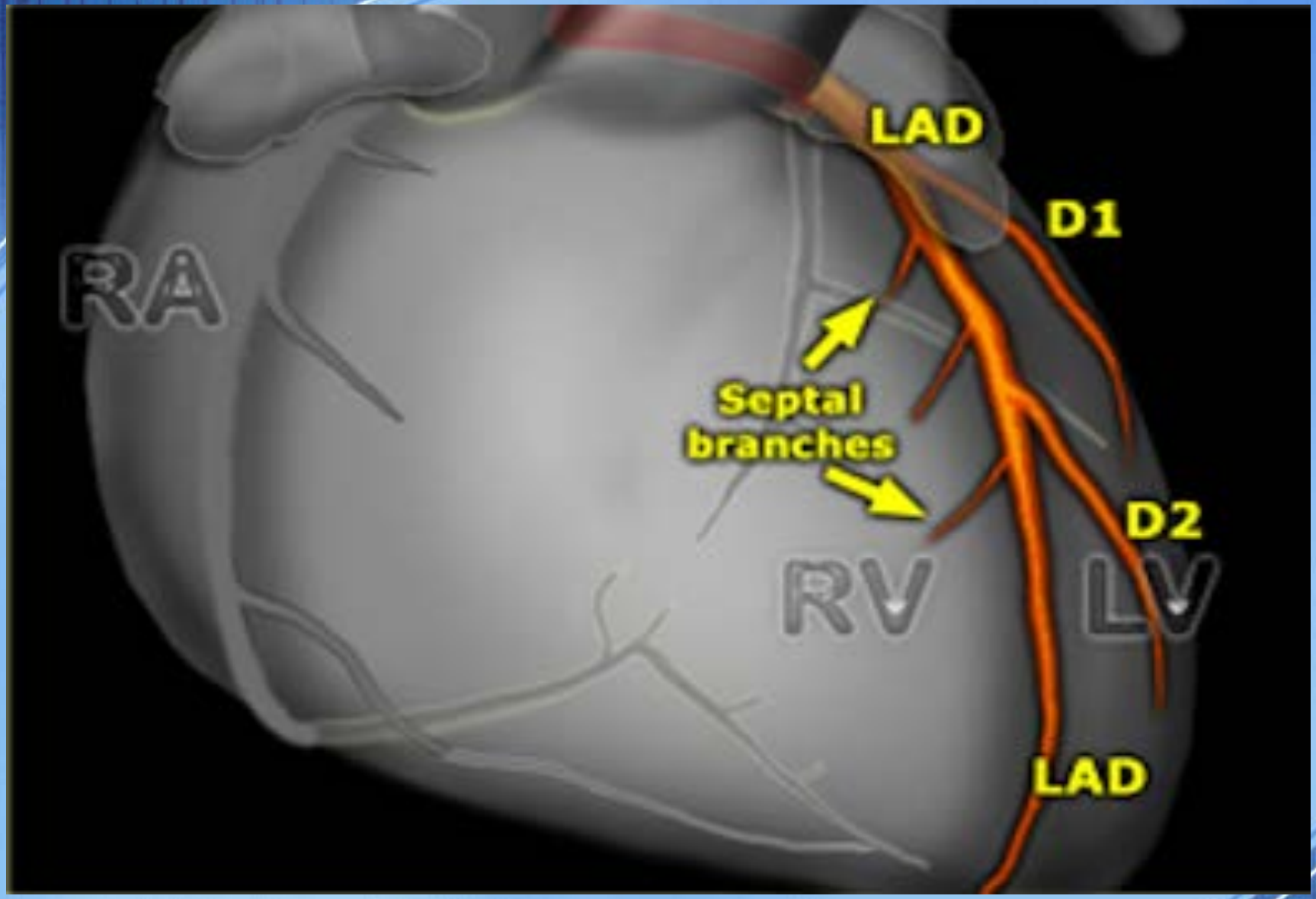
- **STEMI:** ST elevation, elevated cardiac enzymes
- **NSTEMI**: ST depression, T-wave inversion, **elevated** cardiac enzymes
- **Unstable Angina:** Non specific EKG changes, **normal** cardiac enzymes

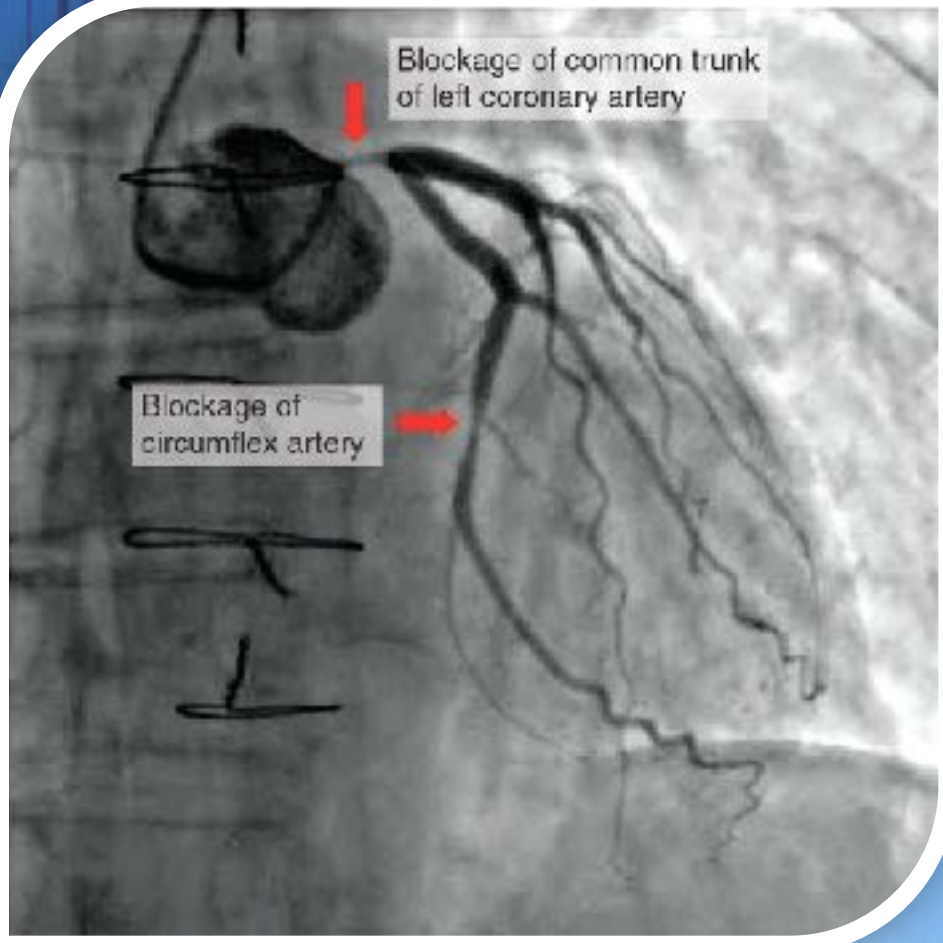

Acute Coronary Syndrome
Electrocardiogram
ST-elevation
No ST-elevation
Cardiac markers
negative
Unstable angina
positive
Myocardial infarction
STEMI
NSTEMI
Q-wave MI
non-Q-wave MI

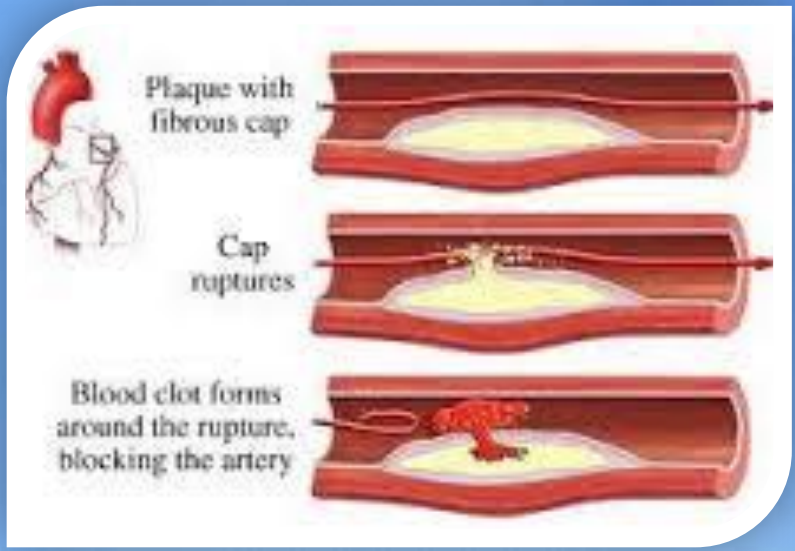
Coronary circulation

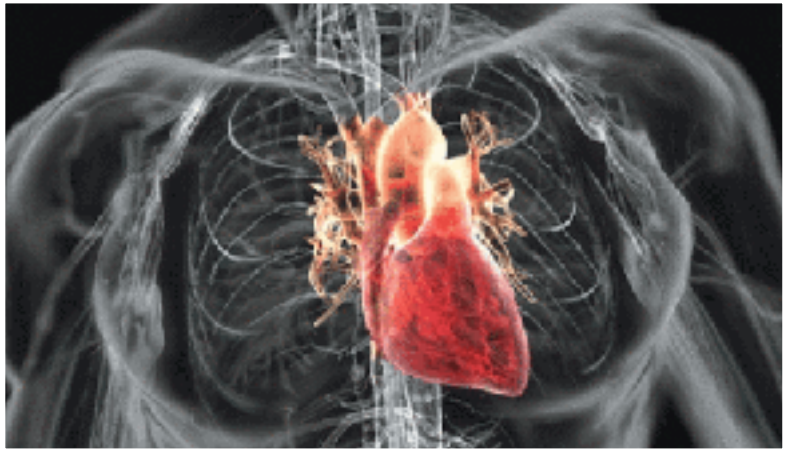


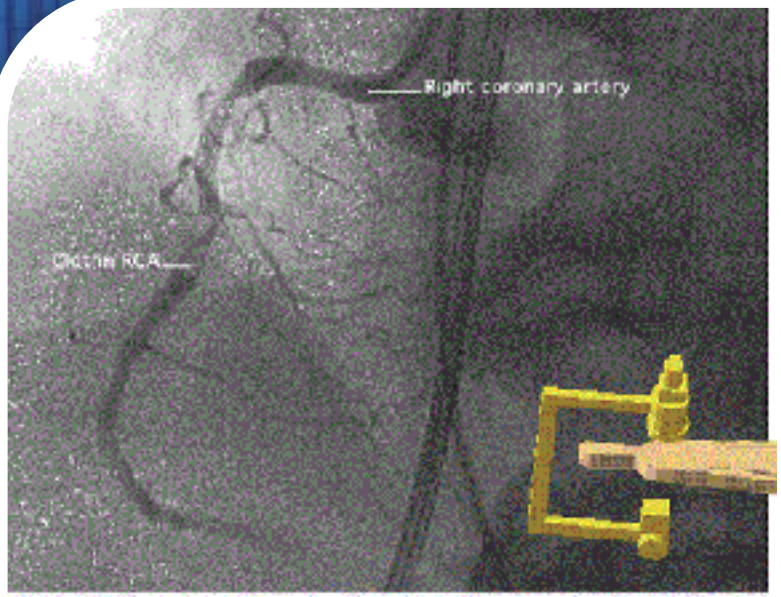

Left Main
RCA
LAD
LCX
D1
M1
RA
M2
D2
AVnode
RV
LV
AM
PDA
LAD

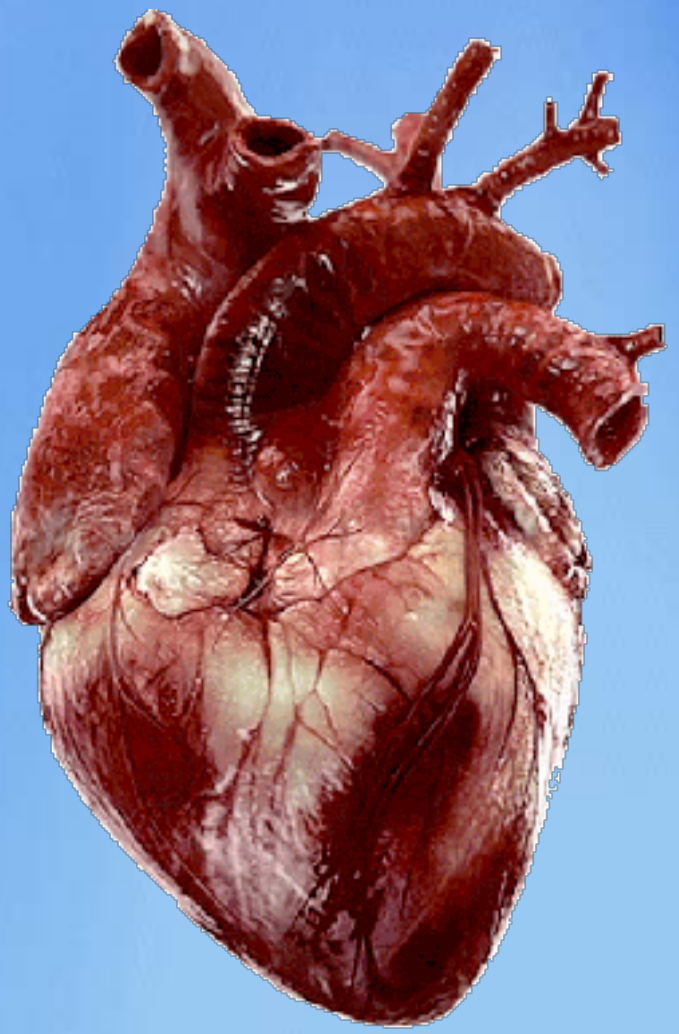

LAD
D1
RA
Septal
branches
D2
RV
LV
LAD


Blockage of common trunk of left coronary artery
Blockage of circumflex artery


Plaque with fibrous cap
Cap ruptures
Blood clot forms around the rupture, blocking the artery




Right coronary artery
I
aVR
II
aVL
III
aVF



ECG localisation

- The electrocardiogram (ECG) is a key investigation in diagnosing acute ST-segment elevation myocardial infarction (STEMI).
- During acute transmural ischaemia, one of the important determinants of the site of coronary artery occlusion is the direction of the vector of ST-segment deviation.
- The injury vector is always oriented **toward** the injured area.
- The lead facing the injury vector head shows ST-segment elevation and the lead facing the vector tail (opposite leads) shows ST segment depression.

Ischaemia at a distance Vs reciprocal changes

- Patients with ST elevation in one territory often have ST depression in other territories.
- The additional ST deviation may represent acute ischaemia due to coronary artery disease in non infarct related arteries (ischaemia at a distance) or may represent pure "mirror image" reciprocal changes.
- Most of the common patterns of remote ST depression probably represent reciprocal changes and not “ischaemia at a distance”.

ECG Leads

- The standard EKG has 12 leads:
  - 3 Standard Limb Leads
  - 3 Augmented Limb Leads
  - 6 Precordial Leads

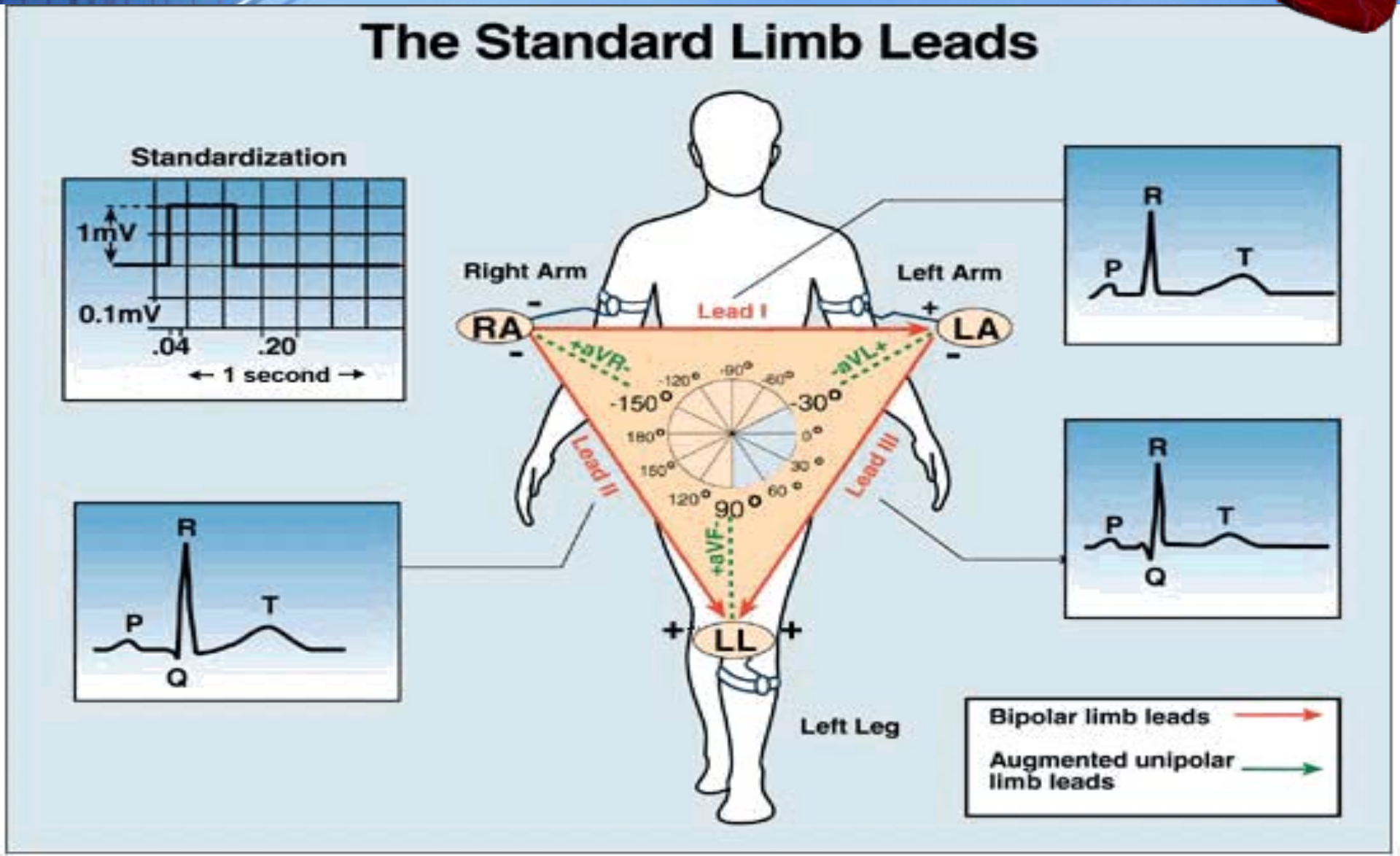
ECG Limb Leads

- Leads are electrodes which measure the difference in electrical potential between either:

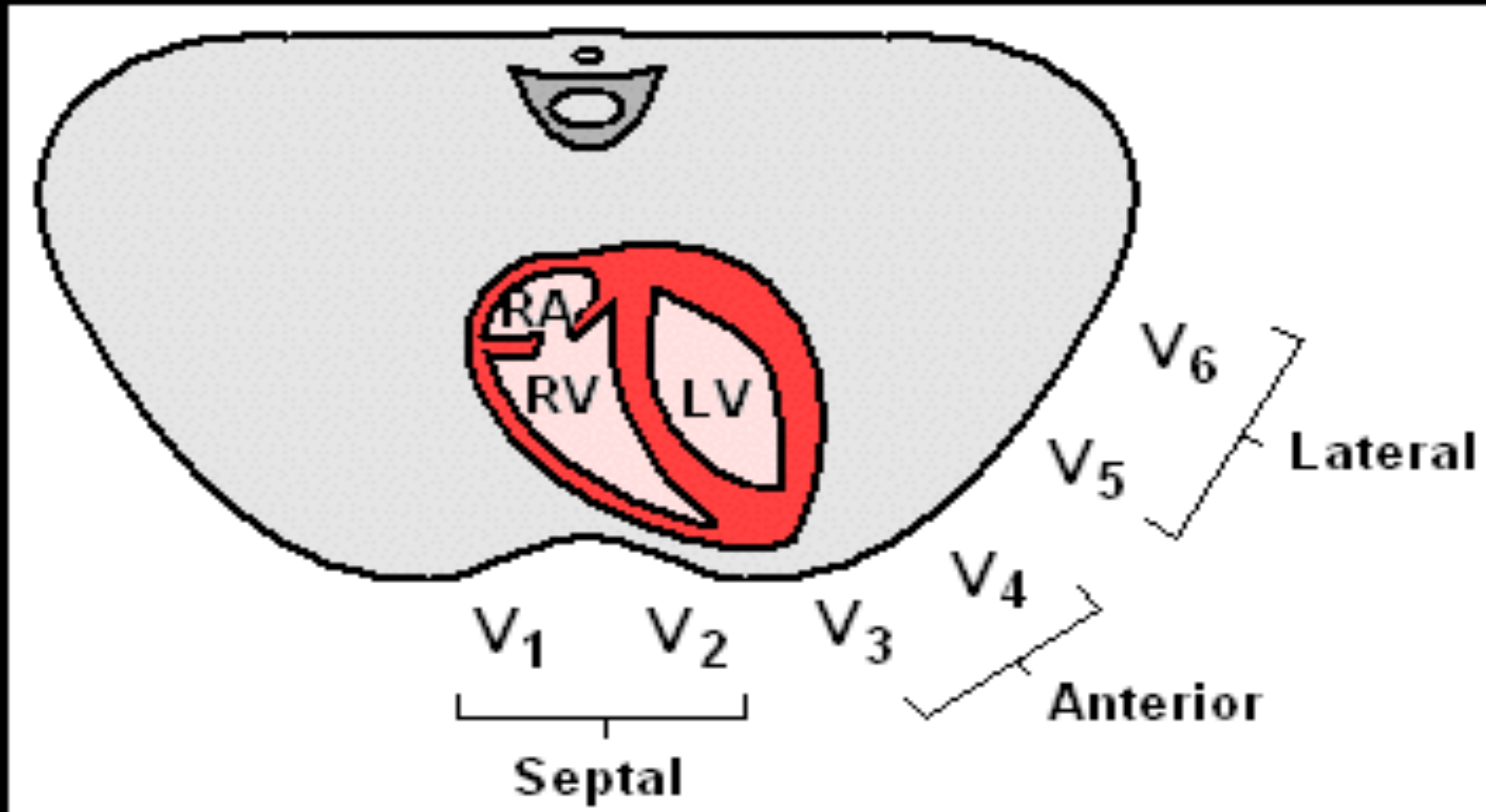
    1. Two different points on the body (bipolar leads)

    2. One point on the body and a virtual reference point with zero electrical potential, located in the center of the heart (unipolar leads)

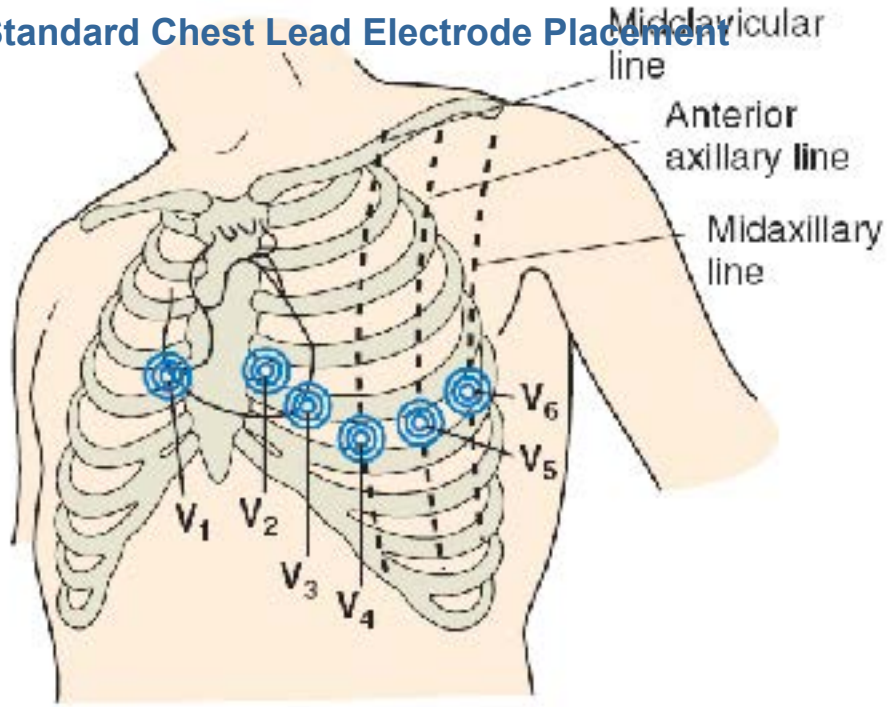
ECG Limb Leads



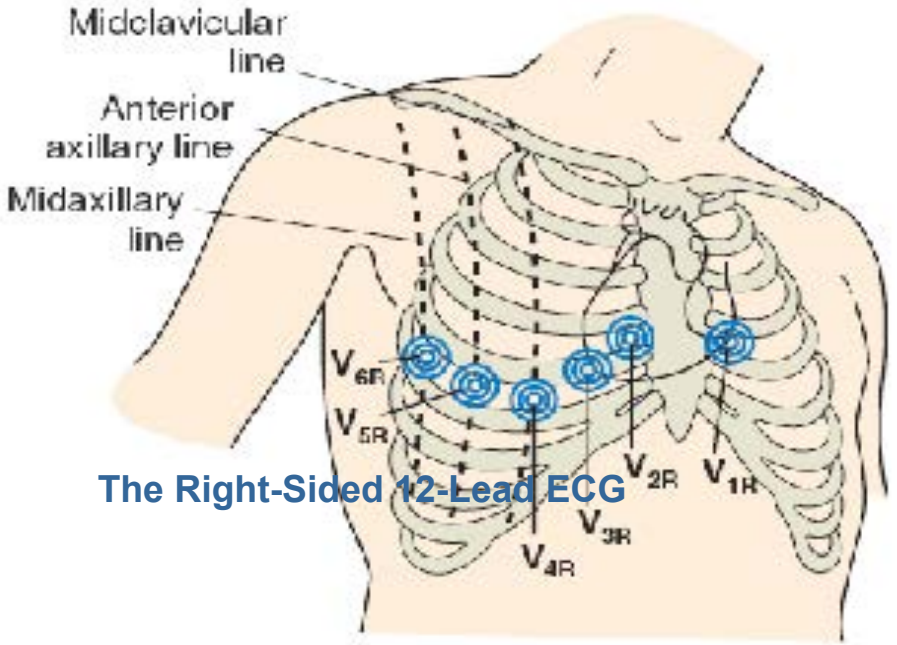
Precordial Leads



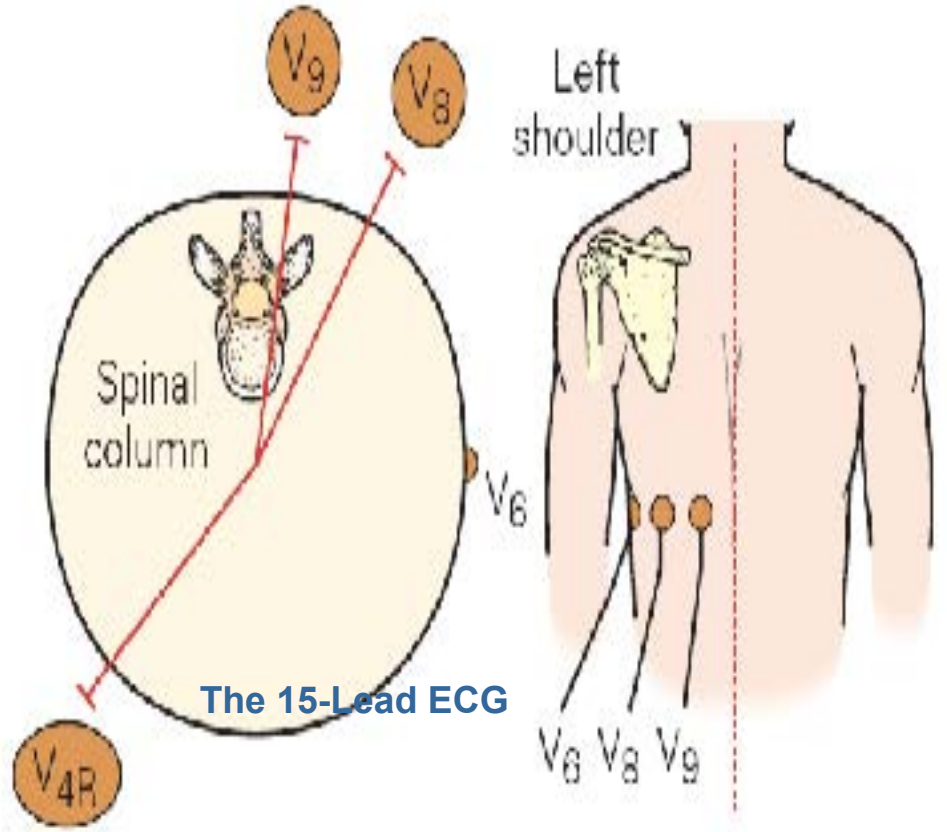
Standard Chest Lead Electrode Placement



Elements of Chest Leads		
Lead	Positive Electrode Placement	View of Heart
V_1	4th Intercostal space to right of sternum	Septum
V_2	4th Intercostal space to left of sternum	Septum
V_3	Directly between V_2 and V_4	Anterior
V_4	5th Intercostal space at left midclavicular line	Anterior
V_5	Level with V_4 at left anterior axillary line	Lateral
V_6	Level with V_5 at left midaxillary line	Lateral



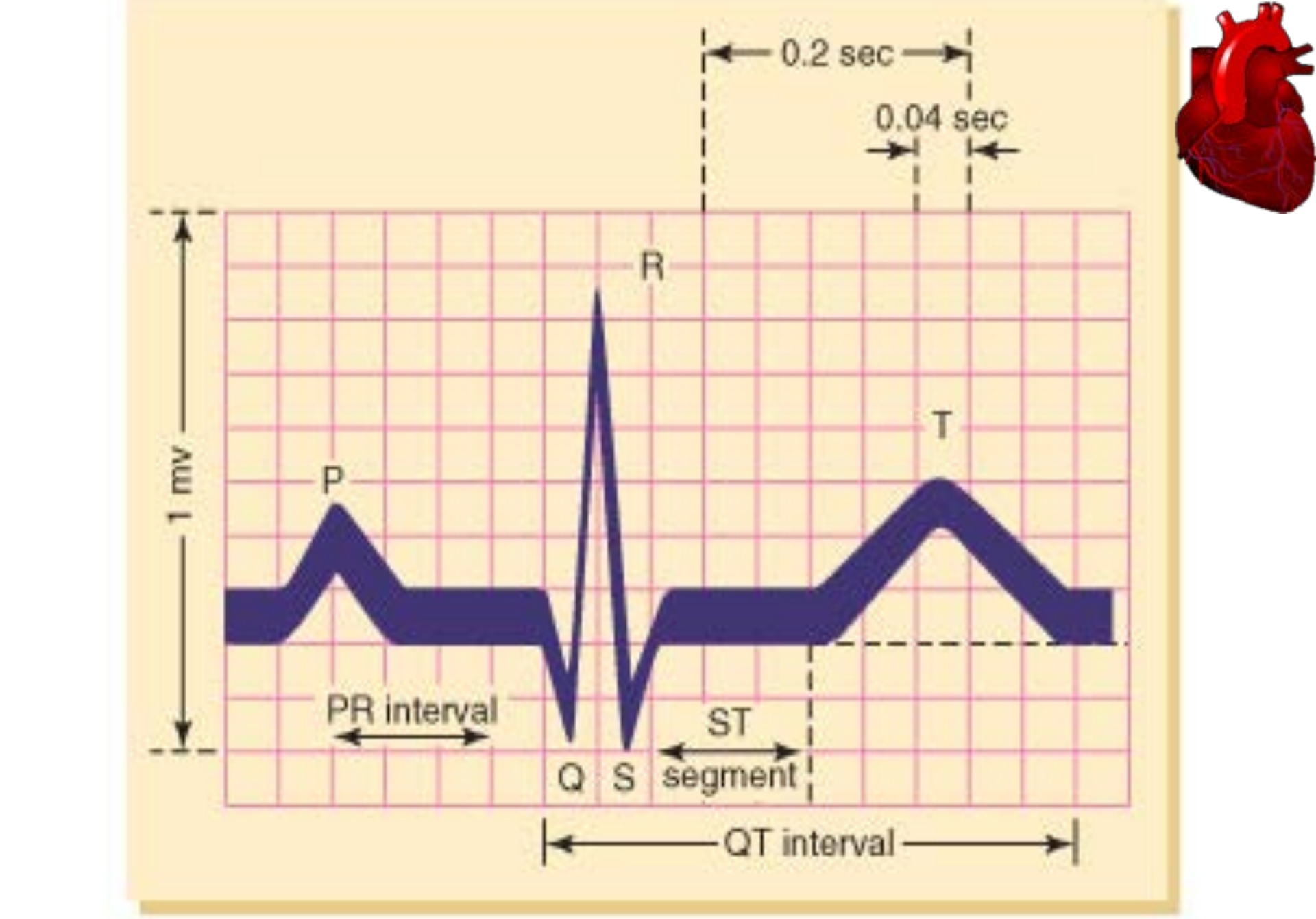
The Right-Sided 12-Lead ECG

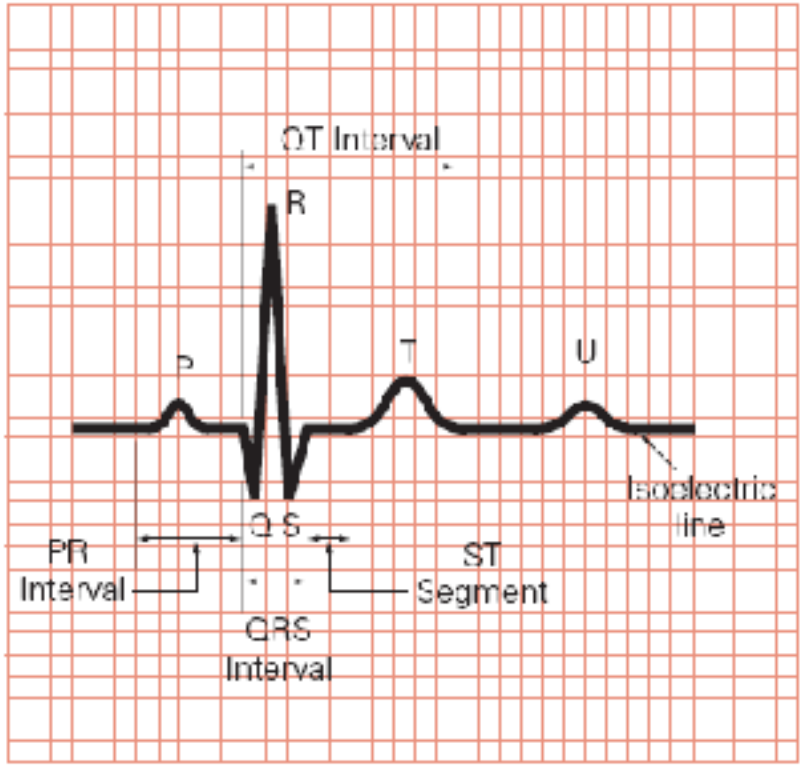


The 15-Lead ECG

Contiguous Leads

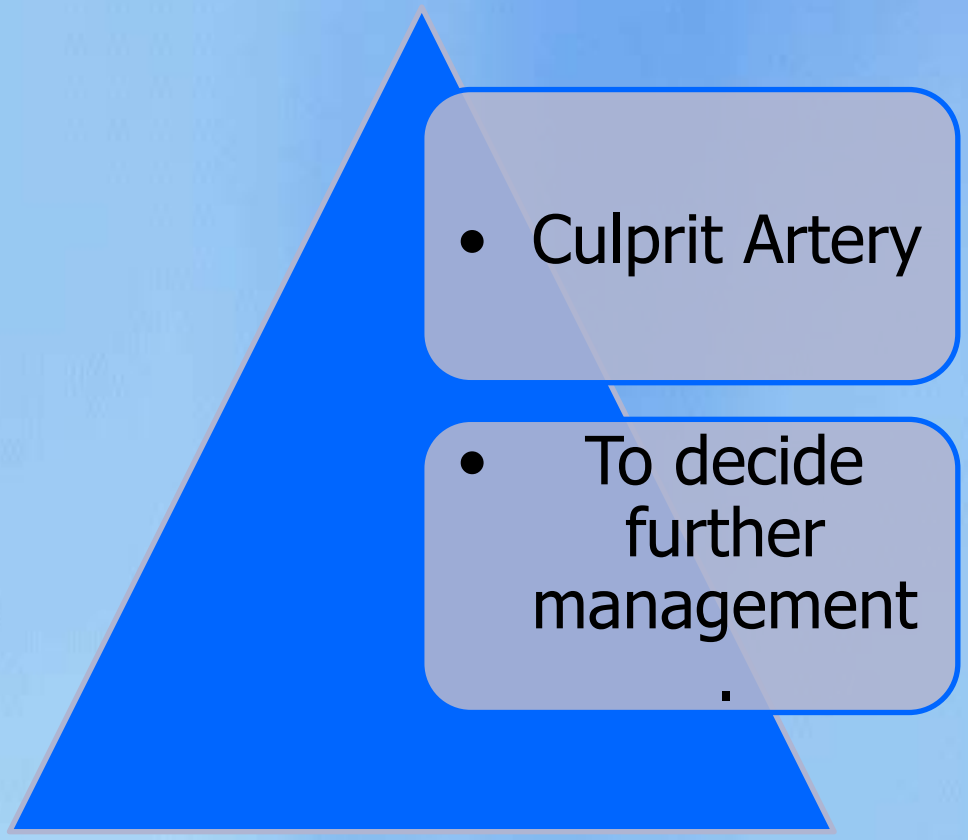
- Lateral wall: I, aVL, V5, V6
- Inferior wall: II, III, avF
- Septum: V1 and V2
- Anterior wall: V3 and V4
- Posterior wall: V7-V9 (leads placed on the patient's back 5th intercostal space creating a 15 lead EKG)





Electrical Components	
Deflection	**Description**
P Wave	First wave seen Small rounded, upright (positive) wave indicating atrial depolarization (and contraction)
PR Interval	Distance between beginning of P wave and beginning of QRS complex Measures time during which a depolarization wave travels from the atria to the ventricles
QRS Interval	Three deflections following P wave Indicates ventricular depolarization (and contraction) Q Wave: First negative deflection R Wave: First positive deflection S Wave: First negative deflection after R wave
ST Segment	Distance between S wave and beginning of T wave Measures time between ventricular depolarization and beginning of repolarization
T Wave	Rounded upright (positive) wave following QRS Represents ventricular repolarization
QT Interval	Measured from beginning of QRS to end of T wave. Represents total ventricular activity.
U Wave	Small rounded, upright wave following T wave Most easily seen with a slow HR. Represents repolarization of Purkinje fibers.

Why Localize ?

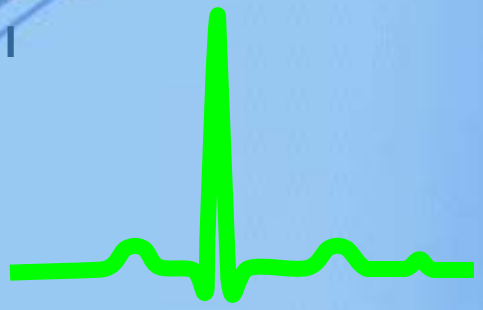


ST segment

- Connects the QRS complex and T wave
- Duration of 0.08-0.12 sec (80-120 msec)

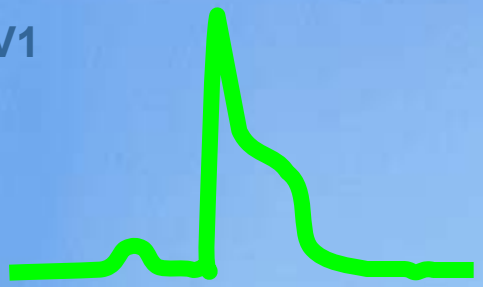
S – T Segment

I



Normal

V1



Elevated

V3

Depressed

T waves

- Represents repolarization or recovery of ventricles
  - Interval from beginning of QRS to apex of T is referred to as the absolute refractory period

T wave morphology

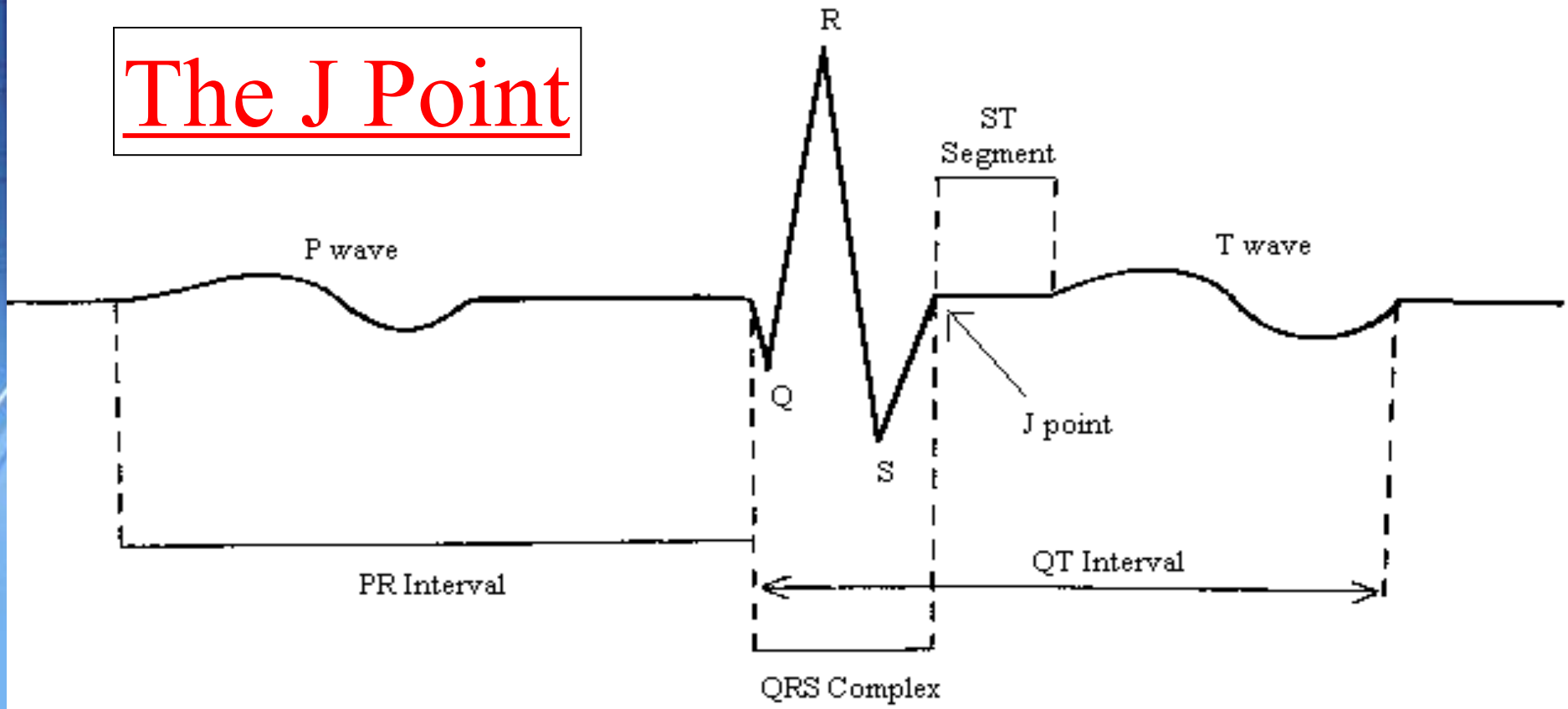
I

Upright T

AVR

Inverted T

The J Point



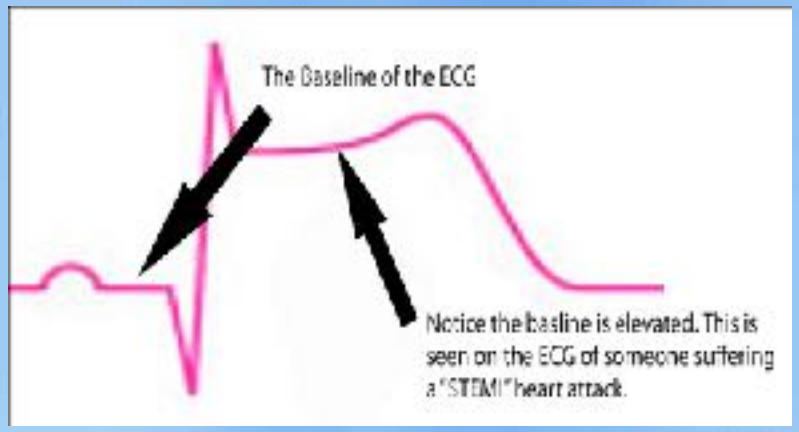
- J point – where the QRS complex and ST segment meet
- ST segment elevation - evaluated 0.04 seconds (one small box) after J point

Significant ST Elevation

- ST segment elevation measurement
  - starts 0.04 seconds after J point
- ST elevation
  - > 1mm (1 small box) in 2 or more contiguous chest leads (V1-V6)
  - >1mm (1 small box) in 2 or more anatomically contiguous leads (ie: II, III, aVF; I, aVL, V5, V6)
- Contiguous lead
  - limb leads that "look" at the same area of the heart or are numerically consecutive chest leads (ie: V1 – V6)

EKG

- STEMI:
  - Q waves , ST elevations, hyper acute T waves; followed by T wave inversions.
  - Clinically significant ST segment elevations:
    - > than 1 mm (0.1 mV) in at least two anatomical contiguous leads
    - or 2 mm (0.2 mV) in two contiguous precordial leads (V2 and V3)



  - Note: LBBB and pacemakers can interfere with diagnosis of MI on EKG

ST Segment Elevation

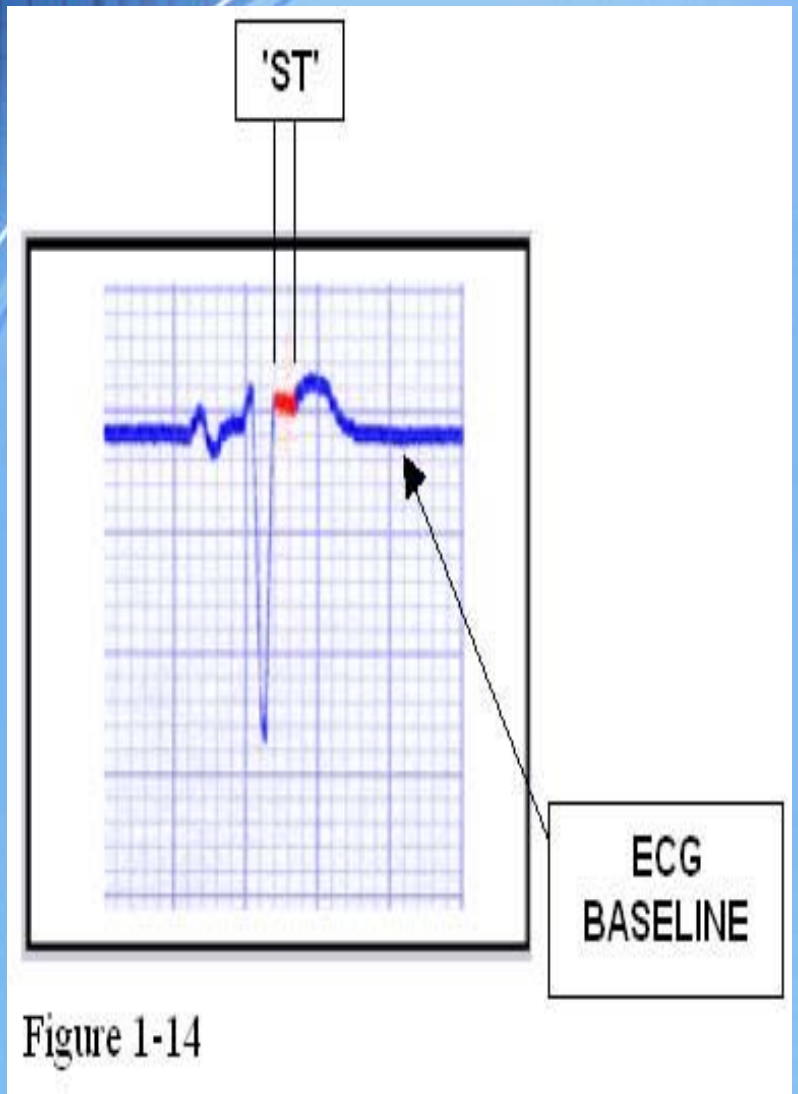
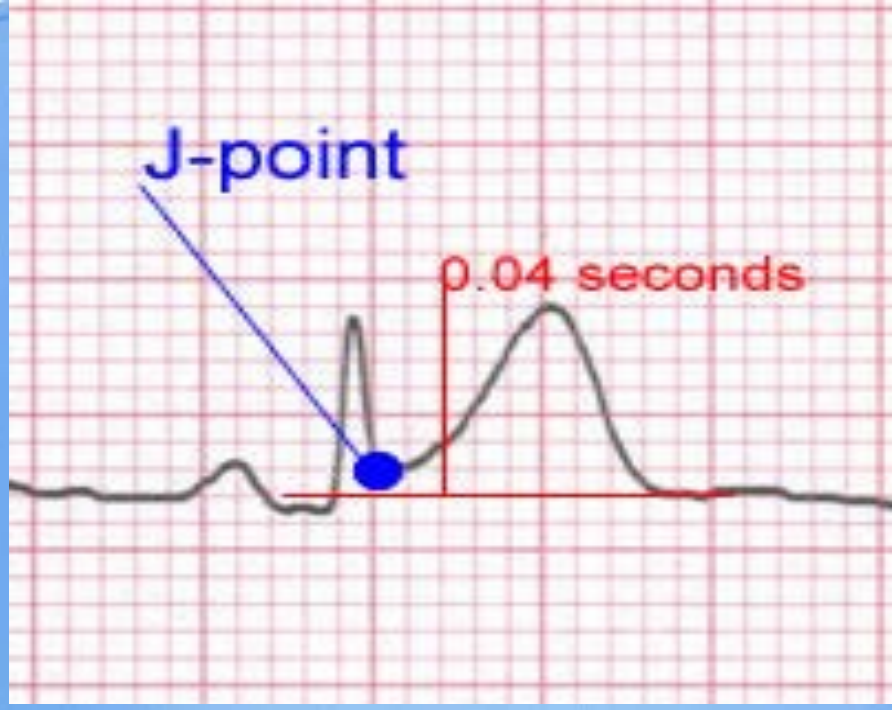


Figure 1-14



EKG

- NSTEMI:
  - ST depressions (0.5 mm at least) or T wave inversions (1.0 mm at least) without Q waves in 2 contiguous leads with prominent R wave or R/S ratio >1.
  - Isolated T wave inversions:
    - can correlate with increased risk for MI
    - may represent Wellen's syndrome:
      - critical LAD stenosis
      - >2mm inversions in anterior precordial leads
- Unstable Angina:
  - May present with nonspecific or transient ST segment depressions or elevations

Localization - Myocardial Infarct

Localization	ST elevation	Reciprocal ST depression	Coronary Artery
Anterior MI	V1-V6	None	LAD
Septal Mi	V1-V4, disappearance of septum Q in leads V5,V6	none	LAD
Lateral MI	I, aVL, V5, V6	II,III, aVF (inferior leads)	LCX
Inferior MI	II, III, aVF	I, aVL (lateral lead)	RCA (80%) or LCX (20%)
Posterior MI	V7, V8, V9	high R in V1-V3 with ST depression V1-V3 > 2mm (mirror view)	RCA or LCX
Right Ventricle MI	V1, V4R	I, aVL	RCA
Atrial MI	PTa in I,V5,V6	PTa in I,II, or III	RCA

The localisation of the occlusion can be adequately visualized using a coronary angiogram (CAG).

Anatomic Groups

I Lateral	aVR None	V_1 Septal	V_4 Anterior
II Inferior	aVL Lateral	V_2 Septal	V_5 Lateral
III Inferior	aVF Inferior	V_3 Anterior	V_6 Lateral

Anatomic Groups

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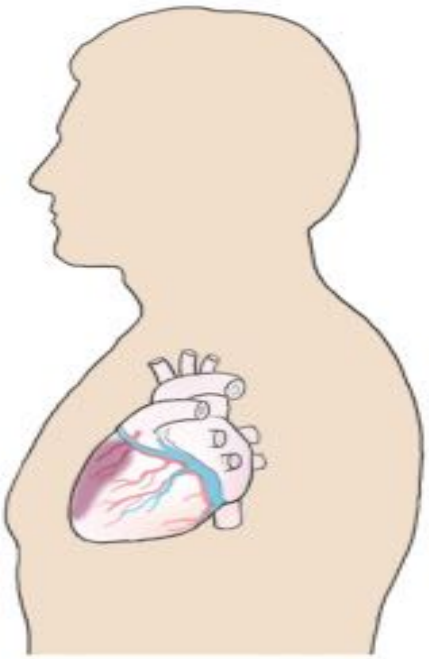
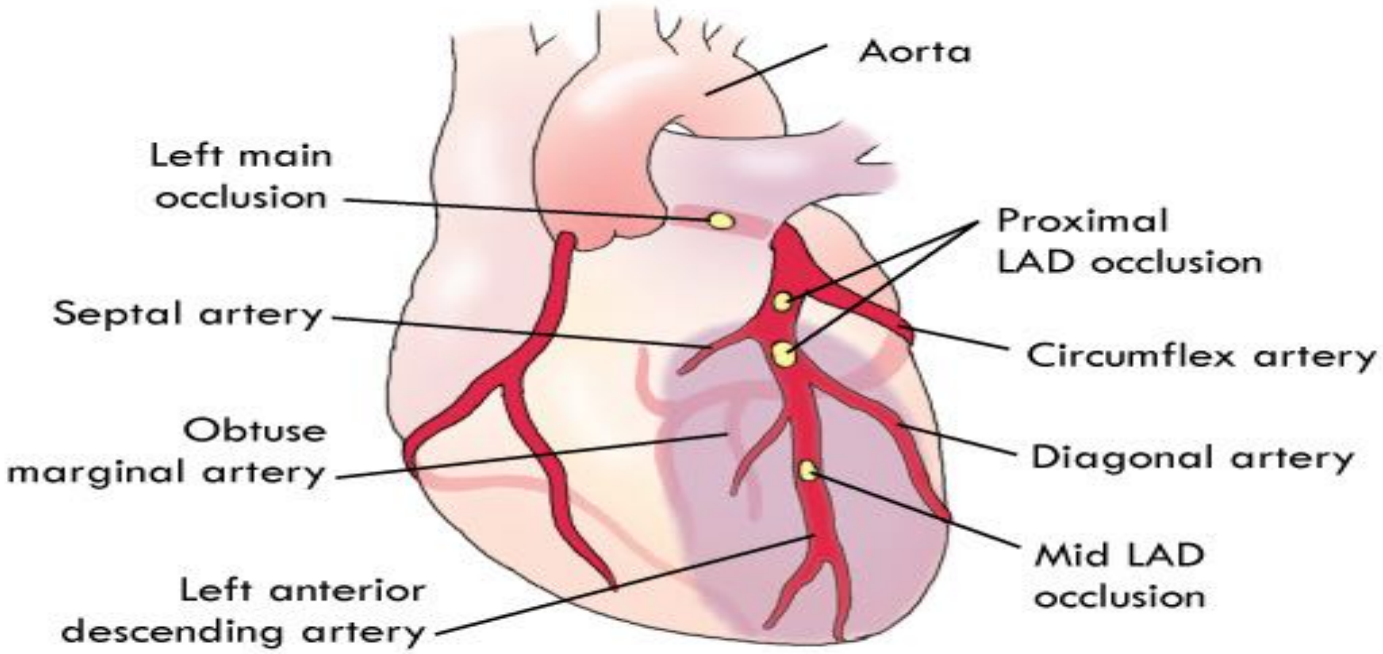
Anterior Wall MI V3, V4

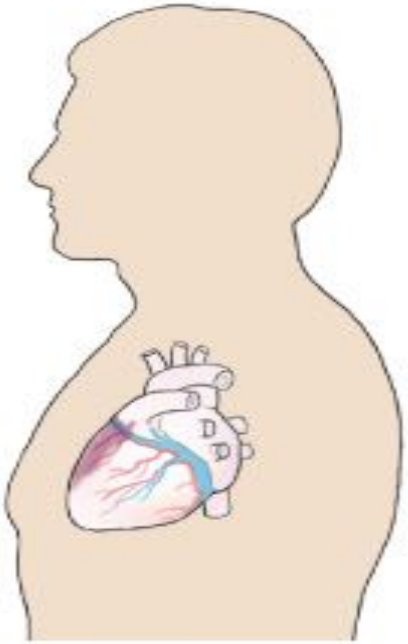


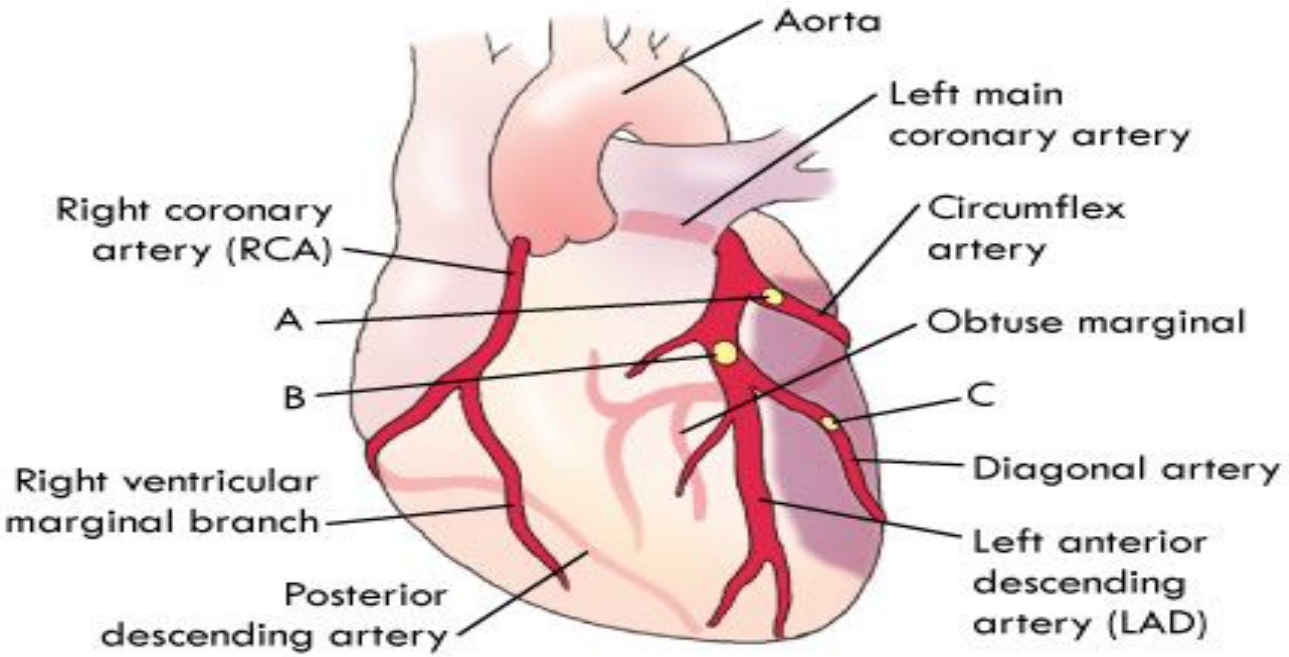


I Lateral	aVR	V_1 Septum	V_4 Anterior
II Inferior	aVL Lateral	V_2 Septum	V_5 Lateral
III Inferior	aVF Inferior	V_3 Anterior	V_6 Lateral

Source: The 12-Lead ECG in Acute Coronary Syndromes, MosbyJems, 2006.

Lateral Wall MI: I, aVL, V5, V6





I Lateral	aVR	V_1 Septum	V_4 Anterior
II Inferior	aVL Lateral	V_2 Septum	V_5 Lateral
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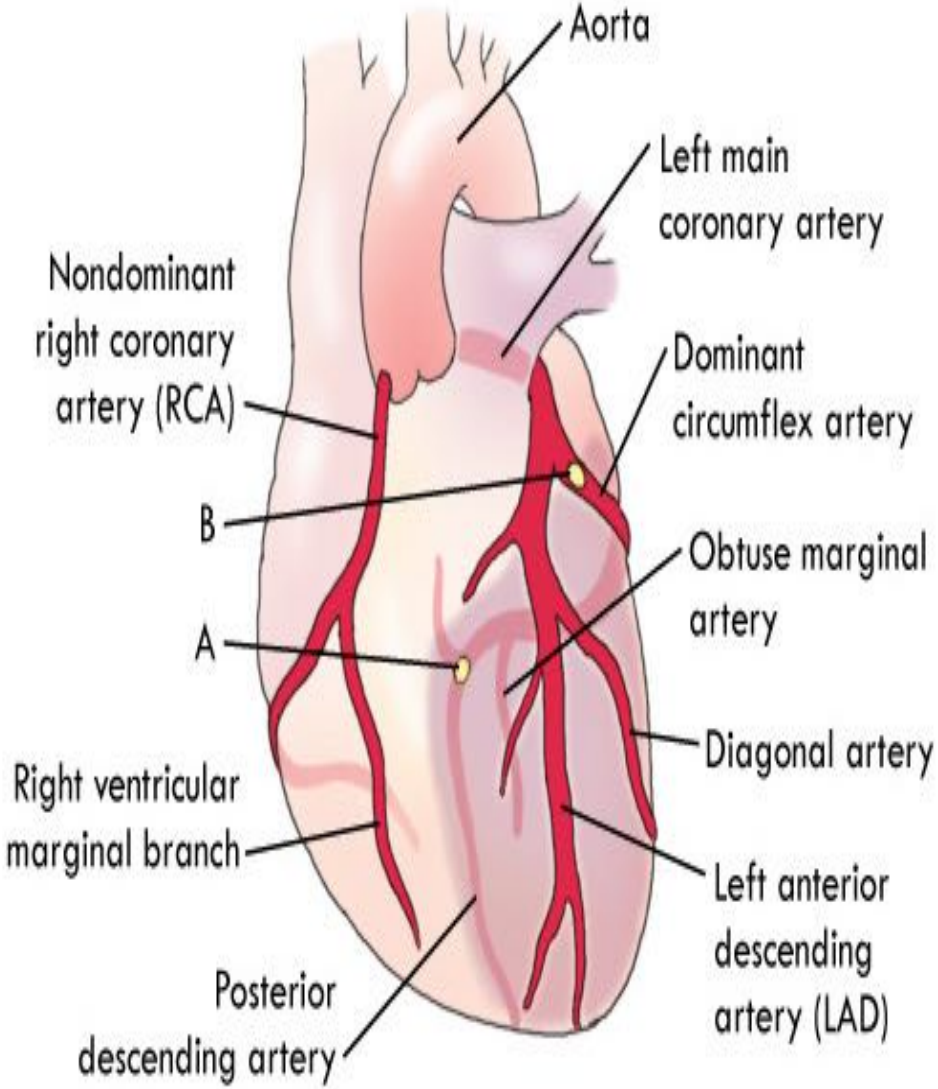
Inferior Wall MI II, III, aVF

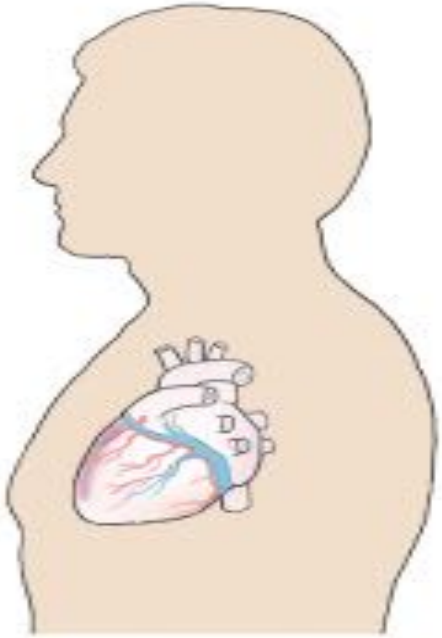


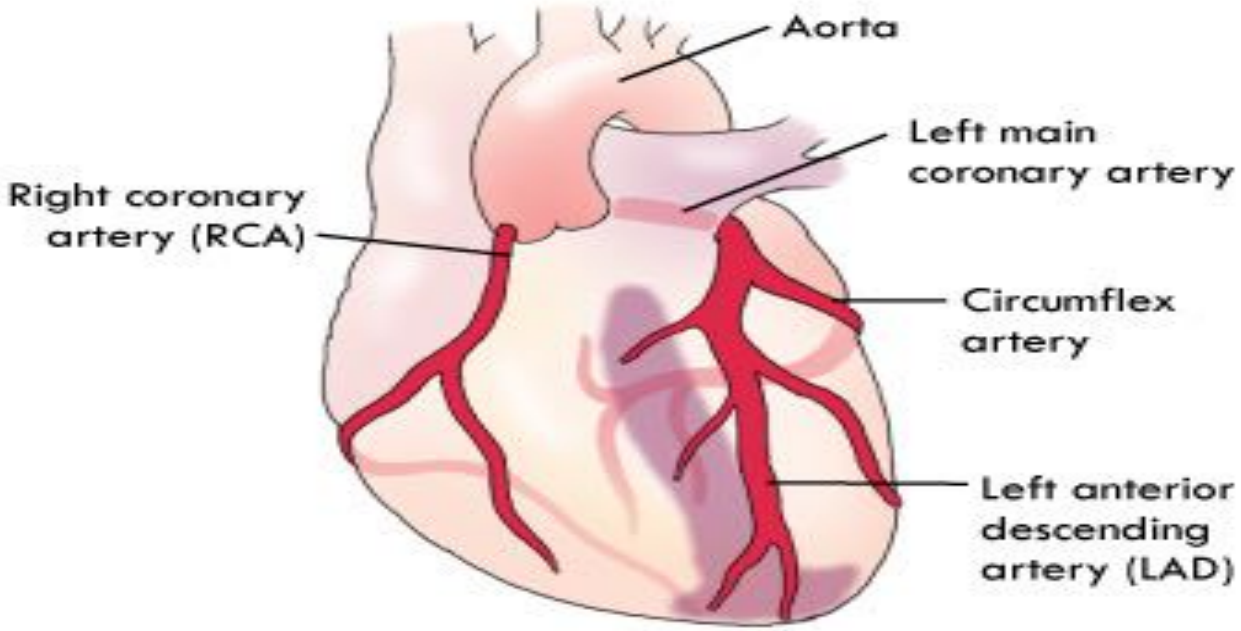
I Lateral	aVR	V_1 Septum	V_4 Anterior
II Inferior	aVL Lateral	V_2 Septum	V_5 Lateral
III Inferior	aVF Inferior	V_3 Anterior	V_6 Lateral

B

Source: The 12-Lead ECG in Acute Coronary Syndromes, MosbyJems, 2006.

Septal MI: Leads V1 and V2

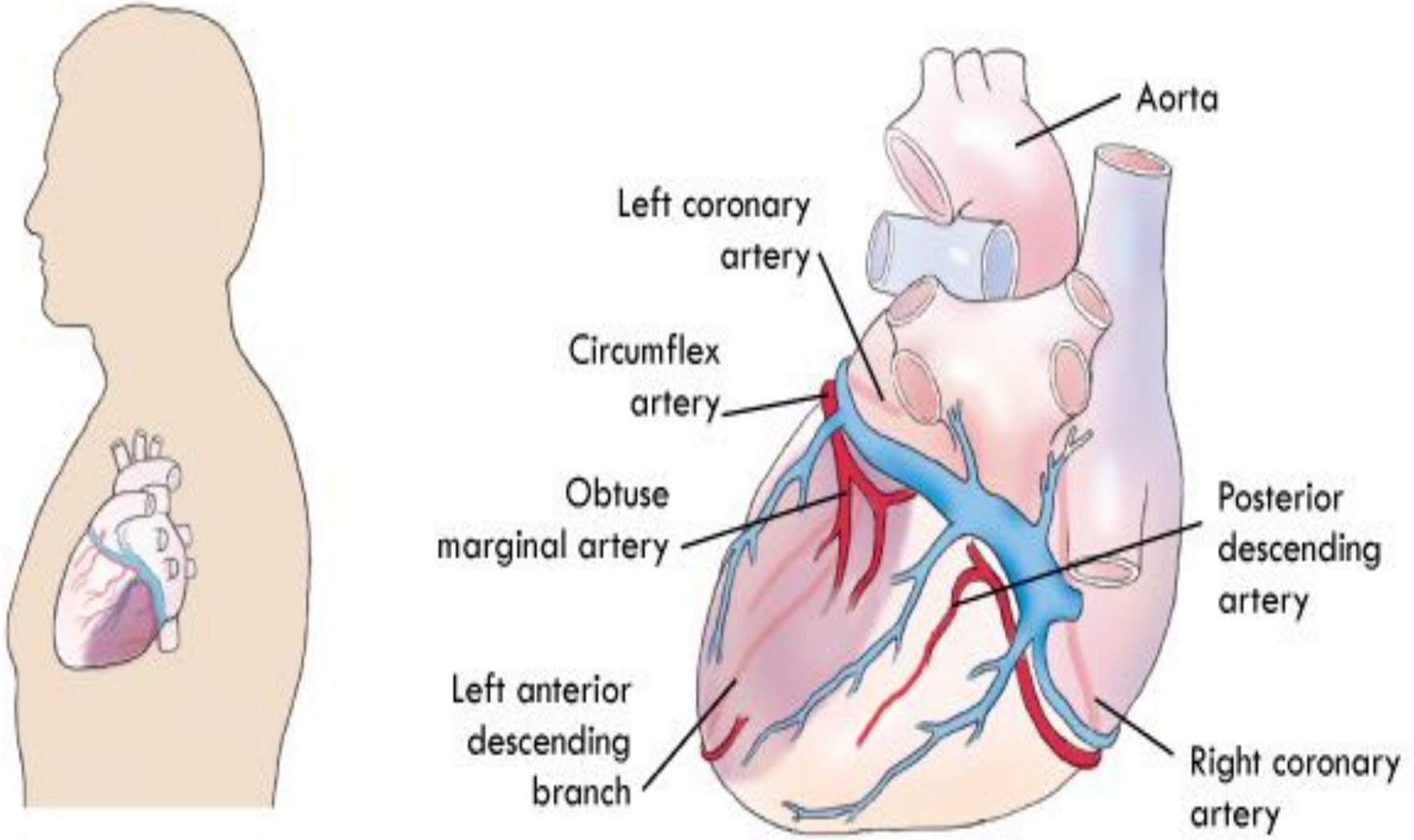




I Lateral	aVR	V_1 Septum	V_4 Anterior
II Inferior	aVL Lateral	V_2 Septum	V_5 Lateral
III Inferior	aVF Inferior	V_3 Anterior	V_6 Lateral

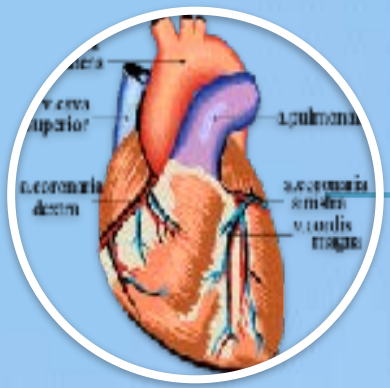
Source: The 12-Lead ECG in Acute Coronary Syndromes, MosbyJems, 2006.

Posterior MI – Reciprocal Changes ST Depression V1, V2, V3



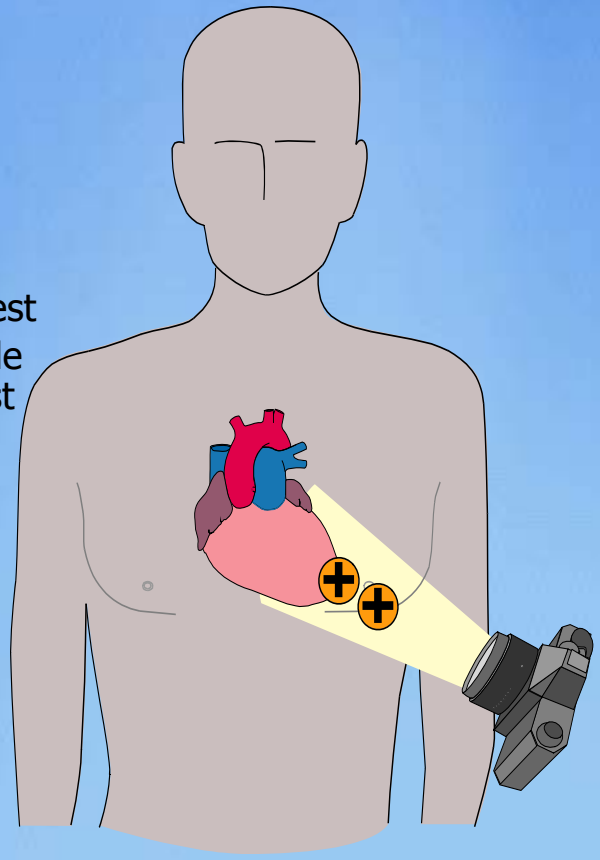
Source: The 12-Lead ECG in Acute Coronary Syndromes, MosbyJems, 2006.

Anterior Wall



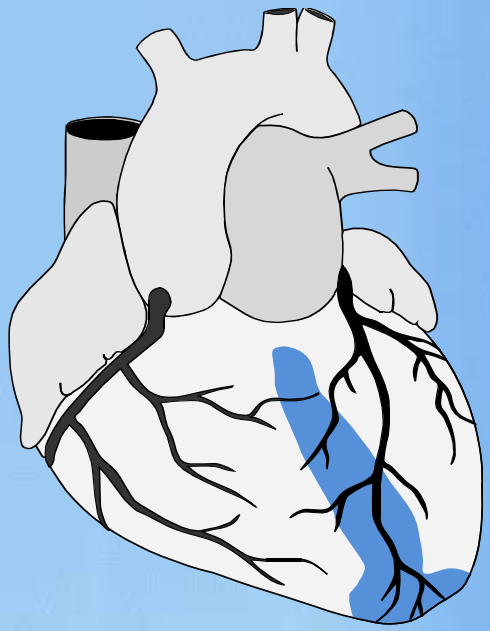
- V3
- V4

- Left anterior chest
- Positive electrode on anterior chest



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

Septal



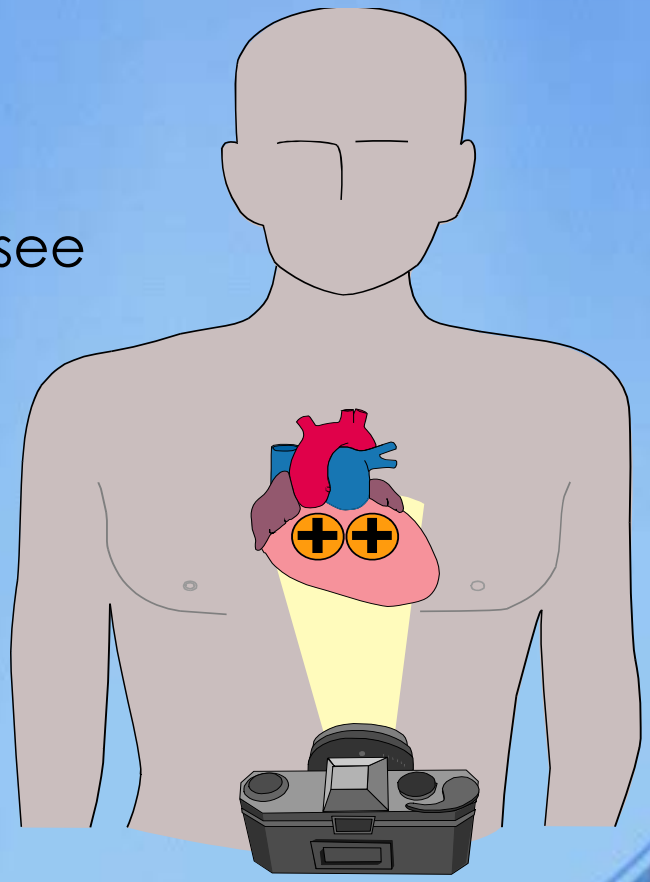
- V1, V2
  - septum is left ventricular tissue

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

Septal Wall

- V1, V2
  - Along sternal borders
  - Look through right ventricle & see septal wall

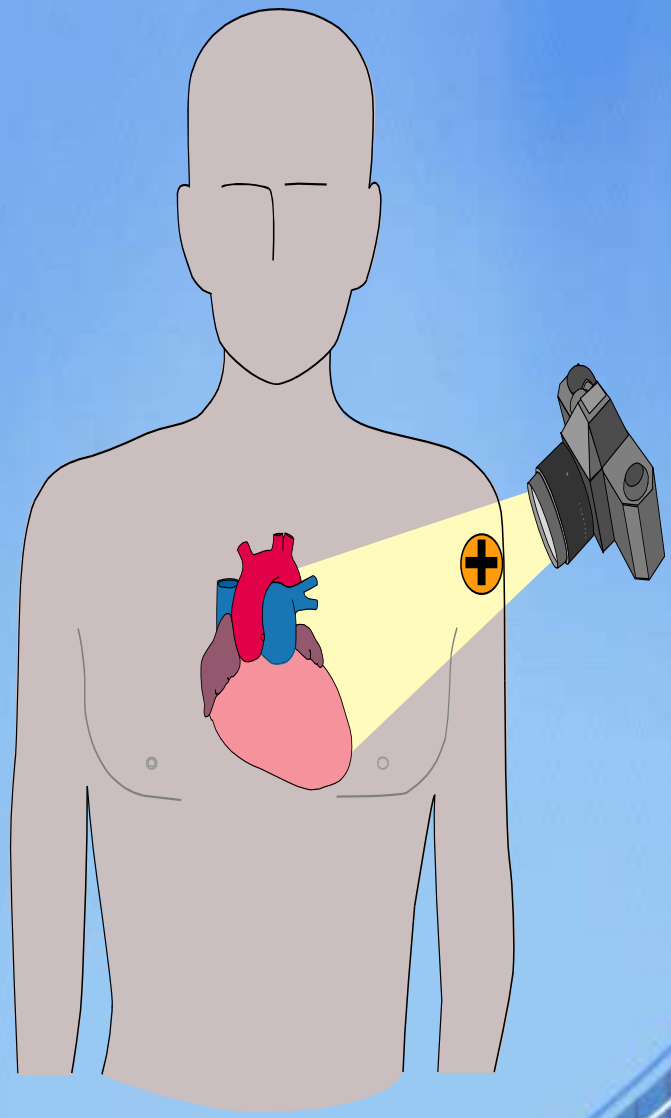
I	aVR	V1	V4
II	aVL	V2	V5
III	aVF	V3	V6



Lateral Wall

- I and aVL
  - View from Left Arm ⊕
  - lateral wall of left ventricle

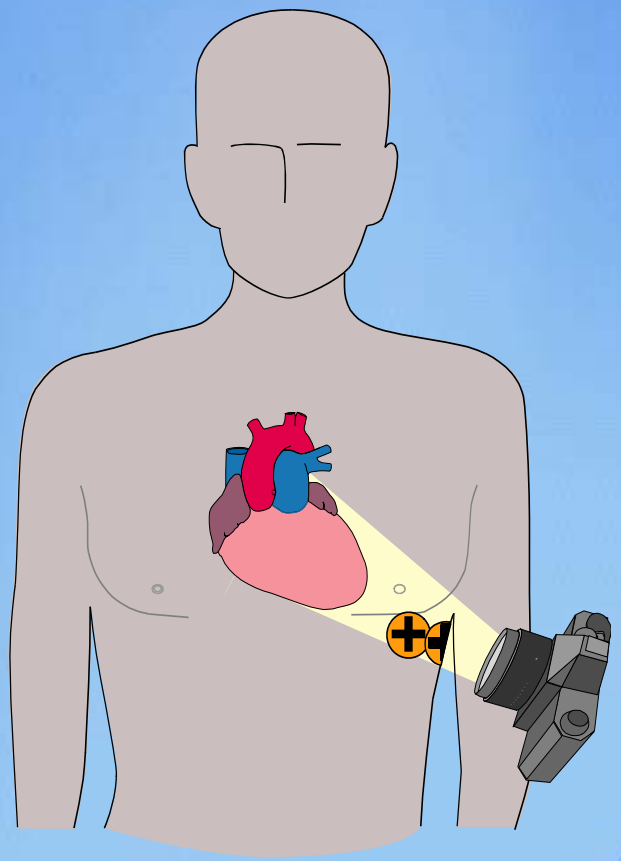
I	aVR	V1	V4
II	aVL	V2	V5
III	aVF	V3	V6



Lateral Wall

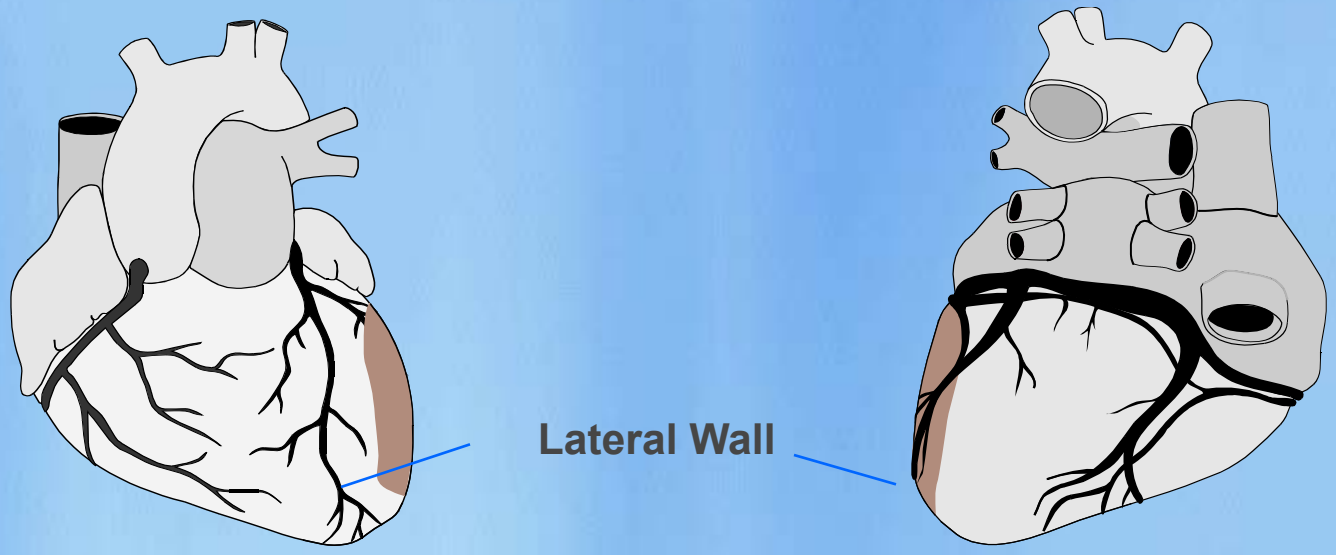
- V5 and V6
  - Left lateral chest
  - lateral wall of left ventricle

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



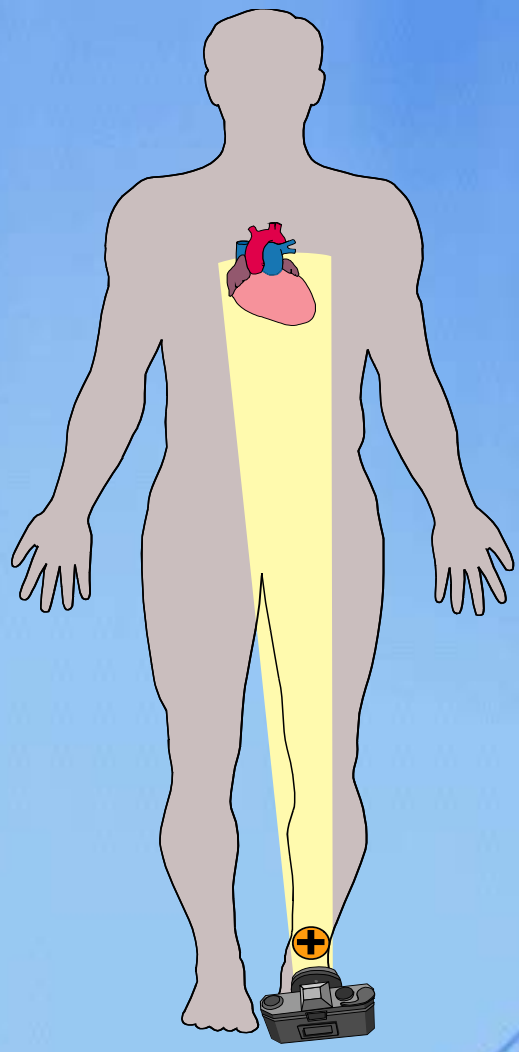
Lateral Wall

- I, aVL, V5, V6
- ST elevation q suspect lateral wall injury



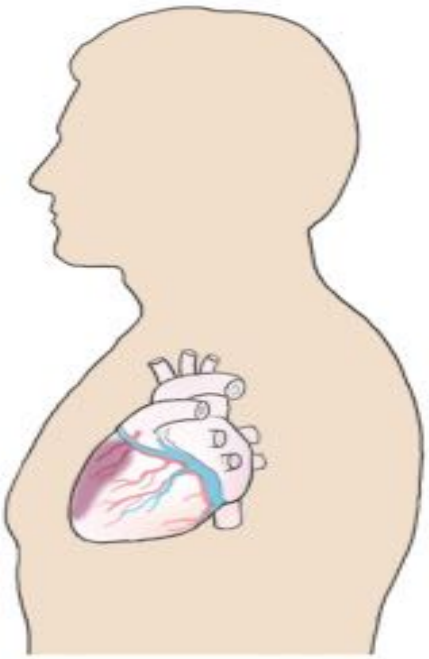
Inferior Wall

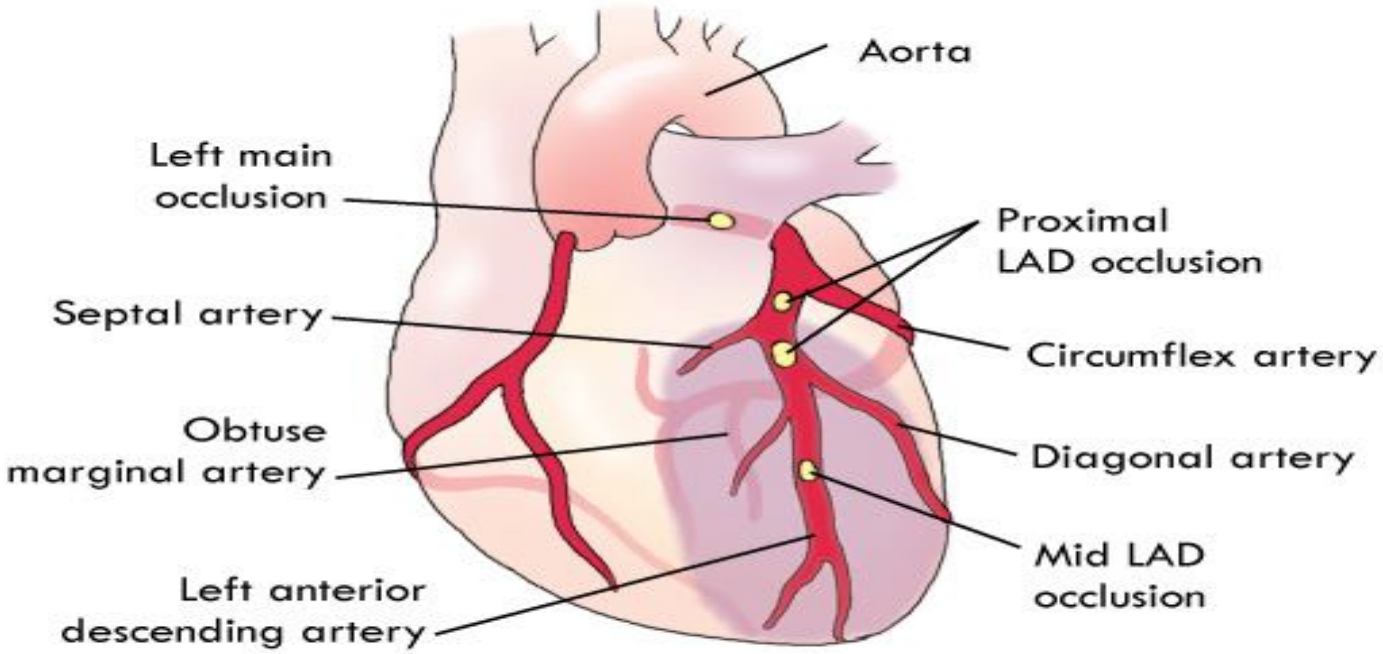
- II, III, aVF
  - View from Left Leg ⊕
  - inferior wall of left ventricle



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

Anterior Wall MI V3, V4

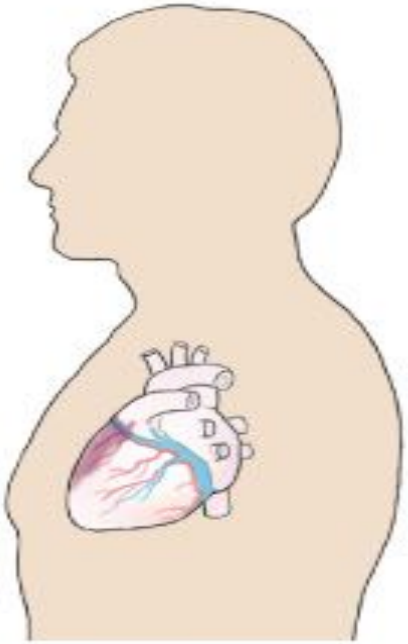


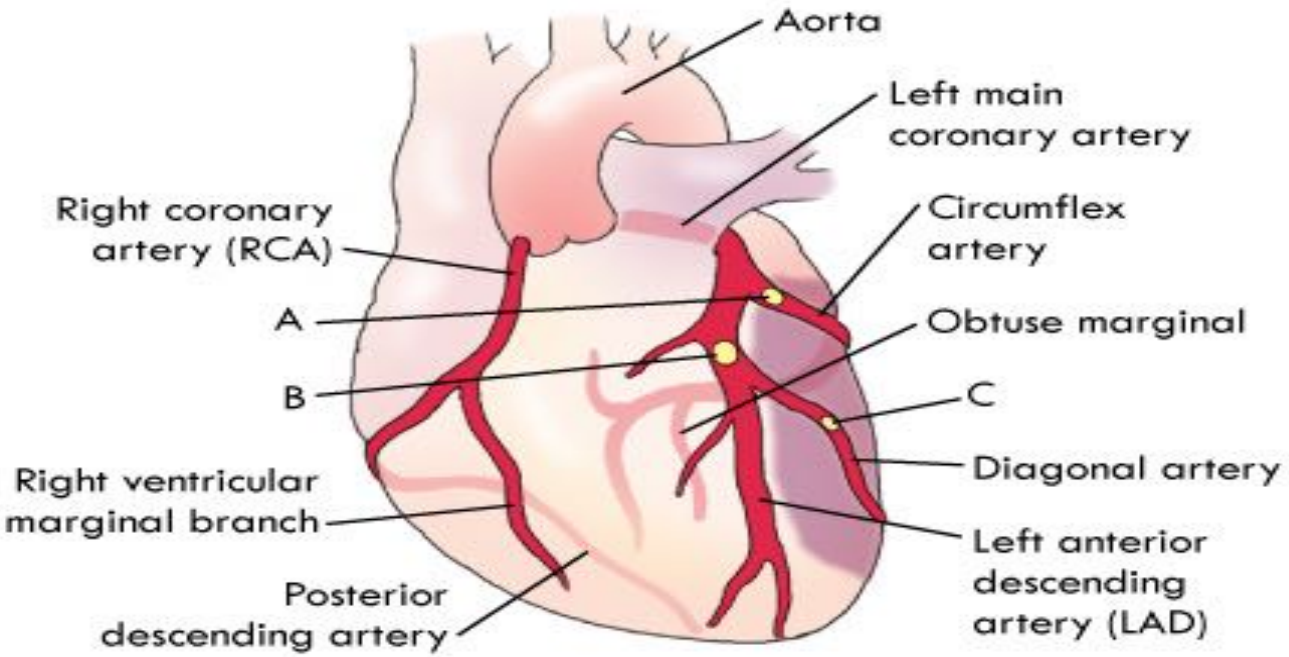


I Lateral	aVR	V_1 Septum	V_4 Anterior
II Inferior	aVL Lateral	V_2 Septum	V_5 Lateral
III Inferior	aVF Inferior	V_3 Anterior	V_6 Lateral

Source: The 12-Lead ECG in Acute Coronary Syndromes, MosbyJems, 2006.

Lateral Wall MI: I, aVL, V5, V6

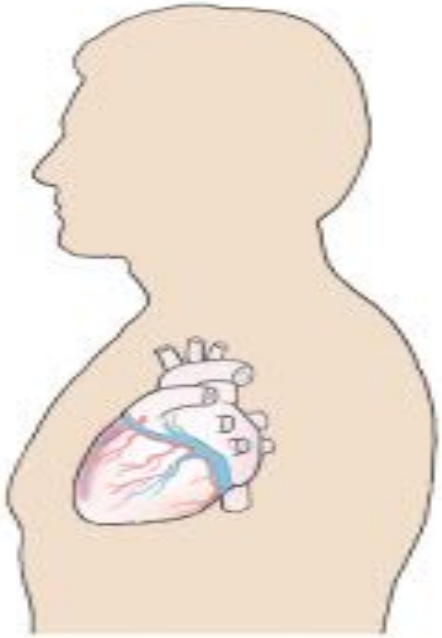


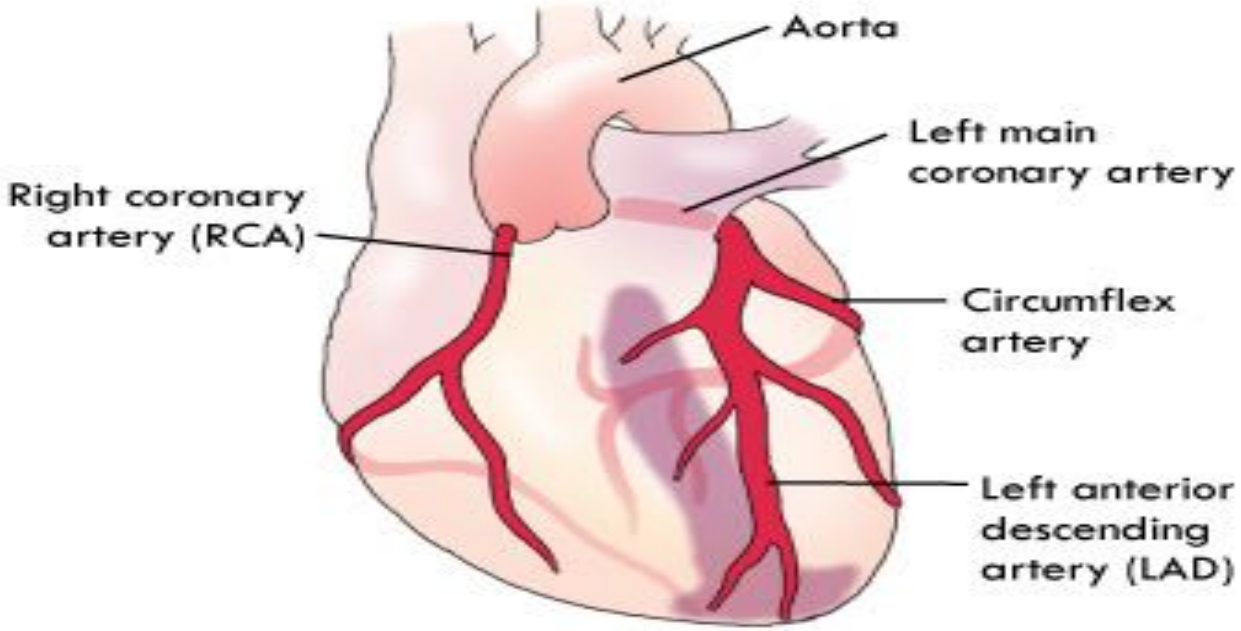


I Lateral	aVR	V_1 Septum	V_4 Anterior
II Inferior	aVL Lateral	V_2 Septum	V_5 Lateral
III Inferior	aVF Inferior	V_3 Anterior	V_6 Lateral

Source: The 12-Lead ECG in Acute Coronary Syndromes, MosbyJems, 2006.

Septal MI: Leads V1 and V2

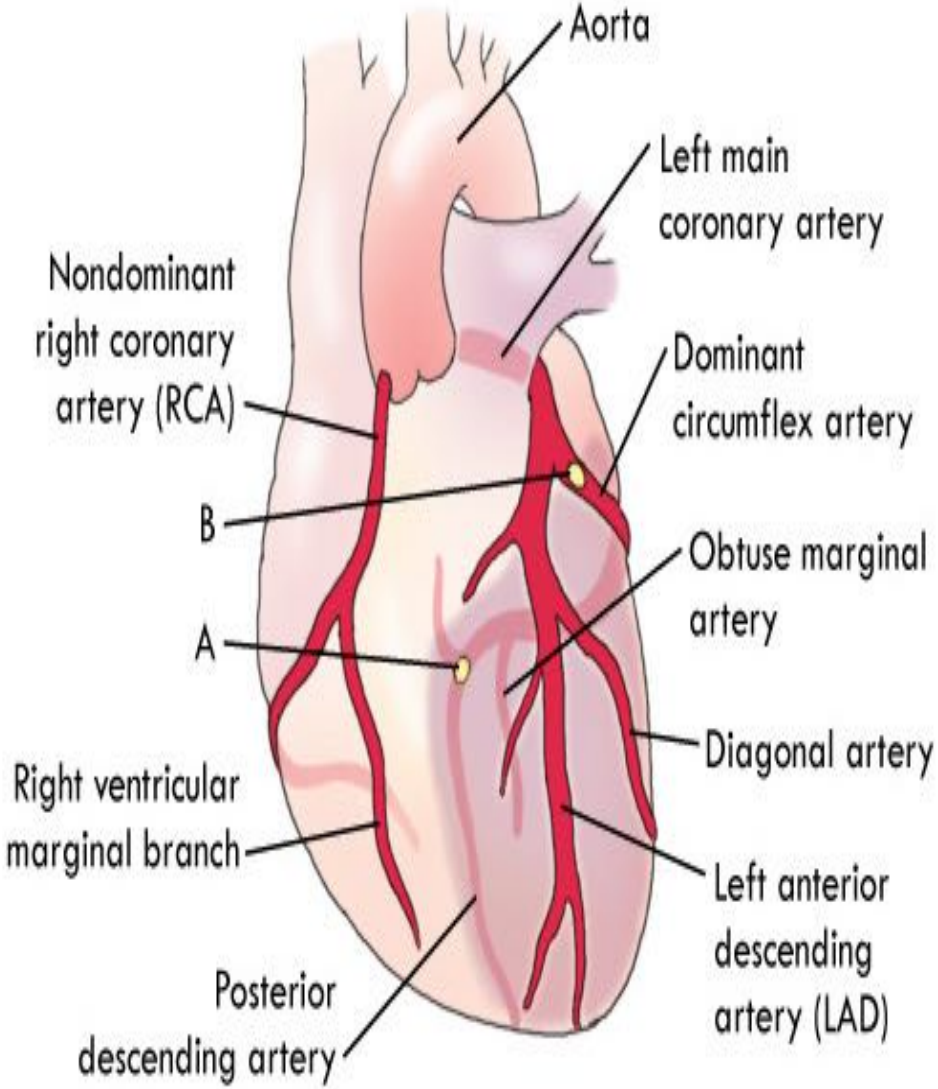




I Lateral	aVR	V_1 Septum	V_4 Anterior
II Inferior	aVL Lateral	V_2 Septum	V_5 Lateral
III Inferior	aVF Inferior	V_3 Anterior	V_6 Lateral

Source: The 12-Lead ECG in Acute Coronary Syndromes, MosbyJems, 2006.

Inferior Wall MI II, III, aVF

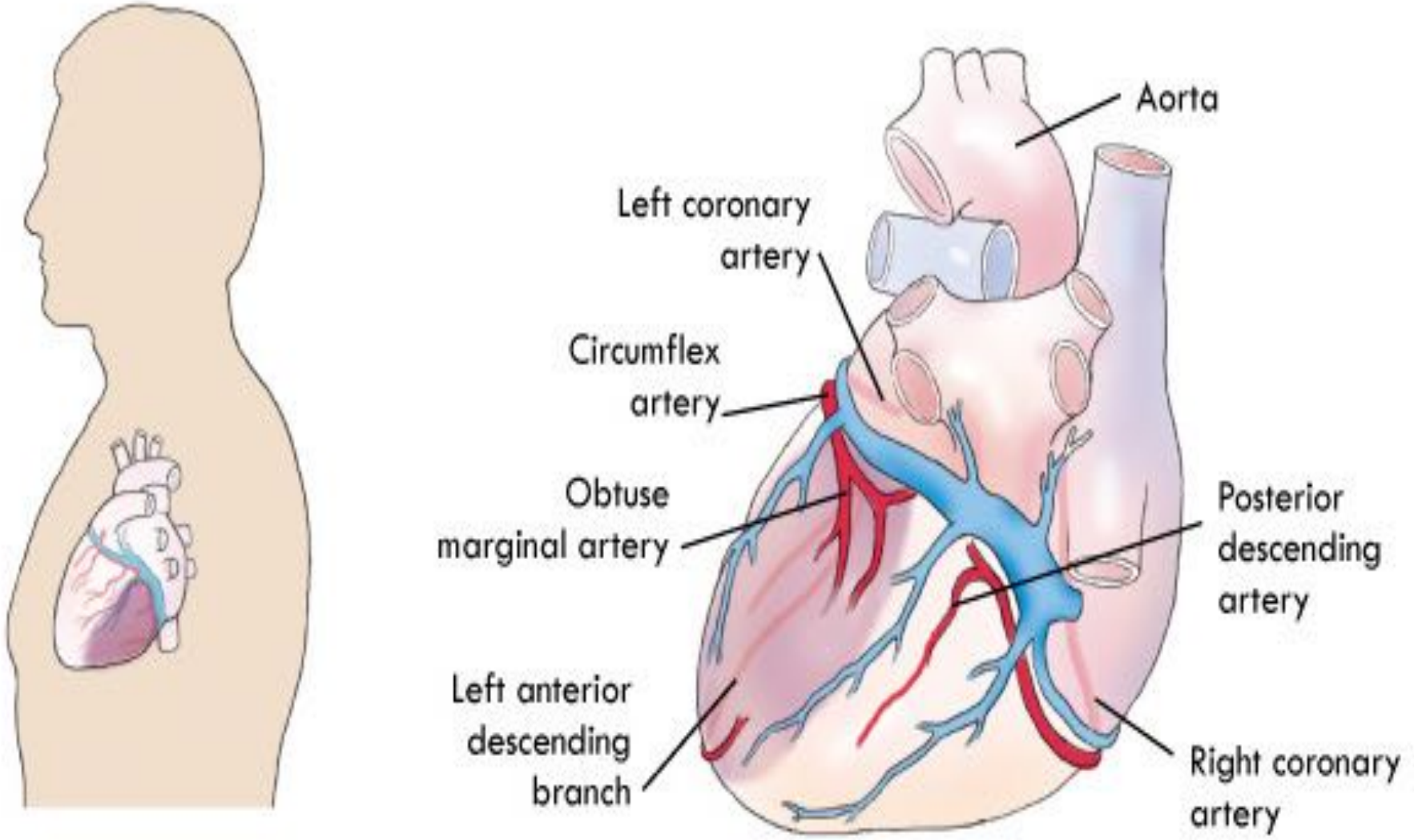


I Lateral	aVR	V_1 Septum	V_4 Anterior
II Inferior	aVL Lateral	V_2 Septum	V_5 Lateral
III Inferior	aVF Inferior	V_3 Anterior	V_6 Lateral

B

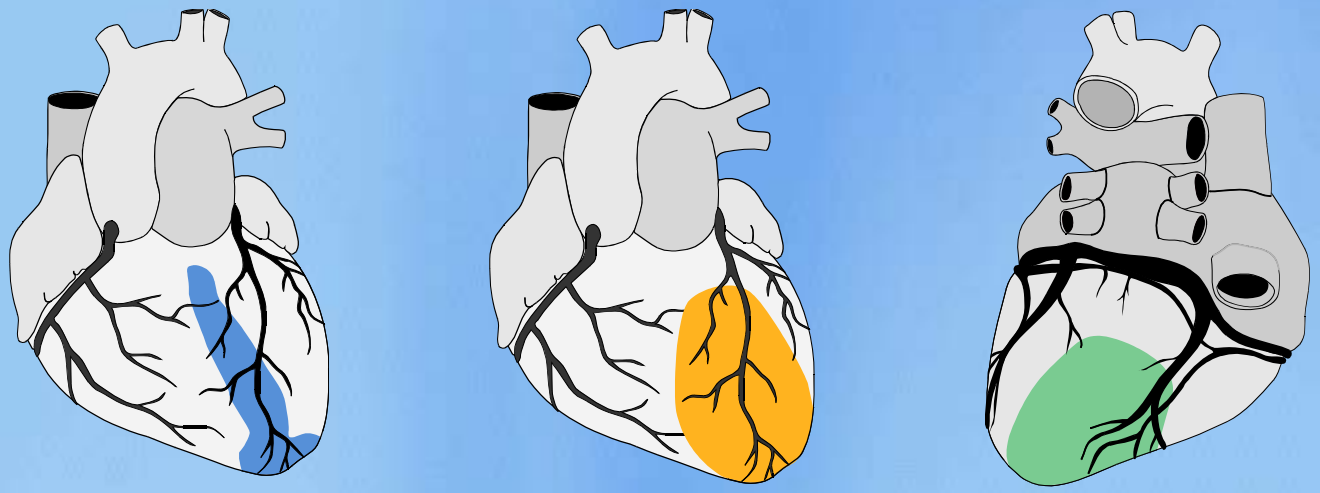
Source: The 12-Lead ECG in Acute Coronary Syndromes, MosbyJems, 2006.

Posterior MI – Reciprocal Changes ST Depression V1, V2, V3



Source: The 12-Lead ECG in Acute Coronary Syndromes, MosbyJems, 2006.

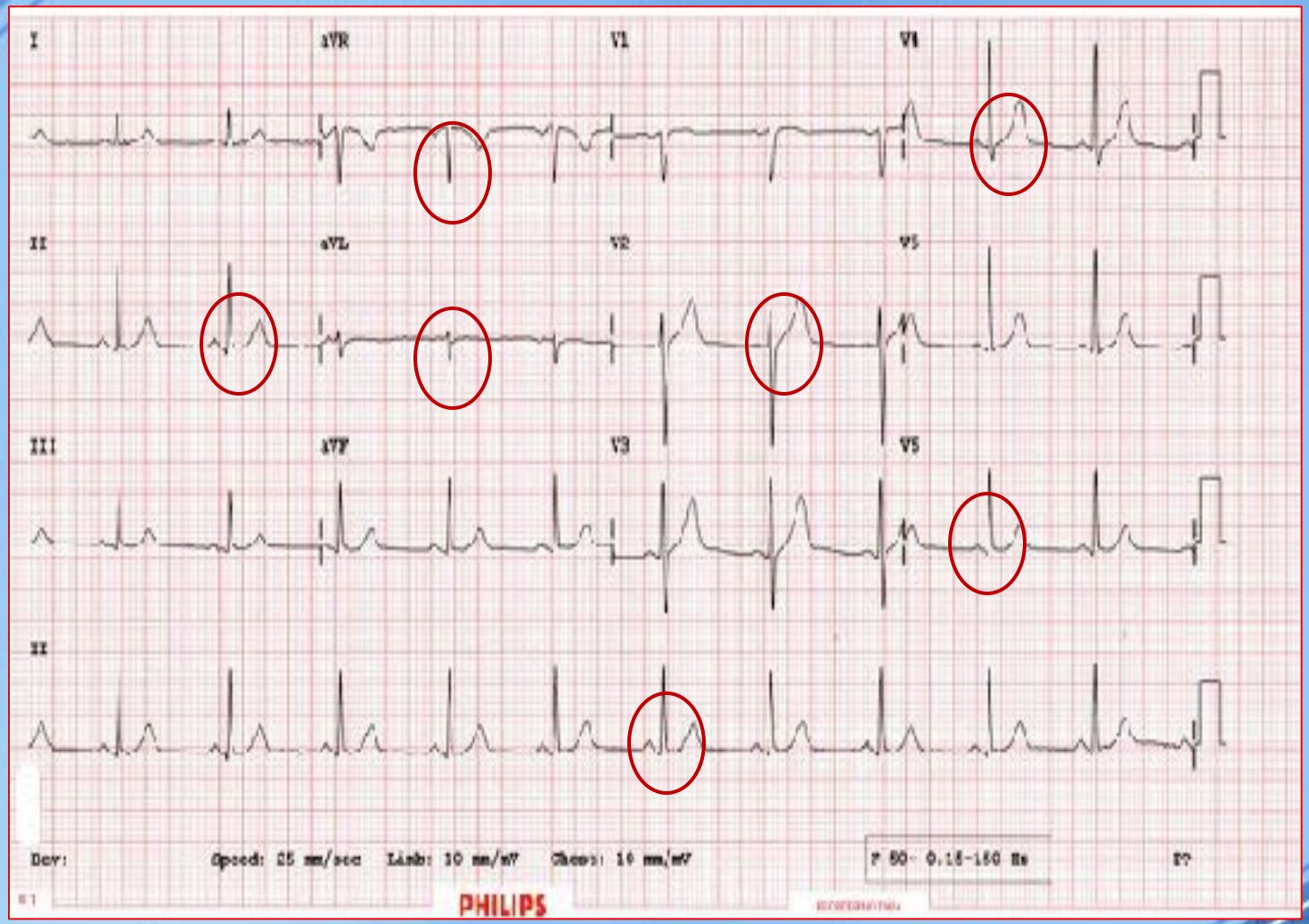
Localization



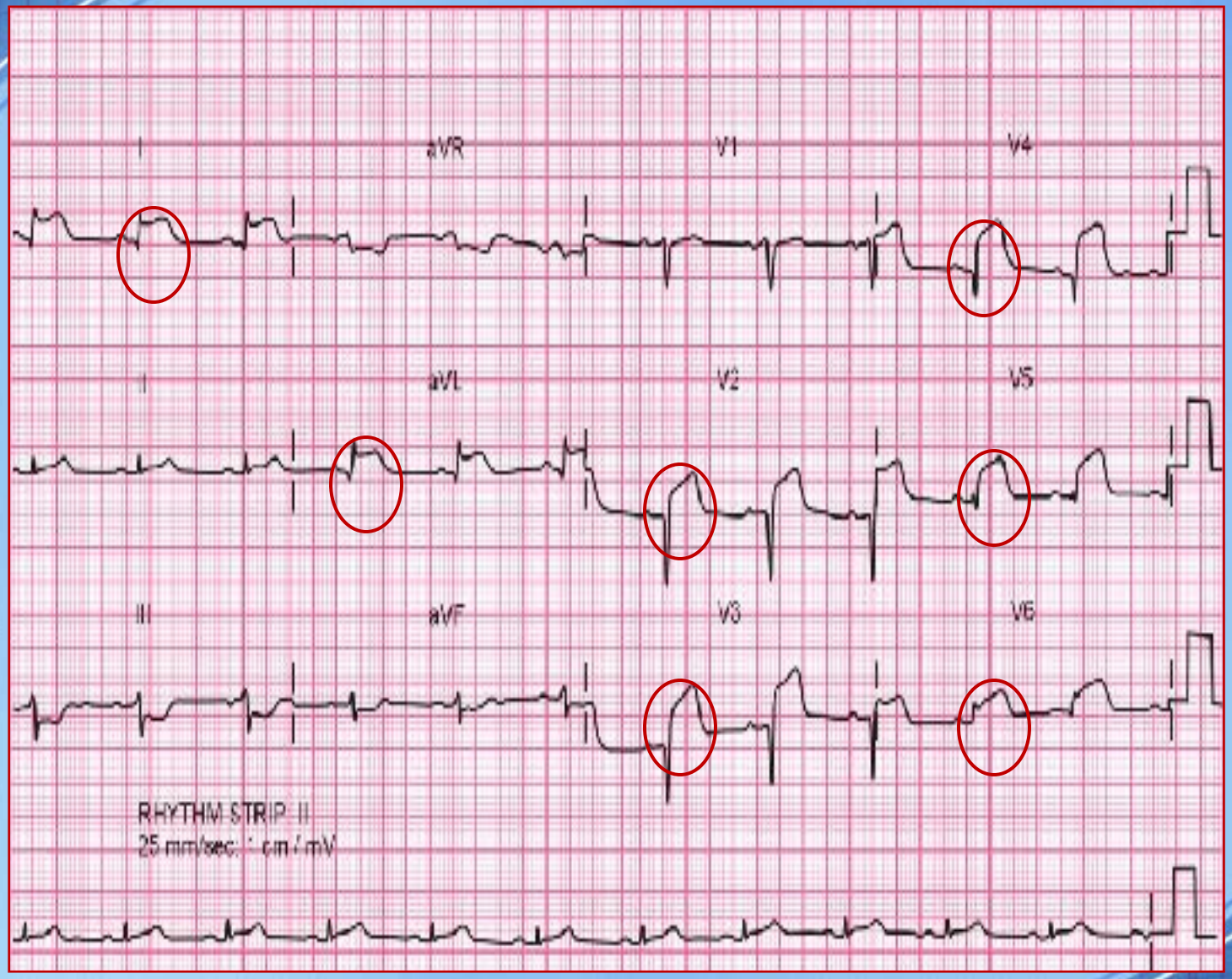
I	aVR	V1	V4
II	aVL	V2	V5
III	aVF	V3	V6

Inferior: II, III, AVF
Septal: V1, V2
Anterior: V3, V4
Lateral: I, AVL, V5, V6

Normal ECG



Acute ST Elevation MI

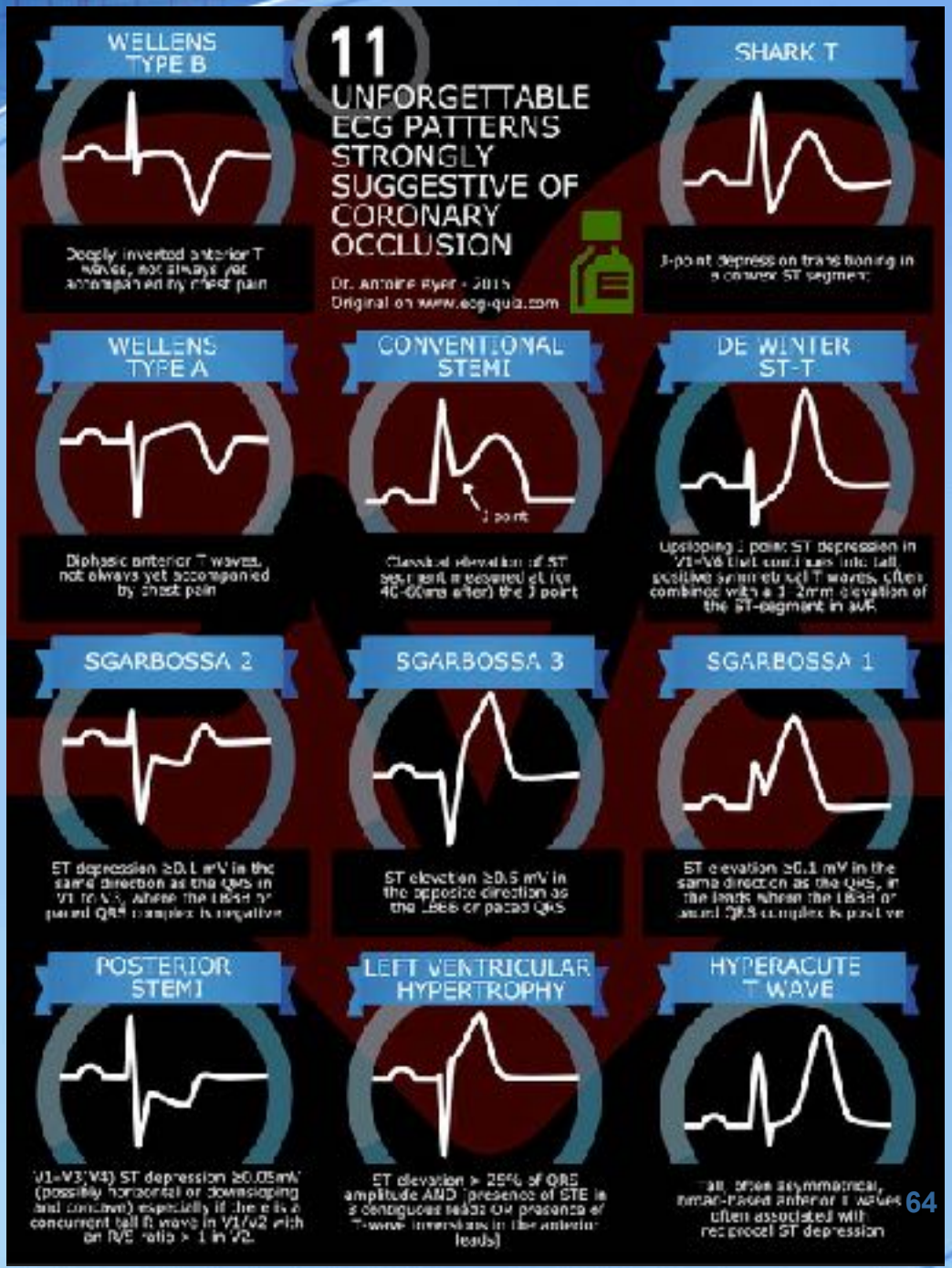


Atypical ECG presentations that deserve promt management in patients with signs and symptoms of ischemia

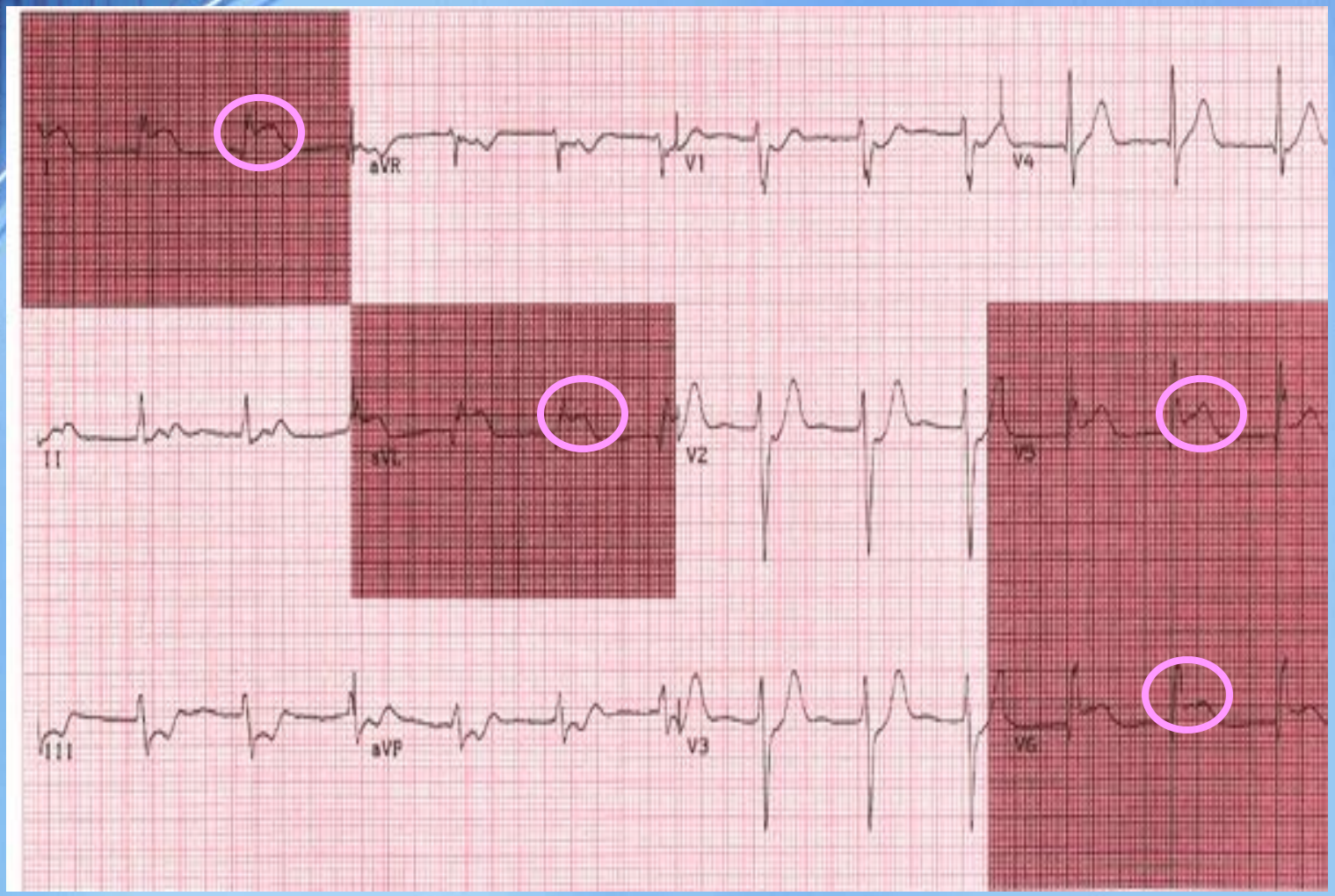
- LBBB.
- Ventricular paced rhythm.
- Patients without diagnostic ST-segment elevation but with persistent ischaemic symptoms.
- Isolated posterior myocardial infarction.
- ST-segment elevation in lead aVR.

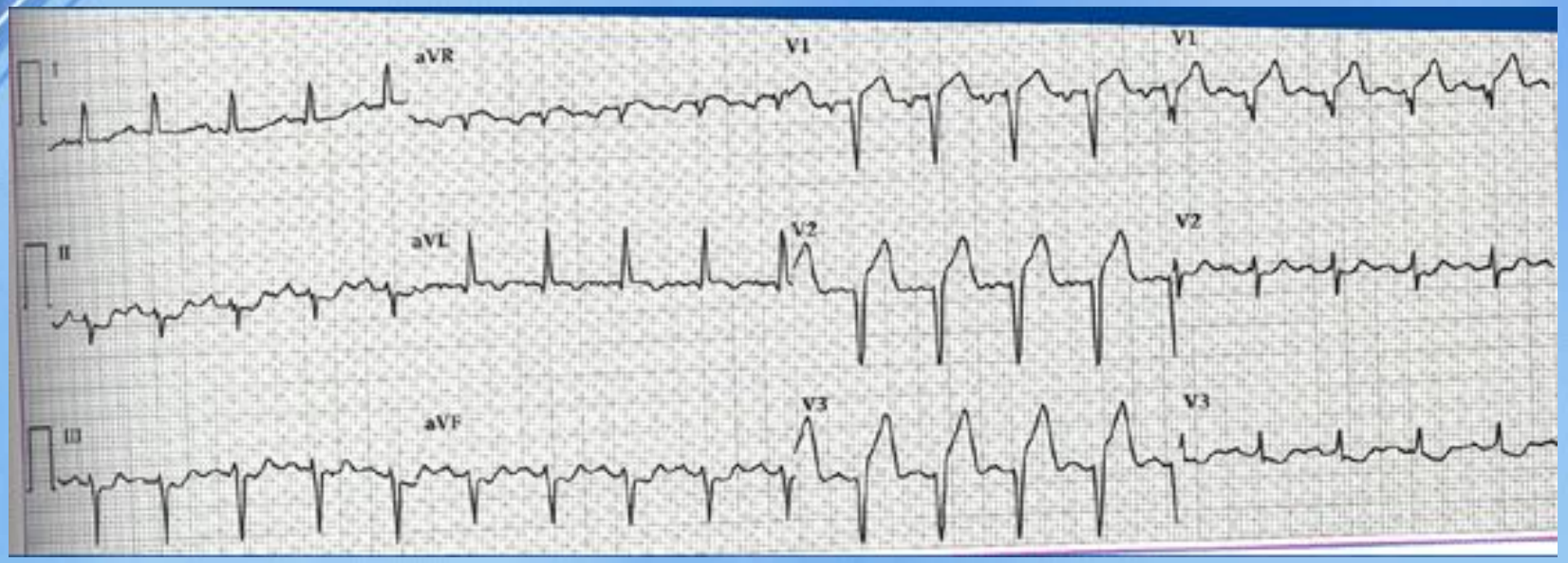
ECG = electrocardiogram, LBBB = left bundle branch block.

European Heart Journal (2012) 33, 2569–2619
doi:10.1093/eurheartj/ehs215

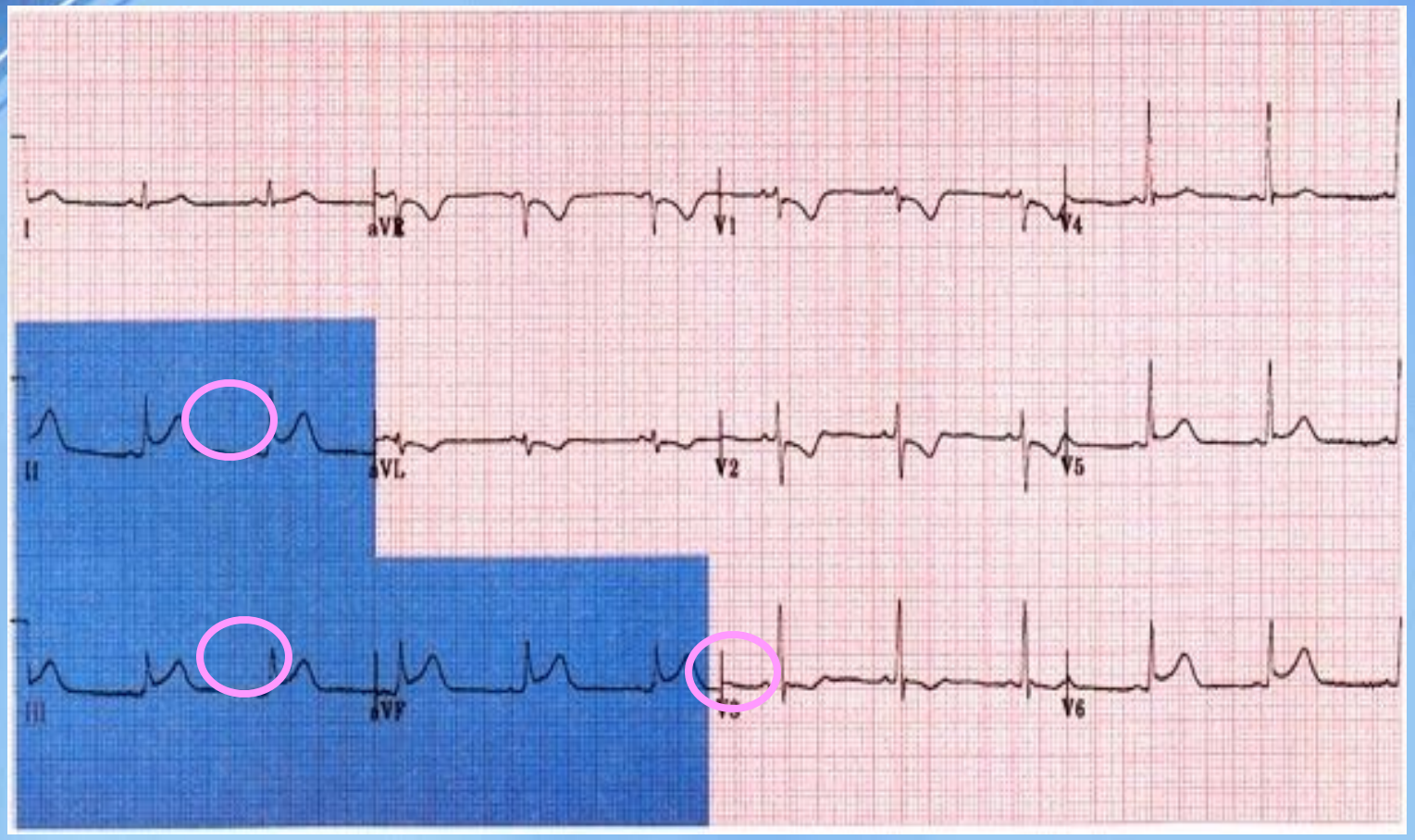

11
UNFORGETTABLE ECG PATTERNS STRONGLY SUGGESTIVE OF CORONARY OCCLUSION
Dr. Antoine Ryer - 2015
Original on www.ecg-quiz.com
WELLENS TYPE B
Deeply inverted anterior T waves, not always yet accompanied by chest pain
SHARK T
J-point depression transitioning to convex ST segment
WELLENS TYPE A
Diphasic anterior T waves, not always yet accompanied by chest pain
CONVENTIONAL STEMI
J point
Classical elevation of ST segment measured at the 40-60ms after the J point
DE WINTER ST-T
Upsloping J point ST depression in V1-V6 that continues into tall, positive symmetrical T waves, often combined with a 1-2mm elevation of the ST-segment in aVR
SGARBOSSA 2
ST depression ≥0.1 mV in the same direction as the QRS in V1 to V3, where the R/S of paced QRS complex is negative
SGARBOSSA 3
ST elevation ≥0.5 mV in the opposite direction as the R/S of paced QRS
SGARBOSSA 1
ST elevation ≥0.1 mV in the same direction as the QRS, in the leads where the R/S of paced QRS complex is positive
POSTERIOR STEMI
V1-V3(V4) ST depression ≥0.05mV (possibly horizontal or downsloping and concave) especially if there is a concurrent tall R wave in V1/V2 with an R/S ratio > 1 in V2.
LEFT VENTRICULAR HYPERTROPHY
ST elevation > 25% of QRS amplitude AND presence of STE in a contiguous lead AND presence of T-wave inversions in the anterior leads)
HYPERACUTE T WAVE
Tall, often asymmetrical, inner-based anterior T waves often associated with reciprocal ST depression

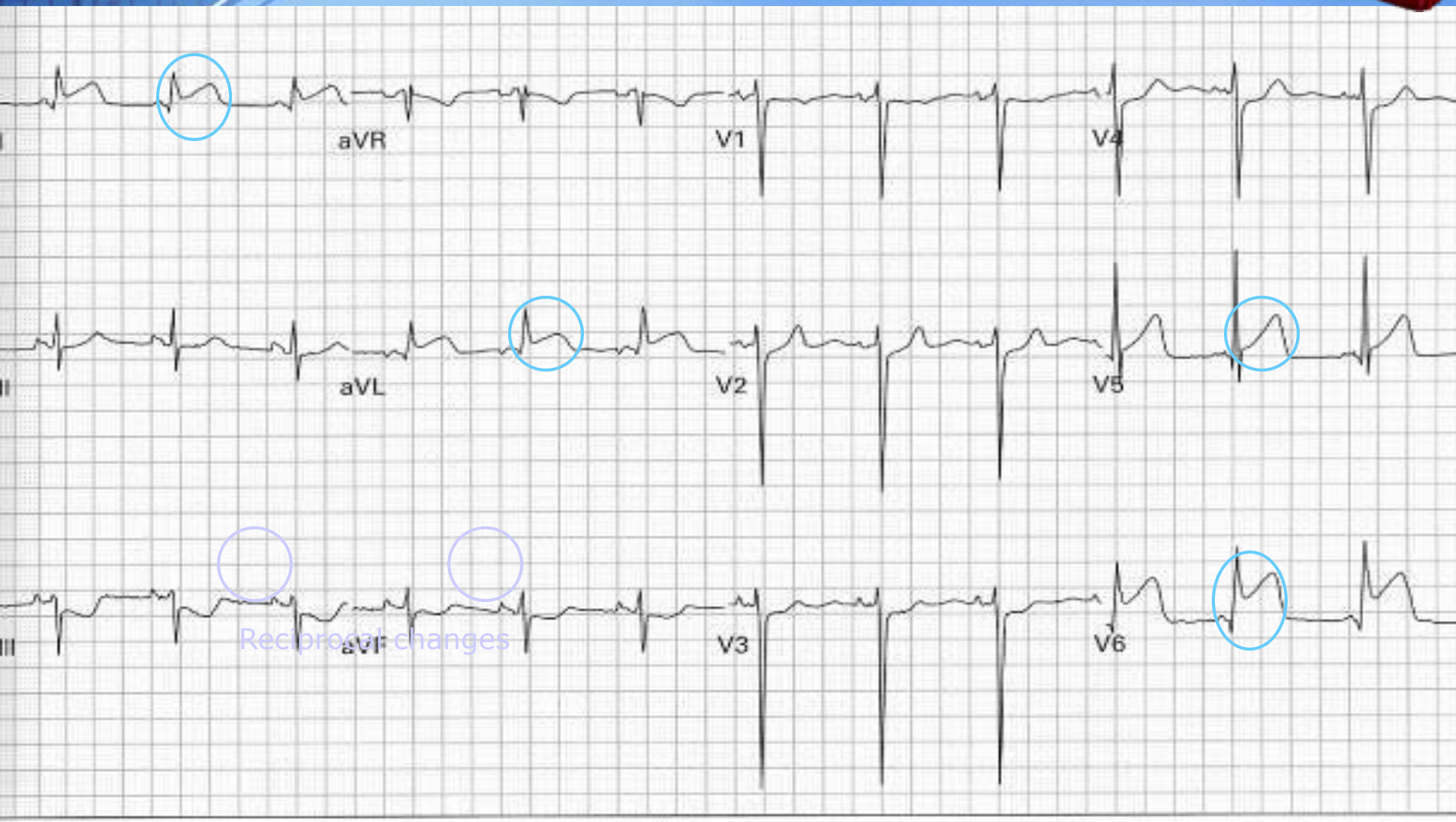
PRACTICE SESSION ! ! !


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



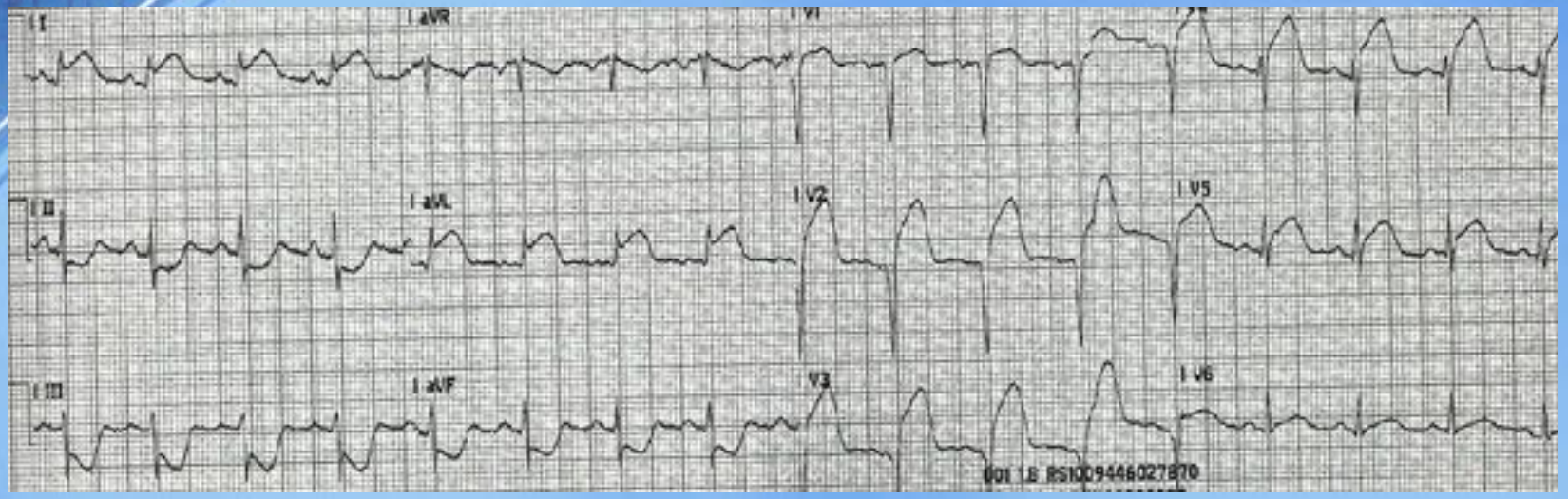
- ST elevations V1, V2, V3, V4


I
aVR
V1
V4
II
aVL
V2
V5
III
aVF
V6

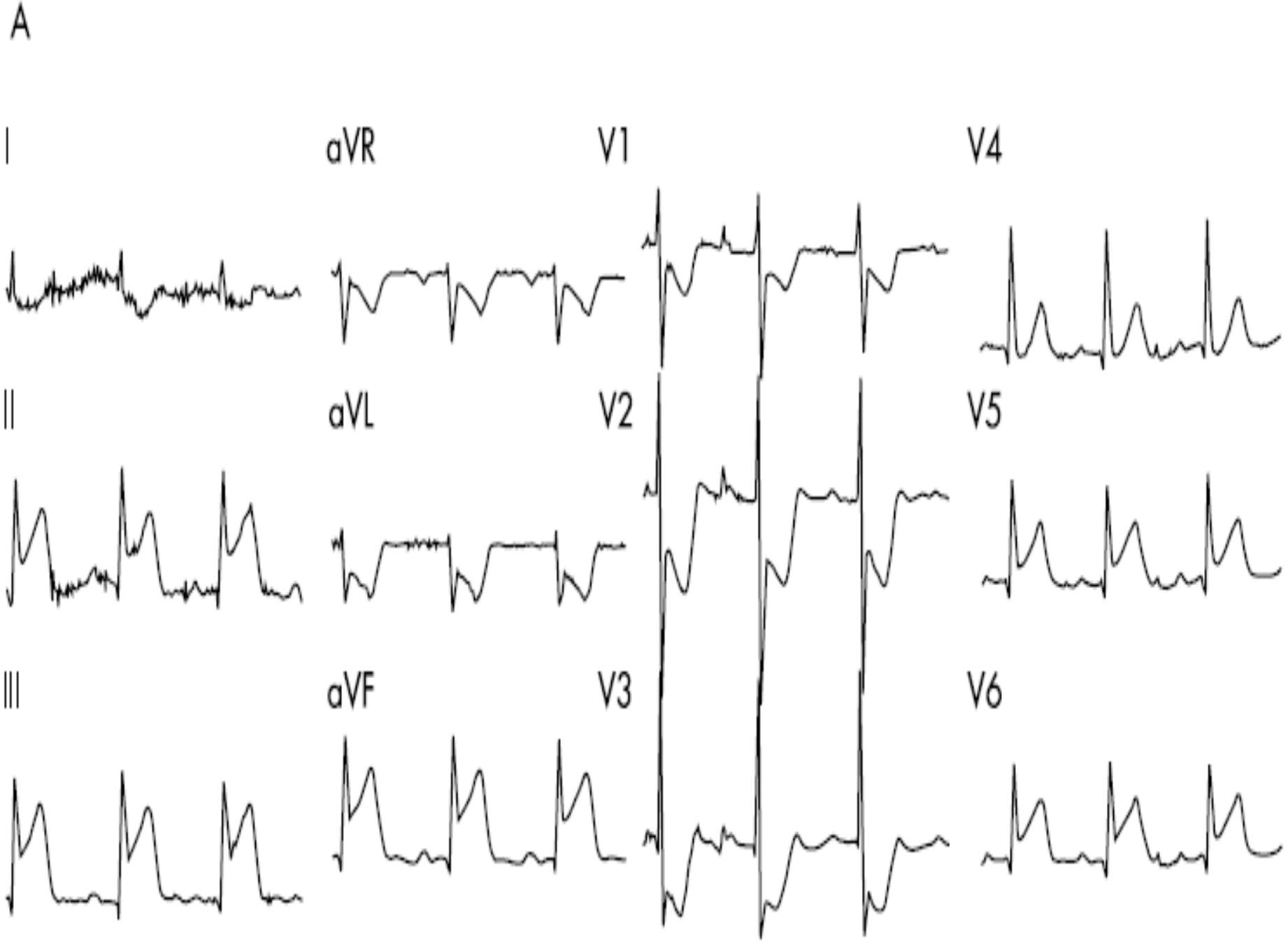


50. 43 year old man reports eight hours of left chest and arm pain

37. 38 year old man with chest pain, nausea, and diaphoresis

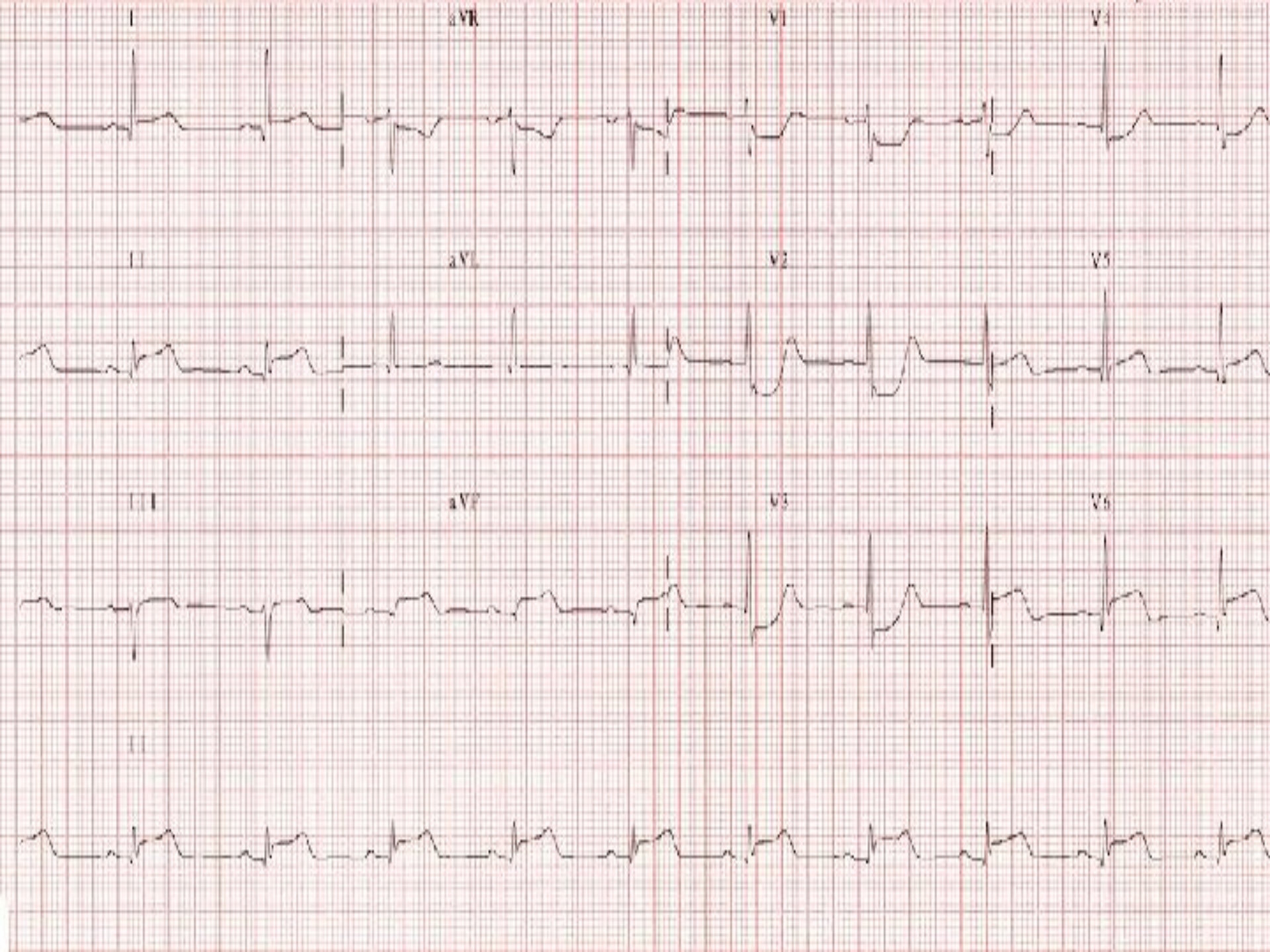


- Anterior MI with lateral involvement
- ST elevations V2, V3, V4
- ST elevations II, AVL, V5


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


I
AVR
V1
V4
II
AVL
V2
V5
III
AVF
V3
V6


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


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

Anterior STEMI

- Anterior STEMI results from occlusion of the left anterior descending artery (LAD).
- Anterior myocardial infarction carries the worst prognosis of all infarct locations, mostly due to larger infarct size.

How to Recognise Anterior STEMI

- ST segment elevation with Q wave formation in the precordial leads (V1-6) ± the high lateral leads (I and aVL).
- Reciprocal ST depression in the inferior leads (mainly III and aVF).

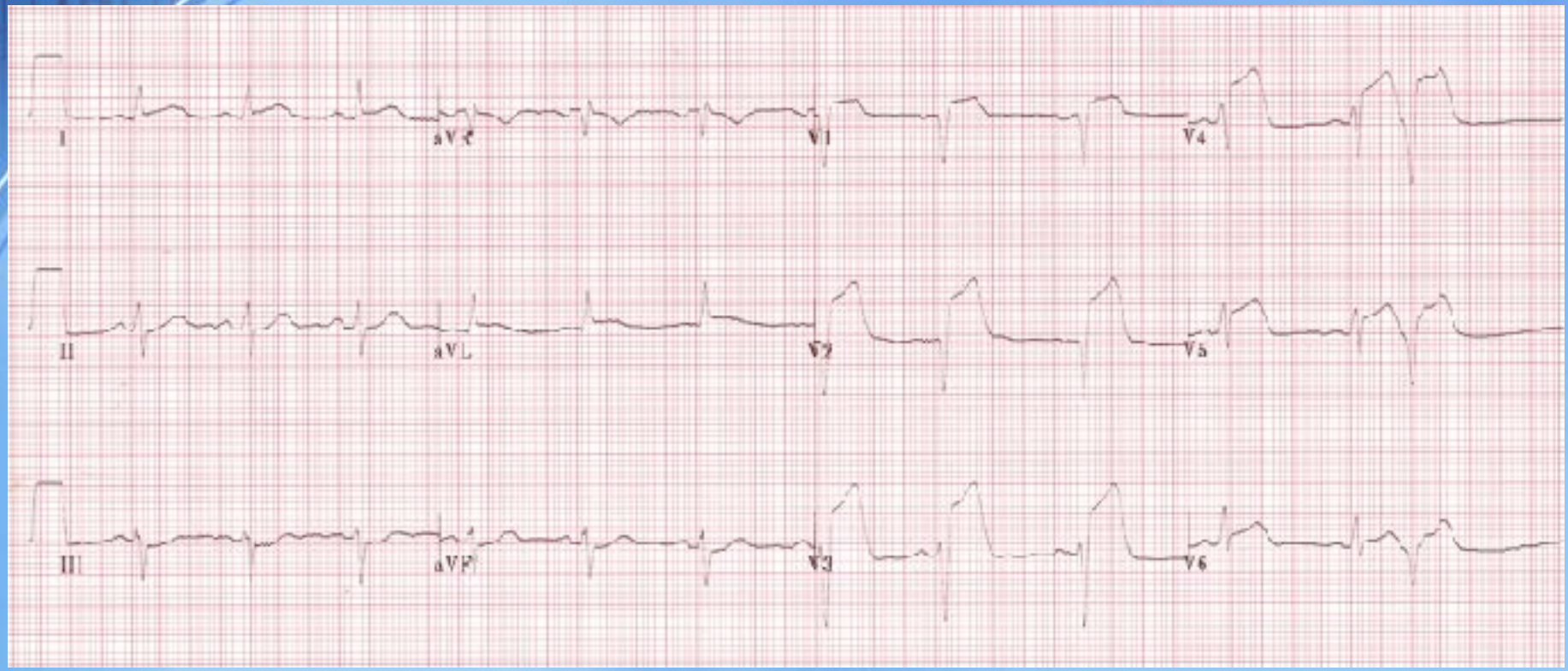
Patterns of Anterior Infarction

- Septal leads = V1-2
- Anterior leads = V3-4
- Lateral leads = V5-6

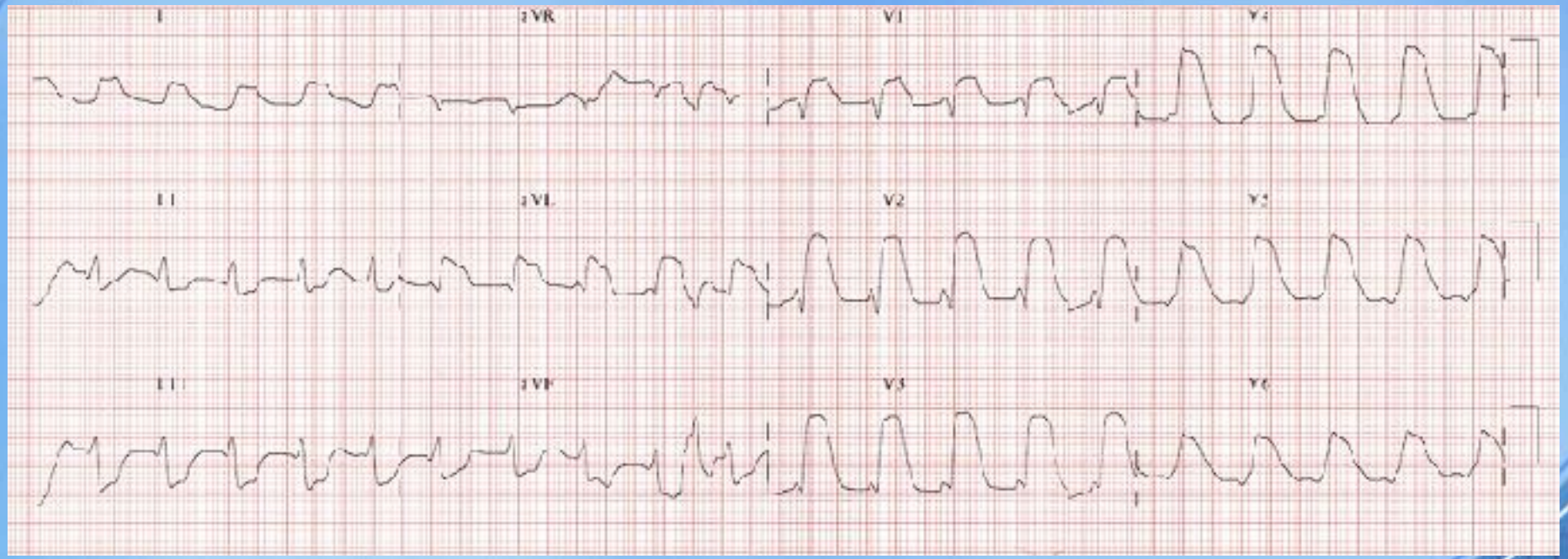
- The different **infarct patterns** are named according to the leads with maximal ST elevation:
- Septal = V1-2
- Anterior = V2-5
- Anteroseptal = V1-4
- Anterolateral = V3-6, I + aVL
- Extensive anterior / anterolateral = V1-6, I + aVL

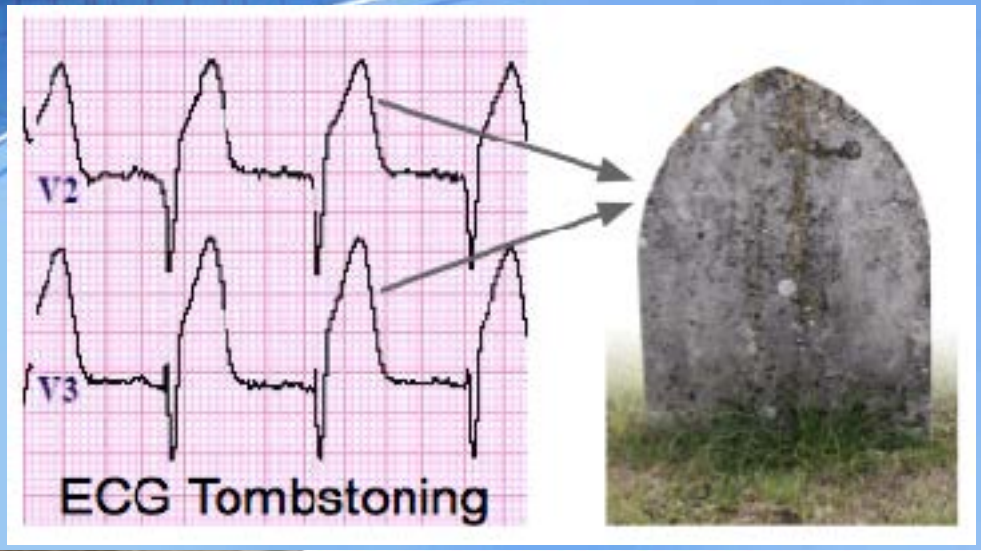

aVR
V1
V4
I
aVL
V2
V5
III
aVF
V3
V6


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


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

- **Extensive anterior MI ("tombstoning" pattern)**
- Massive ST elevation with "tombstone" morphology is present throughout the precordial (V1-6) and high lateral leads (I, aVL).
- This pattern is seen in proximal LAD occlusion and indicates a large territory infarction with a poor LV ejection fraction and high likelihood of cardiogenic shock and death

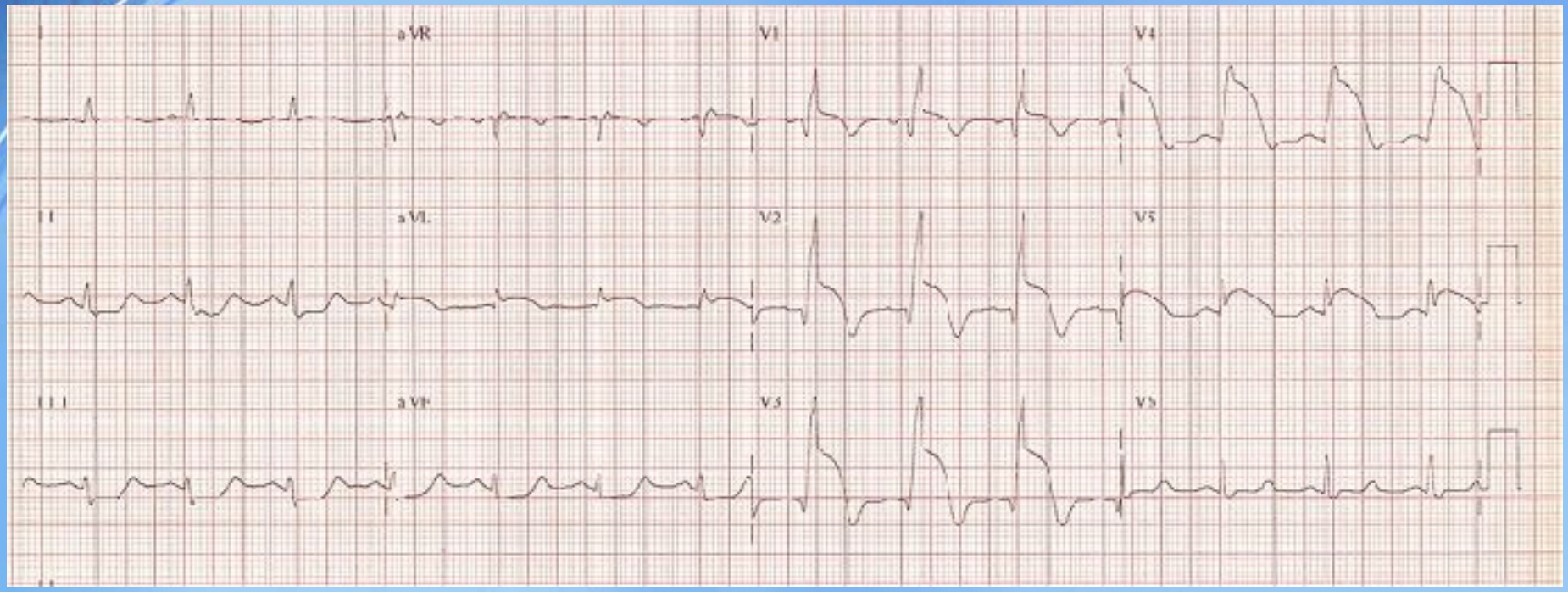


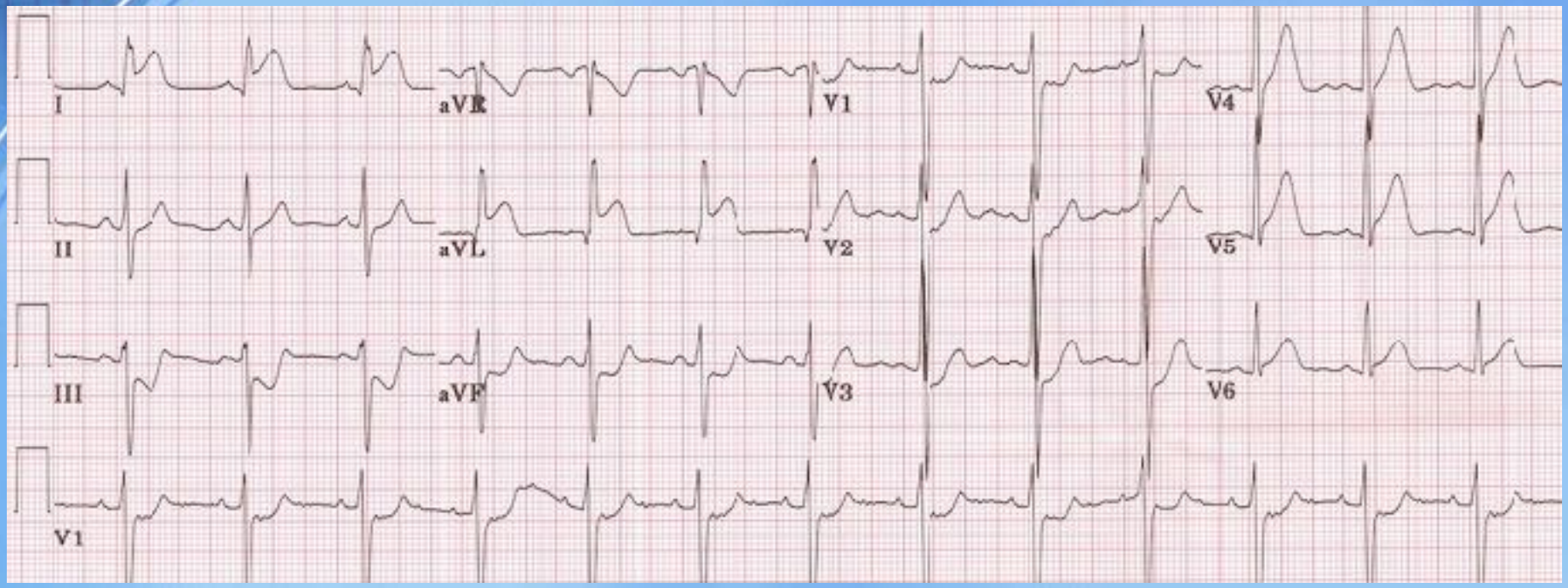


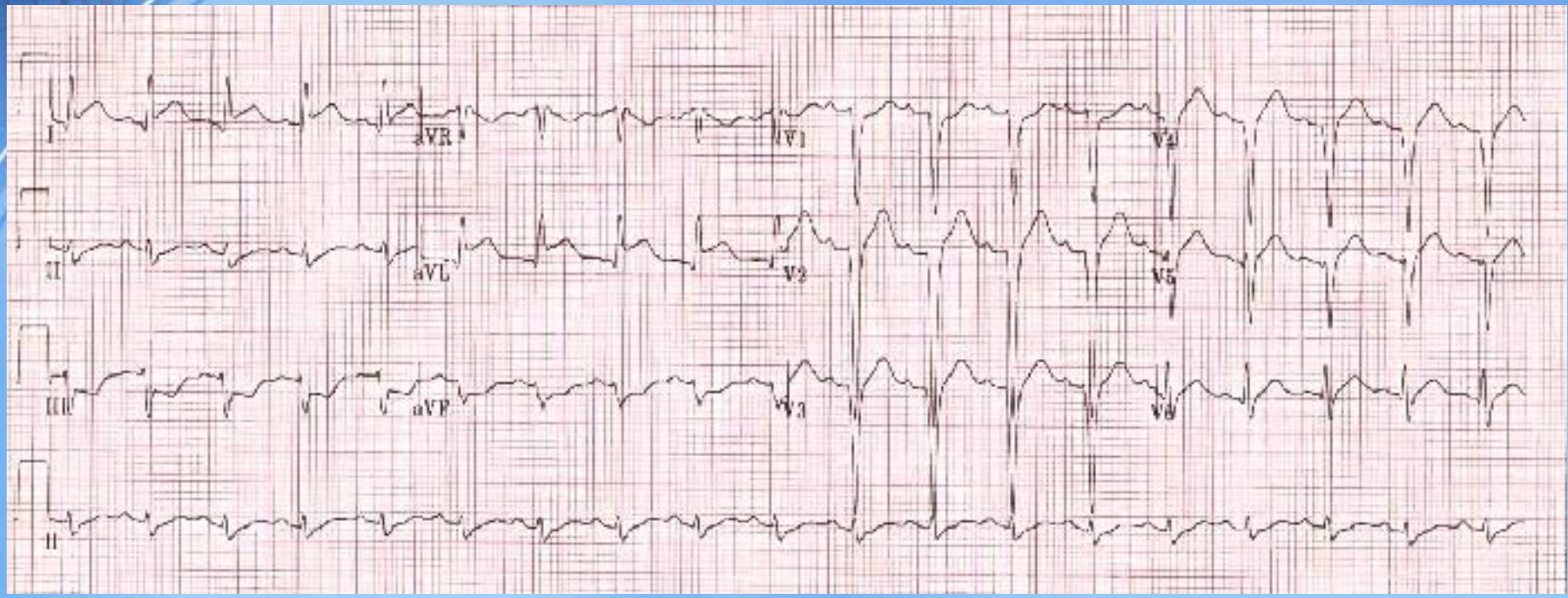
Tombstoning ECG (grave Prognosis)

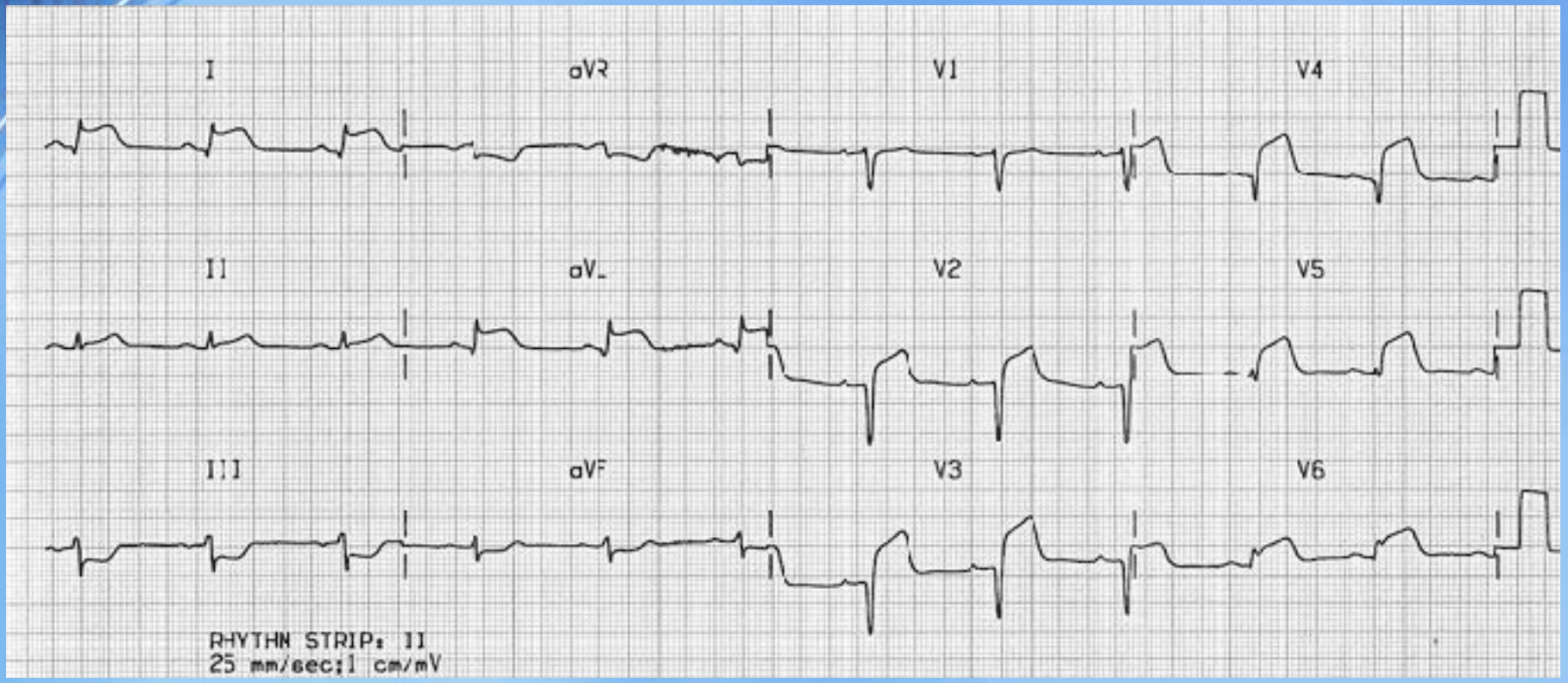
ST segment elevation in the anterior leads (V3 and V4) and sometimes in septal and lateral leads depending on the extent of the myocardial infarction. This ST elevation is concave downward and frequently overwhelms the T wave. This is called "tombstoning" due to the similarity to the shape of a tombstone.

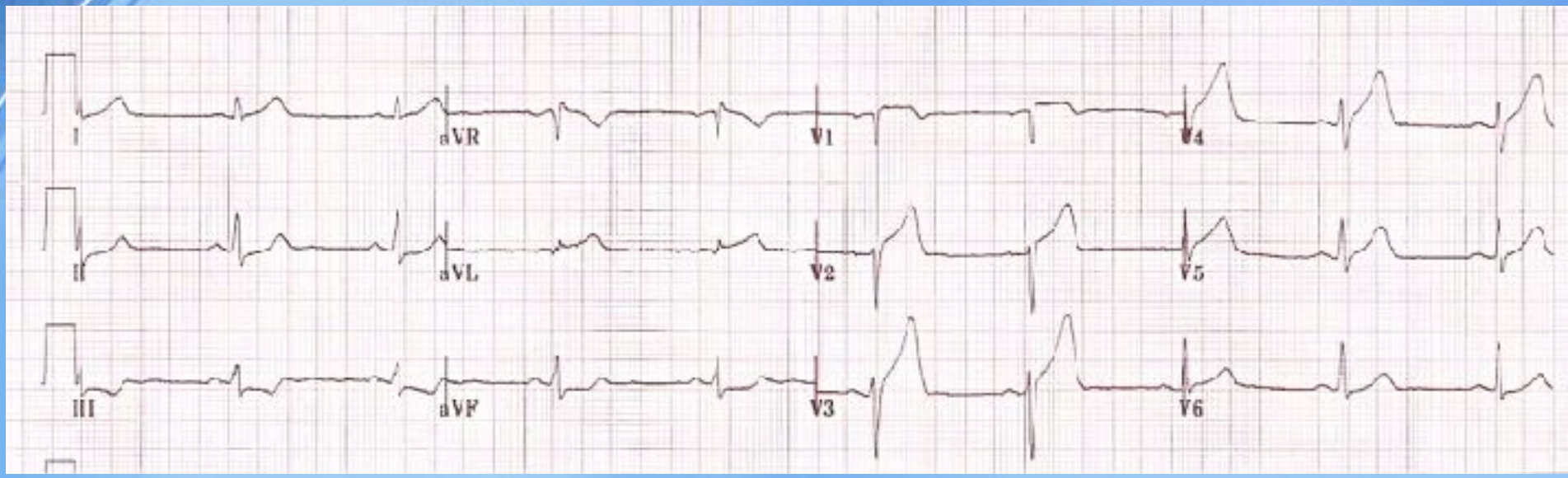
Tombstone ST elevation is an unusual morphological ECG appearance of acute myocardial

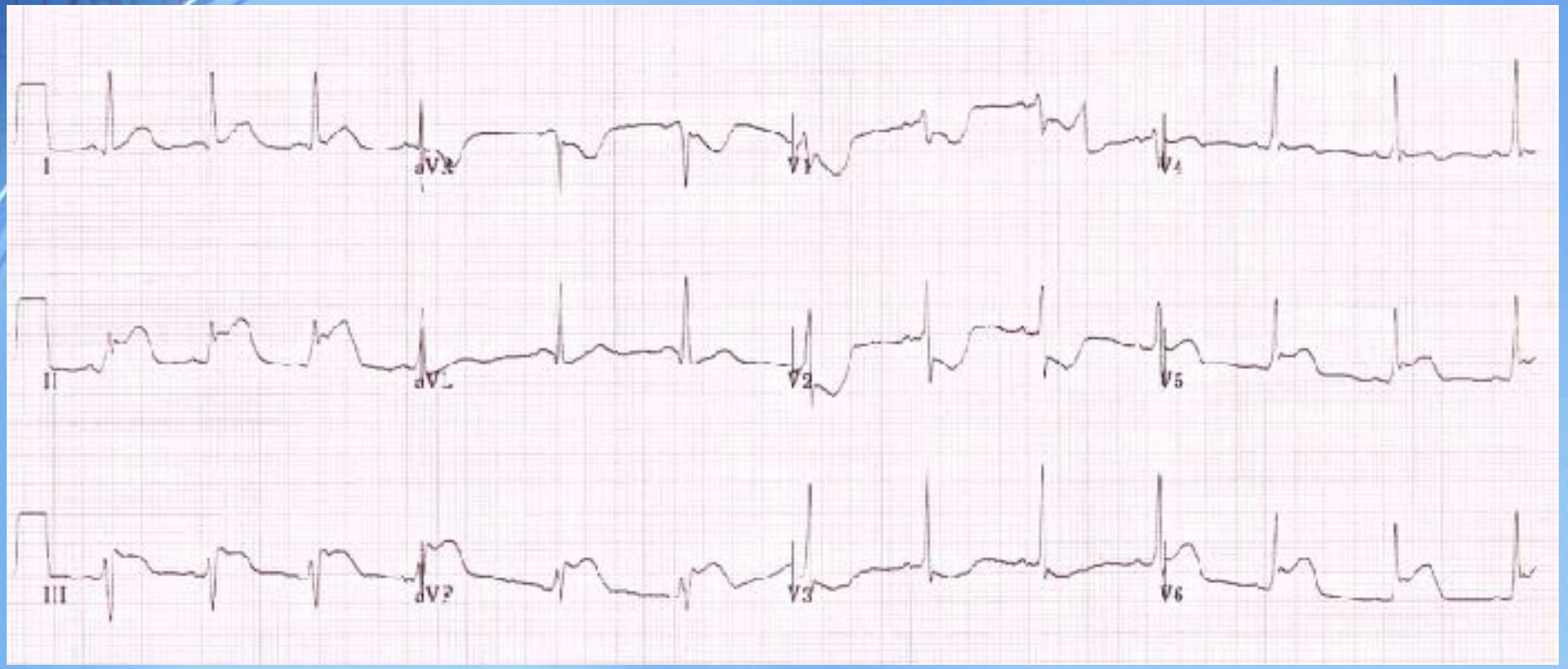

I
aVR
V1
V4
II
aVL
V2
V5
III
aVF
V3
V6

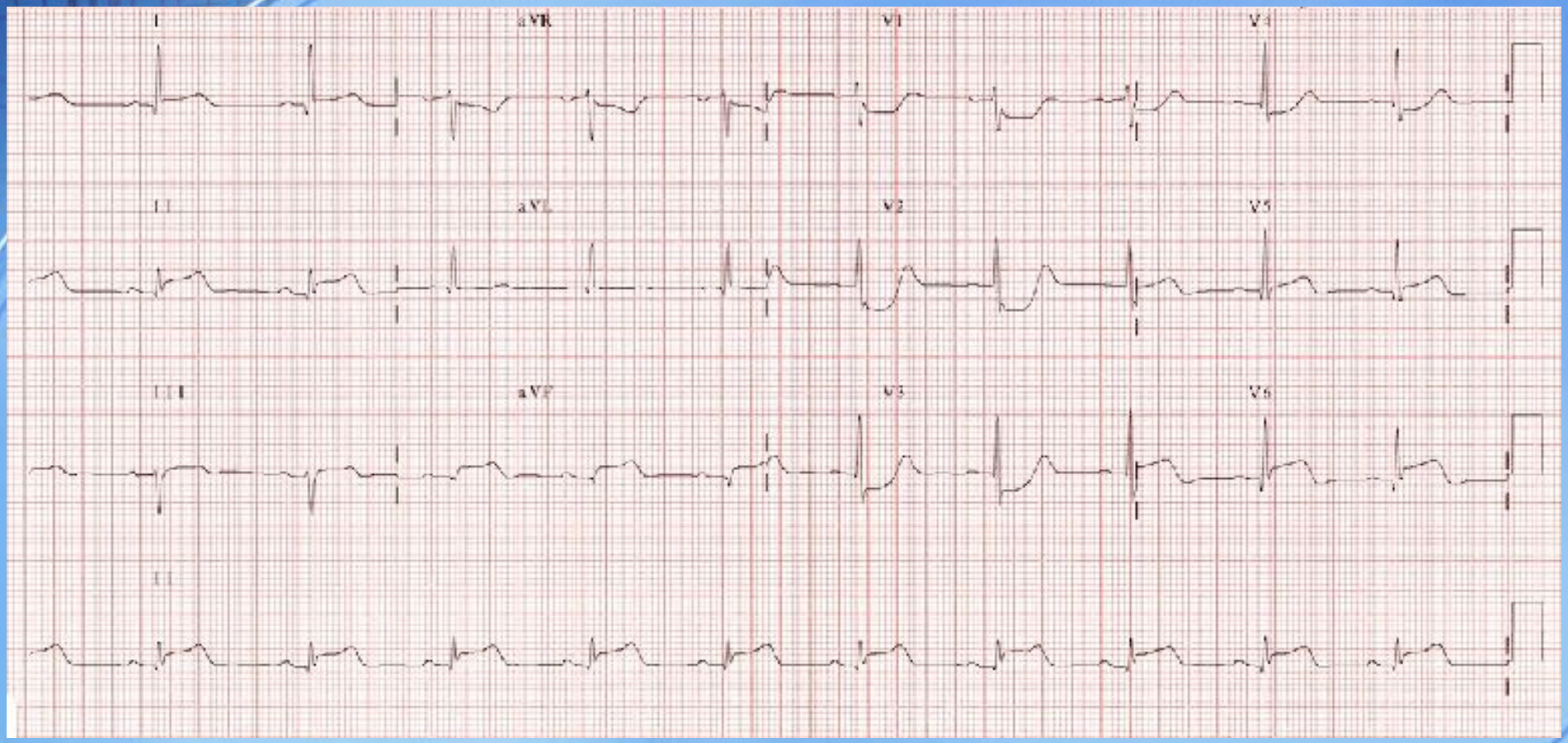

I
aVR
V1
V4
II
aVL
V2
V5
III
aVF
V3
V6
V1


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


I
aVR
V1
V4
II
aVL
V2
V5
III
aVF
V3
V6
RHYTHN STRIP: II
25 mm/sec;1 cm/mV

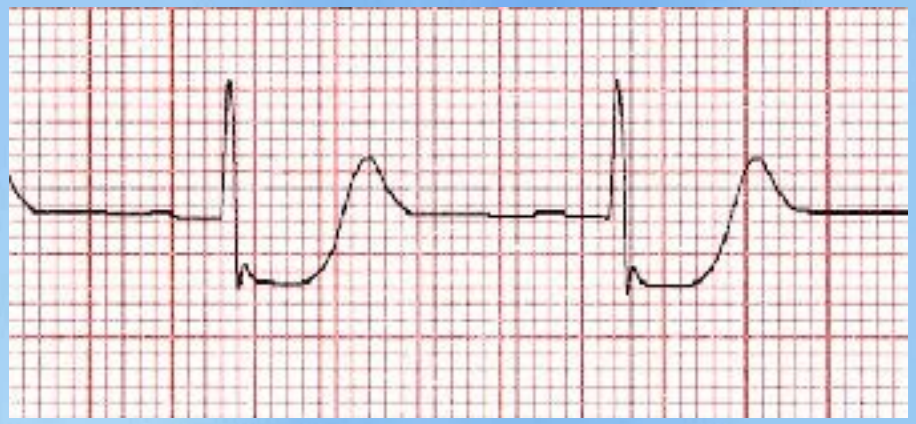

I
aVR
V1
V4
II
aVL
V2
V5
III
aVF
V3
V6

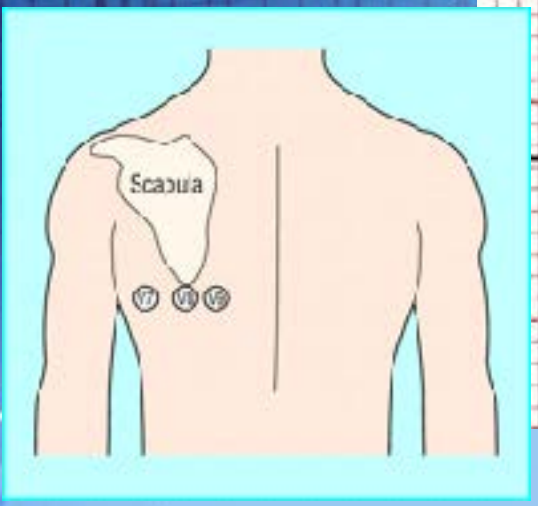

I
aVR
V1
V4
II
aVL
V2
V5
III
aVF
V3
V6

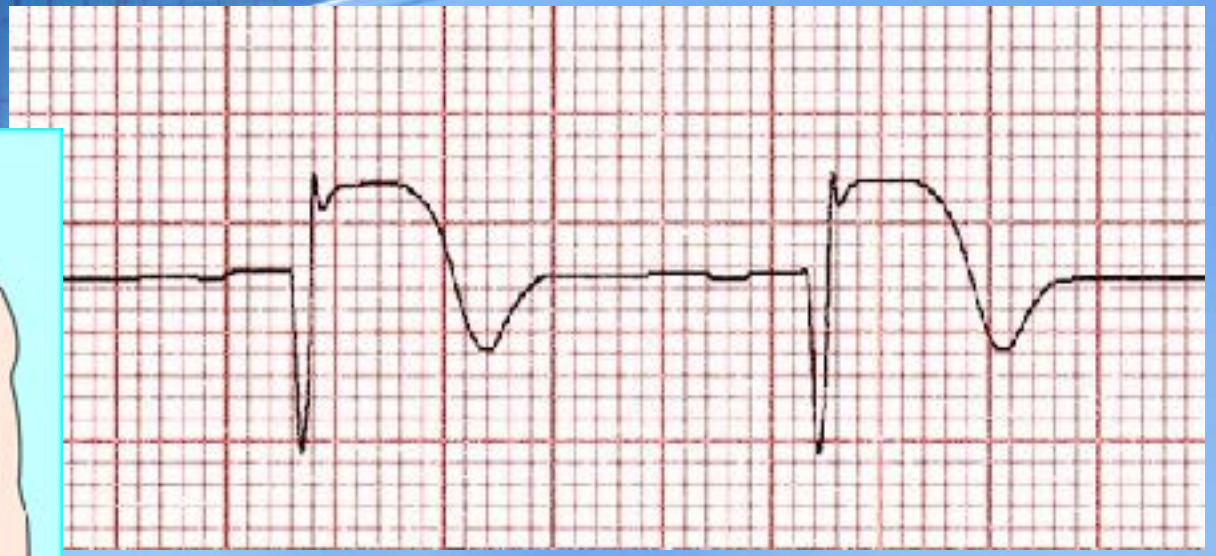

I
aVR
V1
V4
II
aVL
V2
V5
III
aVF
V3
V6
II

Posterior MI is suggested by the following changes in V1-3:

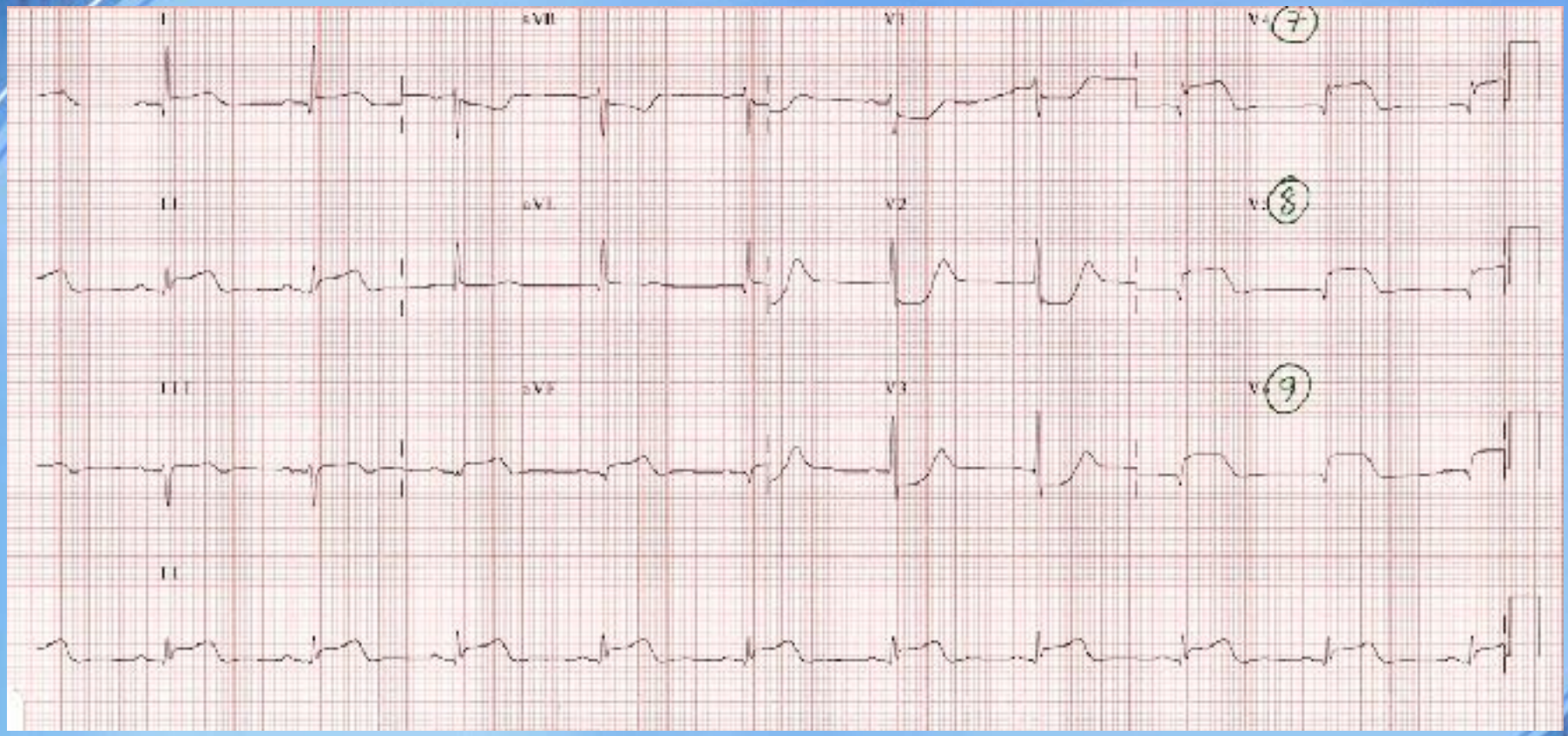
- Horizontal ST depression
- Tall, broad R waves (>30ms)
- Upright T waves
- Dominant R wave (R/S ratio > 1) in V2

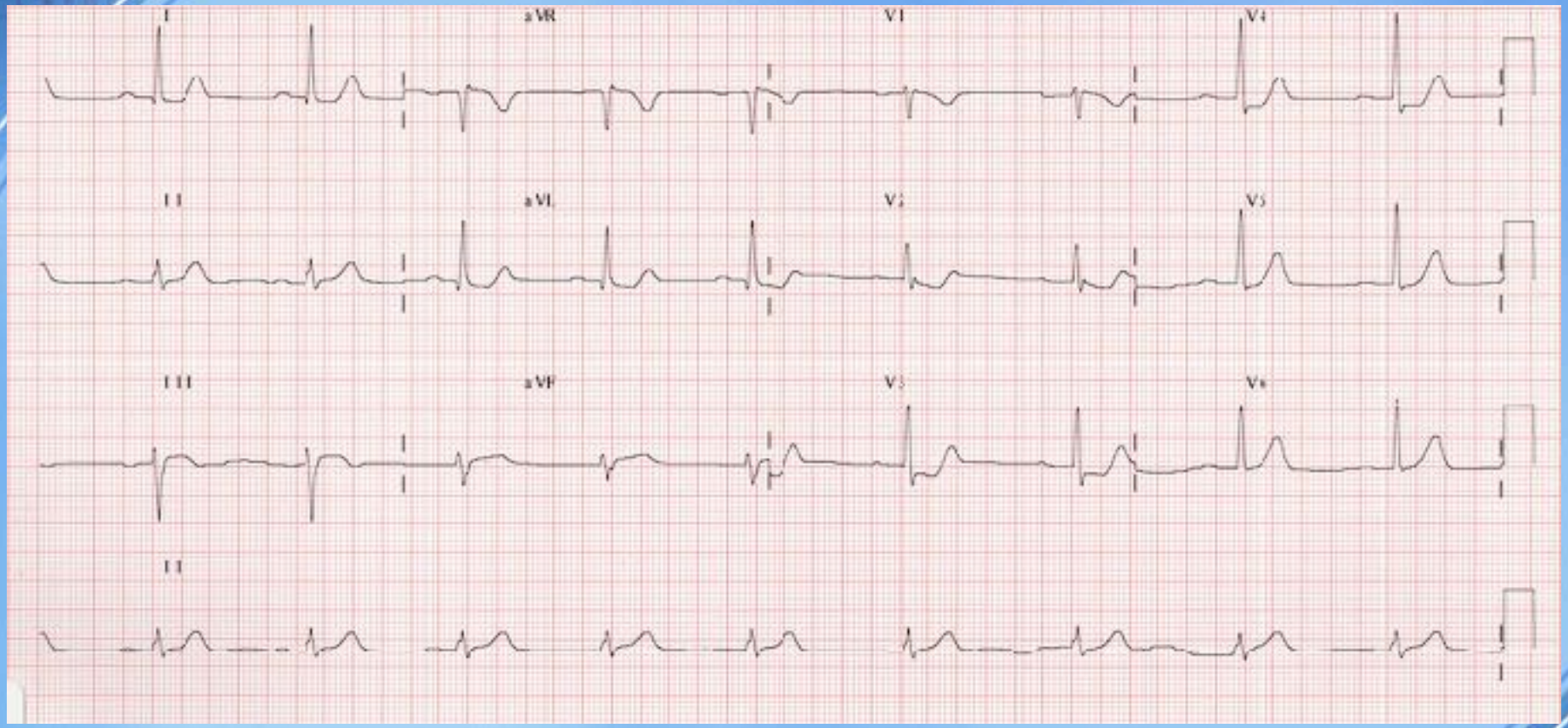






- This picture illustrates the reciprocal relationship between the ECG changes seen in STEMI and those seen with posterior infarction. The previous image (depicting posterior infarction in V2) has been inverted. See how the ECG now resembles a typical STEMI!


I
aVR
V1
V4
7
II
aVL
V2
V5
8
III
aVF
V3
V6
9
II


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