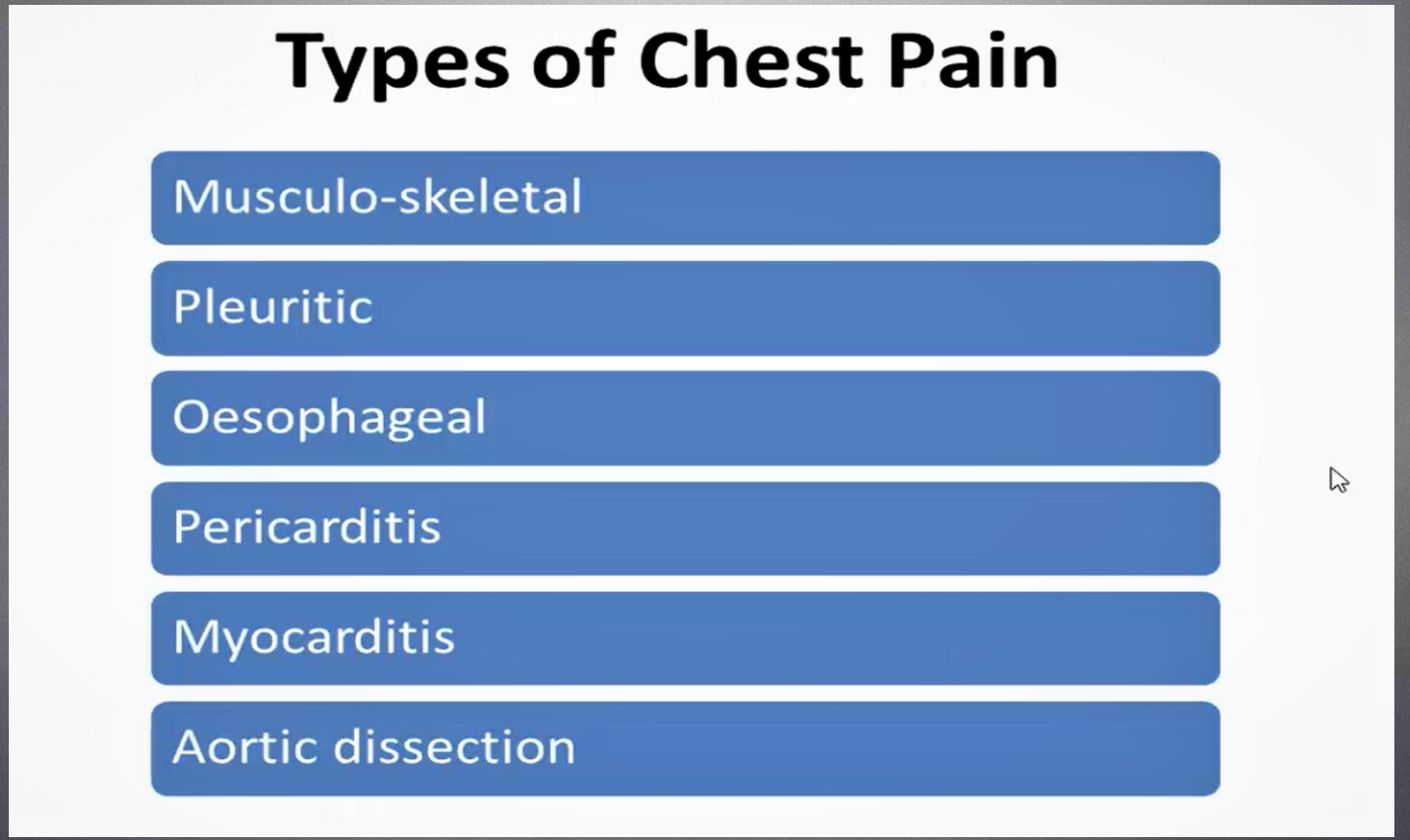
Chest pain &ACS pathophysiology

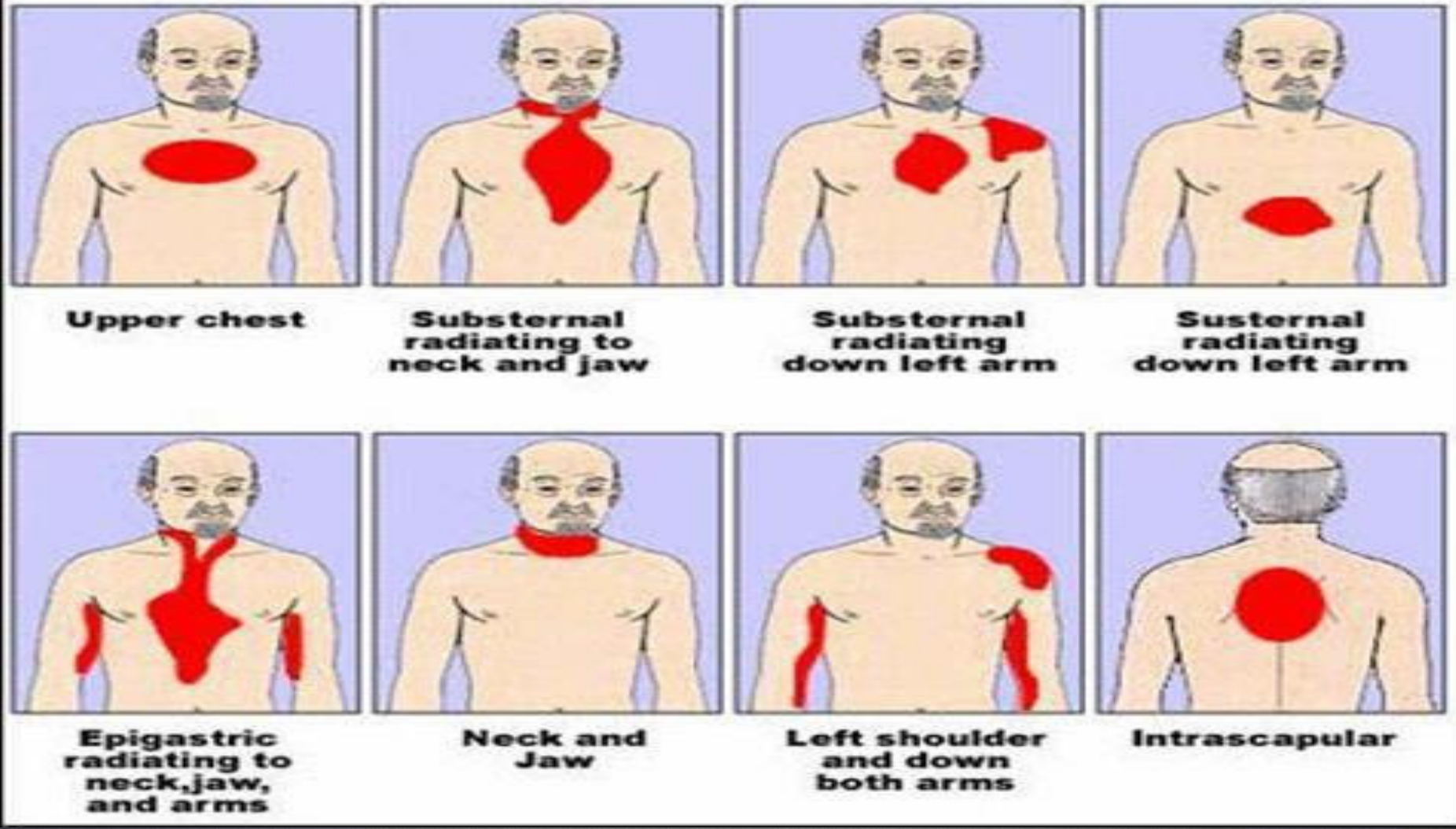
Chest pain


Types of Chest Pain
Musculo-skeletal
Pleuritic
Oesophageal
Pericarditis
Myocarditis
Aortic dissection

Typical cardiac

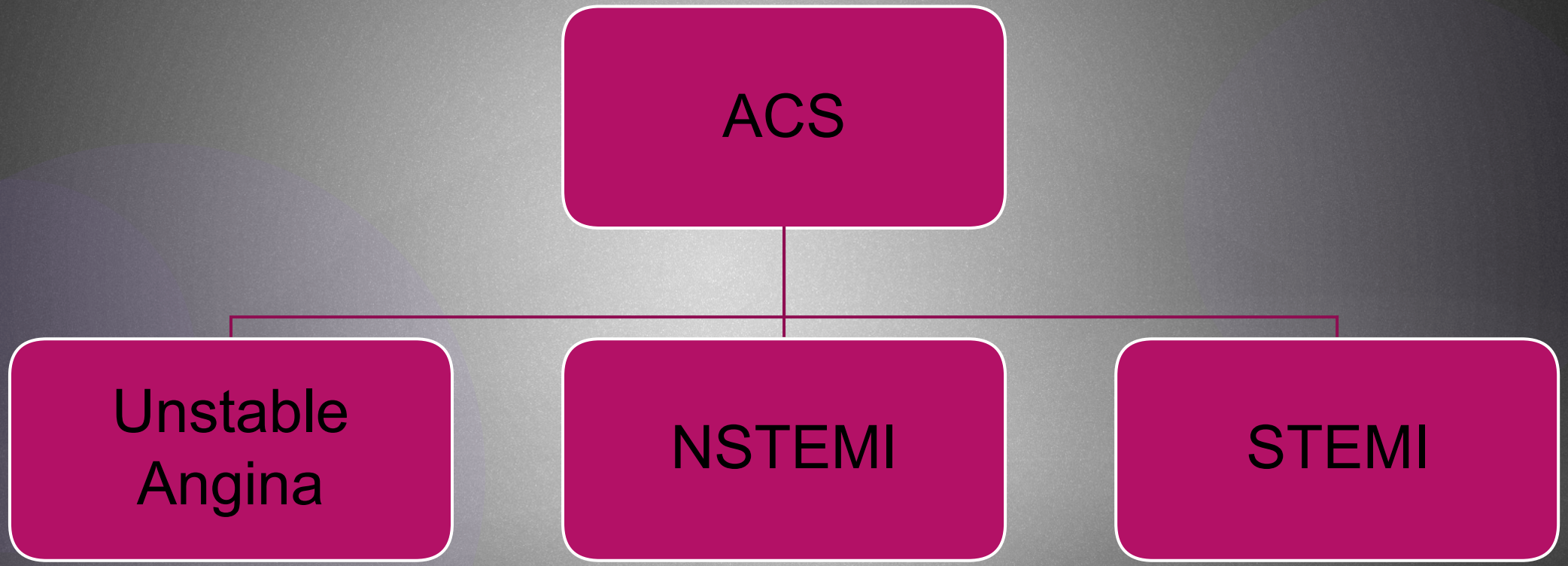
Location	Duration	Character
• Central • Radiation • Visceral type	• >15 minutes • < 24 hours	• Not sharp • Not stabbing • Ache • Burning • Pressure • Not movement or breathing related

Location of chest pain during angina or heart attack

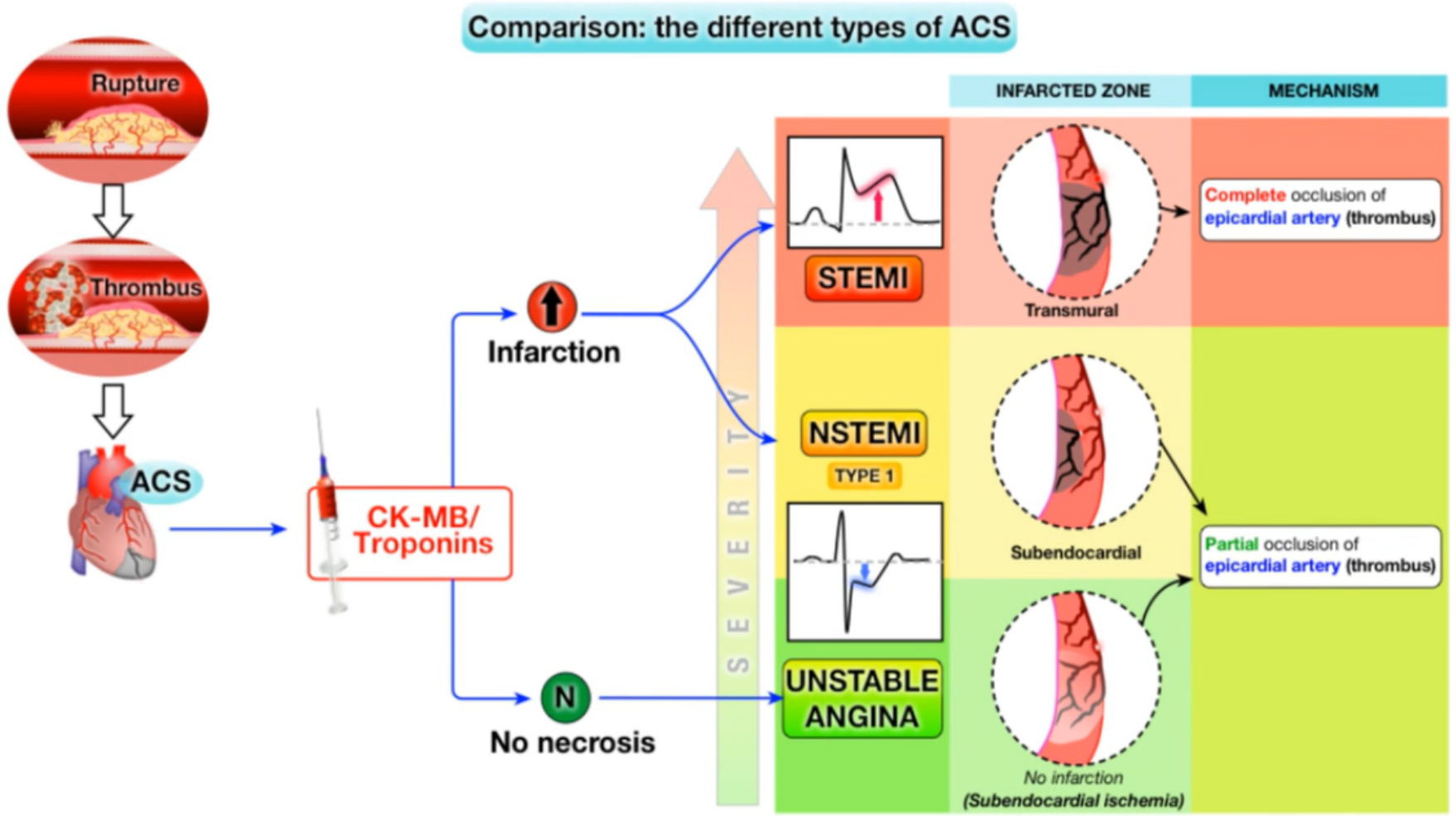


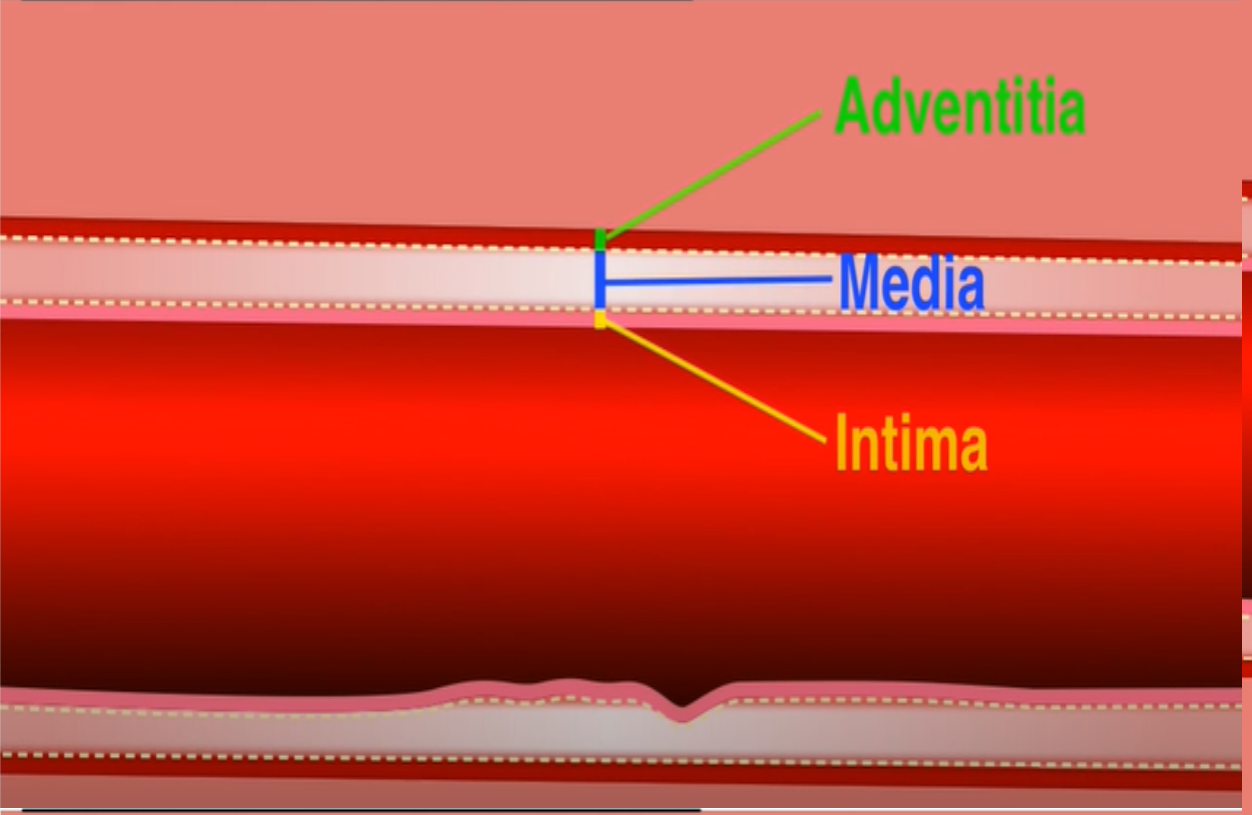
- Acute coronary syndrome occur when myocardial oxygen demand exceeds circulatory supply.

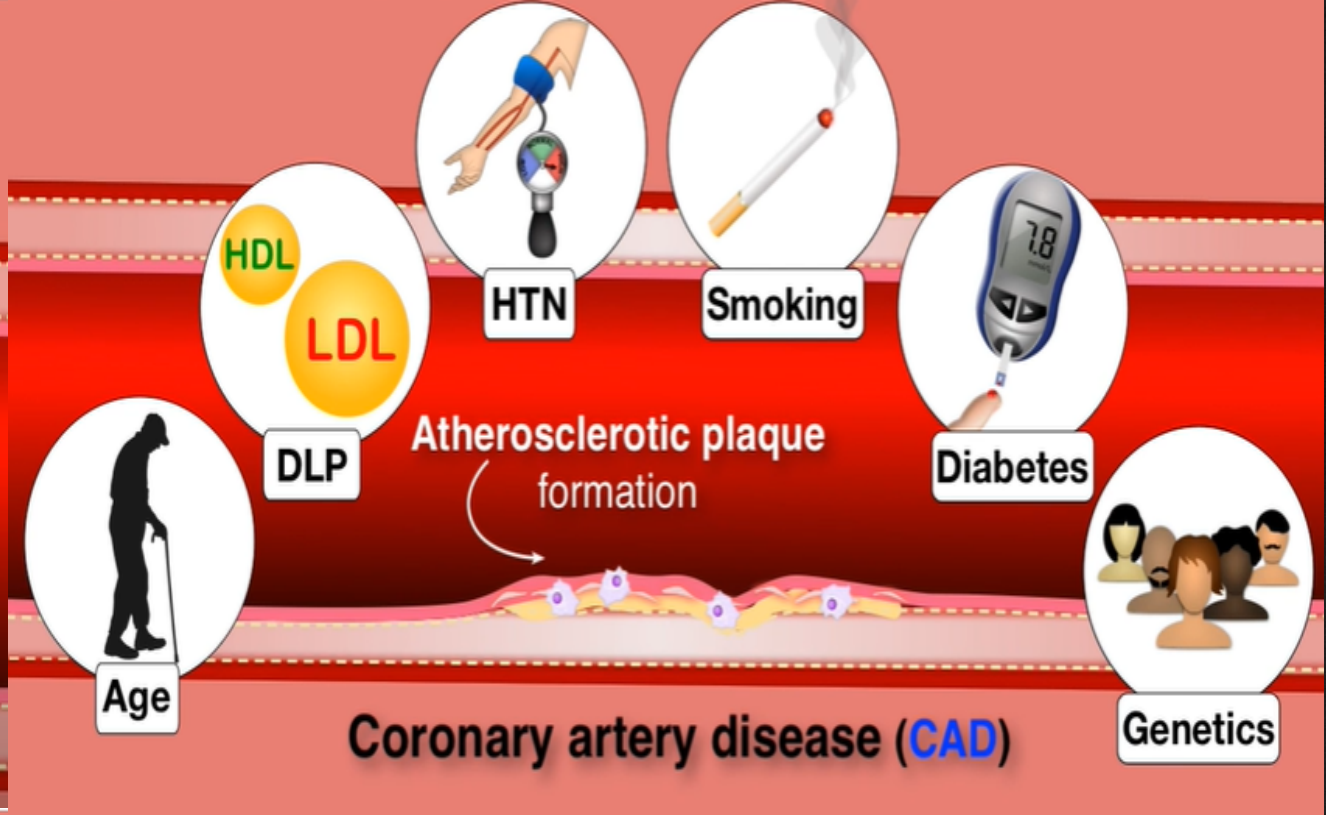
- This results in ischemia, prolonged ischemia results in infarction (myocardial cell necrosis).

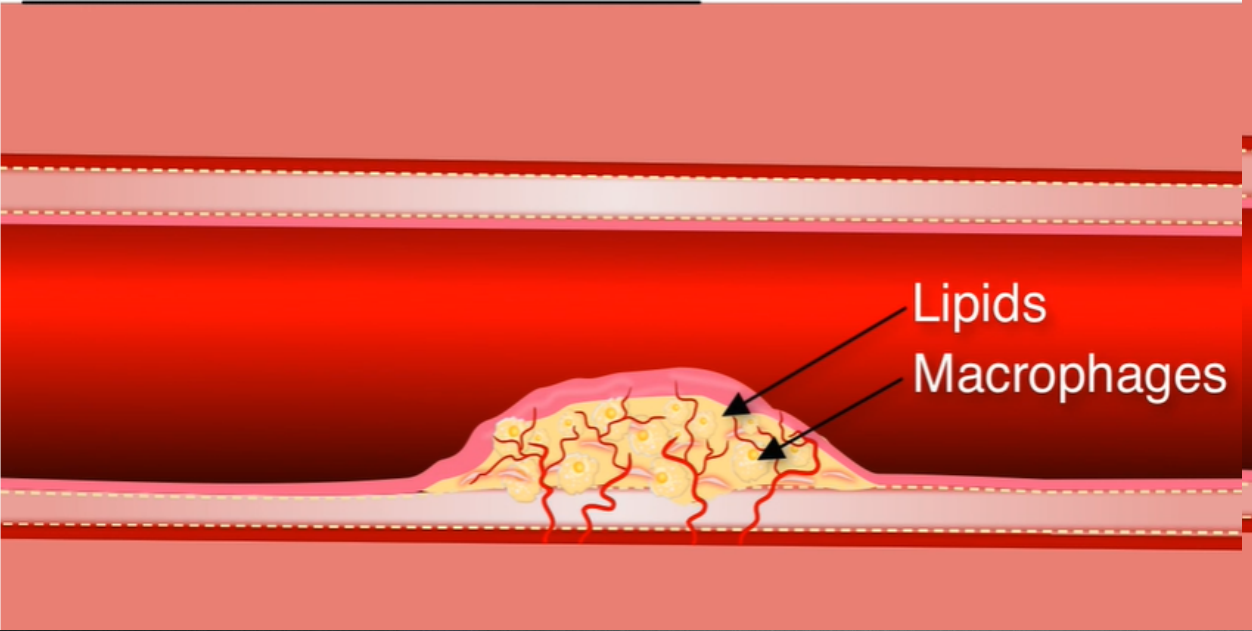

ACS
Unstable Angina
NSTEMI
STEMI

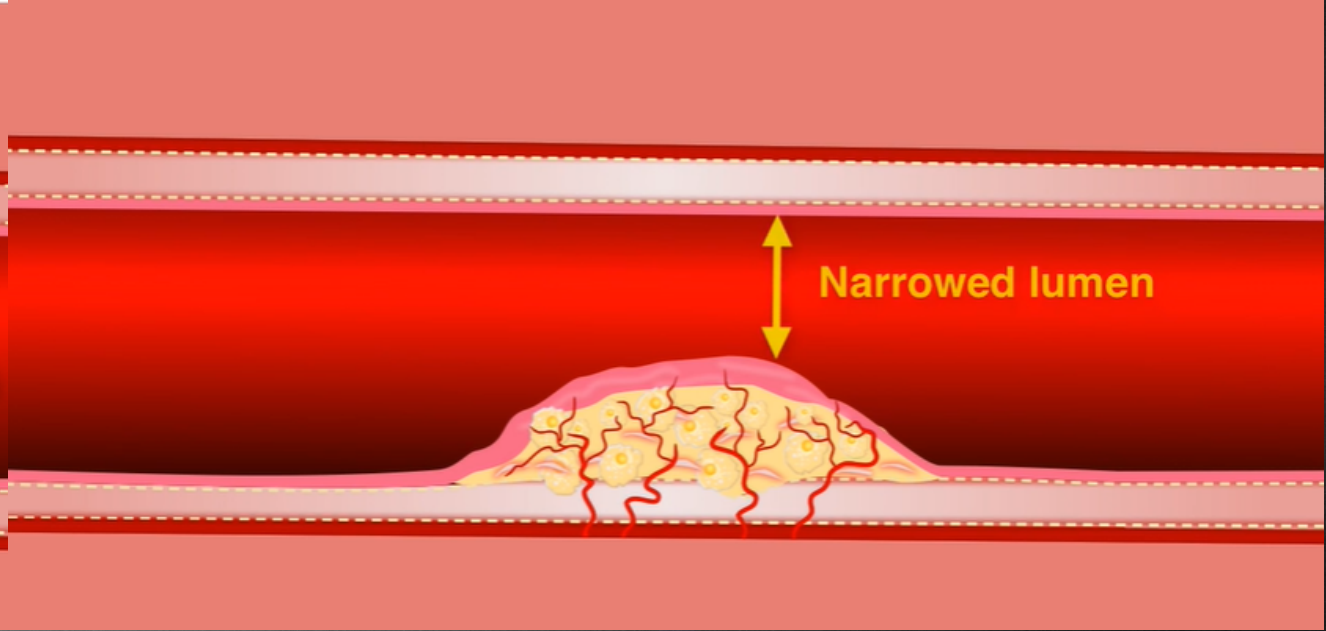
Pathophysiology

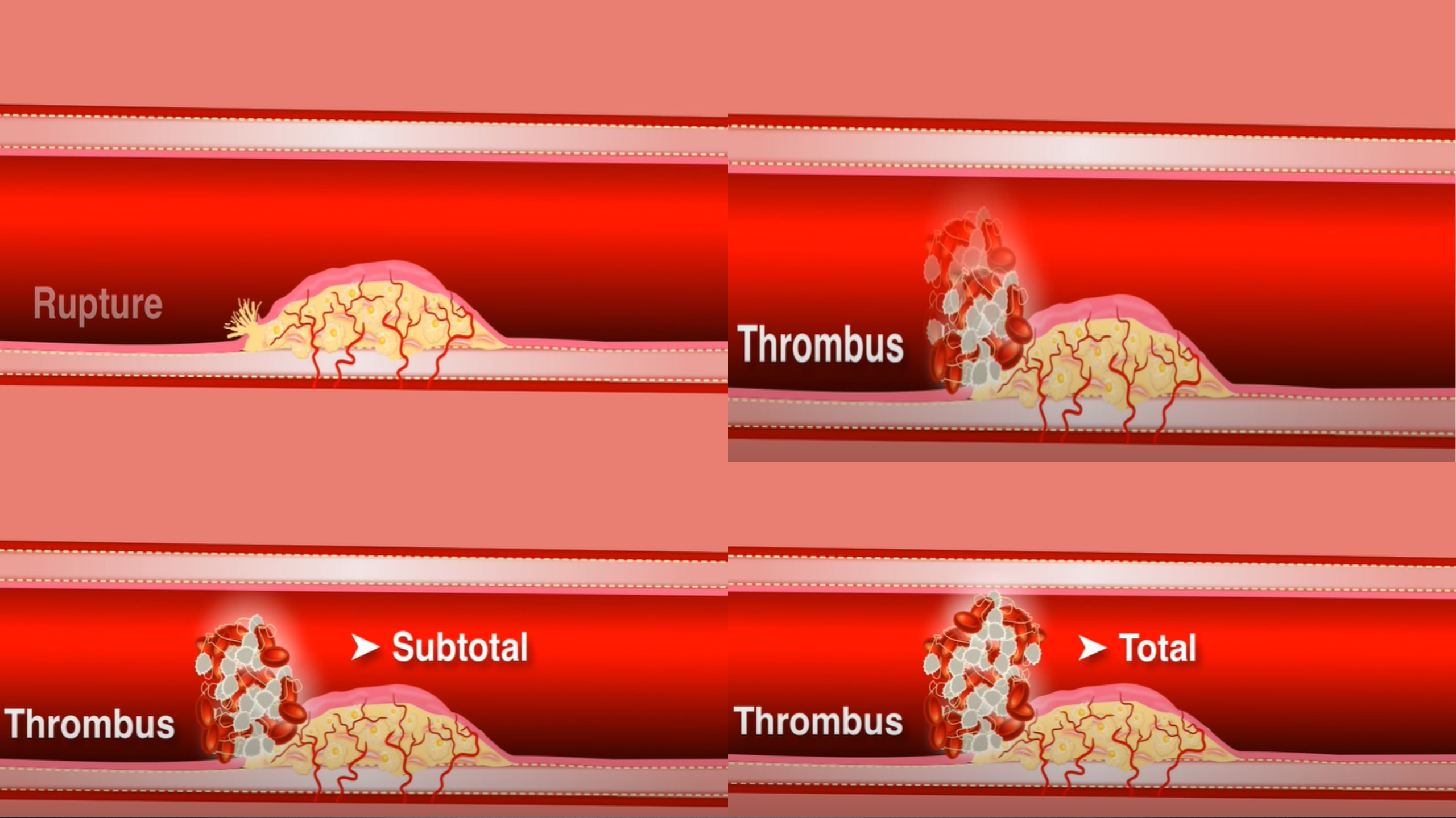


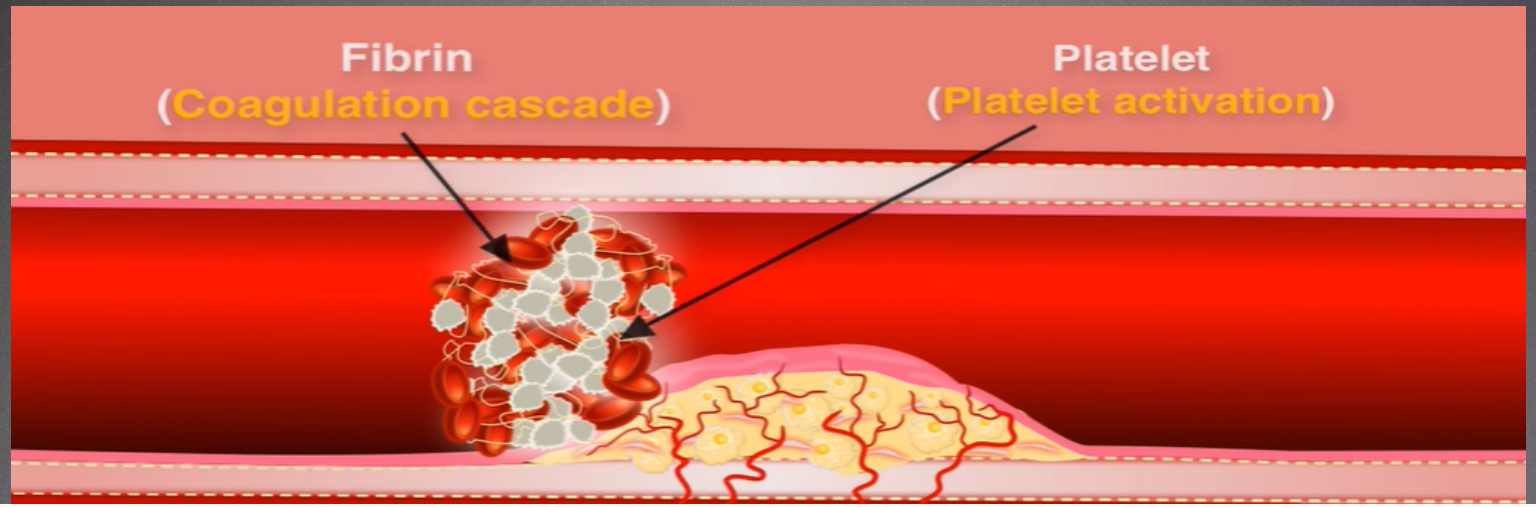

Adventitia
Media
Intima

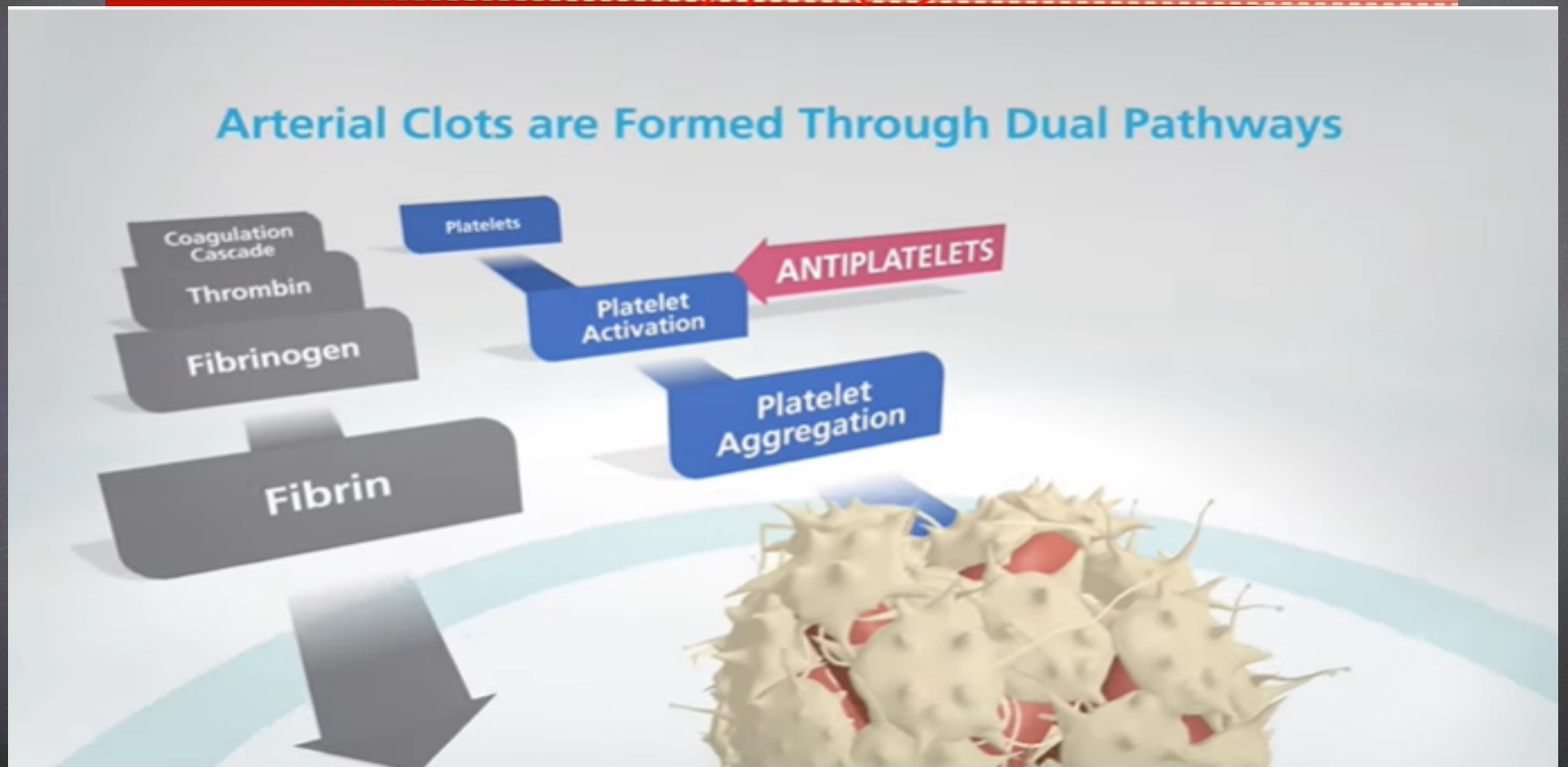

HDL
LDL
DLP
HTN
Smoking
Diabetes
Age
Genetics
Atherosclerotic plaque
formation
Coronary artery disease (CAD)


Lipids
Macrophages

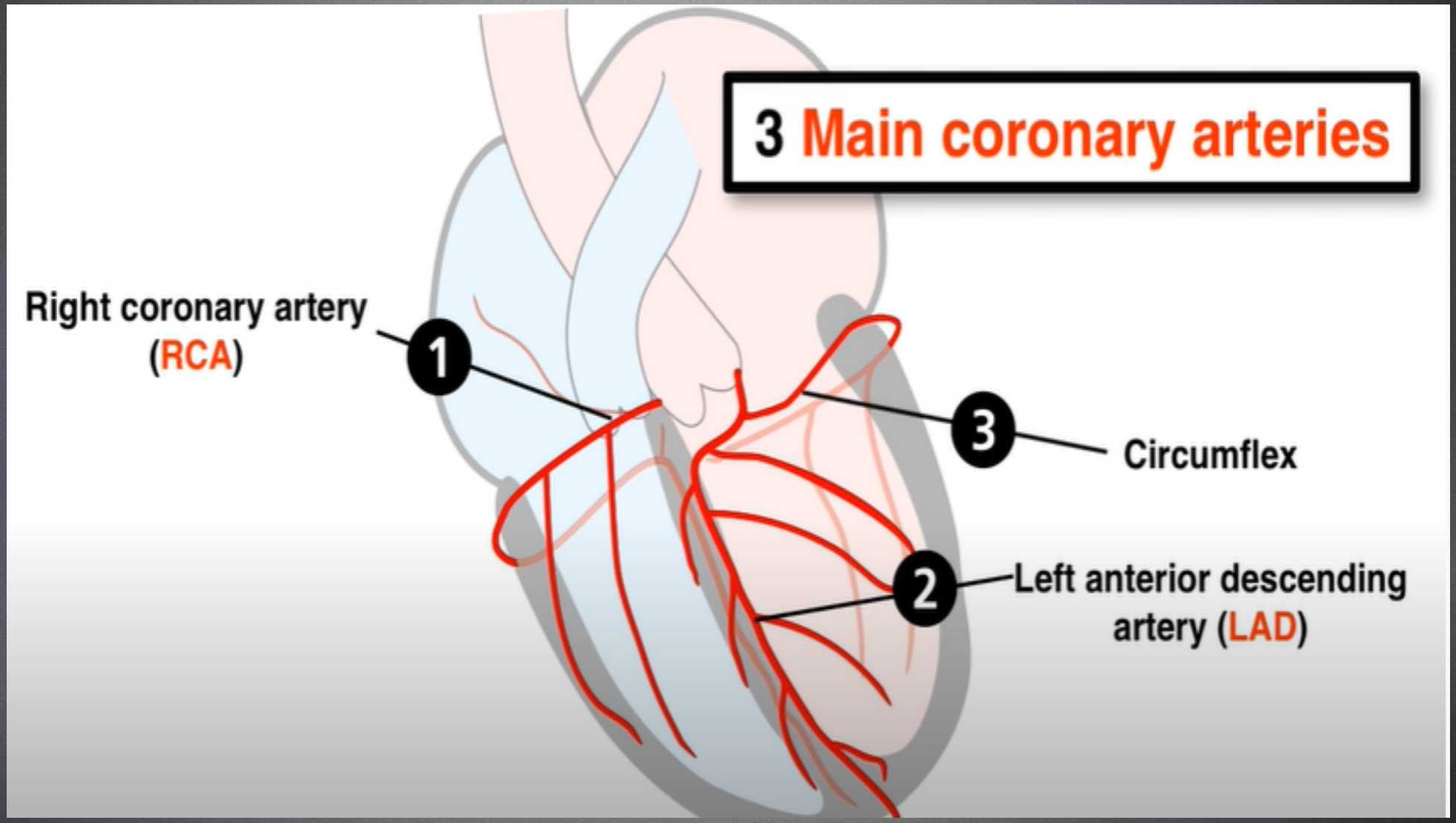

Narrowed lumen

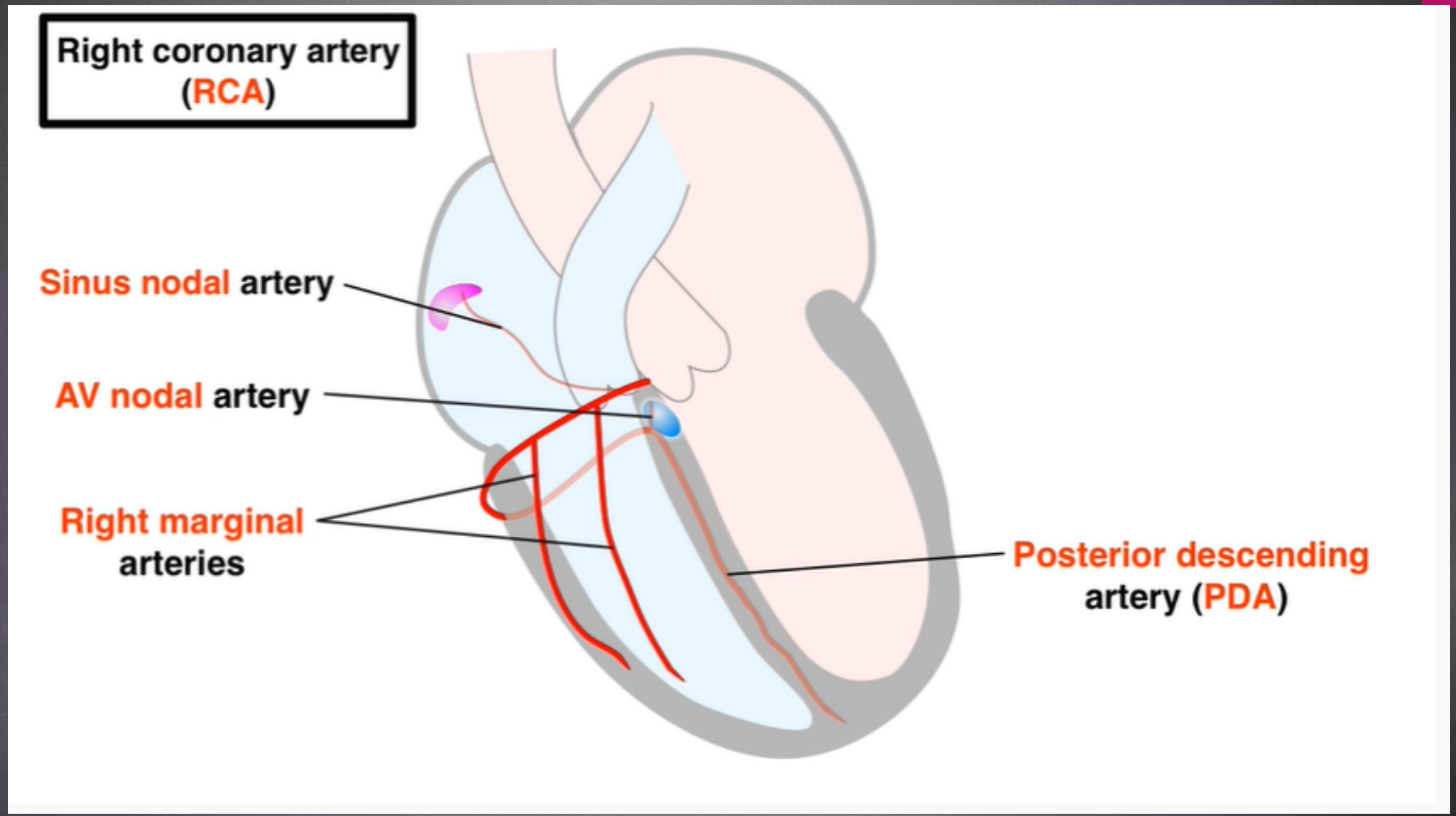

Rupture
Thrombus
Thrombus
Subtotal
Thrombus
Total

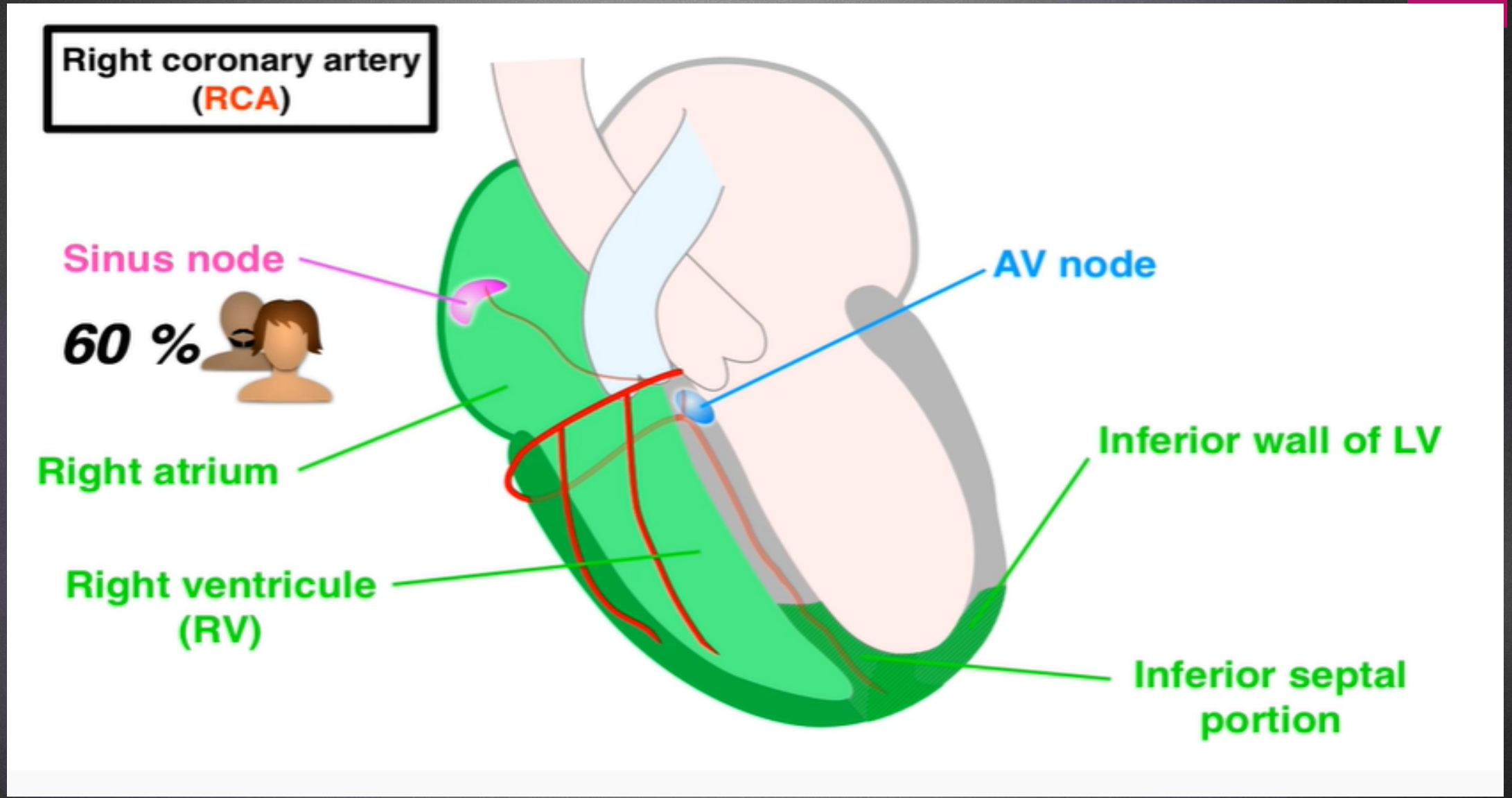

Fibrin
(Coagulation cascade)
Platelet
(Platelet activation)

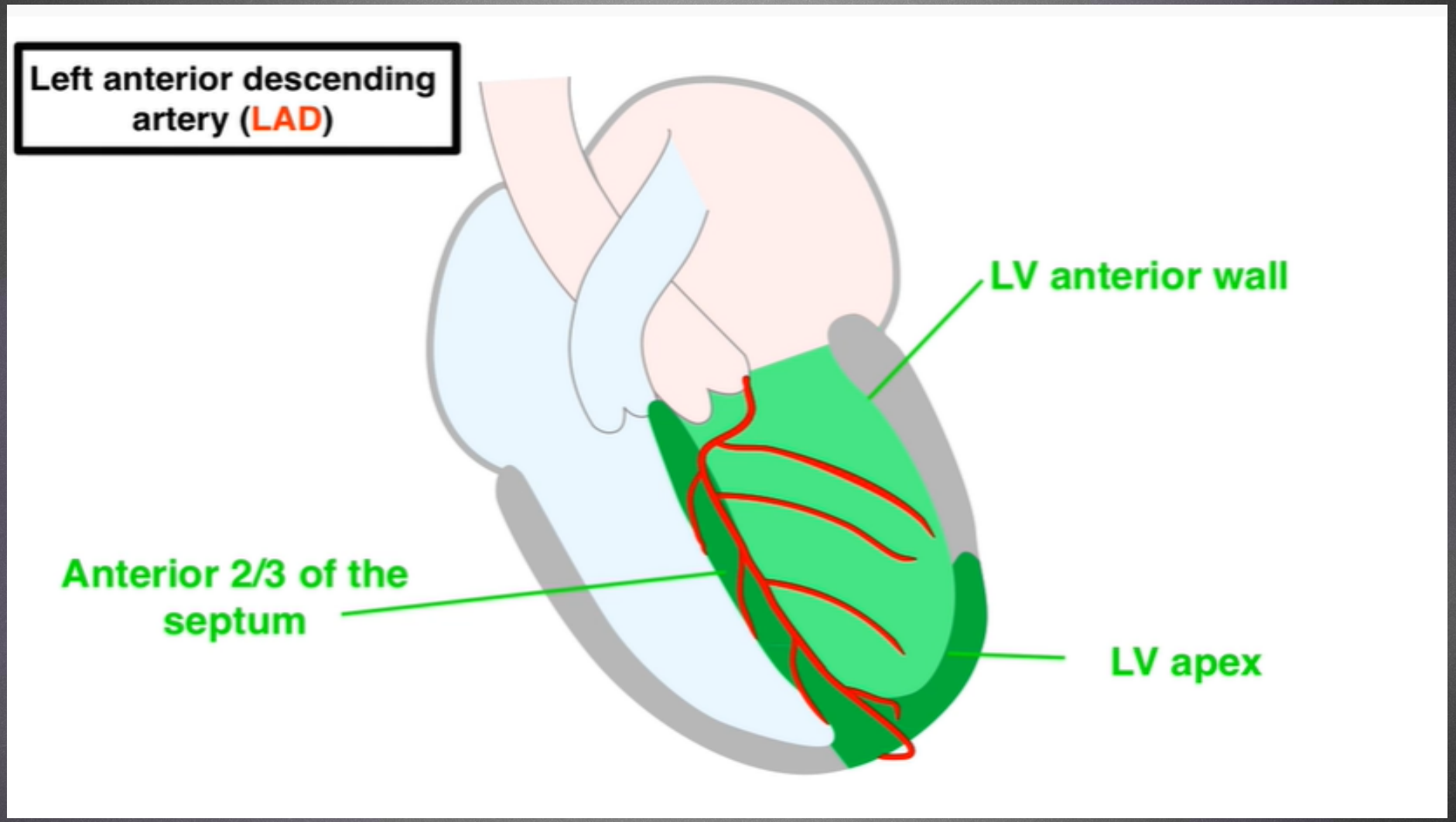

Arterial Clots are Formed Through Dual Pathways
Coagulation Cascade
Thrombin
Fibrinogen
Fibrin
Platelets
Platelet Activation
ANTIPLATELETS
Platelet Aggregation

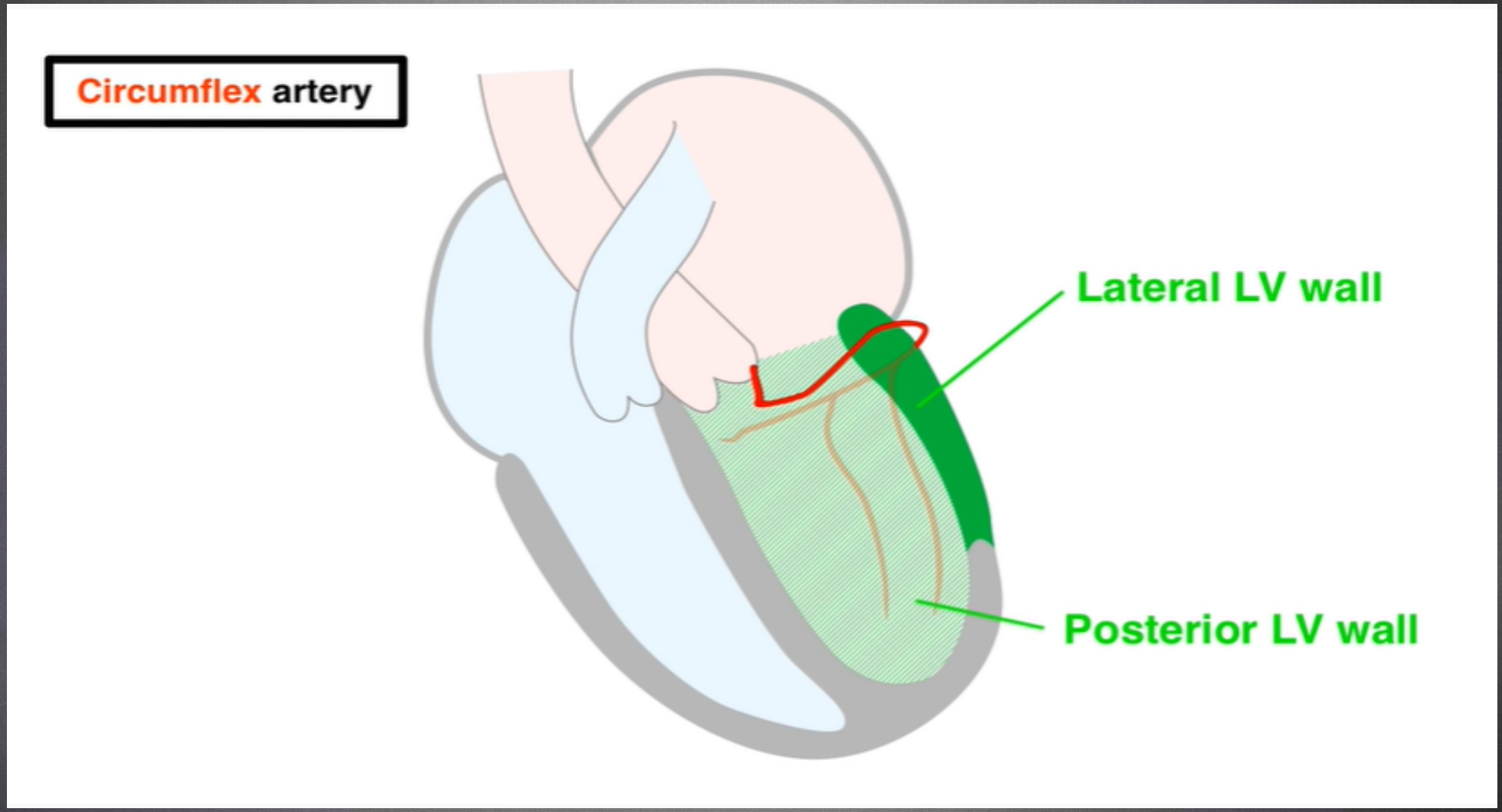

Myocardial
ischemia


3 Main coronary arteries
Right coronary artery (RCA)
1
3
Circumflex
2
Left anterior descending artery (LAD)

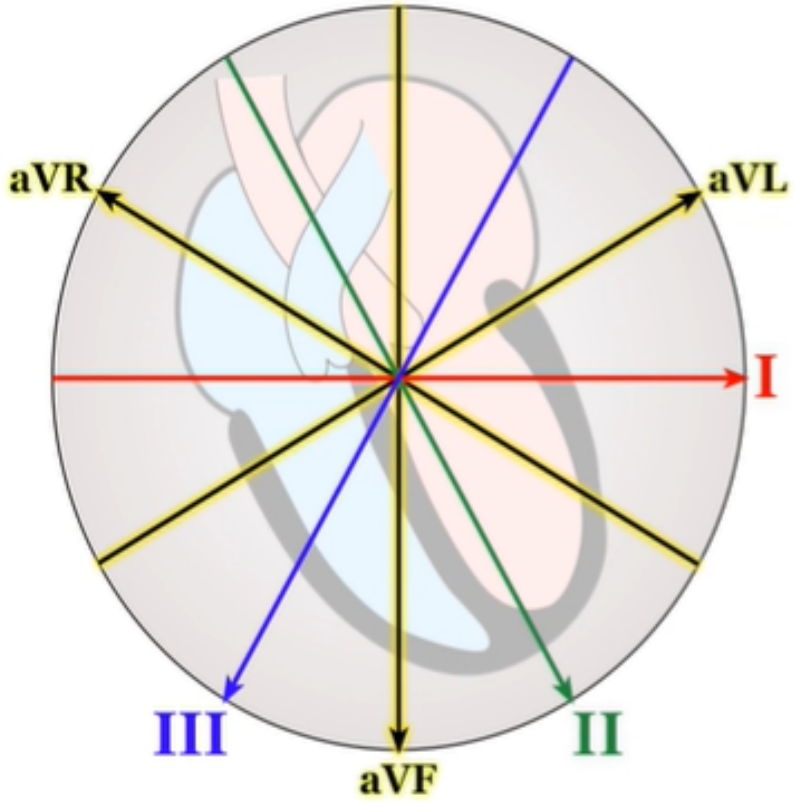

Right coronary artery (RCA)
Sinus nodal artery
AV nodal artery
Right marginal arteries
Posterior descending artery (PDA)


Right coronary artery
(RCA)
Sinus node
60 %
AV node
Right atrium
Inferior wall of LV
Right ventricule
(RV)
Inferior septal
portion

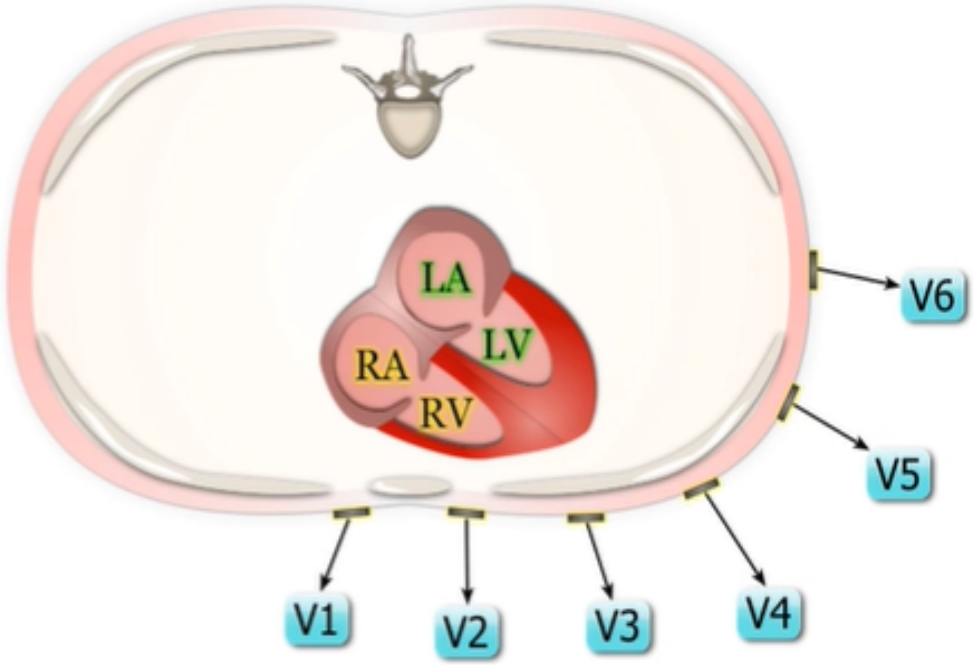

Left anterior descending artery (LAD)
LV anterior wall
Anterior 2/3 of the septum
LV apex


Circumflex artery
Lateral LV wall
Posterior LV wall

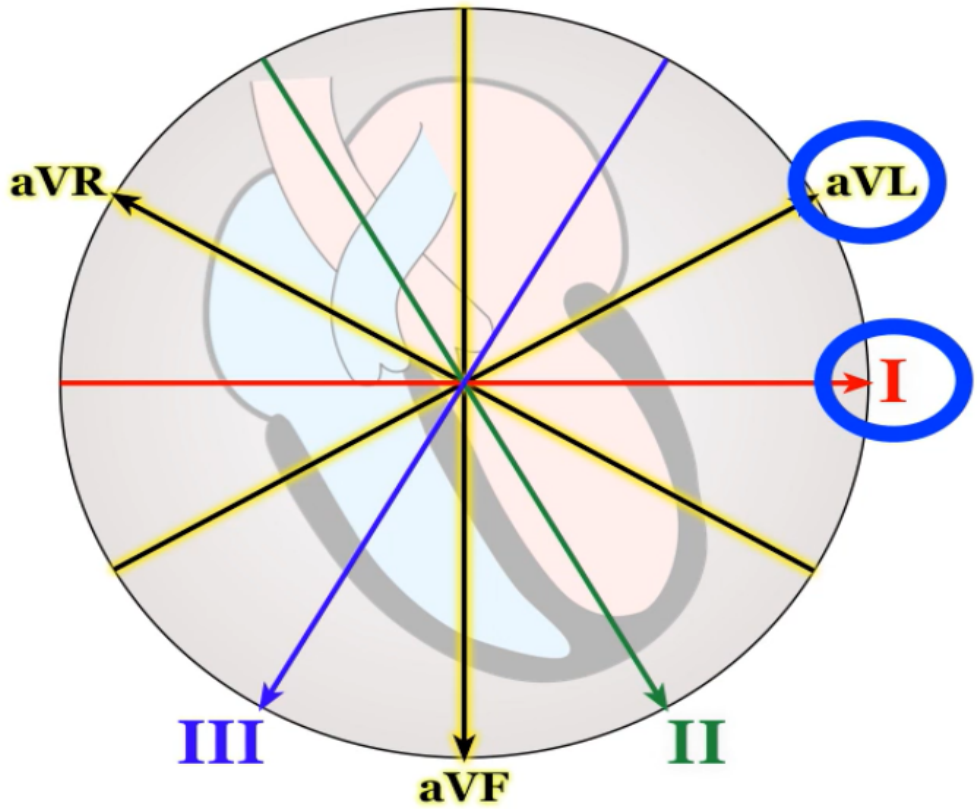
LIMB leads



PRECORDIAL leads



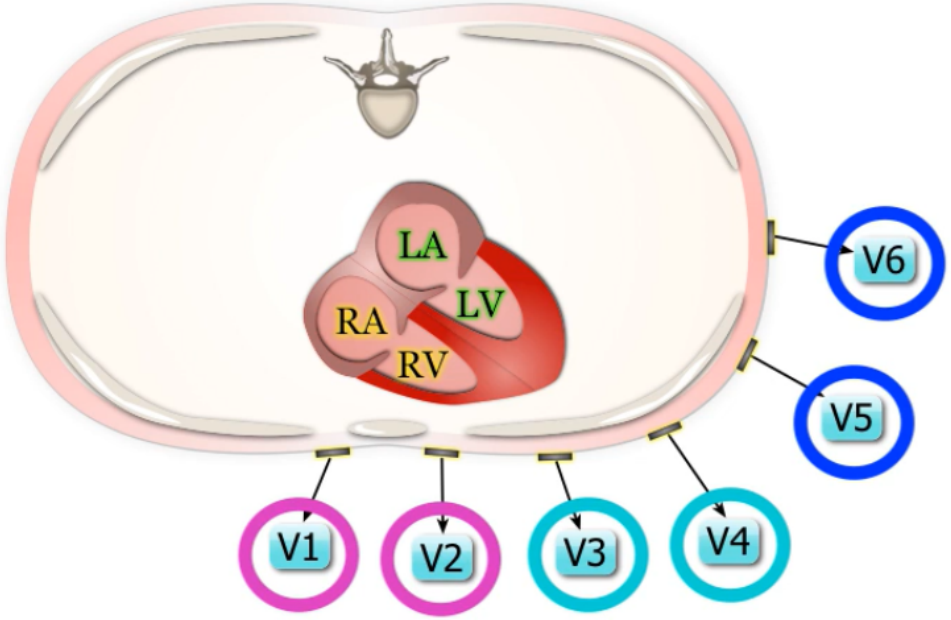
LIMB leads



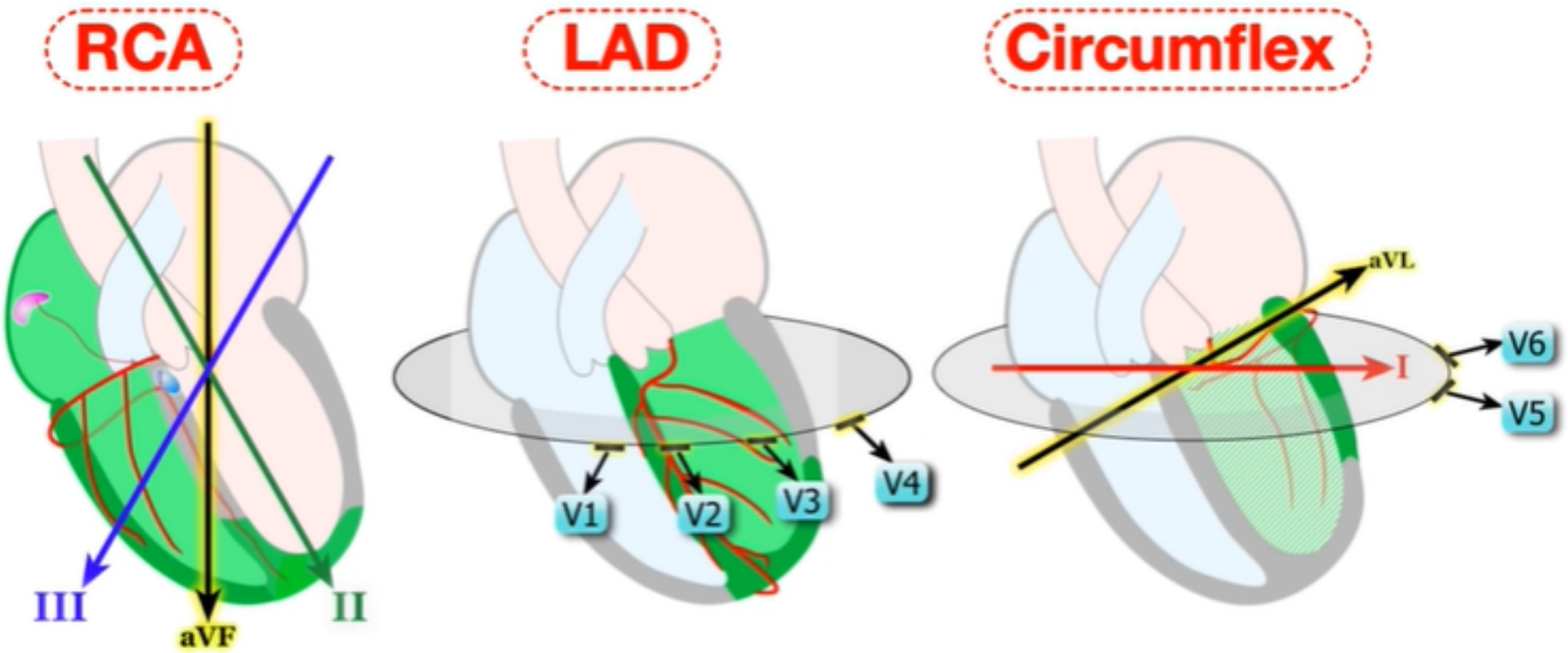
I Lateral	aVR
II Inferior	aVL Lateral
III Inferior	aVF Inferior

PRECORDIAL leads

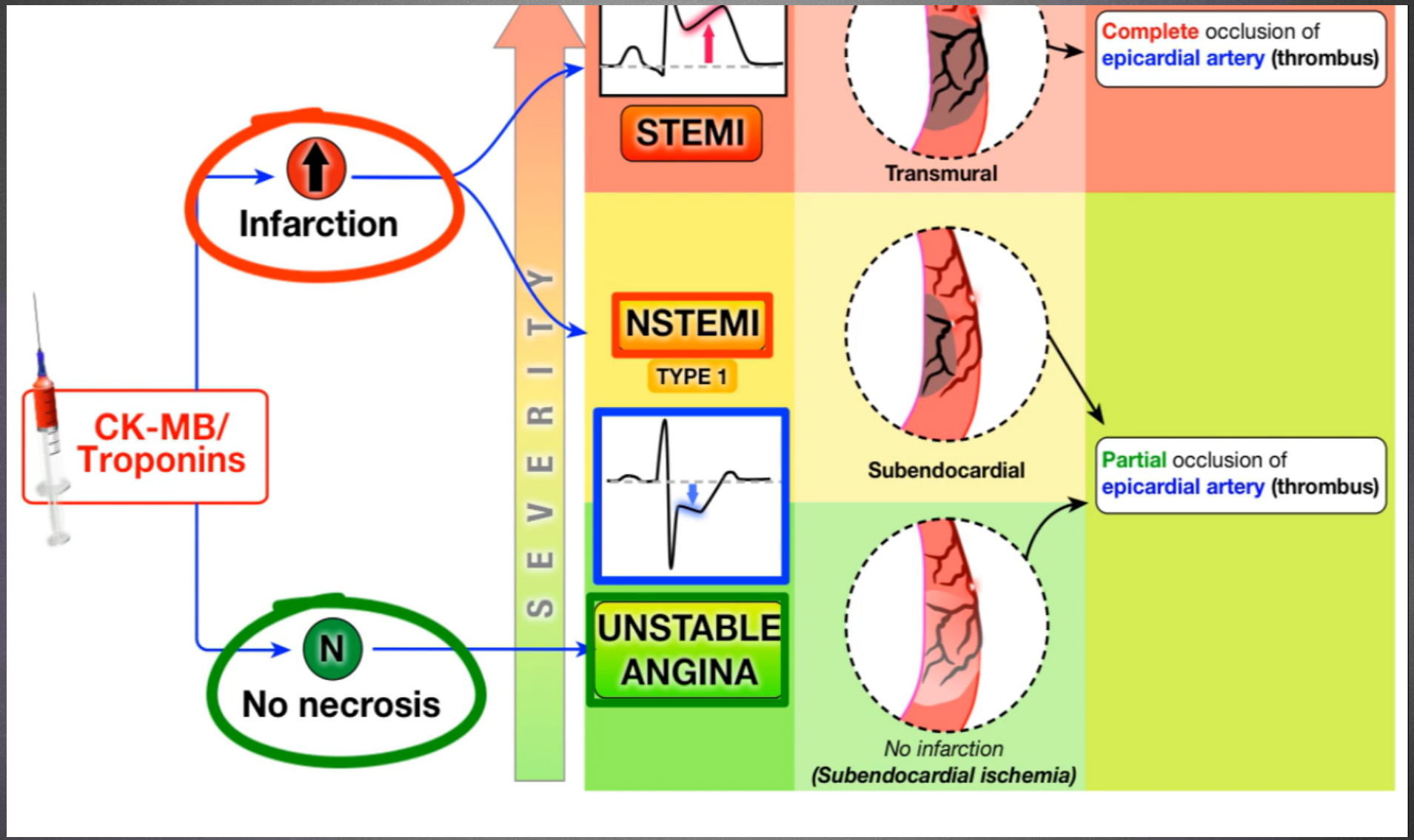
V1 Septal	**V4** Anterior
V2 Septal	**V5** Lateral
V3 Anterior	**V6** Lateral



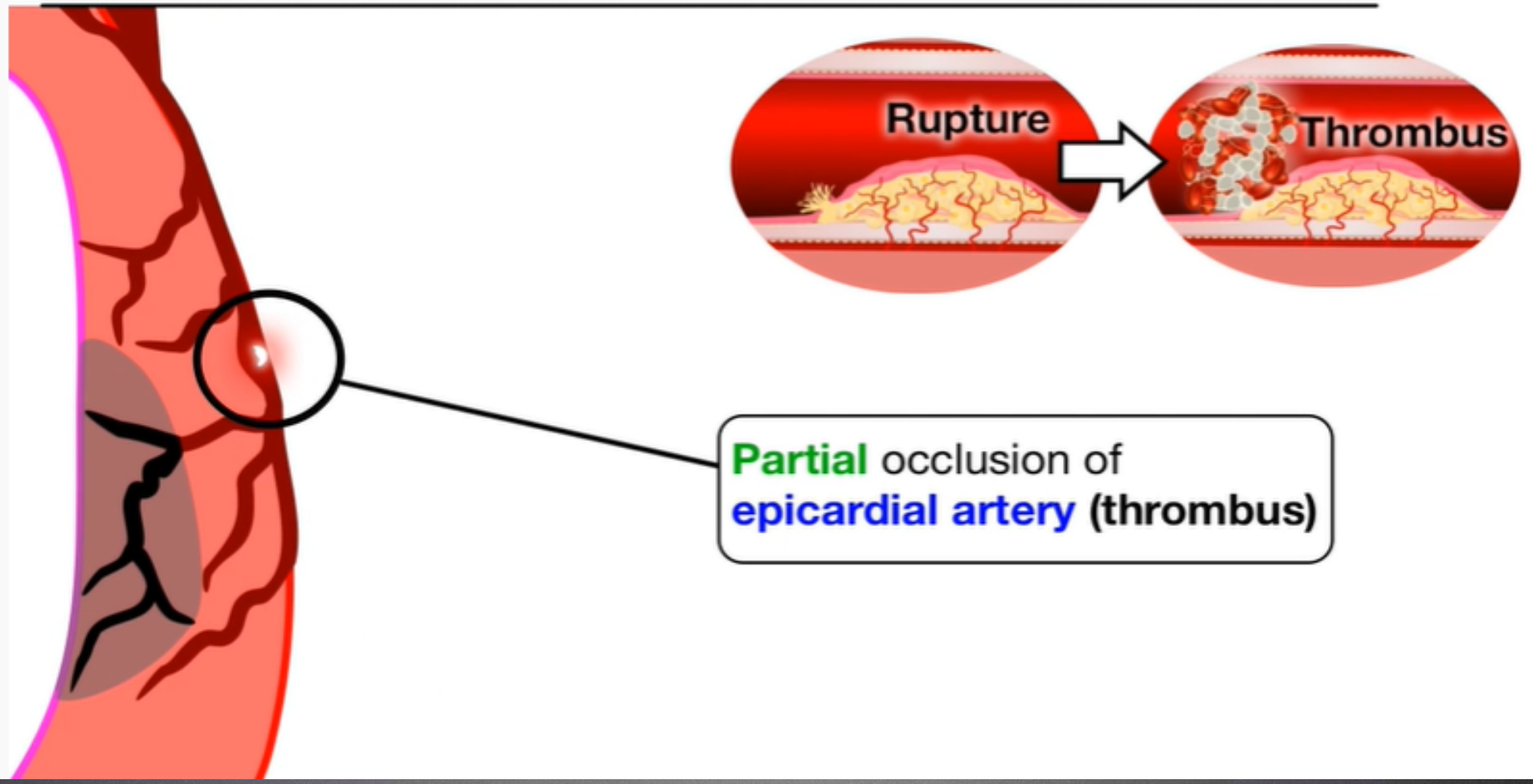
Leads and culprit artery



Inferior	Antero septal	Lateral
II, III, aVF	V1-V4	I, aVL, V5, V6


CK-MB/
Troponins
Infarction
N
No necrosis
SEVERITY
STEMI
NSTEMI
TYPE 1
UNSTABLE
ANGINA
Transmural
Subendocardial
No infarction
(Subendocardial ischemia)
Complete occlusion of
epicardial artery (thrombus)
Partial occlusion of
epicardial artery (thrombus)

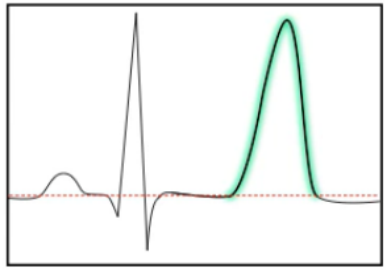
Subendocardial ischemia: **ECG** changes



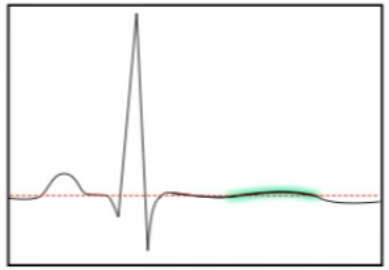
Subendocardial ischemia: **ECG** changes

➤ **Repolarization (ST and T)**

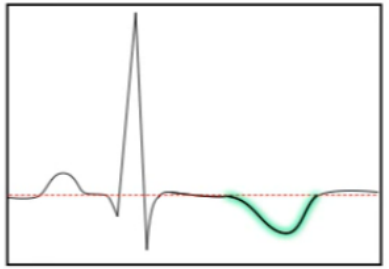
T wave



Hyperacute



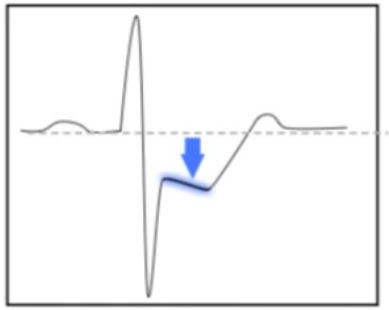
Flattening



Inversion

ST segment

Depression



Unstable Angina

1. Occurs at rest or minimal exertion and usually lasts more than 20 minutes.

2. Being severe and of new onset (i.e. within 1 month).

3. Occurs with a crescendo pattern (brought on by less activity, more severe, more prolonged or increased frequency than previously).

VIRTUAL CARDIOLOGY HOSPITAL

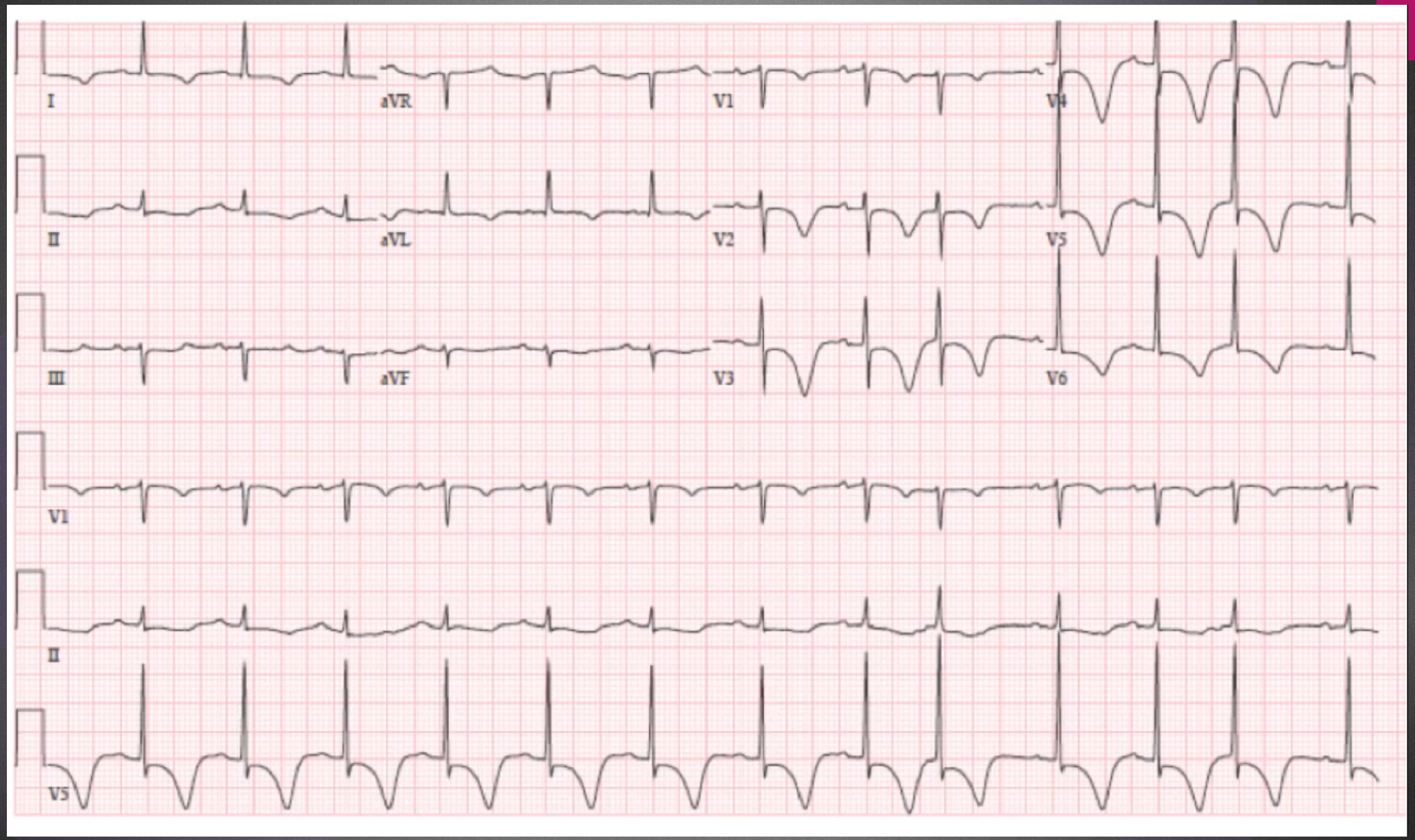
Age: 64

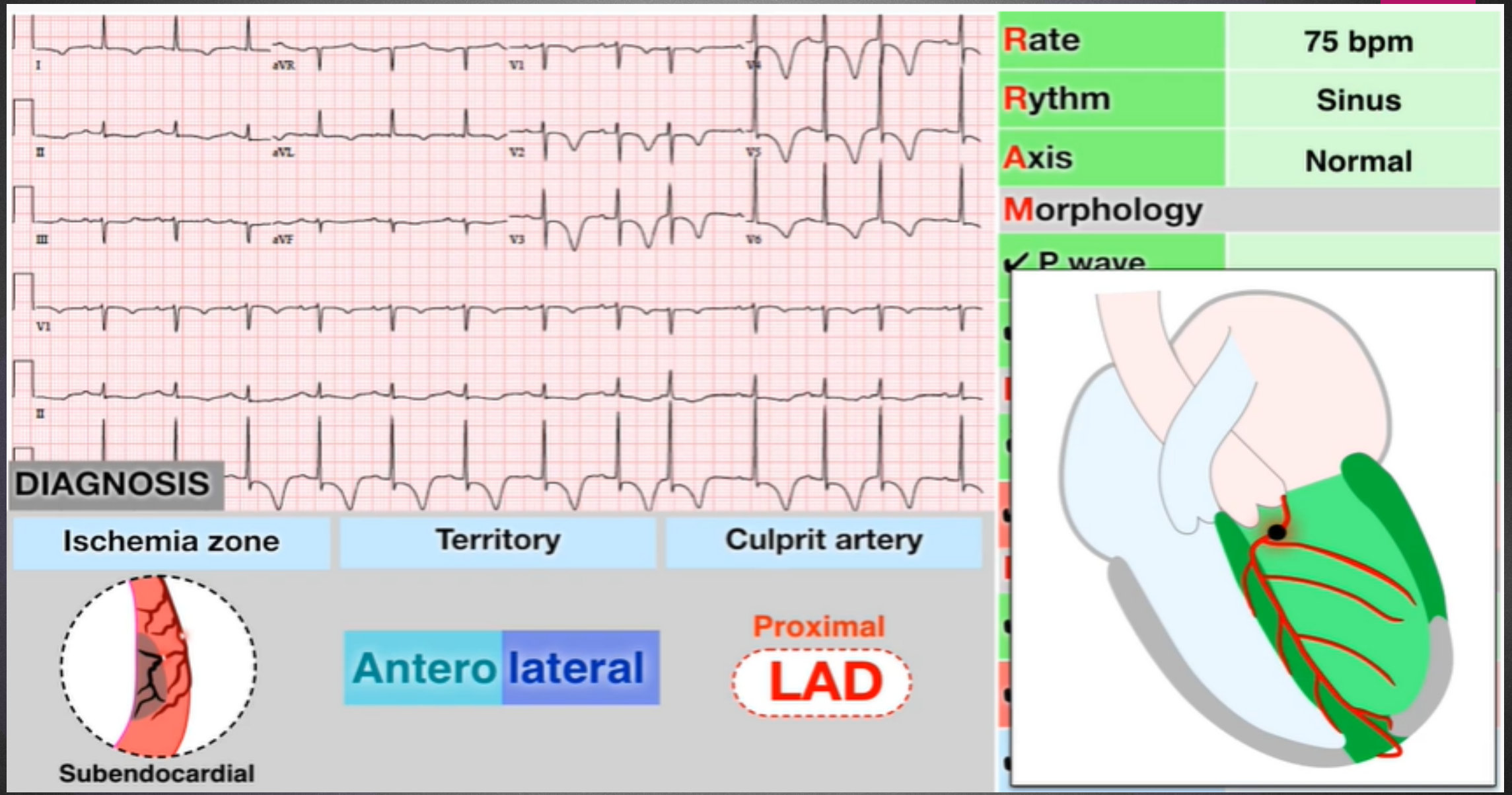
History:

Diabetes

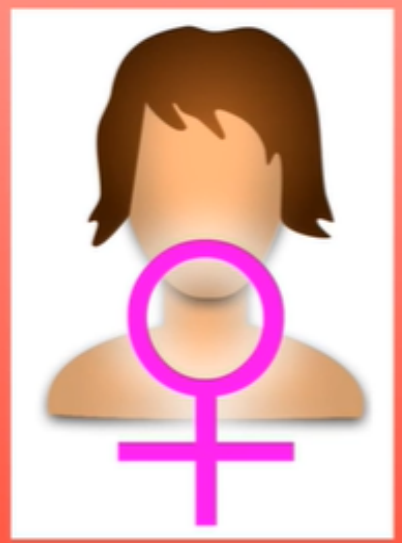
Symptoms:

Retrosternal pressure-like chest pain (2h) radiating to both arms, diaphoresis


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


I
aVR
V1
V4
II
aVL
V2
V5
III
aVF
V3
V6
V1
II
DIAGNOSIS
Ischemia zone
Territory
Culprit artery
Subendocardial
Antero lateral
Proximal
LAD
Rate
75 bpm
Rythm
Sinus
Axis
Normal
Morphology
✓ P wave

VIRTUAL CARDIOLOGY HOSPITAL

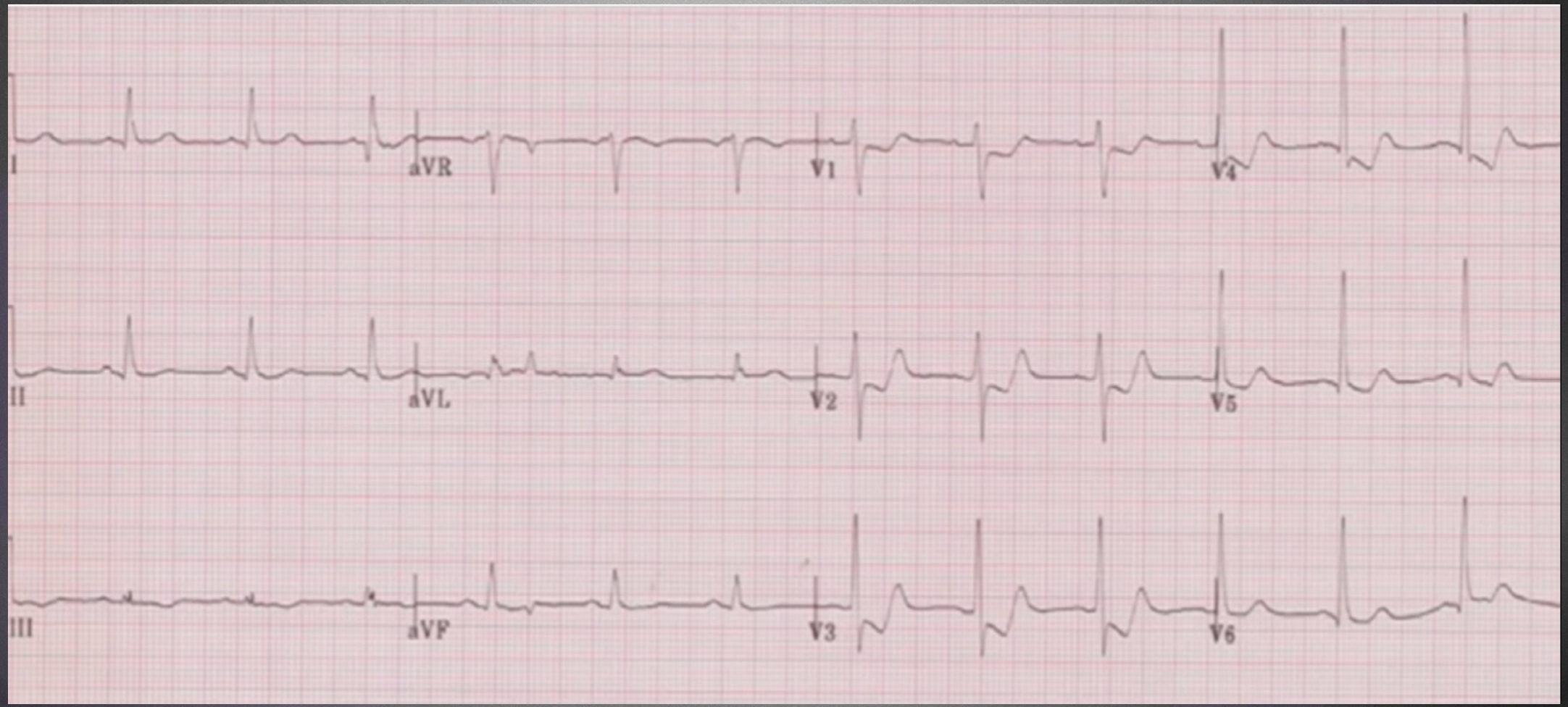


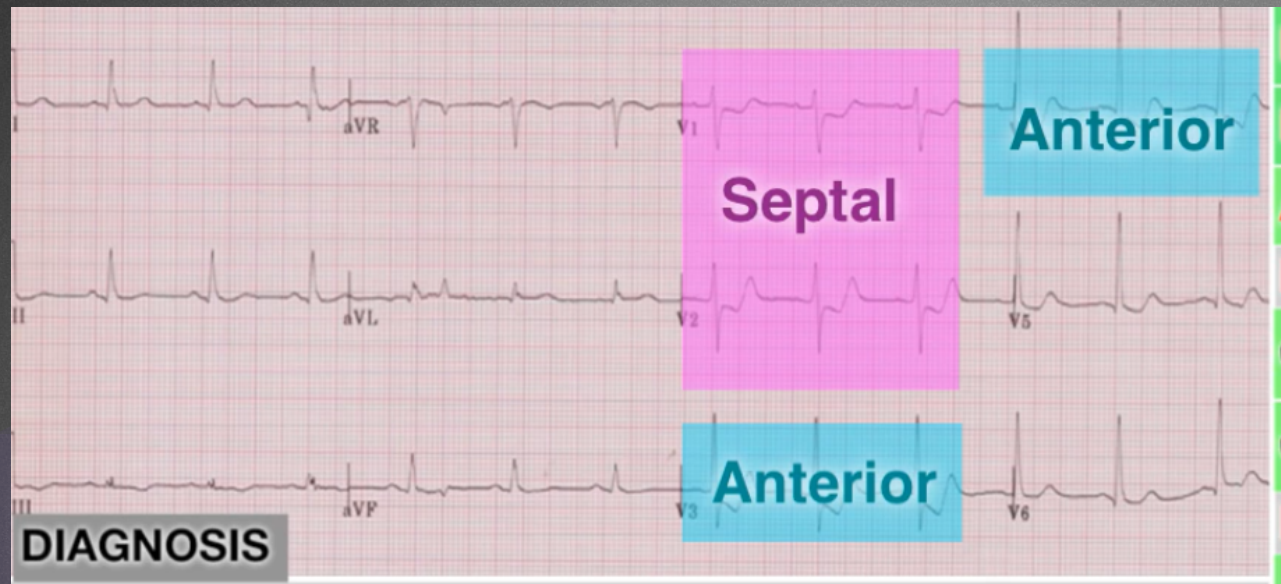
Age: 78

History: ∅

Symptoms:

On-off epigastric pain (few days)

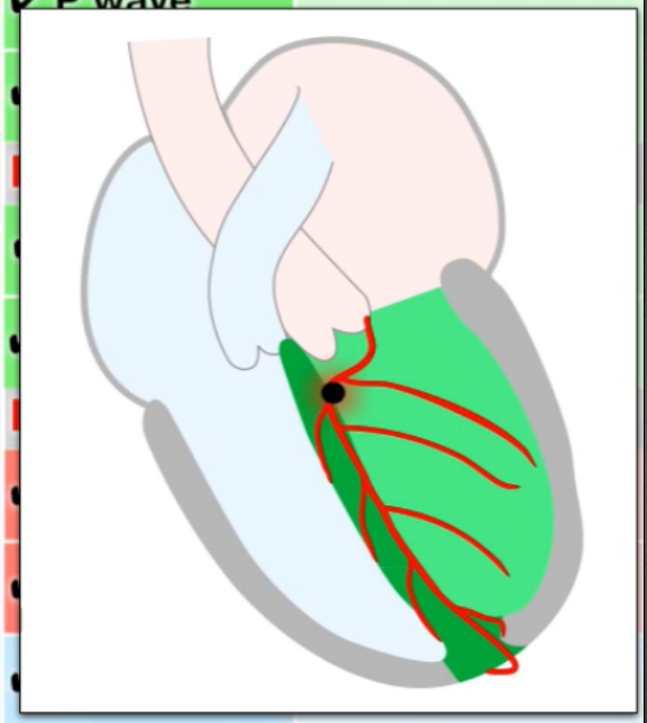

I
aVR
V1
V4
II
aVL
V2
V5
III
aVF
V3
V6



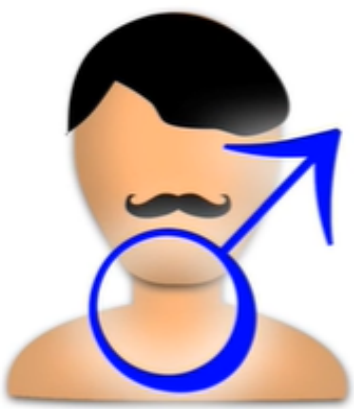
Rate	72 bpm
Rythm	Sinus
Axis	Normal
Morphology	
✓ P wave	

DIAGNOSIS

Ischemia zone	Territory	Culprit artery
Subendocardial	Antero septal	LAD



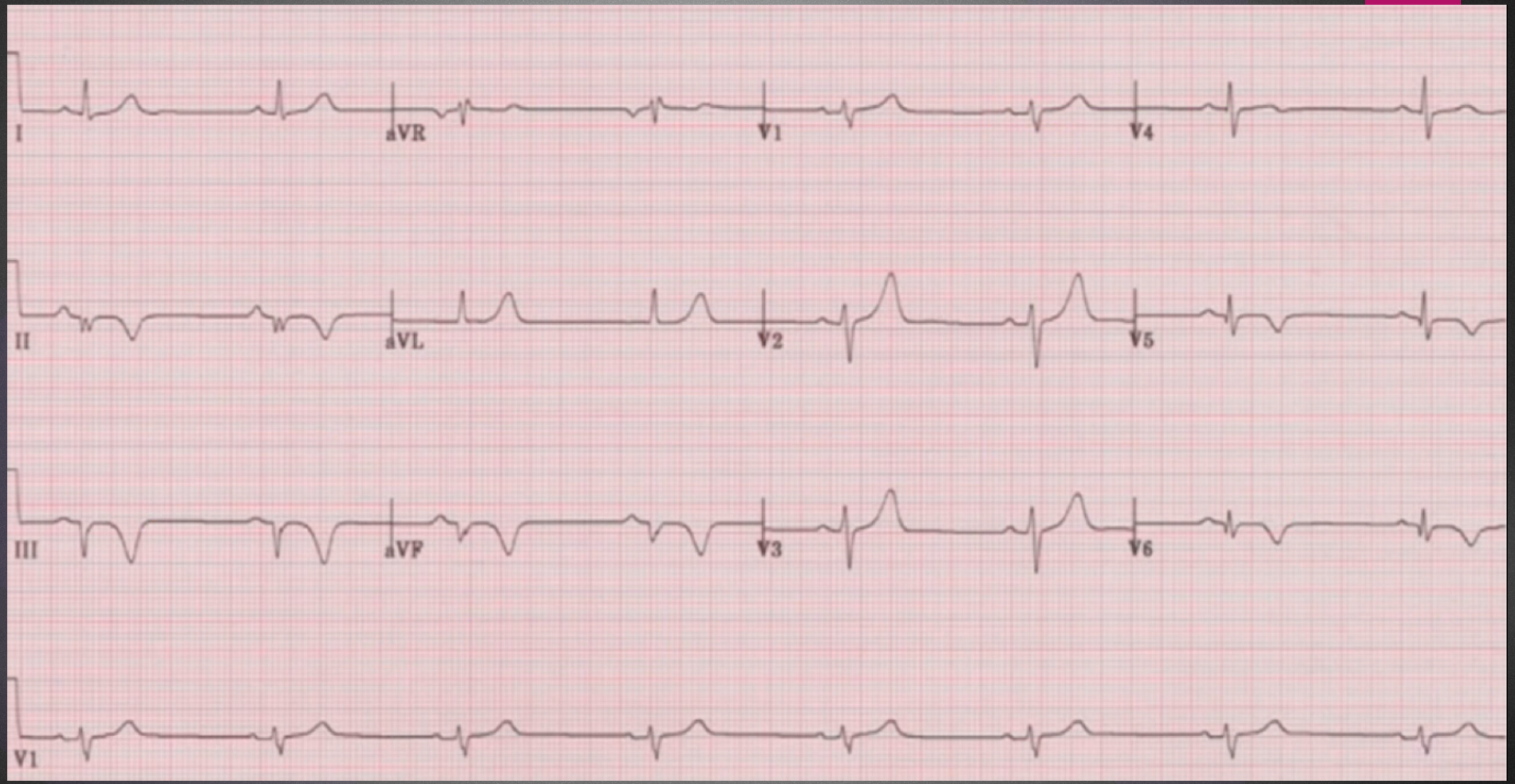
VIRTUAL CARDIOLOGY HOSPITAL

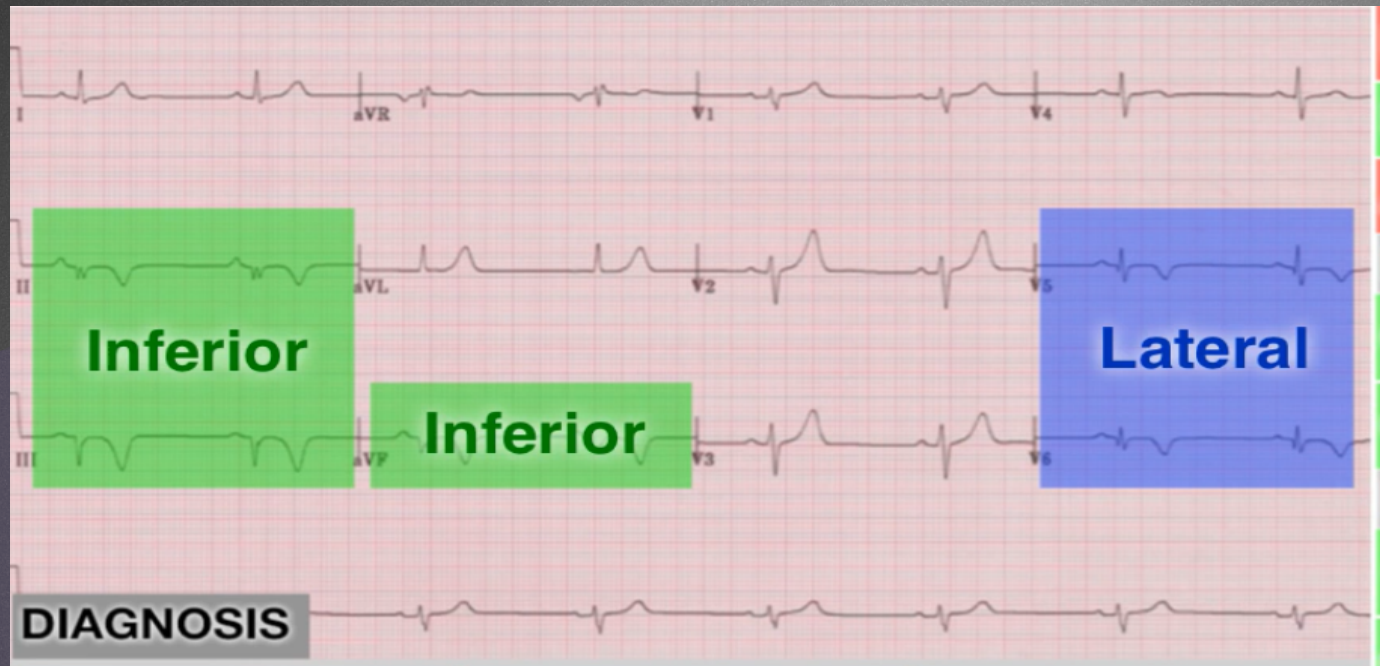


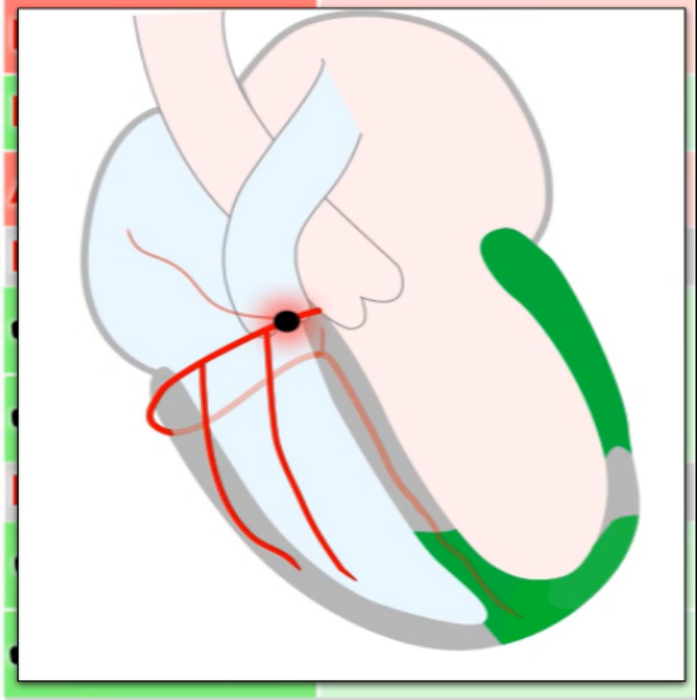
Age: 45

History:
Obesity

Symptoms:
Chest pain, nausea


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

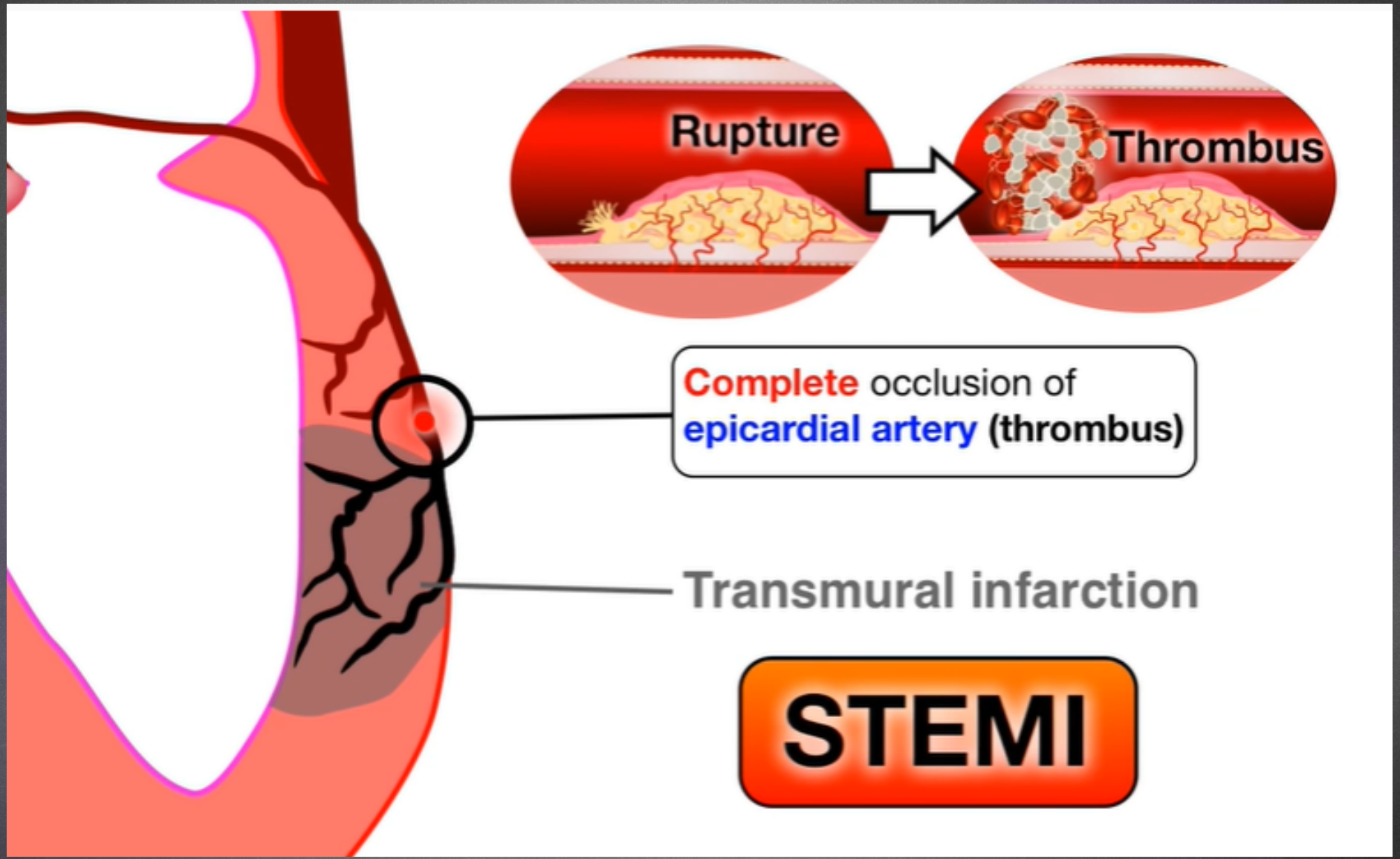


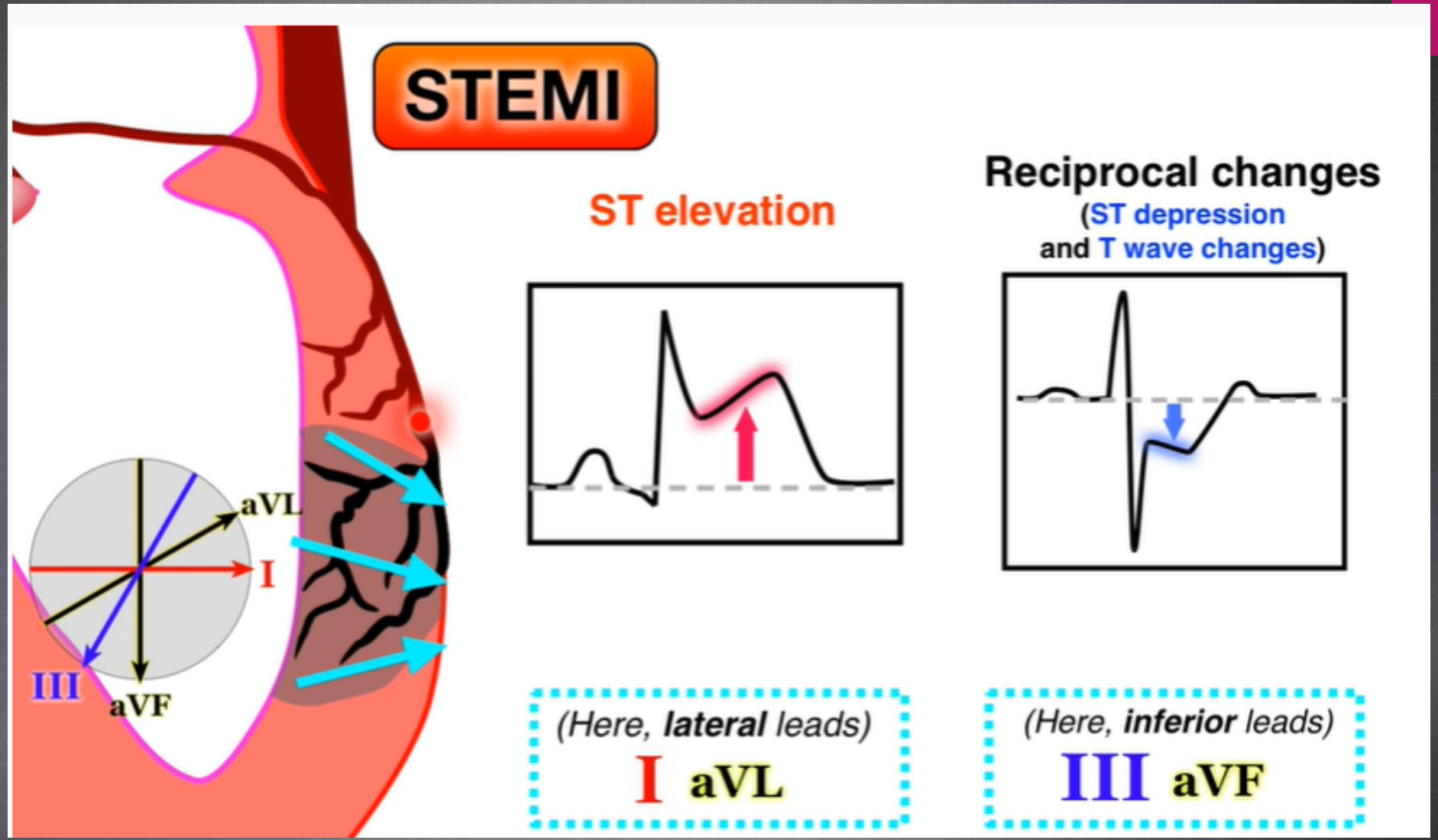


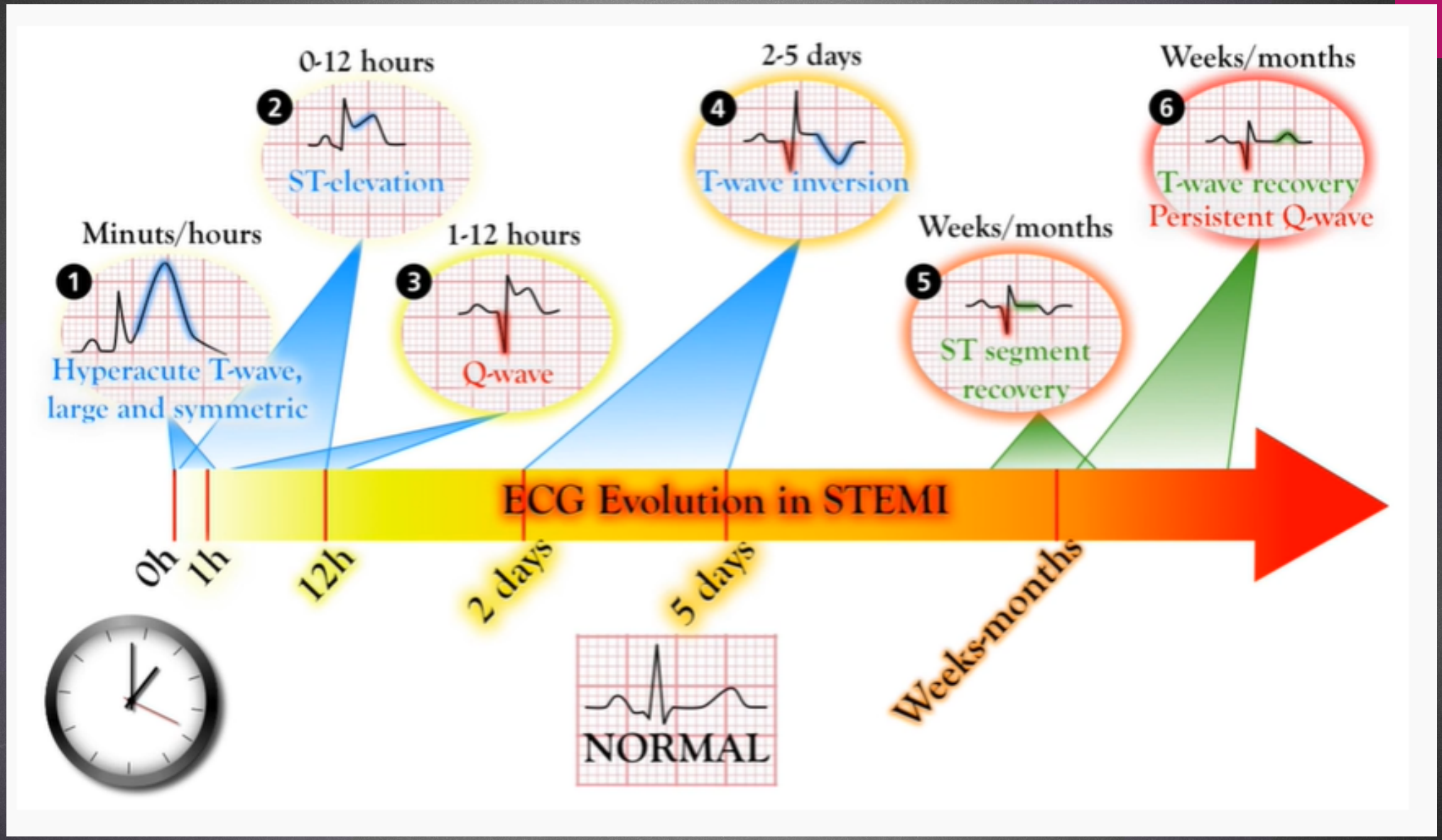
DIAGNOSIS

Ischemia zone	Territory	Culprit artery
Subendocardial  + Old infarct *(Q waves)*	Infero lateral	RCA

Ischemia	
✔ ST segment	
✔ T wave	Inversions (II, III, aVF + V5, V6)
✔ Q wave	Present (II, III, aVF)


Rupture
Thrombus
Complete occlusion of
epicardial artery (thrombus)
Transmural infarction
STEMI


STEMI
ST elevation
Reciprocal changes
(ST depression
and T wave changes)
aVL
I
III
aVF
(Here, lateral leads)
I aVL
(Here, inferior leads)
III aVF


0-12 hours
2
ST-elevation
2-5 days
4
T-wave inversion
Weeks/months
6
T-wave recovery
Persistent Q-wave
Minuts/hours
1
Hyperacute T-wave,
large and symmetric
1-12 hours
3
Q-wave
Weeks/months
5
ST segment
recovery
ECG Evolution in STEMI
0h
1h
12h
2 days
5 days
Weeks-months
NORMAL

VIRTUAL CARDIOLOGY HOSPITAL

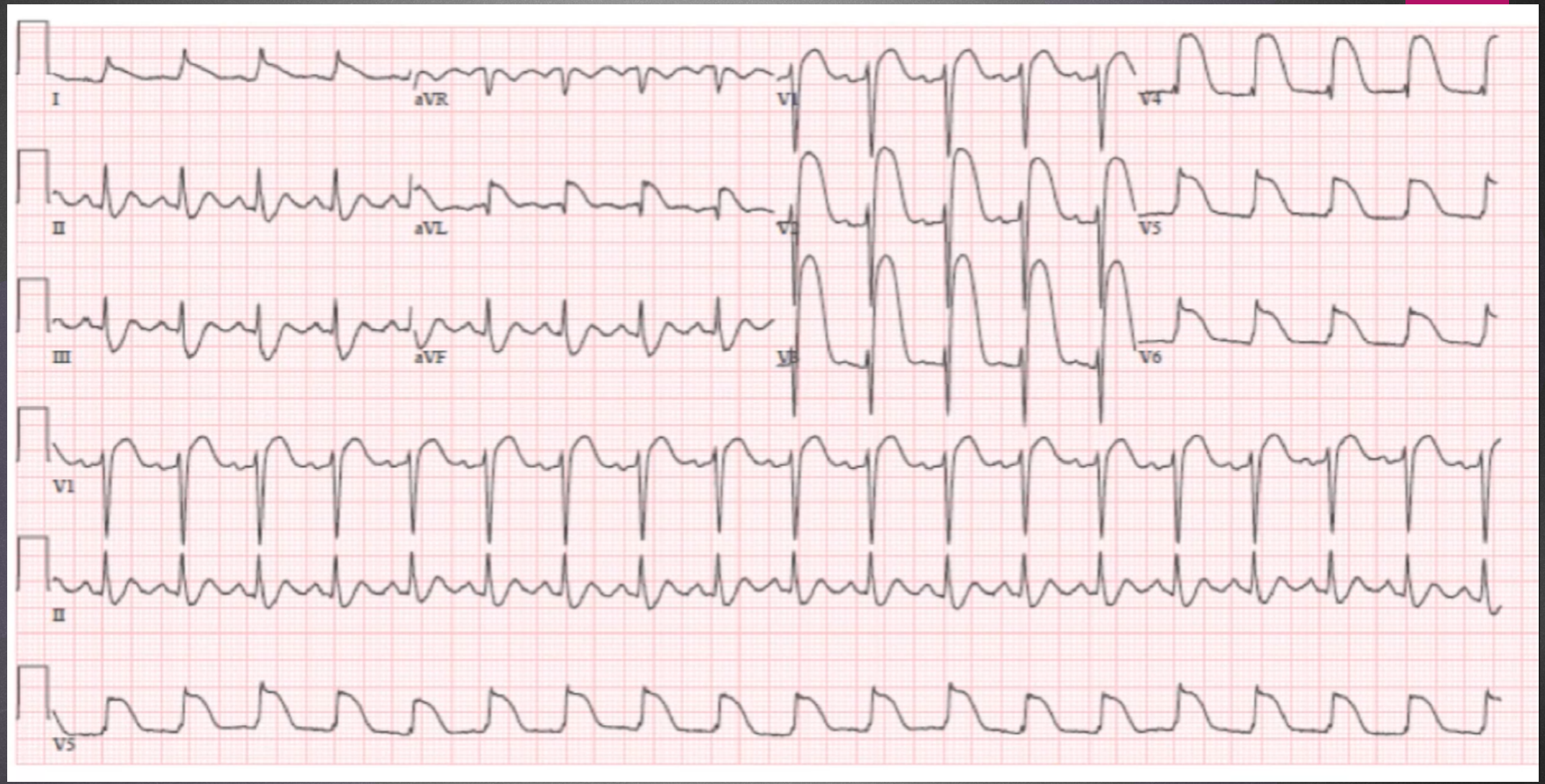
Age: 52

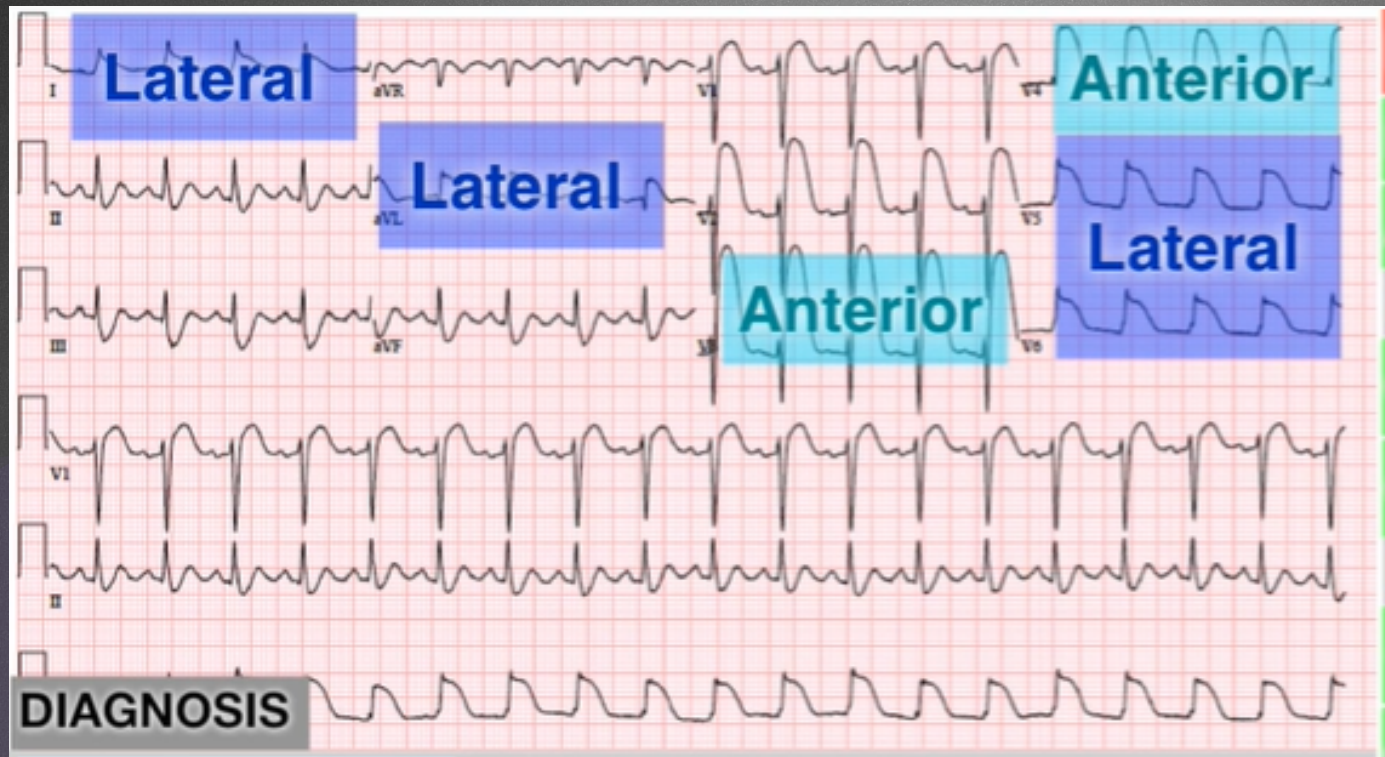
History:

Smoking

Symptoms:

Chest pain, SOB, hypotension

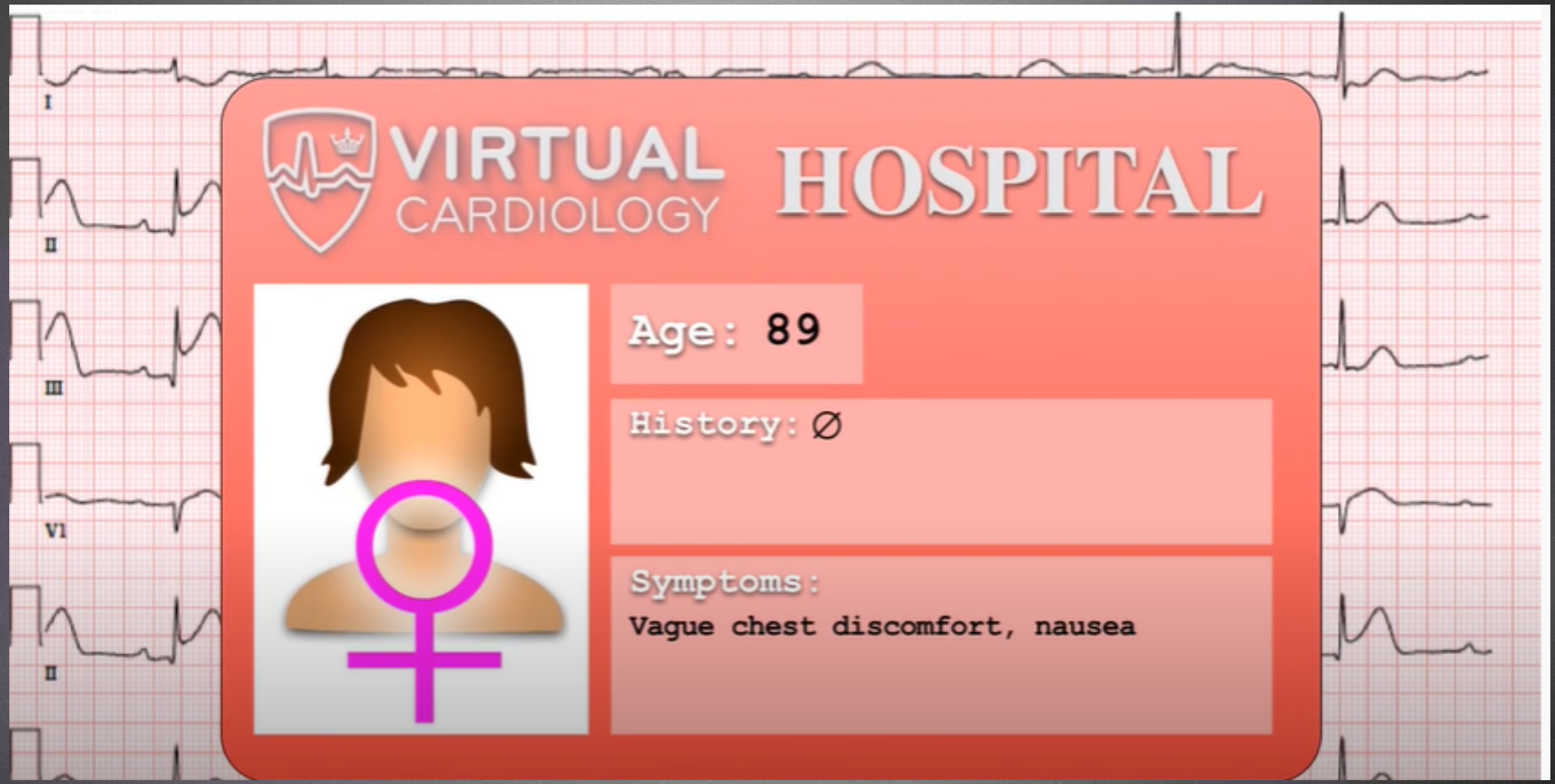

I
aVR
V1
V4
II
aVL
V2
V5
III
aVF
V3
V6
V1
II
V5

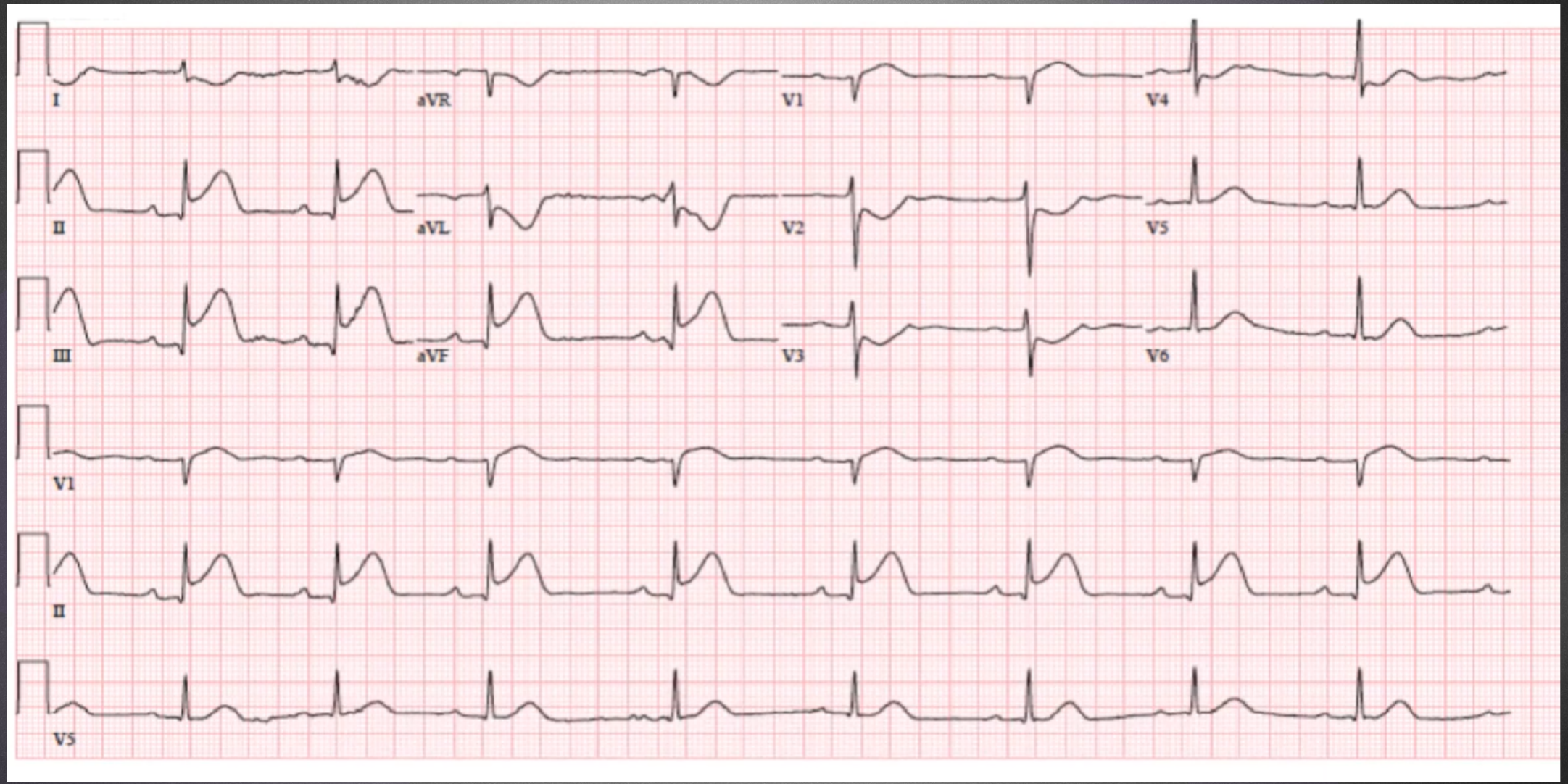


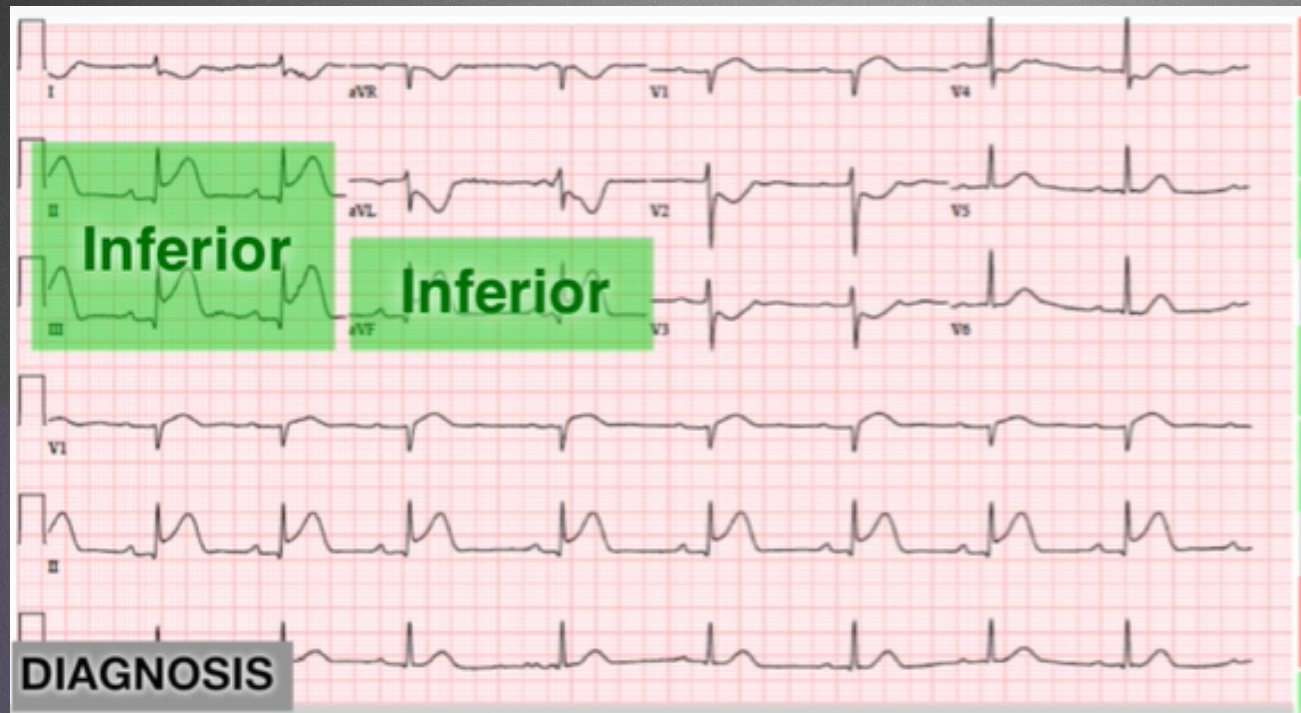
Rate	125 bpm
Rythm	Sinus
Axis	Normal
Morphology	
✔ P wave	Normal size and width
✔ QRS	

Ischemia zone	Territory	Culprit artery
STEMI	Antero lateral	Proximal LAD

Transmural


VIRTUAL
CARDIOLOGY
HOSPITAL
Age: 89
History: ∅
Symptoms:
Vague chest discomfort, nausea

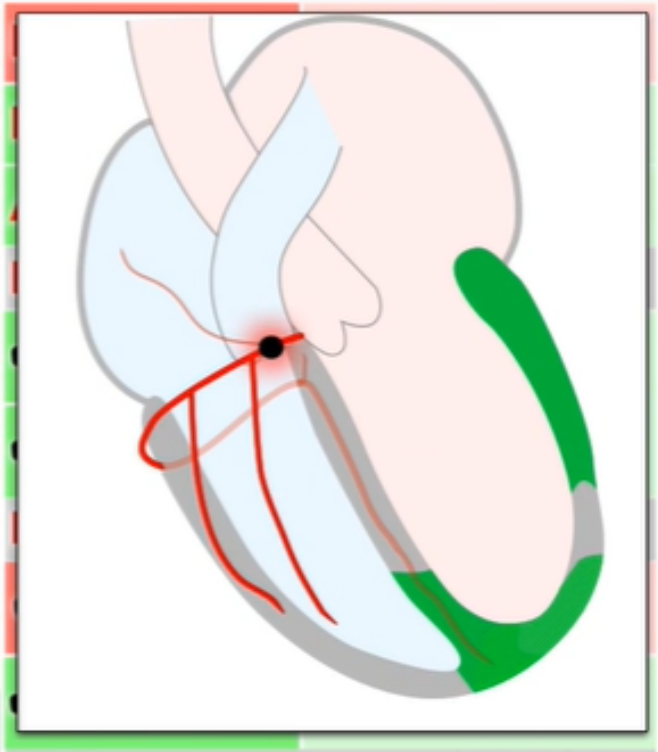

I
aVR
V1
V4
II
aVL
V2
V5
III
aVF
V3
V6
V1
II
V5



DIAGNOSIS

Ischemia zone	Territory	Culprit artery
STEMI	Inferior	RCA

Transmural



Ischemia

✔ ST segment	Elevation (II, III, aVF) Reciprocal ST depression (V2-V4, 1, aVL)

Inferior STEMI

Bradycardia

- Sinus bradycardia
- 2nd degree AV block
- 3rd degree AV block

Mechanisms

1) Ischemia of the **AV nodal artery**

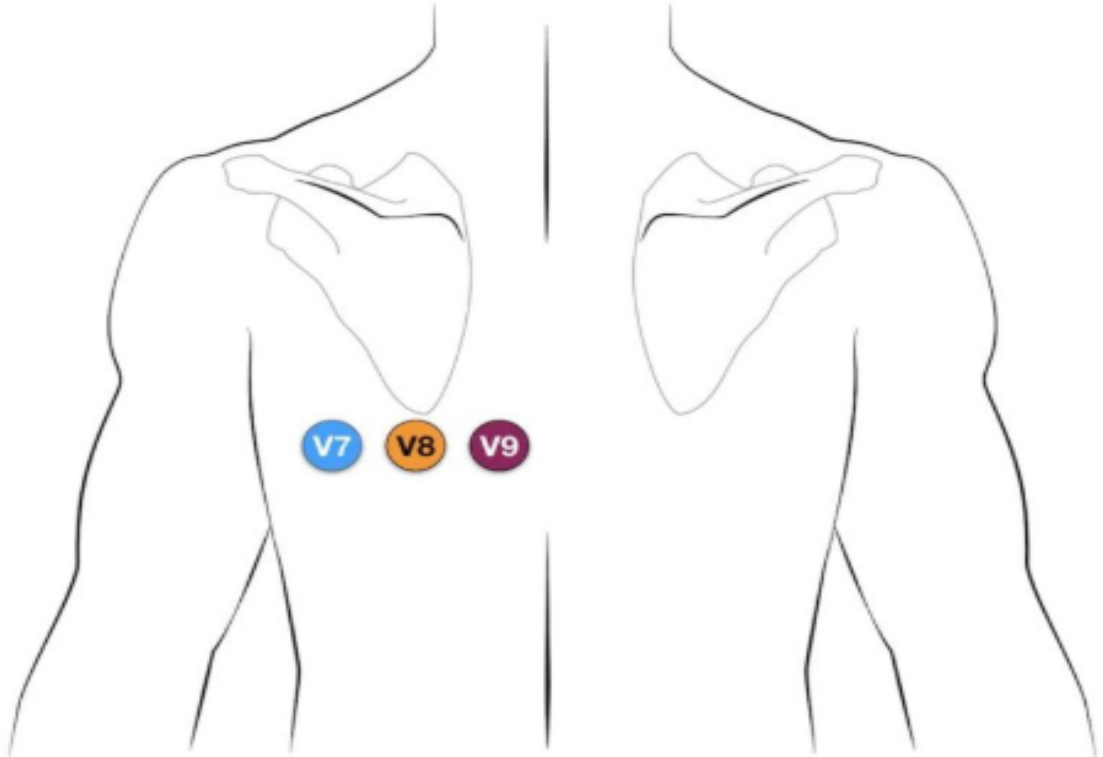
2) **Bezold-Jarisch** reflex

Ventricular stretching → ⇧ **Parasympathetic**

Posterior leads

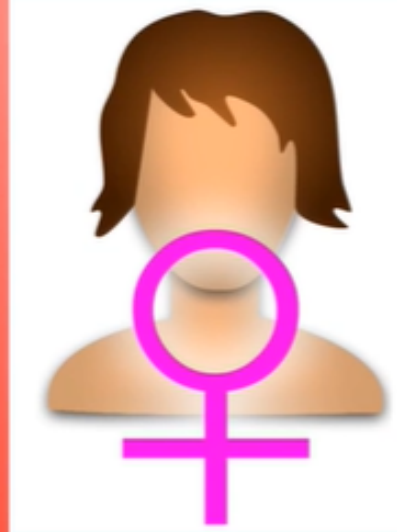
Leads V7-9 are placed on the posterior chest wall in the following positions (see diagram below):

- V7 – Left posterior axillary line, in the same horizontal plane as V6.
- V8 – Tip of the left scapula, in the same horizontal plane as V6.
- V9 – Left paraspinal region, in the same horizontal plane as V6.



Posterior lead placement V7, V8, V9

VIRTUAL CARDIOLOGY HOSPITAL

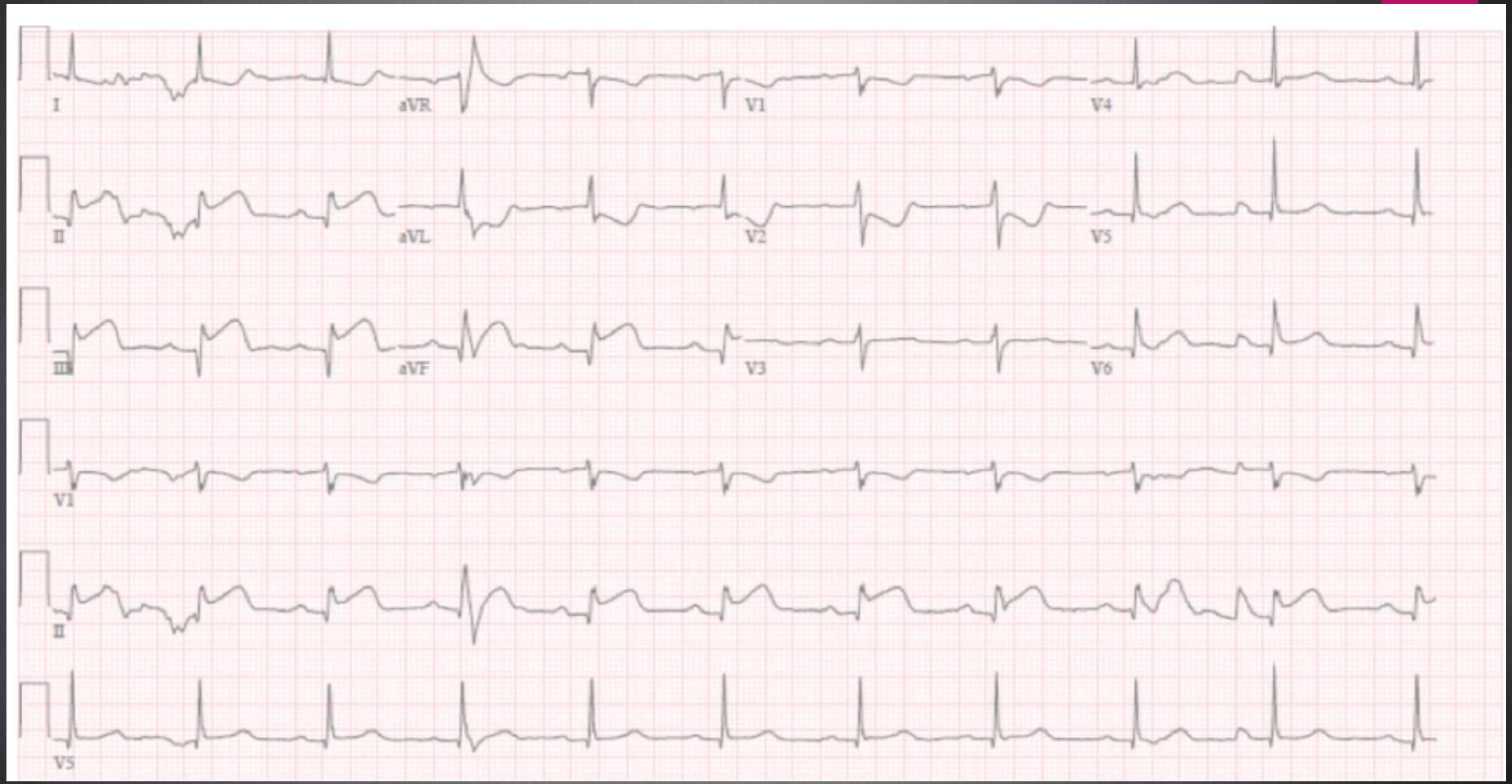


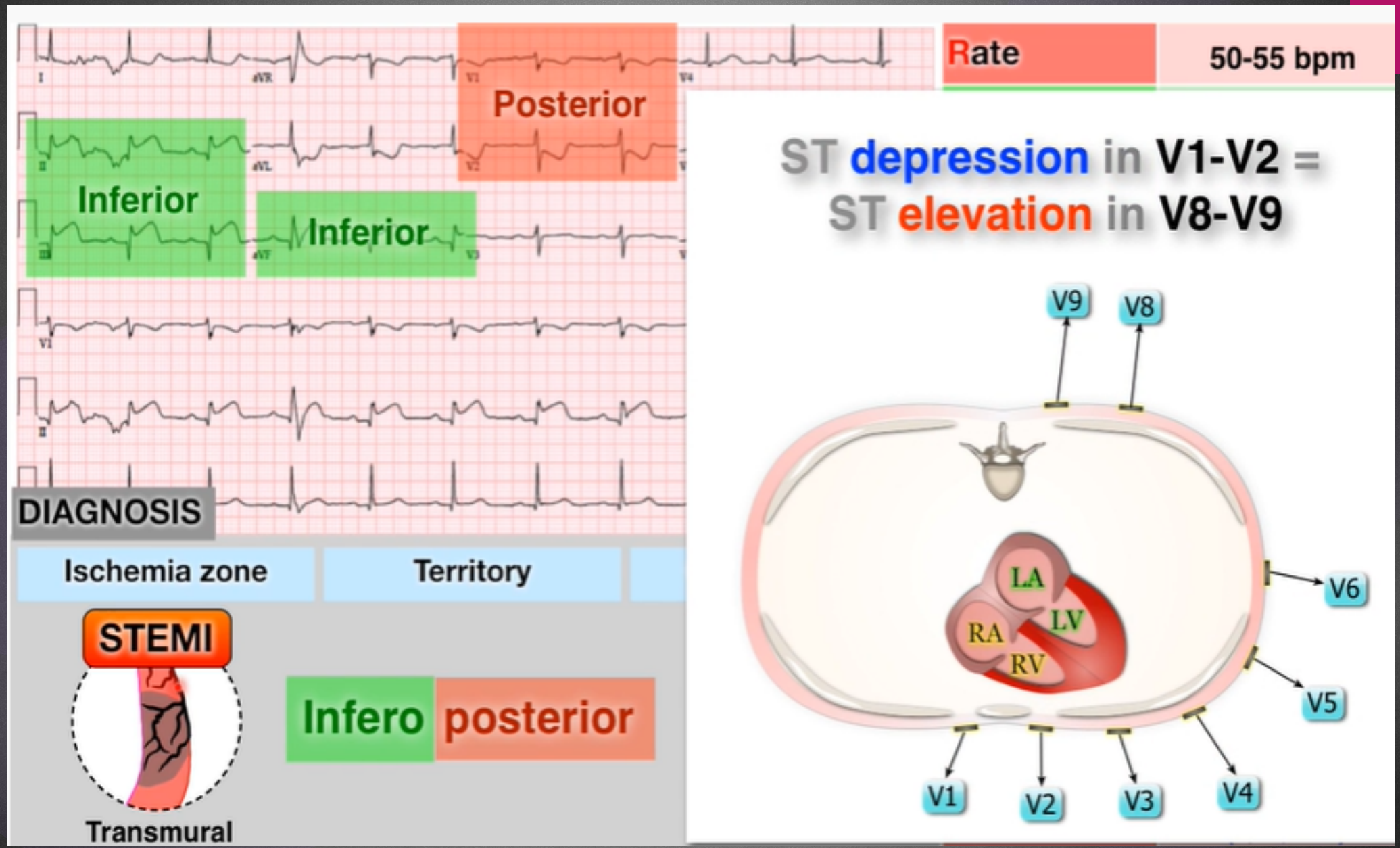
Age: 48

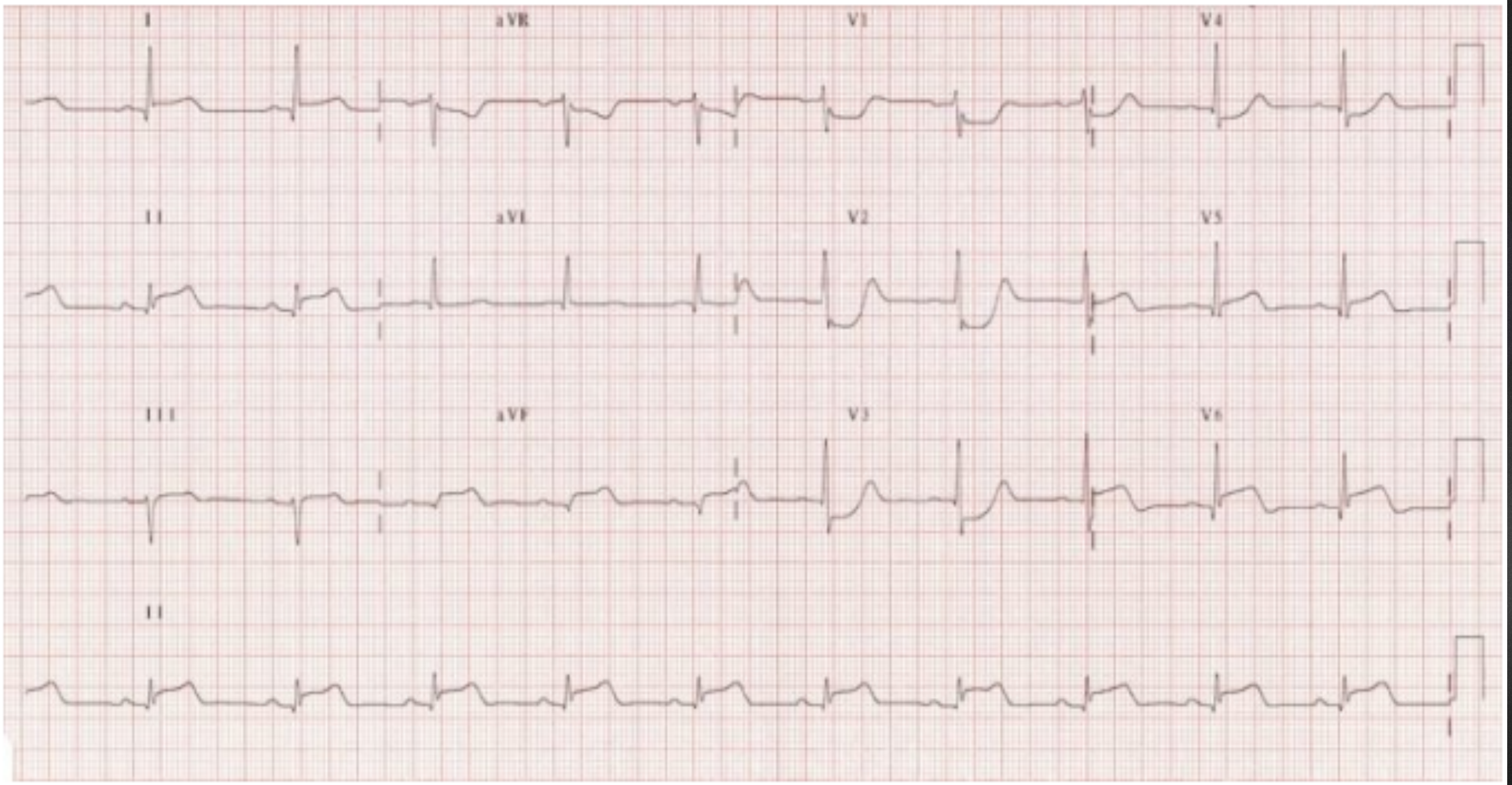
History: ∅

Symptoms:

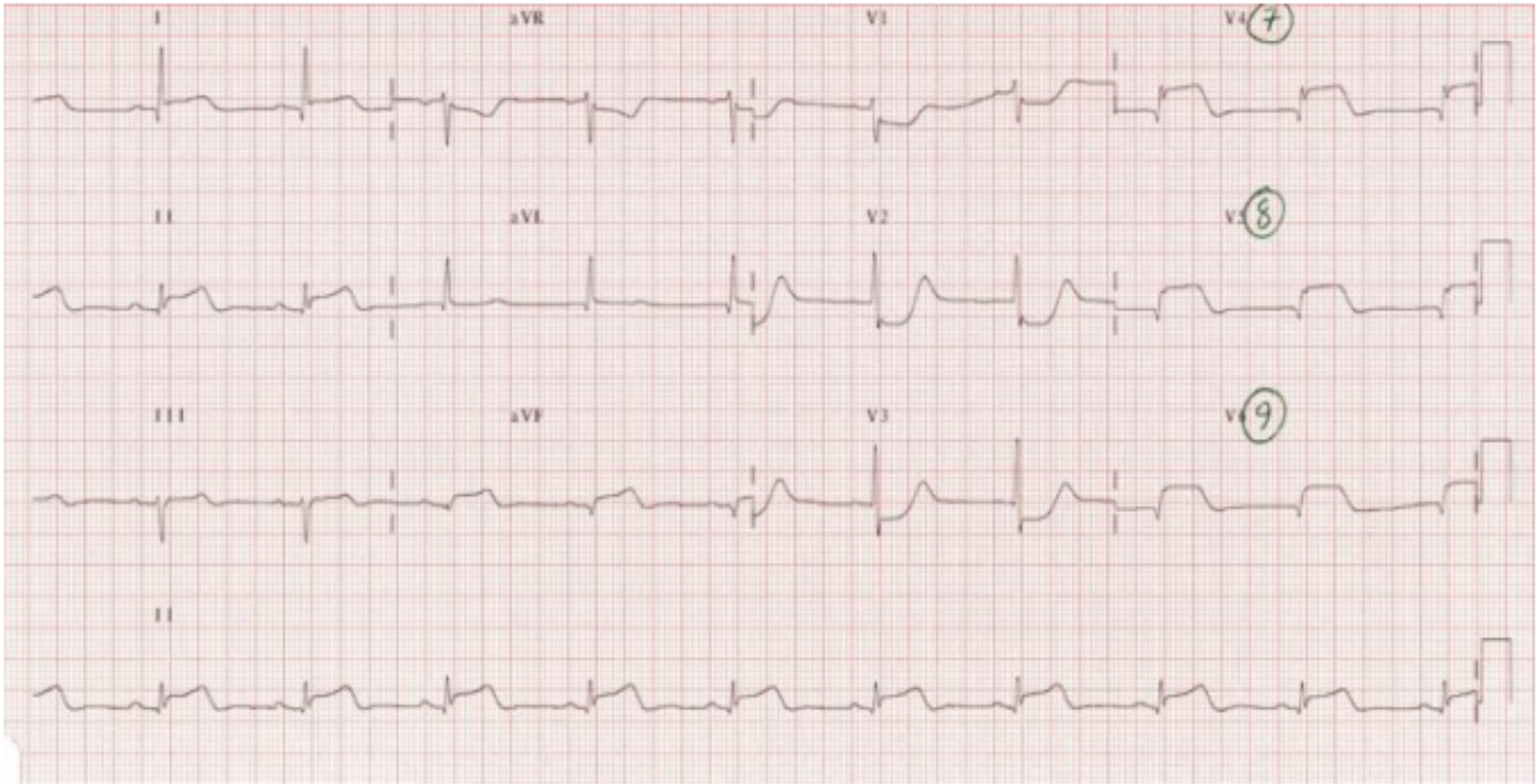
Chest pain, nausea, hypotension, Elevated JVP and clear lungs on physical exam


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

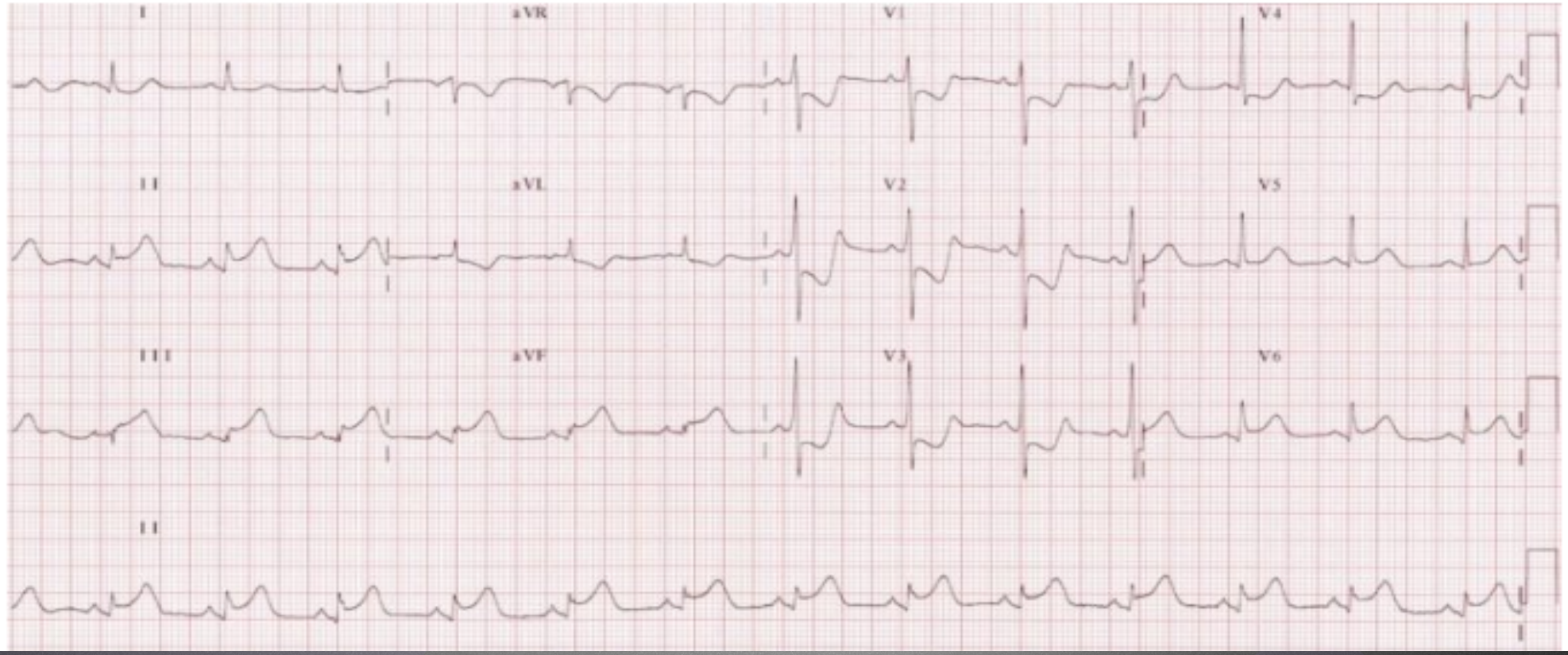

Posterior
Inferior
Inferior
Rate
50-55 bpm
ST depression in V1-V2 =
ST elevation in V8-V9
V9
V8
V6
V5
V4
V3
V2
V1
LA
LV
RA
RV
DIAGNOSIS
Ischemia zone
Territory
STEMI
Transmural
Infero
posterior


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

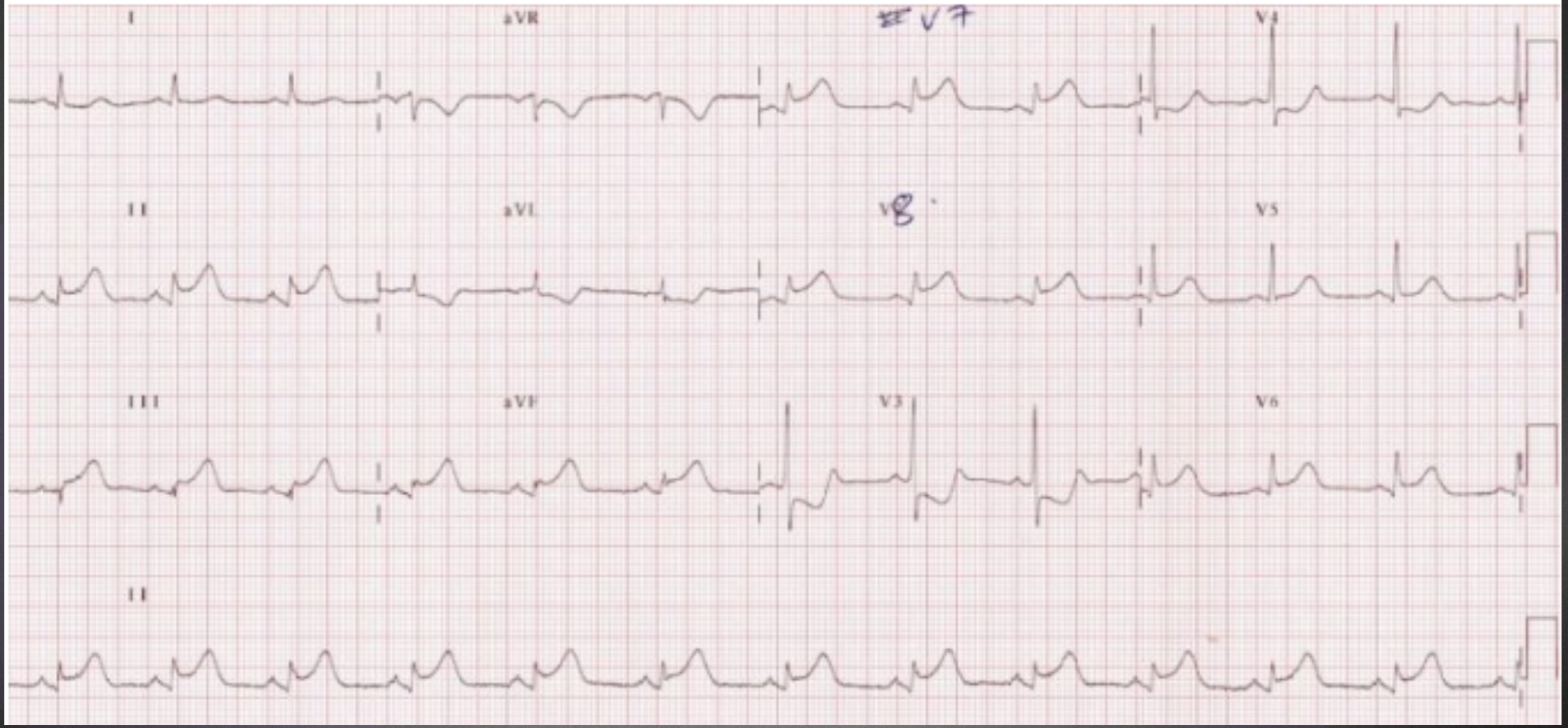
The same patient, with posterior leads recorded:



Patient presenting with central chest pain



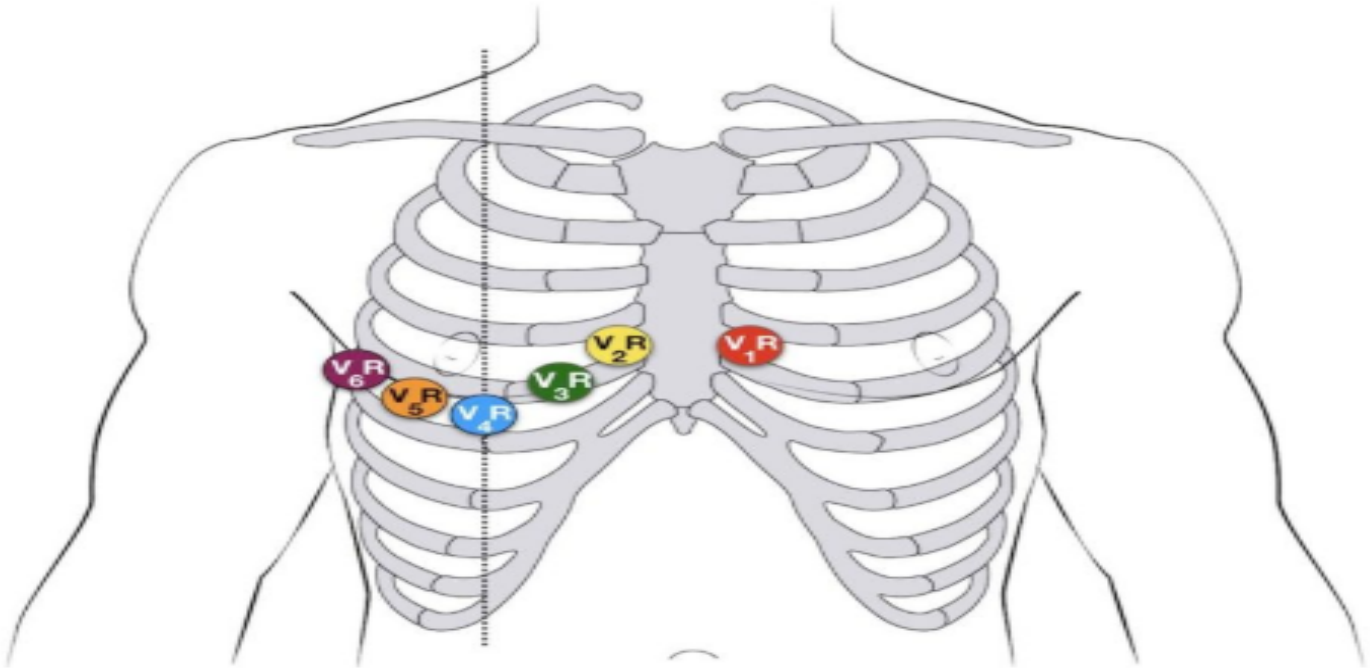
The same patient with posterior leads (V8,9) recorded:

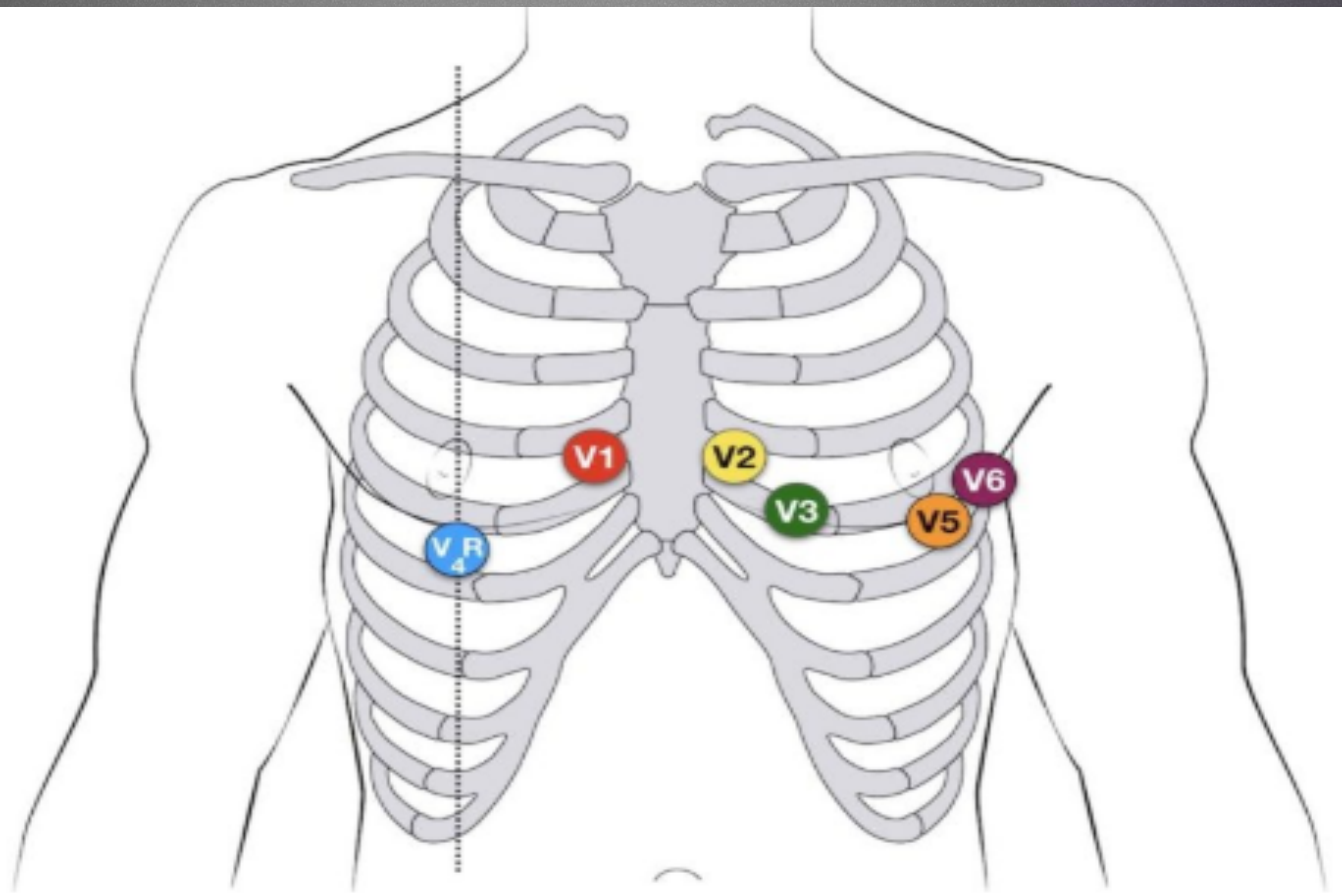


Right-sided leads

There are several approaches to recording a right-sided ECG:

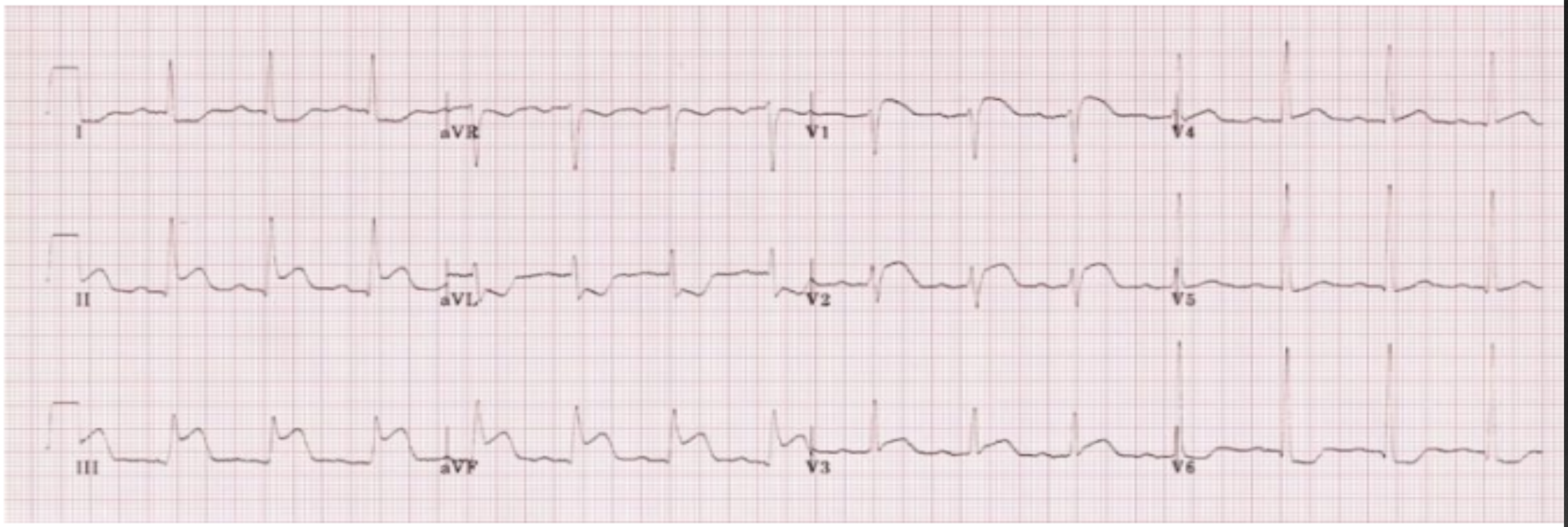
- A complete set of right-sided leads is obtained by placing leads V1-6 in a mirror-image position on the right side of the chest (see diagram, below).
- It may be simpler to leave V1 and V2 in their usual positions and just transfer leads V3-6 to the right side of the chest (i.e. V3R to V6R).
- The most useful lead is V4R, which is obtained by placing the V4 electrode in the 5th right intercostal space in the midclavicular line.
- ST elevation in V4R has a sensitivity of 88%, specificity of 78% and diagnostic accuracy of 83% in the diagnosis of RV MI.





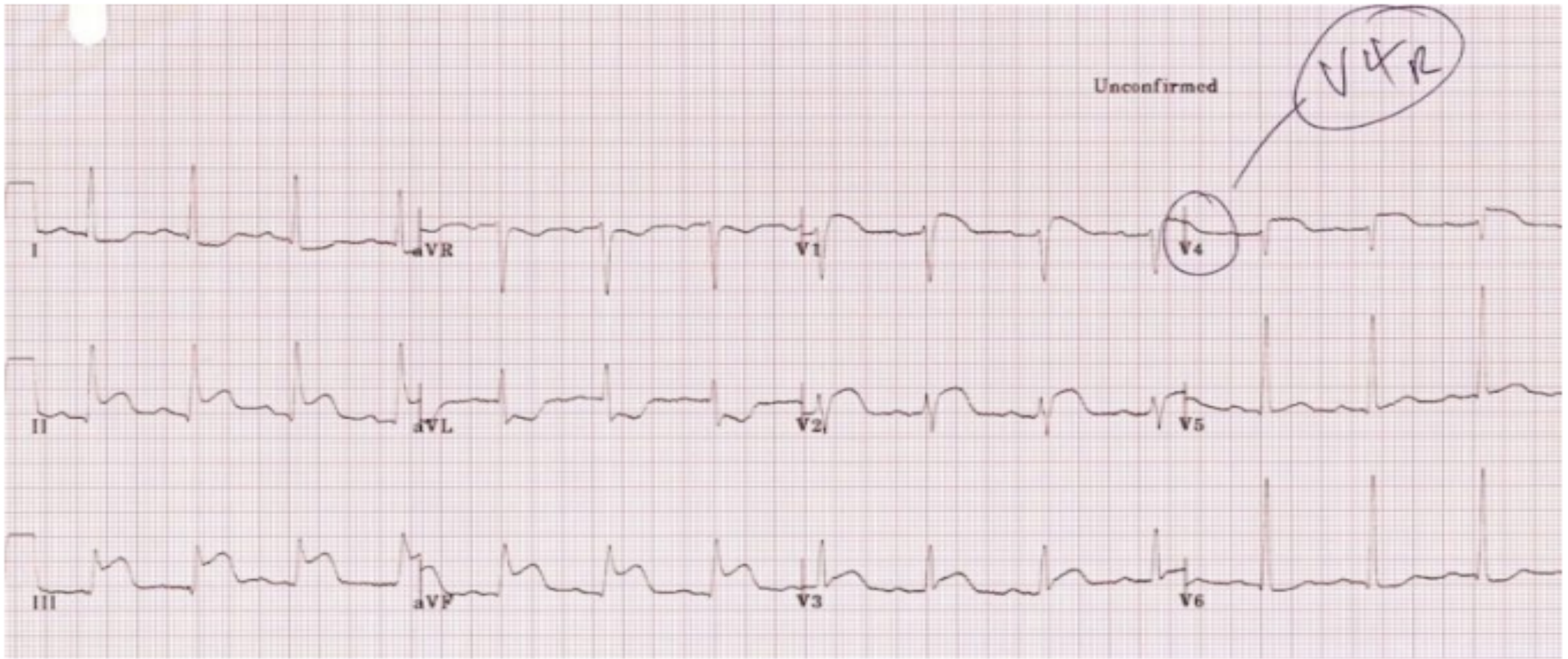
V4R in 12-lead ECG

NB. ST elevation in the right-sided leads is a transient phenomenon, lasting less than 10 hours in 50% of patients with RV infarction.



Inferior STEMI. Right ventricular infarction is suggested by:

- ST elevation in V1
- ST elevation in lead III > lead II

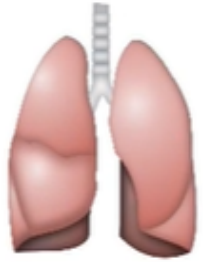


- There is ST elevation in V4R consistent with RV infarction

Classical triad of an RV infarct

1) Hypotension 

2) ⬆ JVP 

3) Clear lungs 

ACS risk scores

- HEART score: scoring system designed to stratify risk of major adverse cardiac events in patients coming to the emergency room with chest pain.
- TIMI score: 14-day risk of death, new/ recurrent, or need to repeat revascularization.
- GRACE score: in-hospital, 6 months, 1 year, 3 years risk of death or MI.

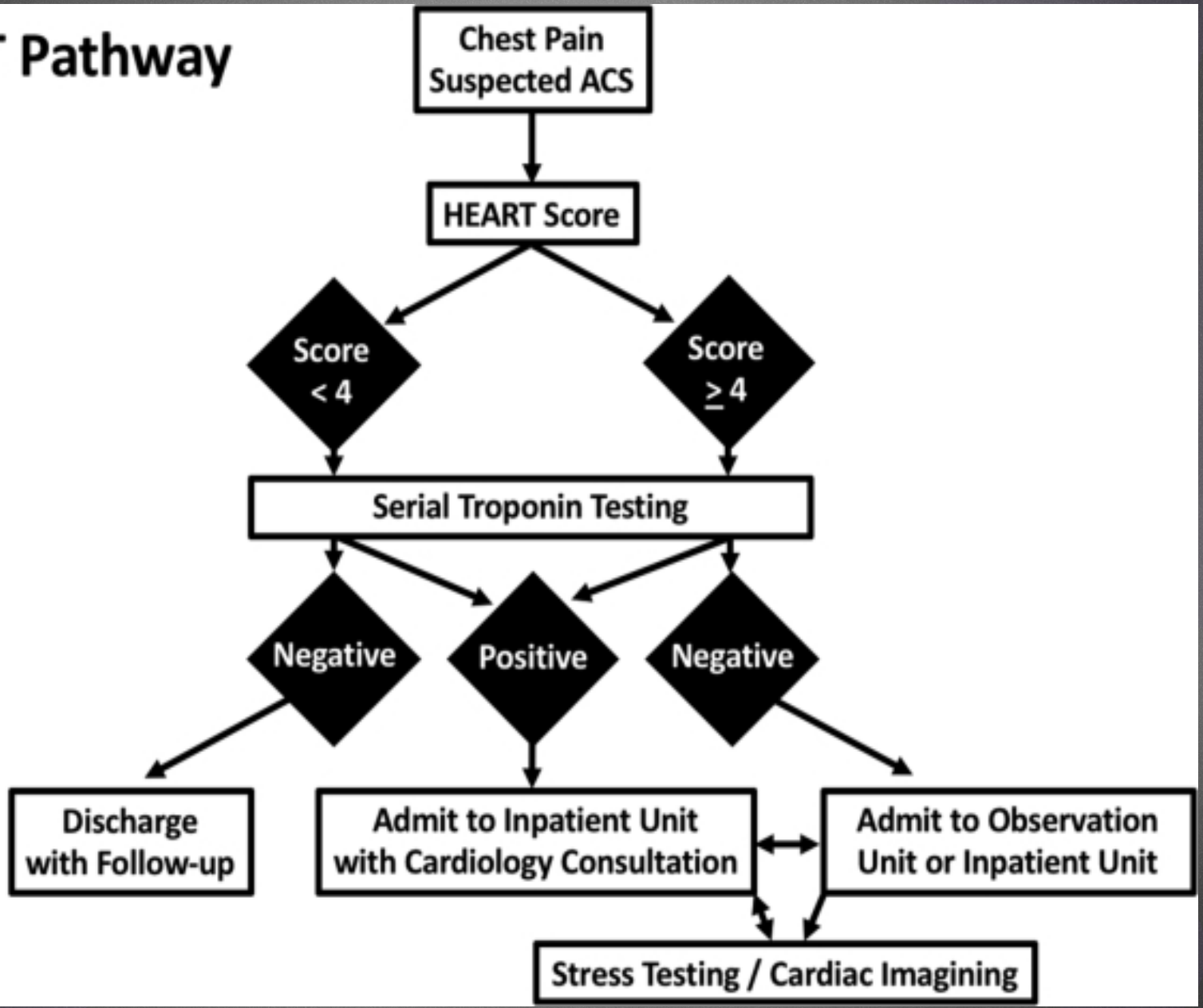
Variable	Description	Score
History	Highly suspicious	2
	Moderately suspicious	1
	Slightly or nonsuspicious	0
ECG	Significant ST-depression	2
	Nonspecific repolarization disturbances	1
	Normal	0
Age	≥65 y	2
	45 to 65 y	1
	≤45 y	0
Risk factors	≥3 risk factors*, or history of atherosclerotic disease†	2
	1 or 2 risk factors	1
	No risk factors known	0
Troponin	≥3x normal limit	2
	1 to 2x normal limit	1
	≤normal limit	0

Total score: 0 to 10 points. 0 to 3 points, low risk; 4 to 6 points, intermediate risk; 7 to 10 points, high risk.

*Risk factors: hypertension, hypercholesterolemia, diabetes mellitus, family history of premature coronary artery disease, current smoking (or quit smoking <1 month ago), and obesity (body mass index ≥30 kg/m^2).

†History of atherosclerotic disease: previous myocardial infarction, percutaneous

The HEART Pathway



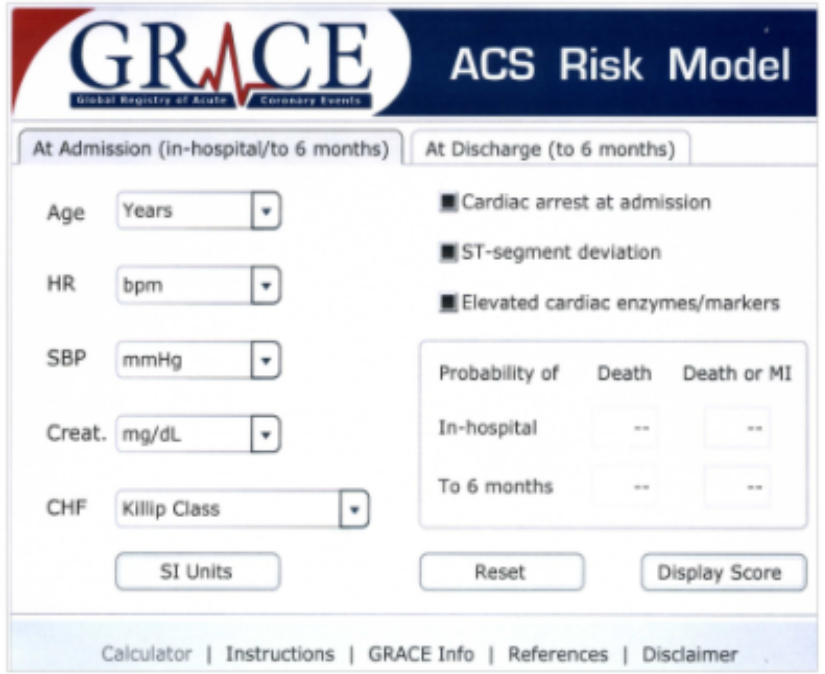
TIMI Risk Score for UA/NSTEMI

Estimates risk at **14 days** of all-cause mortality, new or recurrent MI, or severe recurrent ischemia requiring urgent revascularization for patients with unstable angina and non-ST elevation MI.

The TIMI Score was developed in AMERICA to predict adverse outcomes in patients with **UA and NSTEMI.** The TIMI risk score is composed of seven independent risk factors:

Age ≥ 65 years,
Markers (elevated cardiac markers)
ECG (ST-segment depression at presentation)
Risk Factors (3 or more cardiovascular risk factors)
Ischemic chest pain (at least 2 or more anginal events in the previous 24hrs)
Coronary stenosis (prior stenosis of 50% or more)
Aspirin (aspirin usage in the past 7 days)

Score	Risk of heart event
0 to 1	4.7%
2	8.3%
3	13.2%
4	19.9%
5	26.2%
6 to 7	At least 40.9%



The predicted 6 month mortality expressed as a percentage is then stratified into a level of risk (see below):

1.5% or below Lowest

>1.5 3% Low

>3% 6% Intermediate

>6% 9% High

Over 9% Highest

Treatment strategies (pharmacological and mechanical) are then recommended by NICE based on the level of risk as determined by GRACE (see later in session).

Figure 12: Initial risk assessment and management of ACS according to GRACE score as suggested by NICE Guidelines (2010) [69]:

Step 1: Risk stratification using GRACE Risk Model:

Step 1

Predicted 6 month mortality:

1.5% or below	Lowest risk
>1.5 – 3.0%	Low risk
>3.0 – 6.0%	Intermediate risk
>6.0%	High risk

Intervention depends on score as in Table below

Step 2

Step 2: Initial management of ACS as per Table below:

Intervention	GRACE RISK SCORE (predicted 6 month mortality)		
	1.5% or below (Lowest risk)	1.5 - 3% (Low risk)	> 3% (Intermediate or high risk)
	Admit to AAU but refer for review cardiology within 24 hours		Admit to CCU or CARDIOLOGY ward
ASPIRIN 300mg PO STAT then 75mg daily	✓	✓	✓
BISOPROLOL 2.5-5.0mg PO daily (if not contra-indicated)	✓	✓	✓
FONDAPARINUX* 2.5mg S/C daily; use UFH if eGFR<20ml/min	✓	✓	✓
CLOPIDOGREL* 600mg PO STAT then 75mg daily		✓	✓
TIROFIBAN* *(infusion as per protocol and continued for 72 hours)*			✓
Early ANGIOGRAPHY (within 96 hours of presentation)			✓
ISOSORBIDE DINITRATE infusion only if ongoing pain *(as per protocol)*			✓

ED management of STEMI

- Relief of pain and anxiety.
- Oxygen supplement.
- Nitroglycerin.
- Antiplatelets
- Heparin.

- GTN
  - If required in the setting of a STEMI this should be given as an IV infusion, rather than topically or sublingually
  - Indications:
    - Pain, not controlled by adequate doses of opioid analgesia.
    - Acute severe hypertension
    - Acute cardiogenic pulmonary edema associated with hypertension

- Anti-Platelet Therapy
  - In all patients with possible ACS and without genuine contraindications, aspirin dissolved or chewed) should be given as soon as possible after presentation
  - Additional antiplatelet and anticoagulation therapy, or other therapies such as beta-blockers, should not be given to patients without a confirmed or probable diagnosis of ACS.

- Aspirin 300 mg po then 100 – 150 mg daily thereafter.
- Aspirin is then continued indefinitely unless it is not tolerated or an indication for anticoagulation becomes apparent.
- Note that other NSAIDs should not be given due to an increased risk of MACE (i.e major adverse cardiac event) in patients subsequently shown to have ACS.

- Ticagrelor (in PCI patients)
  - loading dose, 180 mg followed by 90 mg B.D
  - Careful assessment of bleeding risk should be undertaken before using these agents.
  - Avoid if emergency coronary artery bypass grafting may be required, (e.g. ongoing ischaemia, extensive ECG changes, hemodynamic instability).

- Dual antiplatelet therapy (i.e. with aspirin and a P2Y12 inhibitor (clopidogrel or ticagrelor) should be prescribed for up to 12 months in patients with confirmed ACS, regardless of whether coronary revascularisation was performed. The use of Prasugrel for up to 12 months should be confined to patients receiving PCI.
- Consider continuation of dual antiplatelet therapy beyond 12 months if ischaemic risks outweigh the bleeding risk of P2Y12 inhibitor therapy; conversely, consider discontinuation if bleeding risk outweighs ischaemic risks.

- Clopidogrel is used in patients undergoing fibrinolysis, (more experience with this agent) or if there are specific CI to ticagrelor or prasugrel
  - Avoid if emergency coronary artery bypass grafting is likely
  - Give loading dose, 300-600 mg orally, then 75 mg daily

- Heparin or enoxaparin
  - With PCI
    - Heparin (i.e. “unfractionated”) bolus dose of 5000 units should be given in cases of patients who are to receive PCI for their STEMI.
  - With fibrin-specific fibrinolysis
    - Heparin bolus loading dose with the first fibrinolytic dose and then commence heparin infusion
  - Alternatively:
    - Enoxaparin, 1 mg/kg SC (or a reduced dose, 0.75 mg/kg SC in the elderly or those with renal impairment) 12 hourly
  - Heparin or enoxaparin is not required in patients with successful revascularization and without other indication for anticoagulation

- Glycoprotein IIb/IIIa Inhibitors
  - An IV glycoprotein IIb/IIIa inhibitor in combination with heparin is recommended at the time of PCI among patients:
    - With high risk clinical and angiographic characteristics.
    - Who continue to have ischemia despite other treatments.
  - Agents available include:
    - Abciximab, (Trade name Reopro)
    - Eptifibatide (Trade name Integrilin)
    - Tirofiban, (Trade name Aggrastat)
  - The need for, and the specific agent to be used, will be determined by the treating cardiologist.

- Bivalirudin (direct thrombin inhibitor)
  - Bivalirudin (0.75 mg/kg intravenously with 1.75 mg/kg/h infusion) may be considered as an alternative to glycoprotein IIb/IIIa inhibition and heparin among patients with ACS undergoing PCI with clinical features associated with an increased risk of bleeding events

Reperfusion therapy

- Early reperfusion primary PCI.
- Early reperfusion thrombolysis.

Reperfusion Strategy

- Indications
  - All patients who present within 12 hours of symptom onset of STEMI should be considered for a reperfusion strategy, unless they have severe co-morbidities.
  - Reperfusion is not routinely recommended in patients who present more than 12 hours after symptom onset. It may be considered however in selected cases when:
    - There are ongoing symptoms
    - There is ongoing electrical and /or hemodynamic (cardiogenic shock) instability.
  - For reperfusion therapy after 12 hours PCI is preferred over thrombolysis.

- Choice of Reperfusion Strategy
  - The ideal treatment for all STEMIs is acute PCI or in some cases emergency CABGs
  - Primary PCI is preferred for reperfusion therapy in patients with STEMI if it can be performed within 90 minutes of first medical contact
  - If this time frame is not possible, then fibrinolytic therapy is preferred for those without contraindications.

- PCI / CABGs
  - Any patient identified as having a STEMI should prompt activation of a "CODE STEMI" response
  - Note that "on site" cardiac surgical backup is not considered essential for a PCI intervention.
  - Whilst on site cardiac surgical backup is not essential, networks of urgent referral nonetheless need to be in place.
  - CAGS is considered in cases of:
    - Failed PCI, (ongoing symptoms/ instability)
    - Some complications following PCI.
    - Suitable coronary vessel anatomy discovered on angiography, not readily amenable to PCI

- Thrombolysis
  - There are 3 fibrin-specific fibrinolytic agents available in Australia:
    - tPA (Trade name Alteplase) – Infusion
    - Tenecteplase (Trade name Metalyse) – Single bolus dose
    - Reteplase (Trade name Rapilysin) -Two standard bolus doses 30 minutes apart

- Failed Thrombolysis
  - This can only be judged definitively by coronary angiography.
  - Indications that reperfusion has been unsuccessful include:
    - Failure of the relief of ischemic chest pain.
    - Failure of the restoration of hemodynamic / electrical stability.
    - Failure of resolution of S-T segment elevation, (as above)

NSTEACS management

RISK STRATIFICATION OF PATIENTS WITH CONFIRMED ACS

Very High Risk

- Haemodynamic instability:
  - Heart failure/ cardiogenic shock
  - Mechanical complications of myocardial infarction
- Life-threatening arrhythmias or cardiac arrest
- Recurrent or ongoing ischaemia (e.g. chest pain refractory to medical treatment) or recurrent dynamic ST segment and/or T wave changes, particularly with:
  - Intermittent ST segment elevation
  - de Winter T wave changes
  - Wellens syndrome (or LMCA syndrome)
  - Widespread ST elevation in two or more coronary territories

High Risk

- Rise and/or fall in troponin level consistent with myocardial infarction
- Dynamic episode of ST segment and/or T wave changes with or without symptoms
- GRACE score >140

Intermediate Risk

- Diabetes mellitus
- Renal insufficiency (glomerular filtration rate < 60mL/min/1.73m2)
- Left ventricular ejection fraction ≤ 40 %
- Prior revascularization:
  - Percutaneous coronary intervention
  - Coronary artery bypass grafting
- GRACE score >109 and <140

Low Risk

- Patients with NSTEACS who have both of:
  - no recurrent symptoms
  - no risk criteria (as listed above)

- Recommended intervention times vary according to the level of risk:
  - Very High Risk NSTEACS: within 2h
  - High Risk NSTEACS: within 24h
  - Intermediate Risk NSTEACS: within 72h
  - Low Risk NSTEACS (no recurrent symptoms and no risk criteria): selective invasive strategy guided by provocative testing for inducible ischaemia


thank you