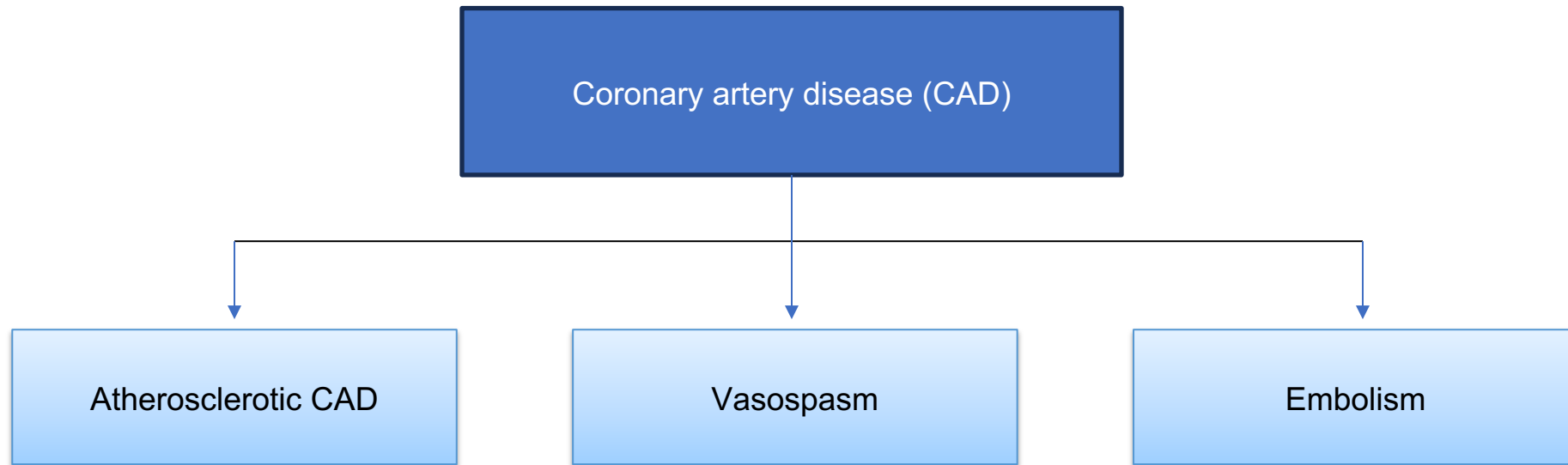


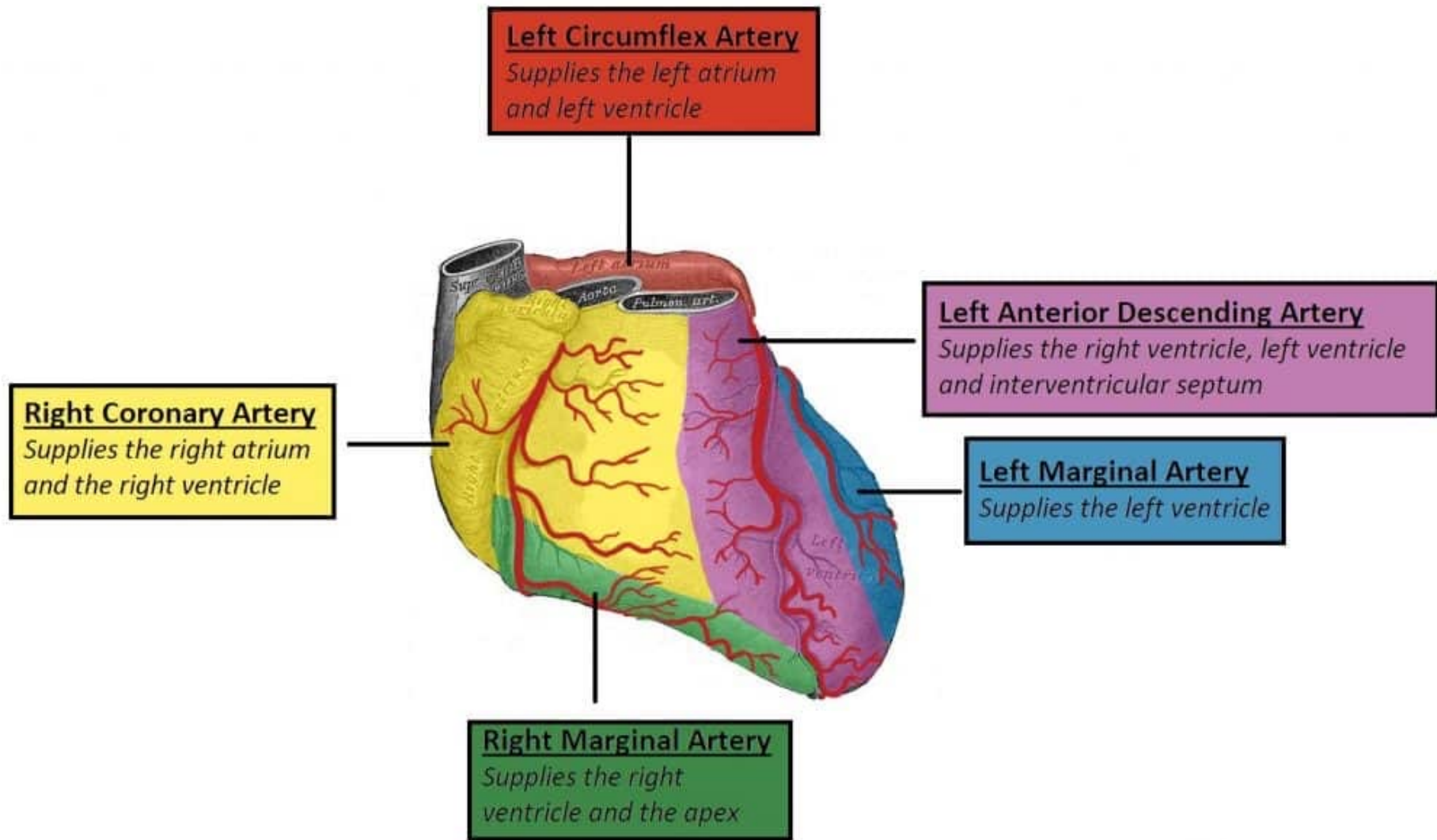
Cardiac pathophysiology

Coronary artery disease

By StudyAid Presenter
Lars Tande

CAD





Oxygen supply-demand mismatch

↓ Oxygen supply

Atherosclerosis

- Plaque rupture
- Thrombosis
- Stenosis

Vasospasm (stenosis)

↑ **HR** (inefficient)

Anemia (lowered oxygen carrying capacity)

↑ Oxygen demand

↑ **HR** (increased work of heart muscle)

Anemia (increased work of heart muscle)

↑ **Afterload** (working against resistance, increased work of heart muscle)

Atherogenesis

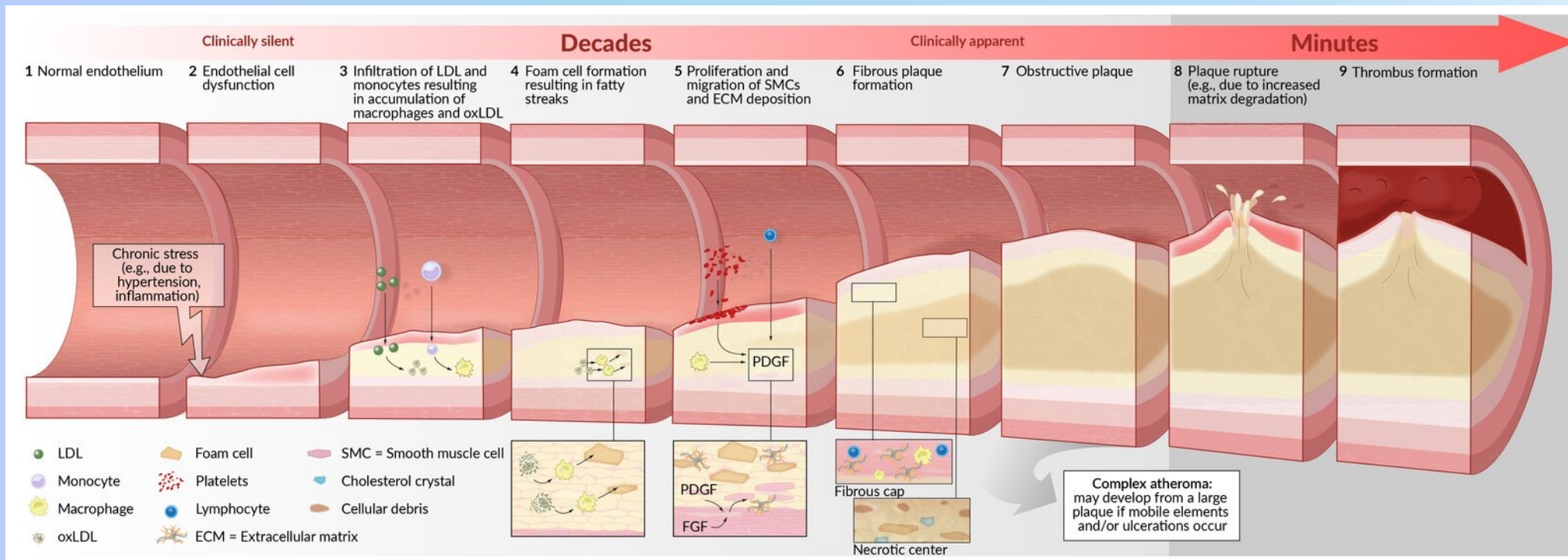
1. Stressed endothelium leads to endothelial dysfunction
 - Inflammation, monocytes and lymphocytes migration
 - Platelet adhesion -> PDGF and cytokines
 - PDGF stimulates smooth muscle cells (SMCs) in tunica intima -> fibroblasts -> myofibroblasts
2. Inflammation
 - Monocytes ingest cholesterol from oxidized LDL -> foam cell
 - Many foam cells: **fatty streak** (early lesion)
3. Macrophages and SMCs produce ECM
 - Fibrous cap formed on top of the atheroma
4. Inflammatory cells weaken the fibrous cap!
 - Secretion of matrix metalloproteinases weakens the fibrous cap
5. Calcification
6. **Plaque rupture**
 - Exposure of thrombogenic material (collagen)
 - Formation of thrombus -> MI

Atherosclerosis

1. Abdominal aorta (peripheral artery disease, AAA, embolism)
2. Coronary arteries (CAD)
3. Popliteal arteries (peripheral artery disease)
4. Carotid bifurcation/ICA (cerebral ischemia/stroke)
5. Circle of Willis (cerebral ischemia/stroke, aneurysm, dementia)
6. Renal arteries (prerenal CKD, renovascular hypertension)

Coronary artery disease

Most commonly due to atherosclerosis leading to stenosis of coronary vessels -> oxygen supply-demand mismatch



Risk factors for CAD development

Modifiable

Smoking 
Hypertension 
Hyperlipidemia 
Diabetes  
Obesity 
Physical inactivity 

Non-modifiable

Increasing age  
Male sex 
Family history 
Genetic abnormalities 

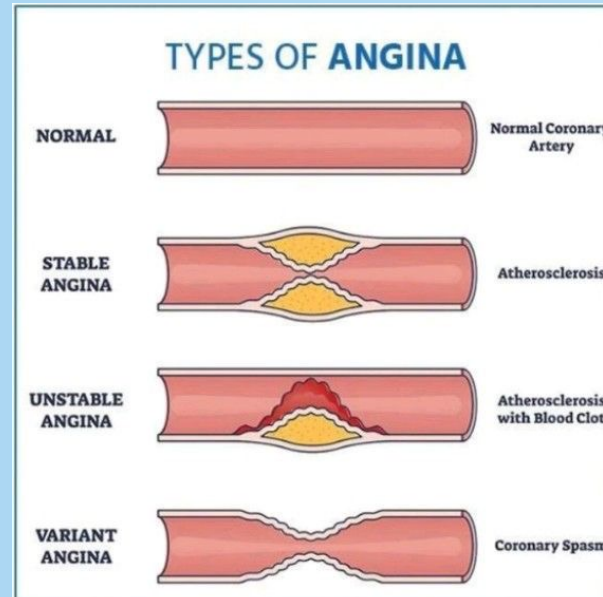
Stable angina vs acute coronary syndrome (ACS)

Stable angina

Slow buildup of atheroma

Causing gradual worsening of dyspnea and chest pain **with exertion**

Pain free at rest



ACS

Unstable angina (UA)

NSTEMI

STEMI

Common for all of them is that there is chest pain **at rest**

Three criteria:

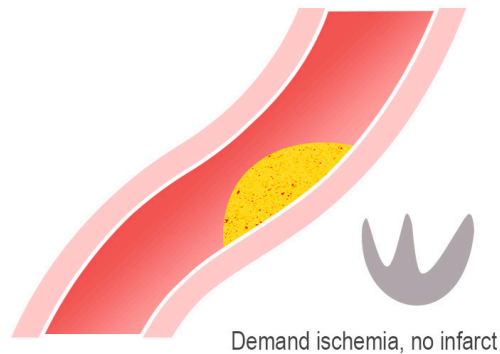
- **Symptoms** (retrosternal chest pain, radiating to arm, jaw, neck, at rest, dyspnea, nausea, diaphoresis, syncope)
- **ECG changes** (deviations)
- **Cardiac biomarkers** (dynamics of troponins)

You don't need all criteria, but the more positive criteria the stronger the suspicion

ACUTE CORONARY SYNDROME

1 STABLE ANGINA

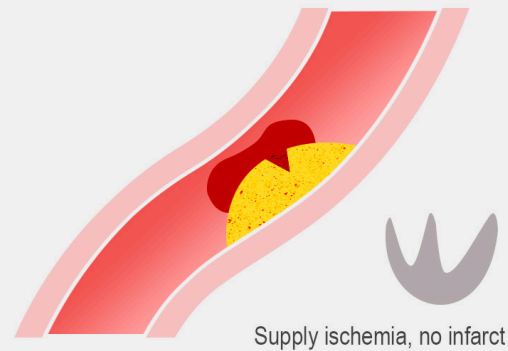
Angina pain develops when there is increased demand in the setting of a stable atherosclerotic plaque. The vessel is unable to dilate enough to allow adequate blood flow to meet the myocardial demand.



Normal

2 UNSTABLE ANGINA

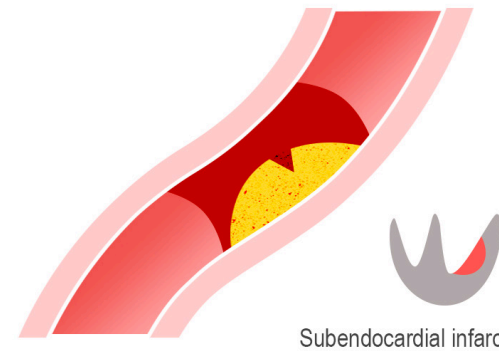
The plaque ruptures and a thrombus forms around the ruptured plaque, causing partial occlusion of the vessel. Angina pain occurs at rest or progresses rapidly over a short period of time.



Normal

3 NSTEMI

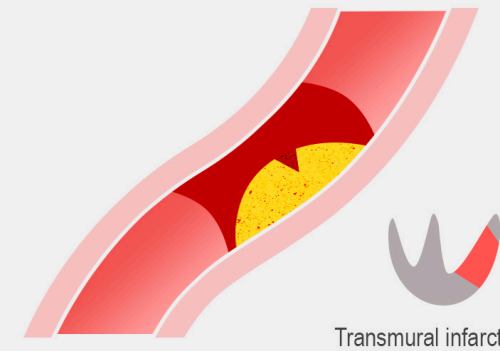
During an NSTEMI, the plaque rupture and thrombus formation causes partial occlusion to the vessel that results in injury and infarct to the subendocardial myocardium.



Elevated

4 STEMI

A STEMI is characterized by complete occlusion of the blood vessel lumen, resulting in transmural injury and infarct to the myocardium, which is reflected by ECG changes and a rise in troponins.



Elevated

ECG

TROPONINS

This infographic was created by Paula Sneath and Leah Zhao for the Sirens to Scrubs series of CanadiEM.org.

- <https://www.grepmed.com/images/3707/diagnosis-angina-nstemi-definitions-acs>

Clinical picture of stable angina pectoris

- Significant obstruction is usually $\geq 70\%$ of a major epicardial vessel or $\geq 50\%$ of the left main coronary artery
- Atheroma develops over many years, causing gradual constriction
- Gradual, slow worsening of stenosis
- Relief by rest
- Relief by nitroglycerin



Clinical picture of ACS

Symptoms

Typical:

- Retrosternal pain - radiating to left jaw and/or arm
 - Worsened by exertion
 - No improvement after nitroglycerin

Atypical: (women, elderly, diabetic patients)

- Dyspnea
- Fatigue
- Nausea

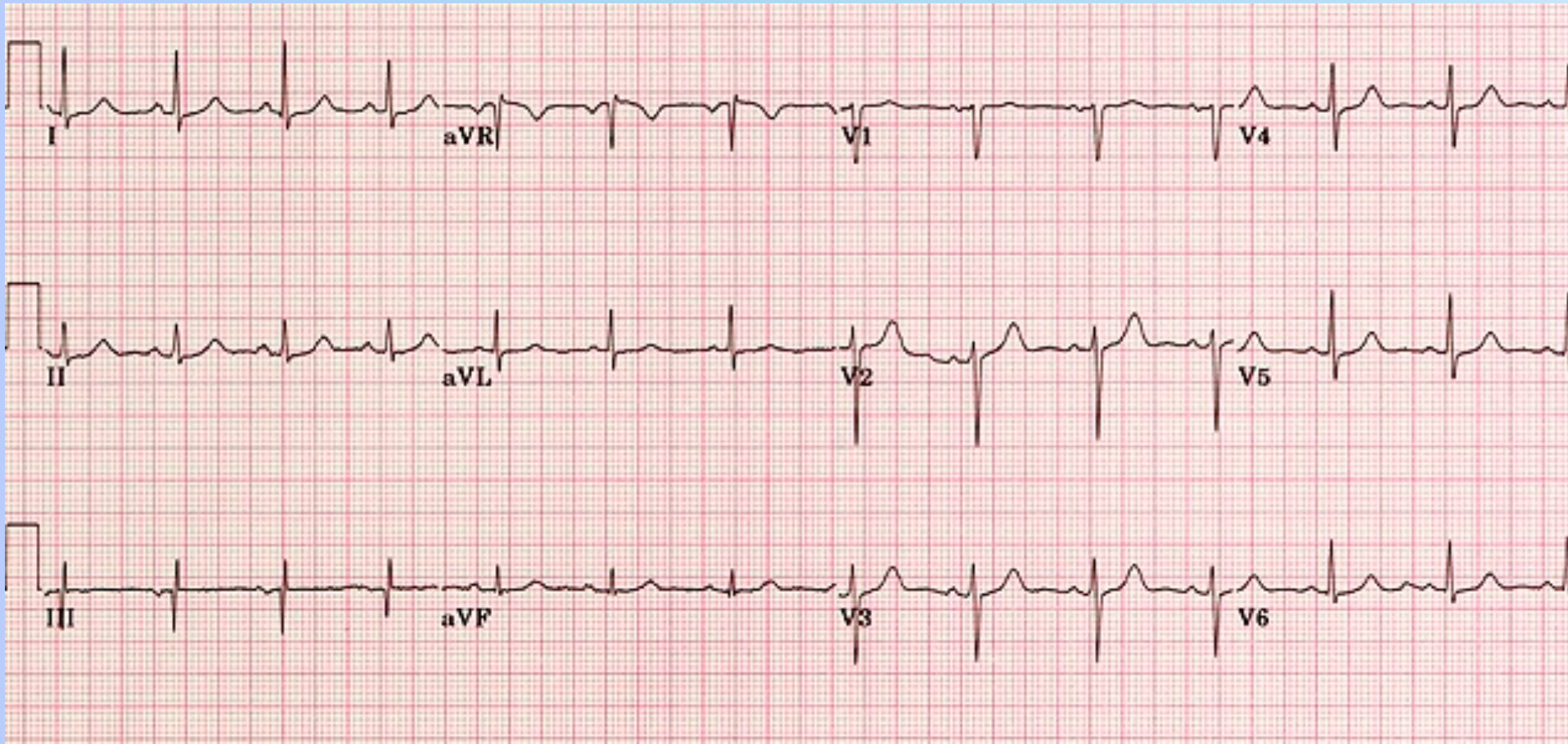
Silent

- No symptoms, but signs (detectable on ECG or cardiac markers)

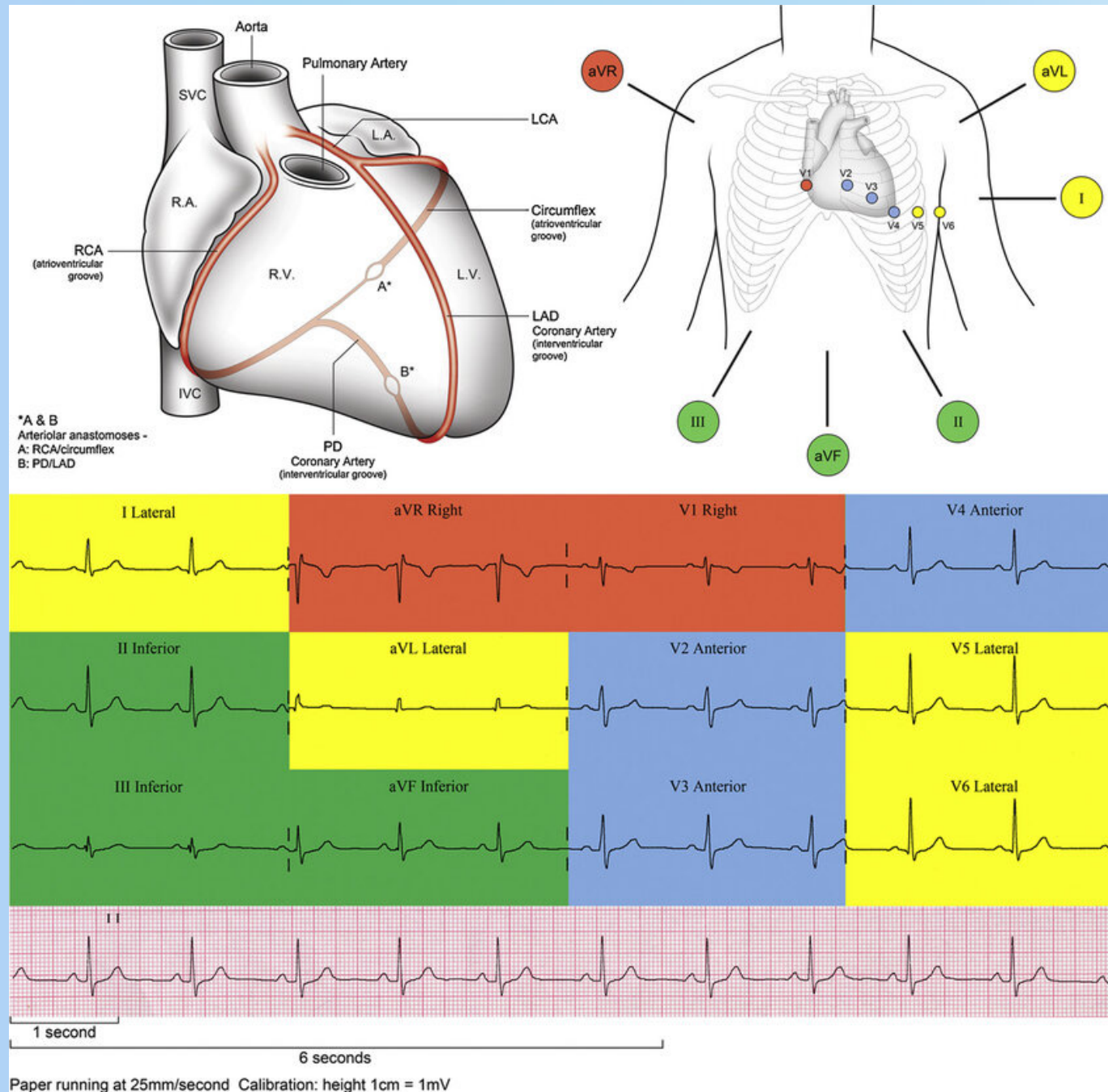


	NSTEMI	STEMI
PATHOPHYSIOLOGY	- Classically due to partial occlusion of a coronary artery - Affects the inner layer of the heart (subendocardial infarction)	- Classically due to complete occlusion of a coronary artery - Affects the full thickness of the myocardium (transmural infarction)
ECG	No ST-elevation It can be normal, or nonpecific (ST depression, loss of R waves or T wave inversion)	ST elevation In 2 contiguous leads
BIOMARKERS	Elevated within 1-6 hours	Elevated within 1-6 hours
TREATMENT	- Anticoagulants - Statins - Beta blockers - ACEIs - Pain management	- Immediate revascularization - Fibrinolytic therapy

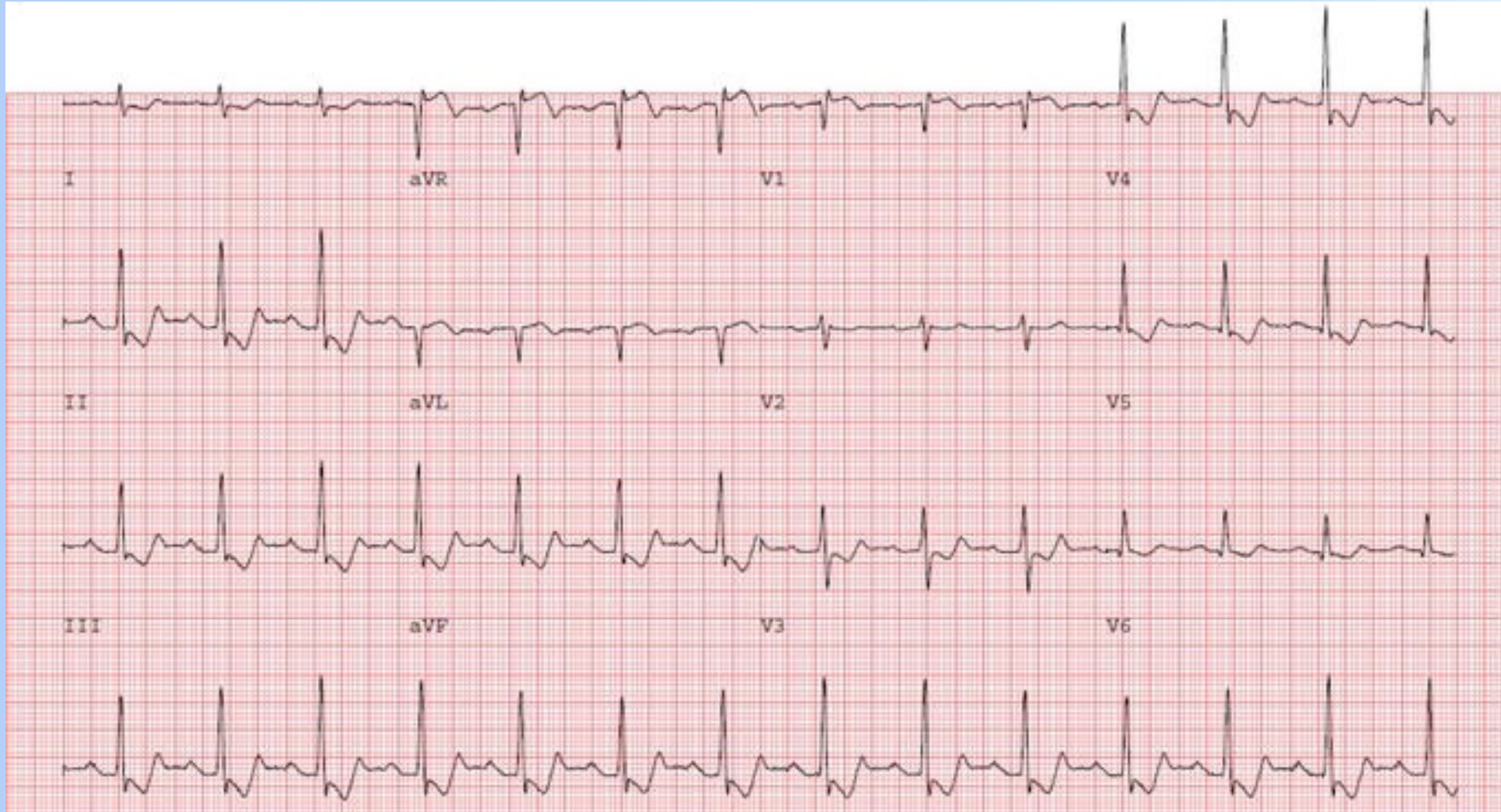
A quick ECG crash course



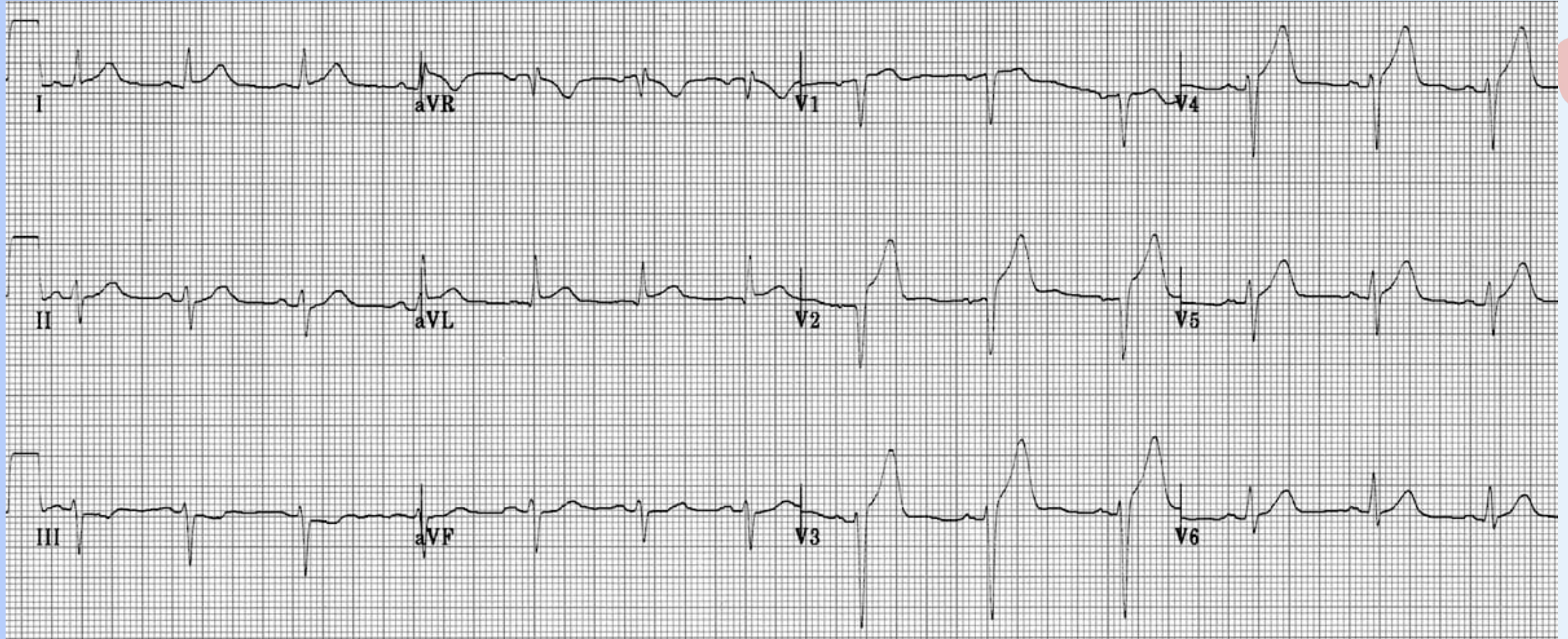
1. Rate
2. Rhythm
3. P-wave morphology
4. Axis
(normal, LAD, RAD, extreme deviation)
5. PR-interval
(≤ 220 ms or it is a block)
6. QRS-complex
(time, amplitude, R-progression, Q-waves)
7. QTc-time (≤ 460 ms)
8. ST-segment
(elevation, horizontal or downsloping depression)
9. T-wave (inversion, U-wave)
10. Comparison

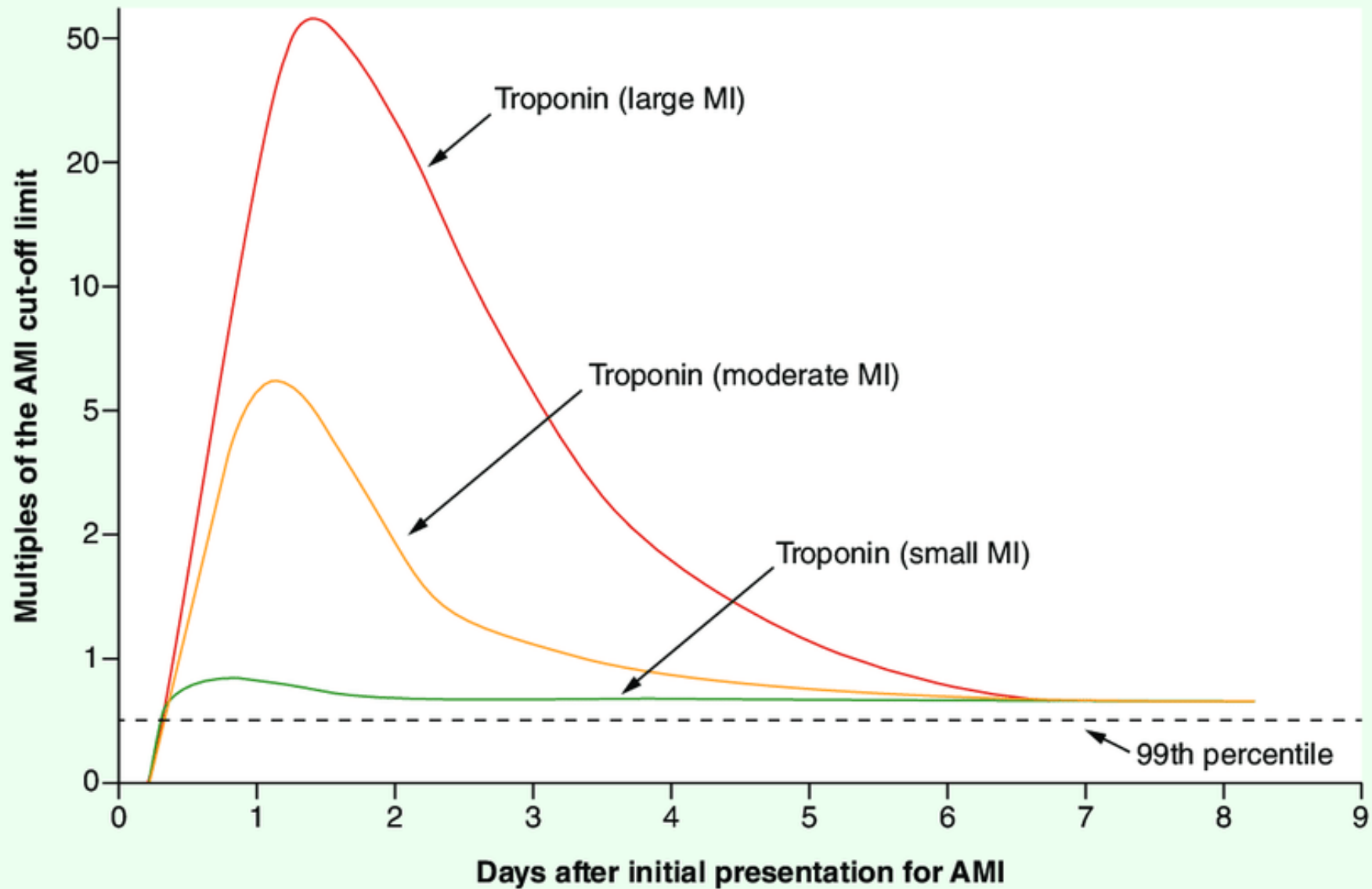


Ischemia on ECG



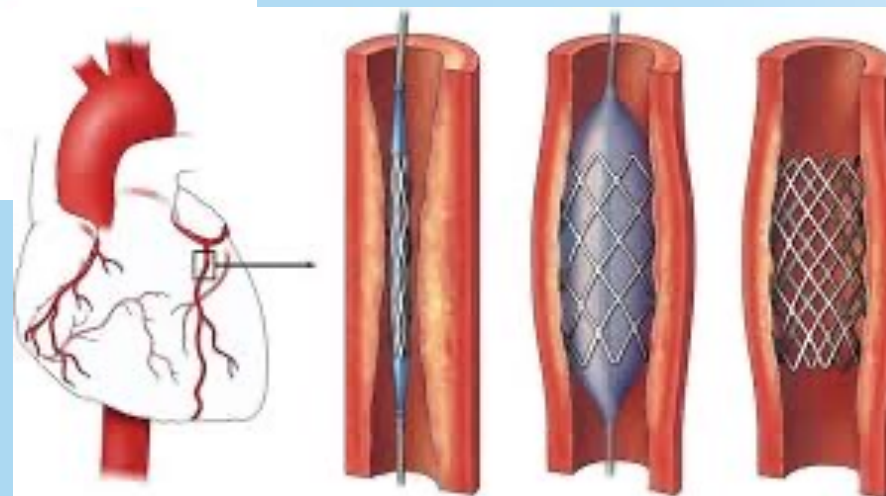
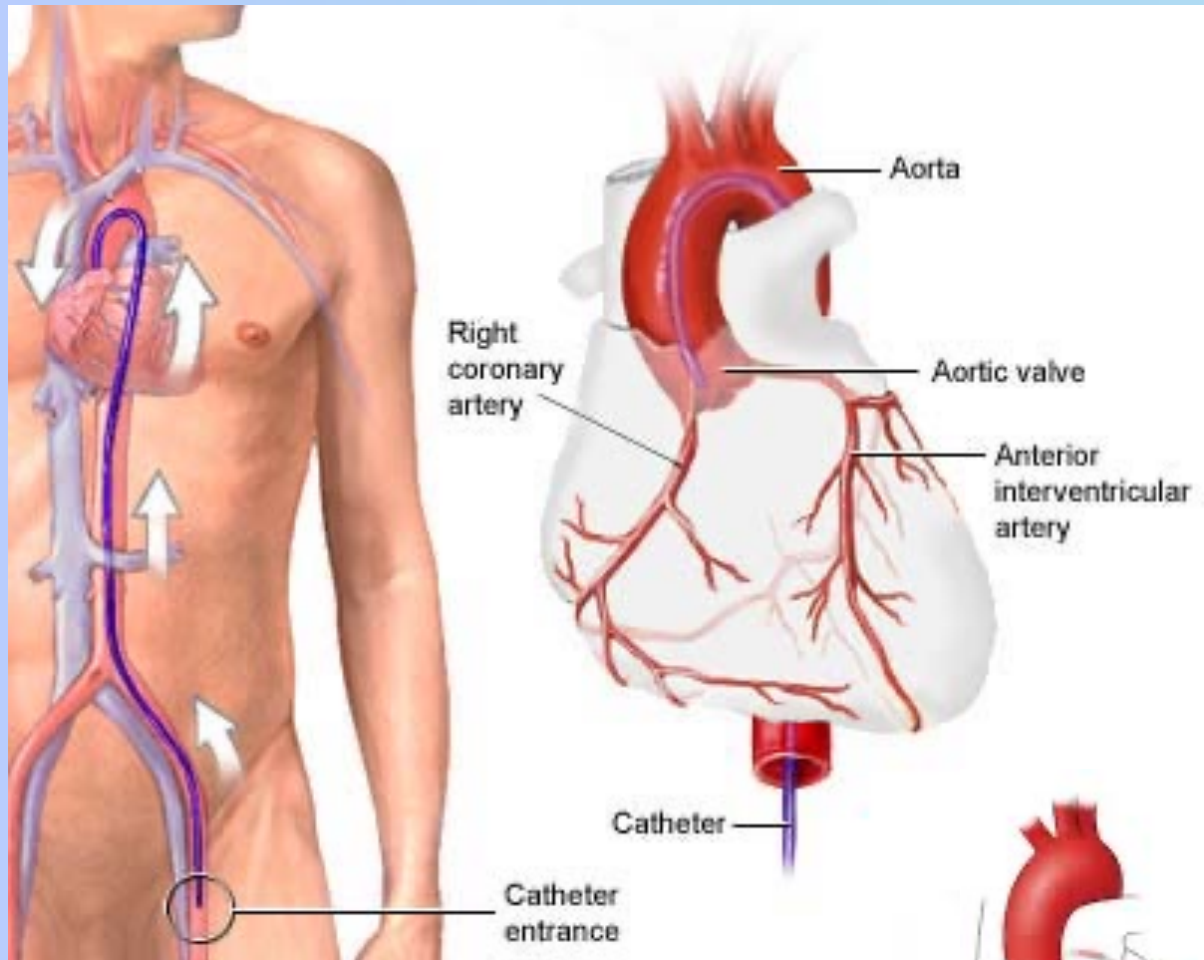
Ischemia on ECG





Treatment

- Stable angina: 🕒
 - Nitrates
 - Prophylaxis (aspirin, statins, BB, CCB)
 - Lifestyle changes
 - Sometimes CABG/PCI
- ACS: 🚑
 - Unstable angina
 - Anticoagulation
 - Anti-ischemic drugs (nitrates, BB)
 - DAPT (aspirin + P2Y₁₂-inhibitor)
 - Statins
 - NSTEMI
 - Coronary angiography (PCI or CABG if indicated)
 - Anticoagulation
 - Anti-ischemic drugs (nitrates, BB)
 - DAPT (aspirin + P2Y₁₂-inhibitor)
 - Statins
 - STEMI
 - Immediate reperfusion
 - PCI if it can be performed within 120 mins from first medical contact
 - Otherwise, thrombolysis (preferably <30 mins from first medical contact)
 - Anticoagulation
 - Anti-ischemic drugs (nitrates, BB)
 - DAPT (aspirin + P2Y₁₂-inhibitor)
 - Statins

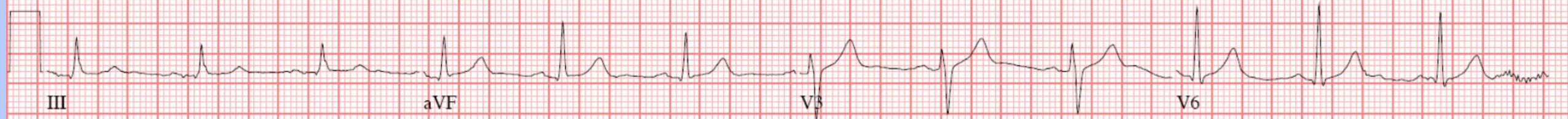
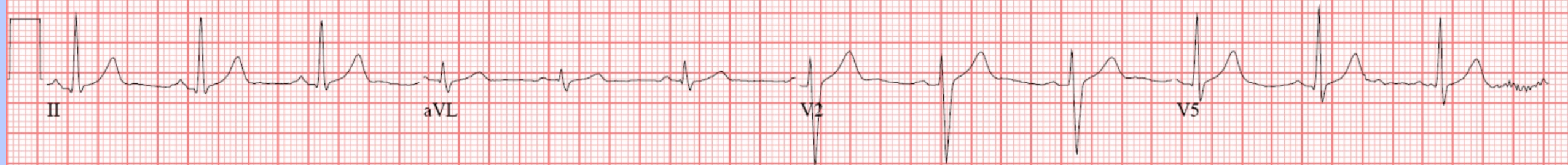
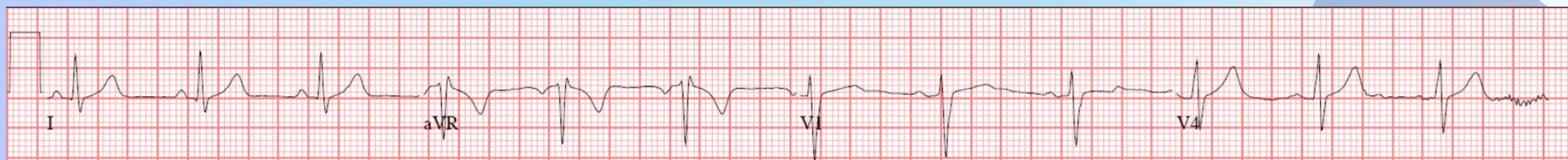


CASES

John, 58M

- Works as a truck driver
- Smoked since 15 y.o., 1 pack a day (43 pack-years)
- Hypertension, treated with ramipril
- DM2, treated with metformin
- Has had episodic chest pain for the past 4 weeks
- Today went to his GP because of pain, who referred him to the hospital for examination
- Received nitroglycerin by ambulance personell, with good effect





Anamnesis, labs, exam

- Anamnesis:

- Retrosternal pressing chest pain that occurs especially during heavy lifting sessions at work
- Some dyspnea, but not always
- Relief after rest
- Never tried nitroglycerin before

- Labs:

- Troponin-I on admission: 4 [<34 ng/L)
- After 1 hour: 5
- After 4 hours: 4

- Physical exam:

- Heart: normal heart sounds, normal rate, normal CRT
- Lungs: vesicular sounds
- Abdomen: no edema or pain on palpation
- Extremities: no edema

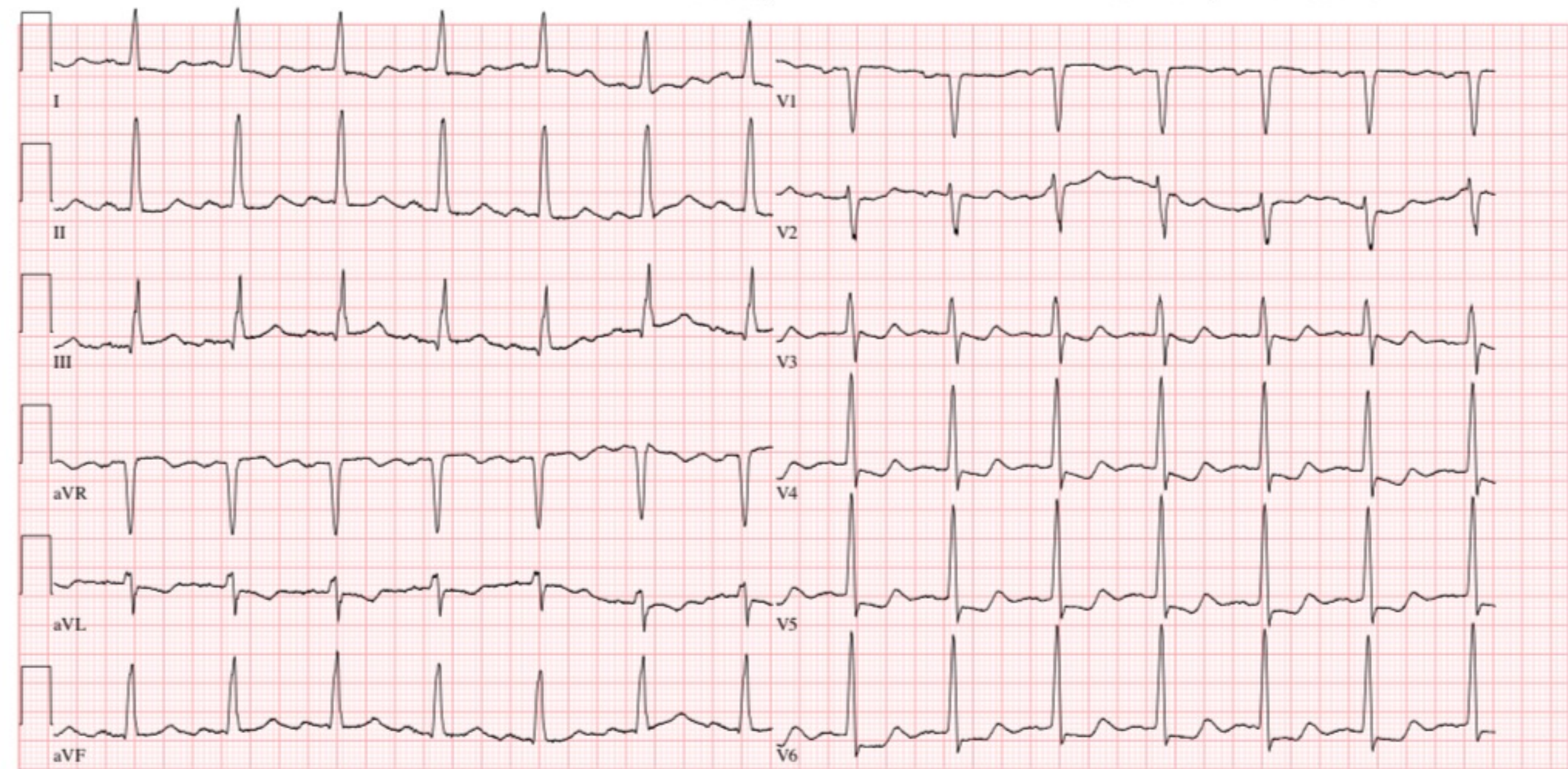
Conclusion

- He has symptoms of stenocardia (AP)
- He has had chest pain, but no ECG changes or cardiac biomarkers
- He feels relief by rest and when taking nitroglycerin
- Stable angina pectoris
- Next steps?
 - Managing risk factors
 - Diabetes, hypertension, smoking, physical inactivity, lipid status
 - Managing symptoms
 - Nitrates (short-acting, long-acting)

Jane, 74F

- Retired doctor, widow
- Smoked 5 years in her youth, quit at 25
- No significant medical history
- Today had sudden onset of pressing retrosternal chest pain while at a café, VAS 8
- Received nitroglycerin by ambulance personell, no effect
- Received fentanyl 150 mcg i.v. with good effect, VAS 8 -> 3





Anamnesis, labs, exam

- Anamnesis:

- Retrosternal pressing chest pain that started 20 minutes ago while sitting still
- No relief from nitrates
- Mother died of heart attack at 68, sister had MI at 64

- Labs:

- Troponin-I on admission: 157 ng/L [<17)
- After 2 hours: 431 ng/L

- Physical exam:

- Skin: sweaty
- Heart: normal heart sounds, slight tachycardia, normal CRT. Pressing chest pain that radiates to the left arm.
- Lungs: slight crackles at the base bilaterally, tachypnoea, moderate dyspnoea
- Abdomen: no edema, discomfort in the epigastrium
- Extremities: slight edema at the ankles

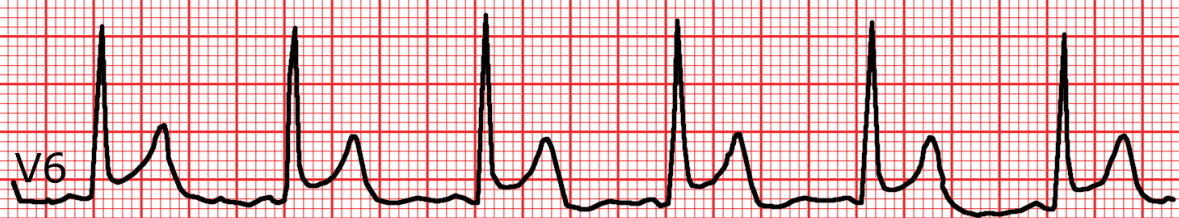
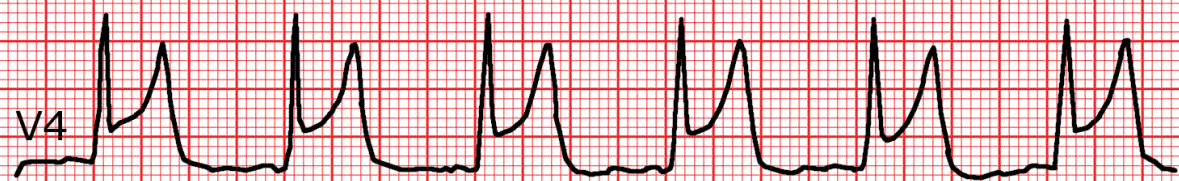
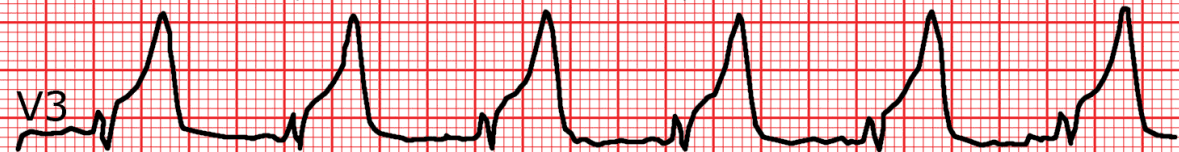
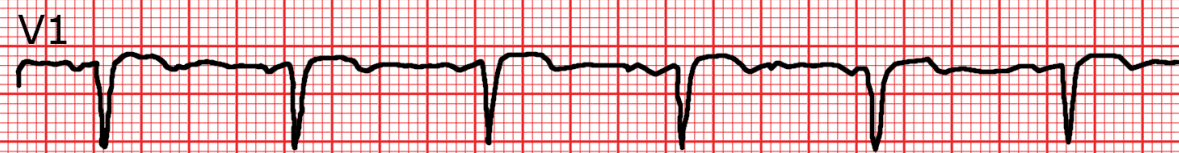
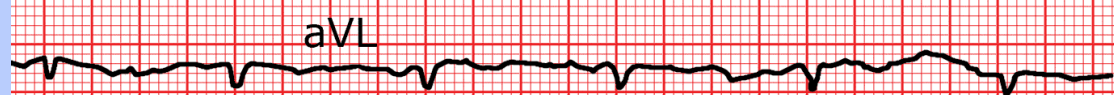
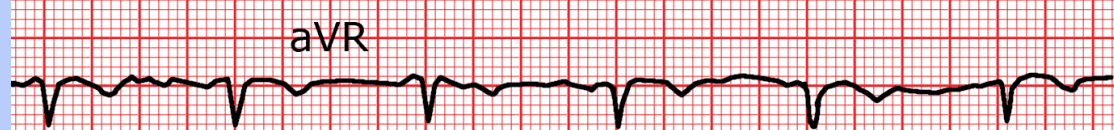
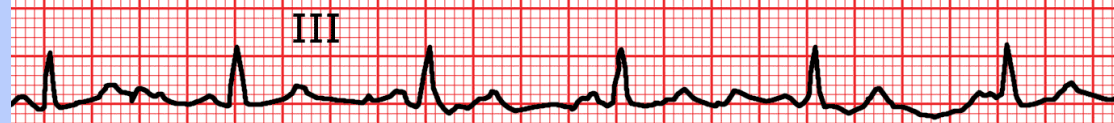
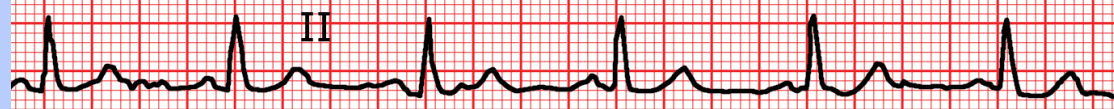
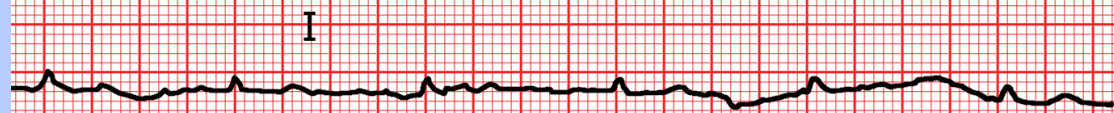
Conclusion

- She has symptoms of ACS
- She has ongoing chest pain, ECG changes with ST-depressions and cardiac biomarkers
- She feels no relief from nitrates
- NSTEMI
- Next steps?
 - DAPT (aspirin 300 mg + P2Y₁₂-inhibitor)
 - Anticoagulation (UFH or LMWH given s.c. to prevent further clot formation)
 - Continuous ECG (cardiac telemetry)
 - Consider coronary angiography
 - Anti-ischemic therapy: nitrates, BB, oxygen
 - Statins, antihypertensive drugs

Jerry, 84M

- Retired plumber, married
- Never-smoker, never-drinker
- Several first-degree family members with CAD
- Woke up at 4 a.m. because of pressing retrosternal chest pain, VAS 10, radiating to his jaw, back, left arm and epigastrium
- Pain was not relieved by nitroglycerin
- Waited 2 hours until he called emergency services
- Was given fentanyl 150 mcg with moderate effect





Anamnesis, labs, exam

- Anamnesis:

- Retrosternal pressing chest pain that started 2 hours ago while sleeping, accompanying dyspnea
- No relief from nitrates

- Labs:

- Troponin-I on admission: 1451 ng/L [<17)
- After 1 hour: 2450 ng/L

- Physical exam:

- Skin: sweaty, pale
- Heart: Pressing retrosternal chest pain that radiates to the jaw, back, left arm, epigastrium. Prolonged CRT 3-4 seconds, tachycardia rate 120, holosystolic murmur best heard at the cardiac apex
- Lungs: crackles at the base bilaterally, tachypnoe, moderate dyspnea
- Abdomen: no edema, pain in the epigastrium
- Extremities: edematous at the ankles
- POCUS: hypokinesia of anterior wall

Conclusion

- She has symptoms of ACS
 - She has ongoing chest pain, ECG changes with ST-elevations and cardiac biomarkers
 - She feels no relief from nitrates
 - STEMI
 - Next steps?
 - Aspirin 300 mg loading dose always
 - Consider P2Y₁₂-inhibitor
 - Closest PCI-lab <120 minutes away -> Urgent coronary angiography and PCI
 - Closest PCI-lab >120 minutes away -> Fibrinolysis ASAP (within 30 mins of contact with emergency services if possible)
- Later on:
- Anti-ischemic therapy: nitrates, BB, oxygen
 - Statins, antihypertensive drugs

larsgulbrandsen.qa@gmail.com