

EKG's and ST Changes That Can Kill You

José A. Rubero, MD, FACEP, FAAEM
Associate Program Director
University of Central Florida/HCA GME Consortium
Emergency Medicine Residency Program




Disclosure

- I have no actual or potential conflict of interest in relation to this program/presentation.
- I have no relevant financial or nonfinancial relationships in the products or services described, reviewed, evaluated or compared in this presentation.
- I do not endorse specifically any test, treatment, or procedure mentioned on this presentation.

Objectives

- Recognize some different types of EKG and ST changes that can kill you
- Recognize what are the atypical EKG presentations in patients with acute myocardial infarction
- Recognize conditions that have EKG's changes that mimics acute myocardial infarction

Typical ST morphology

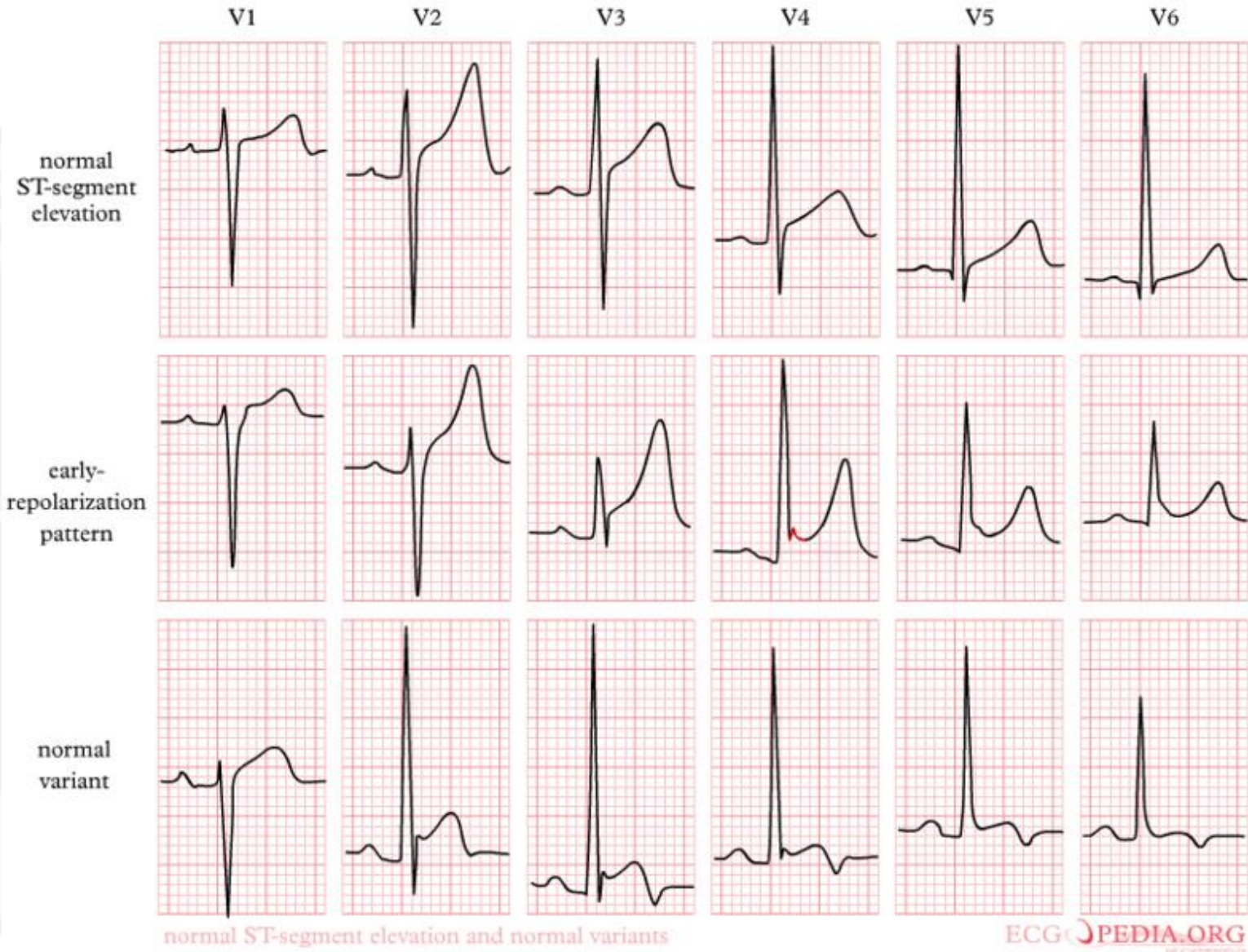
- AMI
 - Convex or straight ST elevation (“frowny face”)
- Benign early repolarization 
 - Concave ST elevation (“smiley face”)
- Pericarditis 
 - Concave ST elevation (“smiley face”) and often associated with PR depression
- BBB 
 - Concave ST elevation (“smiley face”) with discordant QRS complex, usually < 5 mm elevation
- LV aneurysm
 - Usually of V1-V2 and is unchanged if compared to prior EKG’s. Usually has evidence of prior anterior infarction (poor R wave progression and Q waves)

Typical ST morphology

- AMI : convex or straight ST elevation (“frowny face”)
- Benign early repolarization: concave ST elevation (“smiley face”)
- Pericarditis: concave ST elevation (“smiley face”) and often associated with PR depression
- BBB: concave ST elevation (“smiley face”) with discordant QRS complex, usually < 5 mm elevation
- LV aneurysm --> Usually of V1-V2 and is unchanged if compared to prior EKG’s. Usually has evidence of prior anterior infarction (poor R wave progression and Q waves)

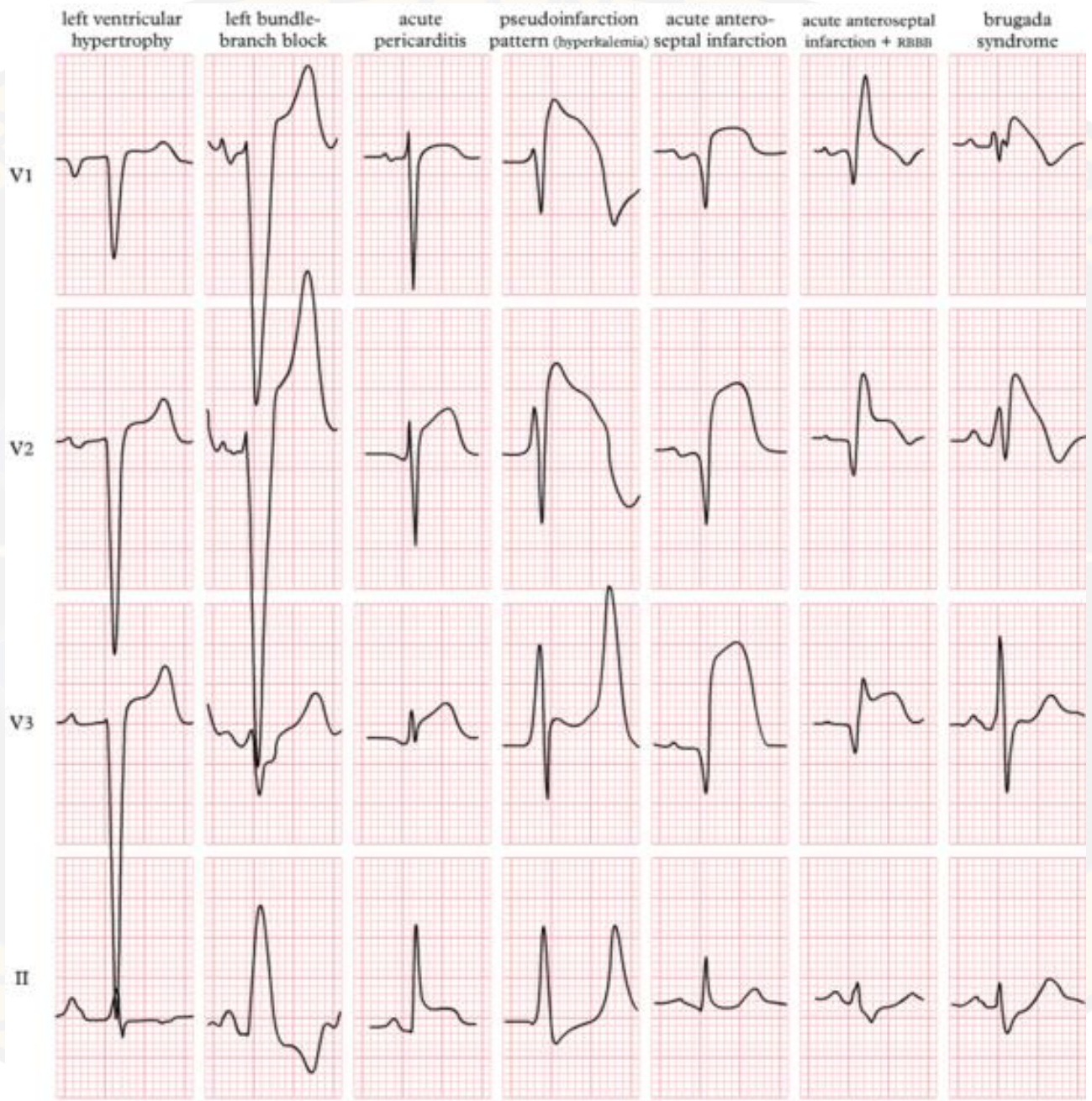
EKG's and ST Changes That Can Kill You

- Early repolarization (well, not really!)
- LVH
- AMI
- RV AMI
- Inverted T-wave in avL
- T wave in v1
- Pericarditis that is not
 - ST elevation in avR
 - Wellen's
 - de Winter
 - Torsades
 - LBBB
 - Pericarditis
 - Brugada's
 - HCM
 - LV aneurysm
 - New RAD
 - Prolonged QTc
 - Pericardial Tamponade
 - PE
 - Slow Vtaq
 - AIVR
 - WPW
 - Hyperkalemia
 - Hypothermia
 - CNS disorders
 - Takotsubo Syndrome
 - Spiked-Helmet Sign



normal ST-segment elevation and normal variants

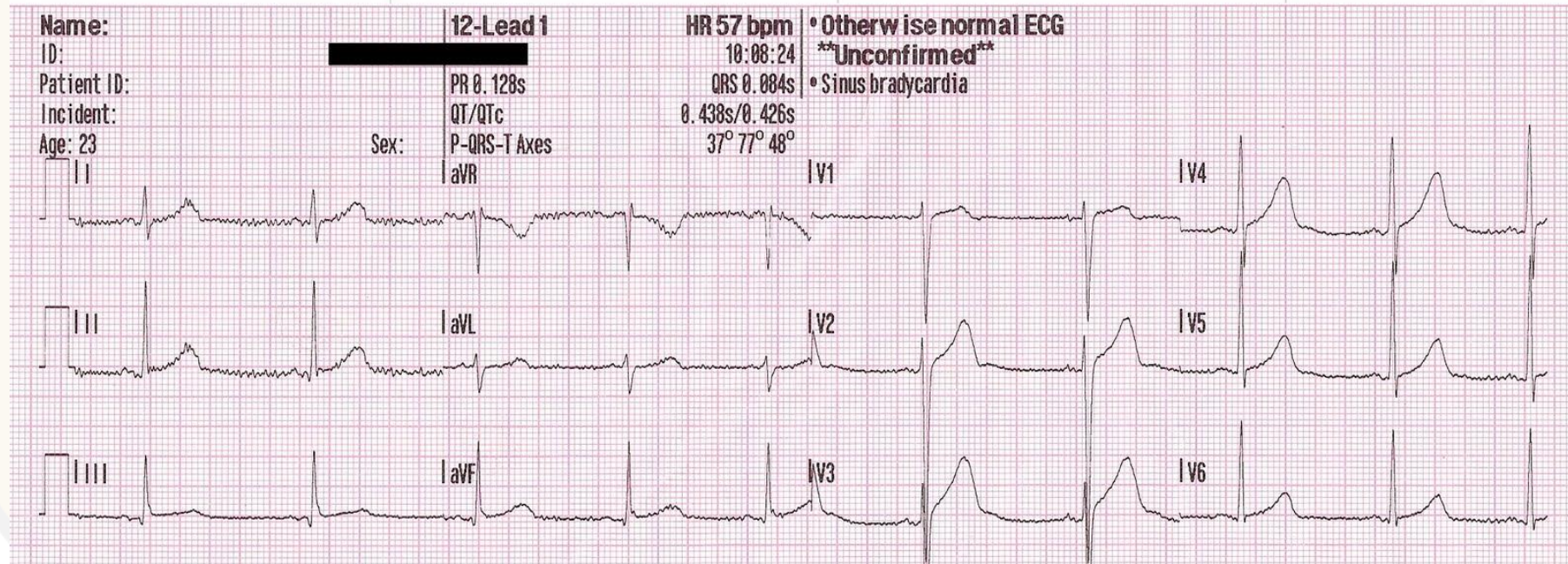
ECG PEDIA.ORG



ST-segment elevation in various conditions

ECG PEDIA.ORG

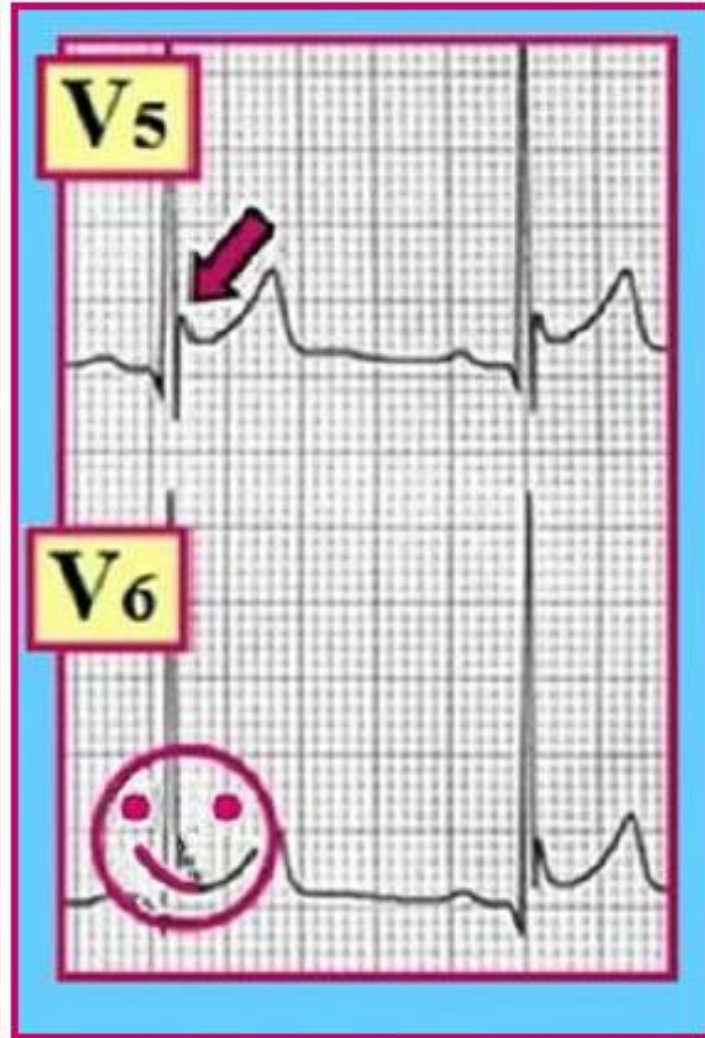
Early Repolarization

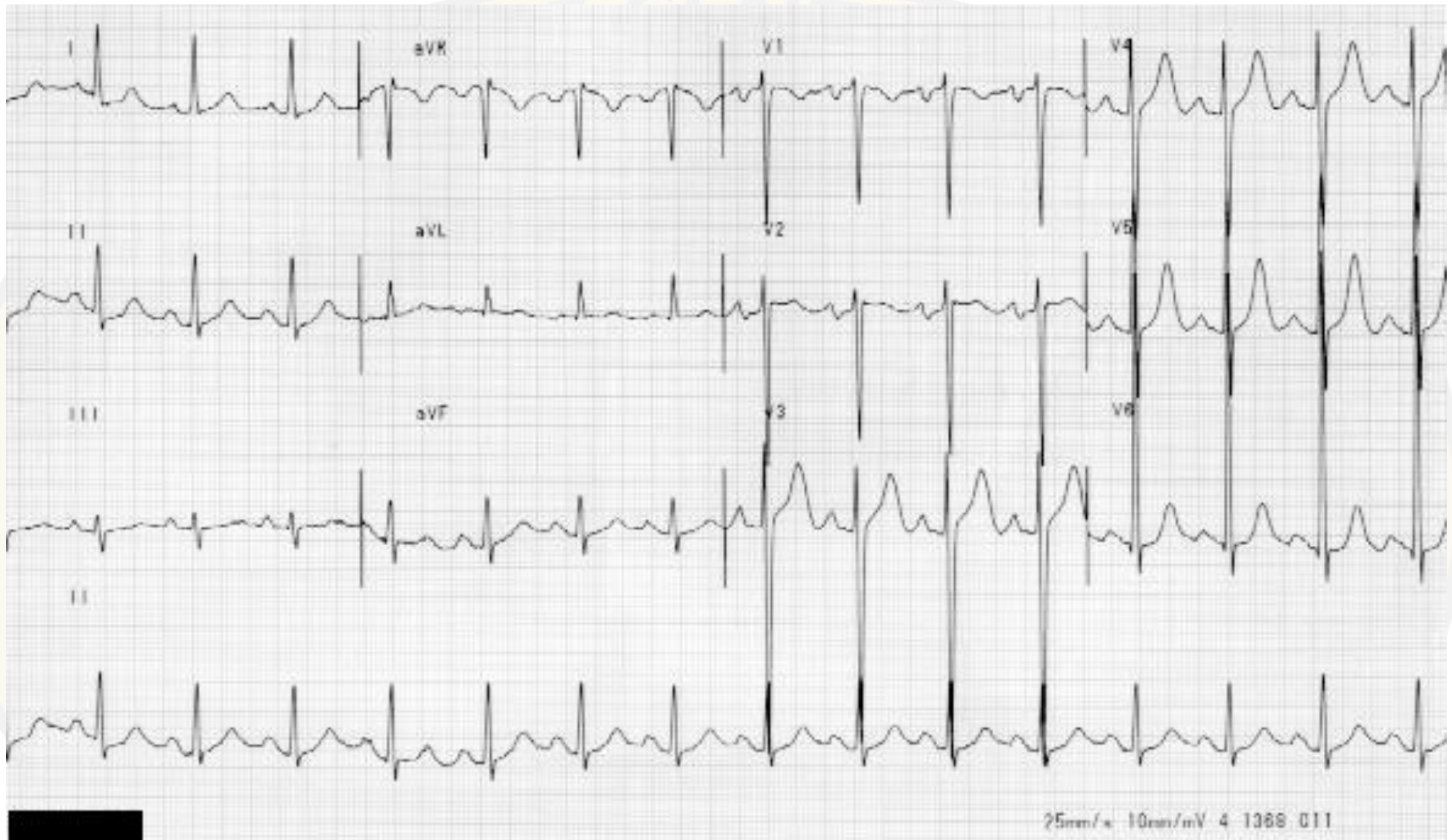


EKG's and ST Changes That Can Kill You

- Early repolarization (well, not really!)
- LVH
- AMI
- RV AMI
- Inverted T-wave in avL
- T wave in v1
- Pericarditis that is not
 - ST elevation in avR
 - Wellen's
 - de Winter
 - Torsades
 - LBBB
 - Pericarditis
 - Brugada's
 - HCM
 - LV aneurysm
 - New RAD
 - Prolonged QTc
 - Pericardial Tamponade
 - PE
 - Slow Vtaq
 - AIVR
 - WPW
 - Hyperkalemia
 - Hypothermia
 - CNS disorders
 - Takotsubo Syndrome
 - Spiked-Helmet Sign

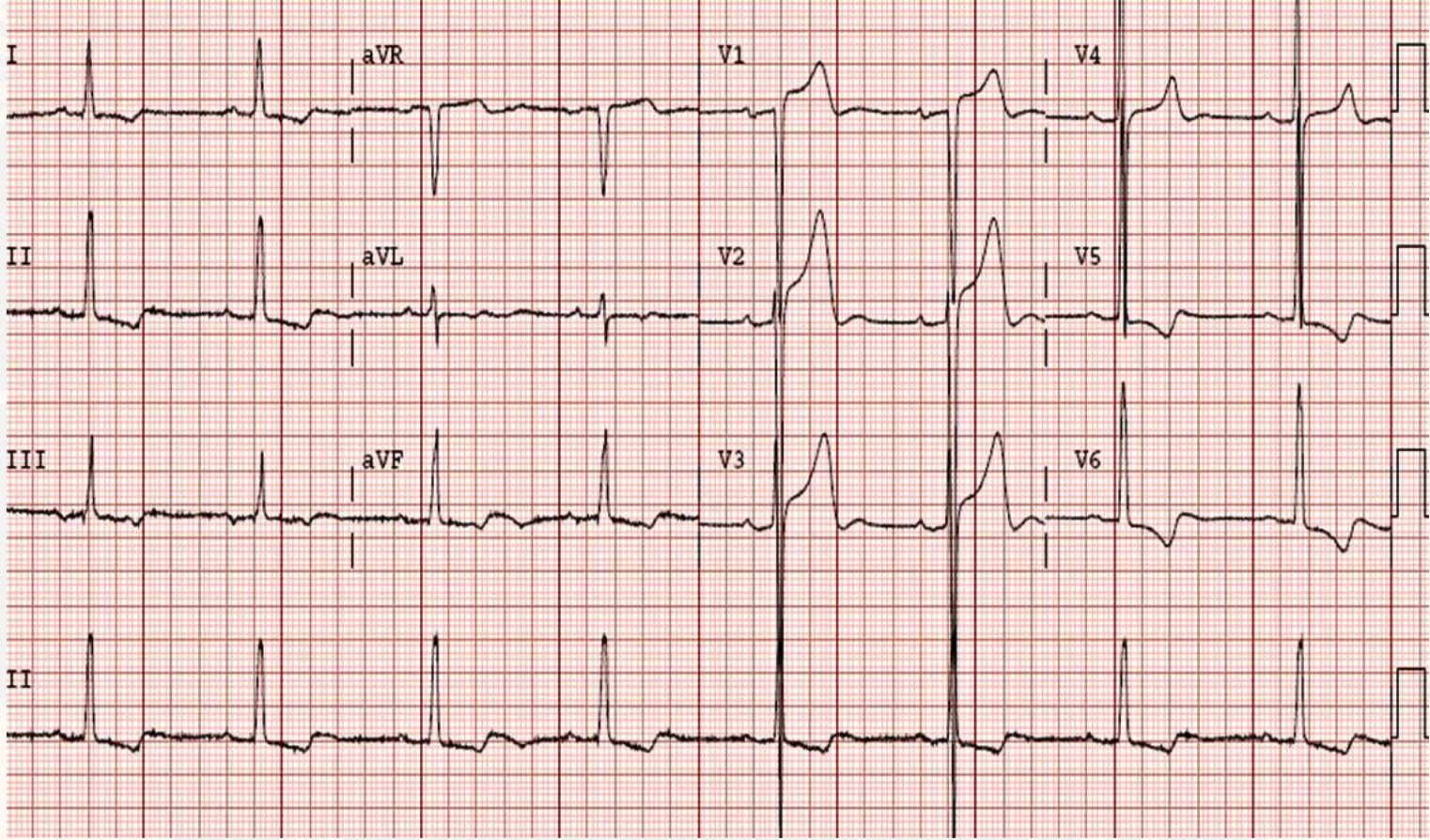
Early Repolarization





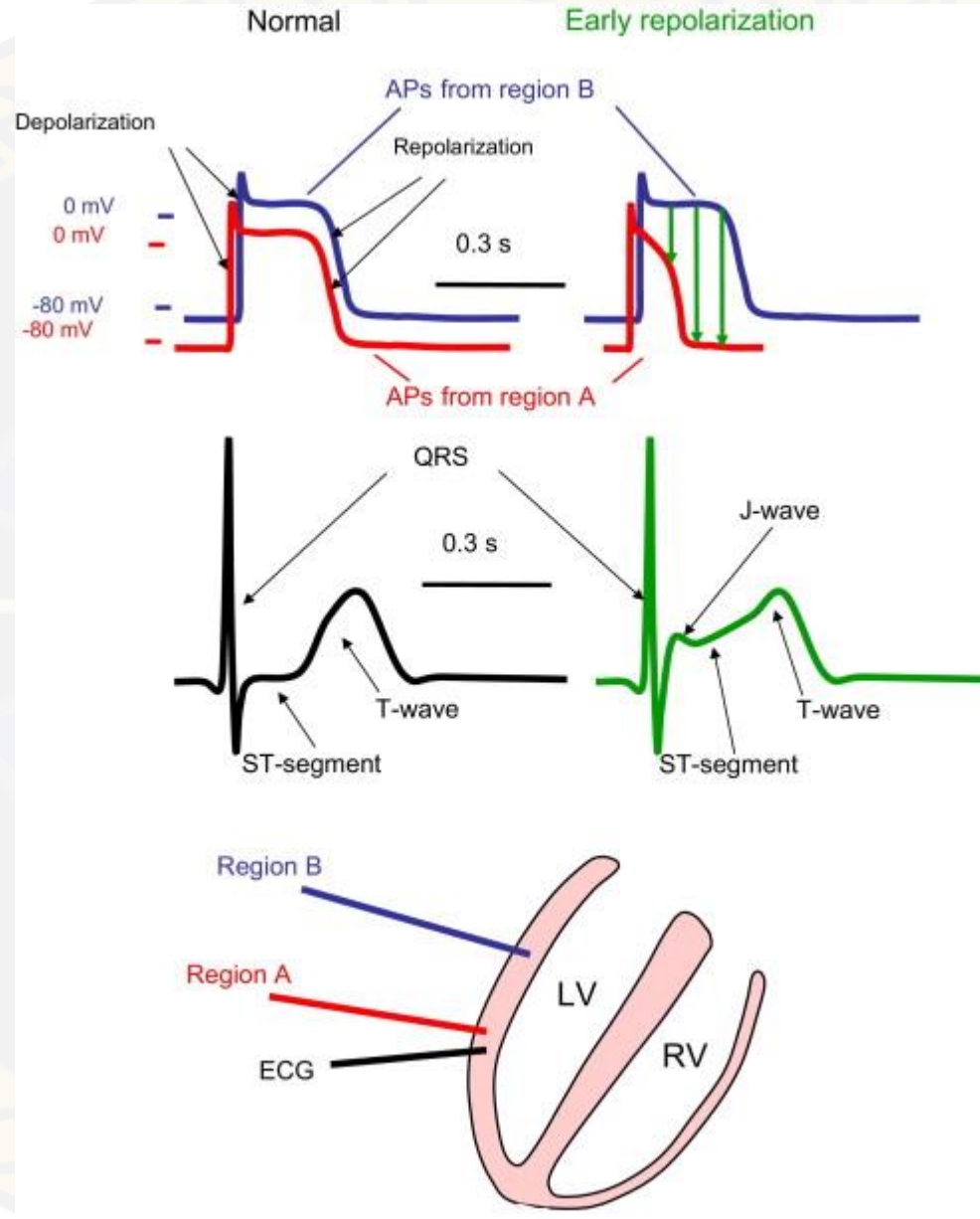
Early repolarization

LVH

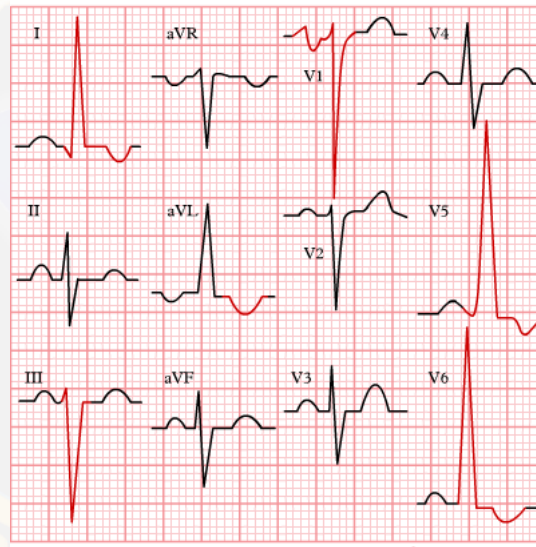
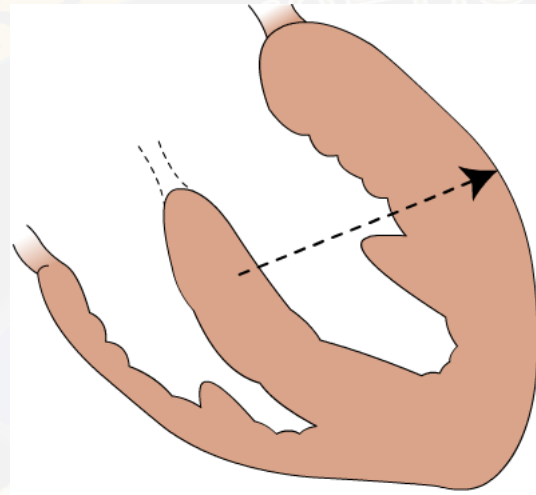


EKG's and ST Changes That Can Kill You

- Early repolarization (well, not really!)
- **LVH**
- AMI
- RV AMI
- Inverted T-wave in avL
- T wave in v1
- Pericarditis that is not
- ST elevation in avR
- Wellen's
- de Winter
- Torsades
- LBBB
- Pericarditis
- Brugada's
- HCM
- LV aneurysm
- New RAD
- Prolonged QTc
- Pericardial Tamponade
- PE
- Slow Vtaq
- AIVR
- WPW
- Hyperkalemia
- Hypothermia
- CNS disorders
- Takotsubo Syndrome
- Spiked-Helmet Sign

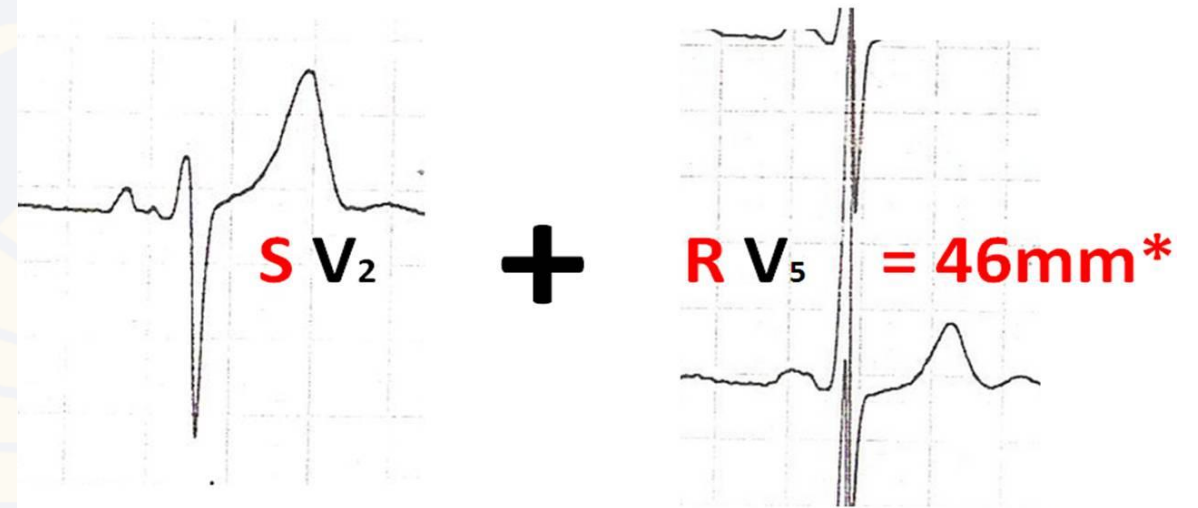


LVH Criteria



left ventricle hypertrophy ECG PEDIA.ORG

LVH by voltage criteria in chest leads



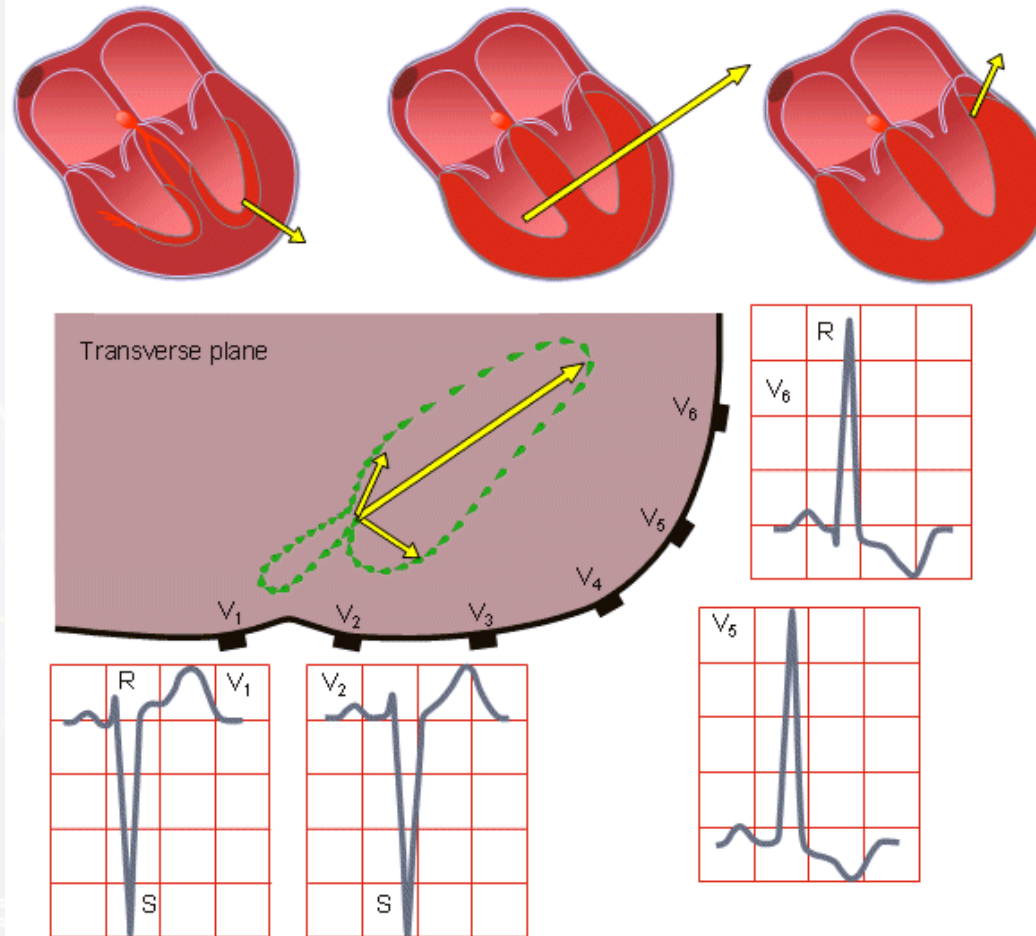
* > 35mm is significant

www.drsvenkatesan.co.in

LVH Criteria

LEFT VENTRICULAR HYPERTROPHY

Large S wave in leads V1 and V2, large R wave in V5 and V6

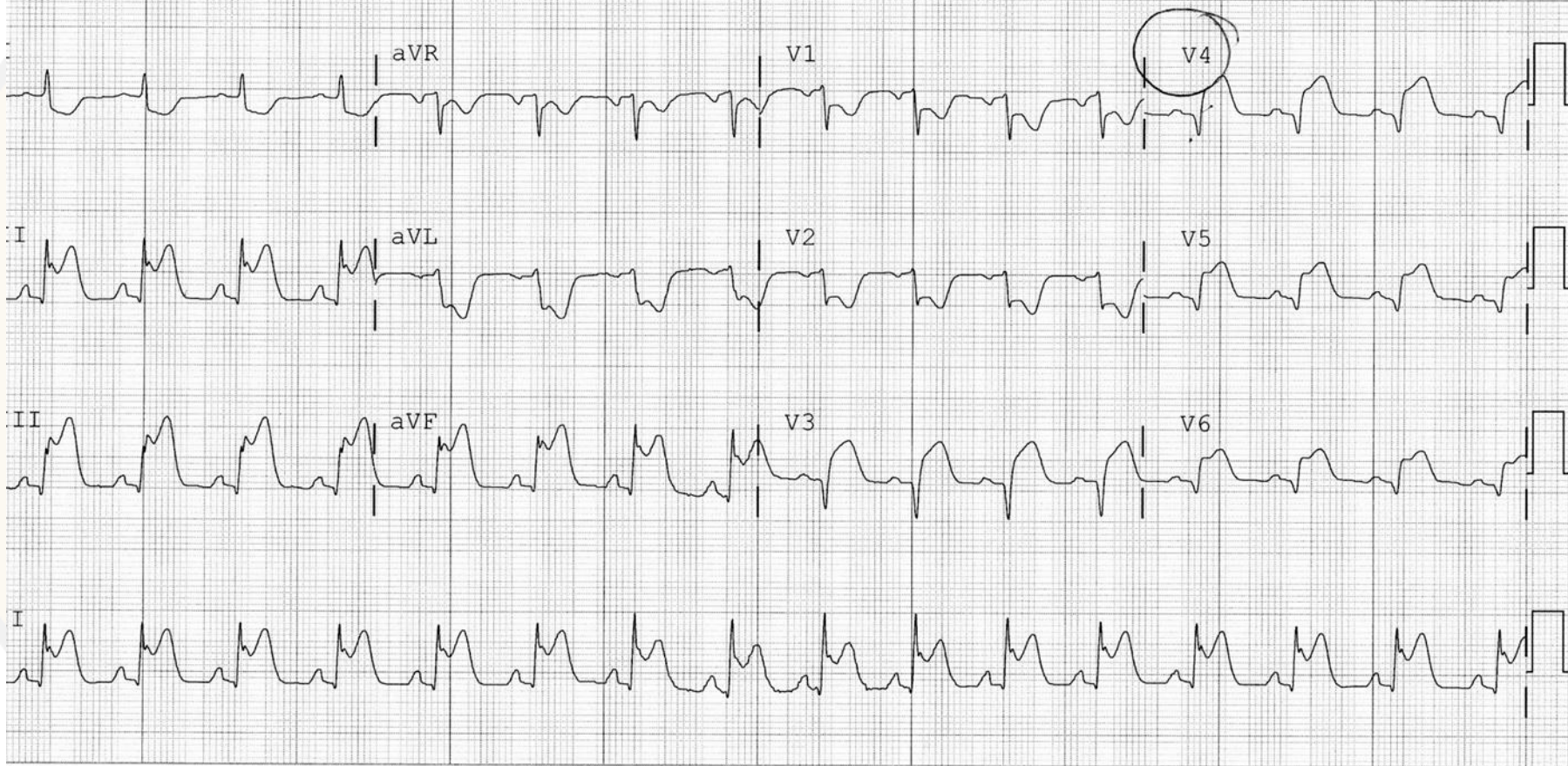


100 PREVIOUS REPORT: 27-Oct-2009 08:33:00 - Abnormal Confirmed

Standard 12
Requested By: RUBERO

Florida Hospital - FH East Orlando (4-06-00)

Preliminary - MD MUST REVIEW



EKG's and ST Changes That Can Kill You

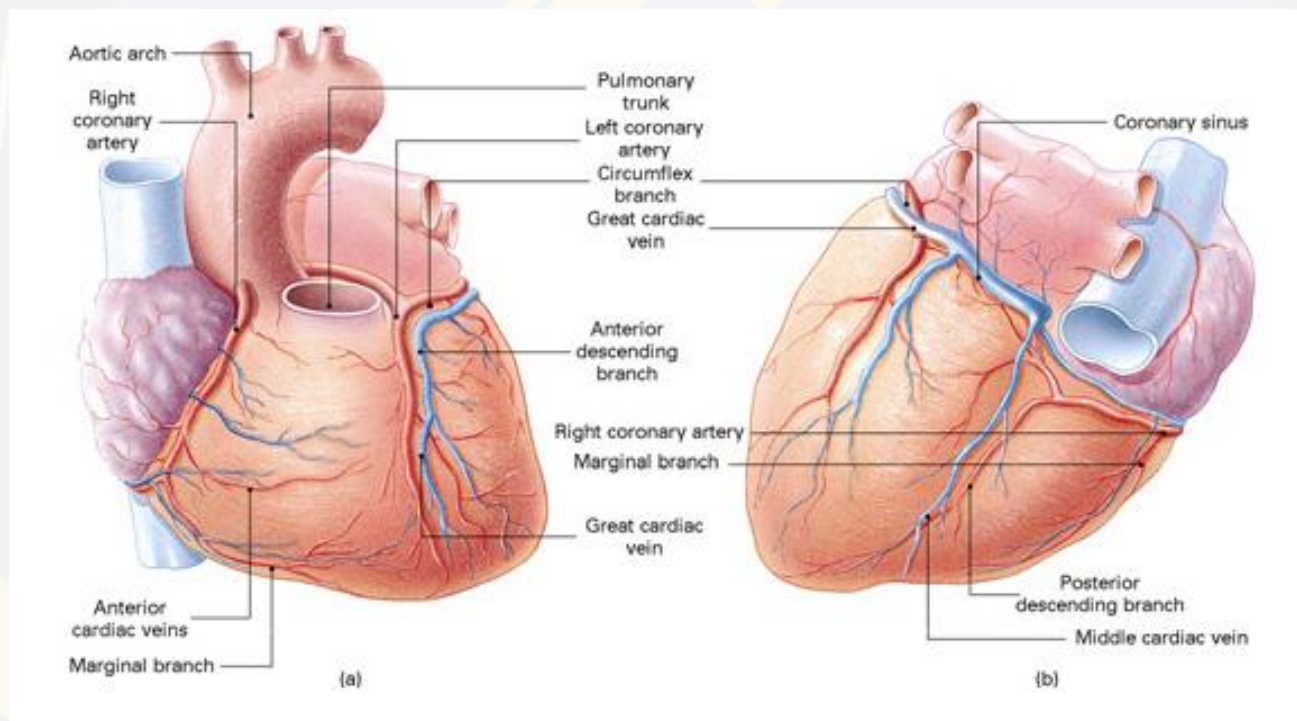
- Early repolarization (well, not really!)
- LVH
- **AMI**
- RV AMI
- Inverted T-wave in avL
- T wave in v1
- Pericarditis that is not
 - ST elevation in avR
 - Wellen's
 - de Winter
 - Torsades
 - LBBB
 - Pericarditis
 - Brugada's
 - HCM
 - LV aneurysm
 - New RAD
 - Prolonged QTc
 - Pericardial Tamponade
 - PE
 - Slow Vtaq
 - AIVR
 - WPW
 - Hyperkalemia
 - Hypothermia
 - CNS disorders
 - Takotsubo Syndrome
 - Spiked-Helmet Sign

What is the first EKG sign for a STEMI?

- Hyperacute T waves
- ST segment elevation
- T wave inversion
- Significant Q waves

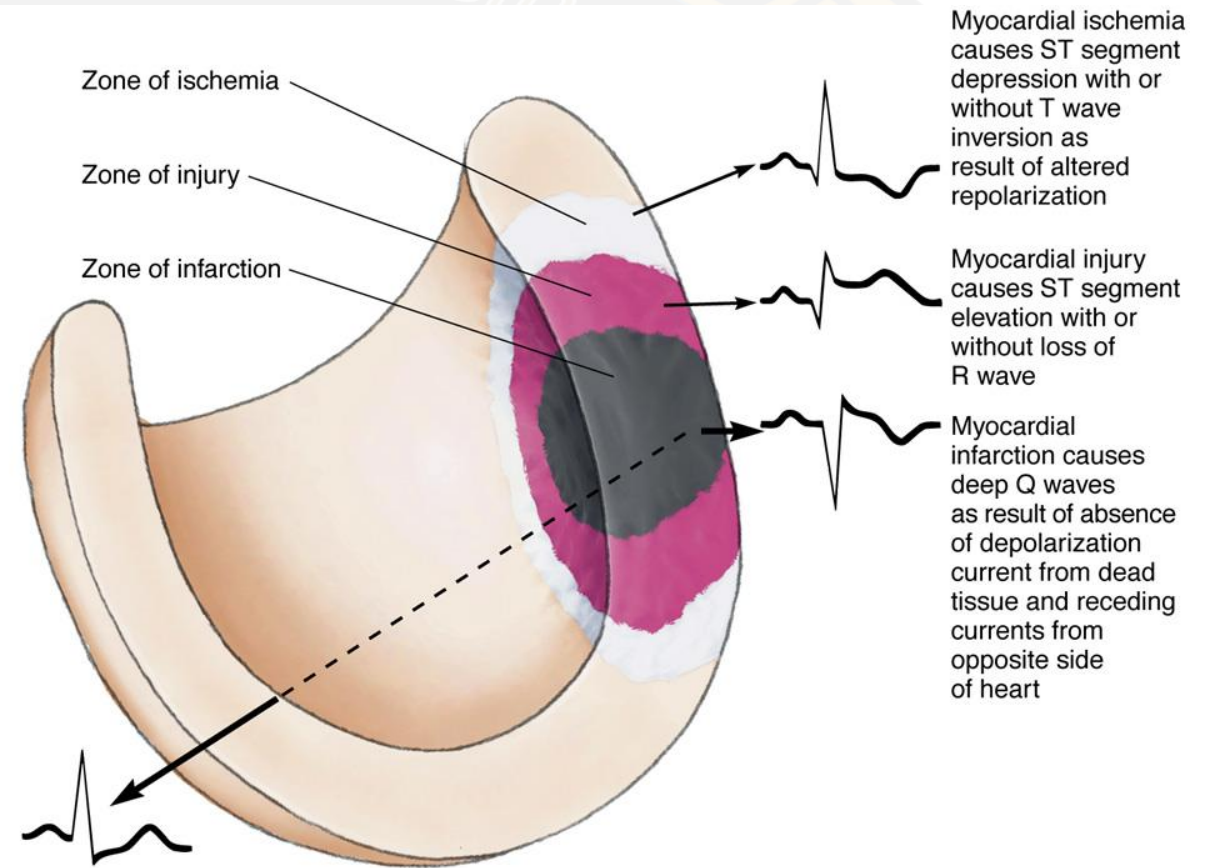
Cardiovascular Anatomy

- Coronary Circulation
 - Collateral Circulation



Disease Findings

- Ischemia
- Injury
- Infarction
 - Subendocardial
 - Transmural

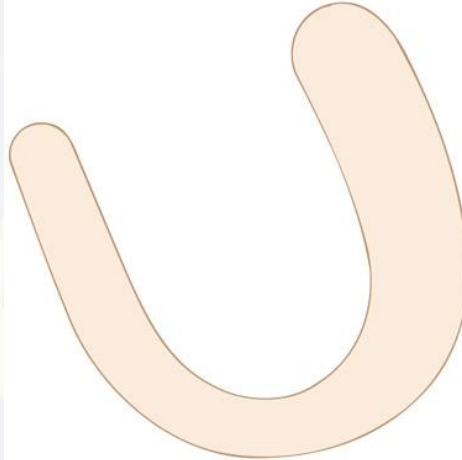


Disease Findings

- Evolution of Acute Myocardial Infarction
 - Subendocardial Infarction

Subendocardial Infarction

Before infarction

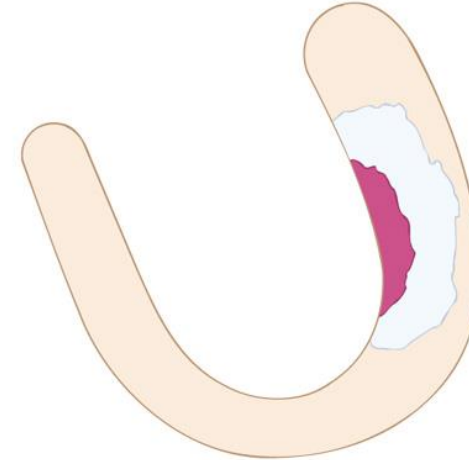


Heart muscle normal



Normal ECG

First few hours



Subendocardial muscle ischemic and injured but not dead



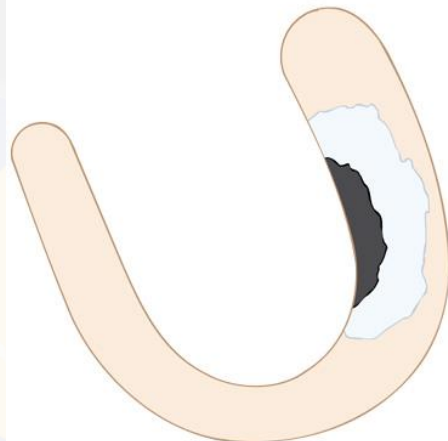
ST depressed or elevated



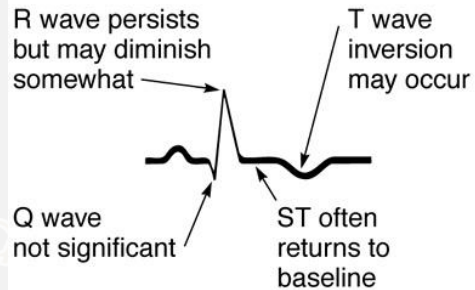
Disease Findings

- Evolution of Acute Myocardial Infarction
 - Subendocardial Infarction

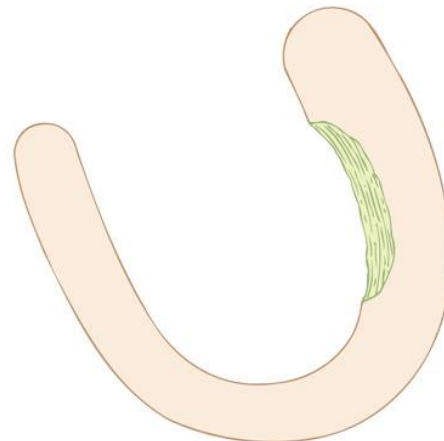
First several days



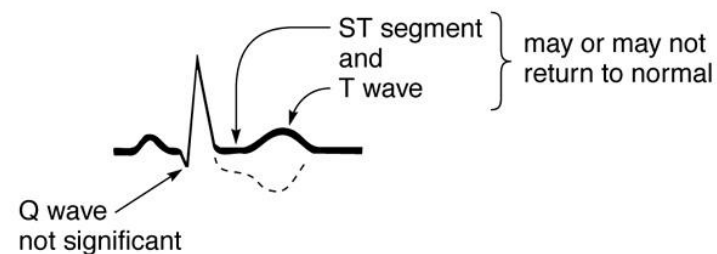
Some subendocardial muscle dies, but lesion does not extend through entire heart wall



After several weeks or months



Lesion heals. Some subendocardial fibrosis may occur but does not involve entire thickness of heart wall



Subendocardial MI

- Associated with variable ST and T wave changes

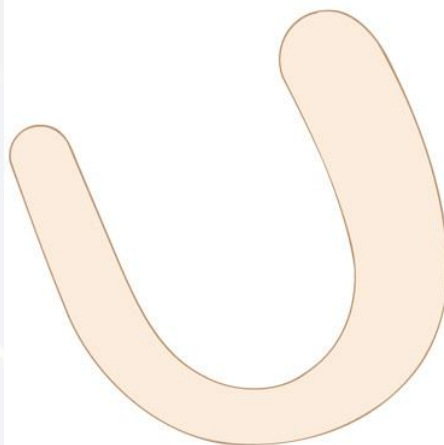
Disease Findings

- Evolution of Acute Myocardial Infarction

- Transmural Infarction

Transmural Infarction

— Before coronary occlusion —

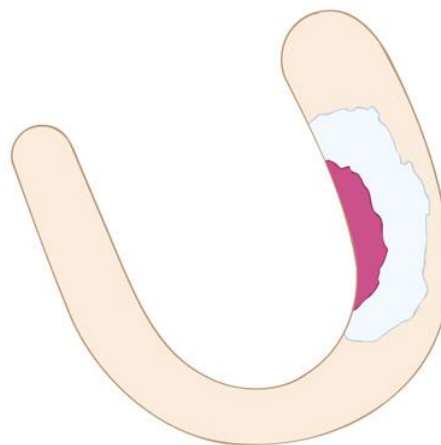


Heart muscle normal

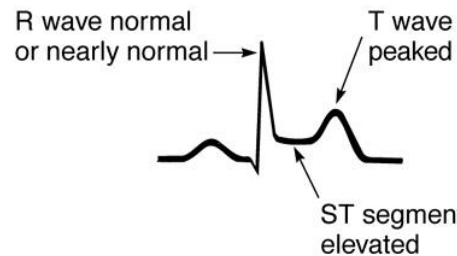


Normal ECG

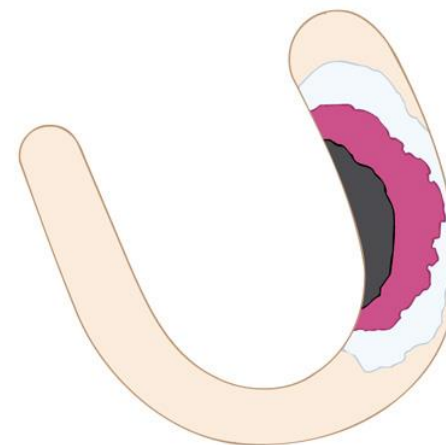
— Onset and first several hours —



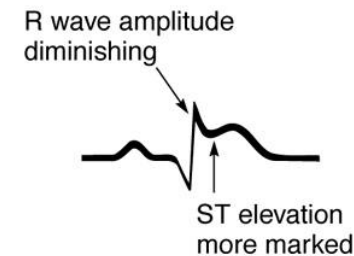
Subendocardial injury and myocardial ischemia. No cell death (infarction) yet



— First day —

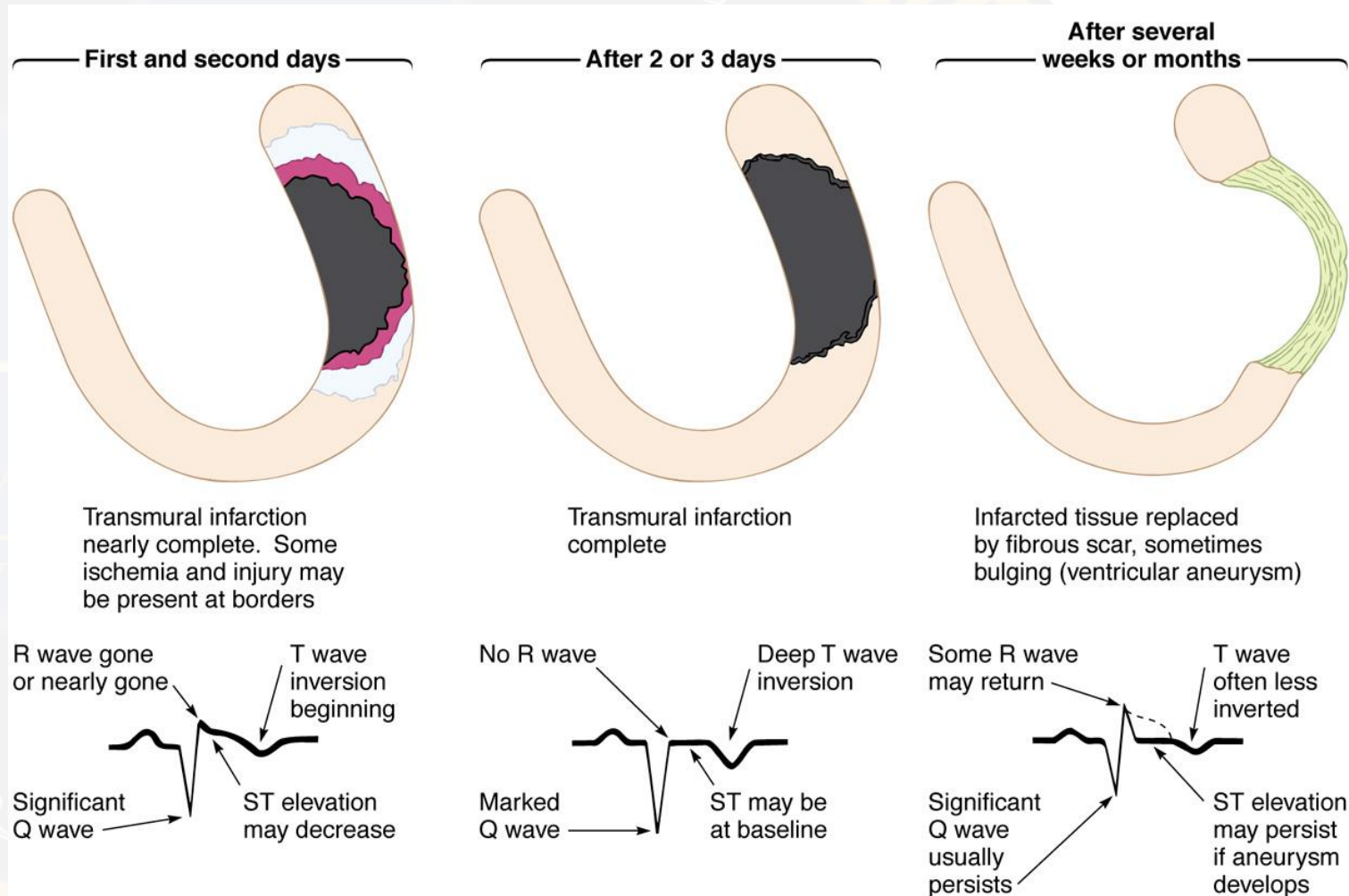


Ischemia and injury extend to epicardial surface. Subendocardial muscle dying in area of most severe injury



Disease Findings

- Evolution of Acute Myocardial Infarction
 - Transmural Infarction

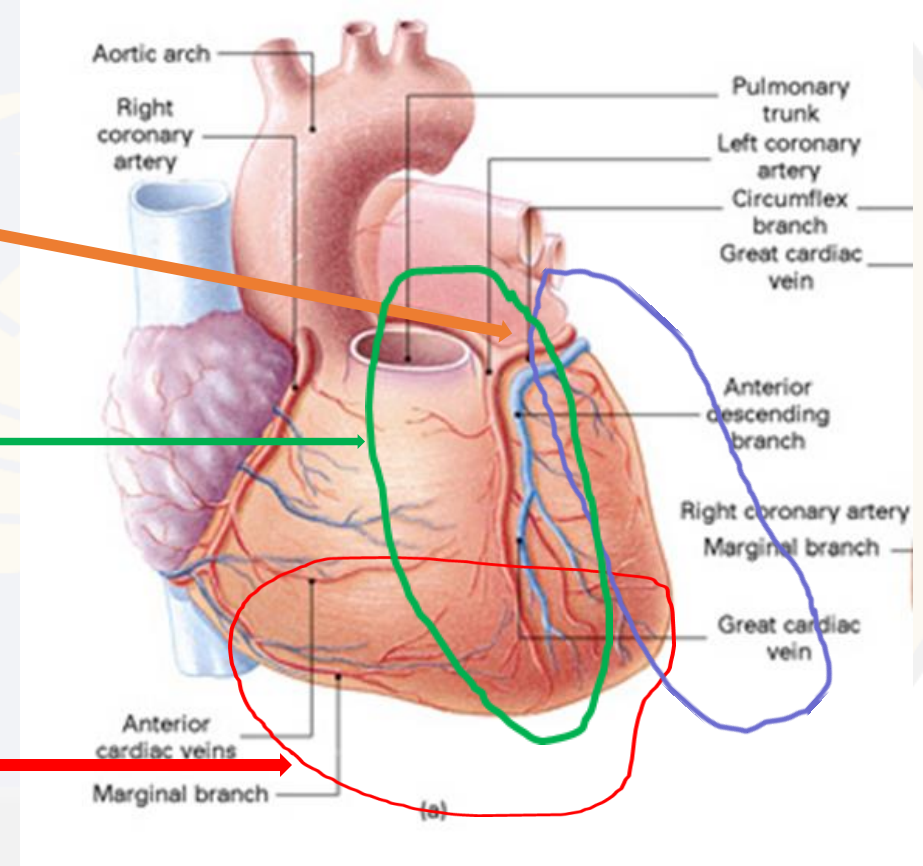
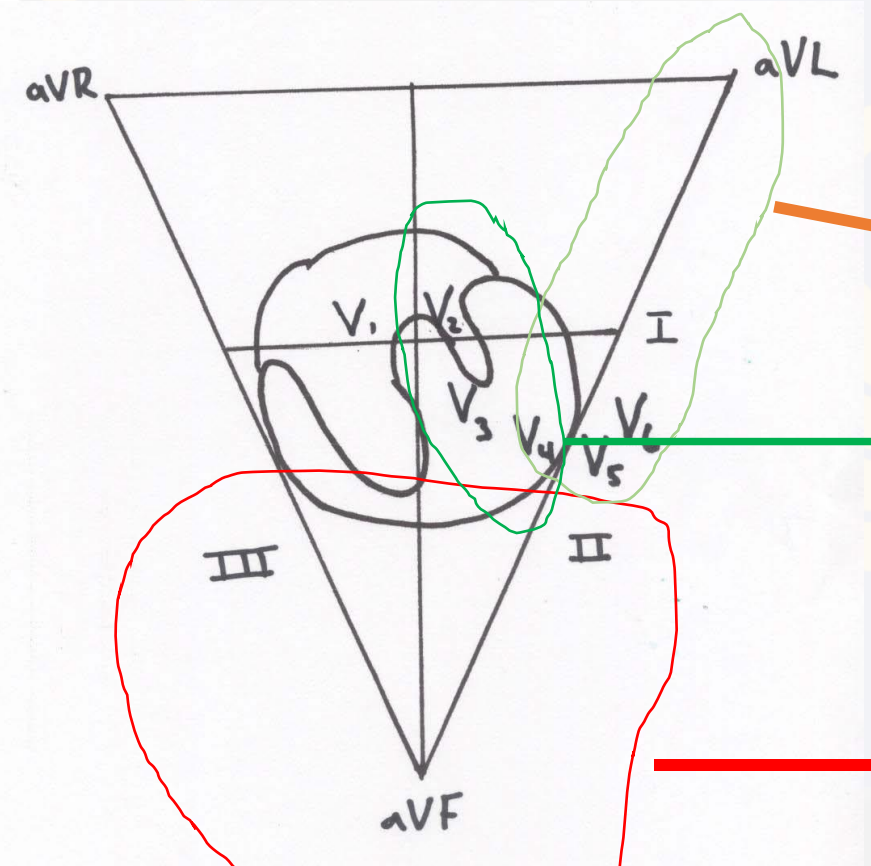


Transmural MI

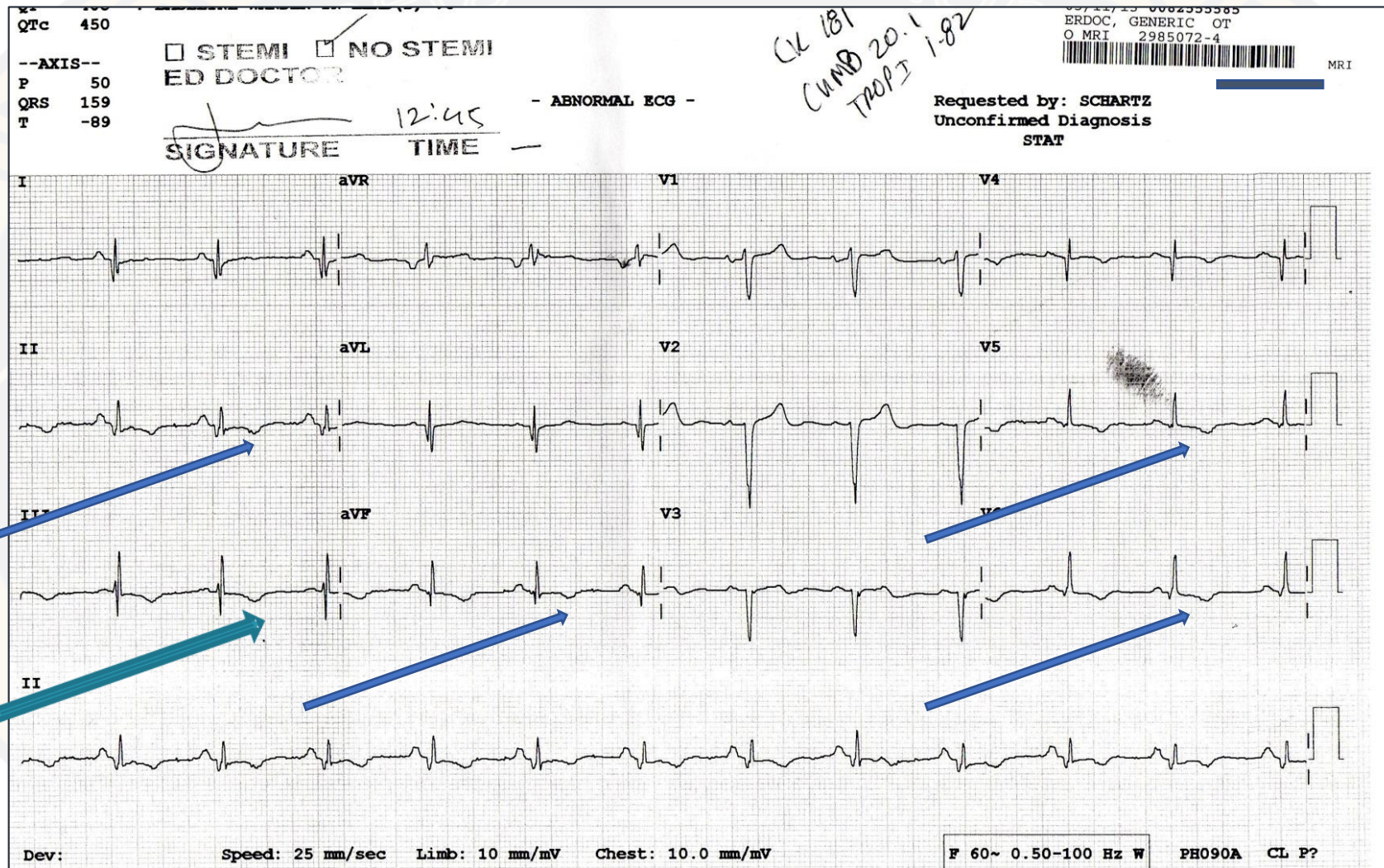
- Anterior MI
 - LAD
 - STE V₁-V₆
 - Inferior reciprocal changes
 - Anteroseptal V₁-V₄
- Anterolateral
 - LAD or anterior trunk
 - STE V₃-V₆, I, aVL
 - Inferior reciprocal changes
- Lateral
 - Left circumflex or diagonal branch from LAD
 - STE V₅-V₆, I, aVL
 - Inferior reciprocal changes

Transmural MI

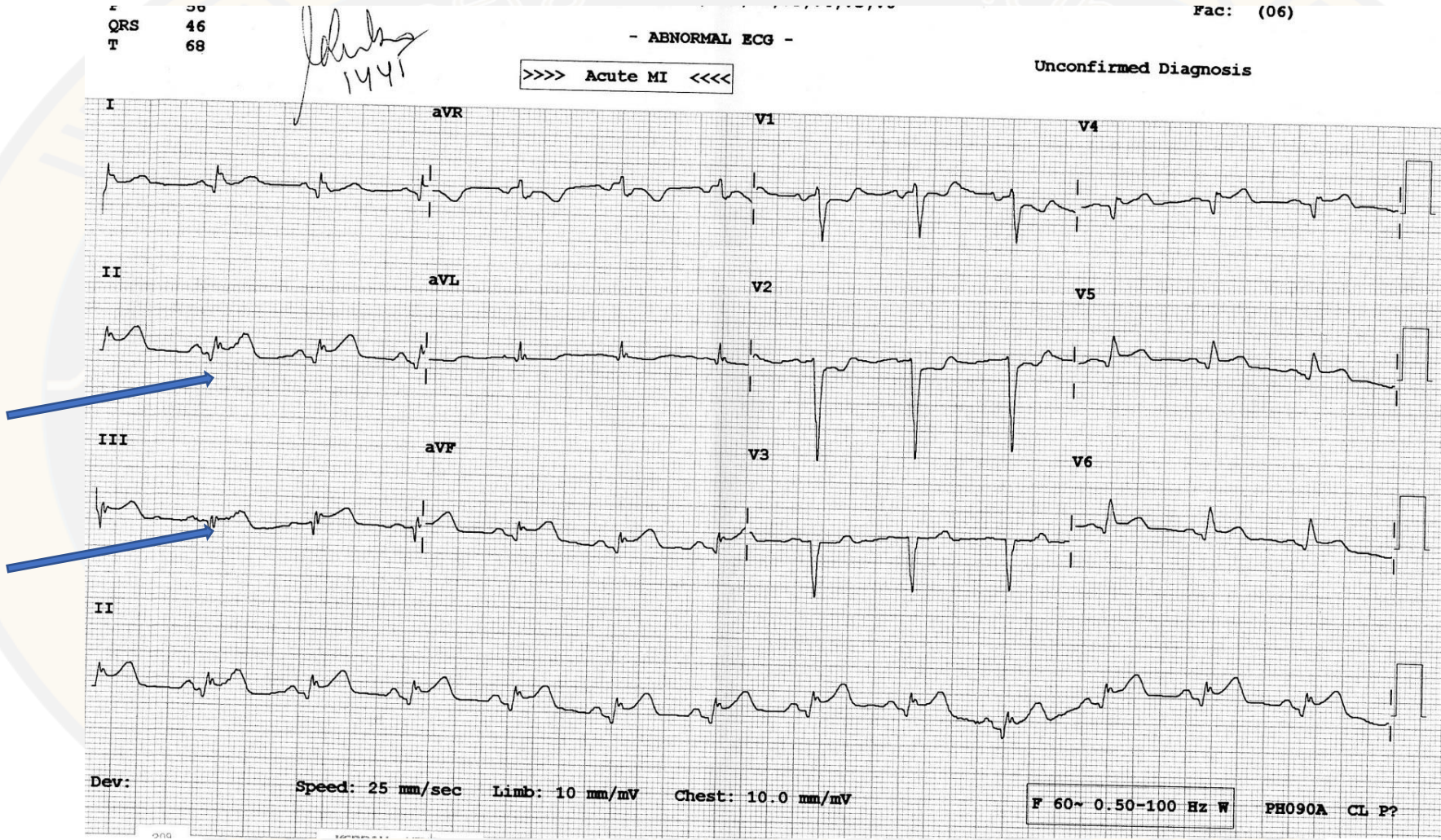
- Inferior
 - RCA (90%)
 - STE II, III, aVF
 - Reciprocal changes most common in lead aVL, may be I
 - Always consider possibility of concurrent posterior or RV involvement
- Posterior
 - Large R wave with ST depression in V_1 - V_3
 - Mirror image of septal MI
 - Usually associated with inferior MI, less commonly with lateral MI
 - RCA or Left circumflex



What is an ischemic change?



What is an injury change?



Disease Findings

- Localization of Acute Myocardial Infarction

Table 2-5 LOCATION OF MYOCARDIAL ISCHEMIA/INFARCTION

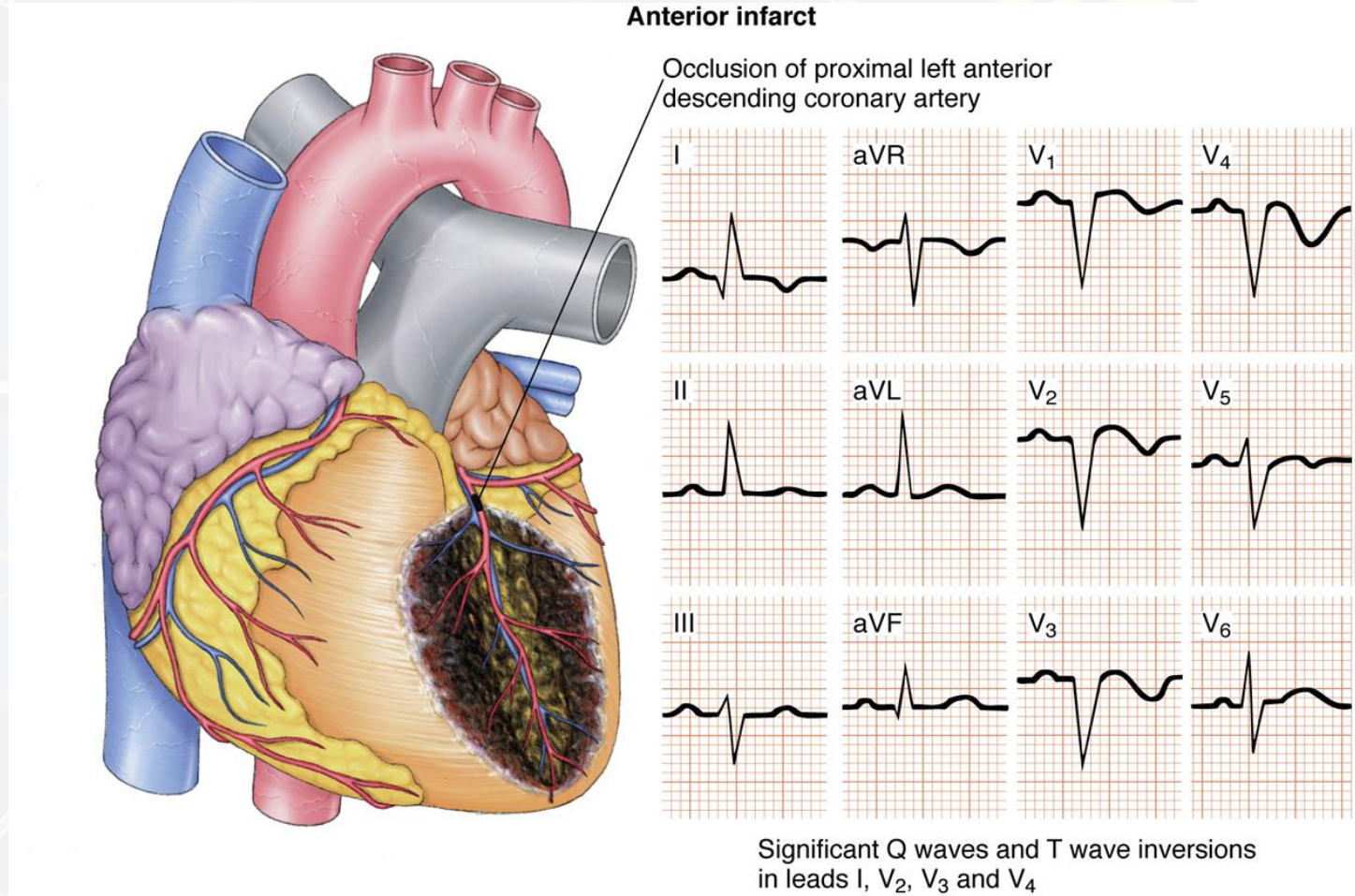
Location	Leads
Anterior	I, V ₂ , V ₃ , and V ₄
Anteriolateral	I, aVL, V ₅ , and V ₆
Lateral	V ₅ and V ₆
High lateral	I and aVL (often with V ₅ , V ₆)
Inferior	II, III, and aVF
Inferolateral	II, III, aVF, and V ₆
True posterior	Reciprocal changes in V ₁ and V ₂

Septal $\equiv V_1 - V_2$

Anteroseptal $\equiv V_1 - V_4$

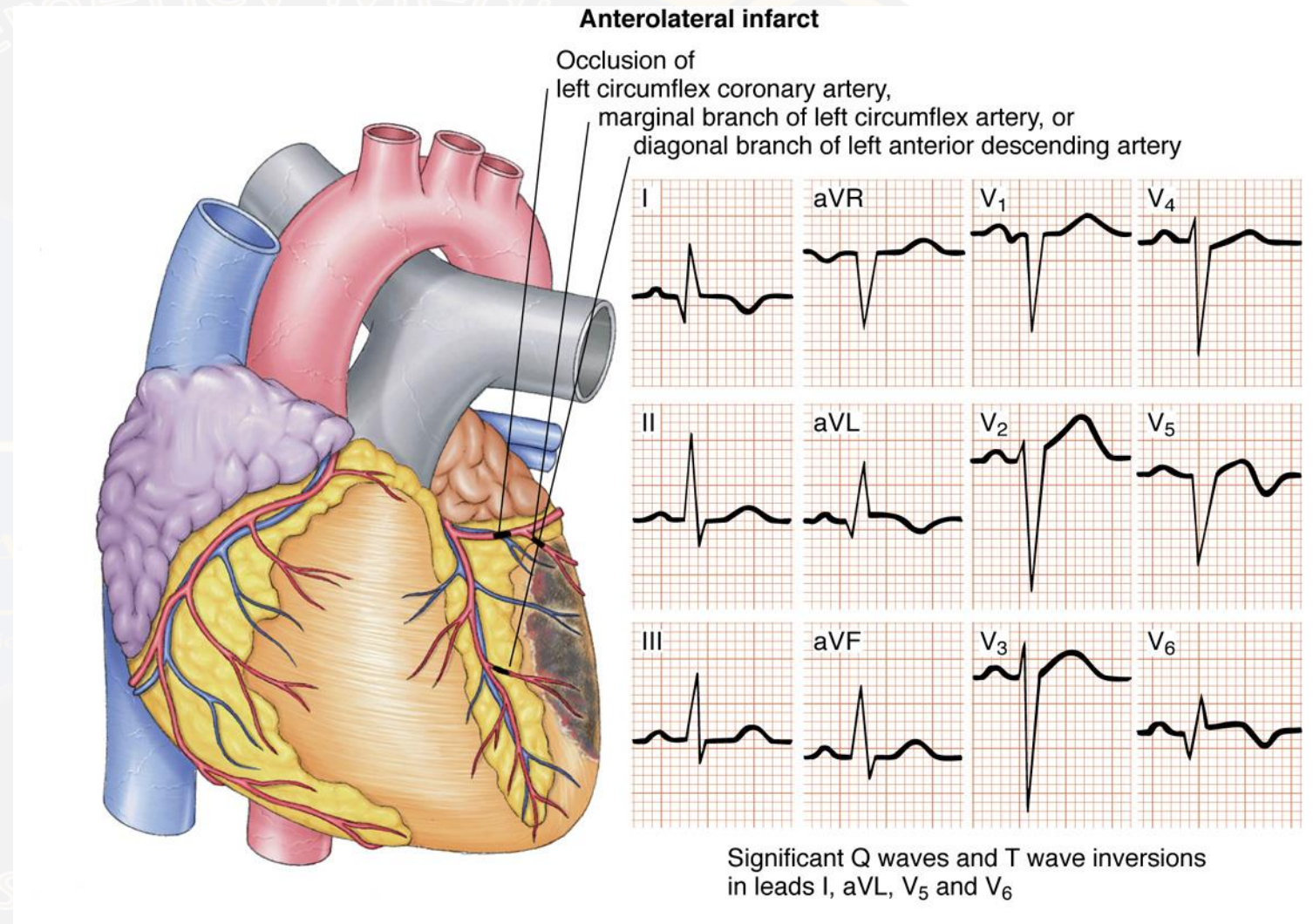
Disease Findings

- Anterior



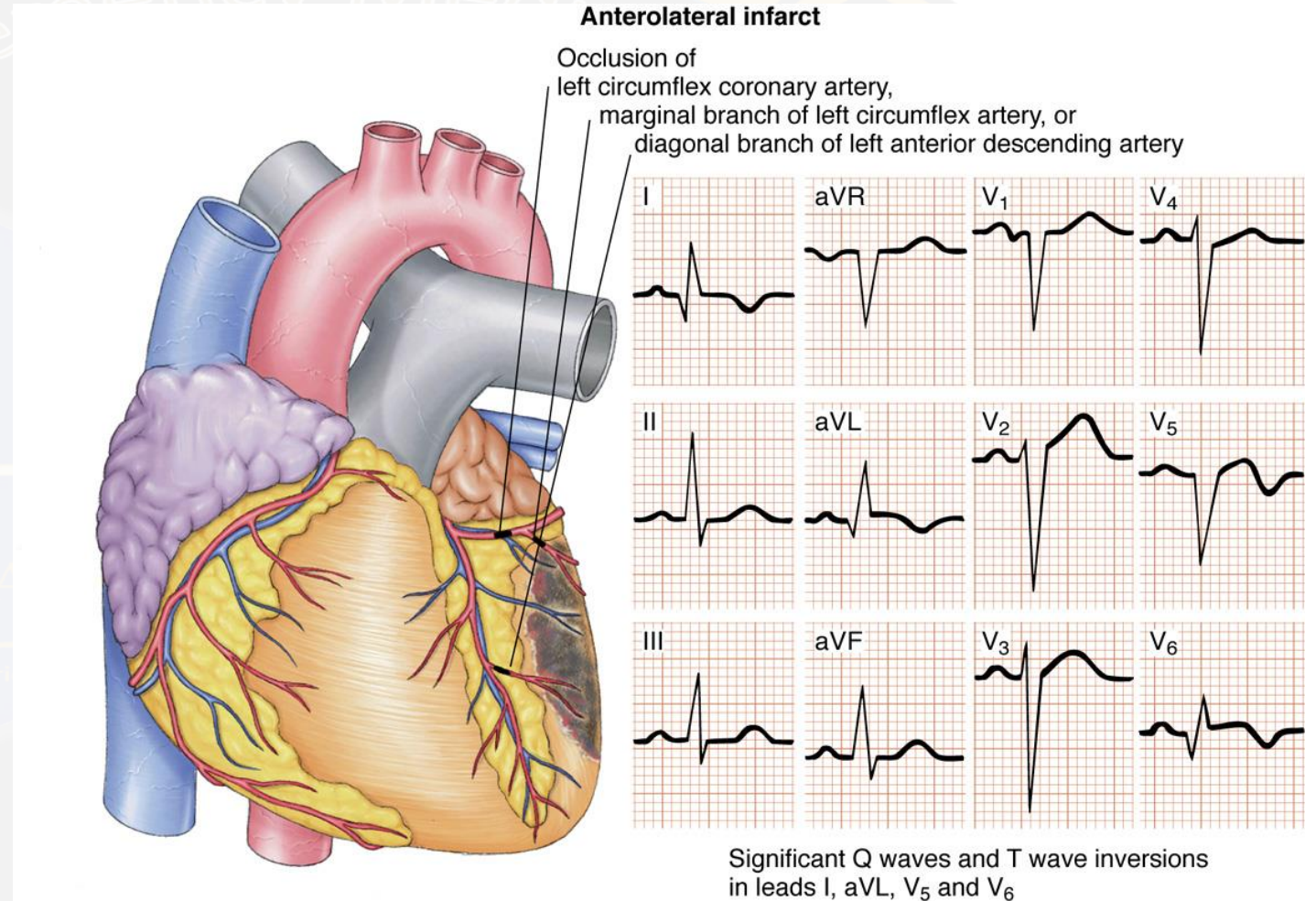
Disease Findings

- Anterolateral



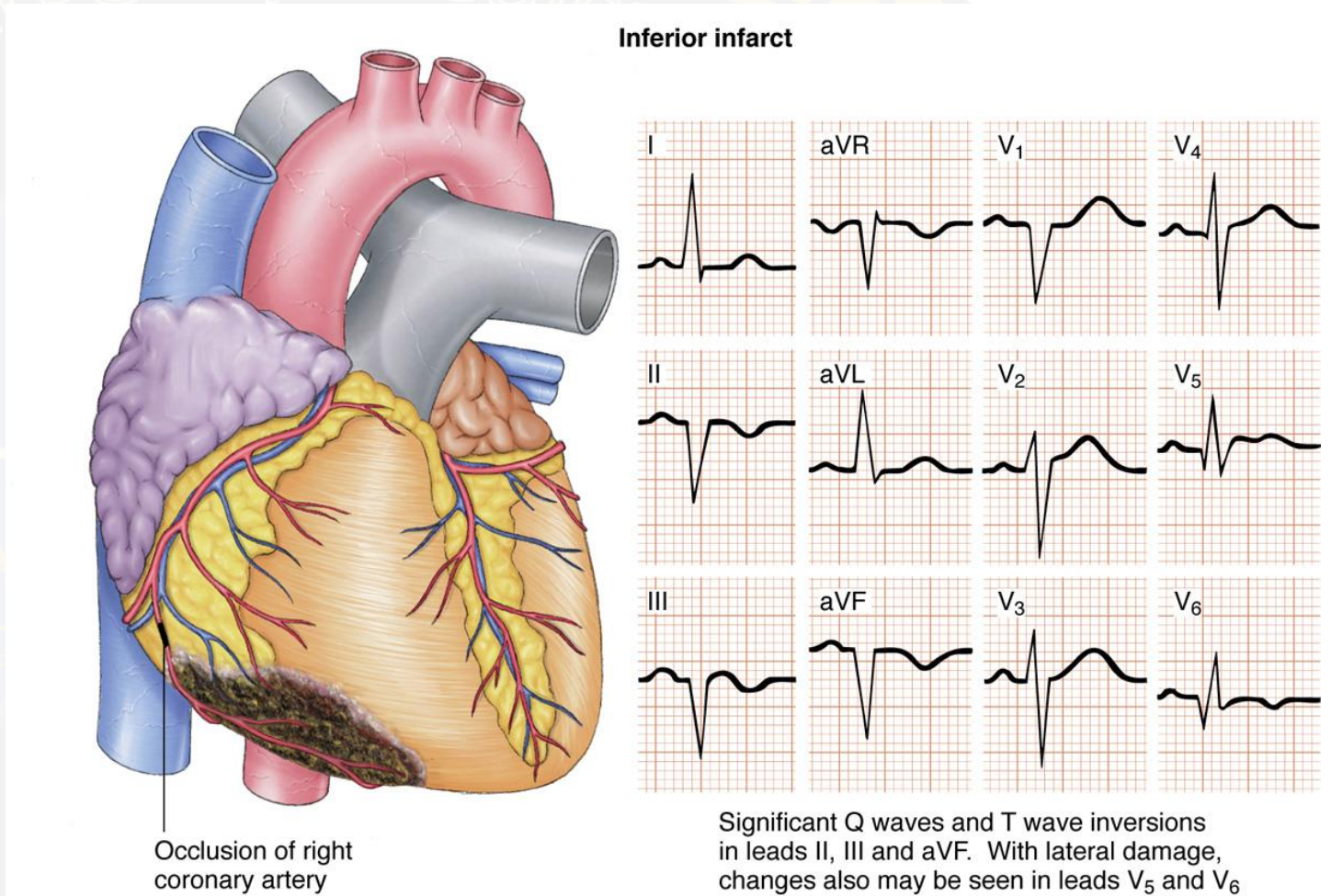
Disease Findings

- Anterolateral
- Lateral
- High Lateral



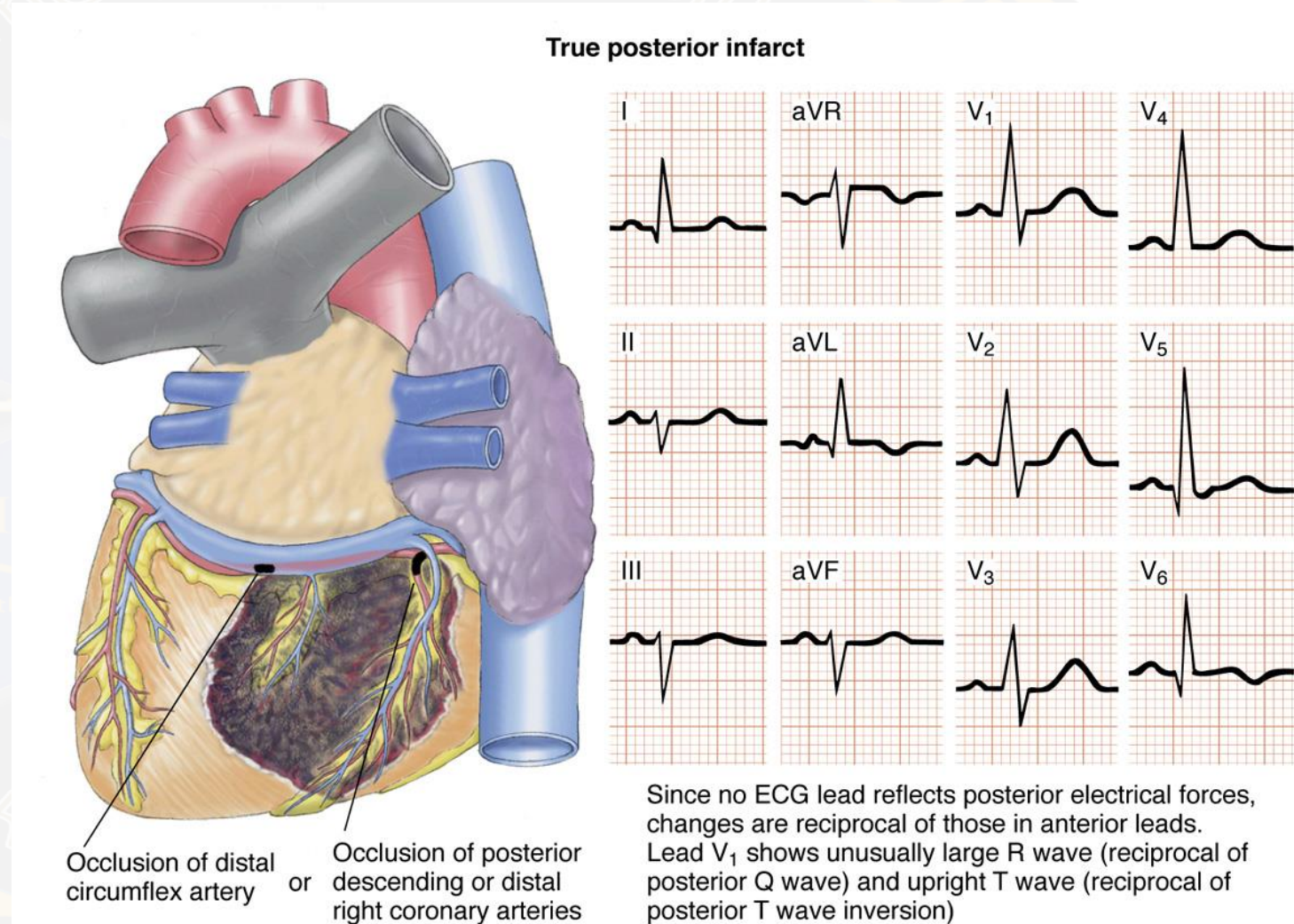
Disease Findings

- Inferior
- Inferolateral

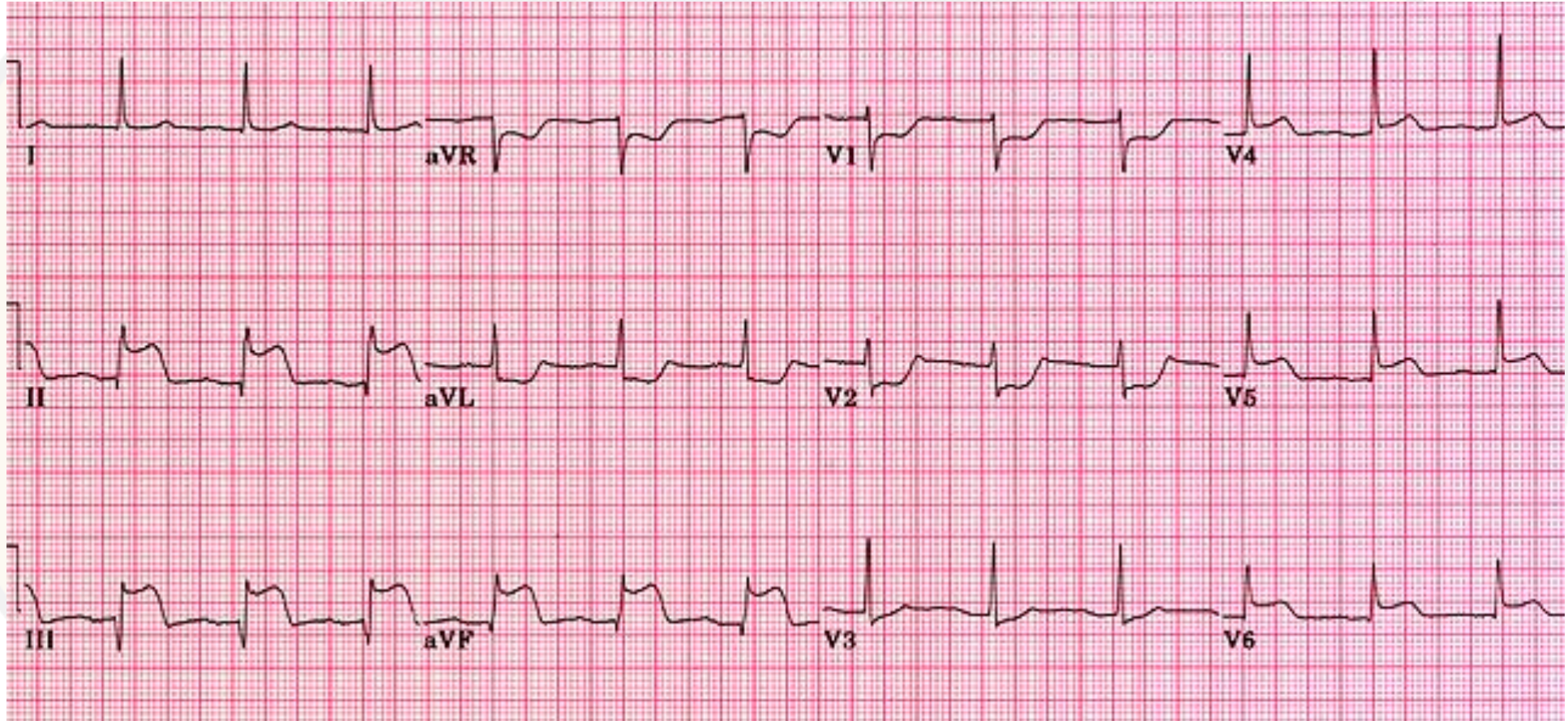


Disease Findings

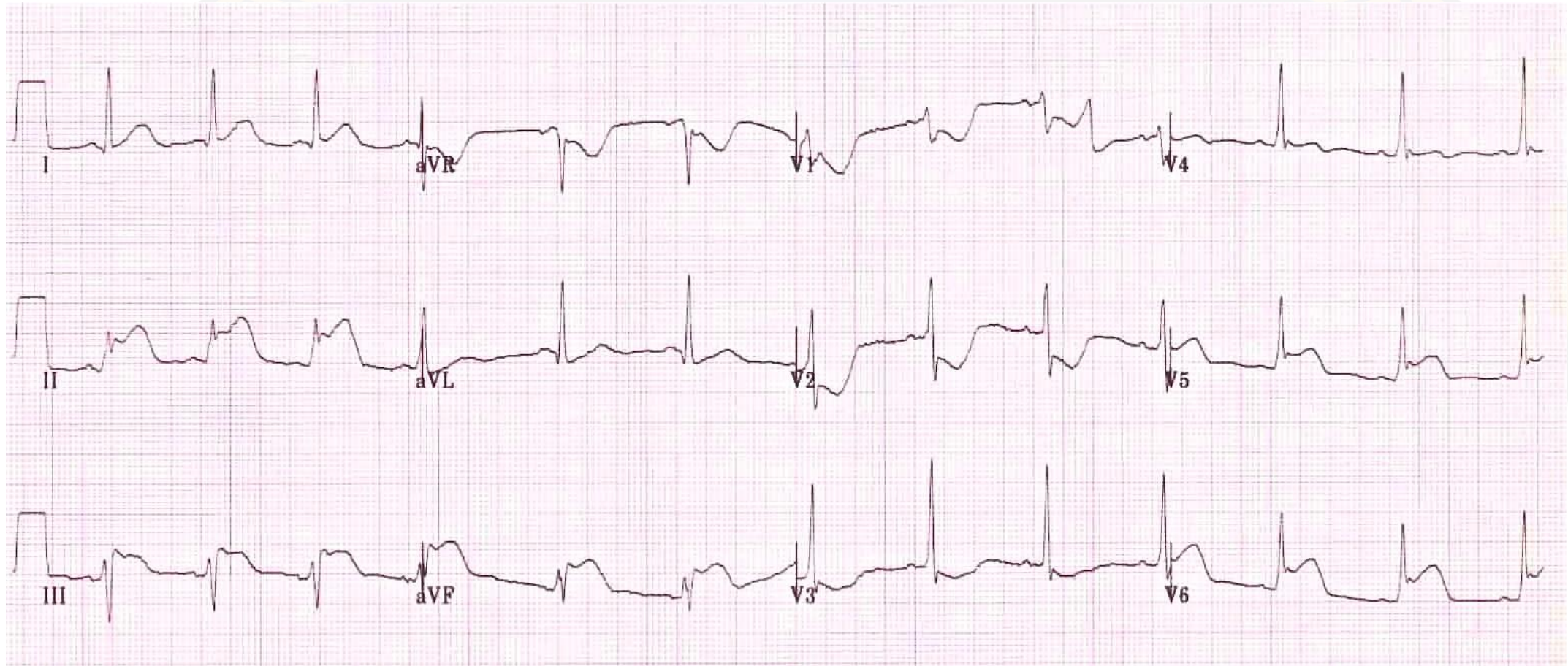
- True Posterior



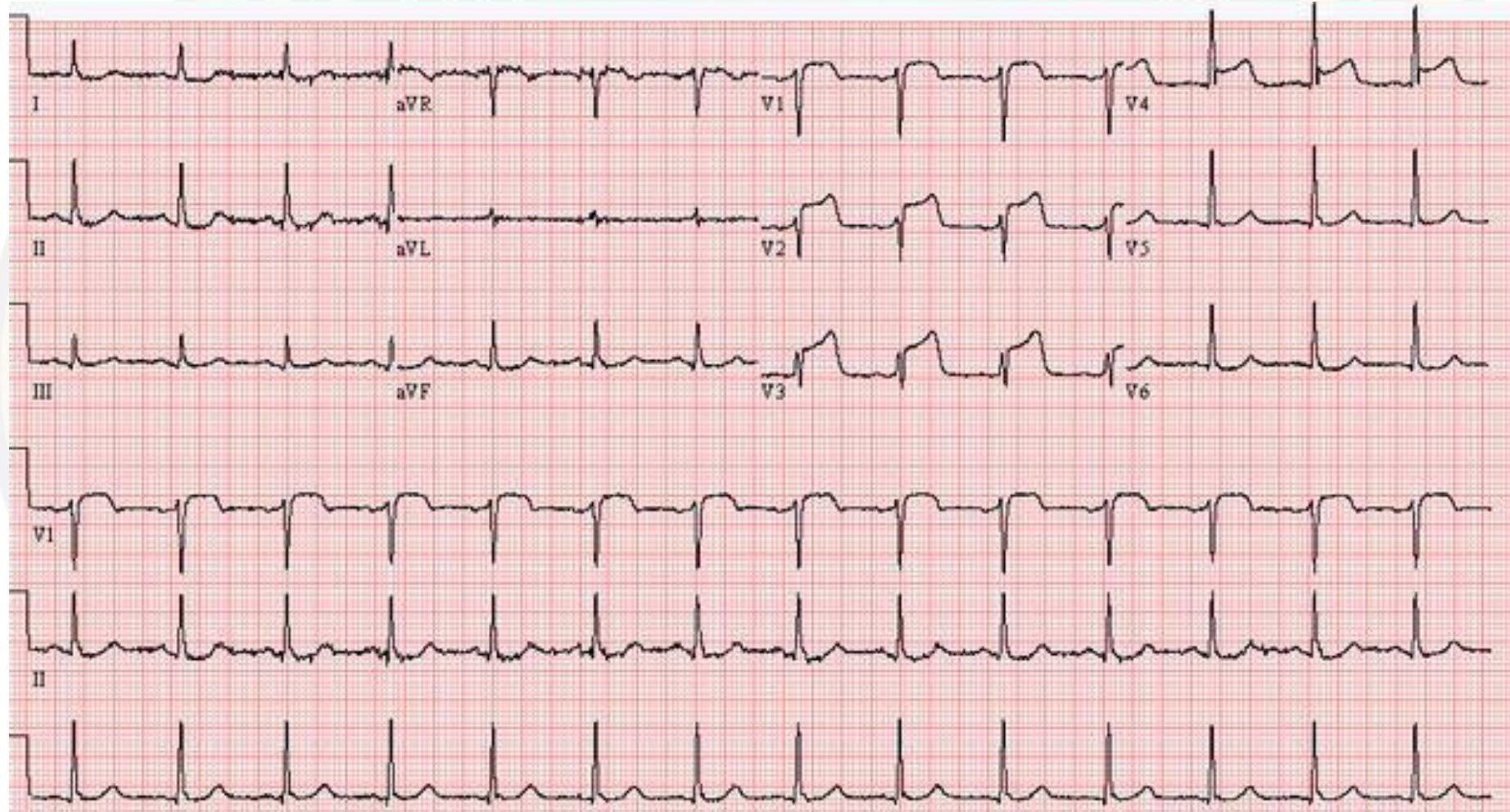
Inferior MI



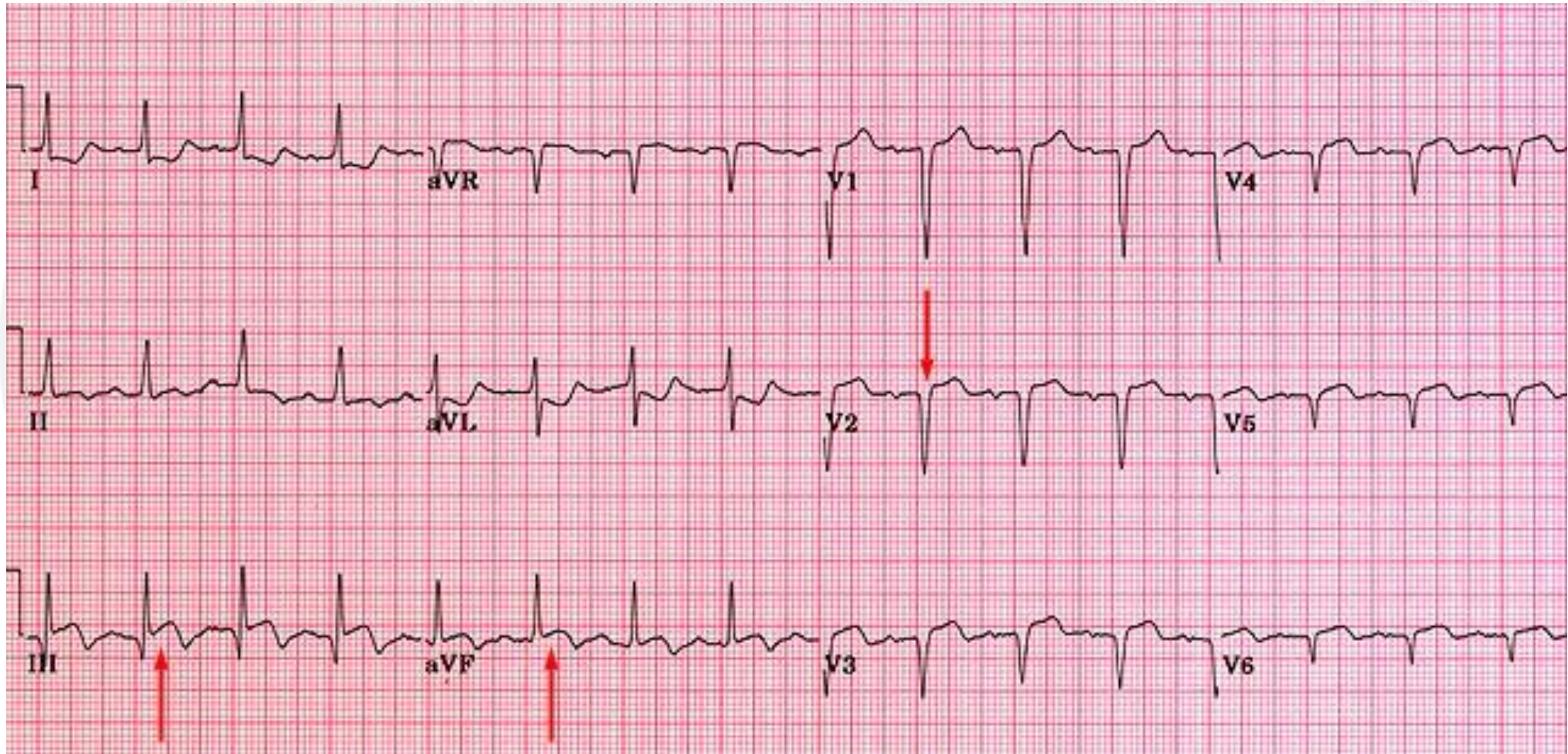
Inferolateral MI



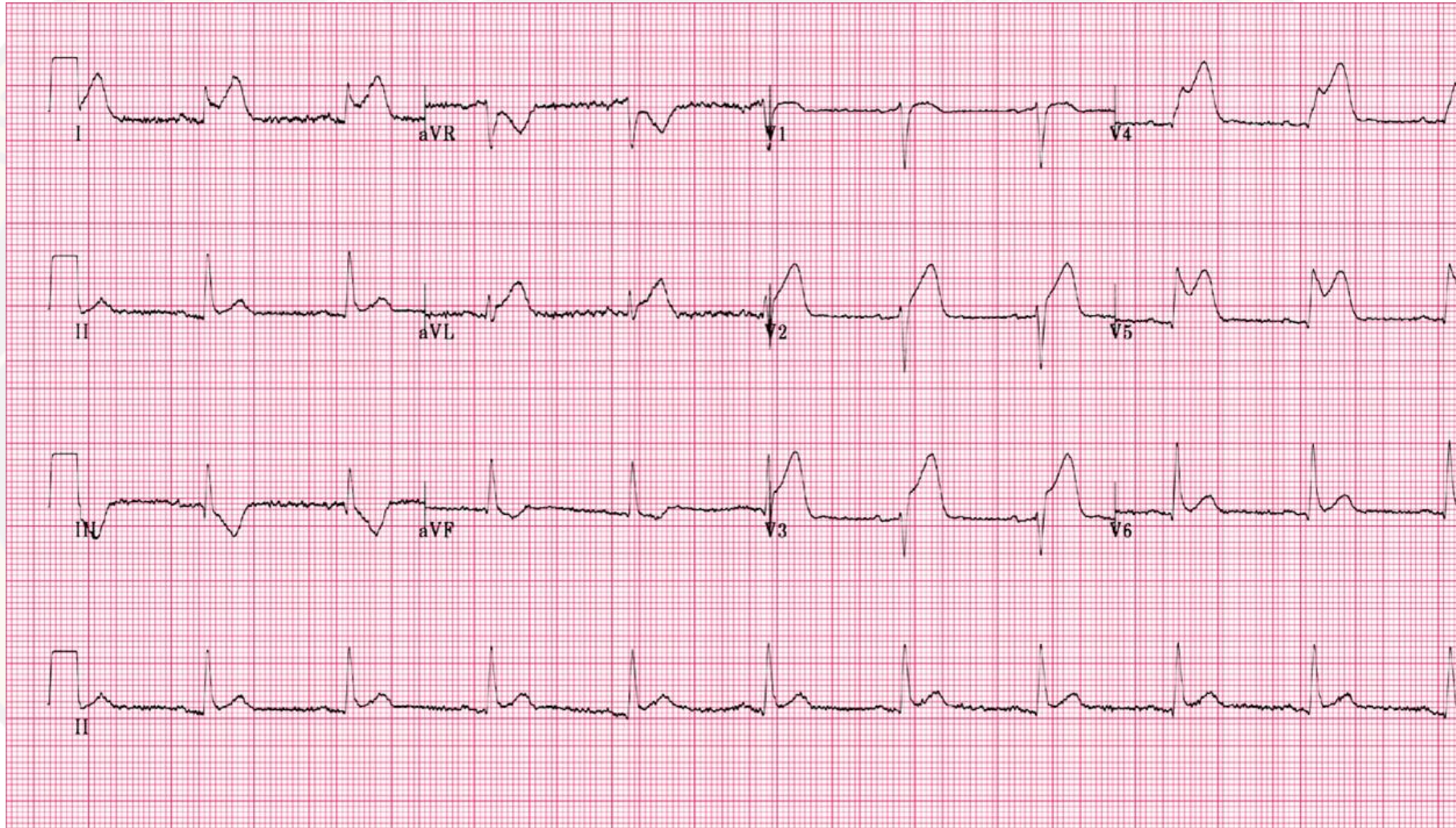
Anterior MI



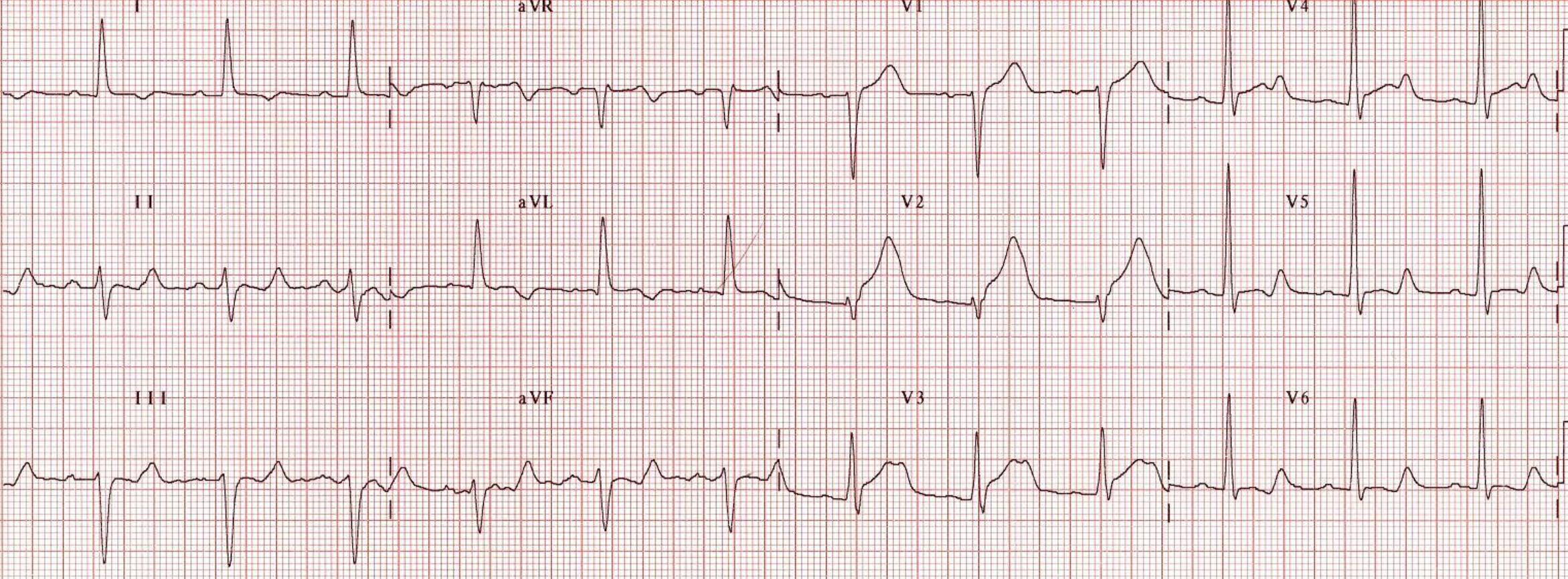
Anteriorinferior MI



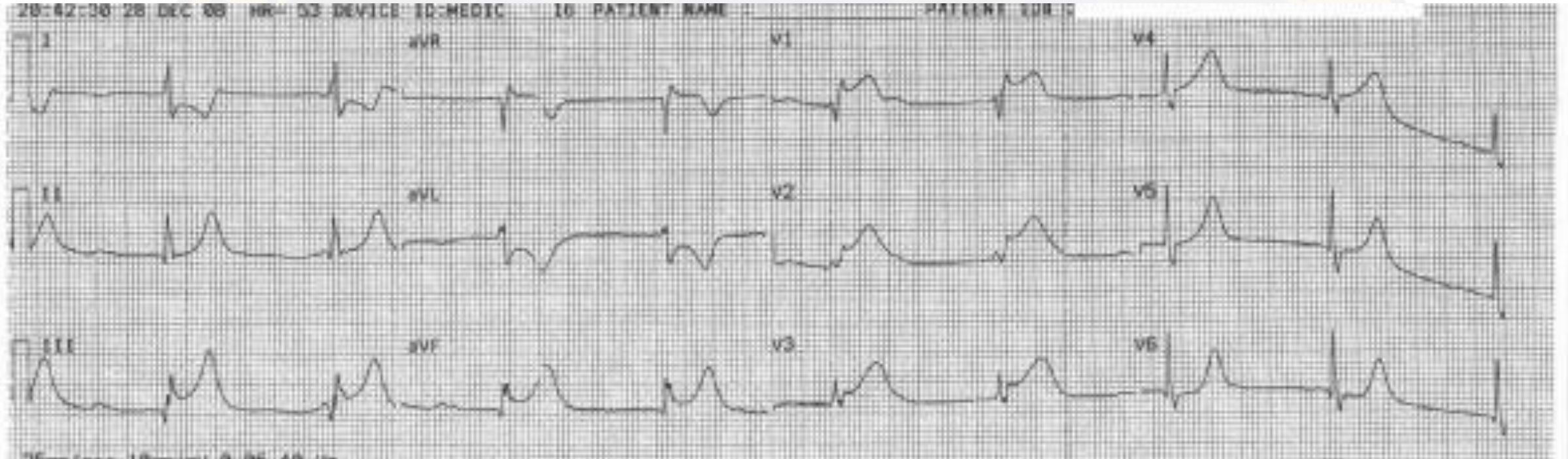
Anterolateral MI



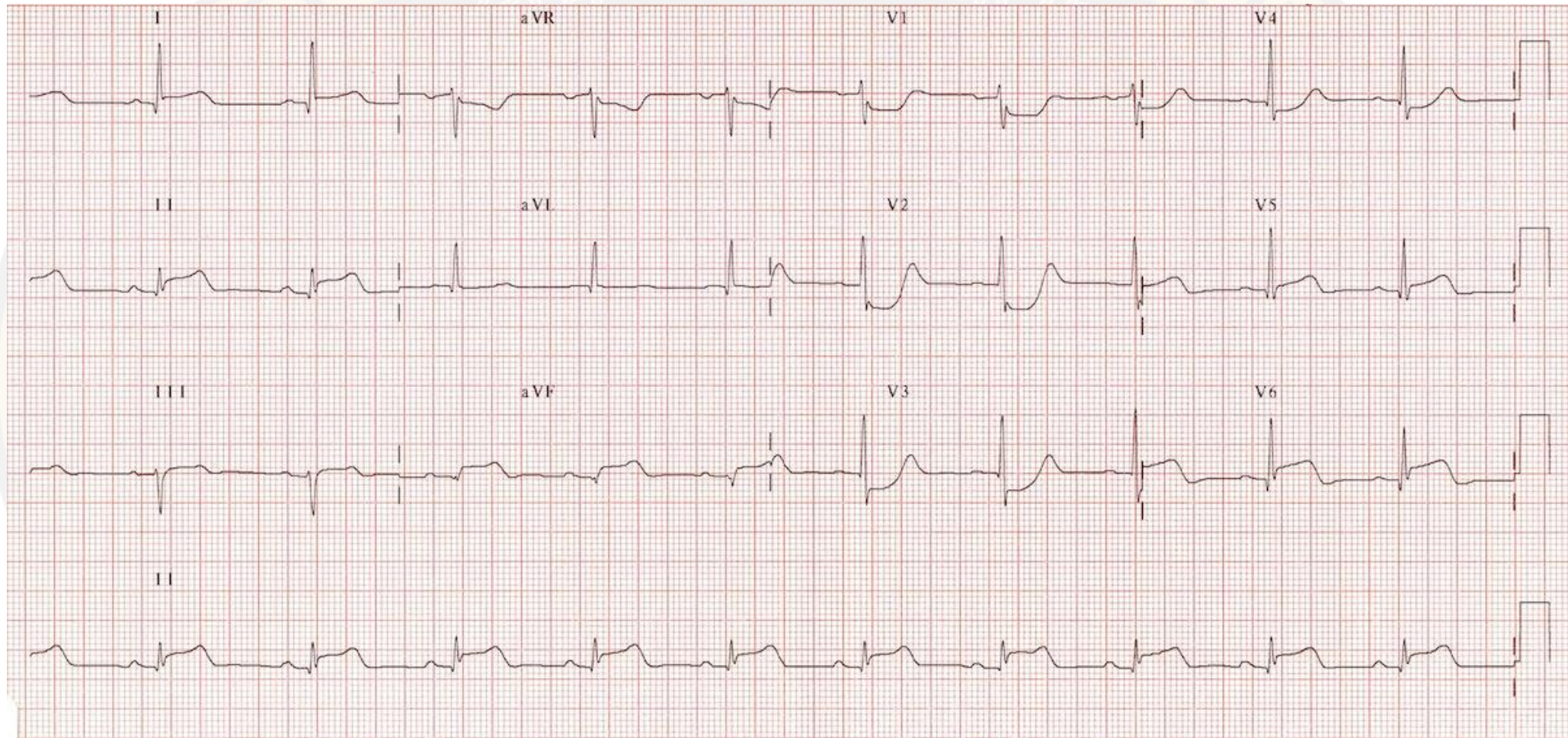
Septal MI



Inferoseptal



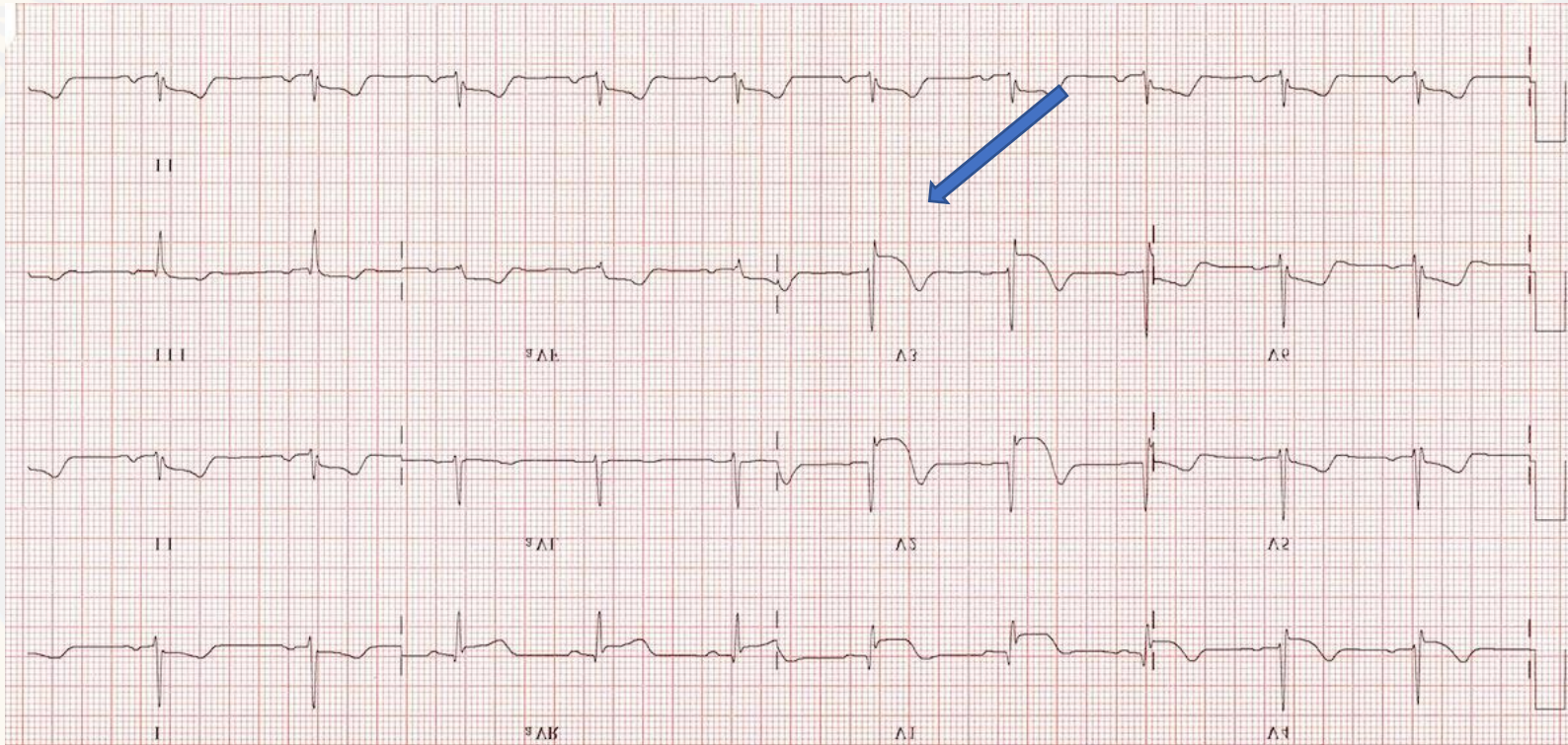
Posterior MI

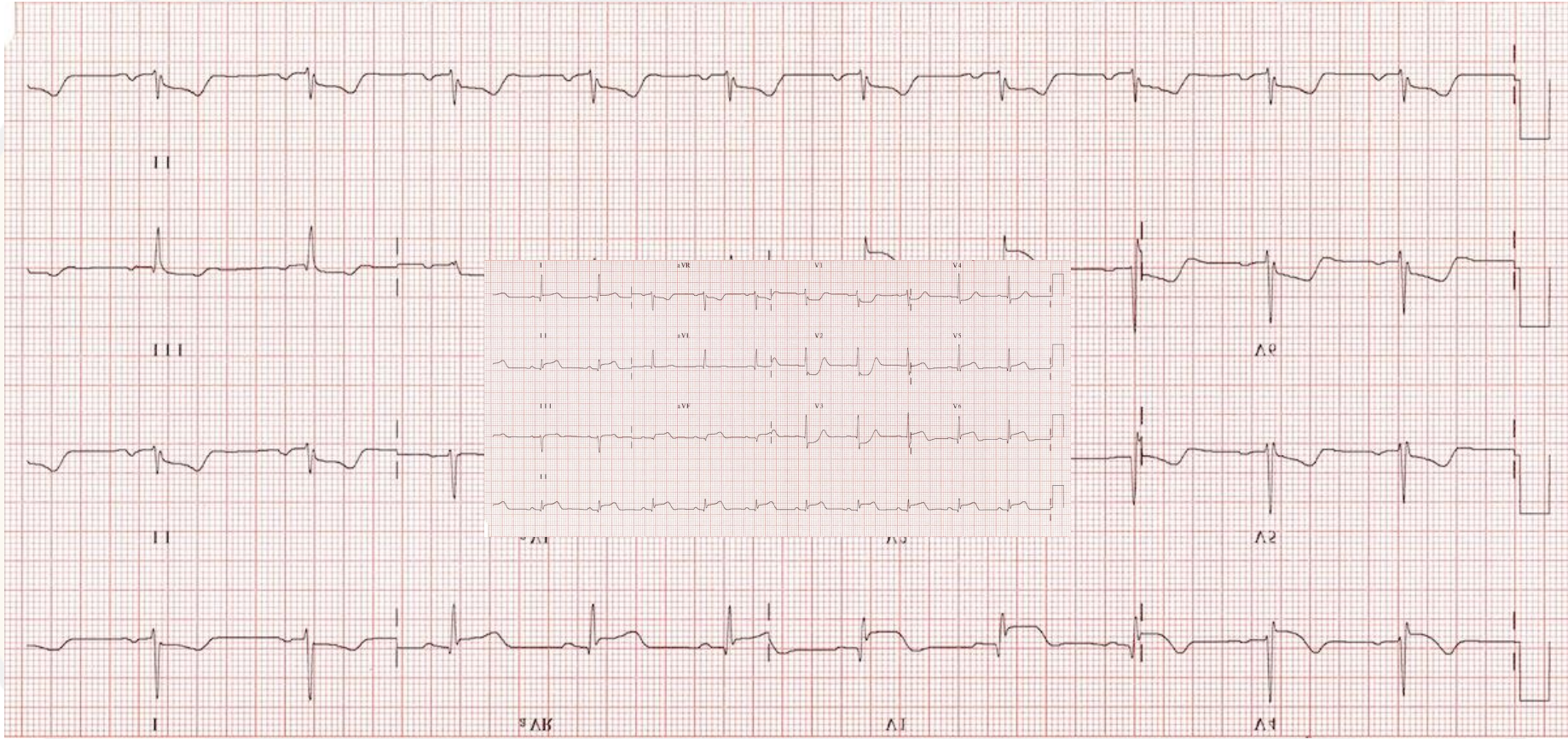


ST-depression ≥ 0.5 mm in V_1 - V_3 after a tall R wave

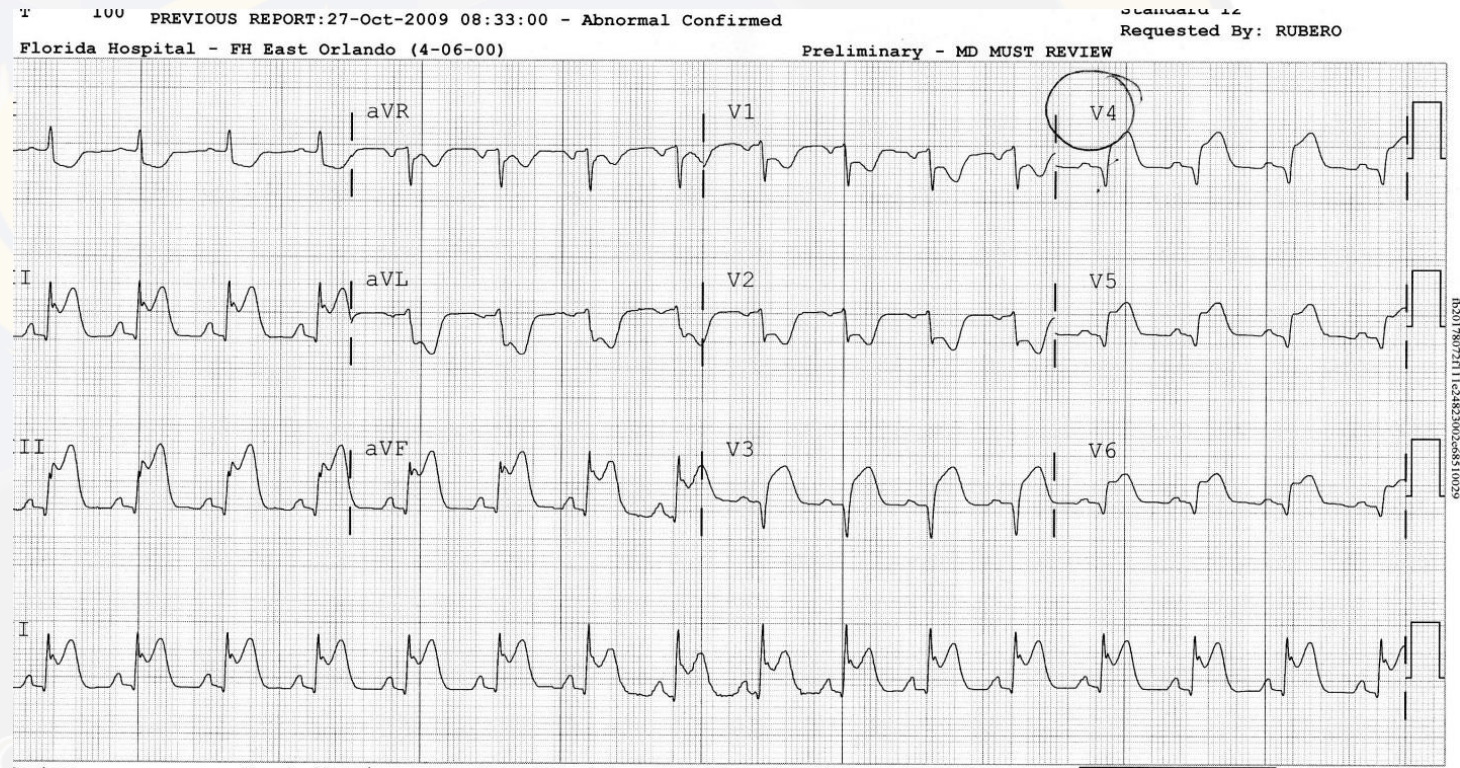
Posterior MI

Reverse EKG and upside down





- You give ASA and NTG when the BP ↓...
- What happened?
- Remember the first EKG?



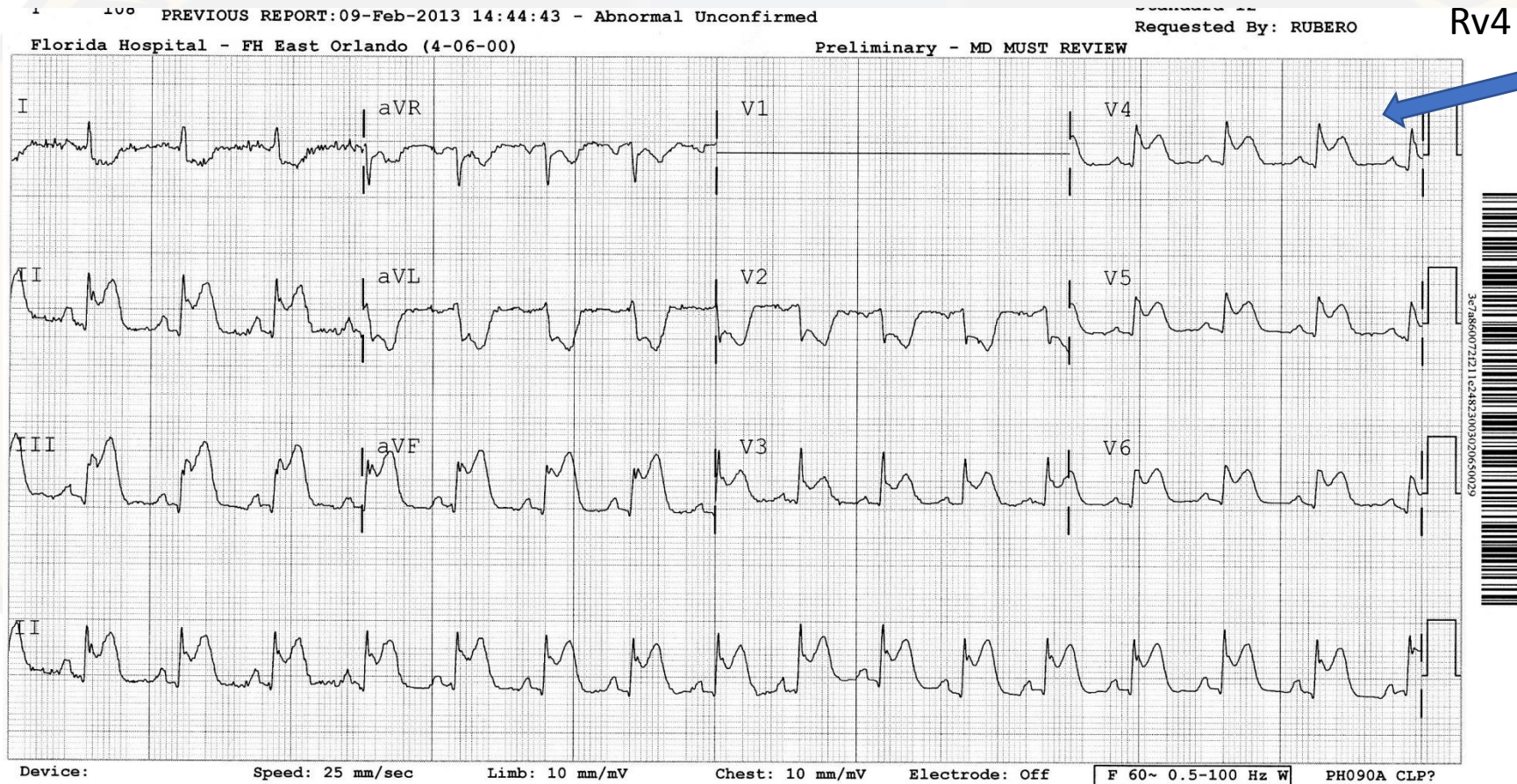
EKG's and ST Changes That Can Kill You

- Early repolarization (well, not really!)
- LVH
- AMI
- **RV AMI**
- Inverted T-wave in avL
- T wave in v1
- Pericarditis that is not
 - ST elevation in avR
 - Wellen's
 - de Winter
 - Torsades
 - LBBB
 - Pericarditis
 - Brugada's
 - HCM
 - LV aneurysm
 - New RAD
 - Prolonged QTc
 - Pericardial Tamponade
 - PE
 - Slow Vtaq
 - AIVR
 - WPW
 - Hyperkalemia
 - Hypothermia
 - CNS disorders
 - Takotsubo Syndrome
 - Spiked-Helmet Sign

Right Ventricle MI

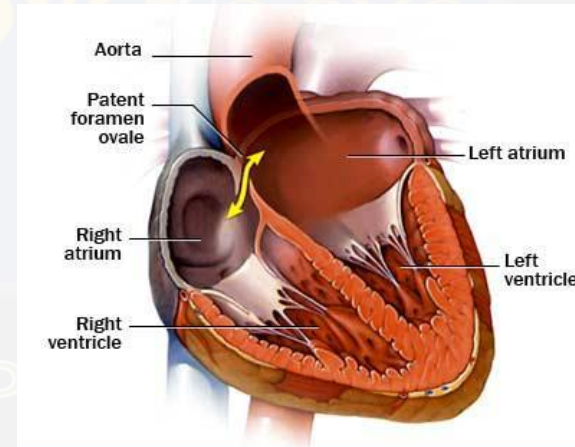
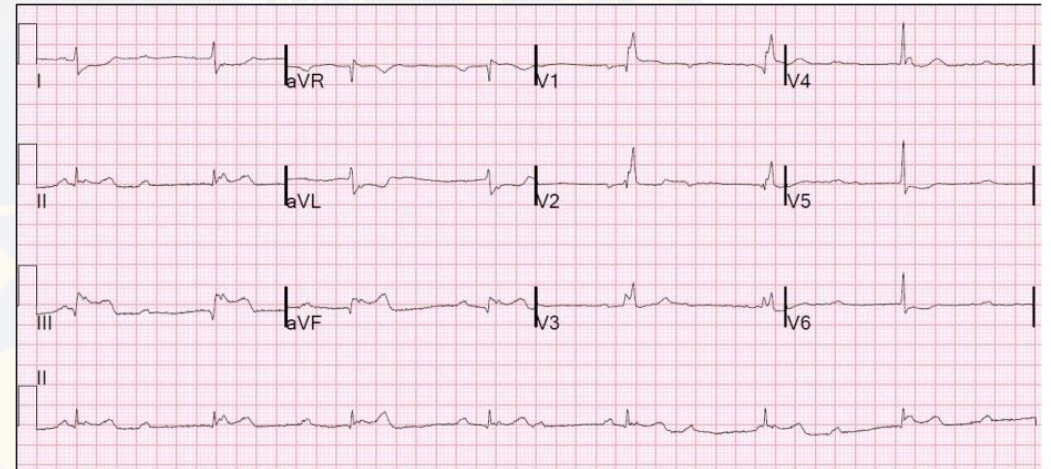
- BP will drop when giving NTG
- JVD +++; Lungs: CTA
- Extensive Inferior AMI
 - RCA occlusion
- Do right side EKG
- Treat hypotension with IVF's, Dobutamine

Right Side EKG



RV AMI Complications

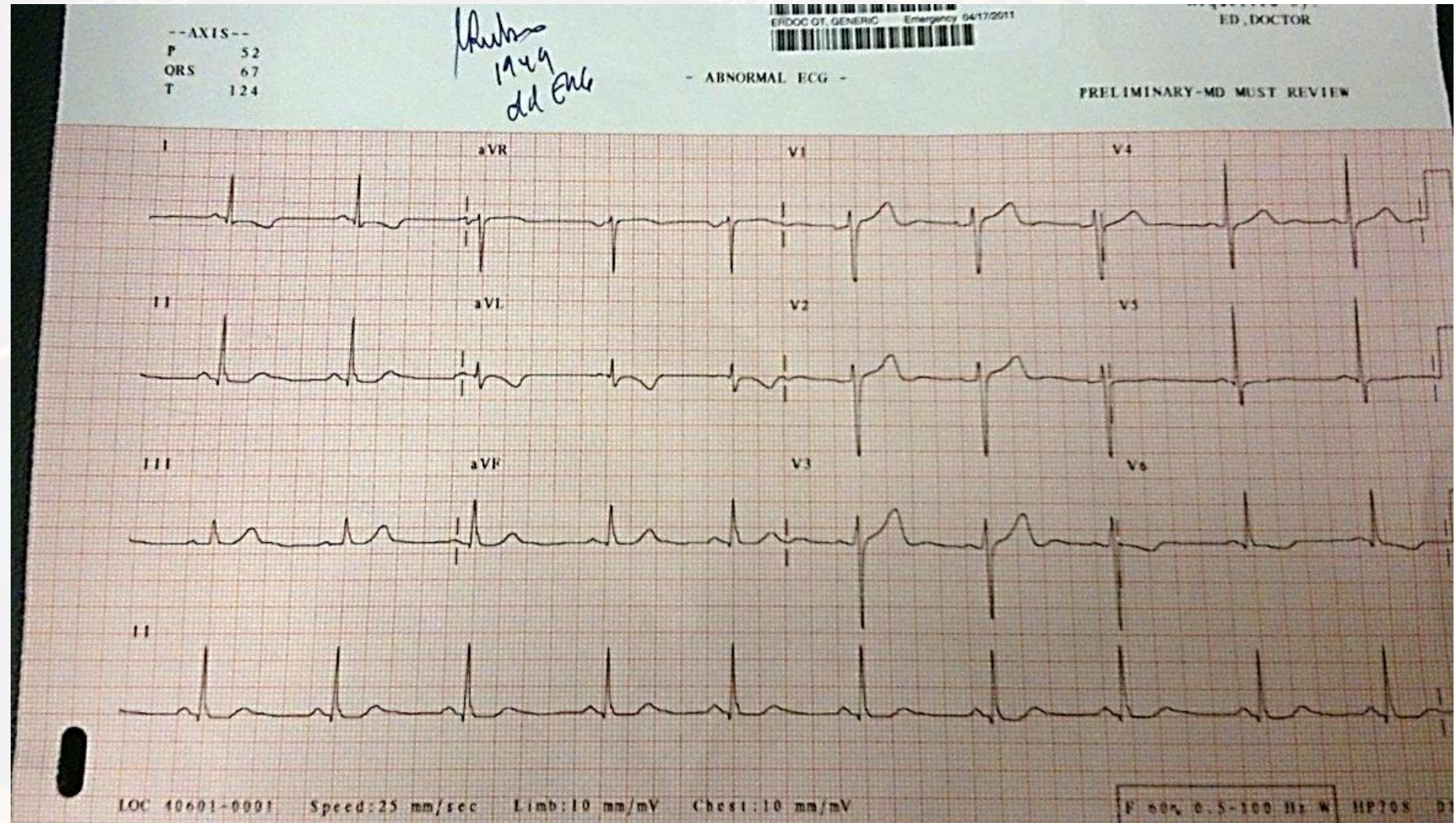
- Cardiogenic shock
- High-degree AV Block
- Afib
- Ruptured of interventricular septum
- Tricuspid regurgitation
- Opening of patent foramen ovale
 - Causing right to left shunt
 - Hypoxia



© Mayo Foundation for Medical Education and Research. All rights reserved.

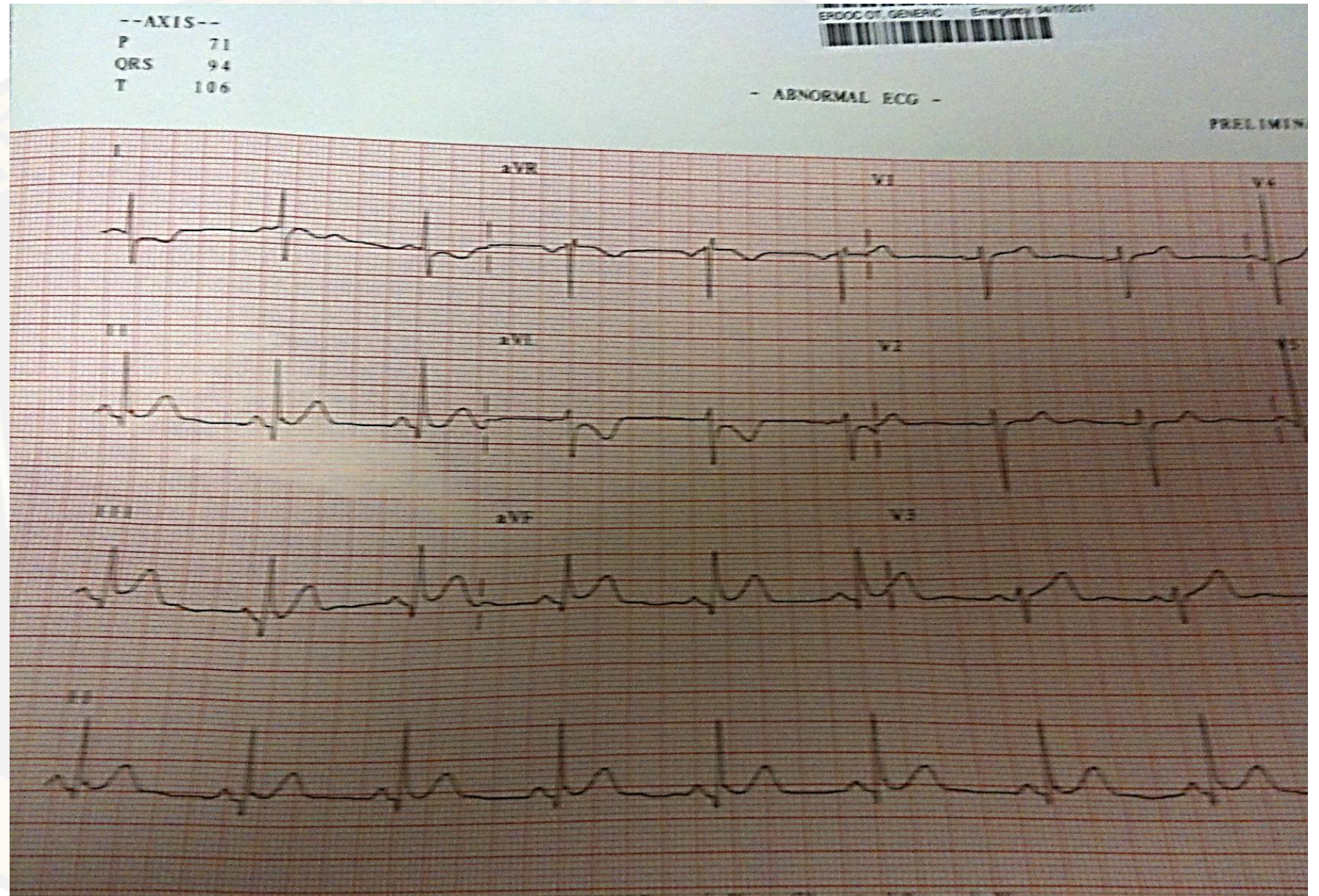
Other EKG Changes Suggesting AMI

- 46 y/o male with chest pain



- Call STEMI

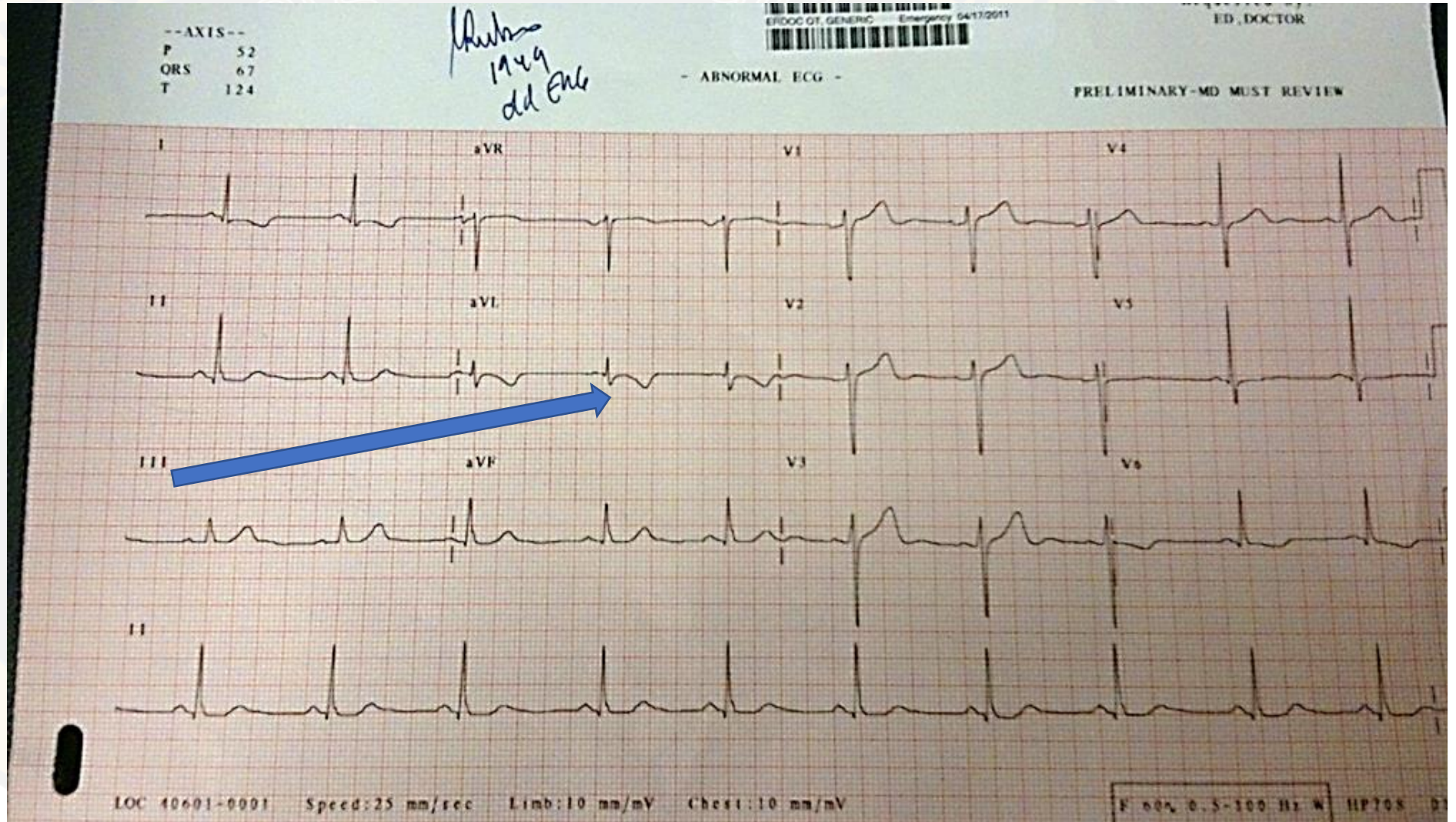
ECG #2



EKG's and ST Changes That Can Kill You

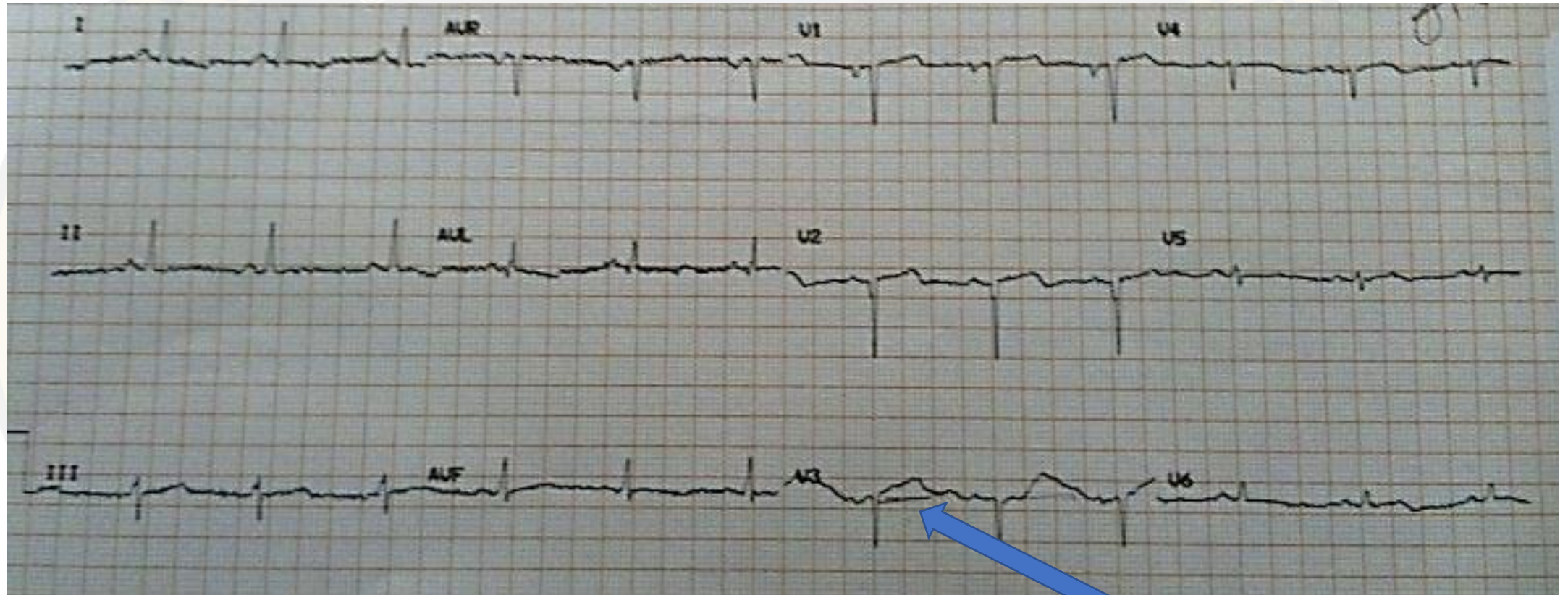
- Early repolarization (well, not really!)
- LVH
- AMI
- RV AMI
- **Inverted T-wave in avL**
- T wave in v1
- Pericarditis that is not
- ST elevation in avR
- Wellen's
- de Winter
- Torsades
- LBBB
- Pericarditis
- Brugada's
- HCM
- LV aneurysm
- New RAD
- Prolonged QTc
- Pericardial Tamponade
- PE
- Slow Vtaq
- AIVR
- WPW
- Hyperkalemia
- Hypothermia
- CNS disorders
- Takotsubo Syndrome
- Spiked-Helmet Sign

- An inverted T-wave in aVL is often associated to inferior MI



- Exceptions
 - LVH
 - LBBB

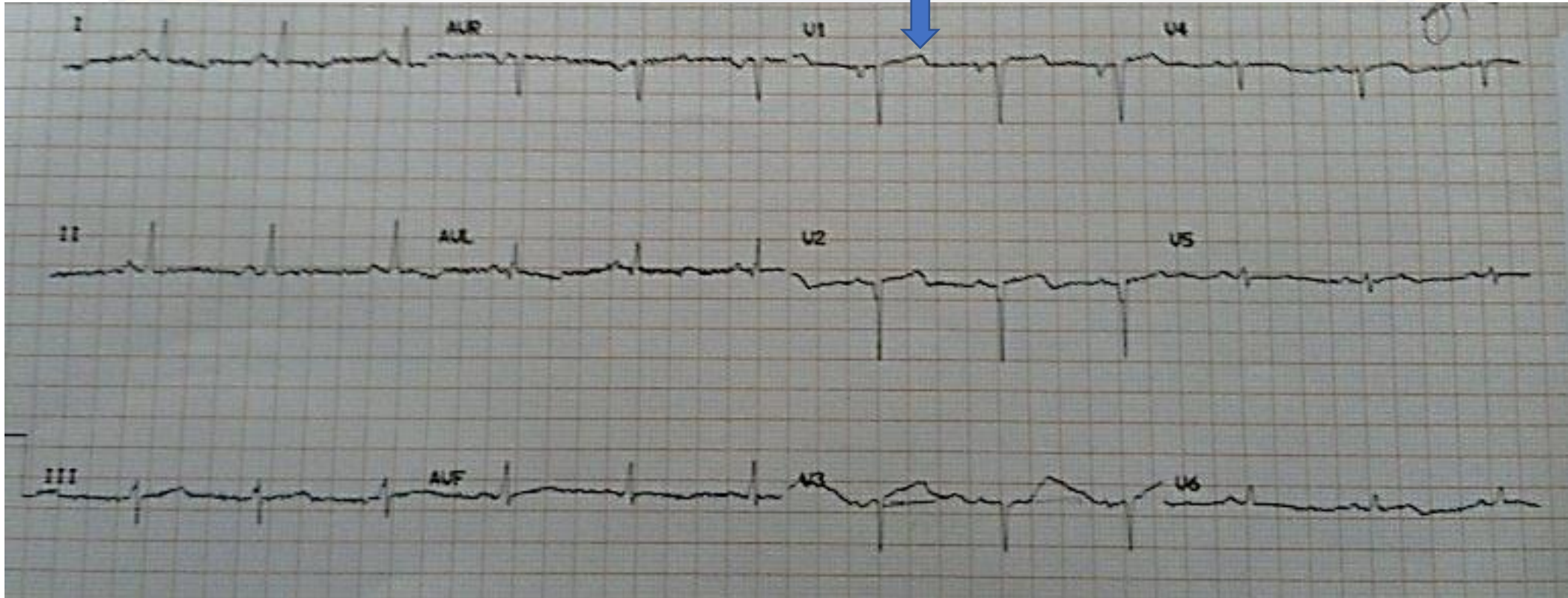
- 63 y/o man with right arm and hand pain



Documented as artifact

- Why I called STEMI?

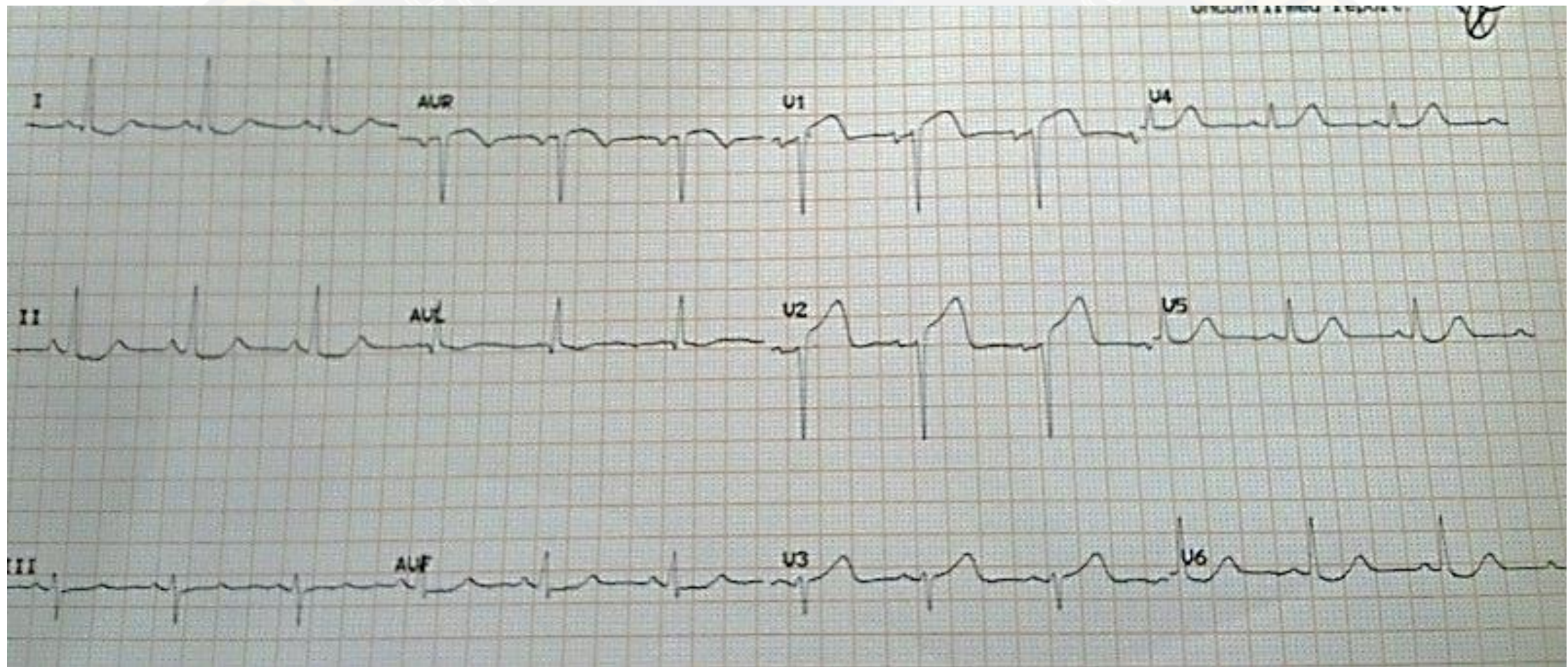
Upright T waves in V1 not normal, early STEMI



EKG's and ST Changes That Can Kill You

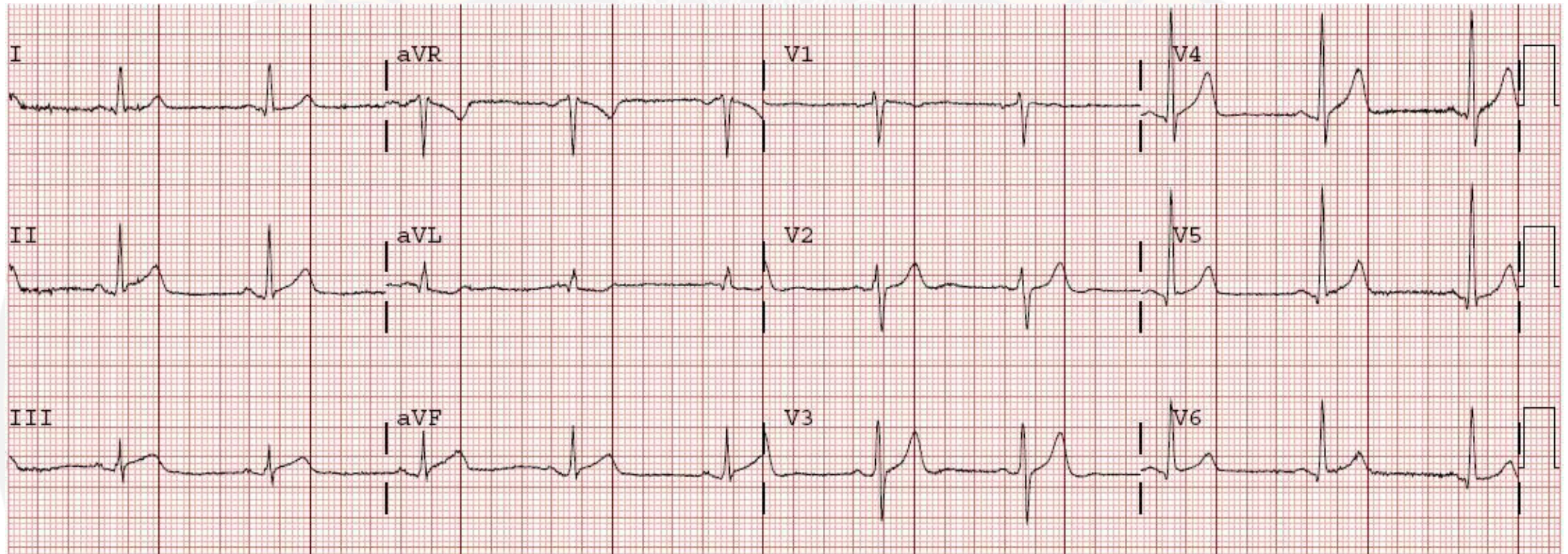
- Early repolarization (well, not really!)
- LVH
- AMI
- RV AMI
- Inverted T-wave in avL
- **T wave in v1**
- Pericarditis that is not
- ST elevation in avR
- Wellen's
- de Winter
- Torsades
- LBBB
- Pericarditis
- Brugada's
- HCM
- LV aneurysm
- New RAD
- Prolonged QTc
- Pericardial Tamponade
- PE
- Slow Vtaq
- AIVR
- WPW
- Hyperkalemia
- Hypothermia
- CNS disorders
- Takotsubo Syndrome
- Spiked-Helmet Sign

ECG #2



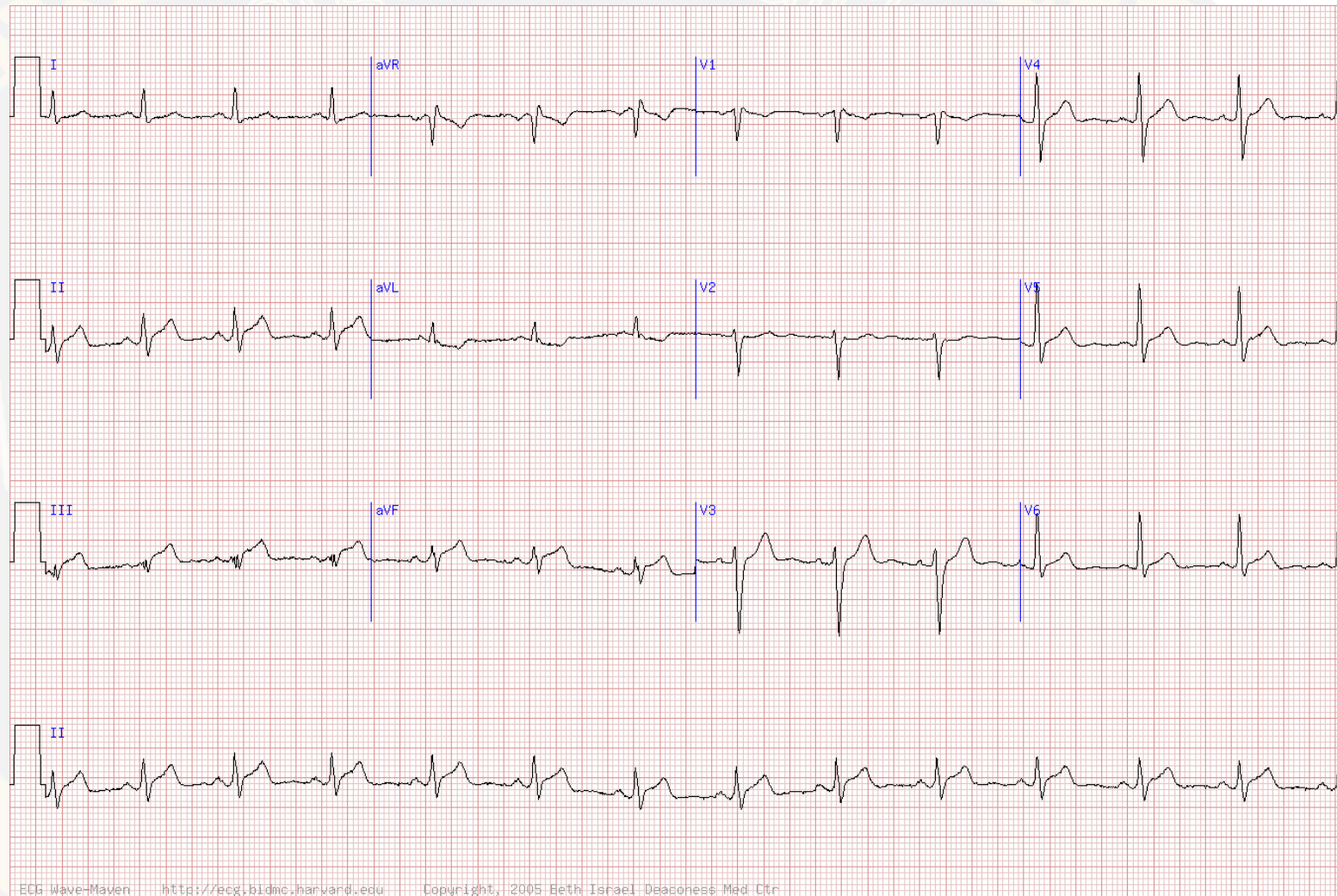
- T wave in V1 is normally flat or inverted
 - Occasionally is upright
 - In the elderly, usually not good
- Associated to left circumflex or RCA disease
- Also,
 - LVH
 - LBBB
 - Brugada
 - Pulmonary emboli

- 28 y/o male with chest pain and SOB



- Patient was discharged with the diagnosis of early repolarization vs. pericarditis
 - Will follow up with cardiology

- Patient returned by ambulance c/o increased CP after collapsing

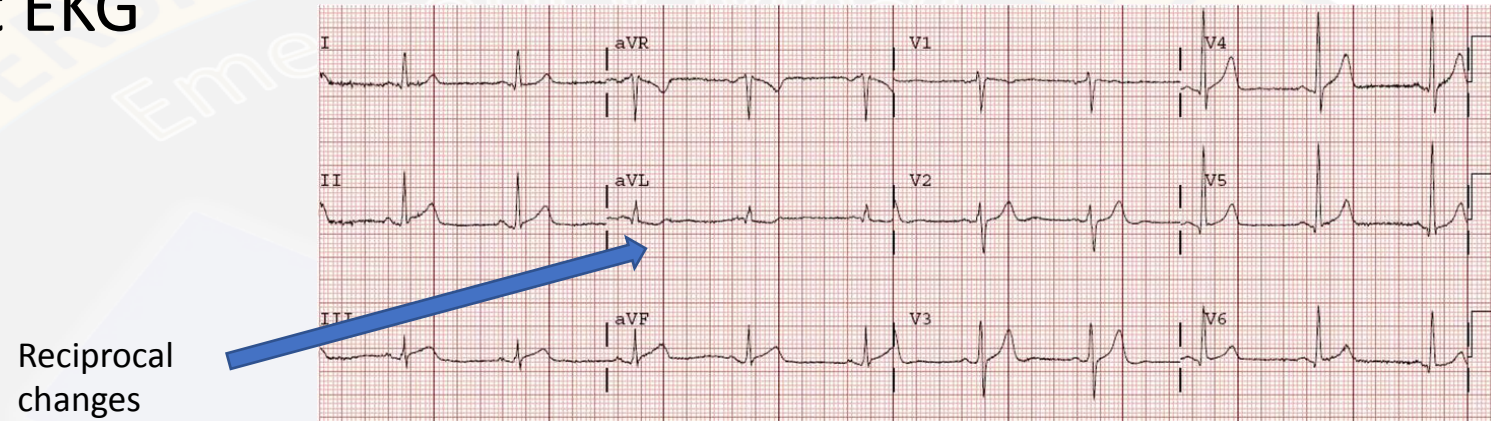


- I called STEMI

EKG's and ST Changes That Can Kill You

- Early repolarization (well, not really!)
- LVH
- AMI
- RV AMI
- Inverted T-wave in avL
- T wave in v1
- **Pericarditis that is not**
- ST elevation in avR
- Wellen's
- de Winter
- Torsades
- LBBB
- Pericarditis
- Brugada's
- HCM
- LV aneurysm
- New RAD
- Prolonged QTc
- Pericardial Tamponade
- PE
- Slow Vtaq
- AIVR
- WPW
- Hyperkalemia
- Hypothermia
- CNS disorders
- Takotsubo Syndrome
- Spiked-Helmet Sign

- I reviewed first EKG

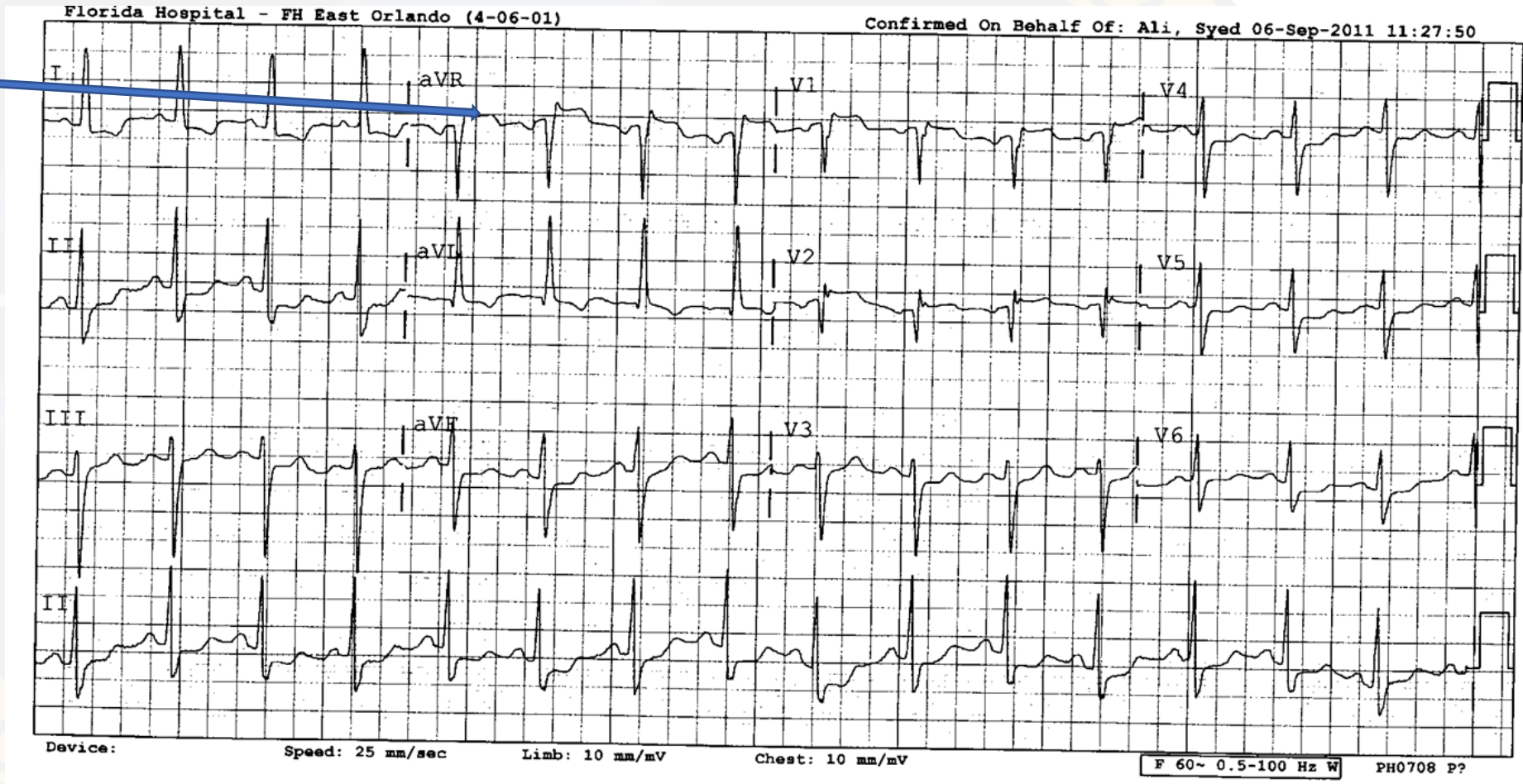
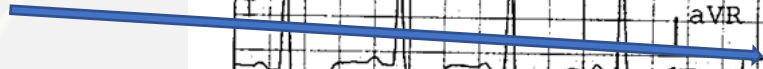


- Pericarditis does not have reciprocal changes



- 53 y/o female with CP and SOB

ST \uparrow in aVR



- Call STEMI
- Why?

EKG's and ST Changes That Can Kill You

- Early repolarization (well, not really!)
- LVH
- AMI
- RV AMI
- Inverted T-wave in avL
- T wave in v1
- Pericarditis that is not
 - **ST elevation in avR**
 - Wellen's
 - de Winter
 - Torsades
 - LBBB
 - Pericarditis
 - Brugada's
- HCM
- LV aneurysm
- New RAD
- Prolonged QTc
- Pericardial Tamponade
- PE
- Slow Vtaq
- AIVR
- WPW
- Hyperkalemia
- Hypothermia
- CNS disorders
- Takotsubo Syndrome
- Spiked-Helmet Sign

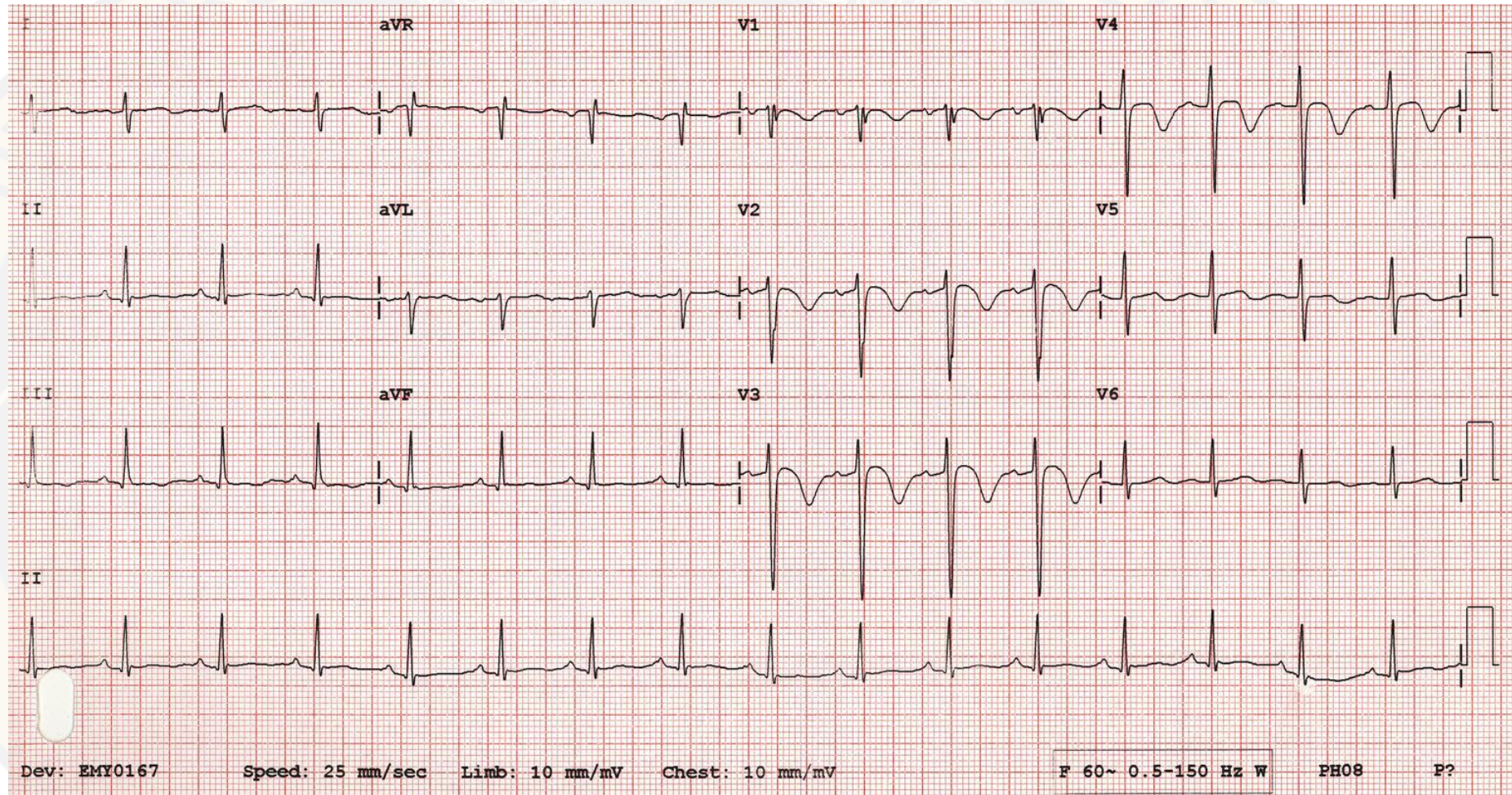
The forgotten lead

- LMA occlusion
- If ST \uparrow in aVR in addition
 - Consider LMA and/or LAD occlusions
- Treatment
 - PCI
 - CABG
 - Thrombolytic not work

“Widow Maker”

- Lesion in the main LCA or proximal LAD can have severe consequences, as suggested by the common nickname given to this vessel: “widow maker”
- The LAD supplies the anterior wall of the heart, including both ventricles, as well as the septum
- An occlusion in this vessel can result in serious ventricular dysfunction, thus placing the patient at serious risk for congestive heart failure (CHF) and death

52 y/o male with CP



Wellen syndrome

EKG's and ST Changes That Can Kill You

- Early repolarization (well, not really!)
- LVH
- AMI
- RV AMI
- Inverted T-wave in avL
- T wave in v1
- Pericarditis that is not
 - ST elevation in avR
 - **Wellen's**
 - de Winter
 - Torsades
 - LBBB
 - Pericarditis
 - Brugada's
 - HCM
 - LV aneurysm
 - New RAD
 - Prolonged QTc
 - Pericardial Tamponade
 - PE
 - Slow Vtaq
 - AIVR
 - WPW
 - Hyperkalemia
 - Hypothermia
 - CNS disorders
 - Takotsubo Syndrome
 - Spiked-Helmet Sign

Wellen's Syndrome

- Criteria

Criteria of Wellens' syndrome
Prior history of chest pain
Chest pain with normal ECG
Normal or minimally elevated cardiac enzymes
No pathologic precordial Q waves or loss of R waves
ST segment in V2 and V3 that is isoelectric or minimally elevated (1mm), concave or straight
Symmetric and deep T-wave inversion or biphasic T-waves in V2 to V5 or V6 in pain free periods
Tight proximal LAD stenosis

- Refers to these specific electrocardiographic (ECG) abnormalities in the precordial T-wave segment, which are associated with critical stenosis of the proximal left anterior descending (LAD) coronary artery

Wellens' syndrome

- Pattern of **deeply inverted or biphasic T waves in V2-3**
 - Highly specific for a **critical stenosis of the left anterior descending artery (LAD)**.
- Patients may be pain free by the time the ECG is taken and have normally or minimally elevated cardiac enzymes;
 - However, they are at extremely **high risk for extensive anterior wall MI** within the next few days to weeks.

Wellens' syndrome

- Due to the critical LAD stenosis,
 - These patients usually require invasive therapy
 - Poorly with medical management
 - May suffer MI or cardiac arrest if inappropriately stress tested

Understanding The T Wave Changes

- The following sequence of events is thought to occur in patients with Wellens' syndrome:
 1. A sudden occlusion of the LAD,
 - a. Causing a transient anterior STEMI.
 - b. The patient has chest pain & diaphoresis.
 - c. This stage may not be successfully captured on an ECG recording.

Understanding The T Wave Changes

- The following sequence of events is thought to occur in patients with Wellens' syndrome:
 2. Re-perfusion of the LAD (e.g. due to spontaneous clot lysis or prehospital aspirin).
 - a. The chest pain resolves.
 - b. ST elevation improves and T waves become biphasic or inverted.
 - c. The T wave morphology is identical to patients who reperfuse after a successful PCI.

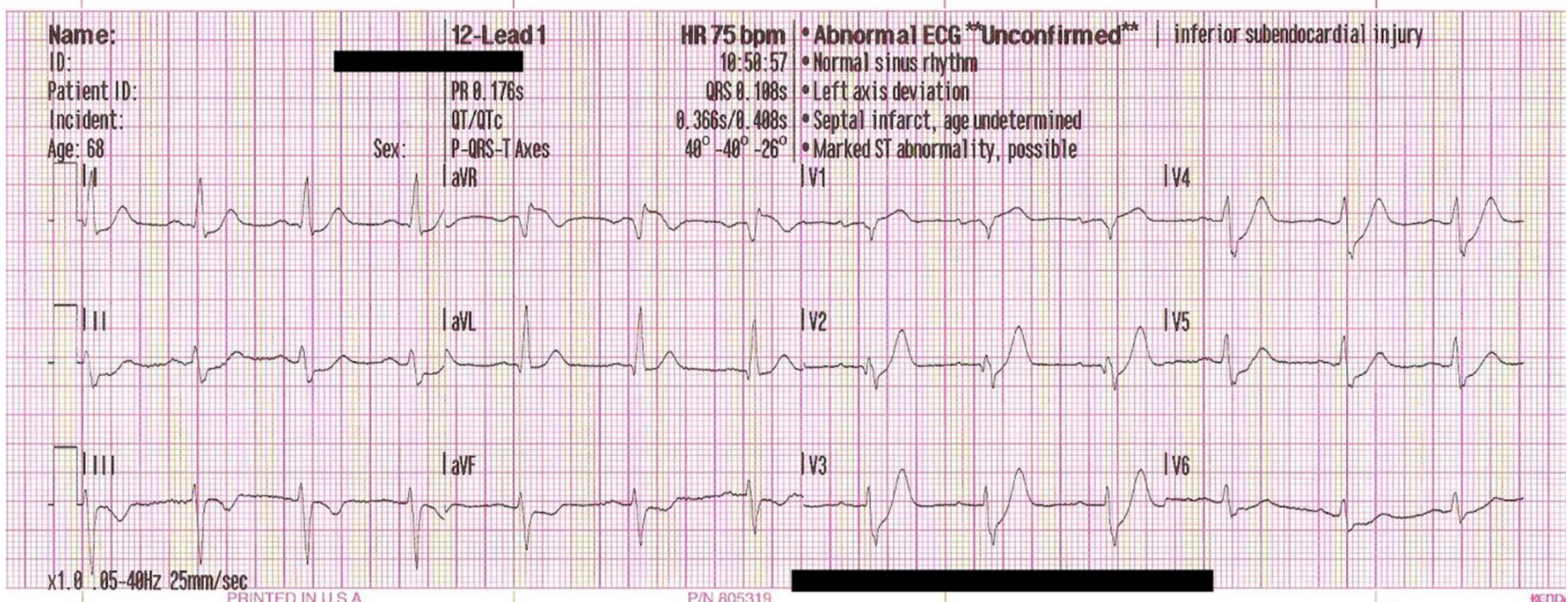
Understanding The T Wave Changes

- The following sequence of events is thought to occur in patients with Wellens' syndrome:
 3. If the artery remains open, the T waves evolve over time from biphasic to deeply inverted.
 4. The coronary perfusion is unstable, however, and the LAD can re-occlude at any time.
 - a. If this happens, the first sign on the ECG is an apparent normalization of the T waves — so-called “pseudo-normalization”.
 - b. The T waves switch from biphasic/inverted to upright and prominent.
 - c. This is a sign of hyperacute STEMI and is usually accompanied by recurrence of chest pain, although the ECG changes can precede the symptoms.

Understanding The T Wave Changes

- The following sequence of events is thought to occur in patients with Wellens' syndrome:
 5. If the artery remains occluded, the patient now develops an evolving anterior STEMI.
 6. Alternatively, a “stuttering” pattern may develop, with intermittent reperfusion and re-occlusion.
 - a. This would manifest as alternating ECGs demonstrating Wellens' and pseudonormalization/STEMI patterns.

- This sequence of events is not limited to the anterior leads — similar changes may be seen in the inferior or lateral leads, e.g. with RCA or circumflex occlusion.
- Also, the inciting event does not necessarily have to be thrombus formation:
 - Wellens' syndrome may also occur in normal coronary arteries following an episode of vasospasm, as in this case of cocaine-induced vasospasm.
- However, it is safer to assume the worst (i.e. critical LAD stenosis) and work the patient up for an angiogram.



EKG's and ST Changes That Can Kill You

- Early repolarization (well, not really!)
- LVH
- AMI
- RV AMI
- Inverted T-wave in avL
- T wave in v1
- Pericarditis that is not
 - ST elevation in avR
 - Wellen's
 - **de Winter**
 - Torsades
 - LBBB
 - Pericarditis
 - Brugada's
 - HCM
 - LV aneurysm
 - New RAD
 - Prolonged QTc
 - Pericardial Tamponade
 - PE
 - Slow Vtaq
 - AIVR
 - WPW
 - Hyperkalemia
 - Hypothermia
 - CNS disorders
 - Takotsubo Syndrome
 - Spiked-Helmet Sign

New ECG Sign of Proximal LAD Occlusion

- de Winter STEMI

- 1-3 mm upsloping ST-segment depression at the J point in the leads V₁ to V₆ that continued into tall, positive symmetrical T waves in the precordial leads
- Absence of ST elevation in the precordial leads
- ST segment elevation (0.5mm-1mm) in aVR
- “Normal” STEMI morphology may precede or follow the deWinter pattern
- Found to have proximal LAD occlusion

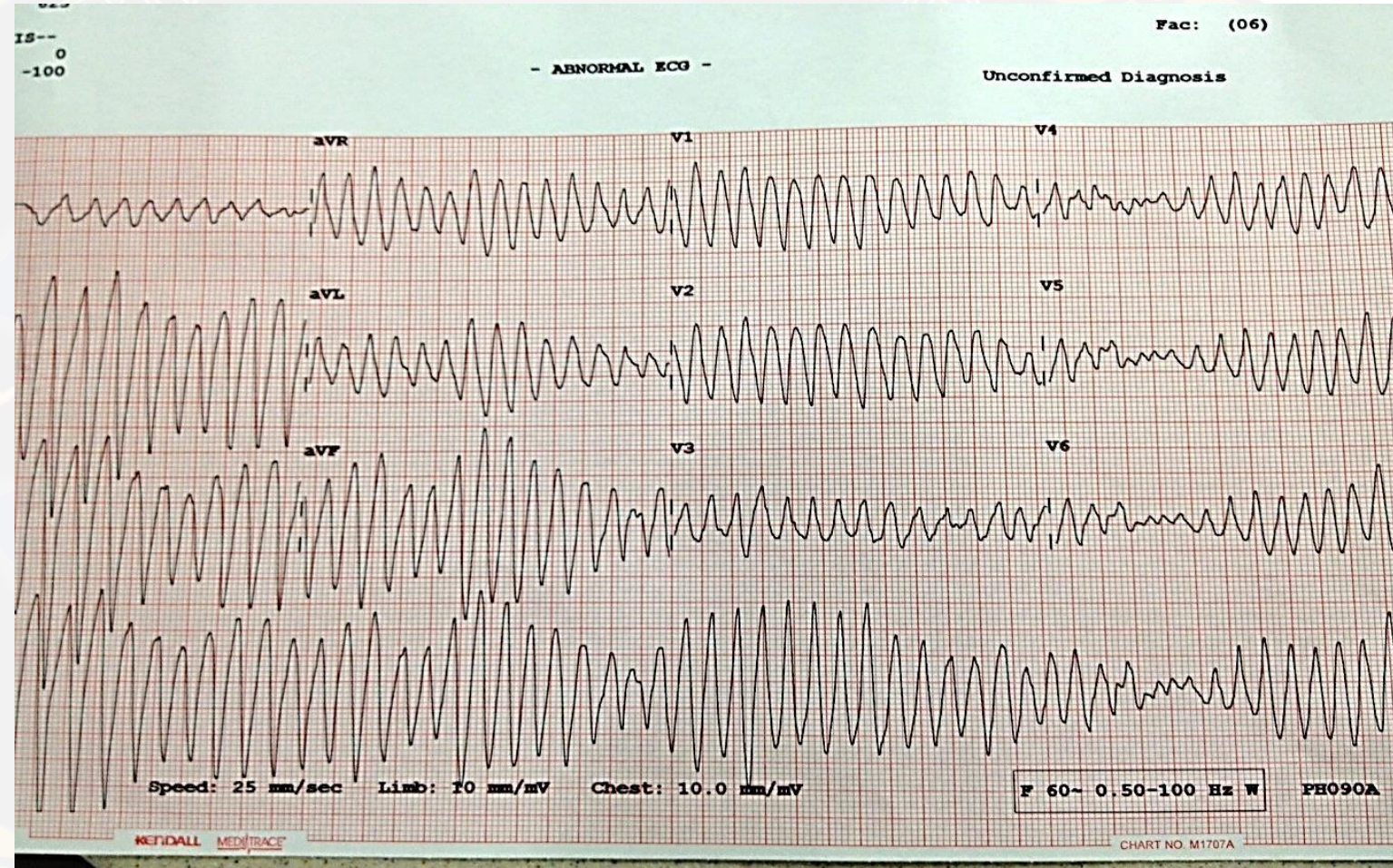
“de Winter” ST/T-wave complexes



The de Winter ECG pattern

- An **anterior STEMI equivalent** that presents *without* obvious ST segment elevation.
- Key diagnostic features include **ST depression** and **peaked T waves** in the **precordial leads**.
- Seen in **~2% of acute LAD occlusions** and is under-recognised by clinicians.
- Unfamiliarity with this high-risk ECG pattern may lead to under-treatment (e.g. failure of cath lab activation), with attendant negative effects on morbidity and mortality.

- Patient started complaining of Chest pain when suddenly.....
- She collapsed.....

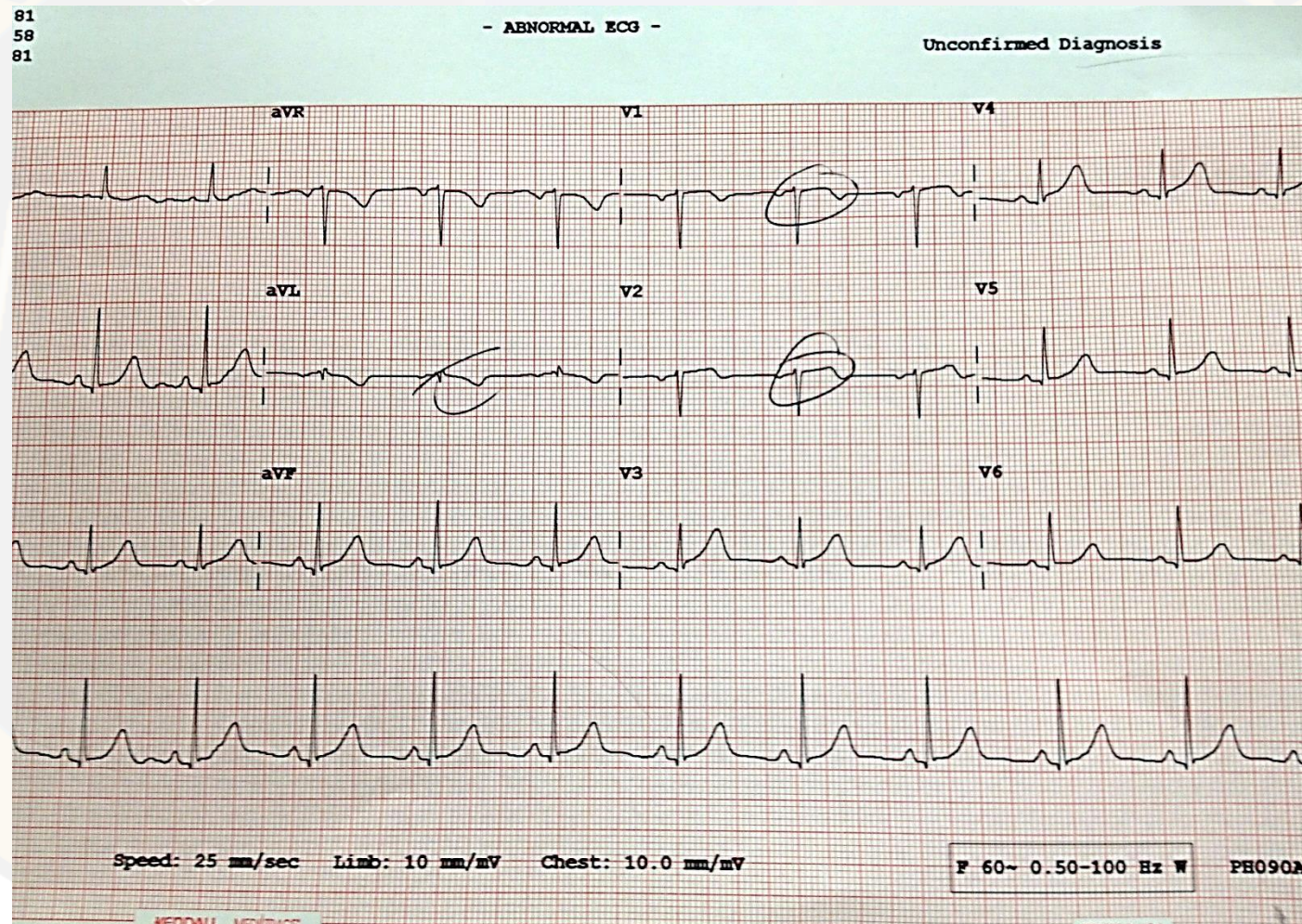


- What is going?
 - She is having a seizure?
 - Someone is tickling her?
 - She is dancing?
 - Torsade's de Pointe
- What is the treatment?
 - Anticonvulsant?
 - Stop tickling her?
 - Defibrillate
 - Add MgSO4

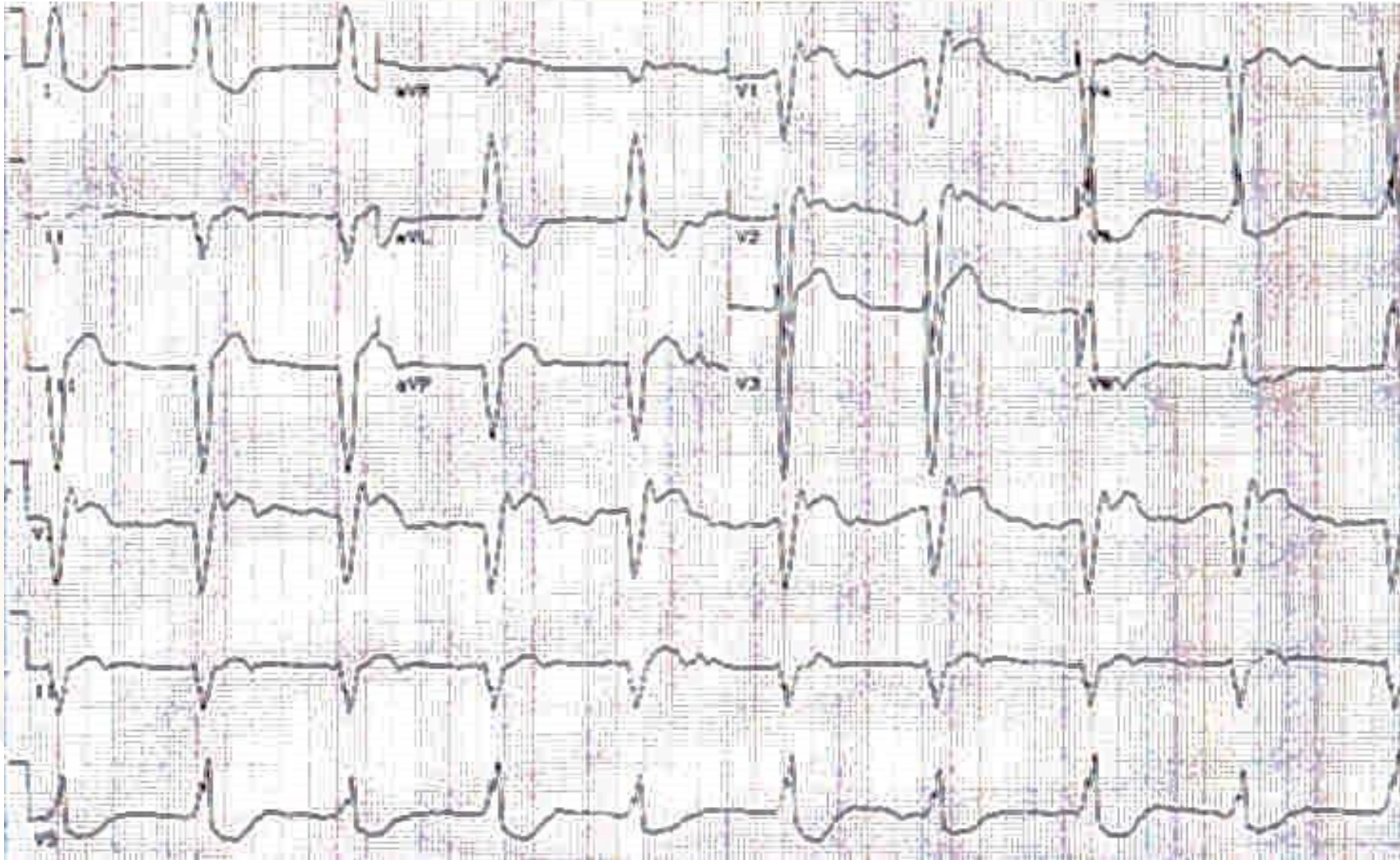
EKG's and ST Changes That Can Kill You

- Early repolarization (well, not really!)
- LVH
- AMI
- RV AMI
- Inverted T-wave in avL
- T wave in v1
- Pericarditis that is not
 - ST elevation in avR
 - Wellen's
 - de Winter
 - **Torsades**
 - LBBB
 - Pericarditis
 - Brugada's
- HCM
- LV aneurysm
- New RAD
- Prolonged QTc
- Pericardial Tamponade
- PE
- Slow Vtaq
- AIVR
- WPW
- Hyperkalemia
- Hypothermia
- CNS disorders
- Takotsubo Syndrome
- Spiked-Helmet Sign

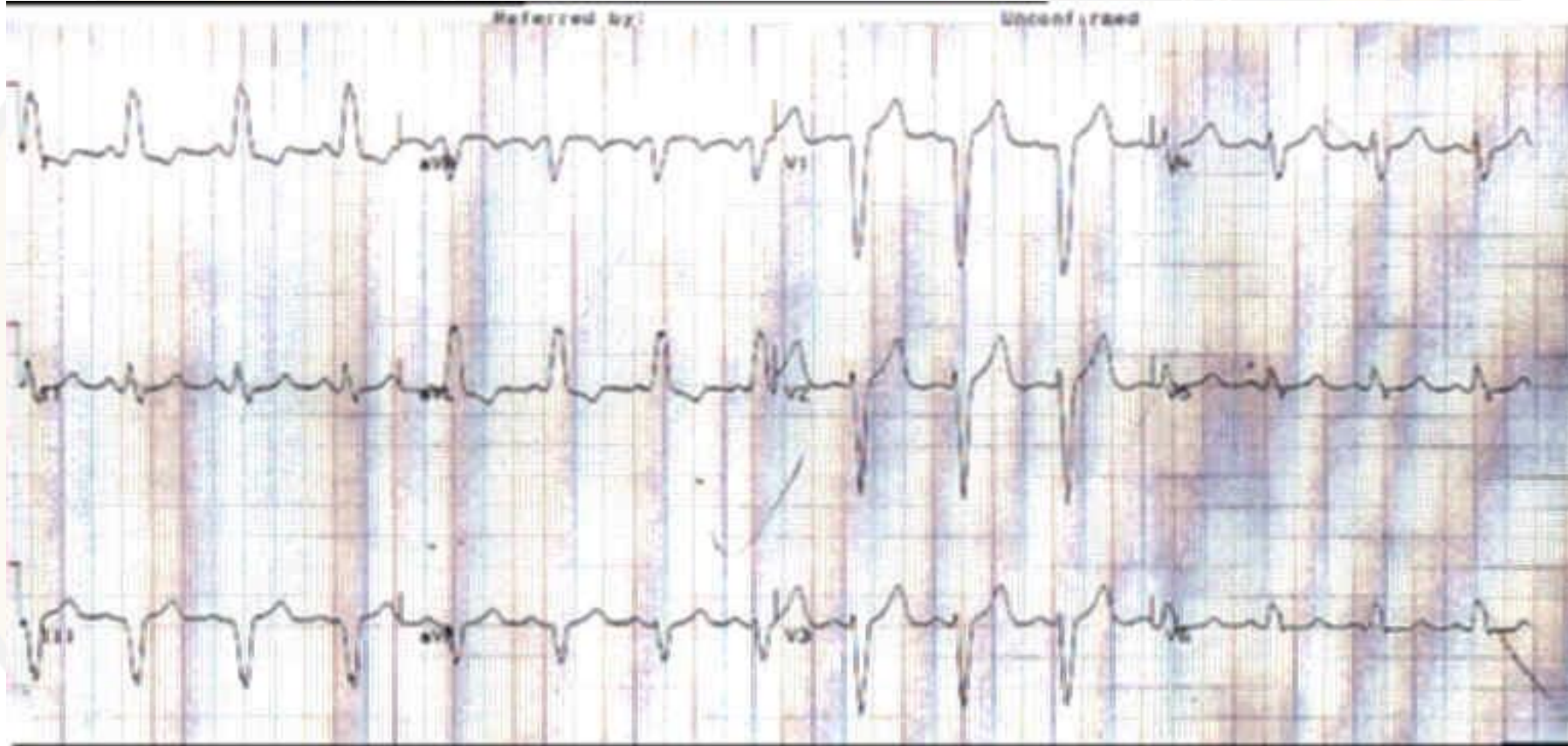
STEMI → Torsade's de Pointe



- Chest pain
- Irradiates to the left side
- SOB
- DOE
- PMHx: none
- Meds: none
- Etc.



Old EKG

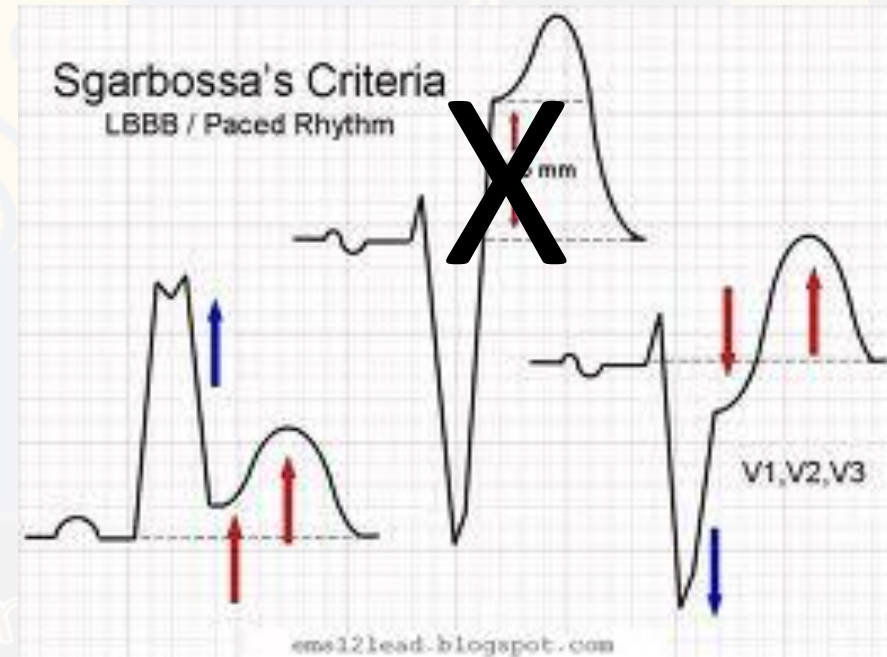


EKG's and ST Changes That Can Kill You

- Early repolarization (well, not really!)
- LVH
- AMI
- RV AMI
- Inverted T-wave in avL
- T wave in v1
- Pericarditis that is not
 - ST elevation in avR
 - Wellen's
 - de Winter
 - Torsades
 - **LBBB**
 - Pericarditis
 - Brugada's
- HCM
- LV aneurysm
- New RAD
- Prolonged QTc
- Pericardial Tamponade
- PE
- Slow Vtaq
- AIVR
- WPW
- Hyperkalemia
- Hypothermia
- CNS disorders
- Takotsubo Syndrome
- Spiked-Helmet Sign

Sgarbossa Criteria

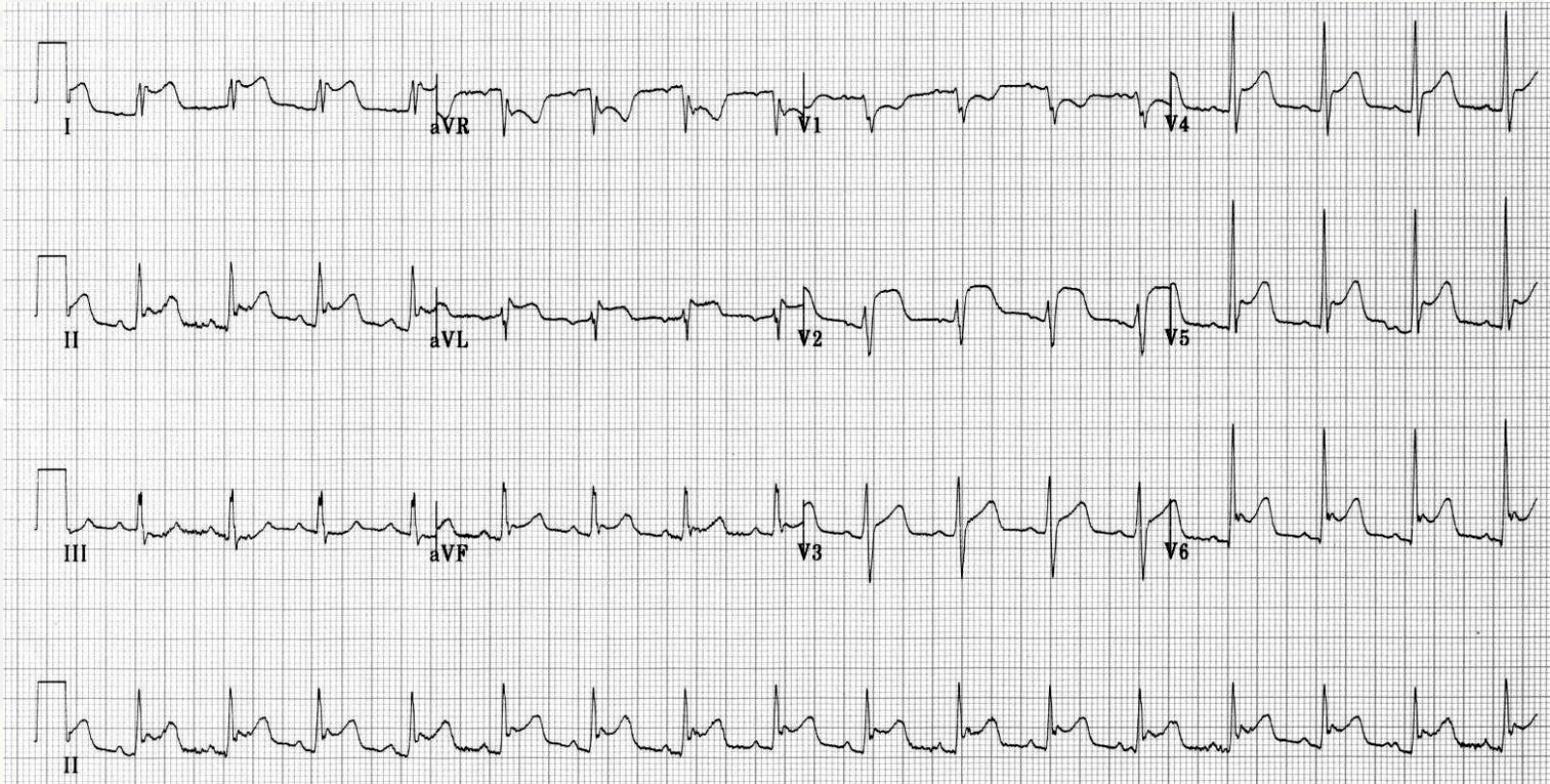
- ST-segment elevation >1 mm in lead with concordant QRS complex = 5 points
- ST-segment depression >1 mm in leads v1, v2, or v3 = 3 points
- ST-segment elevation >5 mm in lead with discordant QRS complex = 2 points
- (3 points or more is positive $\sim 70\%$)



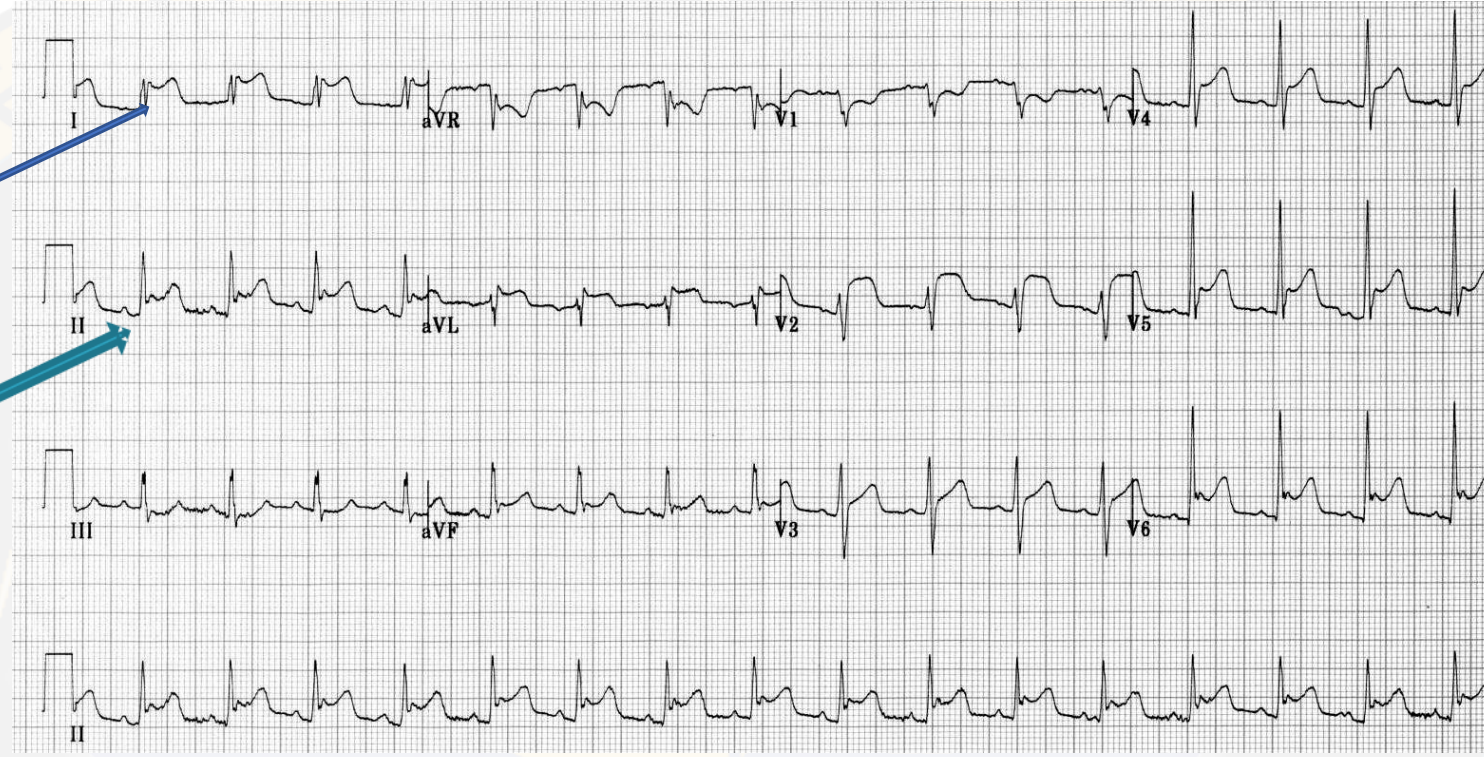
- Chest pain
- Irradiates to the left side
- SOB
- DOE
- PMHx: none
- Meds: none
- Etc.

- VS
 - HR 82; BP 148/90; RR 18; T 99; O2sat 98%
- PE
 - HEENT: WNL
 - Chest: CTA; RRR
 - Abd: WNL
 - Ext: no edema
 - Neuro: WNL

EKG



- What is it?
- STEMI?



- Diffused ST elevations with
- No reciprocal changes
- PR depression



EKG's and ST Changes That Can Kill You

- Early repolarization (well, not really!)
- LVH
- AMI
- RV AMI
- Inverted T-wave in avL
- T wave in v1
- Pericarditis that is not
 - ST elevation in avR
 - Wellen's
 - de Winter
 - Torsades
 - LBBB
 - **Pericarditis**
 - Brugada's
- HCM
- LV aneurysm
- New RAD
- Prolonged QTc
- Pericardial Tamponade
- PE
- Slow Vtaq
- AIVR
- WPW
- Hyperkalemia
- Hypothermia
- CNS disorders
- Takotsubo Syndrome
- Spiked-Helmet Sign



A.

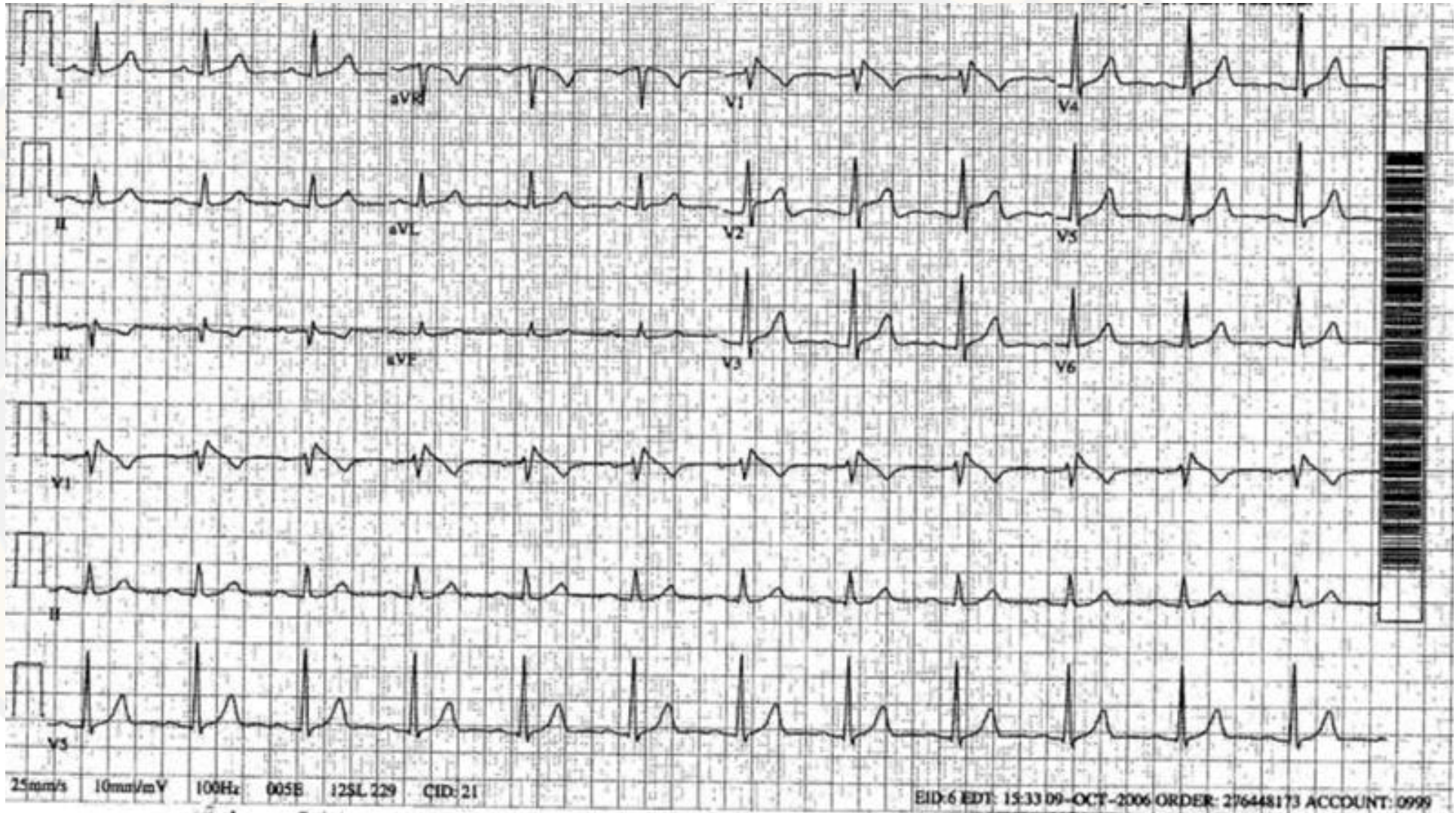


B.

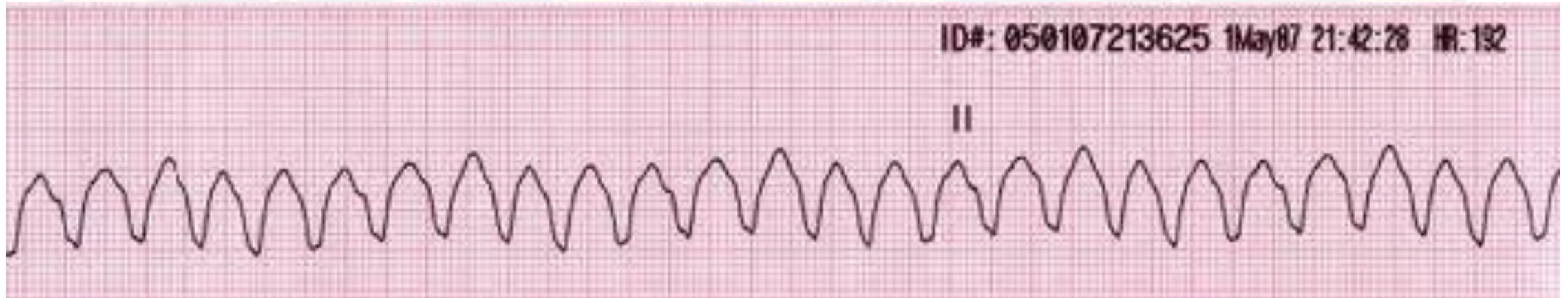


C.

- 28 y/o woman with syncope



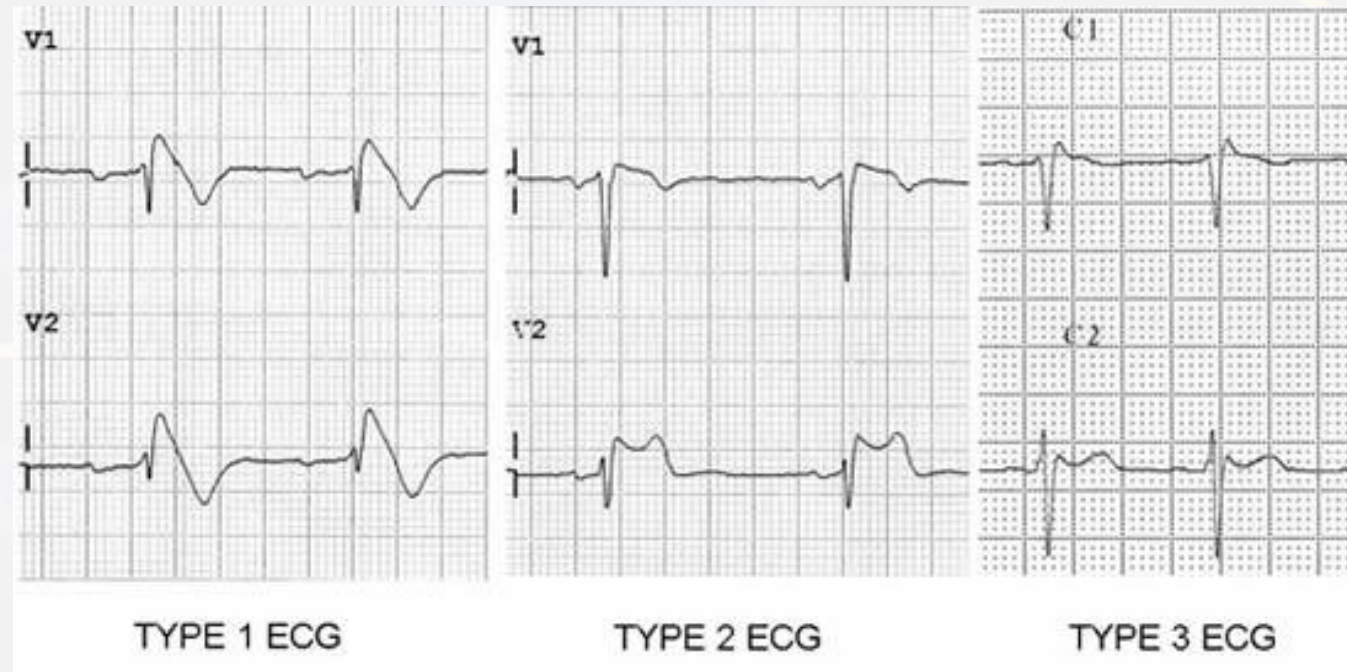
- Patient is discharged
- Patient returned to ED by EMS pulseless with this rhythm



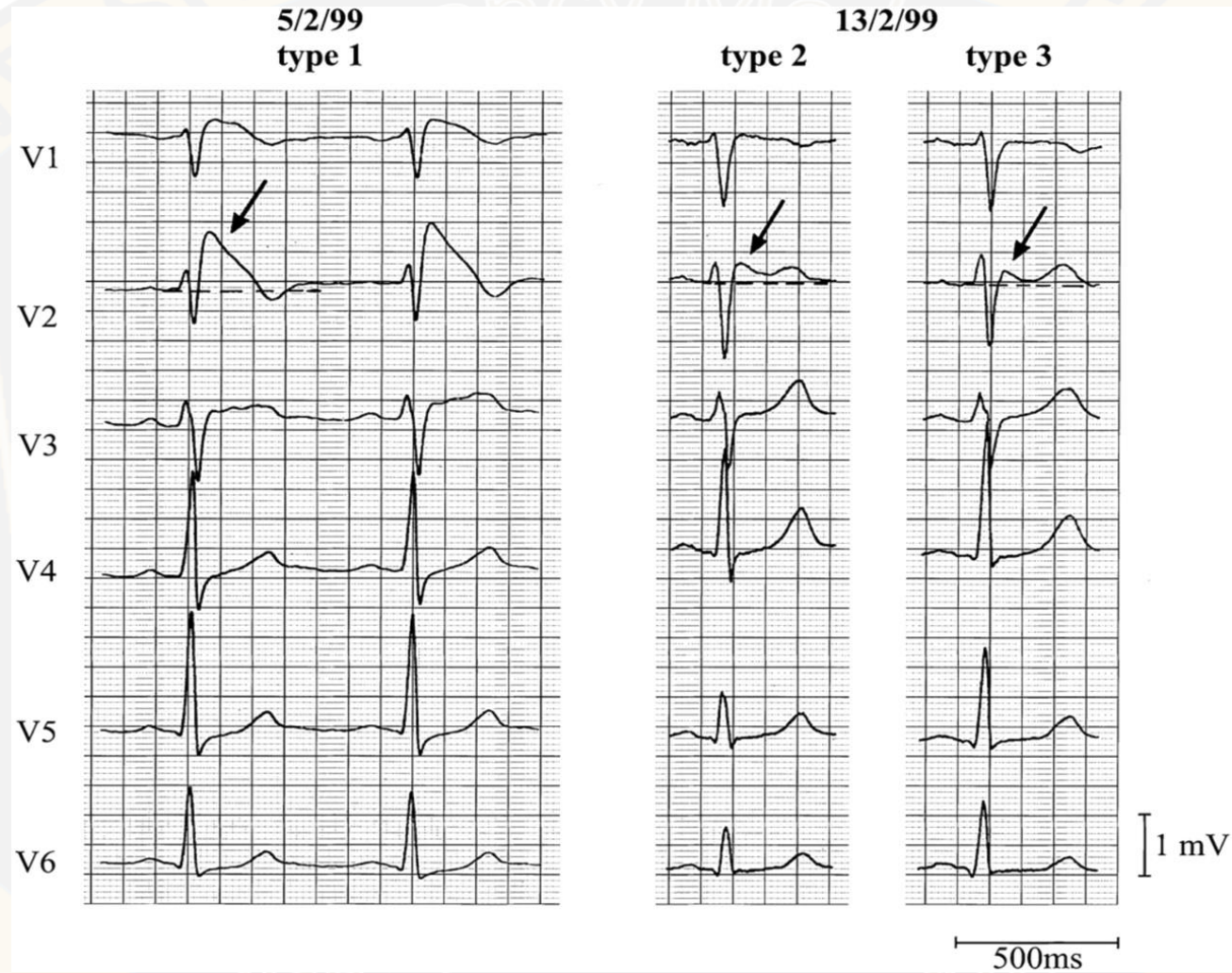
EKG's and ST Changes That Can Kill You

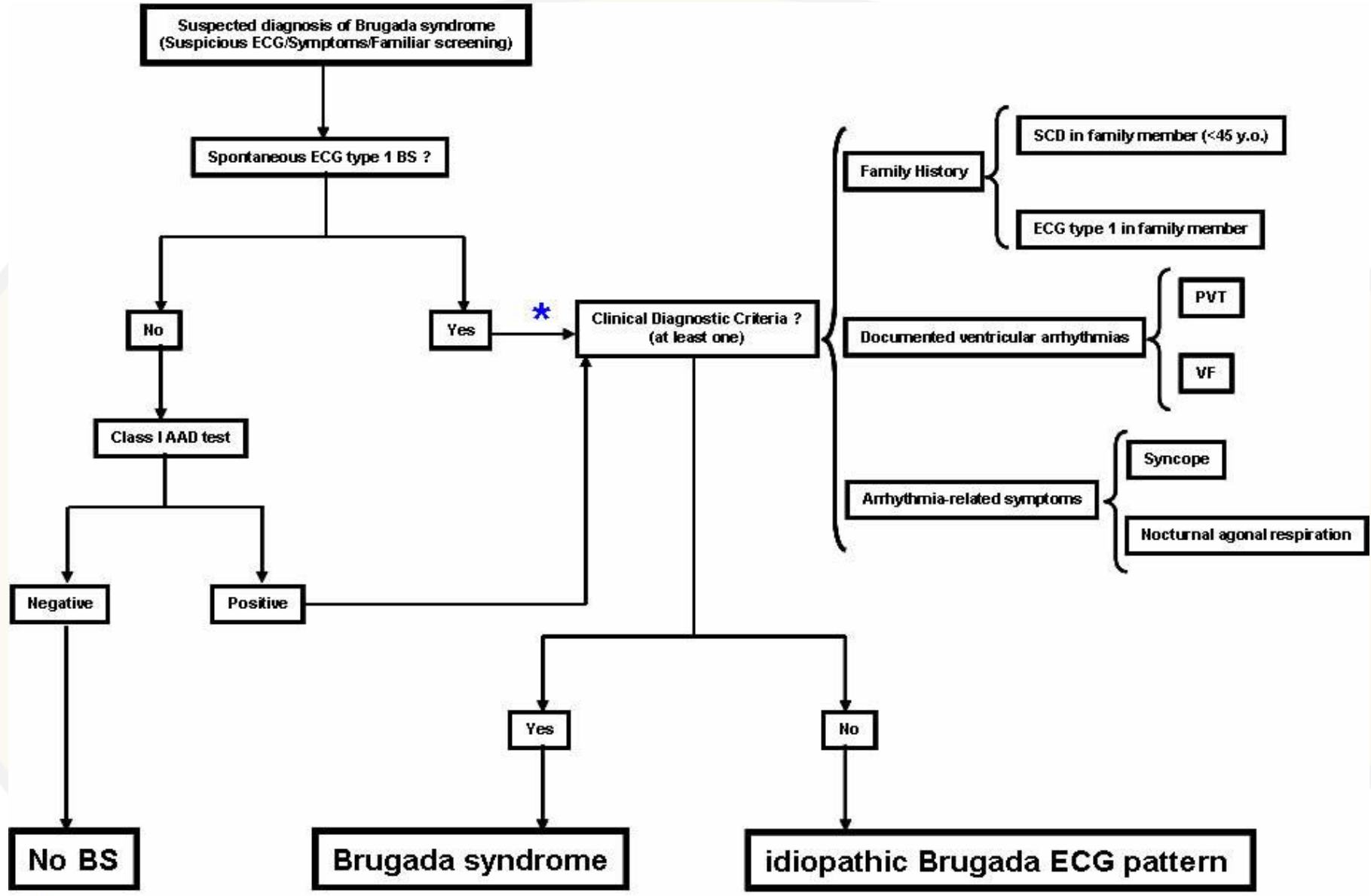
- Early repolarization (well, not really!)
- LVH
- AMI
- RV AMI
- Inverted T-wave in avL
- T wave in v1
- Pericarditis that is not
 - ST elevation in avR
 - Wellen's
 - de Winter
 - Torsades
 - LBBB
 - Pericarditis
 - **Brugadas**
- HCM
- LV aneurysm
- New RAD
- Prolonged QTc
- Pericardial Tamponade
- PE
- Slow Vtaq
- AIVR
- WPW
- Hyperkalemia
- Hypothermia
- CNS disorders
- Takotsubo Syndrome
- Spiked-Helmet Sign

Brugada



ECG changes in the Brugada syndrome

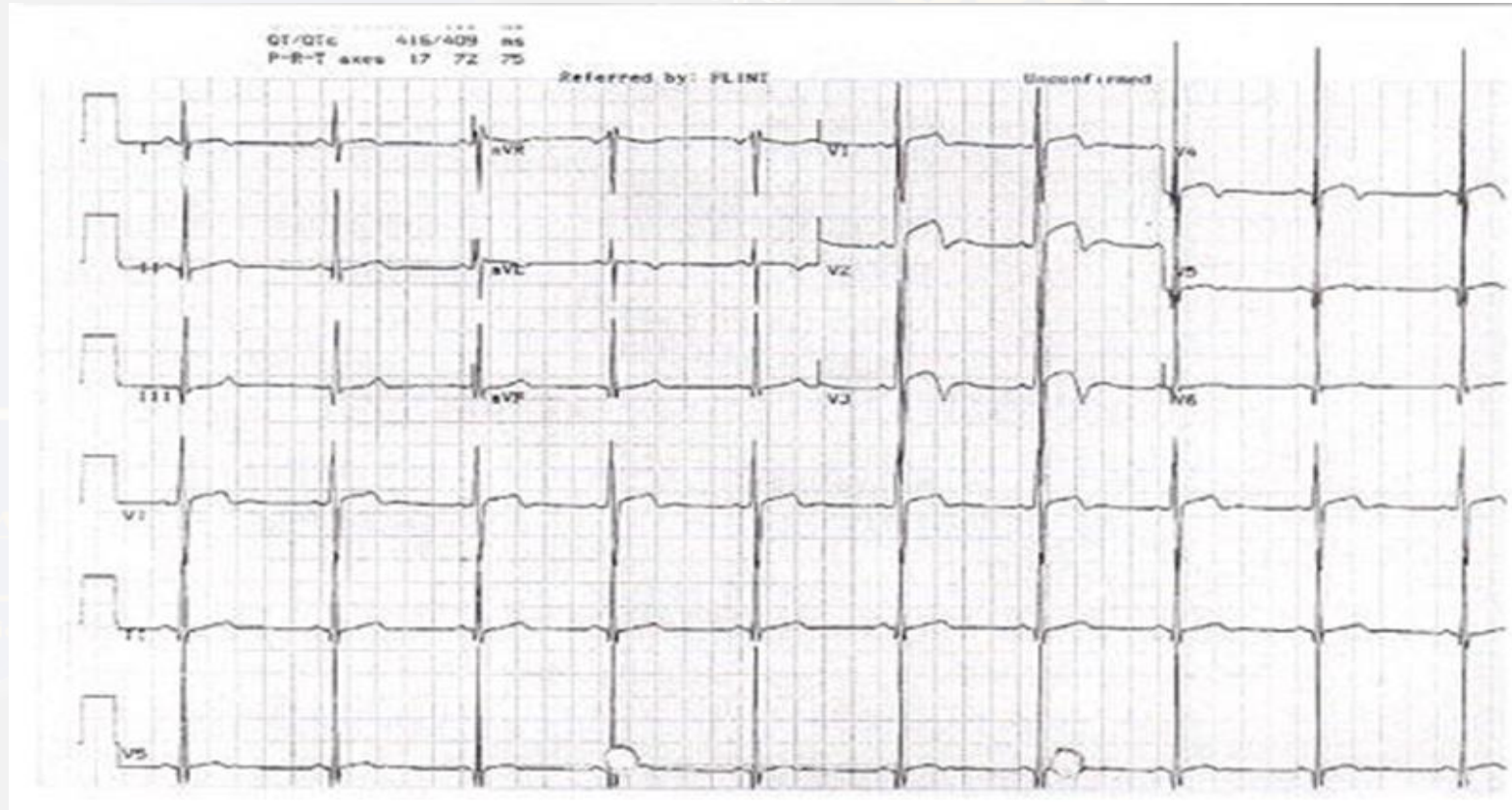




* Exclude confounding factors

- More common cause of sudden death (4-5%)
 - Up to 20% in individuals without structural heart disease
 - Most common in young males <40 y/o

- 19 y/o college student in training
- Dehydrated, sweating
- Not drinking a lot of fluids
- Near-syncope, palpitations



- Patient was discharged after fluids and electrolytes were replaced
- Patient returned to ED by EMS pulseless with the following rhythm

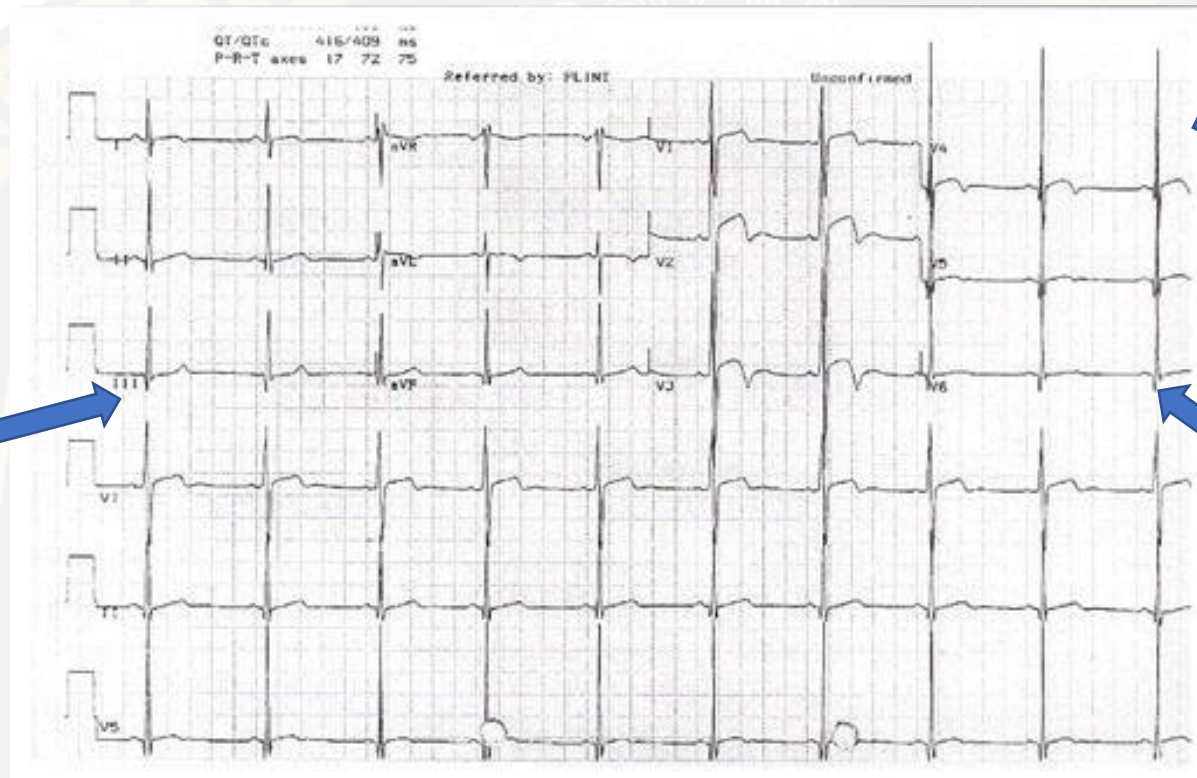


EKG's and ST Changes That Can Kill You

- Early repolarization (well, not really!)
- LVH
- AMI
- RV AMI
- Inverted T-wave in avL
- T wave in v1
- Pericarditis that is not
- ST elevation in avR
- Wellen's
- de Winter
- Torsades
- LBBB
- Pericarditis
- Brugada's
- H(O)CM
- LV aneurysm
- New RAD
- Prolonged QTc
- Pericardial Tamponade
- PE
- Slow Vtaq
- AIVR
- WPW
- Hyperkalemia
- Hypothermia
- CNS disorders
- Takotsubo Syndrome
- Spiked-Helmet Sign

HCM

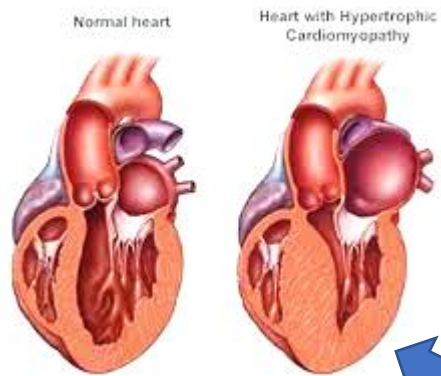
- Genetics factors involved
- 0.02-2% of general population
- Hypertrophied but nondilated left ventricle
 - Thickening is usually asymmetric, involving the septum to a greater extent than the free ventricular wall
 - C-Xray with no CM
- Mortality 3.5% per year
- Symptoms often associated with exertion



Deep narrow Q-waves in the inferior and/or lateral leads

LVH

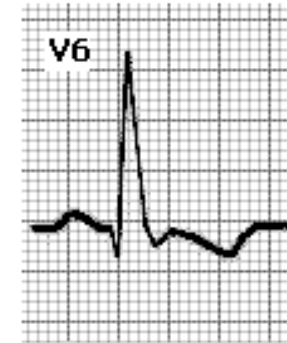
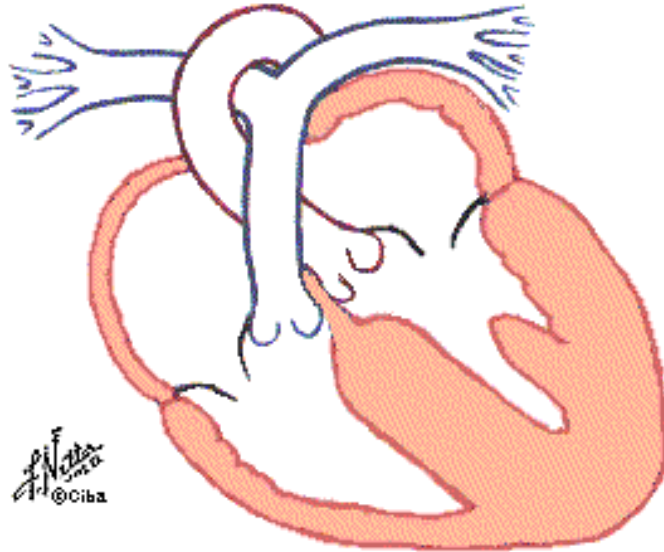
Deep narrow Q-waves in the inferior and/or lateral leads

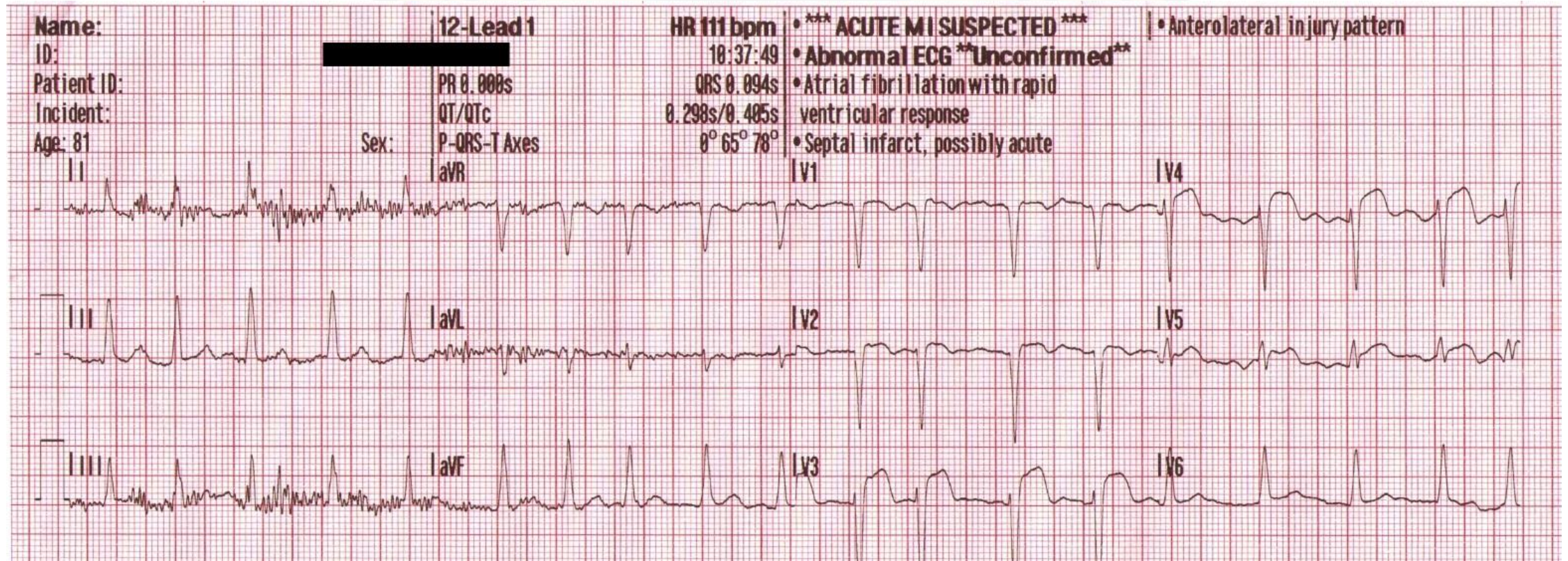


Enlarged septum

HCM

Q Wave in Idiopathic Hypertrophic Cardiomyopathy



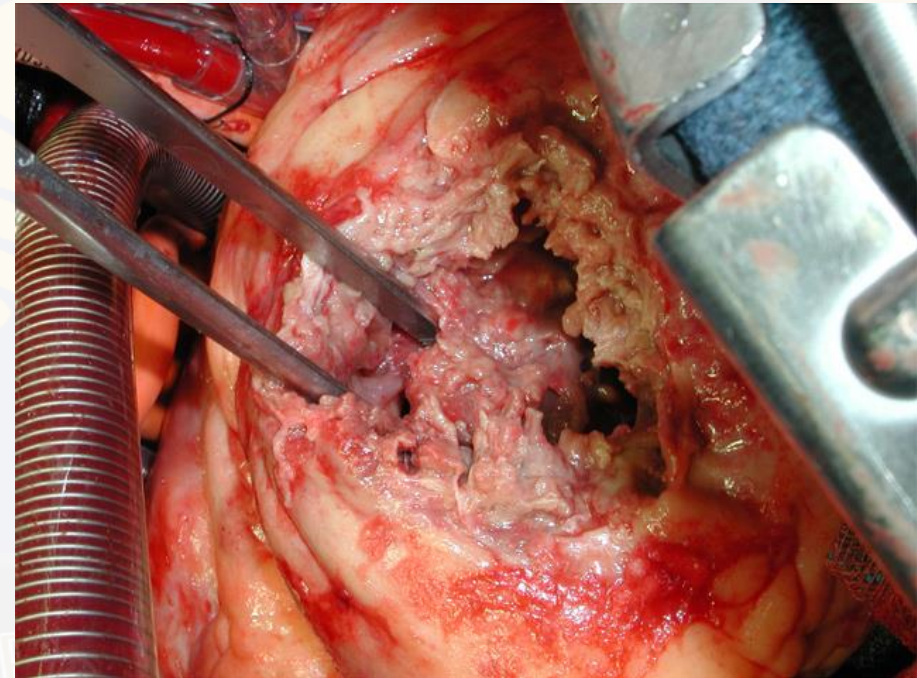


I recognized this patient

EKG's and ST Changes That Can Kill You

- Early repolarization (well, not really!)
- LVH
- AMI
- RV AMI
- Inverted T-wave in avL
- T wave in v1
- Pericarditis that is not
 - ST elevation in avR
 - Wellen's
 - de Winter
 - Torsades
 - LBBB
 - Pericarditis
 - Brugada's
 - HCM
 - **LV aneurysm**
 - New RAD
 - Prolonged QTc
 - Pericardial Tamponade
 - PE
 - Slow Vtaq
 - AIVR
 - WPW
 - Hyperkalemia
 - Hypothermia
 - CNS disorders
 - Takotsubo Syndrome
 - Spiked-Helmet Sign

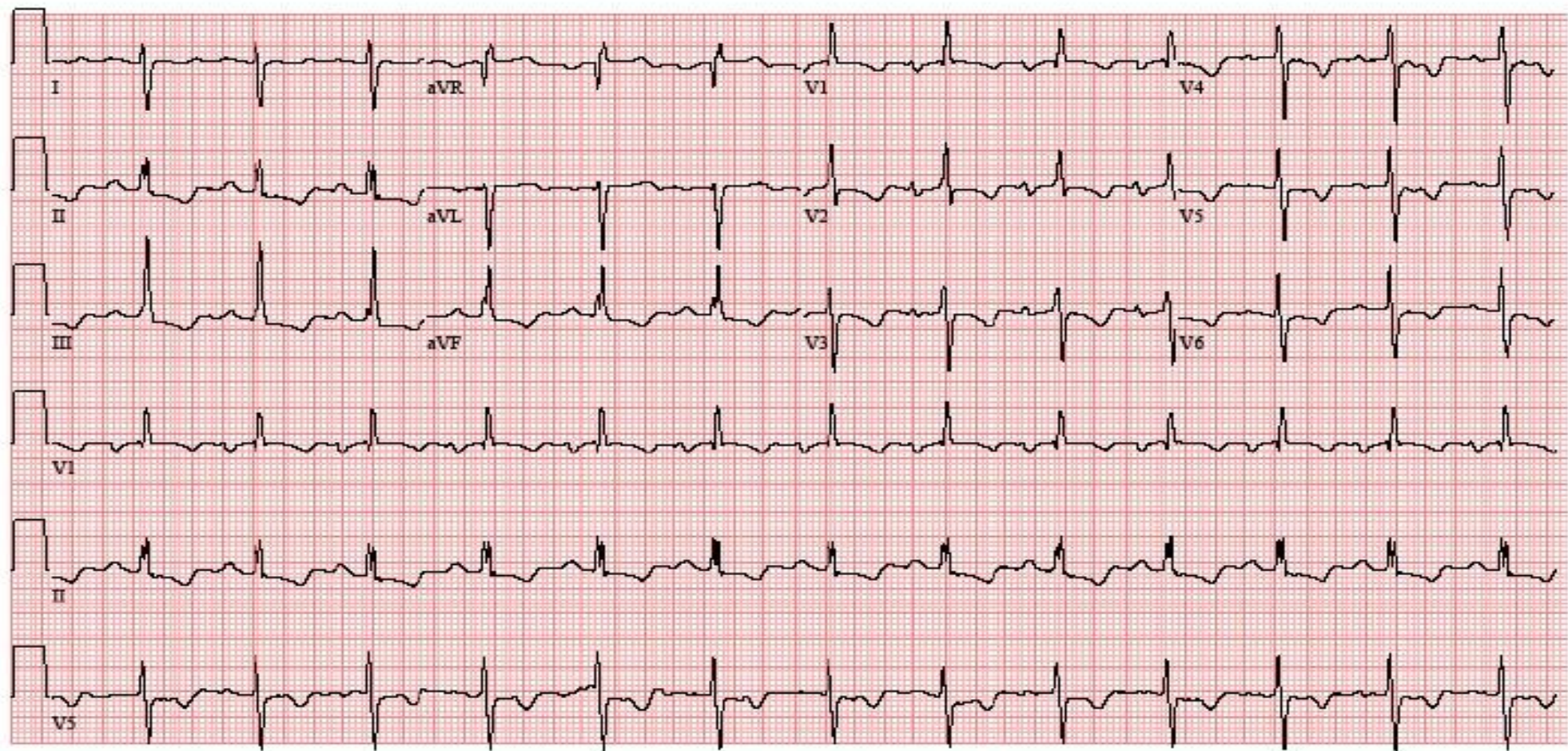
- Persistent left shoulder pain for 5 hours (no CP)
 - I saw this patient and admitted last week c/w mid spine pain
 - I thought that she had a dissection; ordered EKG (not done for 2 hours, nurses thought it was not needed);
 - showed STEMI in anterior leads
- LV Aneurysm



LV aneurysm

- Chronic ST elevation or T wave inversion suggests ventricular aneurysm
- Most common with anterior wall infarcts

ID 279 – This 57 year old woman who had rheumatic fever at age 17 has been suffering from severe dyspnea and fatigue during the past year



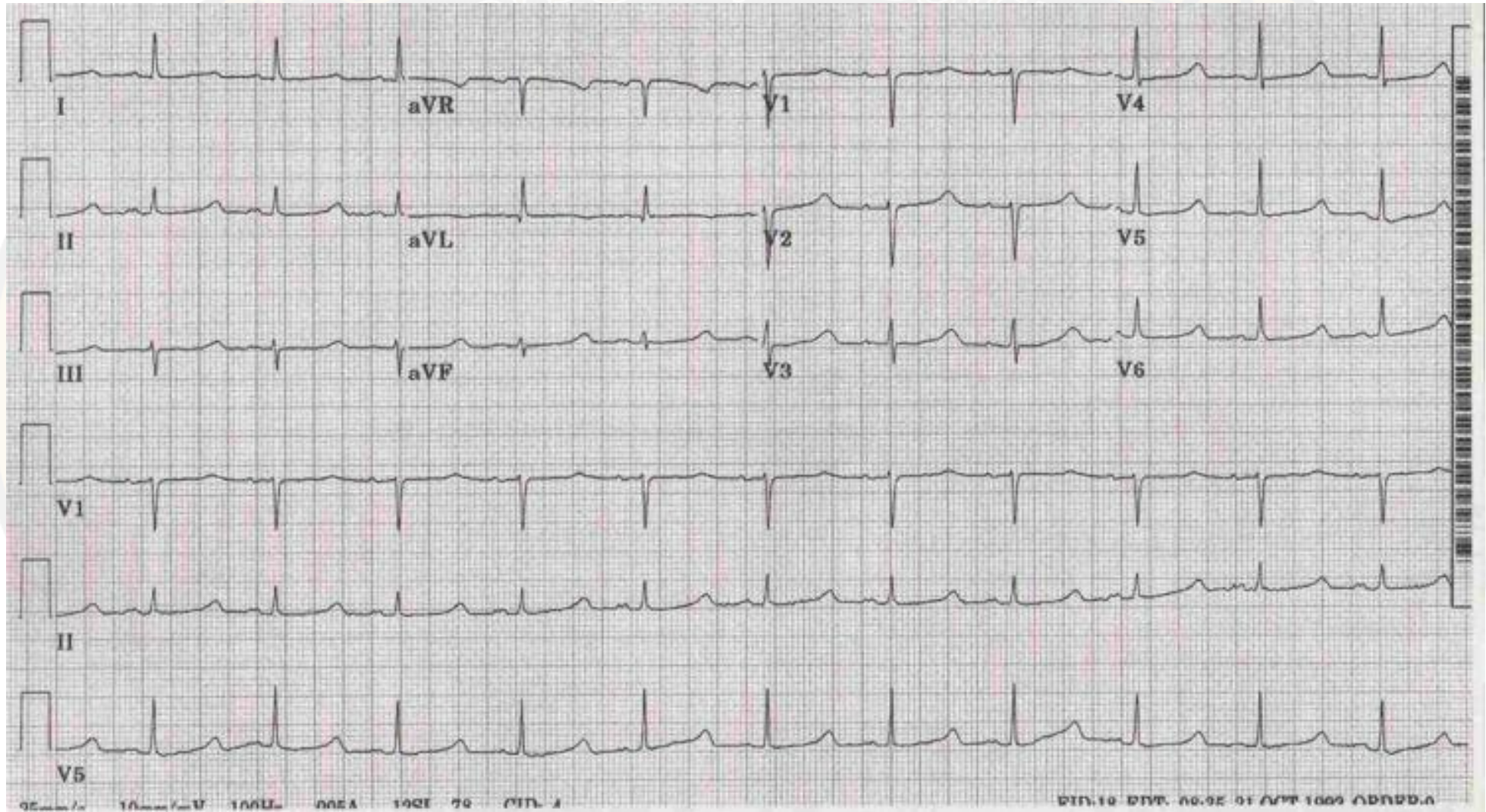
EKG's and ST Changes That Can Kill You

- Early repolarization (well, not really!)
- LVH
- AMI
- RV AMI
- Inverted T-wave in avL
- T wave in v1
- Pericarditis that is not
 - ST elevation in avR
 - Wellen's
 - de Winter
 - Torsades
 - LBBB
 - Pericarditis
 - Brugada's
 - HCM
 - LV aneurysm
 - **New RAD**
 - Prolonged QTc
 - Pericardial Tamponade
 - PE
 - Slow Vtaq
 - AIVR
 - WPW
 - Hyperkalemia
 - Hypothermia
 - CNS disorders
 - Takotsubo Syndrome
 - Spiked-Helmet Sign

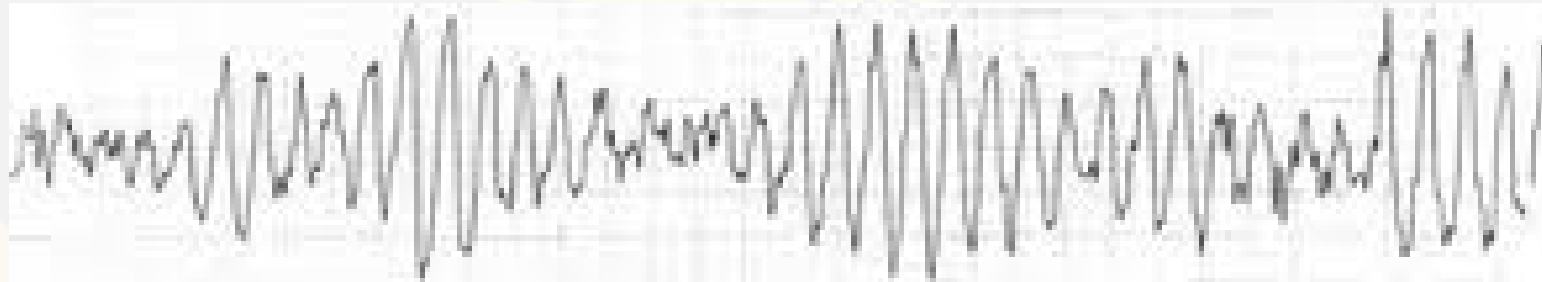
New RAD

- Most common
 - Lead misplaced
 - PE
 - Na channel blocking agent
- RVH
- LPFB
- Dextrocardiac
- Lateral MI
- Ventricular ectopy
- Hyperkalemia
- COPD
- Acute pulmonary disease with right heart strain (PE)
- Overdoses of sodium channel blocking drugs (TCA)

- 40 y/o female presenting with seizures



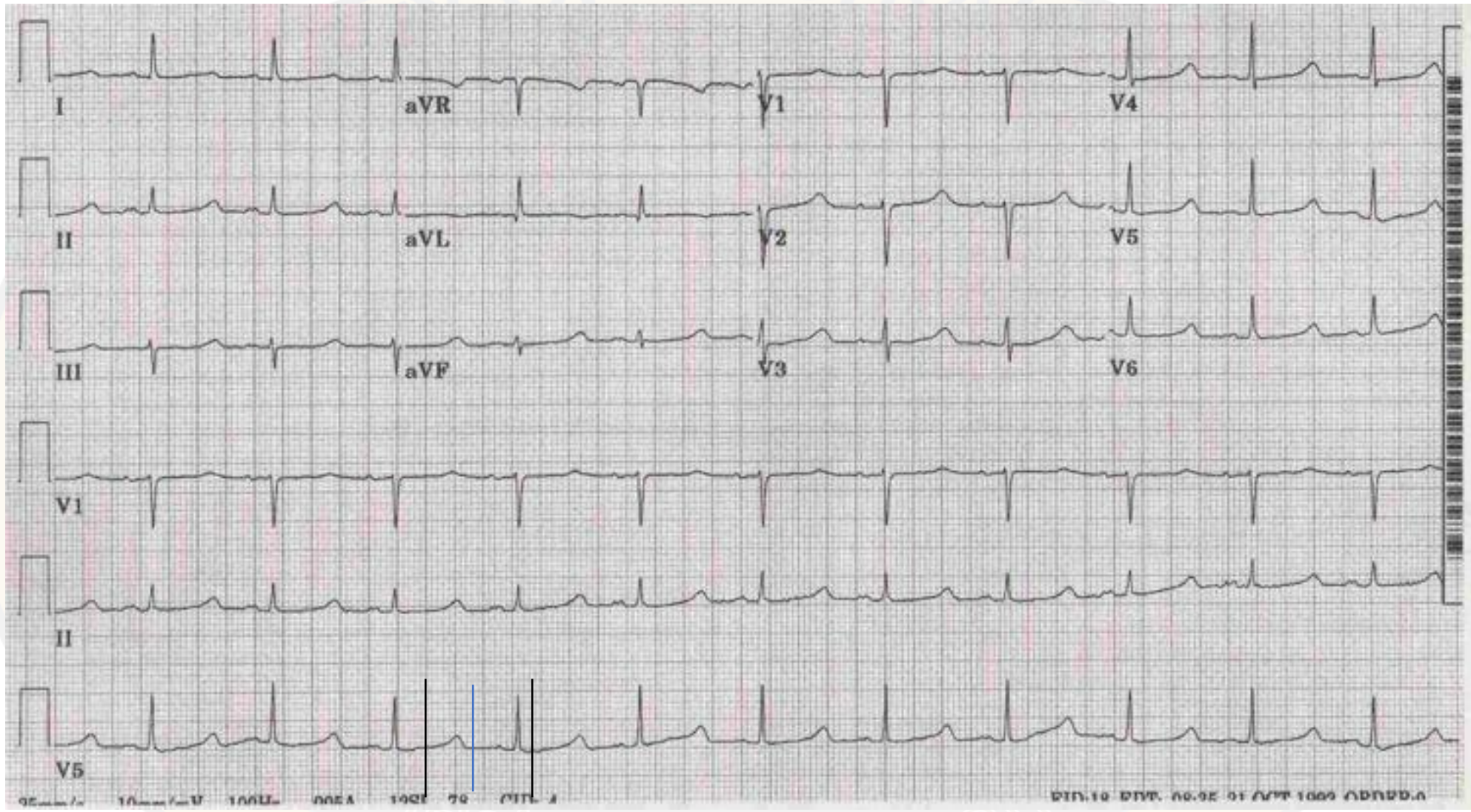
- Patient was observed for 4 hours and discharged home after no seizures
 - CT was WNL
 - Labs WNL except $\text{HCO}_3 = 17$; attributed to “seizure”
 - Neurology was called and will follow up patient as OPD
- Patient returned to ED by EMS pulseless with the following rhythm



- Patient tried to kill herself with TCA earlier
- Patient had syncope episode not a seizure
 - You need to ask the correct questions

EKG's and ST Changes That Can Kill You

- Early repolarization (well, not really!)
- LVH
- AMI
- RV AMI
- Inverted T-wave in avL
- T wave in v1
- Pericarditis that is not
 - ST elevation in avR
 - Wellen's
 - de Winter
 - Torsades
 - LBBB
 - Pericarditis
 - Brugada's
 - HCM
 - LV aneurysm
 - New RAD
 - **Prolonged QTc**
 - Pericardial Tamponade
 - PE
 - Slow Vtaq
 - AIVR
 - WPW
 - Hyperkalemia
 - Hypothermia
 - CNS disorders
 - Takotsubo Syndrome
 - Spiked-Helmet Sign



Prolonged QT-Interval

- Causes
 - Electrolytes abnormalities
 - Hypokalemia
 - Hypomagnesemia
 - Hypocalcemia
 - Na channel blocking medications
 - Antiarrhythmic IA
 - Anticholinergics
 - Cocaine
 - Many antipsychotics (TCA)
 - Some antibiotics (combinations of some macrolides, quinolones with antiarrhythmics)
 - AMI
 - CNS lesions
 - Hypothermia
 - Congenital
 - Deafness
 - Jervell and Lange-Nielsen syndrome
 - No deafness
 - Romano-Ward syndrome

- “corrected” QT-interval: $QTc = QT/\sqrt{RR}$

- Male?

 - > 450 msec

- Female and children?

 - > 460 msec

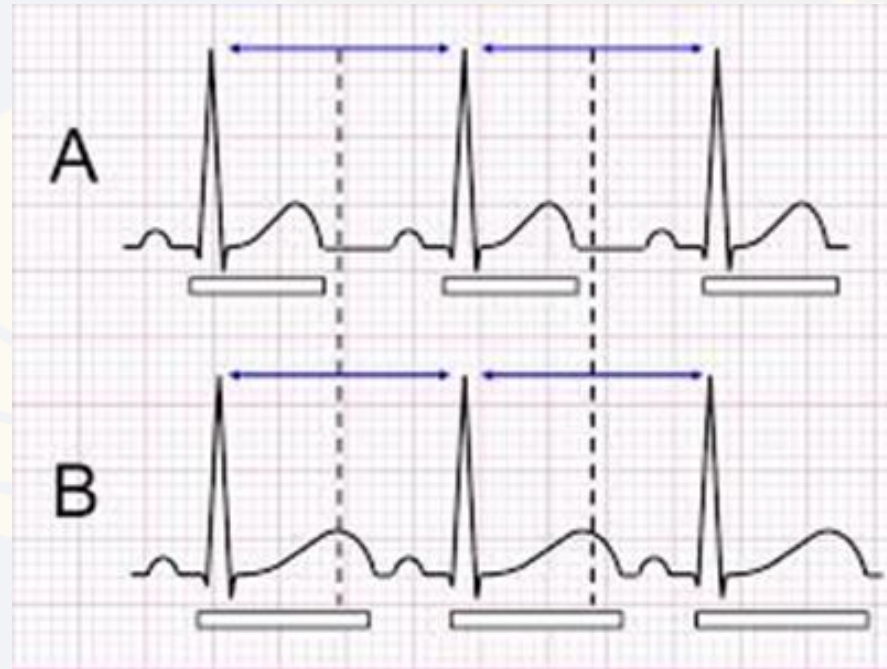
- Not good if > 500 msec

- Treatment

 - Correct

 - Discontinue

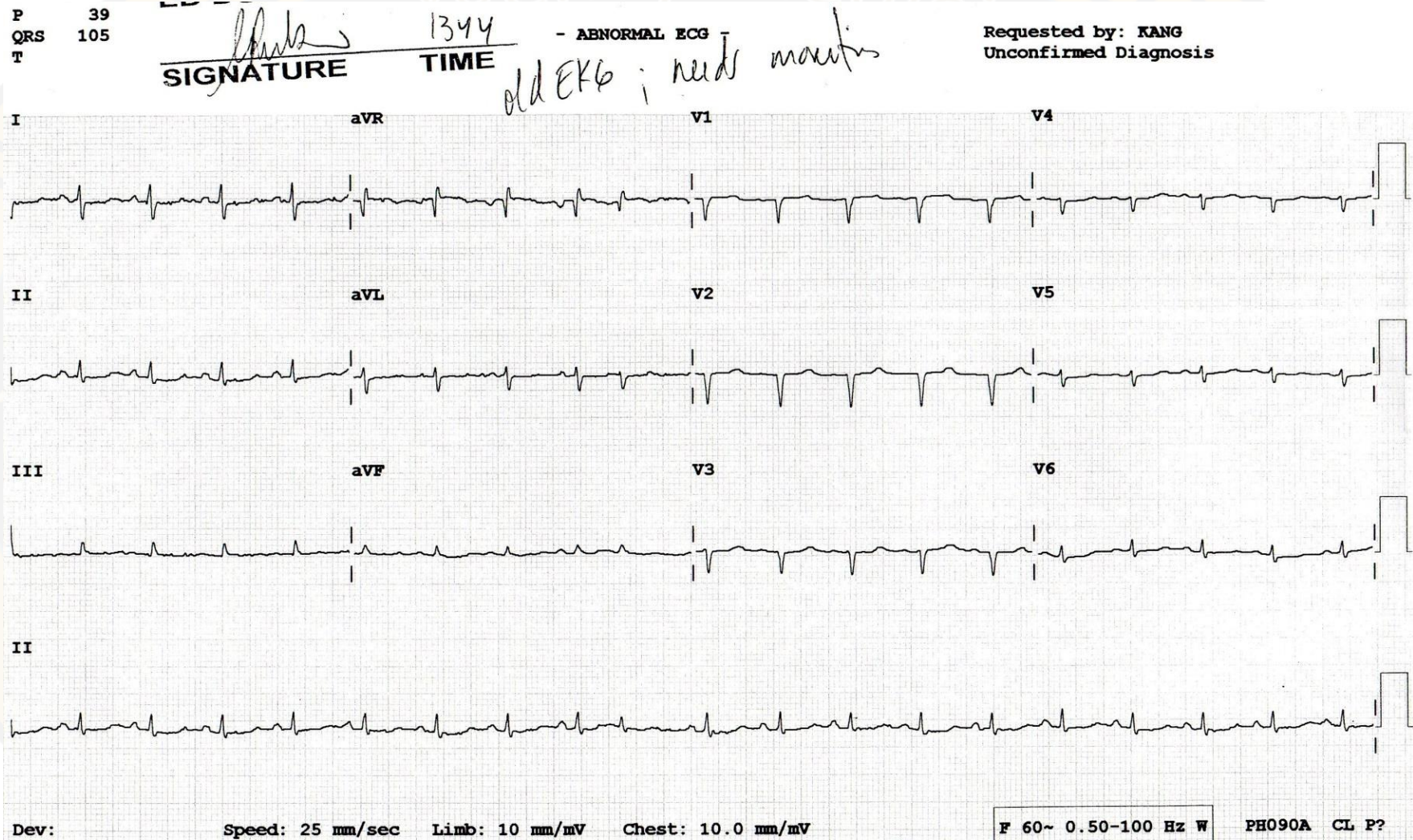
 - MgSO₄



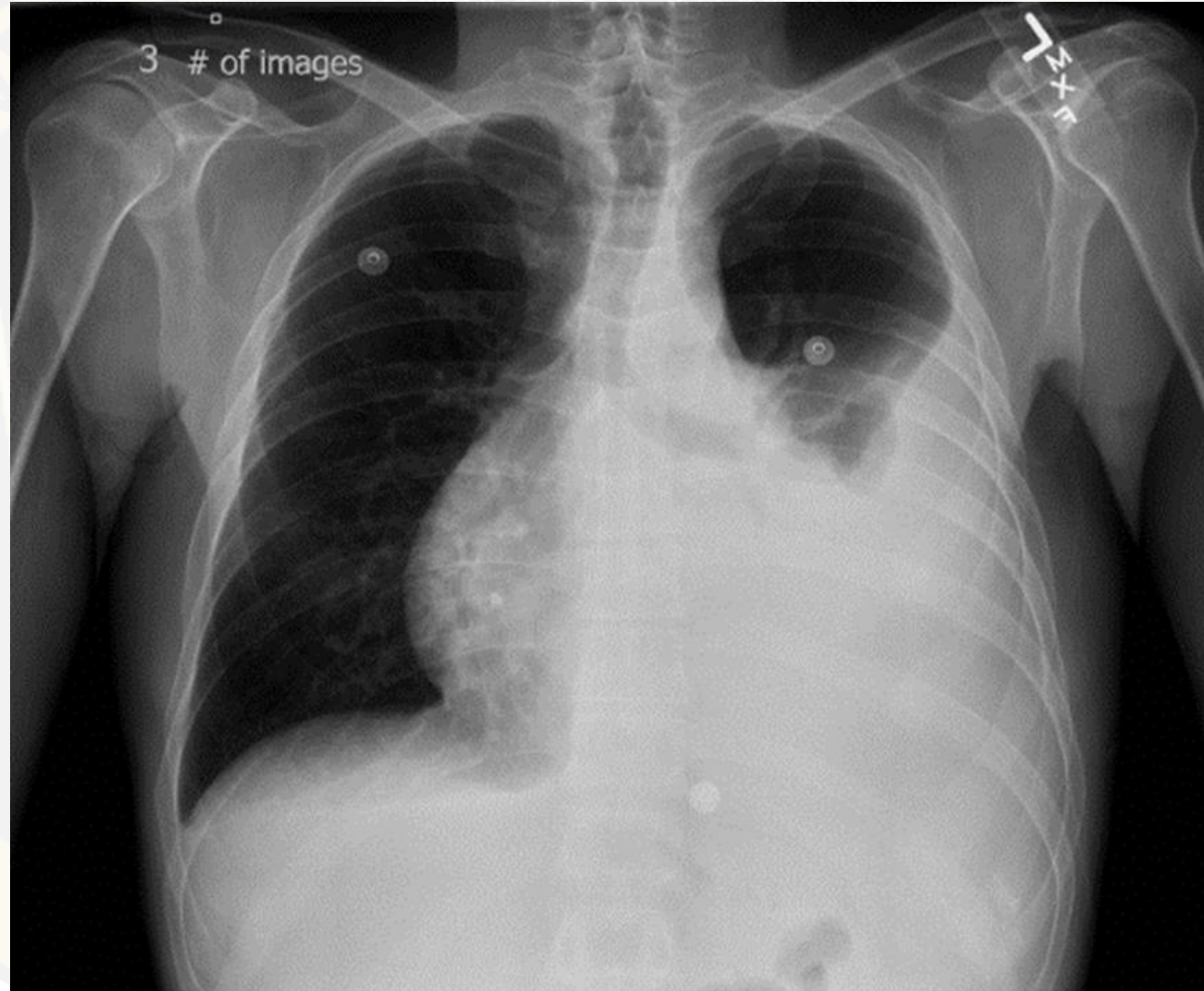
- Chest pain
- Irradiates to the left side
- SOB
- DOE
- PMHx: none
- Meds: none
- SocHx: smoker

- VS
 - HR 112; BP 95/40; RR 18; T 99; O2sat 98%
- PE
 - HEENT: WNL
 - Chest: rales in bases; Taq; distant heart sounds; +JVD
 - Abd: WNL
 - Ext: no edema
 - Neuro: WNL

EKG



CXray



CT



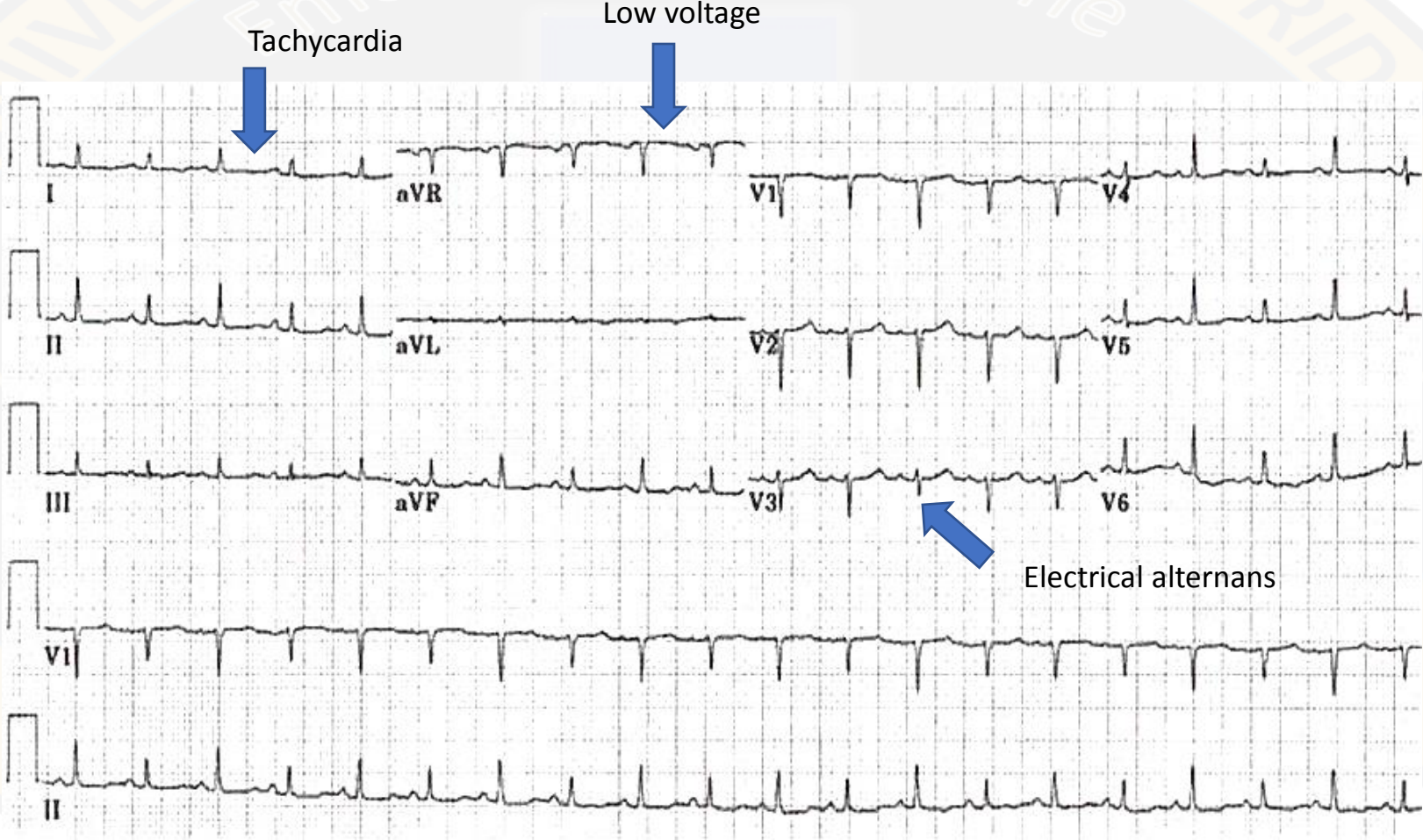


EKG's and ST Changes That Can Kill You

- Early repolarization (well, not really!)
- LVH
- AMI
- RV AMI
- Inverted T-wave in avL
- T wave in v1
- Pericarditis that is not
 - ST elevation in avR
 - Wellen's
 - de Winter
 - Torsades
 - LBBB
 - Pericarditis
 - Brugada's
 - HCM
 - LV aneurysm
 - New RAD
 - Prolonged QTc
 - **Pericardial Tamponade**
 - PE
 - Slow Vtaq
 - AIVR
 - WPW
 - Hyperkalemia
 - Hypothermia
 - CNS disorders
 - Takotsubo Syndrome
 - Spiked-Helmet Sign



Pericardial Tamponade

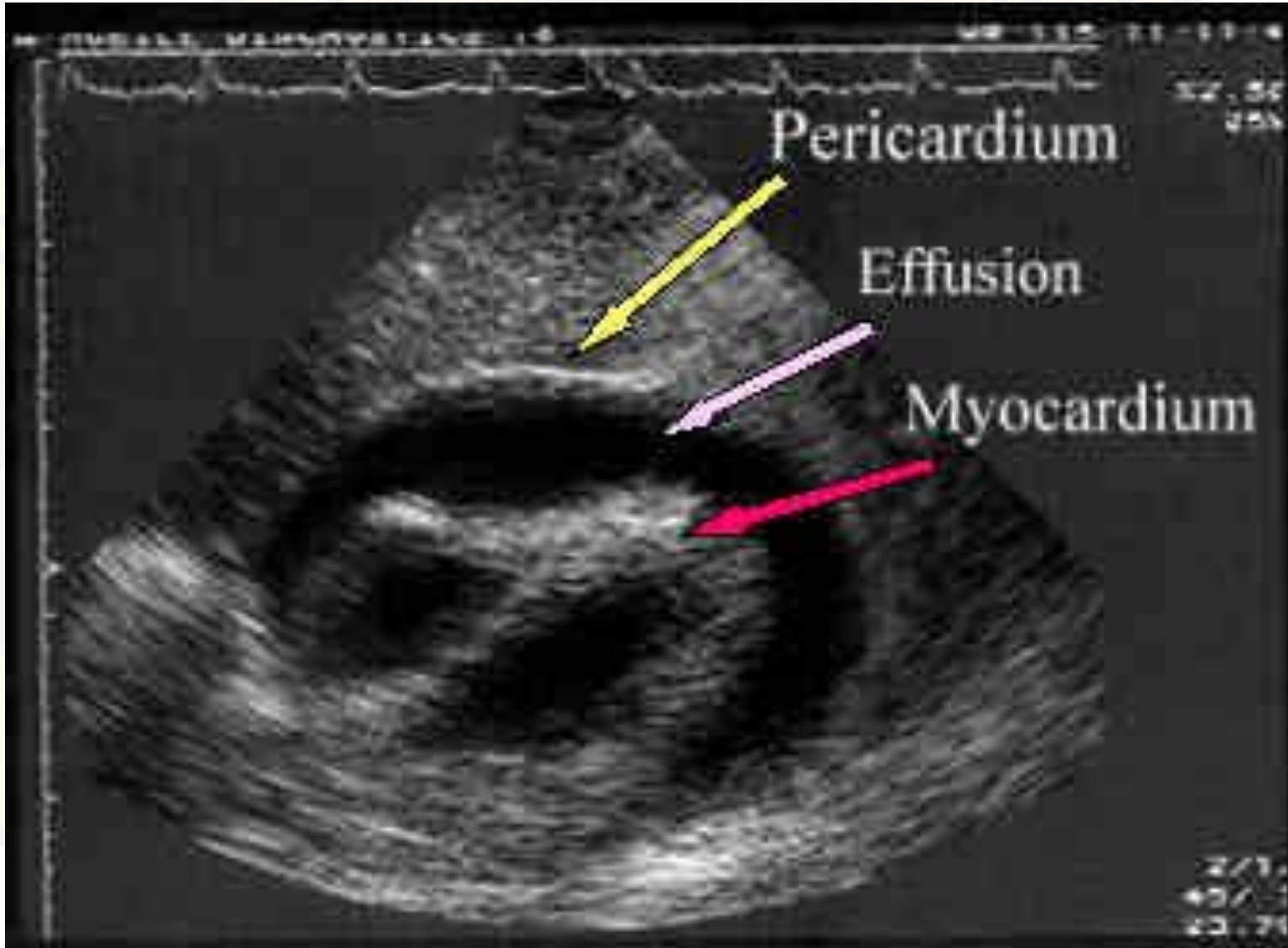


- Beck's triad
 - Hypotension
 - JVD
 - Muffled heart sounds



- Echocardiogram

- Large pericardial effusion
- Diastolic collapse of the right ventricle and the right atrium
- Swinging motion of the heart



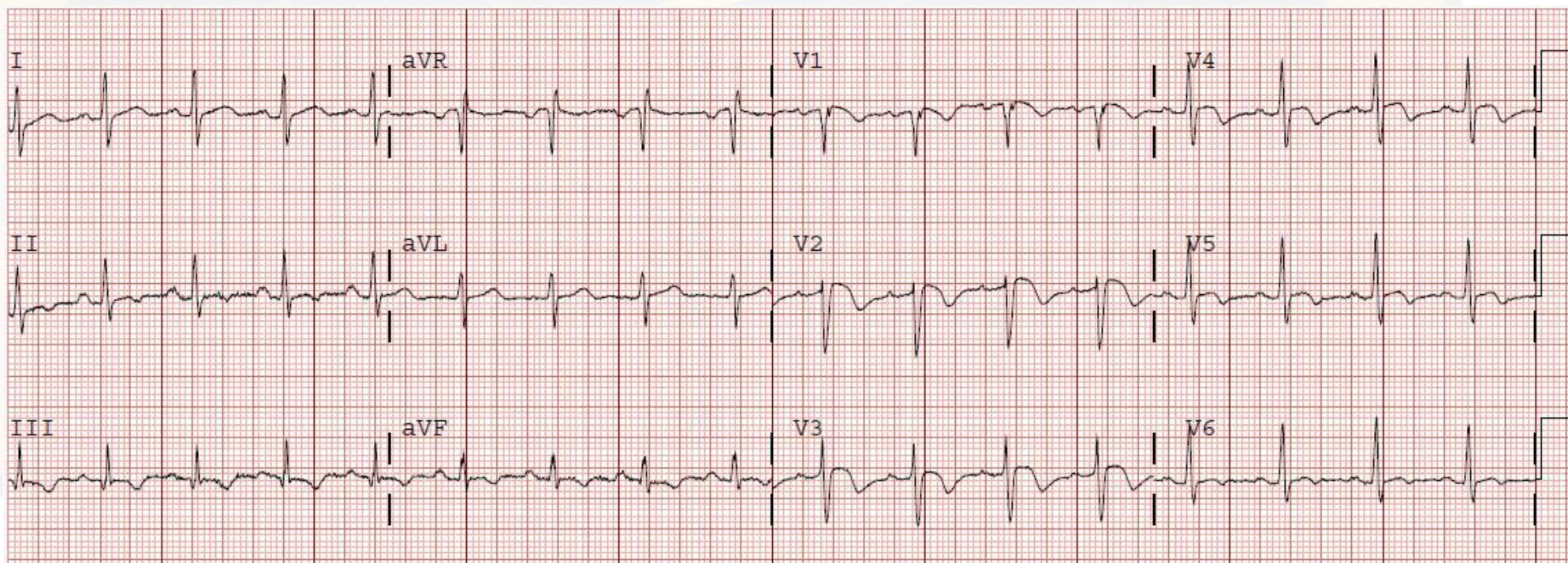
Cardiac Tamponade

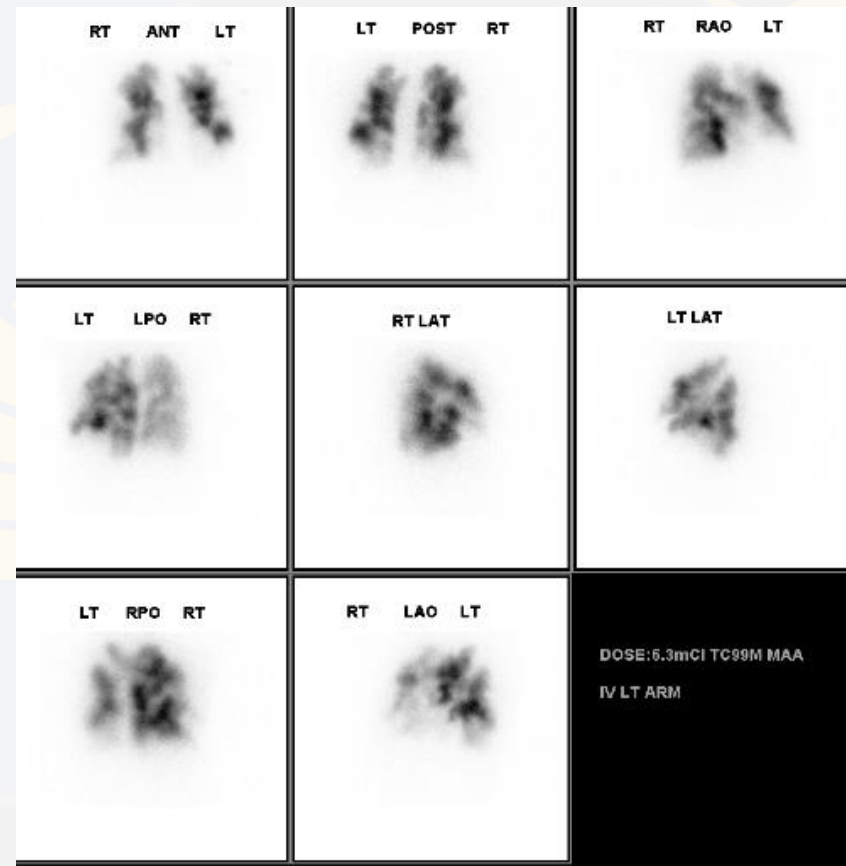
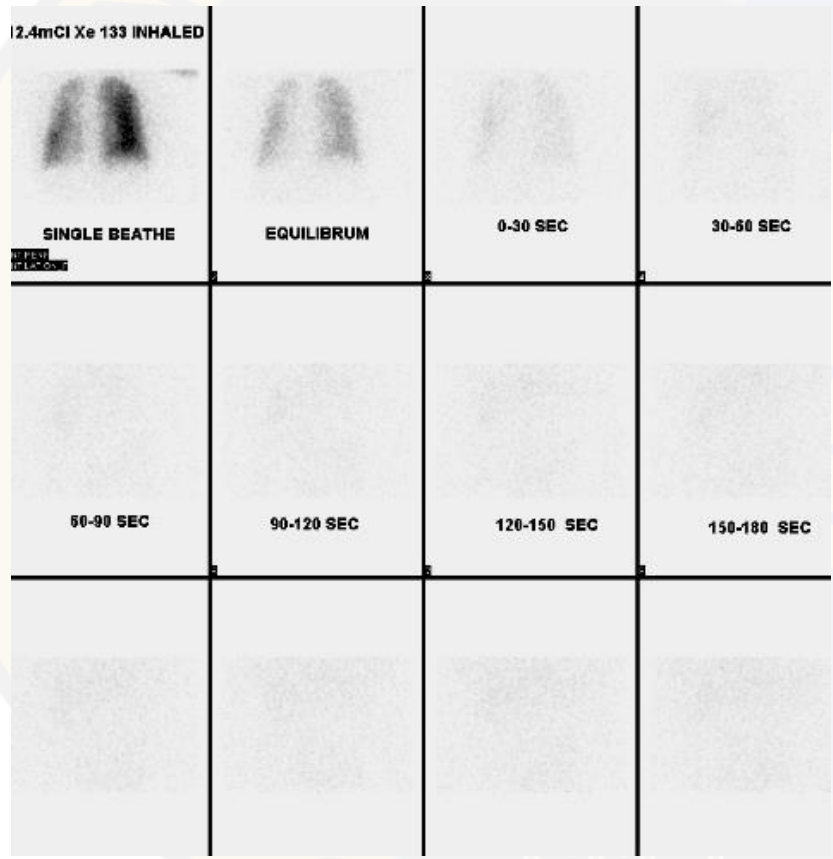
- Management
 - Maintain airway.
 - Administer oxygen.
 - Establish IV access.
 - Consider medication administration:
 - Morphine sulfate
 - Nitrous oxide
 - Furosemide
 - Dopamine/dobutamine

Cardiac Tamponade

- Rapid Transport
 - Run for it!!!
- Pericardiocentesis
 - Pericardiocentesis is the definitive treatment.
 - Insertion of a cardiac needle and aspiration of fluid from the pericardium.
 - Procedure should be performed only if allowed by local protocol.
 - Procedure should be performed only by personnel adequately trained in the procedure.

- 45 y/o female with chest pain, SOB





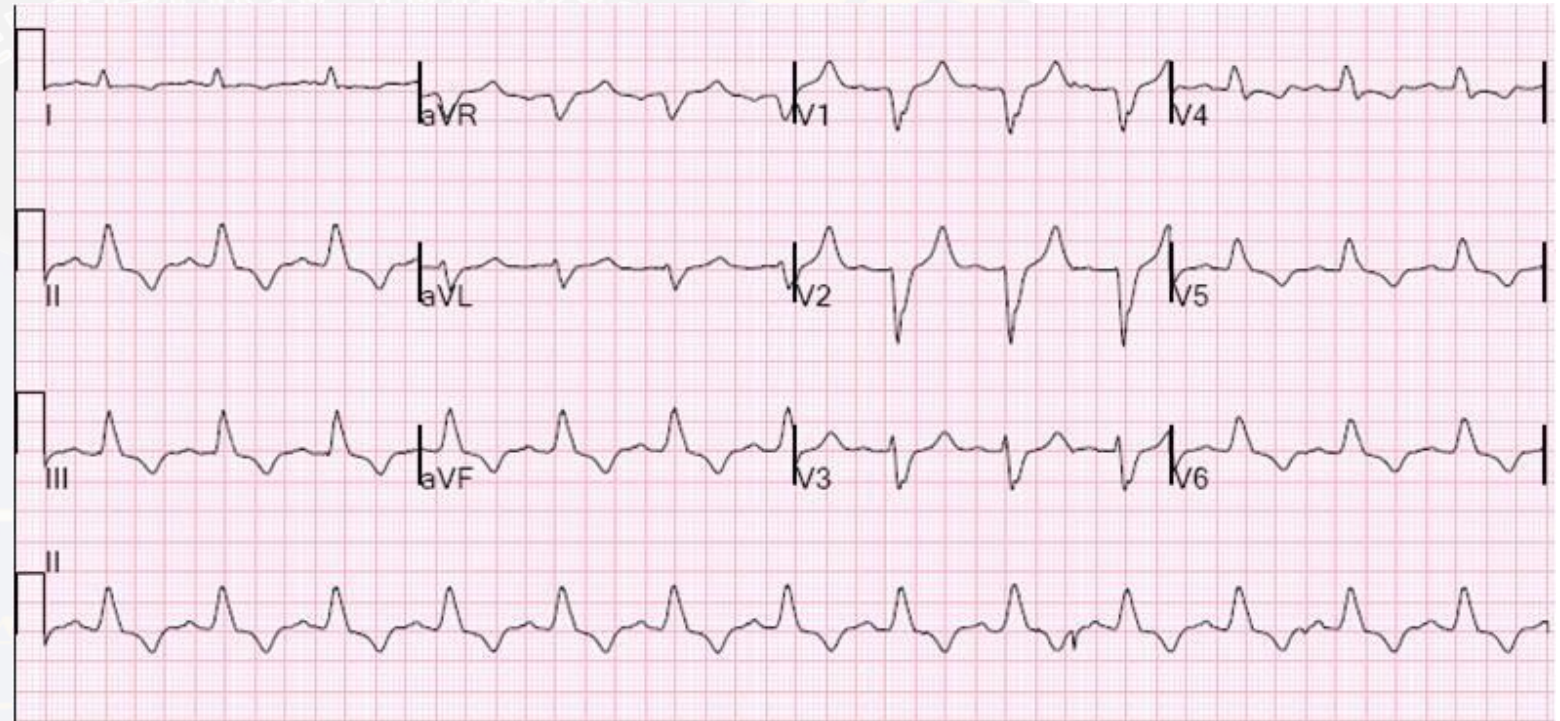
EKG's and ST Changes That Can Kill You

- Early repolarization (well, not really!)
- LVH
- AMI
- RV AMI
- Inverted T-wave in avL
- T wave in v1
- Pericarditis that is not
 - ST elevation in avR
 - Wellen's
 - de Winter
 - Torsades
 - LBBB
 - Pericarditis
 - Brugada's
 - HCM
 - LV aneurysm
 - New RAD
 - Prolonged QTc
 - Pericardial Tamponade
 - PE
 - Slow Vtaq
 - AIVR
 - WPW
 - Hyperkalemia
 - Hypothermia
 - CNS disorders
 - Takotsubo Syndrome
 - Spiked-Helmet Sign

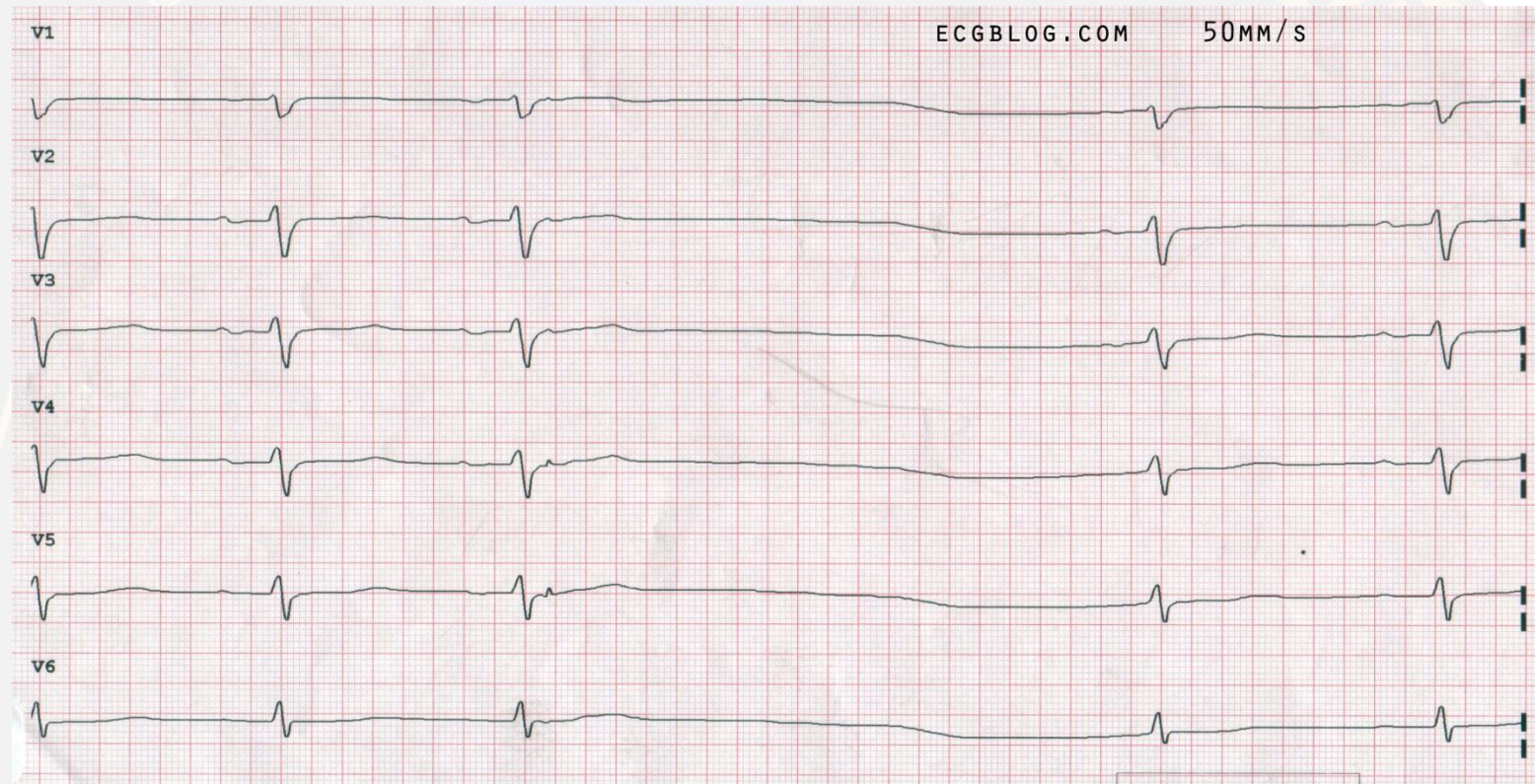
PE

- S1Q3T3
- Inverted T waves in anterior leads

- 67 y/o male with AMS



- Went to slow VTAQ (HR < 120)
- Was given amiodarone when,

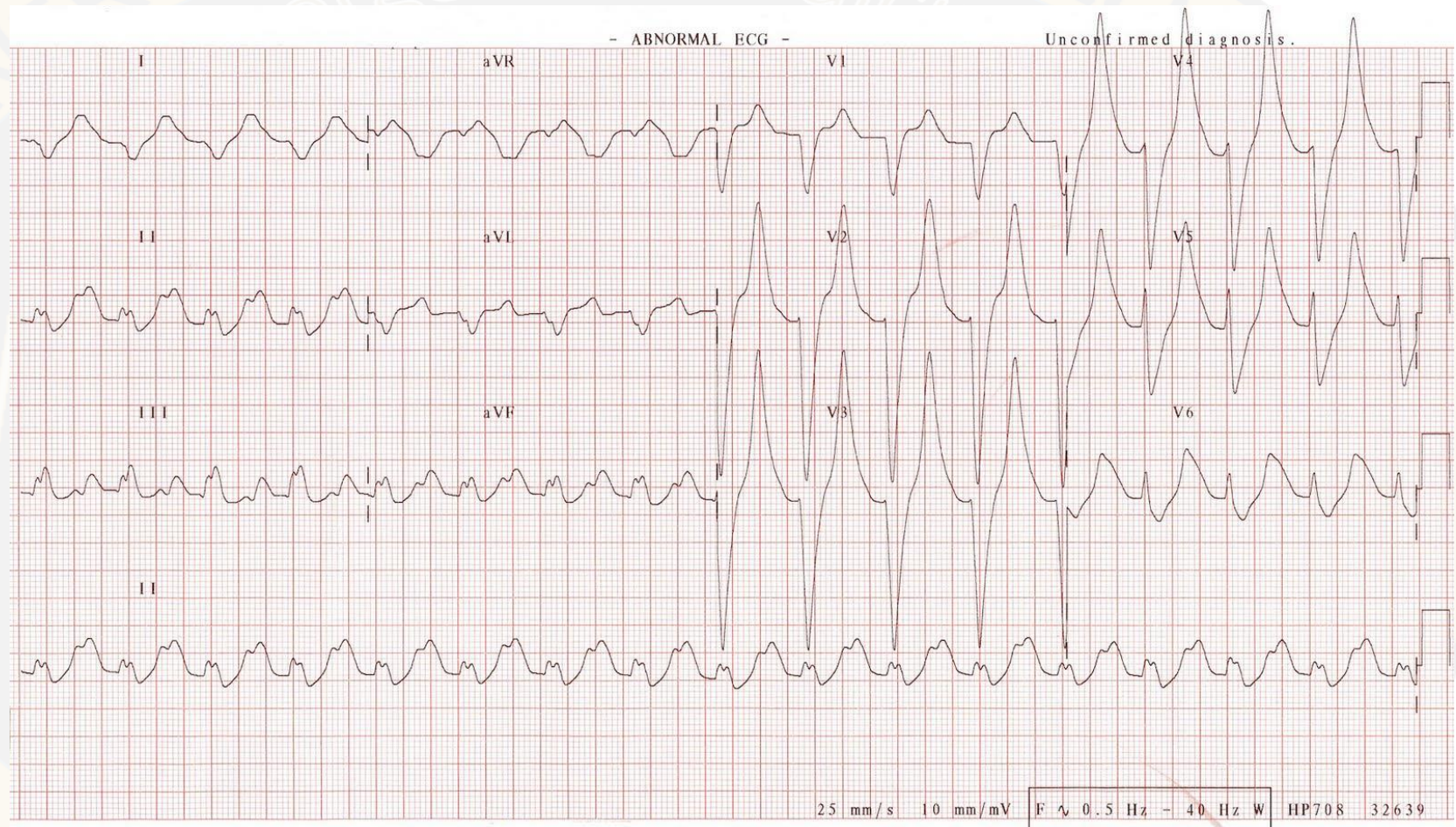


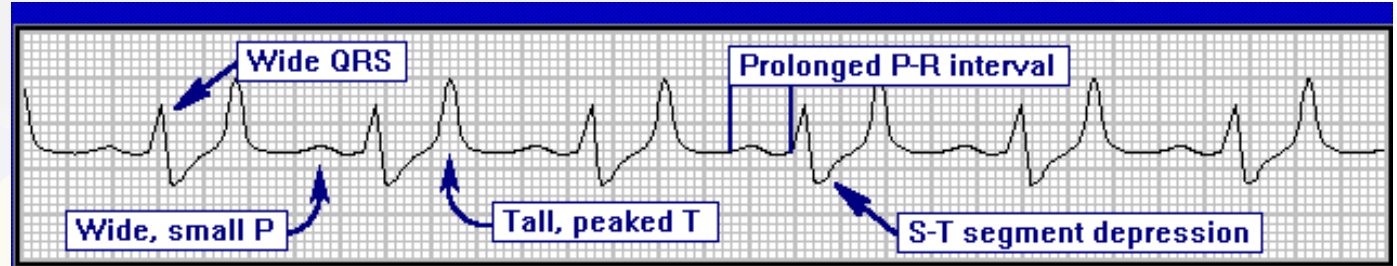
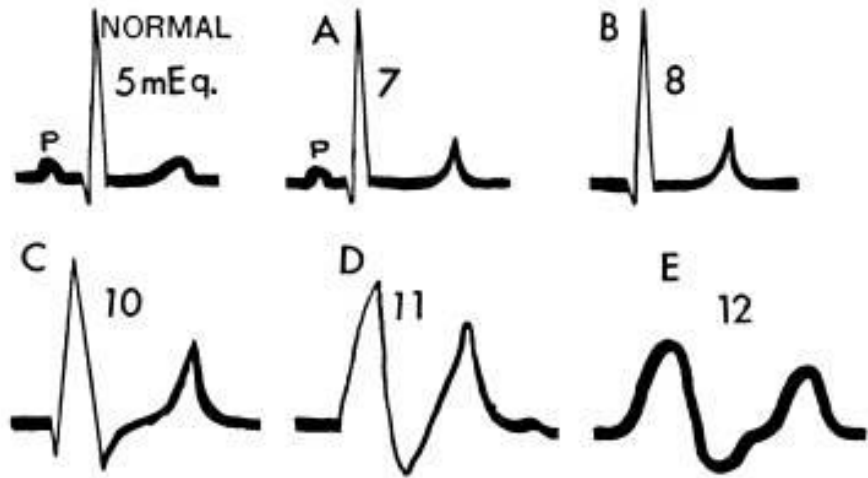
- ESRD; missed HD

EKG's and ST Changes That Can Kill You

- Early repolarization (well, not really!)
- LVH
- AMI
- RV AMI
- Inverted T-wave in avL
- T wave in v1
- Pericarditis that is not
 - ST elevation in avR
 - Wellen's
 - de Winter
 - Torsades
 - LBBB
 - Pericarditis
 - Brugada's
 - HCM
 - LV aneurysm
 - New RAD
 - Prolonged QTc
 - Pericardial Tamponade
 - PE
 - **Slow Vtaq**
 - AIVR
 - WPW
 - Hyperkalemia
 - Hypothermia
 - CNS disorders
 - Takotsubo Syndrome
 - Spiked-Helmet Sign

EKG#2





ECG EFFECTS OF HYPERKALEMIA

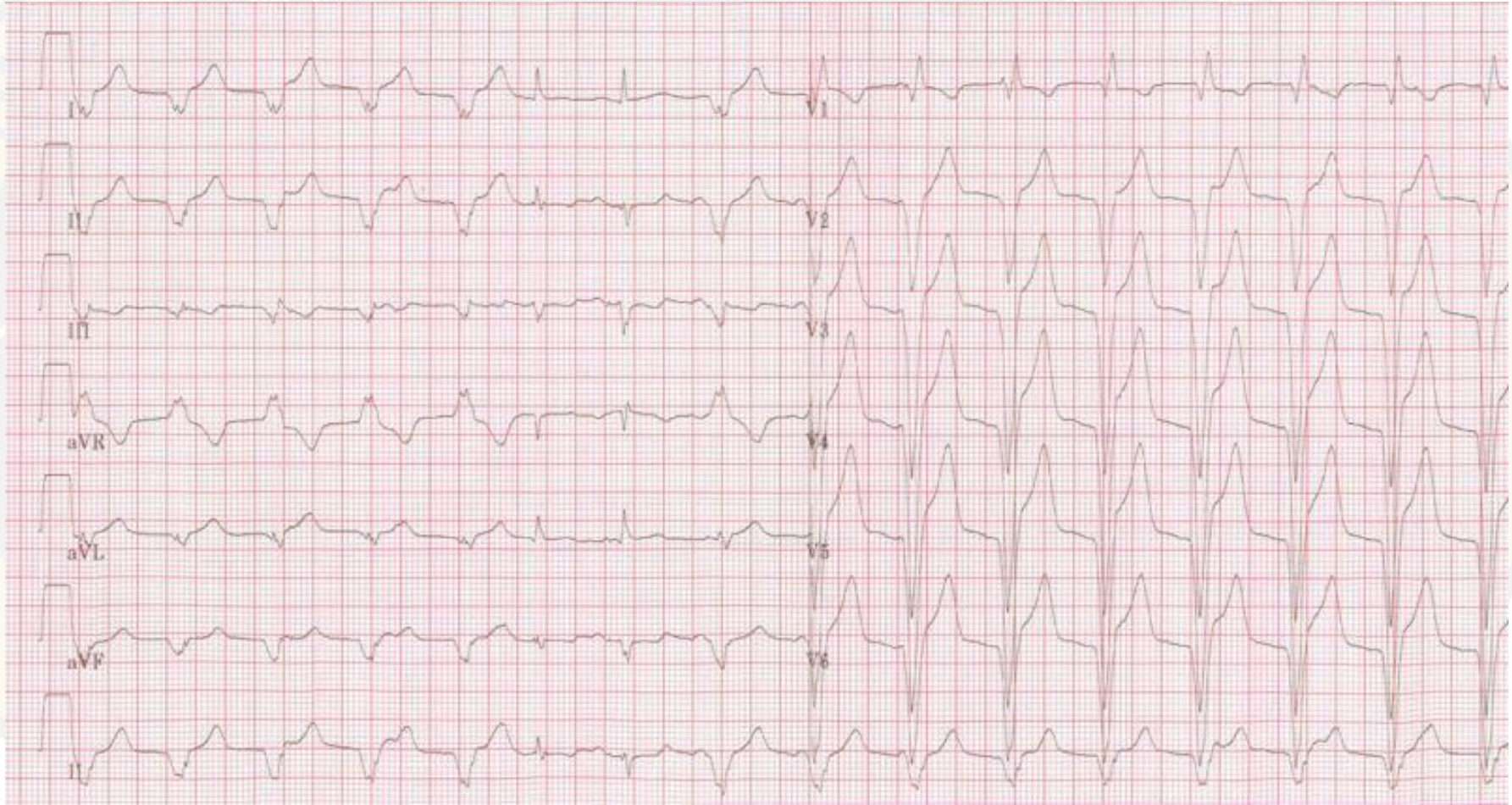
Hyperkalemia exists when the serum potassium level is greater than 5.1 mEq/L. Causes for hyperkalemia include renal failure, adrenal insufficiency, acidosis, trauma or ischemia, potassium replacement therapy, and potassium-sparing drugs [e.g., diuretics such as spironolactone]. Changes in the T wave [tall, peaked or tented] provide the earliest indication that a patient has a high serum potassium level. The following ECG changes may be seen in moderate (above rhythm) to extreme hyperkalemia:

- Wide, tall and tented T waves
- Wide, flat or absent P waves
- Prolonged P-R interval
- S-T segment depression
- Widened QRS complexes

Slow VTACH

- If $< 120/\text{min}$
 - Think about something else
 - Hyperkalemia
 - AIVR
 - Na channel blocking medications
 - Antiarrhythmic IA
 - Anticholinergics
 - Cocaine
 - Many antipsychotics (TCA)
 - Some antibiotics (combinations of some macrolides, quinolones with antiarrhythmics)
- Treat underlying condition

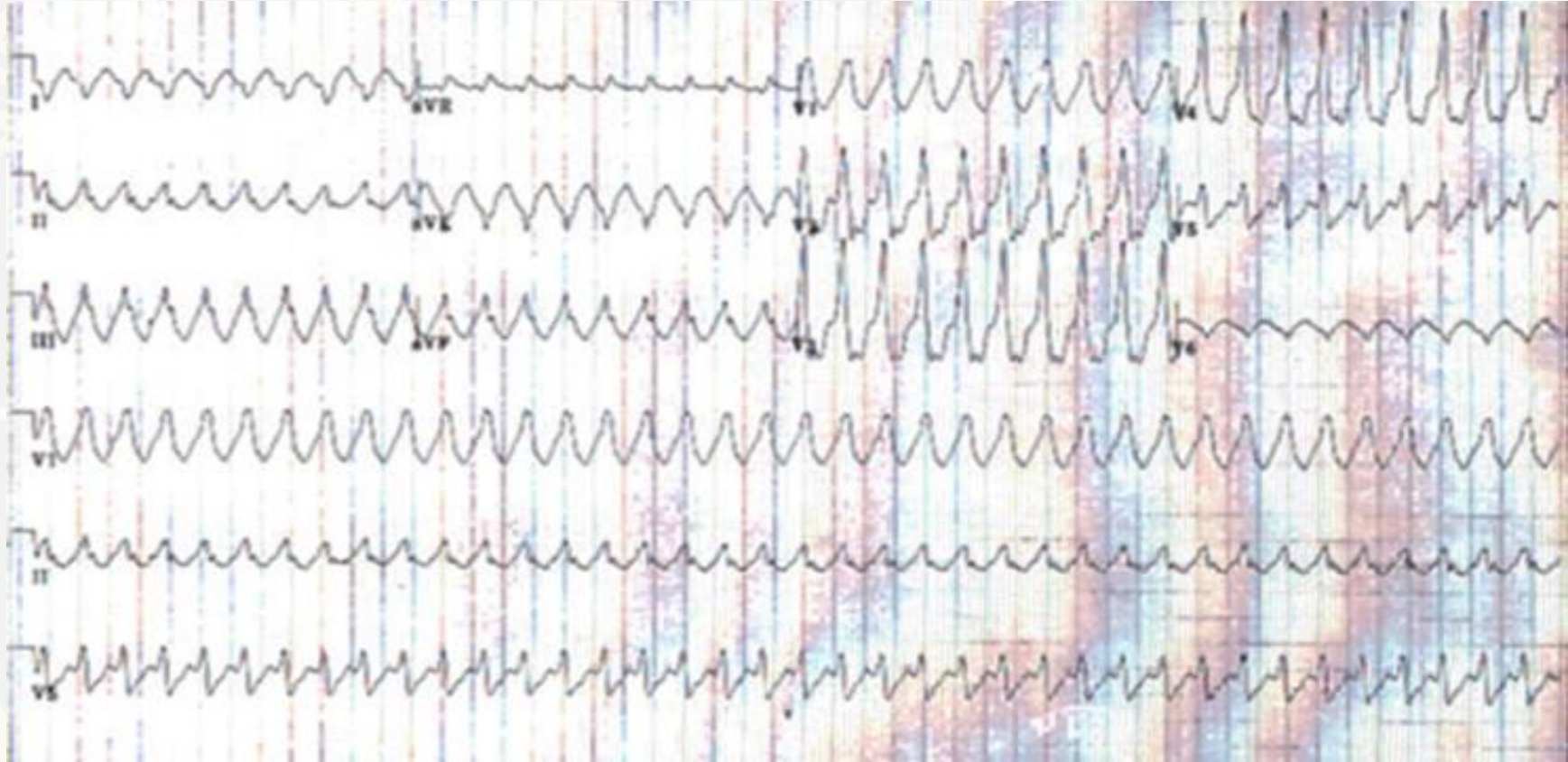
- Also, you may have AIVR after reperfusion post STEMI



EKG's and ST Changes That Can Kill You

- Early repolarization (well, not really!)
- LVH
- AMI
- RV AMI
- Inverted T-wave in avL
- T wave in v1
- Pericarditis that is not
 - ST elevation in avR
 - Wellen's
 - de Winter
 - Torsades
 - LBBB
 - Pericarditis
 - Brugada's
 - HCM
 - LV aneurysm
 - New RAD
 - Prolonged QTc
 - Pericardial Tamponade
 - PE
 - Slow Vtaq
 - **AIVR**
 - WPW
 - Hyperkalemia
 - Hypothermia
 - CNS disorders
 - Takotsubo Syndrome
 - Spiked-Helmet Sign

- 24 y/o male with chest pain and palpitations

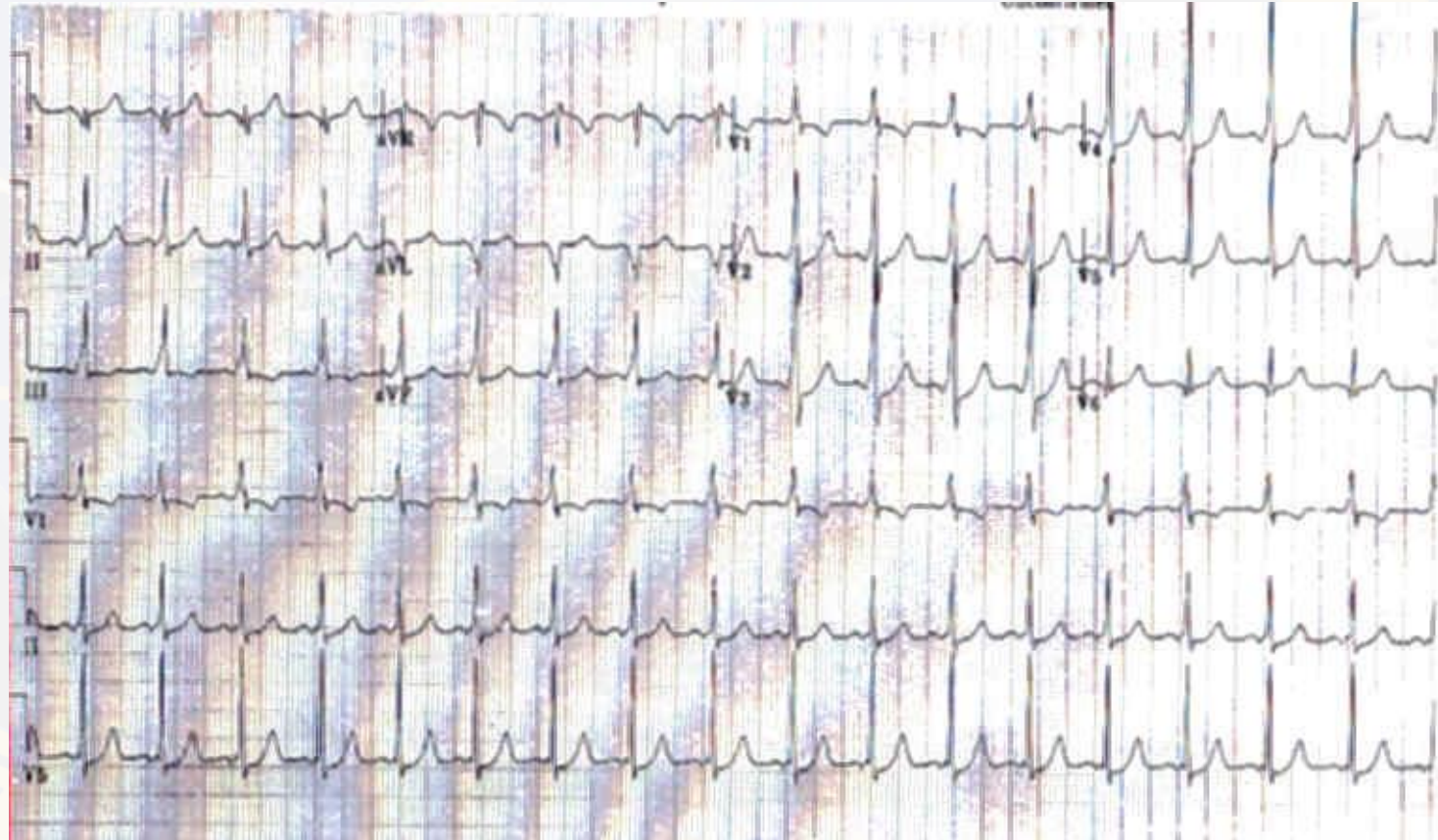


- Diltiazem was given, then

- Patient collapsed



- Old ECG

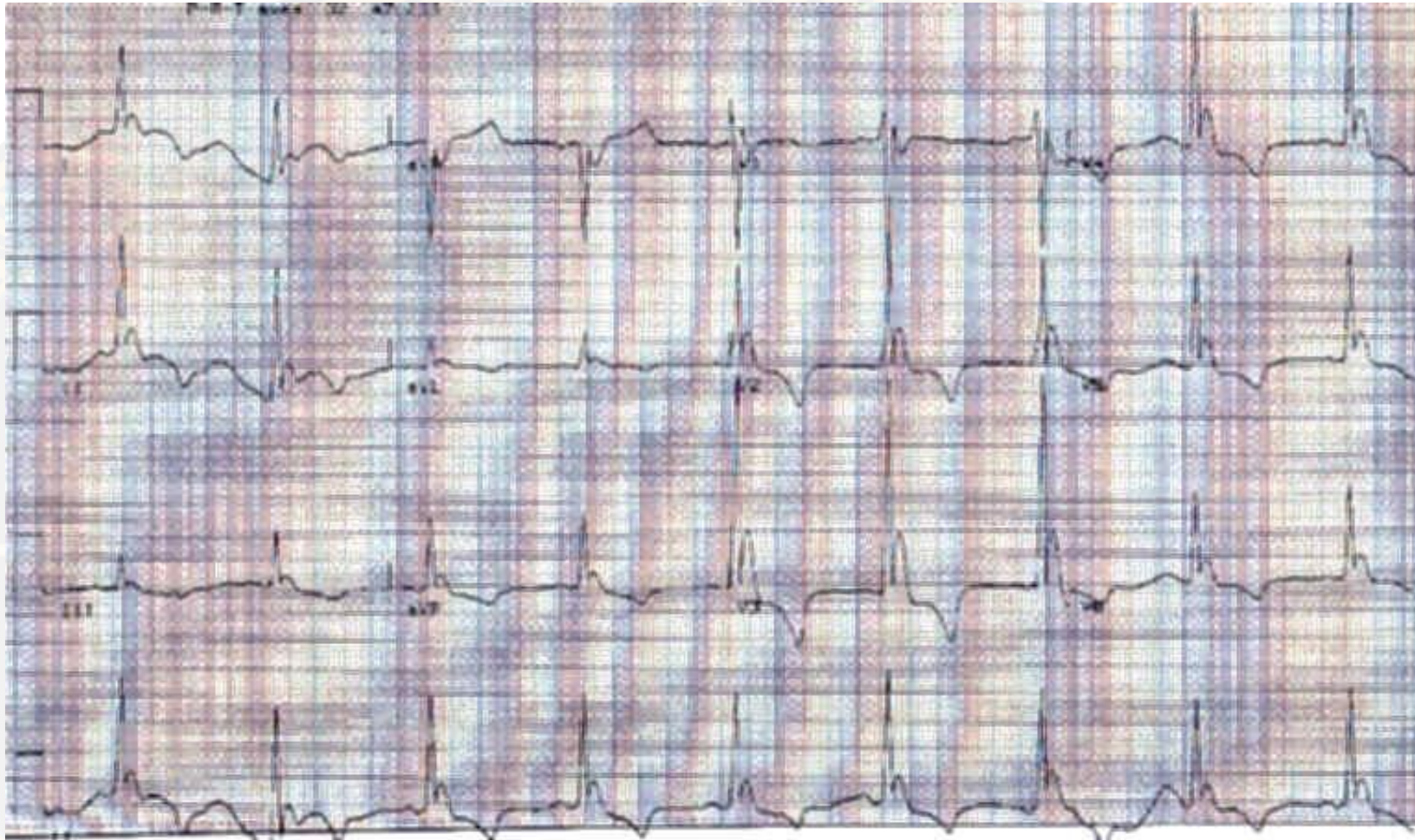


EKG's and ST Changes That Can Kill You

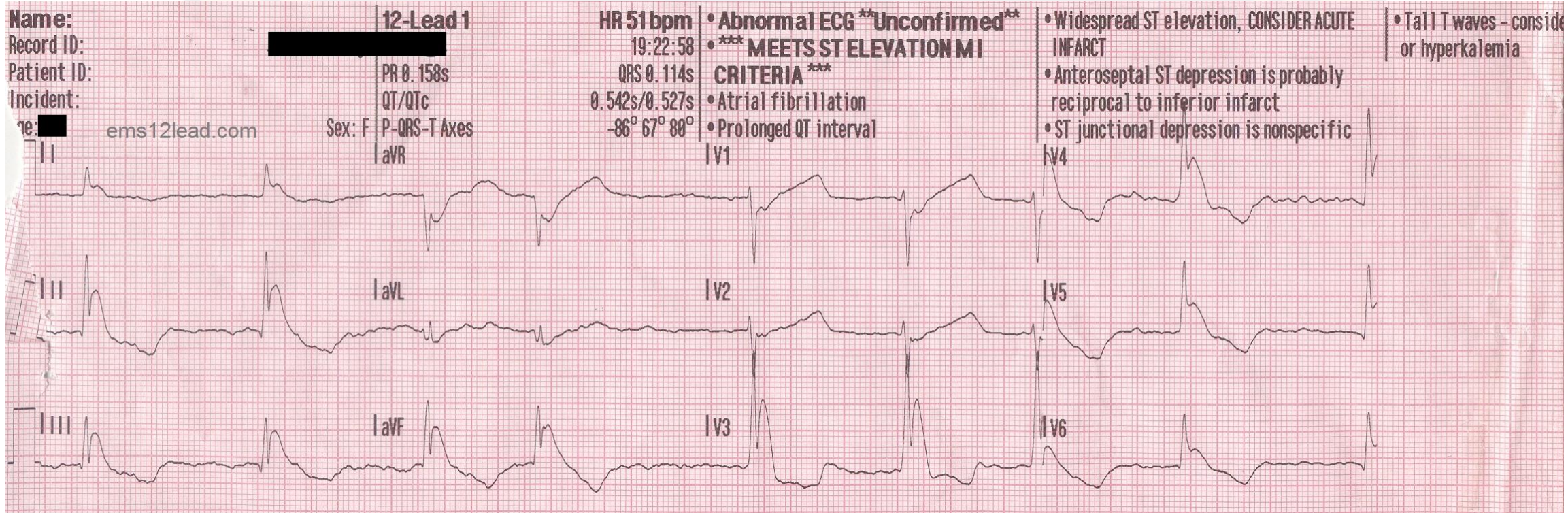
- Early repolarization (well, not really!)
- LVH
- AMI
- RV AMI
- Inverted T-wave in avL
- T wave in v1
- Pericarditis that is not
 - ST elevation in avR
 - Wellen's
 - de Winter
 - Torsades
 - LBBB
 - Pericarditis
 - Brugada's
 - HCM
 - LV aneurysm
 - New RAD
 - Prolonged QTc
 - Pericardial Tamponade
 - PE
 - Slow Vtaq
 - AIVR
 - **WPW**
 - Hyperkalemia
 - Hypothermia
 - CNS disorders
 - Takotsubo Syndrome
 - Spiked-Helmet Sign

- If you have what it looks like a SVT but
 - HR >220/min
 - WPW
 - Different QRS morphology and irregular
 - Aflutter with VR aberrancy (WPW)
 - MAT
- Treatment
 - Cardioversion
 - Procainamide
 - Amiodarone?

- Patient homeless found unresponsive behind a gas station
- His respirations are agonal
- His pulse is bradycardic
- And is colddddd...



Sorry for the EKG but it was from a patient of mine during residency maaaannnyyy years ago



EKG's and ST Changes That Can Kill You

- Early repolarization (well, not really!)
- LVH
- AMI
- RV AMI
- Inverted T-wave in avL
- T wave in v1
- Pericarditis that is not
 - ST elevation in avR
 - Wellen's
 - de Winter
 - Torsades
 - LBBB
 - Pericarditis
 - Brugada's
 - HCM
 - LV aneurysm
 - New RAD
 - Prolonged QTc
 - Pericardial Tamponade
 - PE
 - Slow Vtaq
 - AIVR
 - WPW
 - Hyperkalemia
 - Hypothermia
 - CNS disorders
 - Takotsubo Syndrome
 - Spiked-Helmet Sign

Osborne Waves or “J-Waves”



Here we see the Osborn waves of severe hypothermia (blue arrows).

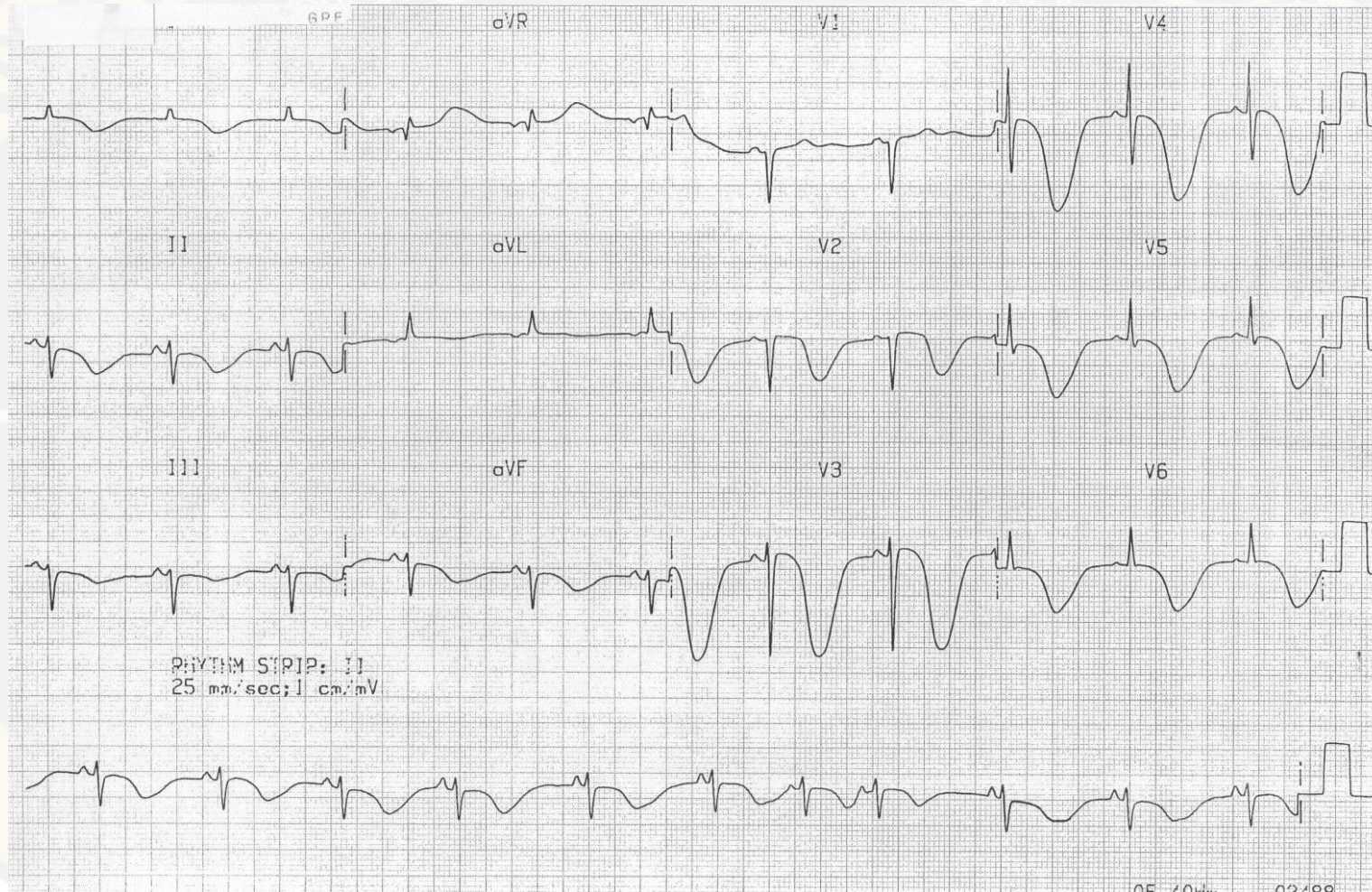
The rhythm is atrial fibrillation.

Bradycardia is present.

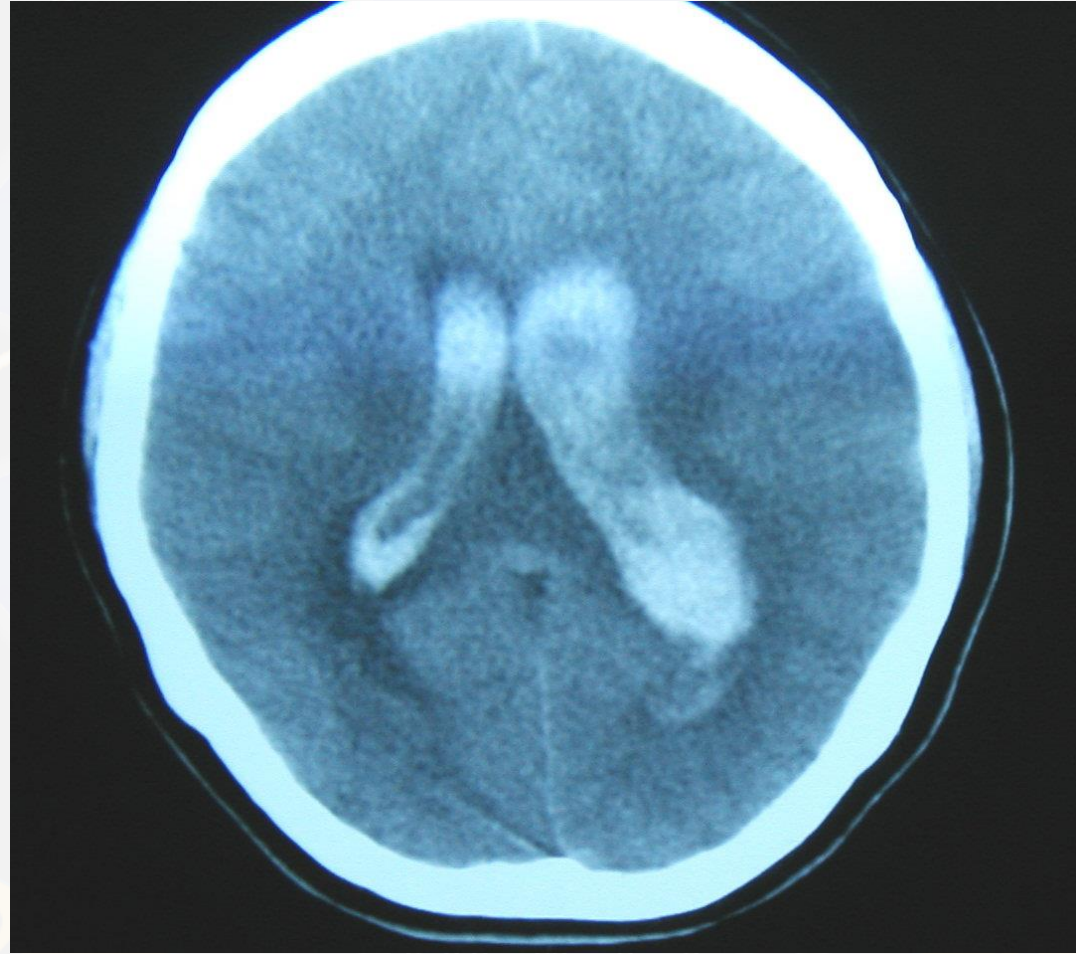
The QT/QTc is prolonged.

The patient's core temperature was measured at 76°F (24°C).

- You are transporting a patient who has AMS
- While transporting the patient, he developed left side weakness, aphasia, and becomes unresponsive
- EKG monitor shows...



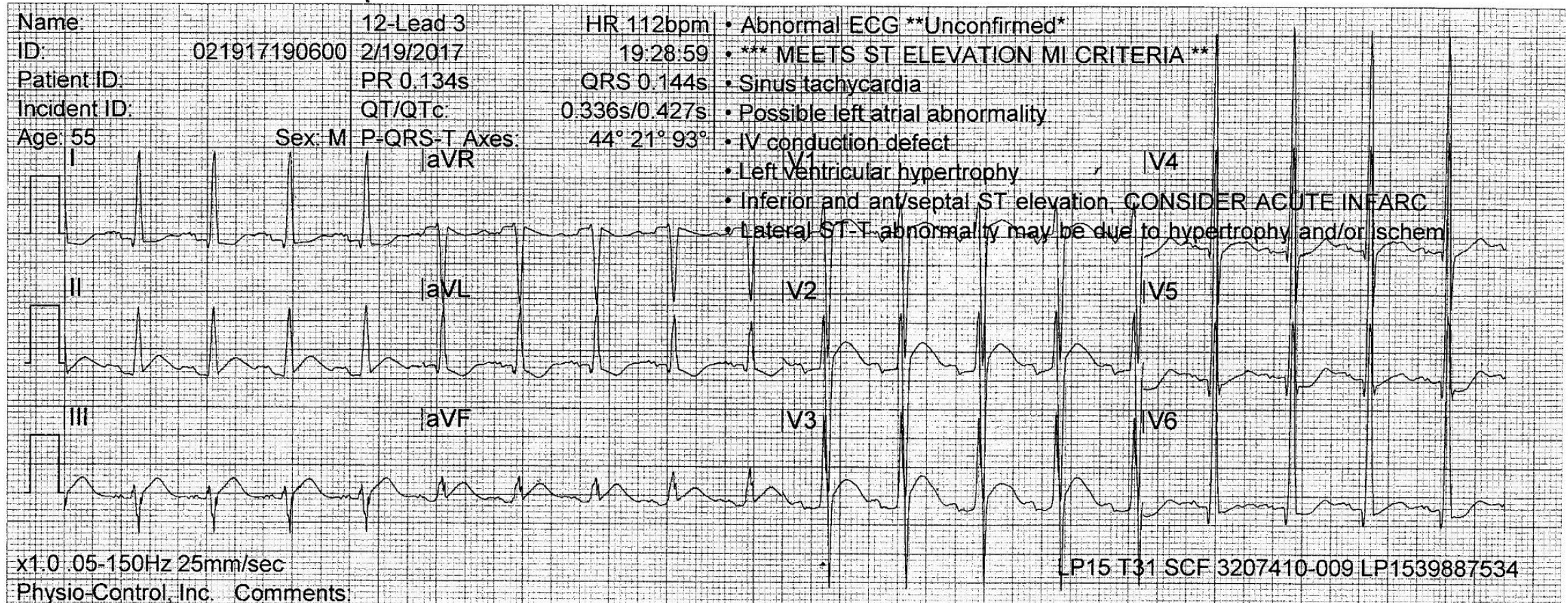
CT showed....



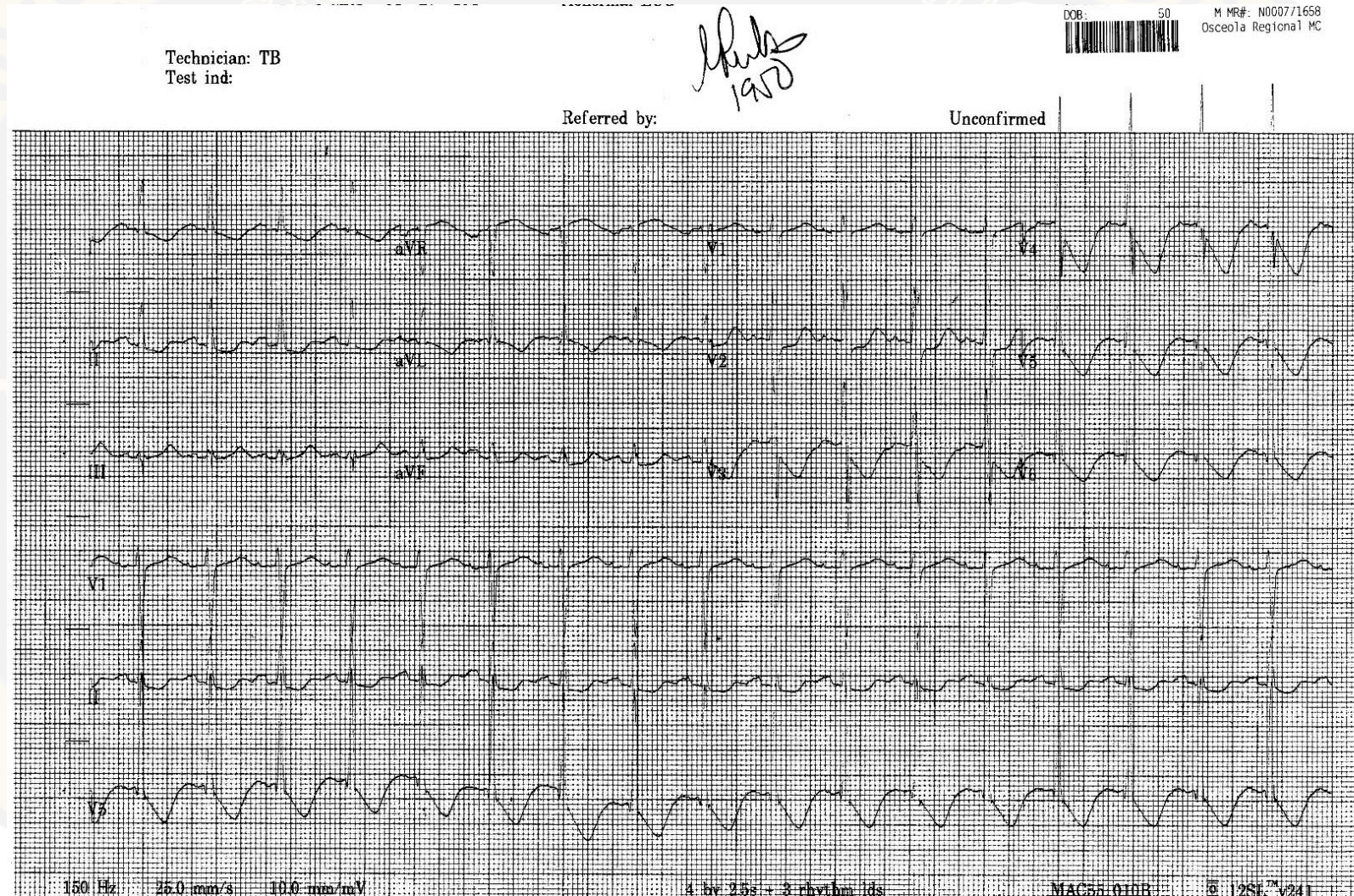
EKG's and ST Changes That Can Kill You

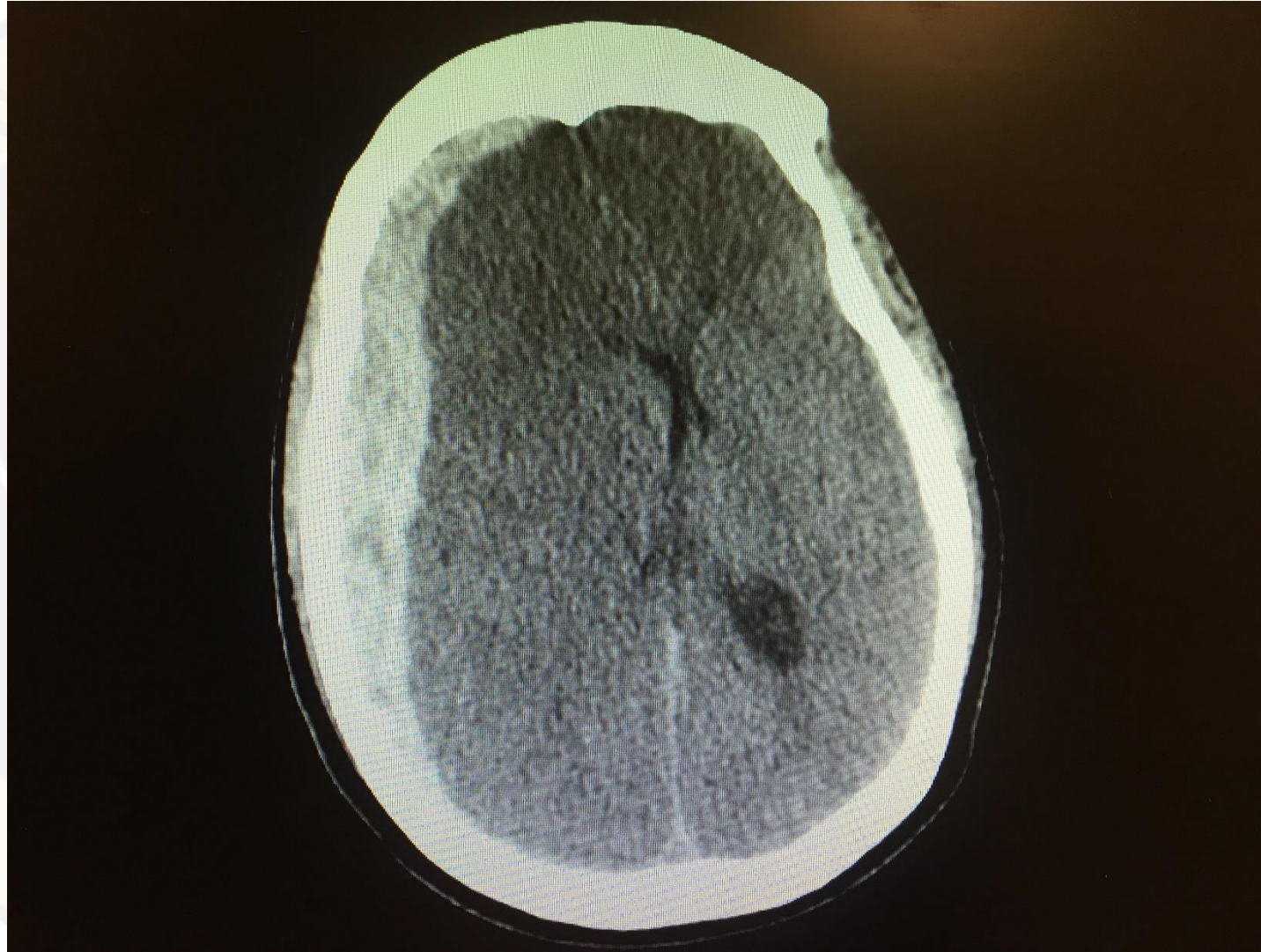
- Early repolarization (well, not really!)
- LVH
- AMI
- RV AMI
- Inverted T-wave in avL
- T wave in v1
- Pericarditis that is not
 - ST elevation in avR
 - Wellen's
 - de Winter
 - Torsades
 - LBBB
 - Pericarditis
 - Brugada's
 - HCM
 - LV aneurysm
 - New RAD
 - Prolonged QTc
 - Pericardial Tamponade
 - PE
 - Slow Vtaq
 - AIVR
 - WPW
 - Hyperkalemia
 - Hypothermia
 - **CNS disorders**
 - Takotsubo Syndrome
 - Spiked-Helmet Sign

ROSC after cardiac arrest



EKG in the ED after arrival





Increased ICP

- It is a clear proof that heart and brain are interconnected by neural network
- All the noted changes occur during myocardial repolarization (i.e.. ST segment)
 - Causing deep T inversion
- The current thinking is...
 - Mediated by adrenergic surge initiated by CNS insult transmitted to myocardium by the sympathetic system
 - Hypothalamic stimulation as well as autonomic dysregulations have been implicated as causative for the ECG changes

Increased ICP

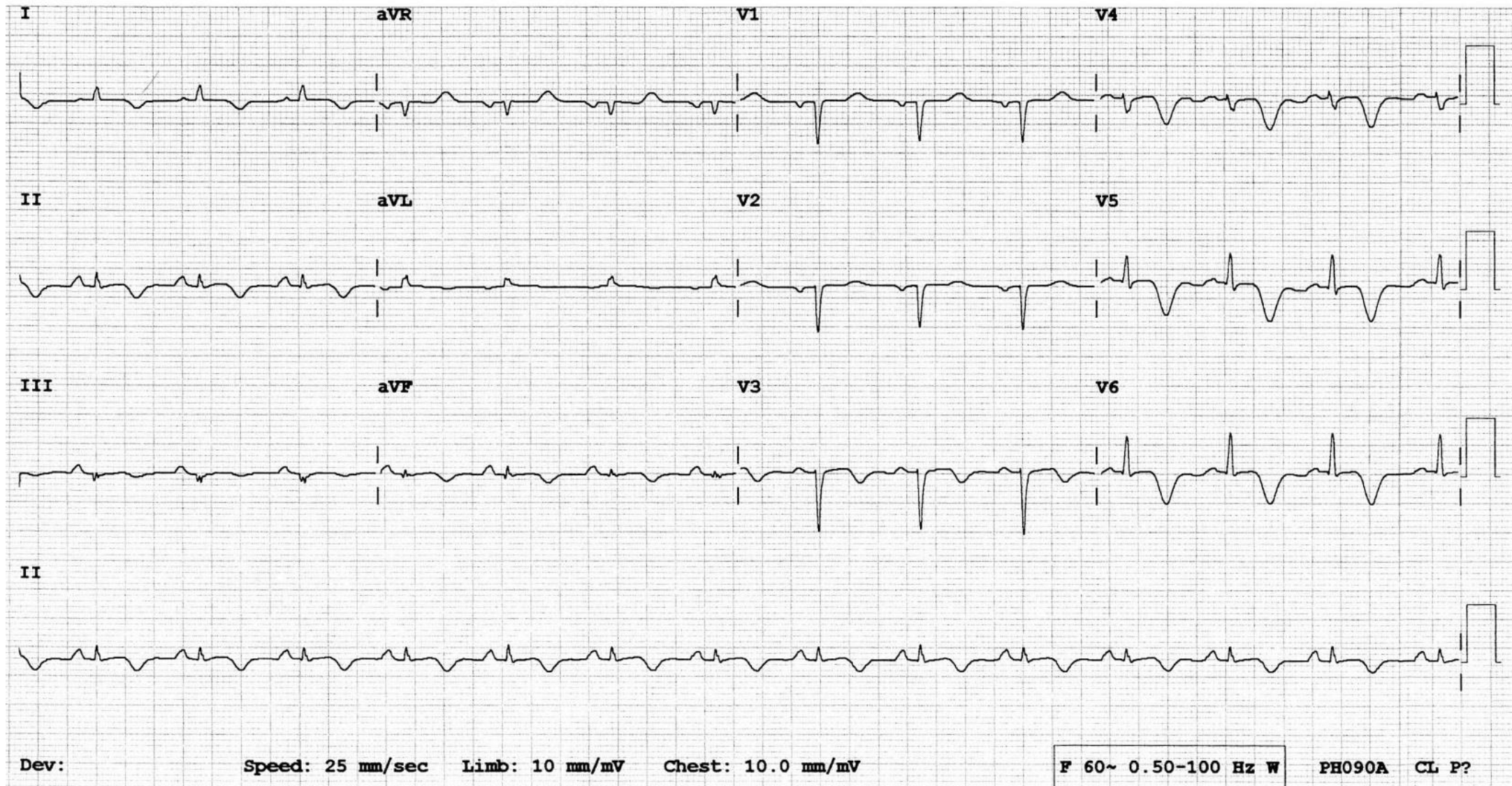
- Causes
 - SAH
 - ICH
 - Traumatic brain injury
 - Massive stroke
- You may also see...
 - Prolonged QTc
 - Bradycardia
 - Diffused ST elevations

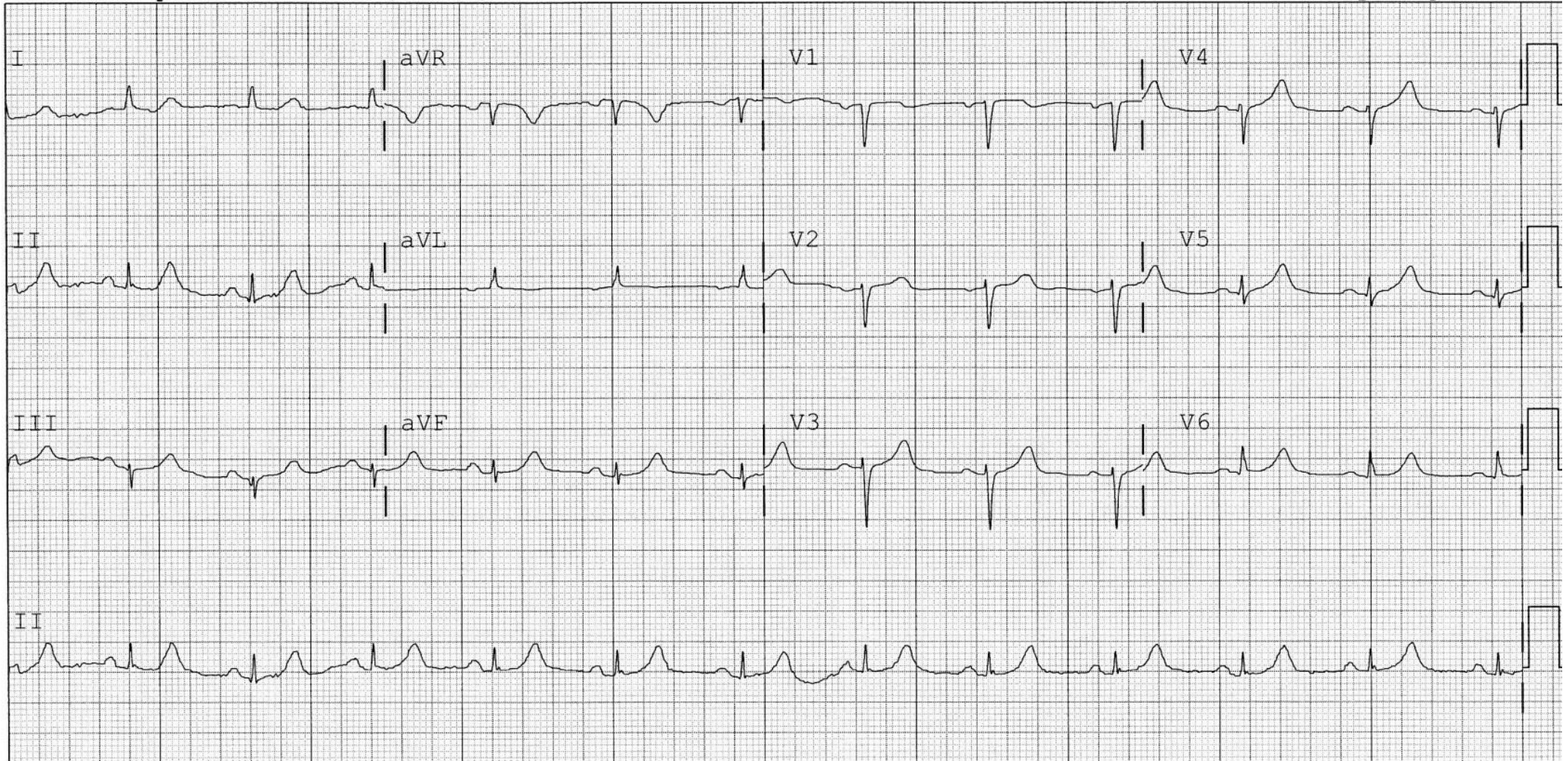
- 48 y/o white female that drove to the ED with the c/o dizziness, chest pressure
- She has a monitor attached to her that looks like this



- She removed it because it got activated and advised people to “get cleared”
- She removed it because she was afraid that it will “shock her” making her to fall down
- She did not take her metoprolol because her BP was low!!!

- PMHx: cardiac condition; had heart catheterization two weeks ago
- PSHx: none
- All/Meds: in the computer!!!
- FamHx: none





Device: 7907

Speed: 25 mm/sec

Limb: 10 mm/mV

Chest: 10 mm/mV

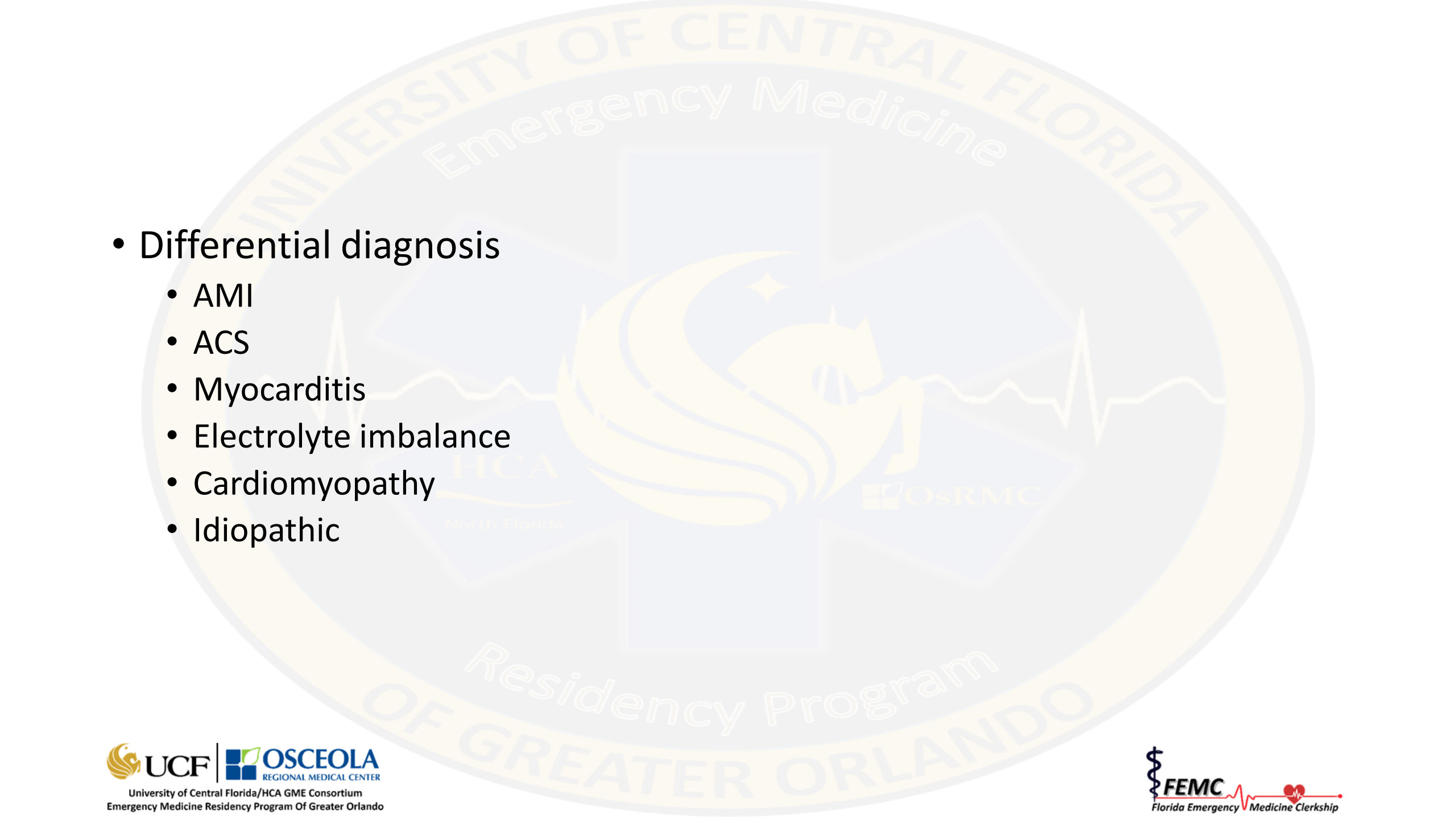
F 60~ 0.5-100 Hz W

PH090A bCLP?

EKG's and ST Changes That Can Kill You

- Early repolarization (well, not really!)
- LVH
- AMI
- RV AMI
- Inverted T-wave in avL
- T wave in v1
- Pericarditis that is not
 - ST elevation in avR
 - Wellen's
 - de Winter
 - Torsades
 - LBBB
 - Pericarditis
 - Brugada's
 - HCM
 - LV aneurysm
 - New RAD
 - Prolonged QTc
 - Pericardial Tamponade
 - PE
 - Slow Vtaq
 - AIVR
 - WPW
 - Hyperkalemia
 - Hypothermia
 - CNS disorders
 - **Takotsubo Syndrome**
 - Spiked-Helmet Sign

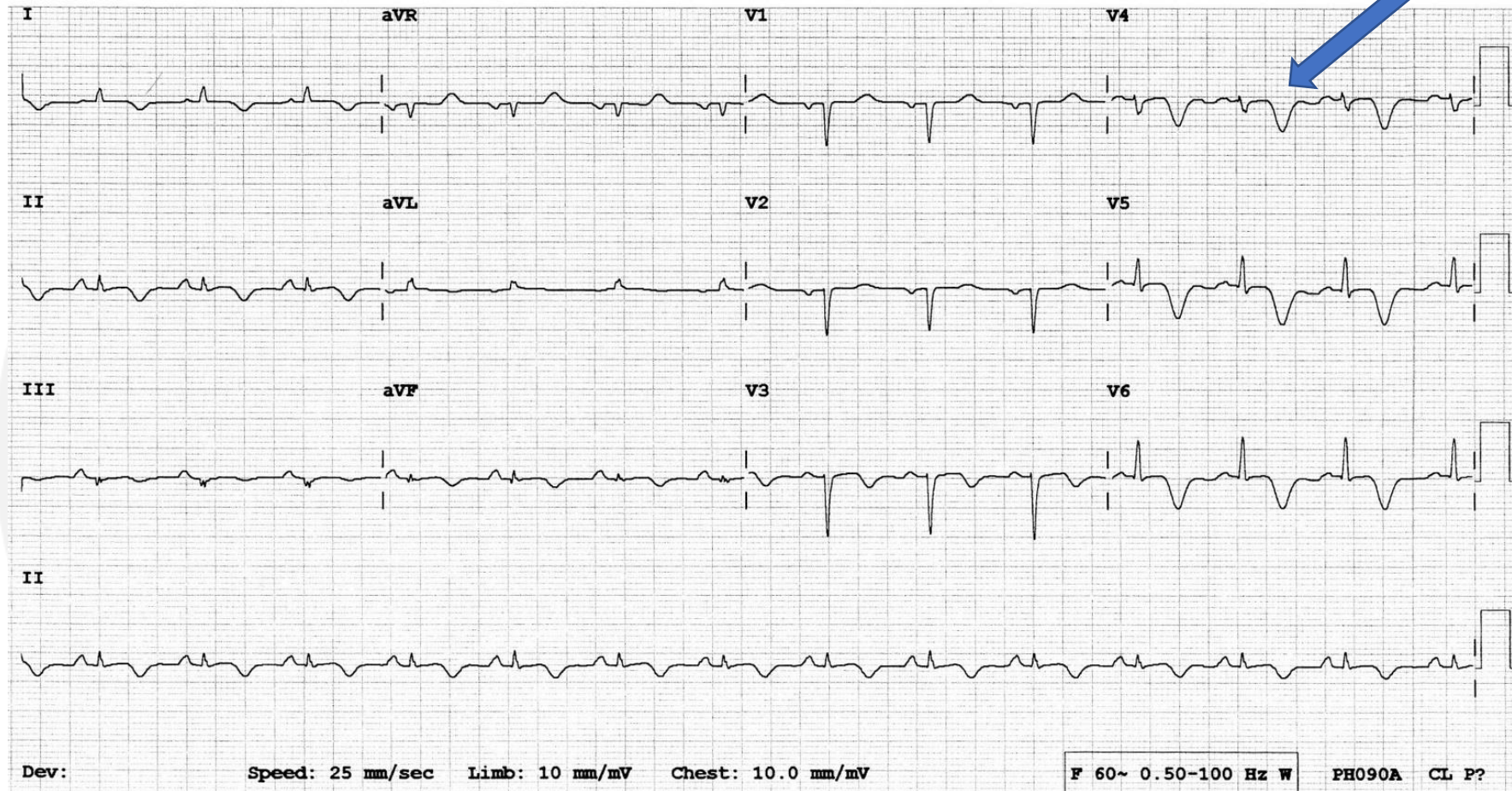
- Holy crap!!!
- STEMI?
- Panic?
- Meds?



- Differential diagnosis

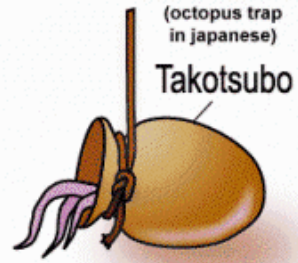
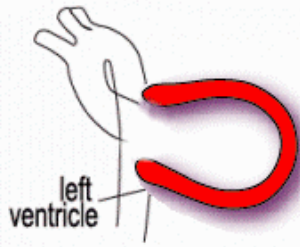
- AMI
- ACS
- Myocarditis
- Electrolyte imbalance
- Cardiomyopathy
- Idiopathic

Diffused T inversion

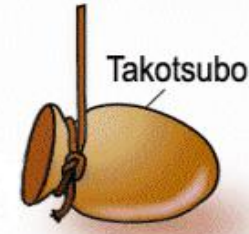
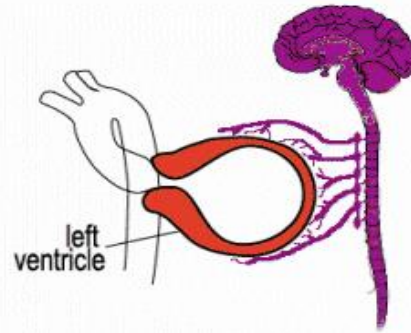


Think AMI but also

Takotsubo syndrome!



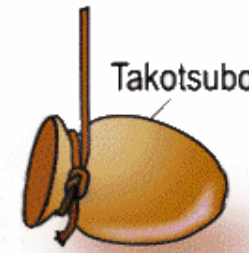
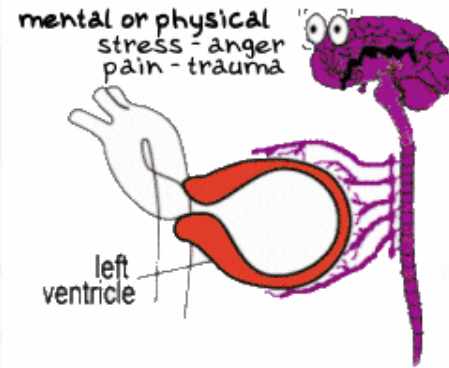
Striped Giraffe Press © 2005



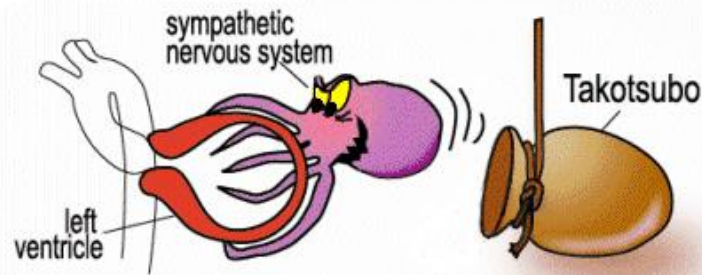
Striped Giraffe Press © 2005



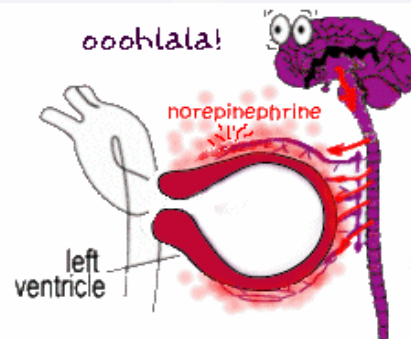
Striped Giraffe Press © 2005



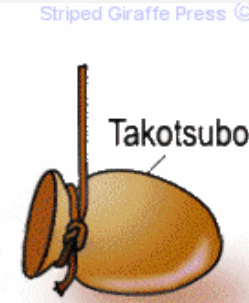
Striped Giraffe Press © 2005



Striped Giraffe Press © 2005

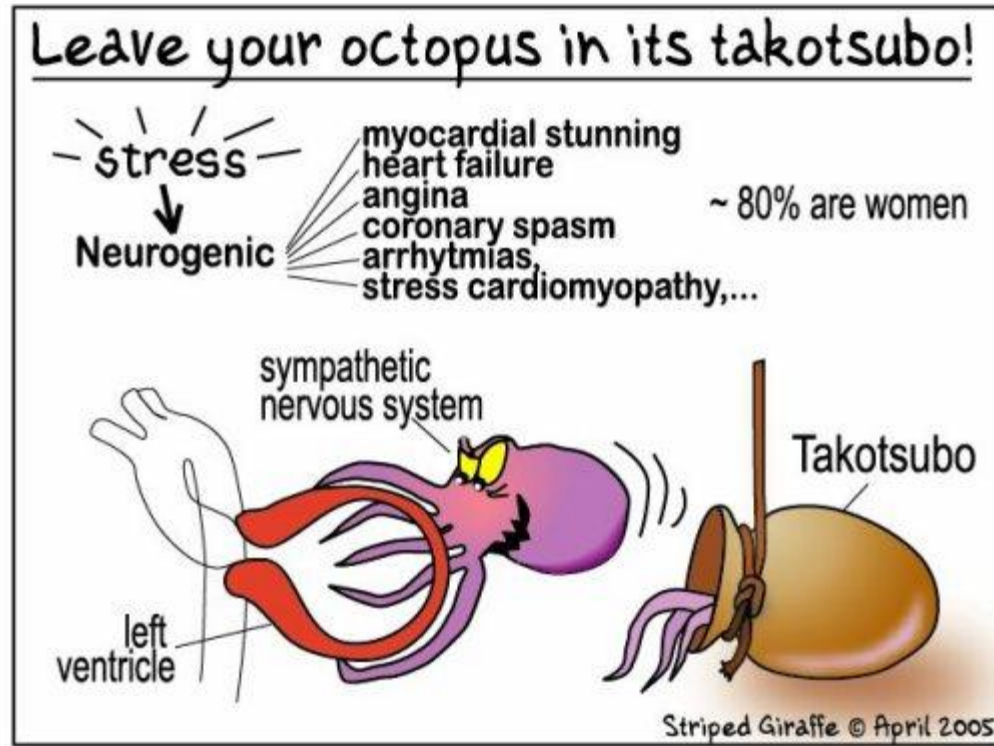


catecholamine-induced transient myocardial stunning

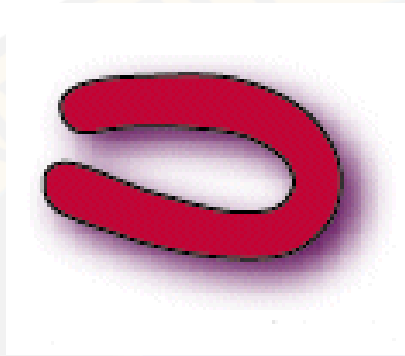


Striped Giraffe Press © 2005

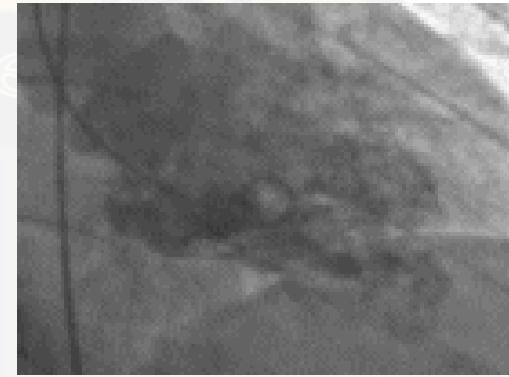
Takotsubo Syndrome



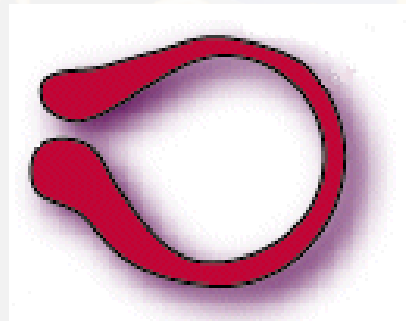
Broken Heart Syndrome or Stress Cardiomyopathy



Normal ventricle



Heart catheterization



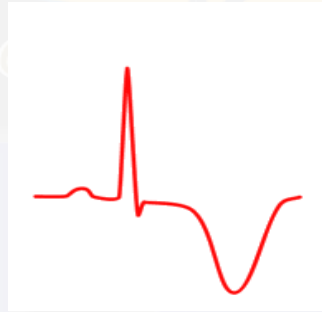
Takotsubo



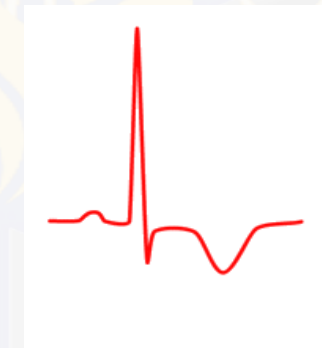
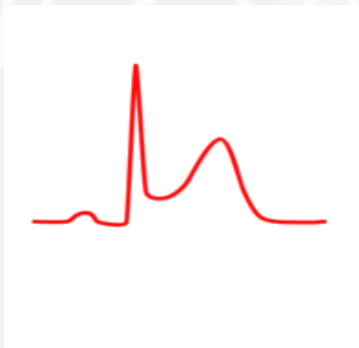
Echo-2D



Stage 1: acute stage,
This stage lasts only a few
hours. Stage of ST
elevation and fairly short
QT interval. The R wave
might be preserved.



Stage 2: sub acute stage.
This stage can last days. QT
segment prolongation and large
and deep negative T waves

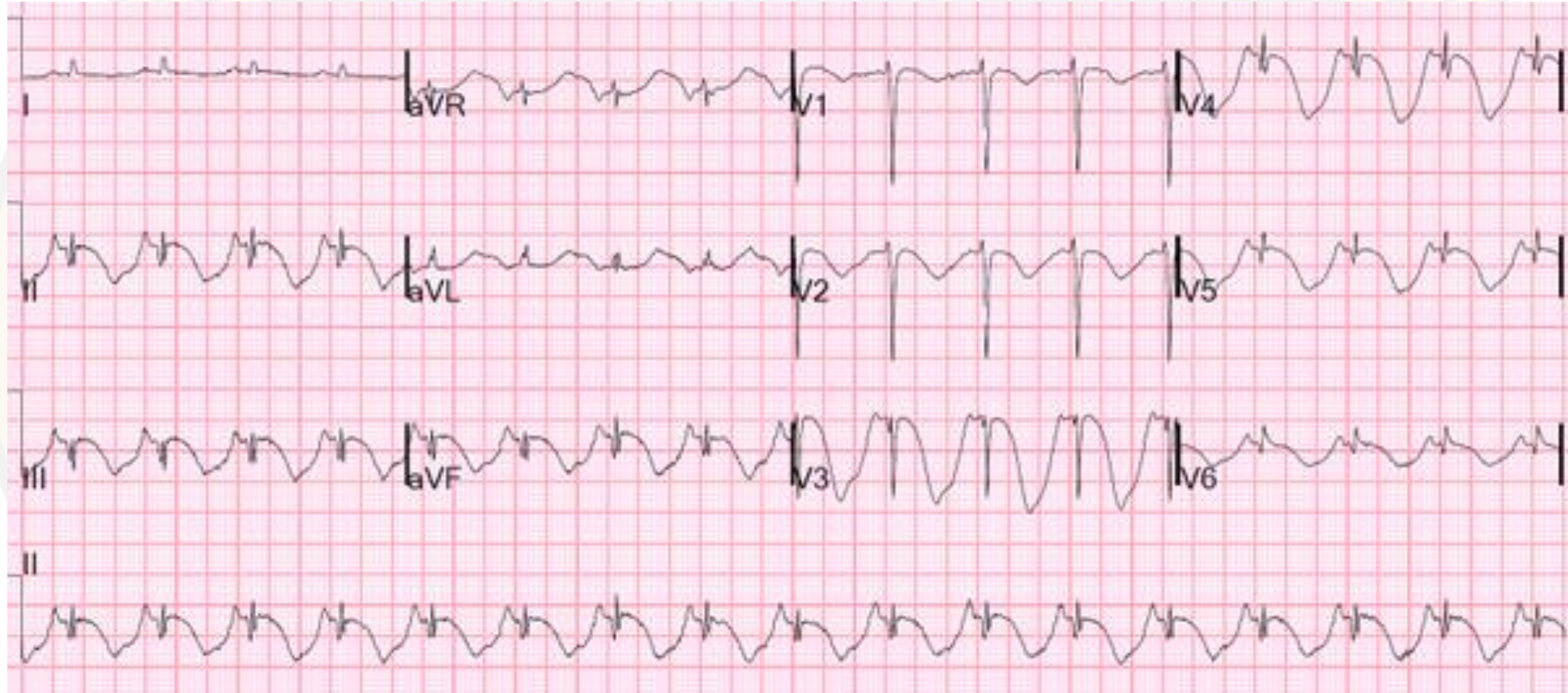


Stage 3: recovery stage. Flipped T
wave persists for days to weeks,
but QT interval is again normal

- So,
- Back to our patient
- Most likely, she did have a run of Vfib or Vtaq
- Patient admitted, metoprolol given, started on Amiodarone while in the ICU

- Patient 65 y/o that was brought in by EMS after complaining of upper abdominal pain for the past 3 hours. The spouse stated that the patient was complaining of some discomfort when he started to vomit and to sweat.
- The spouse went to the bathroom after hearing a noise where the patient was found unresponsive.
- VS: HR 125/min RR 18/min BP 95/60 afebrile O2Sat 92%
- PE: diaphoretic, diffused tenderness

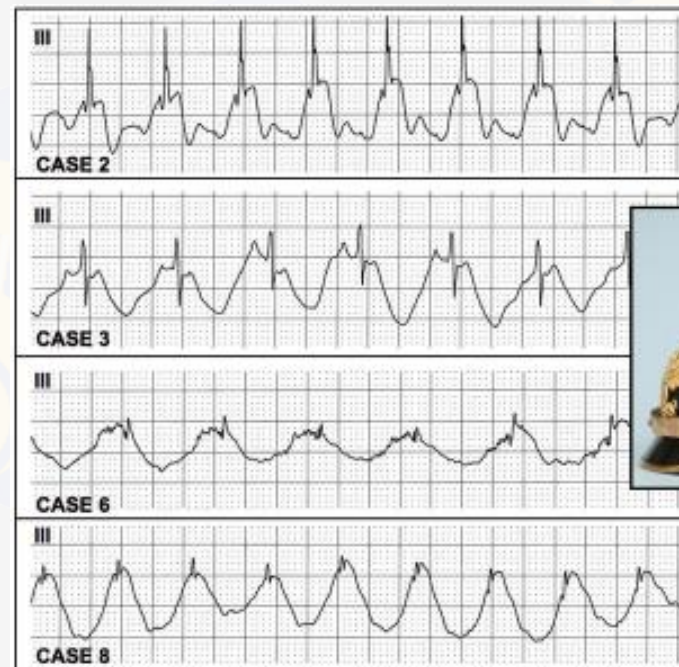
EKG



- Should call STEMI?
- No chest pain, but symptoms are atypical....
- Cardiac enzymes are WNL

- Patient went to CT and had perforated bowel...
- Patient was taken to the OR then, to the ICU...
- Patient did not survive the hospital stay.

EKG



EKG's and ST Changes That Can Kill You

- Early repolarization (well, not really!)
- LVH
- AMI
- RV AMI
- Inverted T-wave in avL
- T wave in v1
- Pericarditis that is not
 - ST elevation in avR
 - Wellen's
 - de Winter
 - Torsades
 - LBBB
 - Pericarditis
 - Brugada's
 - HCM
 - LV aneurysm
 - New RAD
 - Prolonged QTc
 - Pericardial Tamponade
 - PE
 - Slow Vtaq
 - AIVR
 - WPW
 - Hyperkalemia
 - Hypothermia
 - CNS disorders
 - Takotsubo Syndrome
 - Spiked-Helmet Sign

Spiked-Helmet Sign

- Appearance of helmet sign resembling a German military spiked helmet on electrocardiogram more commonly in inferior leads was described earlier in very sick people suffering from non-cardiac ailments.
- Mechanism underlying the appearance of helmet sign is unknown but it was postulated to be due to sudden increase in intra-abdominal pressure or synchronized contraction of the diaphragm with heart.
- Patients with acute abdominal or acute thoracic events occasionally develop a curious electrocardiographic ST-segment elevation, where the upward shift of the baseline starts before the onset of the QRS complex.

- The presence of this “spiked helmet” sign was found to be associated with critical noncardiac illness and high risk of in-hospital death.
- Prompt recognition and management of underlying acute noncardiac conditions resulted in resolution of the spiked helmet sign.
- The changes have been shown to accompany acute abdominal and thoracic events such as pancreatitis, pancreatic cancer, pneumomediastinum, and pneumothorax.

- The exact cause of the spiked helmet ECG pattern is uncertain.
- The most likely mechanism is pulsatile epidermal stretch resulting from an acute rise in intracavitary pressure.
- When seen in the **inferior leads**, this curious ECG pattern should raise the possibility of an acute abdominal event
- One should suspect an intrathoracic pathology if it shows up in the **precordial leads**

- Study a lot....
- See a lot of EKG's....
- So you can see a lot of normal EKG's....
- EKG's changes can mimic anything....
- The important thing is....
- Be able to recognize the one that is not normal!!!

