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# Basic EKG Patterns and Sources of Confusion P STT Changes

— Interactive EKG Workshop —  
Cardiology Day 2021  
Dr. Liane Arcinas

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# Objectives

Through cases, learn about

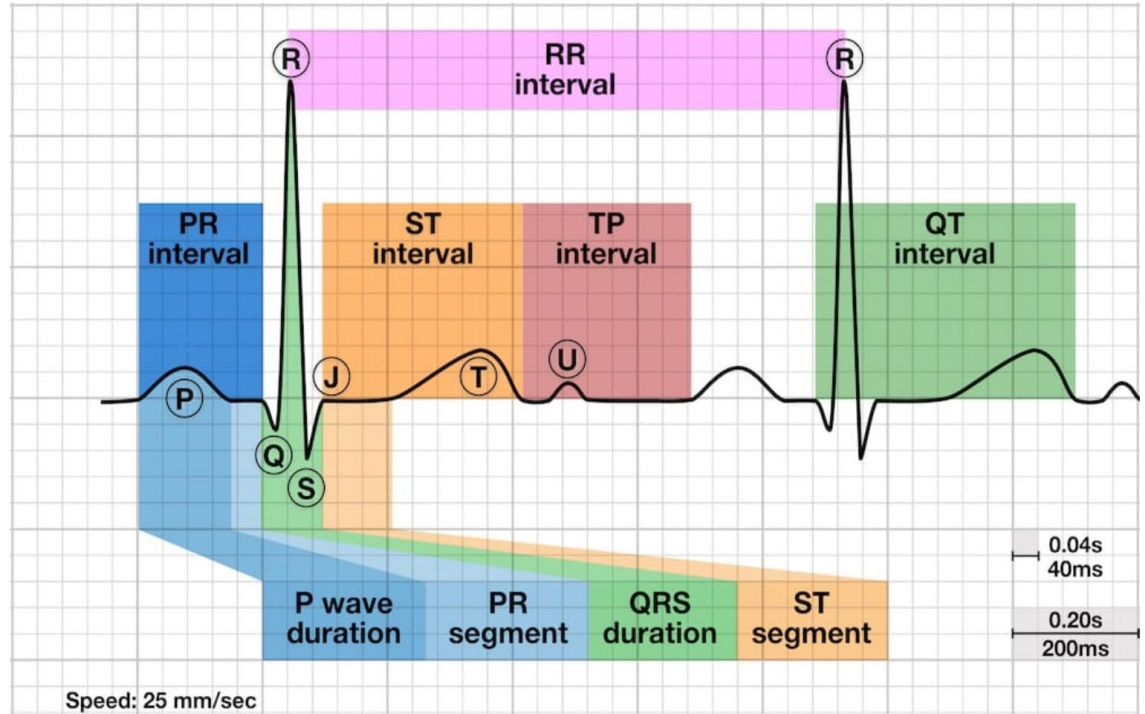
- ST Segment and T Wave
- Typical findings of ST-elevation myocardial infarction in an EKG
- Ddx for ST-T changes **with** chest pain
- Ddx for ST-T changes **without** chest pain

## ST Segment

- Isoelectric line after the QRS complex and the beginning of the T wave
- Represents the period between ventricular depolarization and repolarization

## T Wave

- Ventricular repolarization



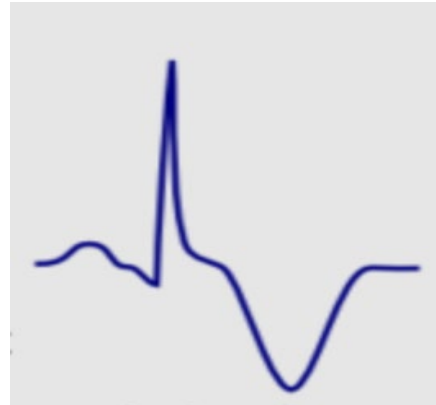
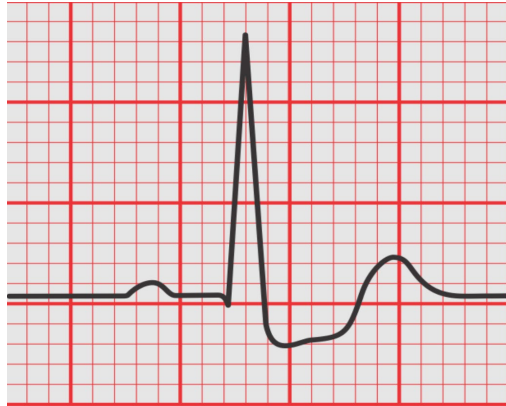
Important causes of ST-T abnormality are **myocardial ischemia, injury and infarction**

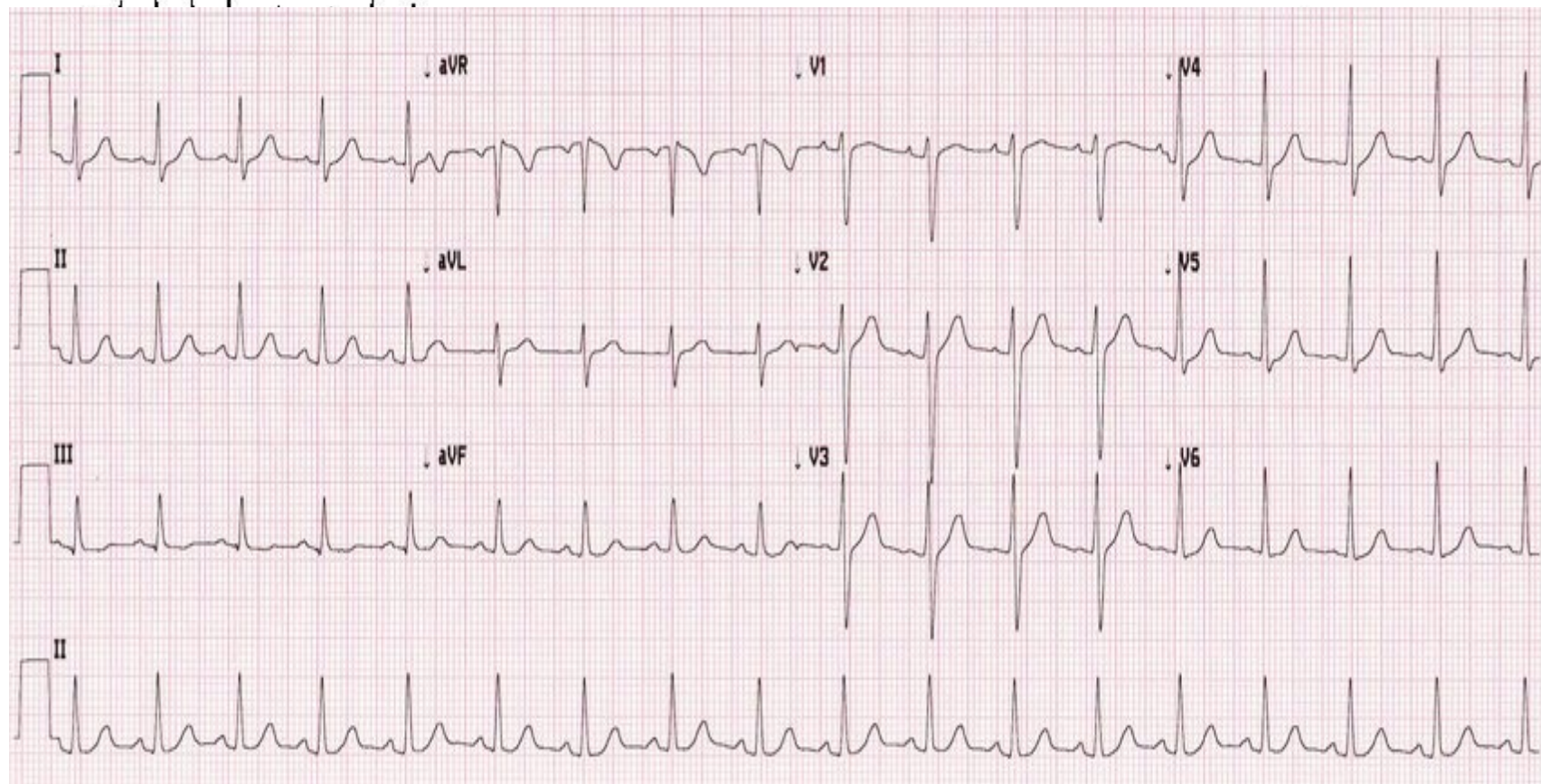
# EKG Terms: Ischemia, Injury & Infarction

## 1. Ischemia

- Oxygen deprivation of myocardial tissue which can be caused by:
  - a. Coronary Occlusion (i.e. ACS)
  - b. Supply -demand imbalance (e.g. during tachyarrhythmia, sepsis, bleeding, etc)

ST segment depression, T wave flattening or inversion





25mm/s 10mm/mV 40Hz 005C 12SL 254 CID: 29

EID:615 EDT: 10:18 27-OCT-2002 ORDER:

# EKG Terms: Ischemia, Injury & Infarction

## 2. Injury

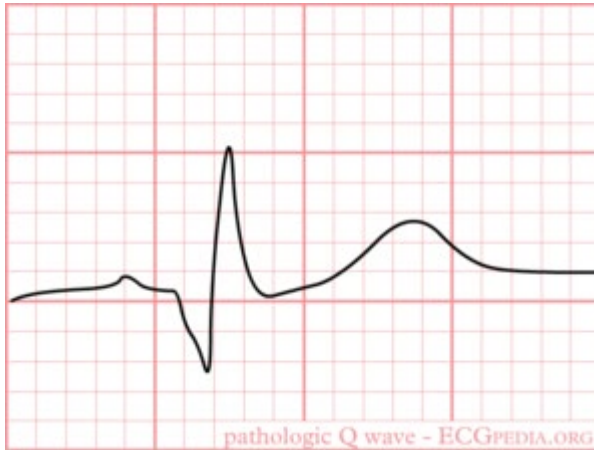
ST-segment elevation

# EKG Terms: Ischemia, Injury & Infarction

## 3. Infarction

- Necrosis of myocardial tissue

### Pathologic Q-wave



- Q wave  $\geq 0.04s$  (1 small box) and/or
- $>25\%$  R wave
- Needs to be in **2** contiguous leads

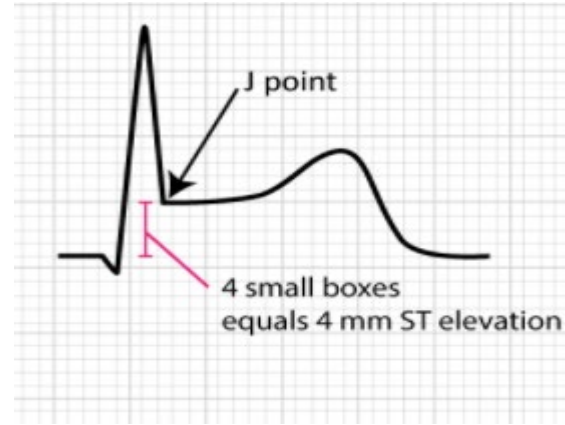
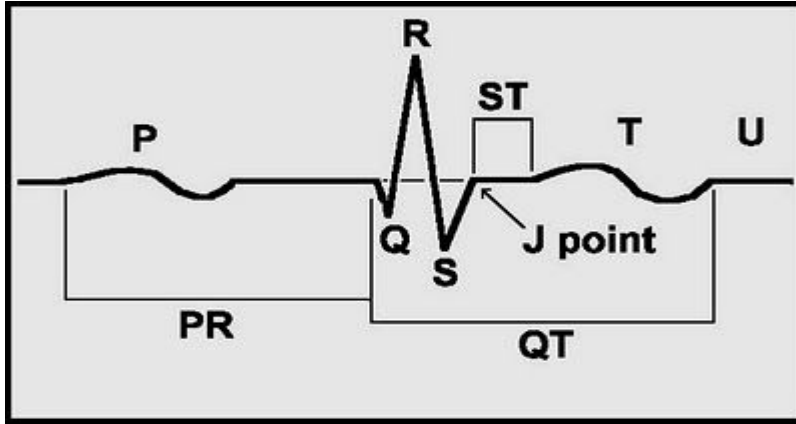
Reported as:

Old or age indeterminate if q wave alone

**Acute or recent infarction if with  
concurrent ST-Elevation**

# EKG Findings of Acute STEMI

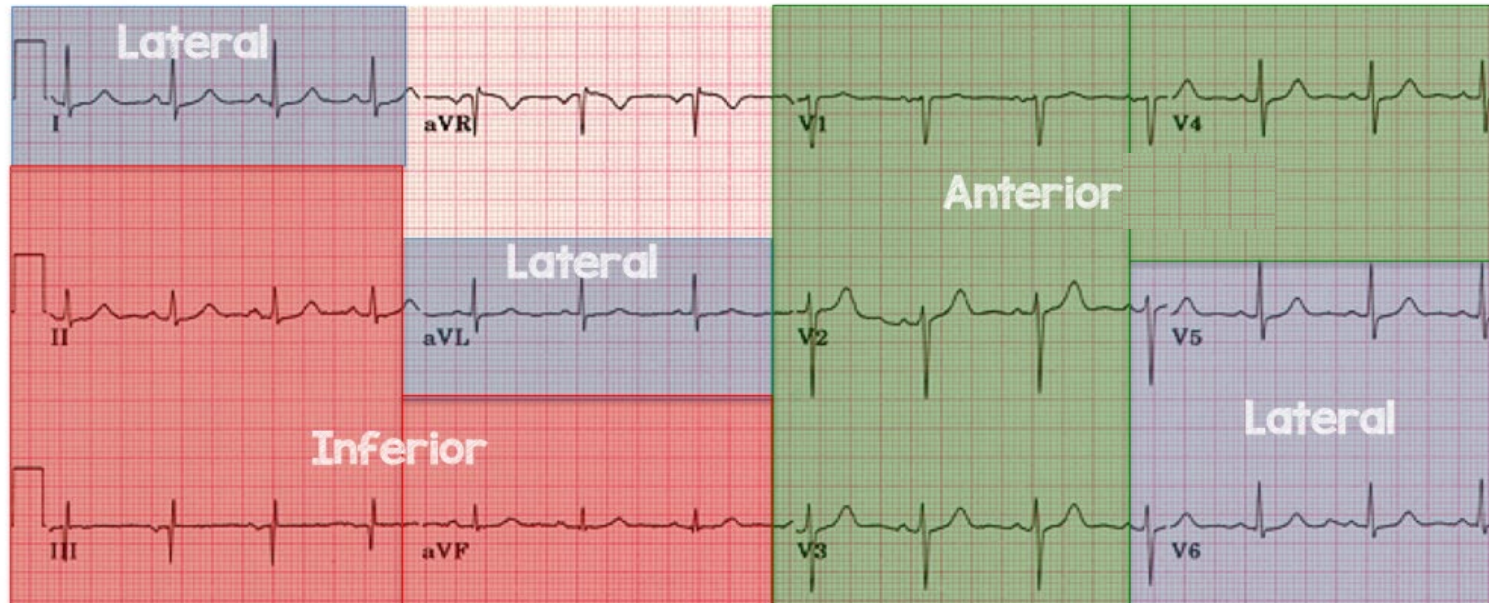
- ST-Elevation from the J-point in  $\geq 2$  contiguous leads



- **V2-V3**
  - Male  $\geq 40$  yo:  $\geq 2$  mm
  - Male  $< 40$  yo:  $\geq 2.5$  mm
  - Female  $\geq 1.5$  mm
- **All other leads:** 1 mm
- Right sided and posterior leads (V3R, V4R, V7, V8, V9):  $\geq 0.5$  mm
- May or may not have an associated pathologic q wave



# Localization of STEMI



**Coronary Anatomy & ECG Leads**

<b>Lateral Leads</b>	<b>I, aVL, V5 - V6</b>	<b>LCx or Diagonal of LAD</b>
<b>Inferior Leads</b>	<b>II, III, aVF</b>	<b>RCA and/or LCx</b>
<b>Anterior/Septal Leads</b>	<b>V1 - V4</b>	<b>LAD</b>

# ST Elevation on EKG: Differential Diagnosis

## STEMI mimics; A mnemonic

Simon Mark Daley (2018)

**R**aised intracranial pressure (Such as SAH or haemorrhagic stroke)

**A**berrant conduction (Left Bundle Branch Block)

**I**nflammation (Pericarditis)

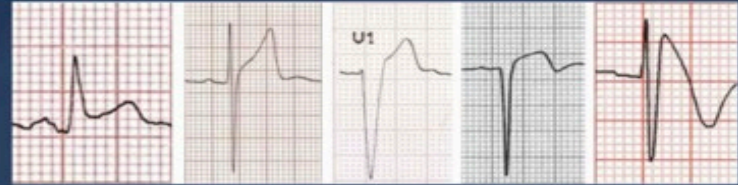
**S**pontaneous coronary artery dissection (SCAD)

**E**lectrolytes (Hyperkalaemia)

**D**evice (Ventricular paced rhythm)

**S**odium channelopathy (Brugada Syndrome)

**T**horacic aortic dissection



**S**pasm of the coronary arteries (Prinzmetal's/variant angina)

**E**mbolism (Pulmonary)

**G**rief (Takotsubo cardiomyopathy)

**M**ycocardial infarction recently (leading to ventricular aneurysm)

**E**nlarged ventricle (Left ventricular hypertrophy)

**N**ormal for them (Early repolarisation)

**T**emperature (Hypothermia)

# STT Changes with Chest Pain

- ACS
  - UA, NSTEMI & STEMI
- Acute Pericarditis
- Aortic Dissection
- Pulmonary Embolism
- Spontaneous Coronary Artery Dissection
- Takotsubo Cardiomyopathy
- Coronary Spasm

# STT Changes without Chest Pain

- Early repolarization
- LVH
- LBBB
- Ventricular Aneurysm
- Raised intracranial pressure
- Electrolyte Abnormalities (hyperkalemia)

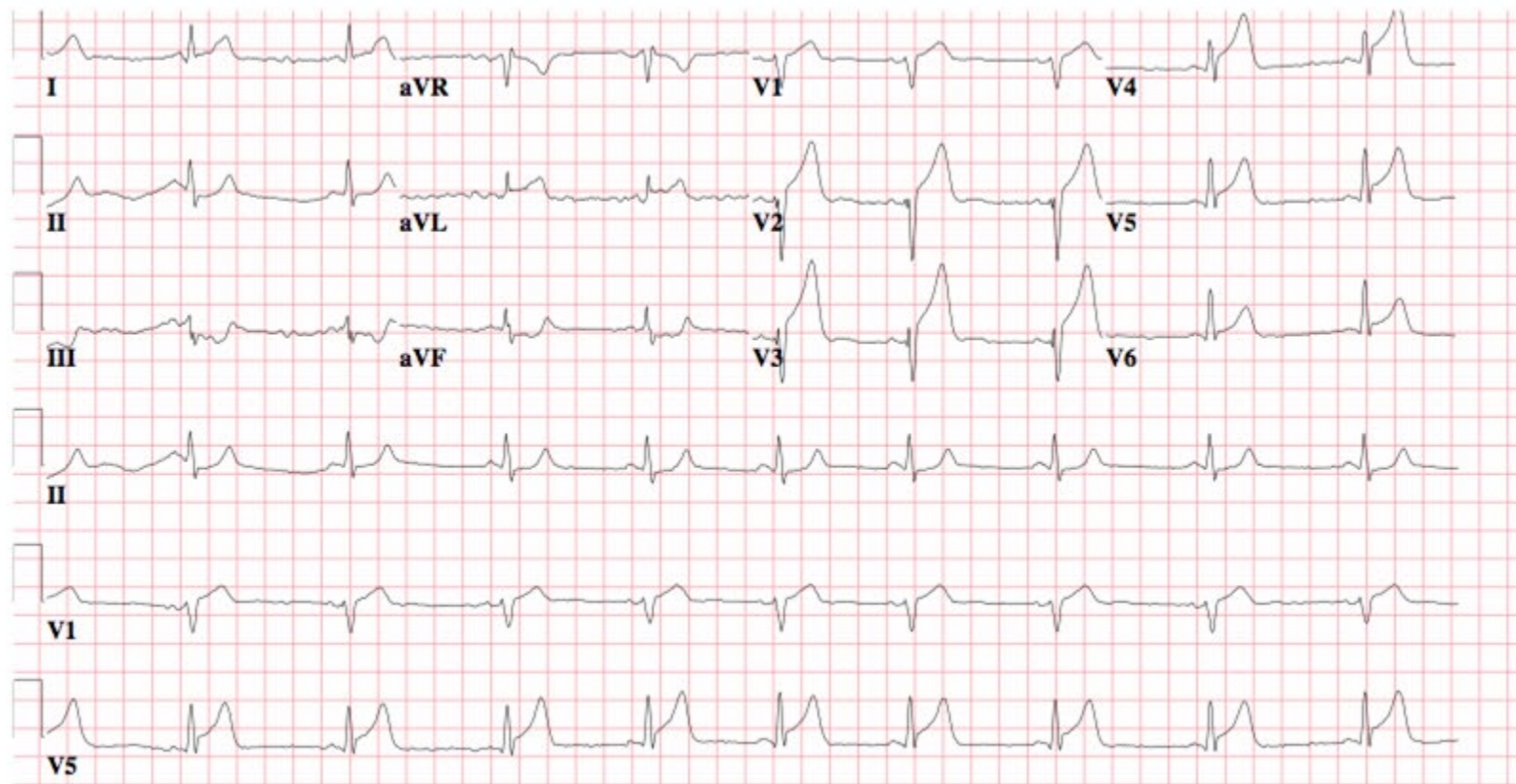
# Case 1

- 43 year old male
  - Past medical history: Asthma
  - Active 2-pack per day smoker
- Presented to community ER after 1 hour of acute onset substernal chest pain at rest.
  - Worst with exertion, radiation to L shoulder
  - With associated diaphoresis and fatigue.





## ECG Case # 1



# POLL

Diagnosis?

- a.** Acute Anterolateral ST -Elevation  
Myocardial Infarction (STEMI)
- b.** Left Ventricular Hypertrophy (LVH)  
with repolarization abnormality
- c.** Acute Pulmonary Embolism
- d.** Pericarditis

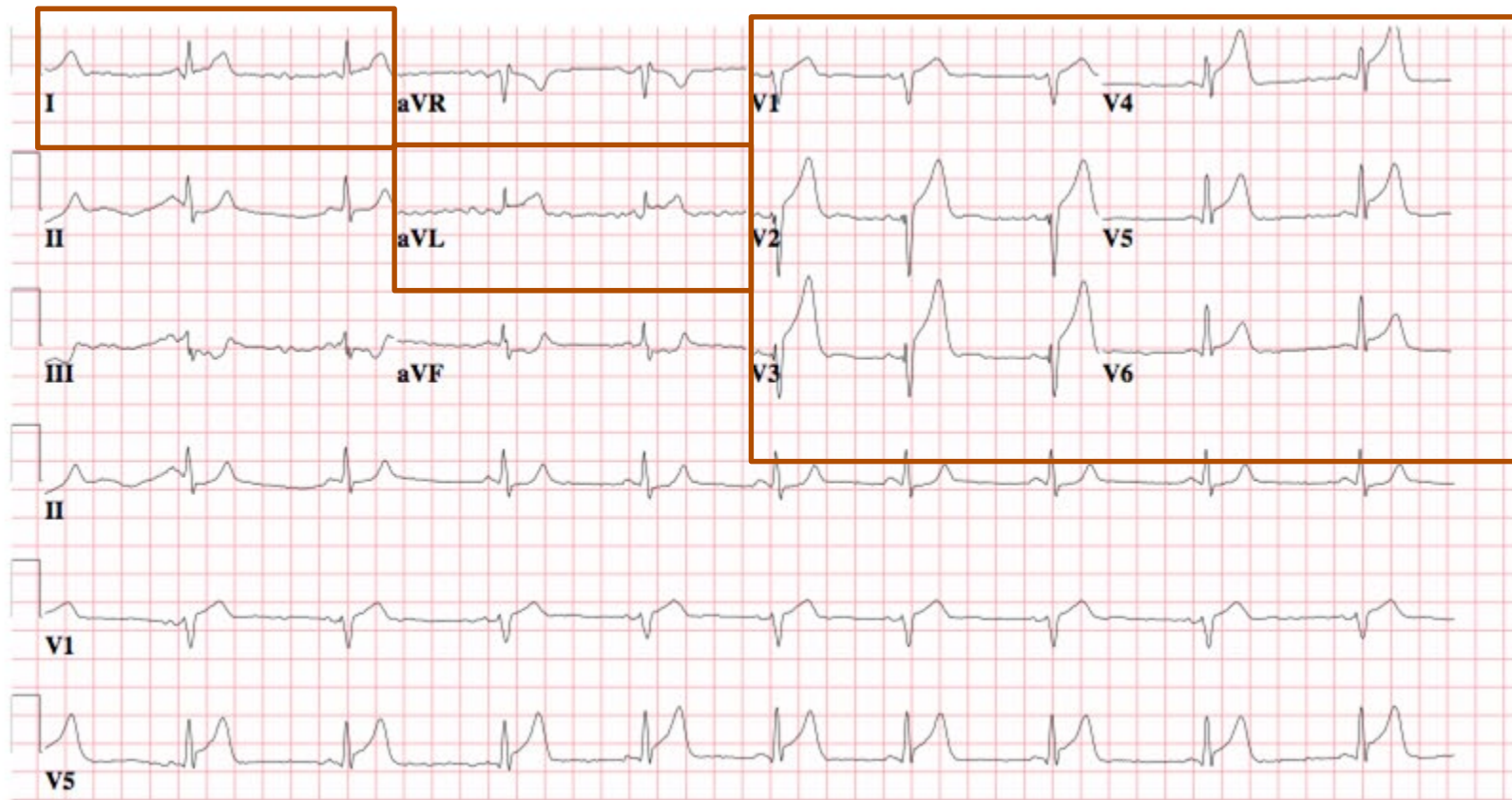
# POLL

Diagnosis?

- a. Acute Anterolateral ST -Elevation Myocardial Infarction (STEMI)
- b. Left Ventricular Hypertrophy (LVH) with repolarization abnormality
- c. Acute Pulmonary Embolism
- d. Pericarditis



## ECG Case # 1

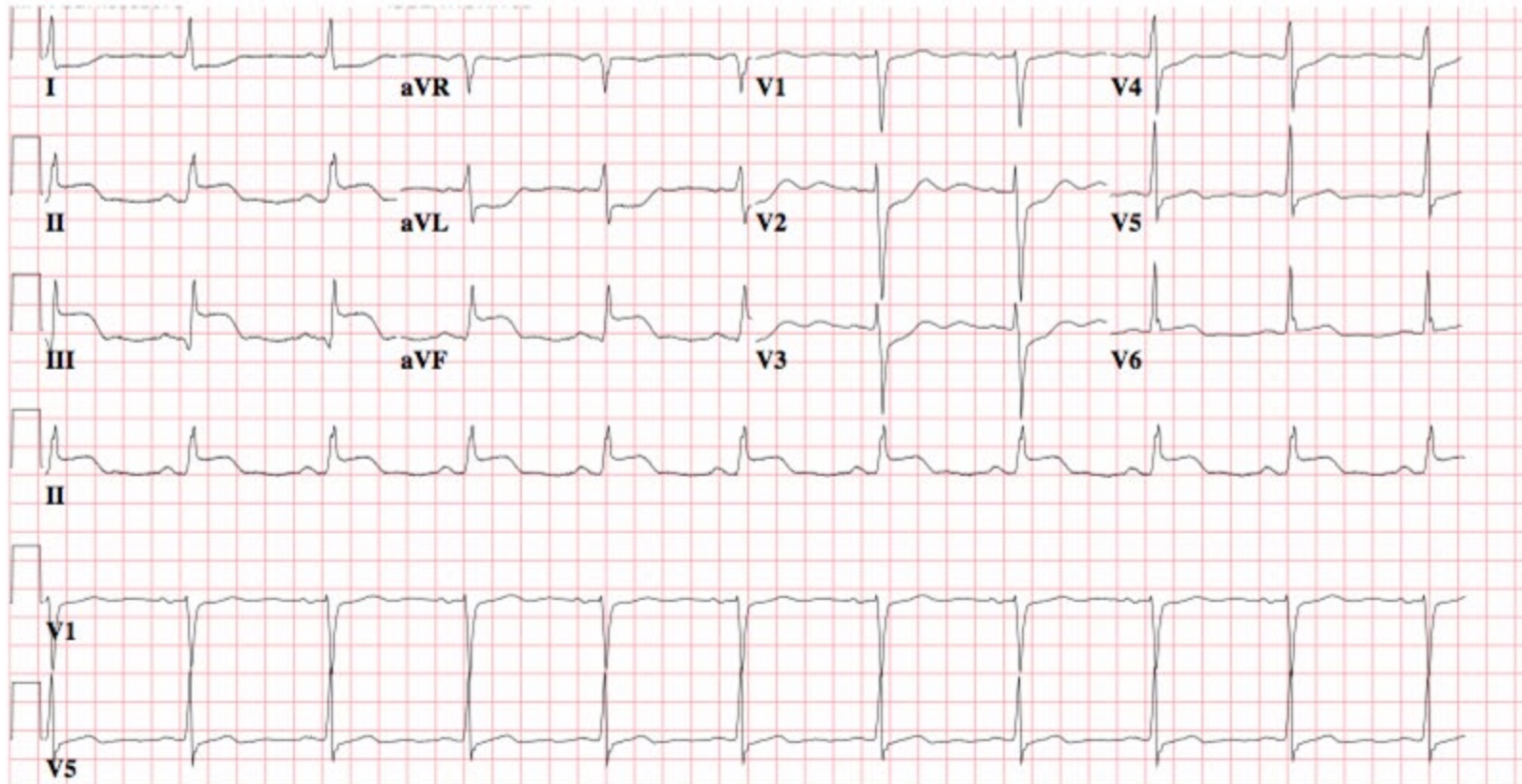


## Case 2

- 55-year-old female smoker
  - No past medical history or medications.
  - Family history of early CAD
    - Dad MI in his 40's
- Developed acute onset chest pressure, called EMS and had ECG performed as follows:



## ECG CASE # 2



## POLL

Diagnosis?

a. Pericarditis

b. Takotsubo Cardiomyopathy (Stress -induced cardiomyopathy)

c. PE

d. Inferoposterior STEMI

e. Aortic Dissection

# POLL

Diagnosis?

a. Pericarditis

b. Takotsubo Cardiomyopathy (Stress -induced cardiomyopathy)

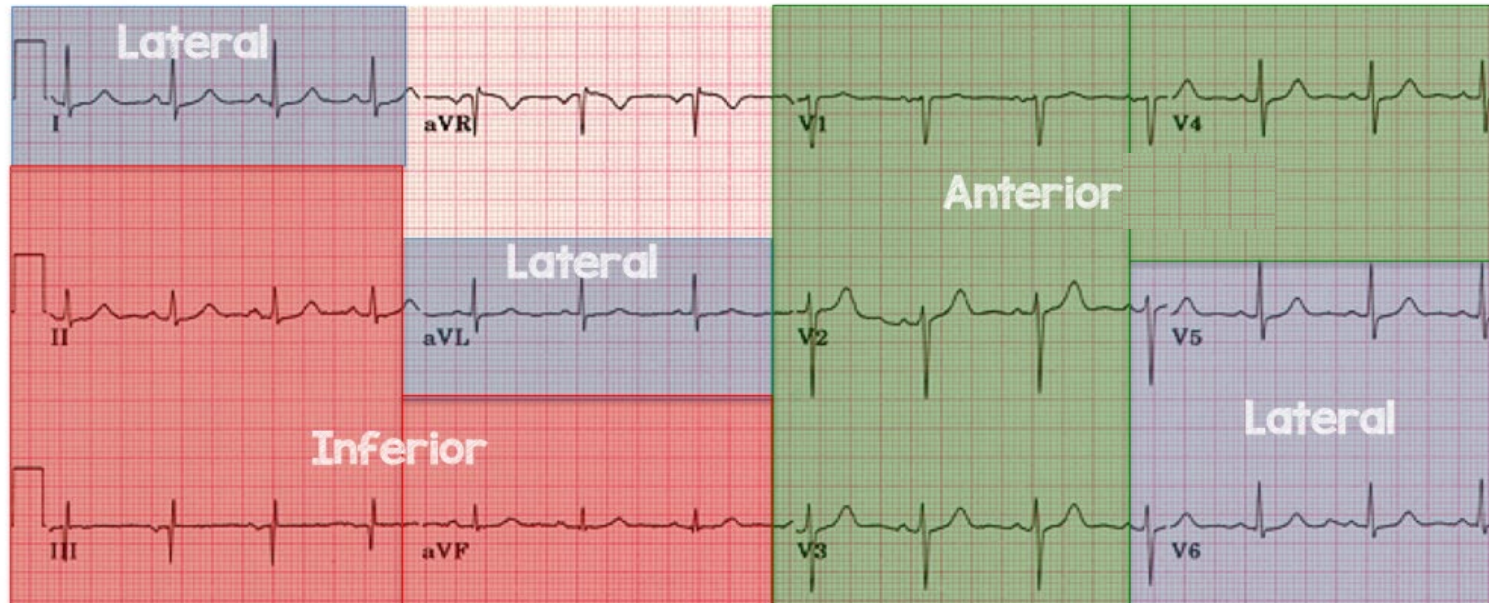
c. PE

d. Inferoposterior STEMI

e. Aortic Dissection



# Localization of STEMI



**Coronary Anatomy & ECG Leads**

<b>Lateral Leads</b>	<b>I, aVL, V5 - V6</b>	<b>LCx or Diagonal of LAD</b>
<b>Inferior Leads</b>	<b>II, III, aVF</b>	<b>RCA and/or LCx</b>
<b>Anterior/Septal Leads</b>	<b>V1 - V4</b>	<b>LAD</b>

# Reciprocal Changes on EKG

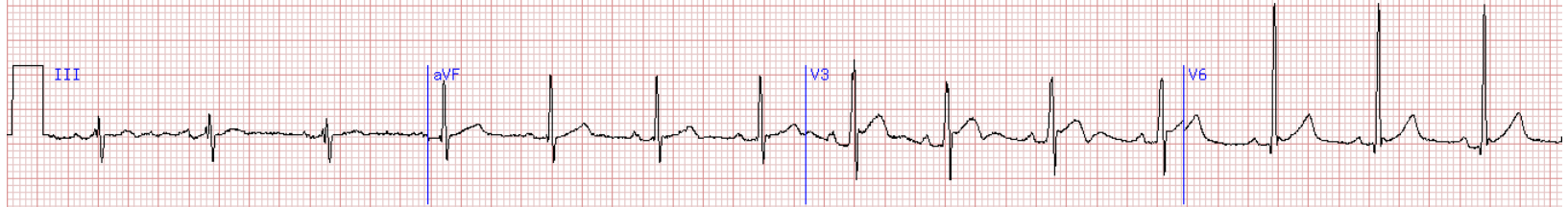
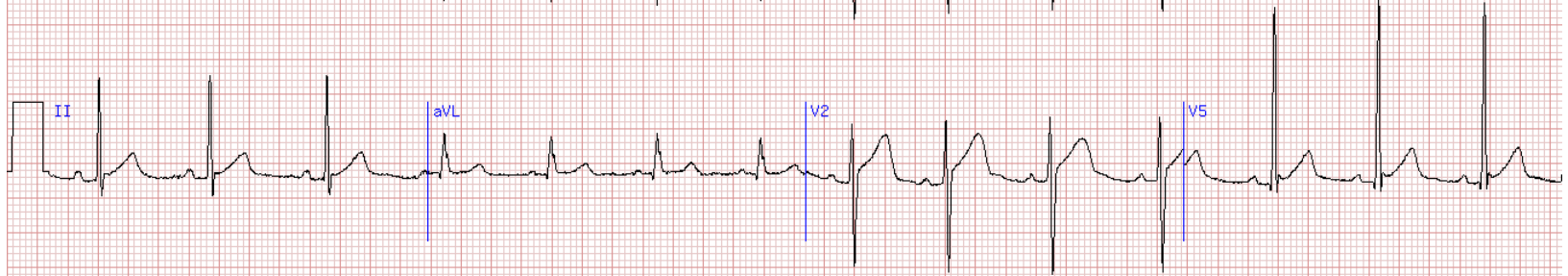
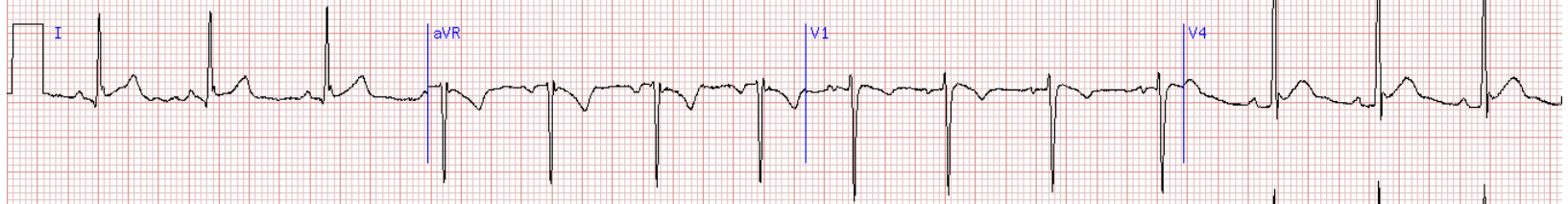
- Don't just look for the ST Elevation, look for reciprocal changes too!
- Supports STEMI diagnosis and may signal larger area at risk!
  - **P**osterior – *anterior reciprocal changes*
  - **A**nterior – not much, some inferior dep on size
  - **I**nferior – *lateral reciprocal changes*
  - **L**ateral <-> *inferior or septal reciprocal changes*
  - **S**eptal – *posterior reciprocal changes*

# Case # 3

18 y.o. healthy male with a normal physical exam with the following EKG:







# POLL

Diagnosis?

- a. Inferolateral STEMI
- b. Early Repolarization
- c. Left Bundle Branch Block
- d. Brugada Syndrome

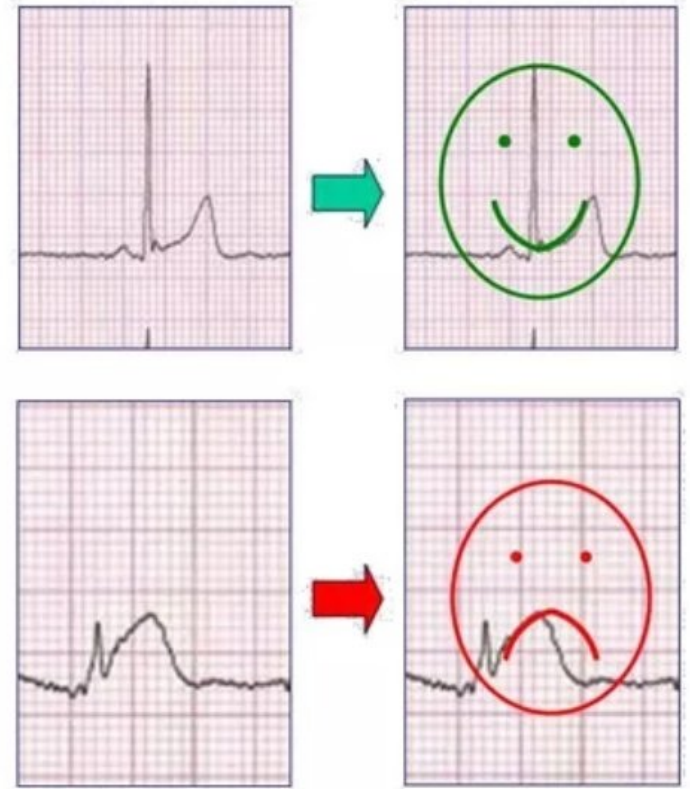
# POLL

Diagnosis?

- a. Inferolateral STEMI
- b. Early Repolarization
- c. Left Bundle Branch Block
- d. Brugada Syndrome

# Early Repolarization Pattern (Jpoint Elevation)

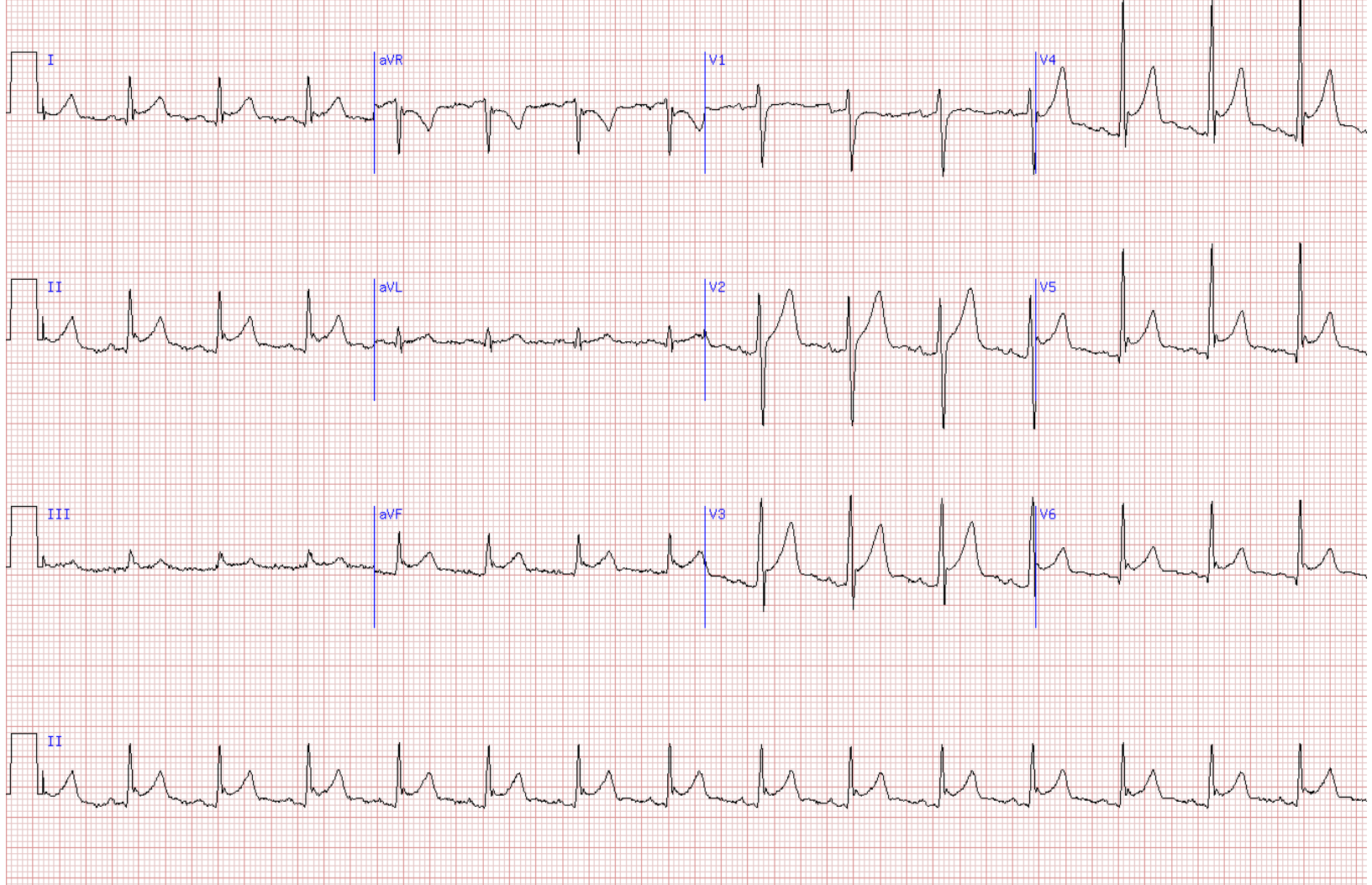
- Positive (**Concave**) Jpoint elevation  $\geq 0.1$  mV in 2 or more contiguous leads with a **notched or slurred** morphology
  - Most commonly in the **inferior and/or lateral precordial leads** but can be generalized
- Found in **5-18%** of the population, usually in **young males <50 yo**
- Nearly always a **benign incidental** finding in asymptomatic patients.



# Case # 4

18 yo male with recent viral illness (sore throat and runny nose)

- Sharp chest pain when taking deep breaths
- EKG as follows:



# POLL

Diagnosis?

- Inferolateral STEMI
- Early Repolarization
- Left Bundle Branch Block
- Pericarditis
- Brugada Syndrome

# POLL

Diagnosis?

- Inferolateral STEMI
- Early Repolarization
- Left Bundle Branch Block
- Pericarditis
- Brugada Syndrome



# Pericarditis

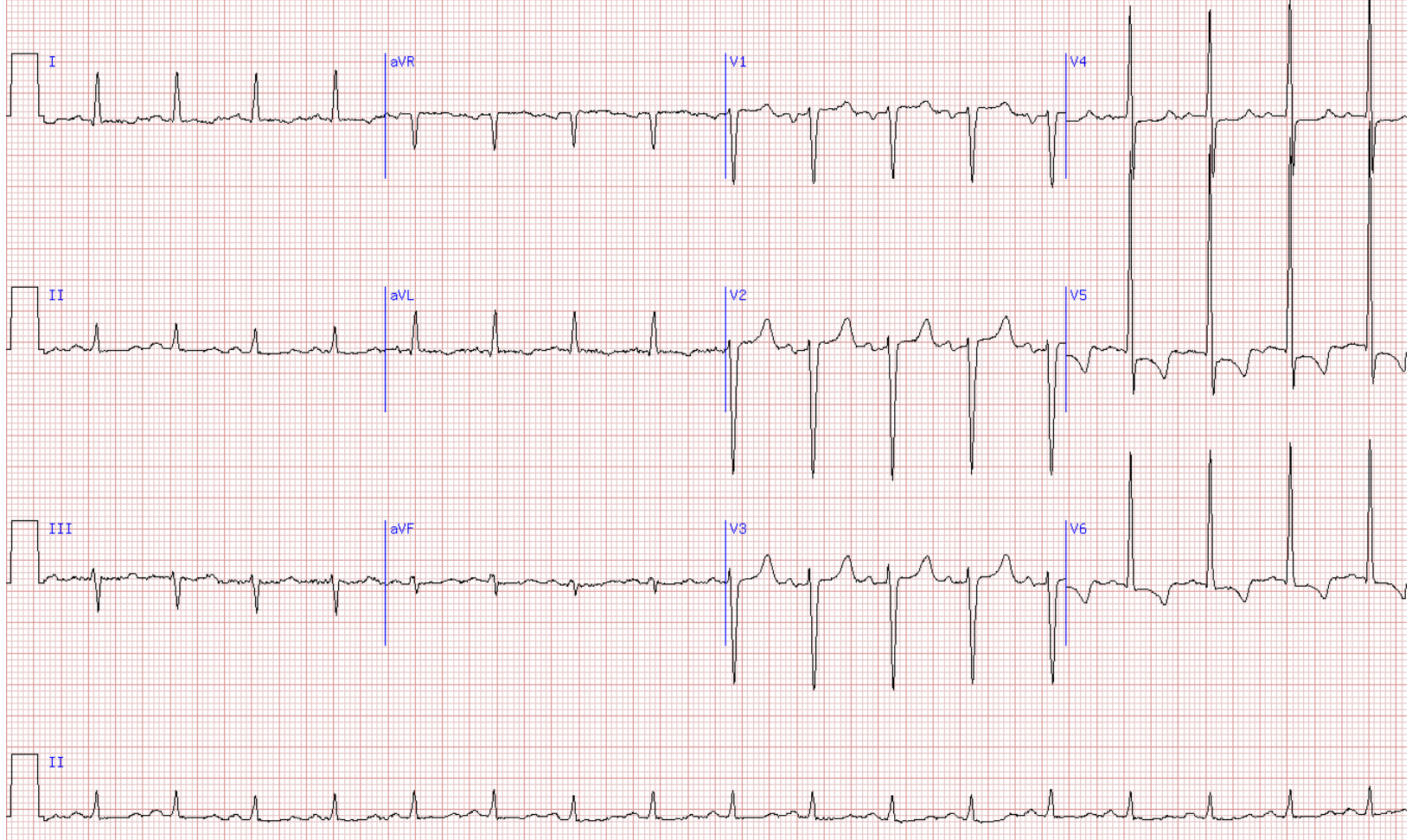
- **ECG findings (Acute):**
  - Widespread concave ST elevation and PR depression throughout most of the limb leads (I, II, III, aVL, aVF) and precordial leads (V2 -6)
  - Reciprocal ST depression and PR elevation in lead aVR( $\pm$  V1)
  - Sinus tachycardia is also common in acute pericarditis due to pain and/or pericardial effusion
- **Stages of Pericarditis ECG Changes**
  - **Stage 1** – widespread STE and PR depression with reciprocal changes in aVR(first two weeks)
  - **Stage 2** – normalisation of ST changes; generalised T wave flattening (1 to 3 weeks)
  - **Stage 3** – flattened T waves become inverted (3 to several weeks)
  - **Stage 4** – ECG returns to normal (several weeks onwards)

Pericarditis	Definition and diagnostic criteria
<b>Acute</b>	<p>Inflammatory pericardial syndrome to be diagnosed with at least 2 of the 4 following criteria:</p> <ol style="list-style-type: none"><li>(1) pericarditic chest pain</li><li>(2) pericardial rubs</li><li>(3) new widespread ST-elevation or PR depression on ECG</li><li>(4) pericardial effusion (new or worsening)</li></ol> <p>Additional supporting findings:</p> <ul style="list-style-type: none"><li>- Elevation of markers of inflammation (i.e. C-reactive protein, erythrocyte sedimentation rate, and white blood cell count);</li><li>- Evidence of pericardial inflammation by an imaging technique (CT, CMR).</li></ul>

# Case # 5

- 81-year-old female that you follow in clinic for longstanding poorly controlled hypertension with the following EKG:





# POLL

Diagnosis?

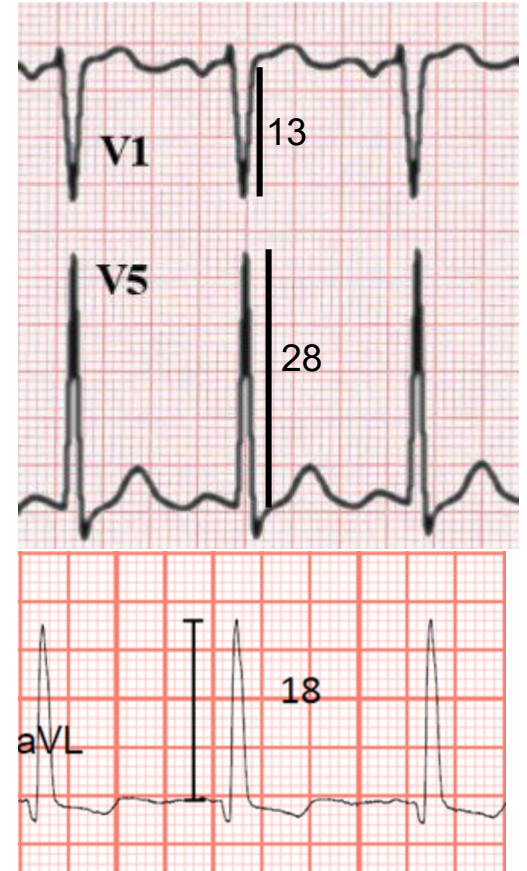
- Acute Anterior Myocardial Infarction
- Benign Early Repolarization
- Left Ventricular Hypertrophy
- Brugada Syndrome

# POLL

- Diagnosis
- Acute Anterior Myocardial Infarction
- Benign Early Repolarization
- Left Ventricular Hypertrophy
- Brugada Syndrome

# Left Ventricular Hypertrophy

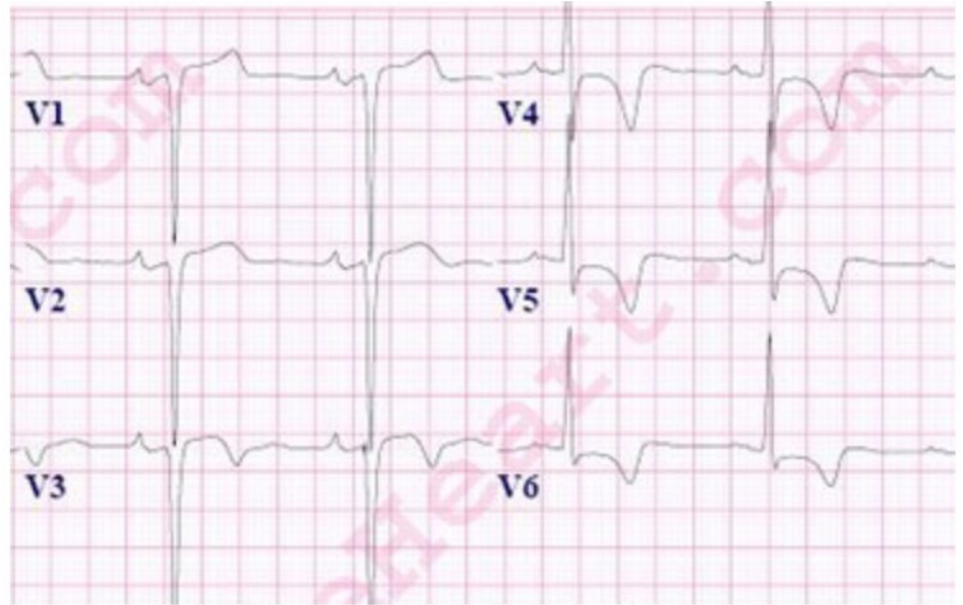
- Sokolow + Lyon
  - $S V_1 + R V_5 \text{ or } V_6 > 35 \text{ mm}$
- Cornell criteria (*Circulation*, 1987;3: 565-72)
  - $S V_3 + R a_{vL} > 28 \text{ mm}$  in men
  - $S V_3 + R a_{vL} > 20 \text{ mm}$  in women
  - Modified Cornell
    - $R \text{ wave } a_{vL} > 12 \text{ mm}$
- Framingham criteria (*Circulation*, 1990; 81:815-820)
  - $R a_{vL} > 11\text{mm}$ ,  $R V_4-6 > 25\text{mm}$
  - $S V_1-3 > 25 \text{ mm}$ ,  $S V_1 \text{ or } V_2 +$
  - $R V_5 \text{ or } V_6 > 35 \text{ mm}$ ,  $R I + S III > 25 \text{ mm}$
- Romhilt + Estes (*Am Heart J*, 1986:75:752-58)
  - Point score system



# Left Ventricular Hypertrophy

“LVH with strain pattern”

- Discordant ST segment depression  
asymmetrical T wave inversion in **left-sided** leads

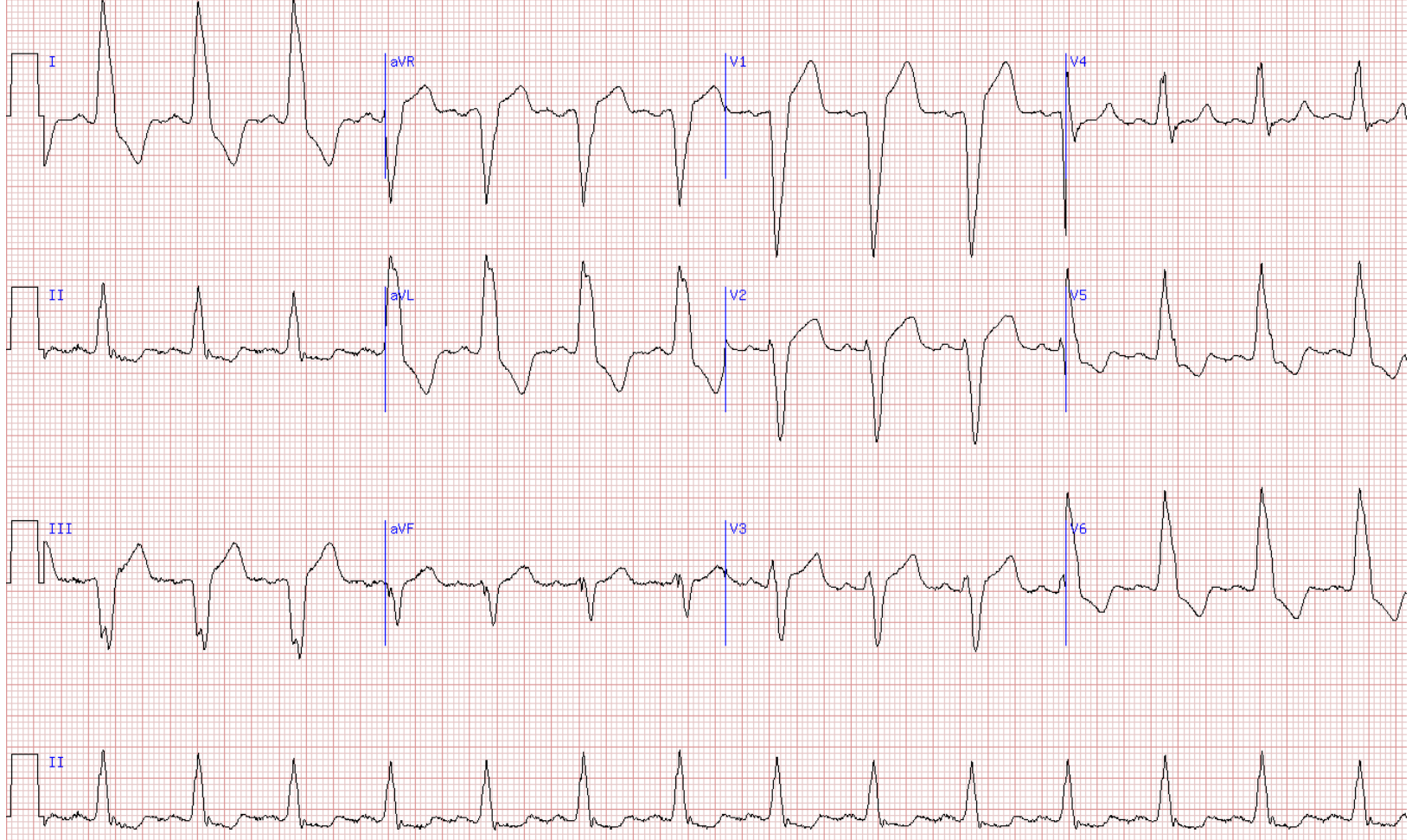


# Case # 6

- 35 year-old male with no known medical history
- Asymptomatic
- Referred to you after he was incidentally noted to have a murmur on annual physical exam, with an EKG as follows:







# POLL

Diagnosis?

- Acute Anterior Myocardial Infarction
- Benign Early Repolarization
- Left Bundle Branch Block
- Brugada Syndrome

# POLL

Diagnosis?

- Acute Anterior Myocardial Infarction
- Benign Early Repolarization
- **Left Bundle Branch Block**
- Brugada Syndrome

# Criteria for LBBB

1. QRS duration  $>120$  ms
2. Broad notched or slurred R wave in leads I, aVL, V5, and V6 and an occasional RS pattern in V5 and V6 attributed to displaced transition of QRS complex.
3. Absent q waves in leads I, V5, and V6
4. R peak time greater than 60 ms in leads V5 and V6
5. ST and T waves usually opposite in direction to QRS.

# Asymptomatic LBBB on EKG

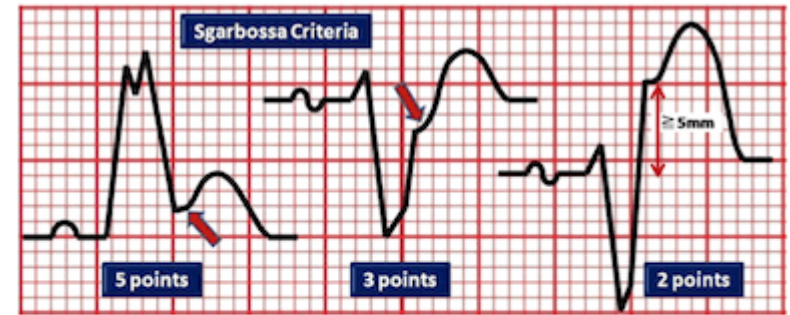
Commonly a pre-existing marker of **underlying structural heart disease**.

- Evaluation for **underlying cause** (e.g. hypertension, heart failure, cardiomyopathies, myocarditis) is warranted.
- Typically would also include an **echocardiogram** for formal structural heart disease and EF assessment.

# LBBB with clinical symptoms of ischemia

## Concordant ST Elevation

(ST elevated with positive QRS) and  
excessive discordant ST depression  
is abnormal.



### Sgarbossa ECG Criteria for LBBB

Concordant STE $\geq 1$ mm	5 points
STD $\geq 1$ mm in V1 – V3	3 points
Discordant STE $\geq 5$ mm	2 points

# Case # 6 Update

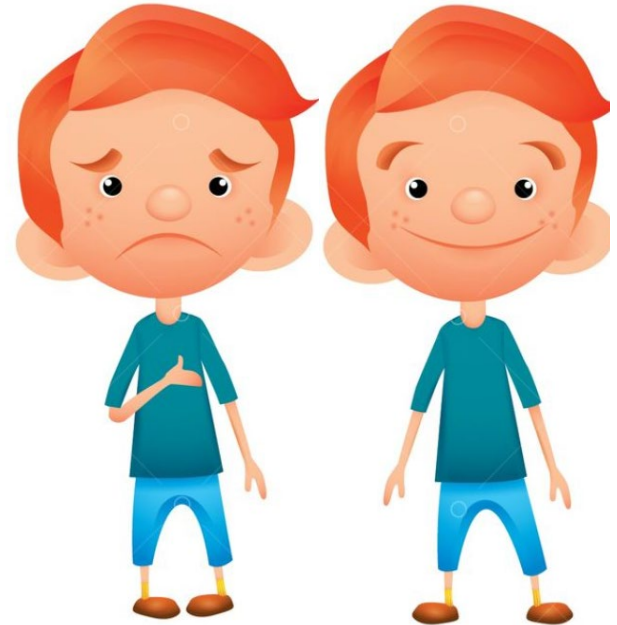
- Echocardiogram revealed hypertrophic cardiomyopathy

## CASE #7

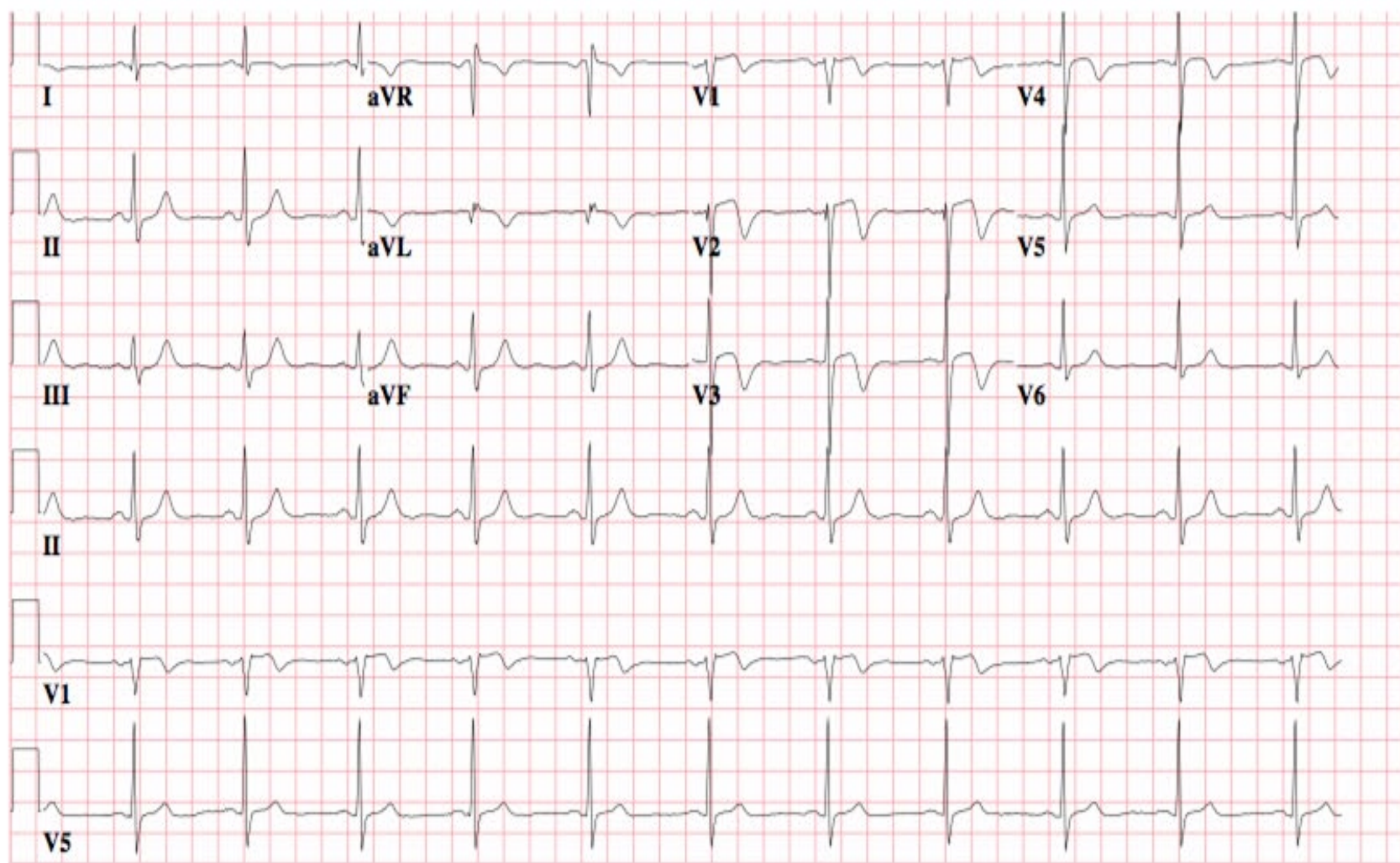
59-year-old male ex-smoker with dyslipidemia and hypertension.

- Stuttering exertional, now at rest, retrosternal chest pain for the past 2 days
- Last episode 30 minutes ago, starting now again
- Troponin T 800

EKG done 25 minutes ago when chest - pain free:







# POLL

Diagnosis and urgency?

- a. NSTEMI with Wellens' Syndrome: Needs emergent angiogram
- b. NSTEMI: Low risk – inpatient angiogram once available
- c. Pericarditis: Non -urgent angiogram
- d. PE: Urgent CT PE
- e. Aortic Dissection: Emergent cardiac surgery

# POLL

Diagnosis and urgency?

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# Wellens Syndrome

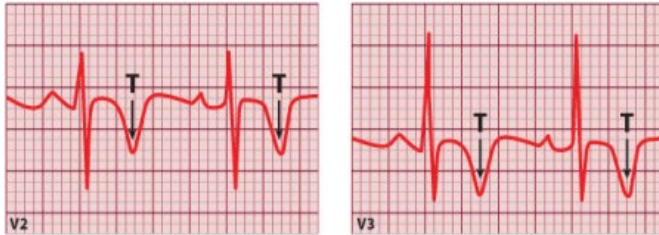
- ECG pattern of **deeply inverted T waves in V2 and V3** , specific for **critical, proximal Left Anterior Descending (LAD) stenosis**
- Typically occurs when the patient is chest-pain free
- High risk for impending large anterior myocardial infarction



# Wellens Syndrome

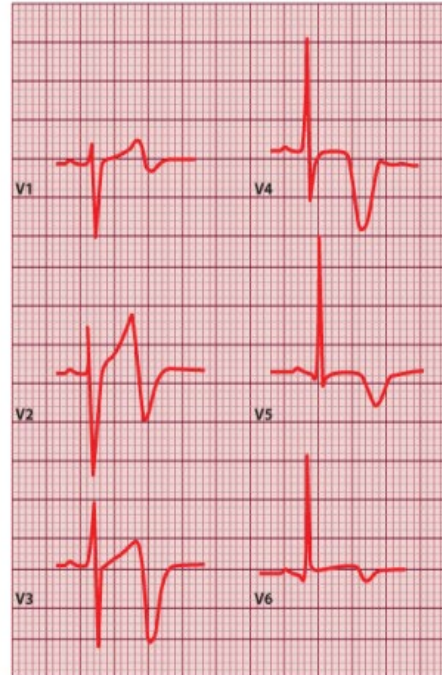
## Type 1 (75% of Cases)

**Deep, symmetrically inverted T waves** in V2 and V3



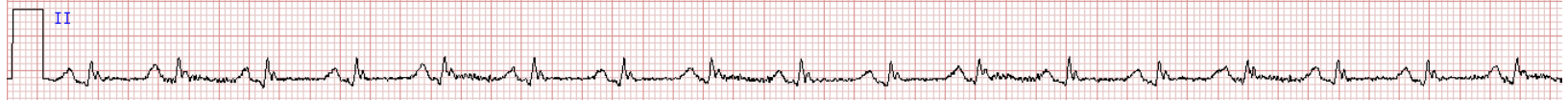
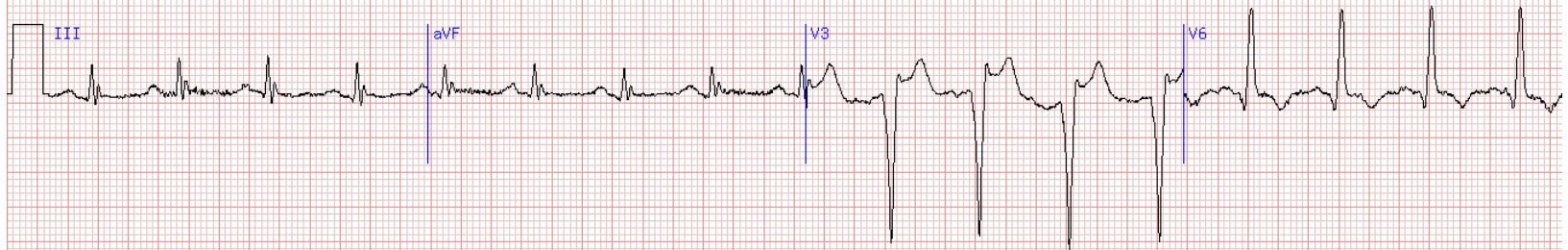
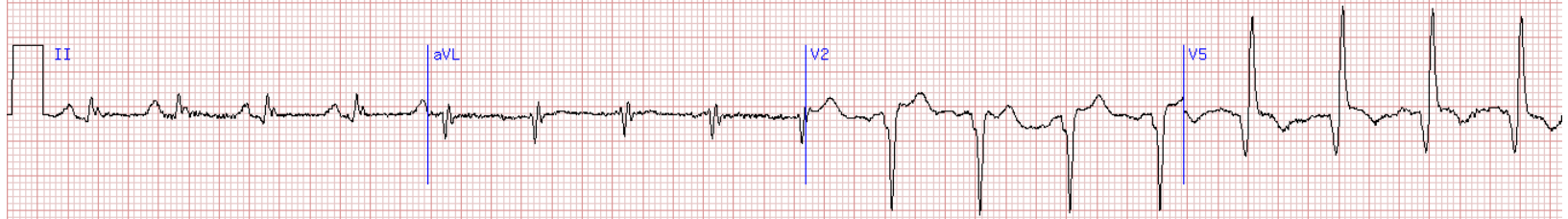
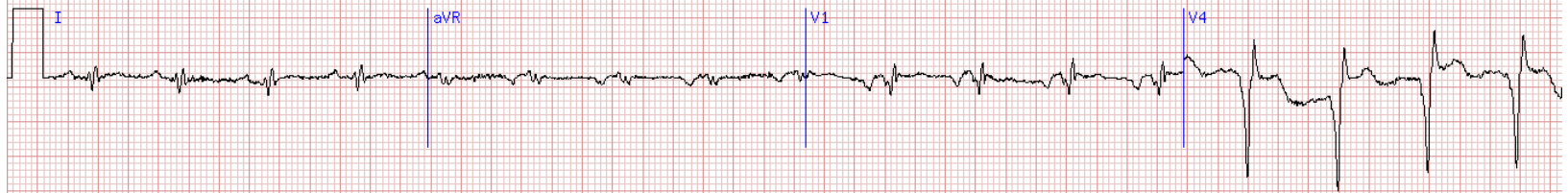
## Type 2 (25% of Cases)

**Biphasic T waves** (initially positive then negative) in V2 and V3



# Case # 8

- 75 yo male with recent anterolateral STEMI x 1 month ago. Treated with stent to LAD
- Presents in your GP clinic for outpatient follow -up. Feeling well. No further recurrence of chest pain since STEMI x 1 month ago.
- Labwork , including troponin, normal.



# Poll

Diagnosis?

- a. Acute anterolateral STEMI
- b. LV aneurysm
- c. Benign early repolarization
- d. Pericarditis



# Poll

Diagnosis?

- a. Acute anterolateral STEMI
- b. LV aneurysm
- c. Benign early repolarization
- d. Pericarditis

# EKG findings of LV aneurysm

- Persistent ST elevation following an acute myocardial infarction
  - Usually post acute STEMI, ST segments return to normal over up to 2 weeks. Q waves can persist. T waves can flatten or invert.
  - This ECG pattern is associated with paradoxical movement of the ventricular wall (ventricular aneurysm).
- 
- **ECG Features of LV Aneurysm**
  - ST elevation seen > 2 weeks following an acute myocardial infarction.
  - Most common in precordial leads. Concave or convex possible
  - Usually associated with well -formed Q or QS waves.
  - T-waves have a relatively small amplitude in comparison to the QRS complex (unlike hyperacute T -waves of acute STEMI).

# Objectives

Through cases, learn about

- Typical findings of ischemia and ST -elevation myocardial infarction in an EKG
- Ischemia and STEMI mimics
- Differentiate a real STEMI from mimickers based on the patient's clinical presentation, exam and investigations

**- END**

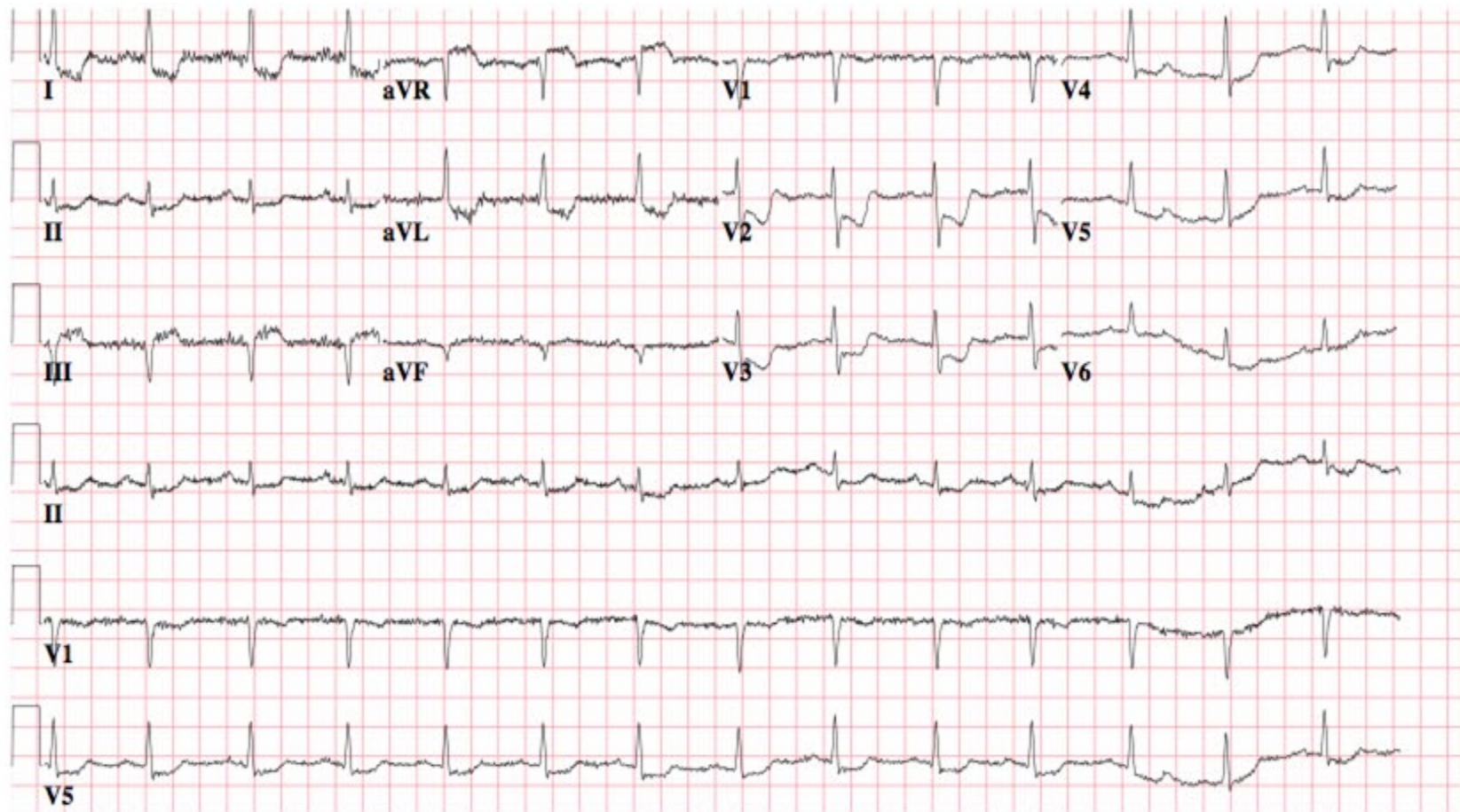
- Questions?

**ADDITIONAL CASES/ EKGs (ONLY IF V  
EXTRA TIME)**

## EXTRA CASE # 1

- 69 year old male with HTN, Dyslipidemia, T2DM, Ex smoker, Prior CVA.
- Px to community hospital with 3 days of chest discomfort.
- Ongoing stuttering CP. BP 100 systolic, HR 75.

ECG:



# Poll

Ischemia/ Risk?

- a. Ischemia: Yes/ High risk – immediately transfer for PCI
- b. Ischemia: No/ Low risk – no PCI needed
- c. Ischemia: Yes/ Low risk – elective PCI
- d. Ischemia: No/ High risk – no PCI needed



# Poll

Ischemia/ Risk?

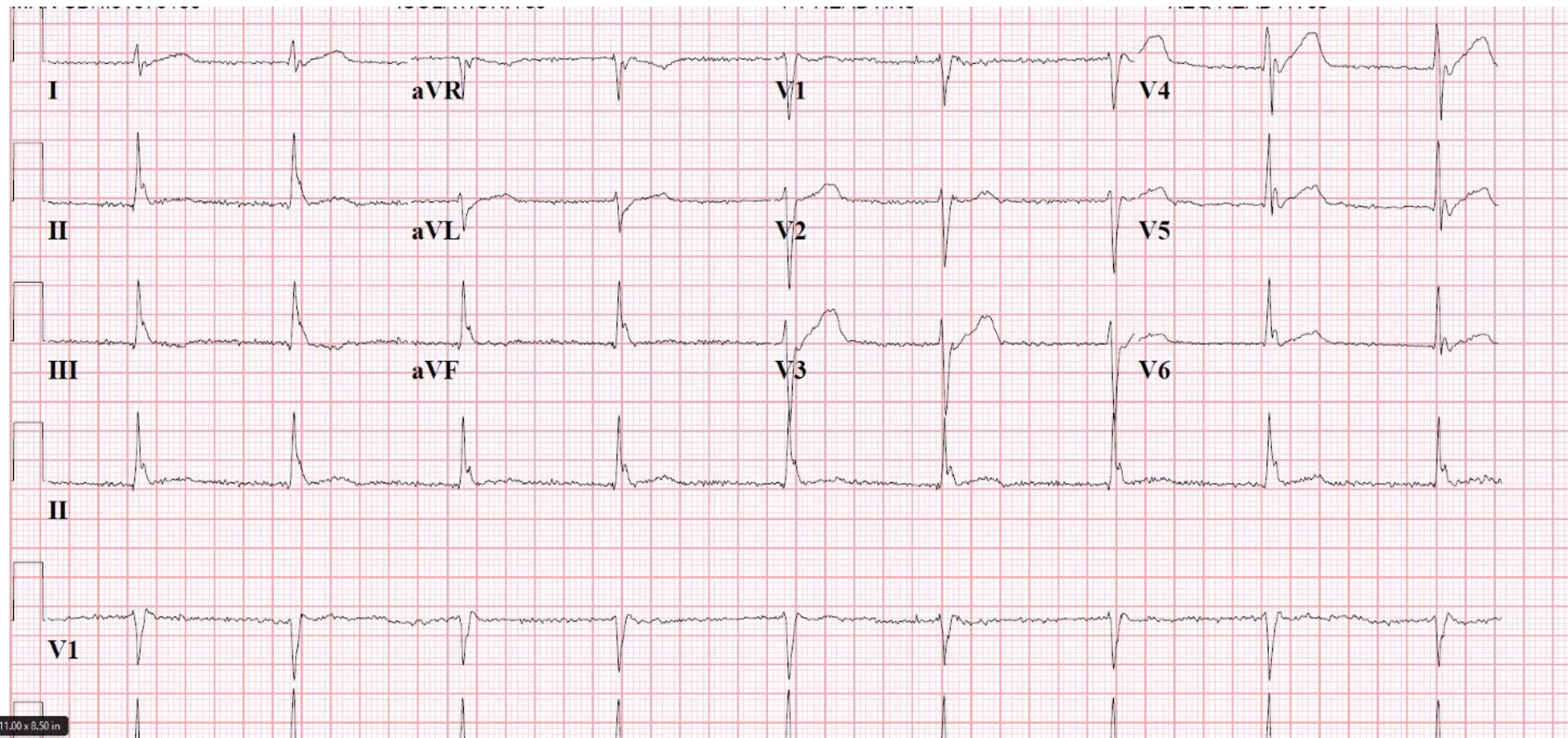
- a. Ischemia: Yes/ High risk – immediately transfer for PCI
- b. Ischemia: No/ Low risk – no PCI needed
- c. Ischemia: Yes/ Low risk – elective PCI
- d. Ischemia: No/ High risk – no PCI needed

# Left Main Artery Stenosis: The Widowmaker

- Global Ischemia/Left Main Stenosis: May look like NSTEMI
- Presents with wide-spread ST depression with inverted T waves maximally in leads V(4 -5)
- Lead aVRST elevation (STE)
- A marker of worse outcomes as associated with Left Main stenosis/Large infarct. Treat as high risk!

# Extra Case # 2

- 25 yo female brought to the ER resuscitation room after overdosing with diltiazem
- Obtunded, 30 °C, 35 bpm, 85/40, 90% 15L NRB



# Poll

Diagnosis?

- a. Inferior STEMI
- b. Hypothermia from diltiazem toxicity
- c. Pericarditis
- d. Takotsubo Cardiomyopathy
- e. Benign Early Repolarization

# Poll

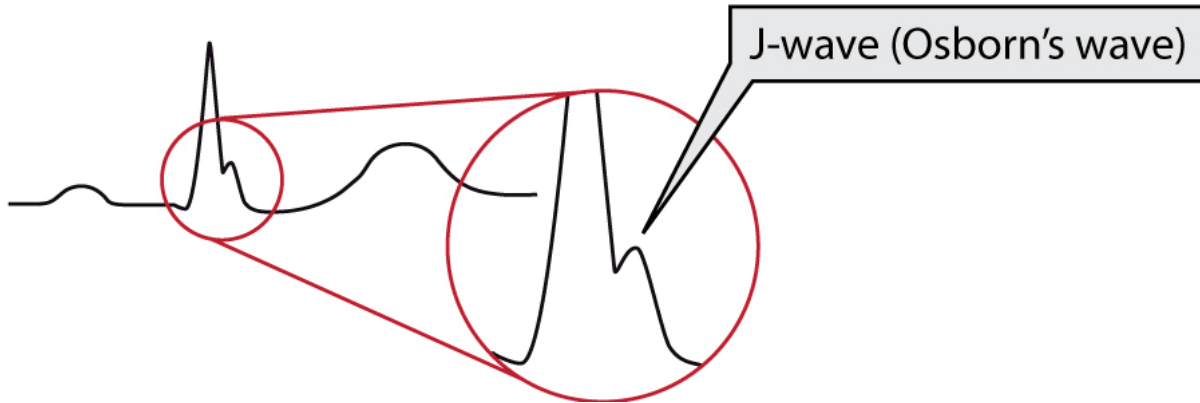
Diagnosis?

- a. Inferior STEMI
- b. Hypothermia from diltiazem toxicity
- c. Pericarditis
- d. Takotsubo Cardiomyopathy
- e. Benign Early Repolarization

# Hypothermia and Osborn Wave

- Positive deflection at the J point with a dome or hump configuration in the setting of hypothermia (typically Temp <30C)

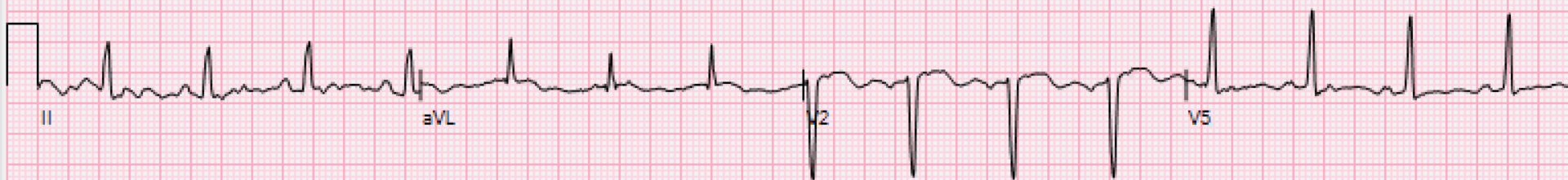
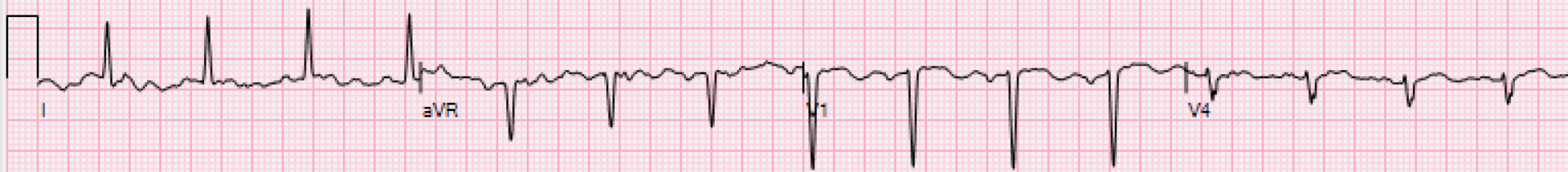
J-wave (Osborn's wave)



# Extra Case # 3

- 81 yo frail female presenting with chest pressure and shortness of breath after her husband passed away.
  - PMHX: Hypertension , anxiety disorder
- Troponin 350 -> 400





# Poll

Likely etiology?

- a. Pericarditis
- b. Pulmonary embolism
- c. Takotsubo cardiomyopathy
- d. NSTEMI

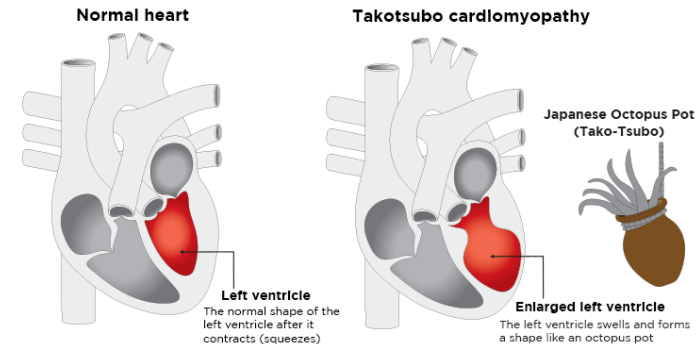
# Poll

Likely etiology?

- a. Pericarditis
- b. Pulmonary embolism
- c. Takotsubo cardiomyopathy
- d. NSTEMI

# Takotsubo@M

- Transient systolic dysfunction usually involving apex of heart in absence of any CAD, often following intense emotional/physical stressor “broken heart syndrome”
- Present with acute CP, CHF, elevated Troponins.
- ECG can get ST elevation (anterior), TW inversions, prolonged QT
- Rule out ACS, treat medically
- Recover by 1-3 months → good prognosis



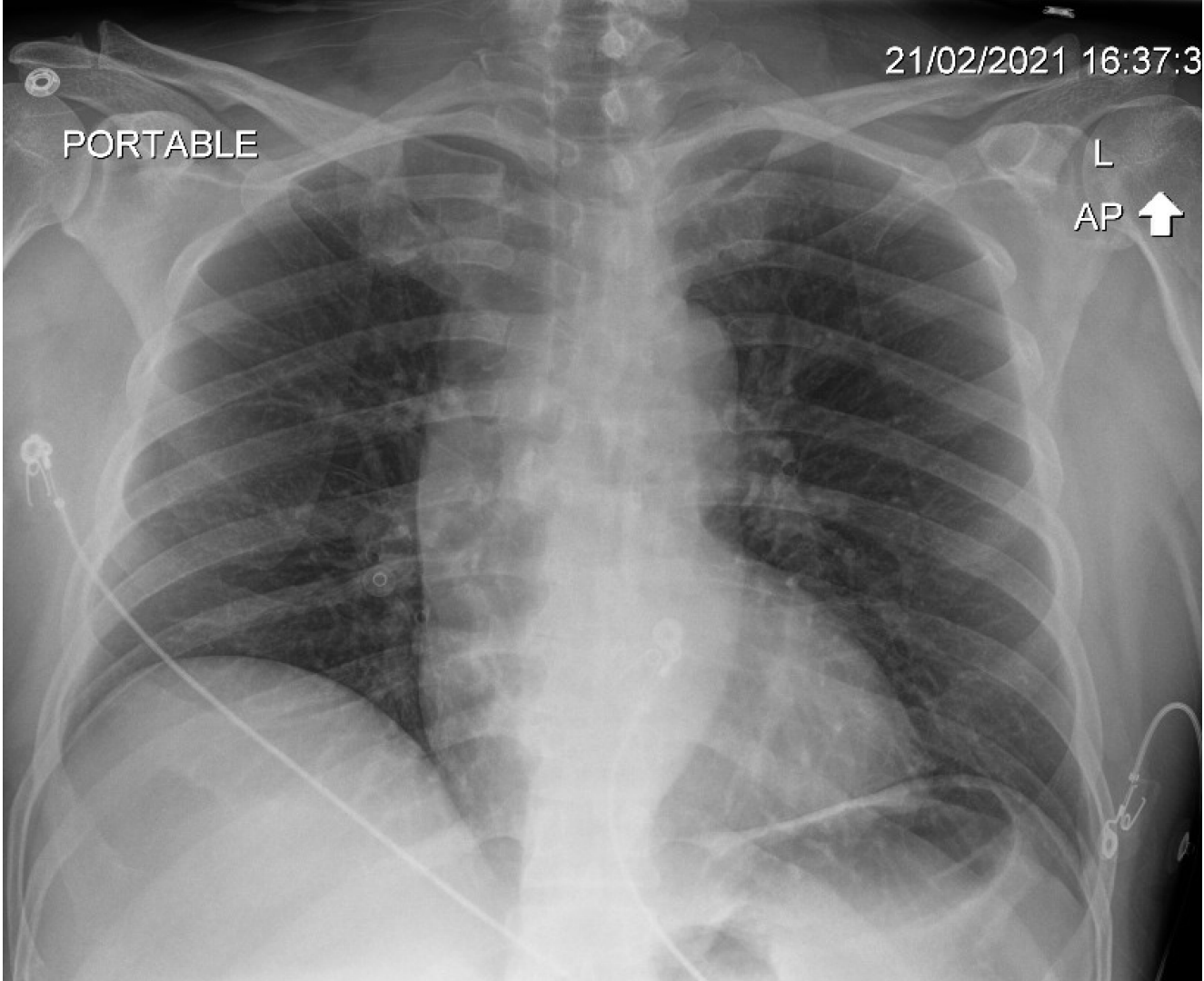
# Extra Case # 4

- 41 yo male acute onset of sharp tearing chest pain while driving
  - PMHX: Longstanding hypertension non-compliant with medications
- CXR and EKG as follows:

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PORTABLE

L  
AP ↑



# Poll

Diagnosis?

- PE
- Aortic dissection
- Ischemia from Left Main/Multivessel disease
- Pericarditis

# Poll

Diagnosis?

- PE
- Aortic dissection
- Ischemia from Left Main/Multivessel disease
- Pericarditis



# EKG during Aortic Dissection

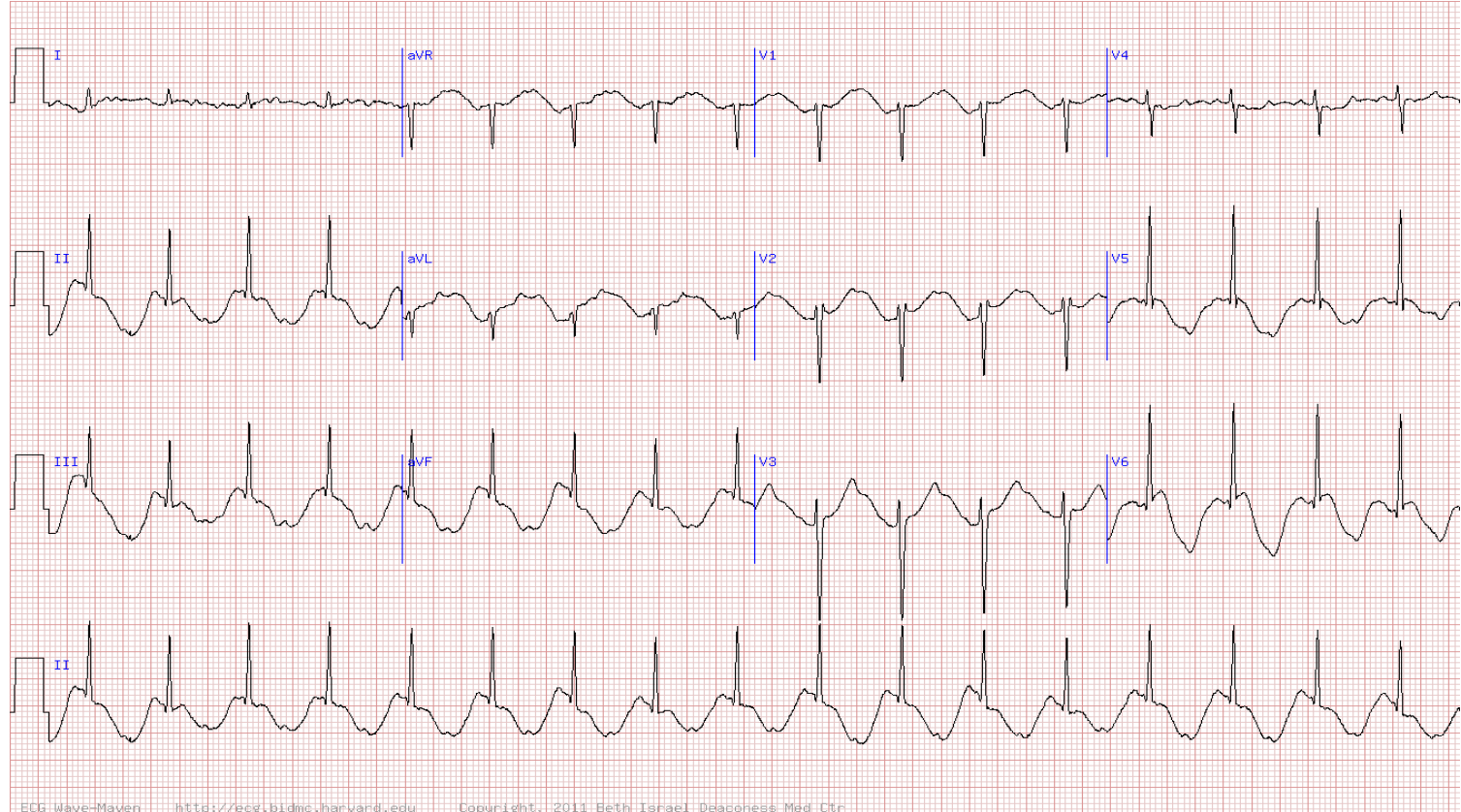
- Normal
- Non-specific ST-T changes (49.7% of cases)
- ST-elevation (3.2% of cases)
  - Typically, **inferior STEMI** (Right Coronary Artery Dissection), but can be any STEMI
- Electrical alternans (tamponade)

# Extra Case # 5

71M with recent anterior STEMI treated with lysis followed by stent to LAD.

While in hospital, acute onset of vertigo with EKG as follows:

# Extra Case # 5



# Poll

Diagnosis?

- Stent thrombosis of LAD stent
- Cerebral hemorrhage
- Ischemia from Left Main/Multivessel disease
- Takotsubo cardiomyopathy

# Poll

Diagnosis?

- Stent thrombosis of LAD stent
- Cerebral hemorrhage
- Ischemia from Left Main/Multivessel disease
- Takotsubo cardiomyopathy

# EKG findings of ICH

- Bleeding into confined space causes rise in ICP (intracranial pressure)
- ECG changes can reflect rising ICP
  - Diffuse/widespread T -Wave inversions
  - QT prolongation
  - Bradycardia: Mediated by *Cushing Reflex* indicated imminent brainstem herniation.
- Look for clinical clues as to why the change in ECG!