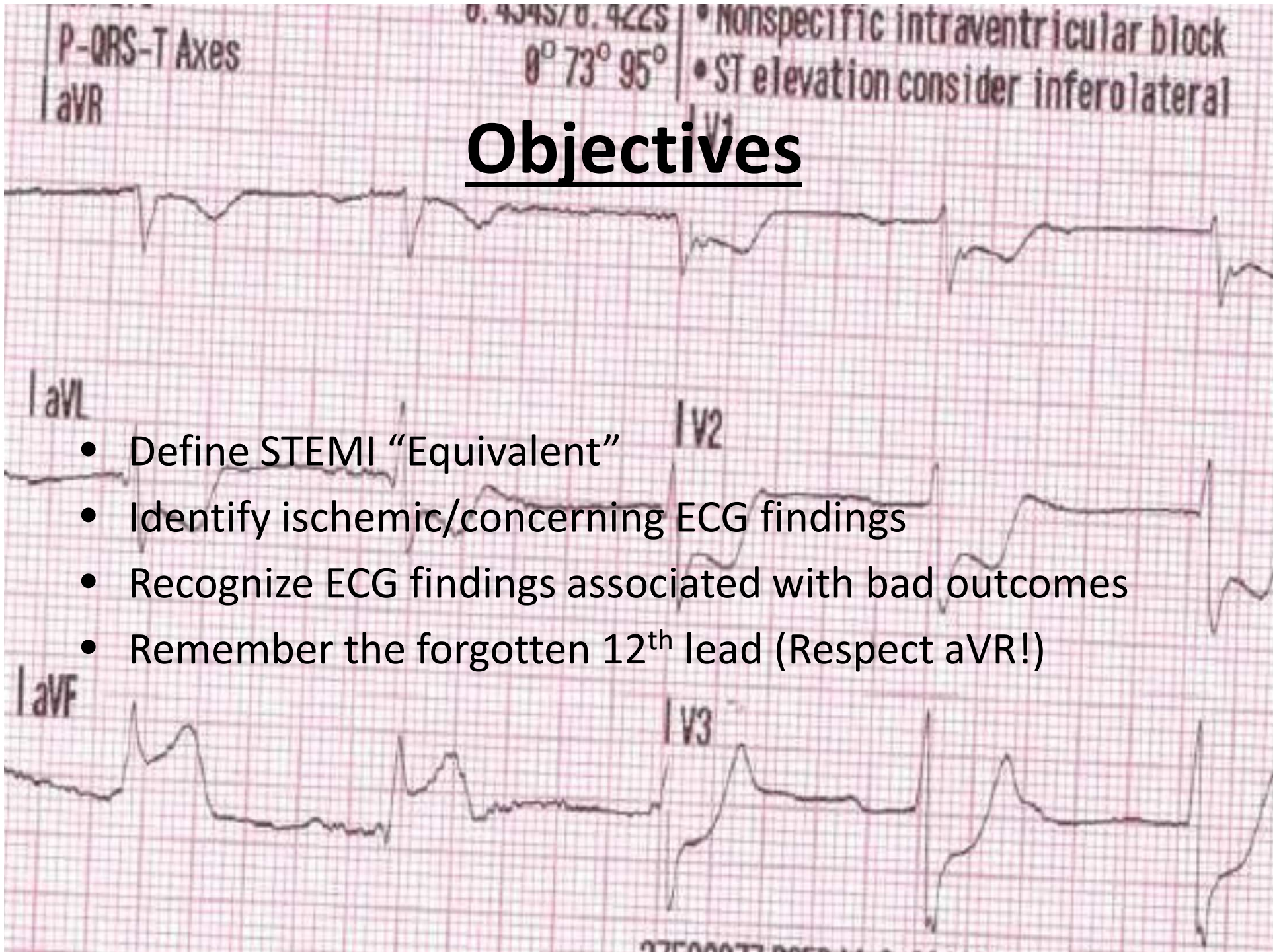


# **Not All that Elevates is STEMI! Deadly Diagnoses in ECG Interpretation**

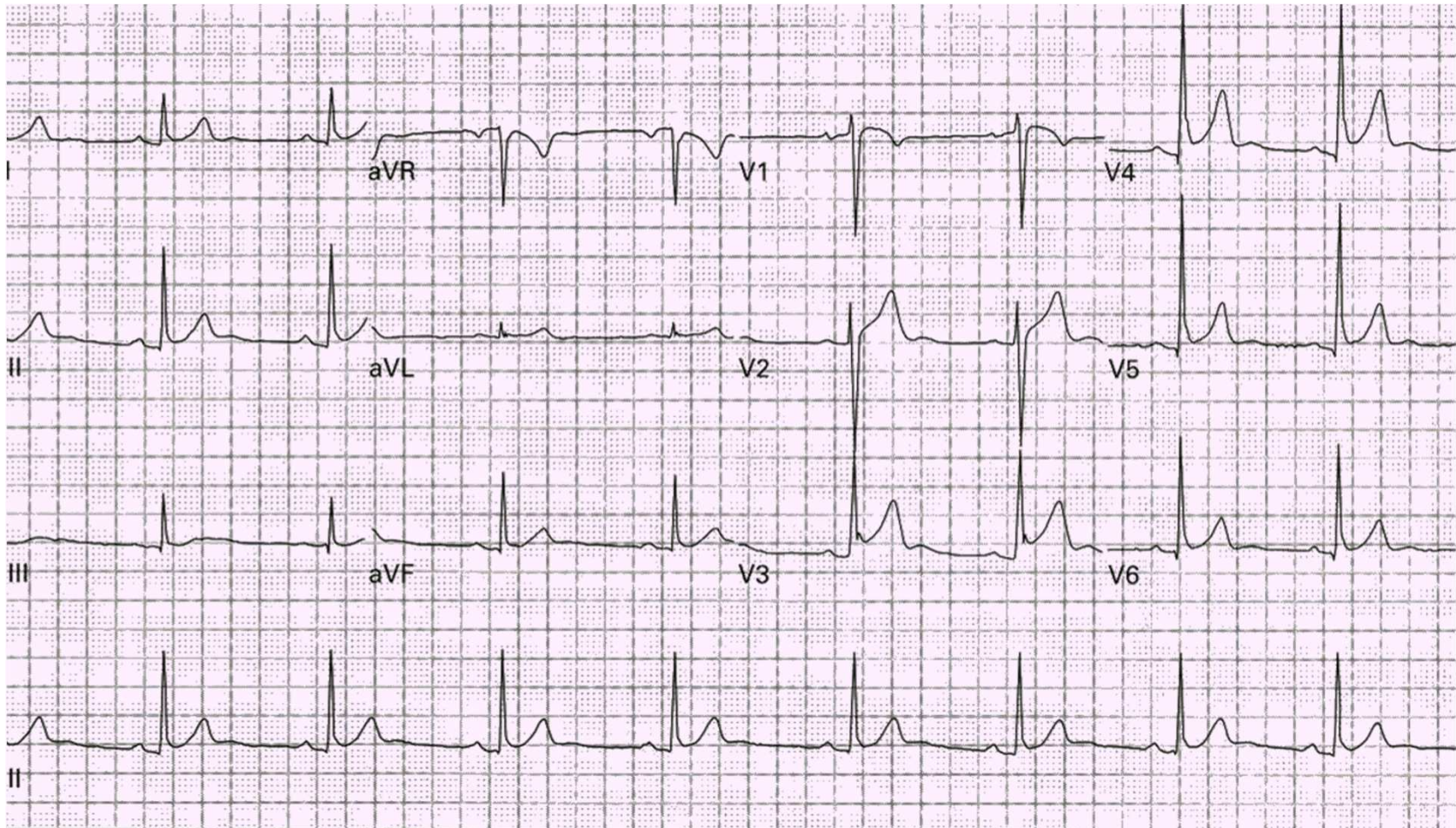
**Benjamin Lawner, DO, MS, FACAP  
Faculty, Strive to Revive Symposium  
American Heart Association**

# Objectives

- Define STEMI “Equivalent”
- Identify ischemic/concerning ECG findings
- Recognize ECG findings associated with bad outcomes
- Remember the forgotten 12<sup>th</sup> lead (Respect aVR!)

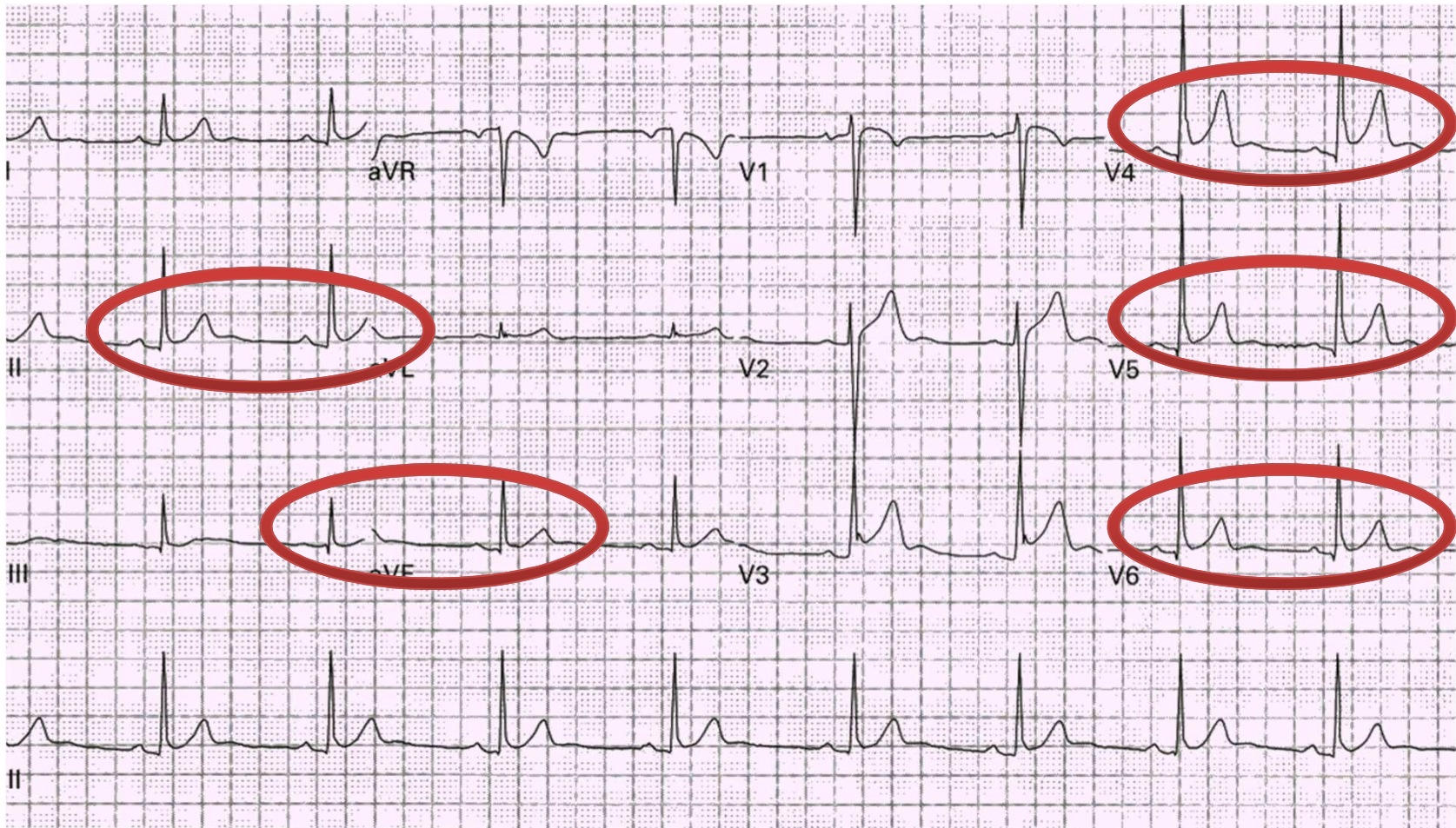


# 37 yo male, inspiratory chest pain



Starting off on a familiar road....

# SR, rate of 50, LVH, pericarditis



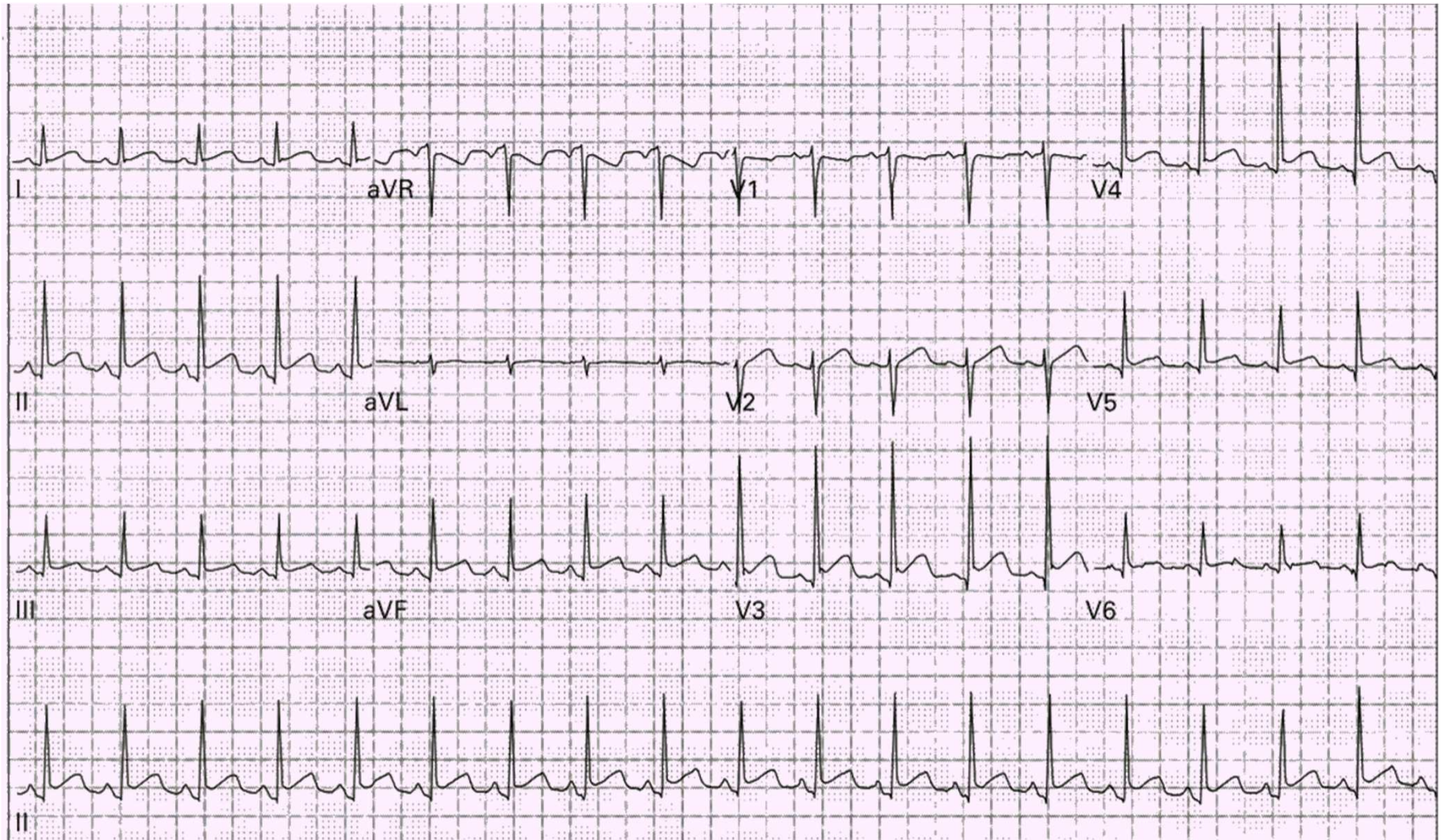
# Pericarditis

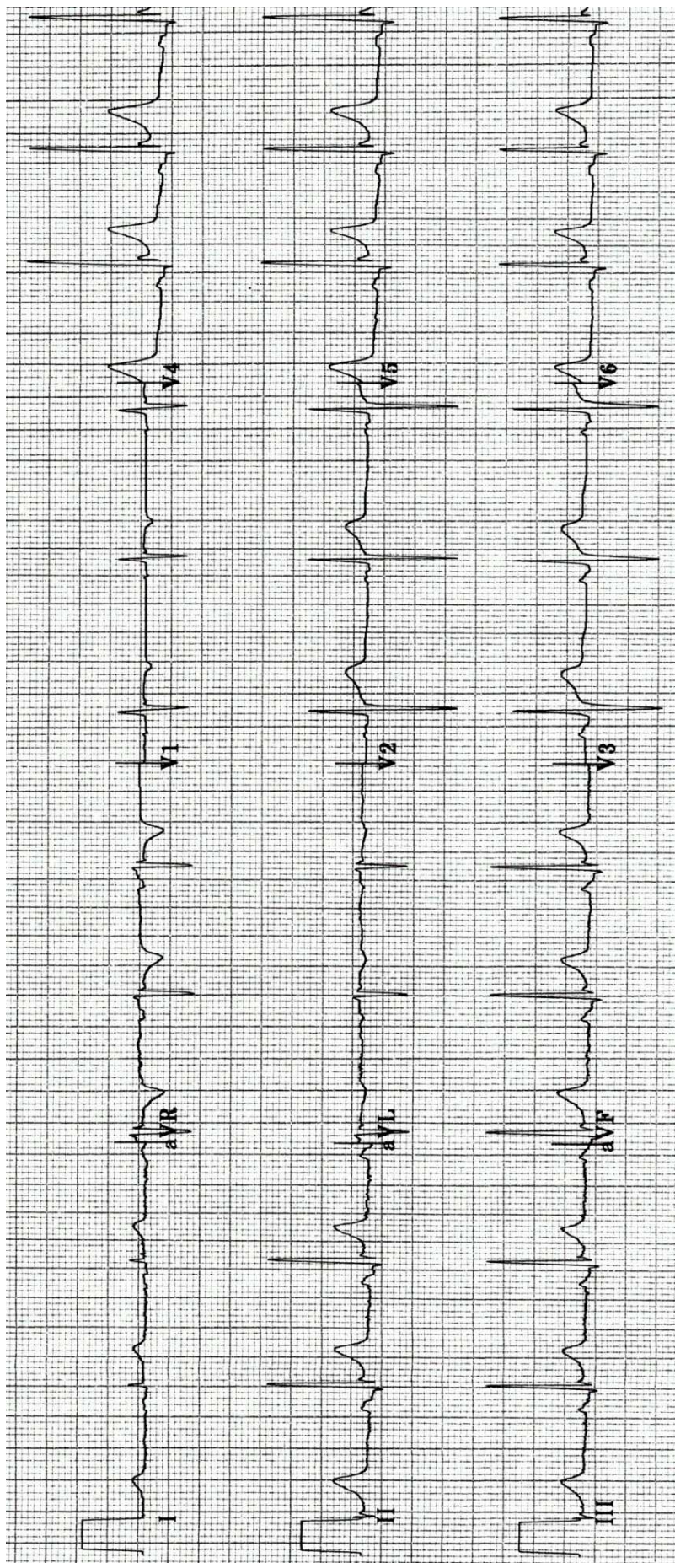
- Absence of reciprocal change
- + friction rub favors pericarditis
- Absence of ST depression
- Widespread PR depression
- Widespread, non anatomic STE
- 10-15% of MI associated with pleuritic/positional pain
- Concave upwards STE

# Pericarditis

- Caution with SLE/RA patients
- Caution with HIV
- NSAID treatment
- Follow up
- Role for ED bedside echocardiography

# Pericarditis

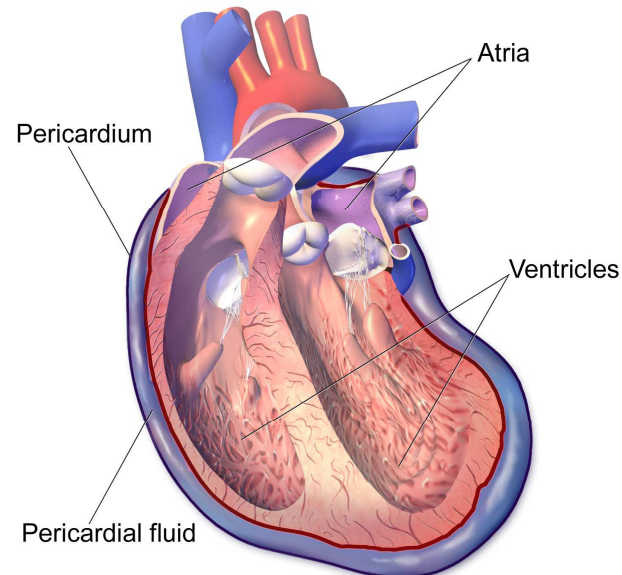






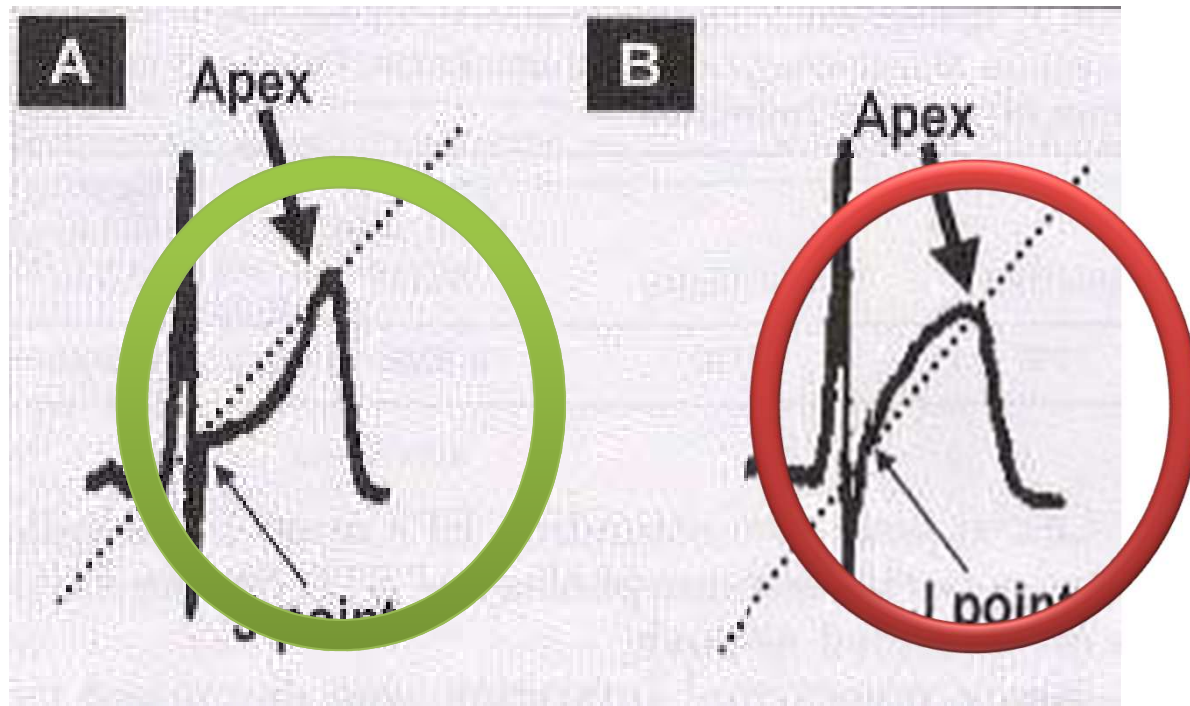
# Pericarditic Pitfalls

- Be mindful of patient age
- Take a thorough history
- Do not diagnose pericarditis in the presence of reciprocal change or ST depression



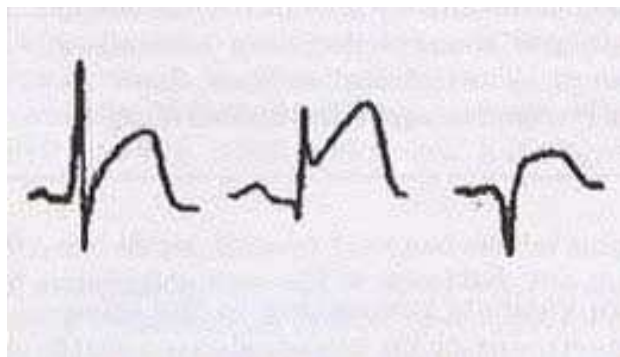
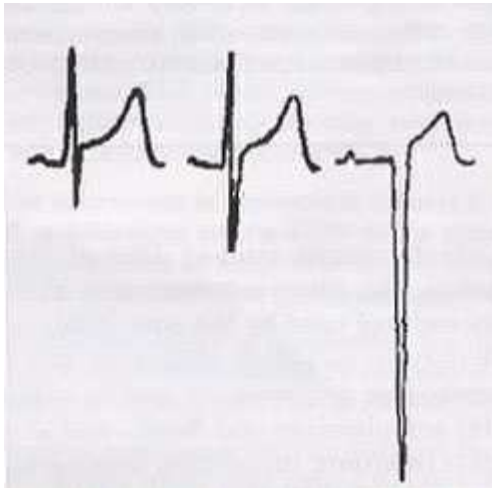
Inflammation of the Pericardium in the Heart

# Ugly STE

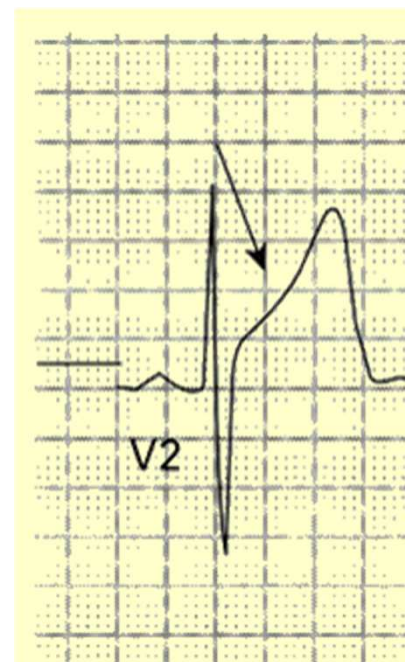


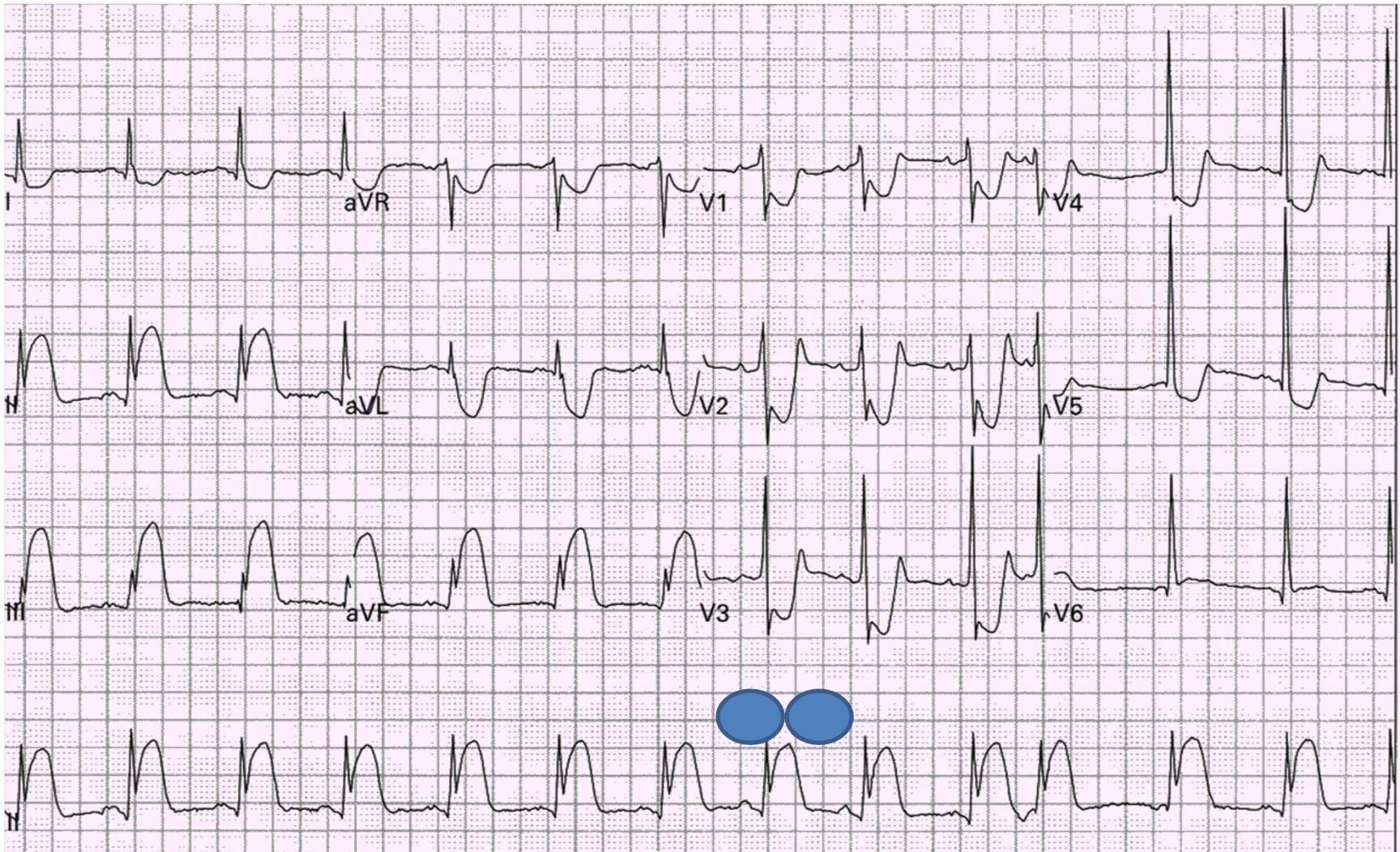
Images from "EKG Interpretation" Michelle Lin, MD

# STE: Concave vs Convex



- Non concave STE favors ACS
- Concave STE does not rule ACS out!
- History important



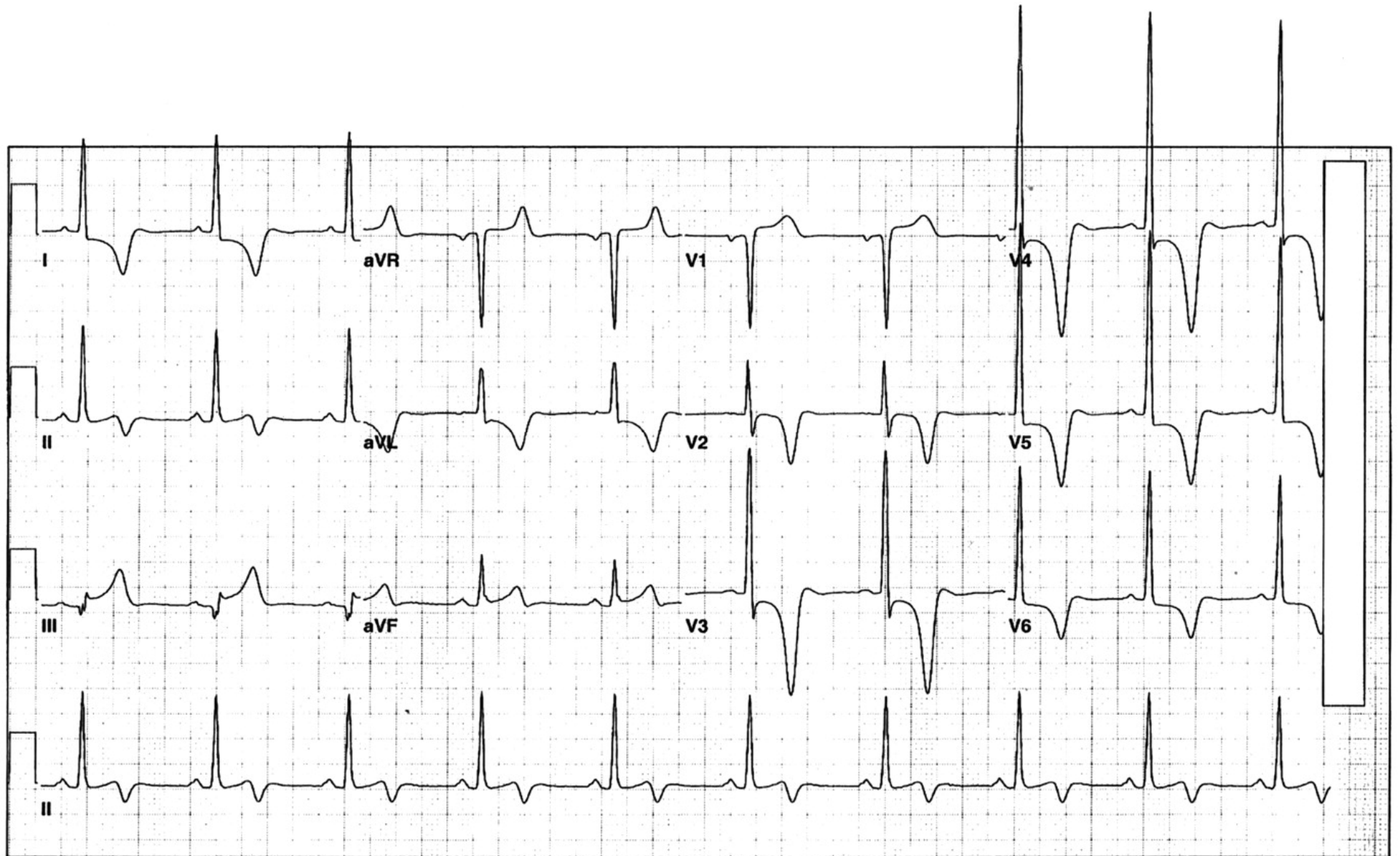


- **Reciprocal change**
- **Convex STE in anatomic distribution**

## **Killer ECG:**

“I was playing basketball when suddenly...”

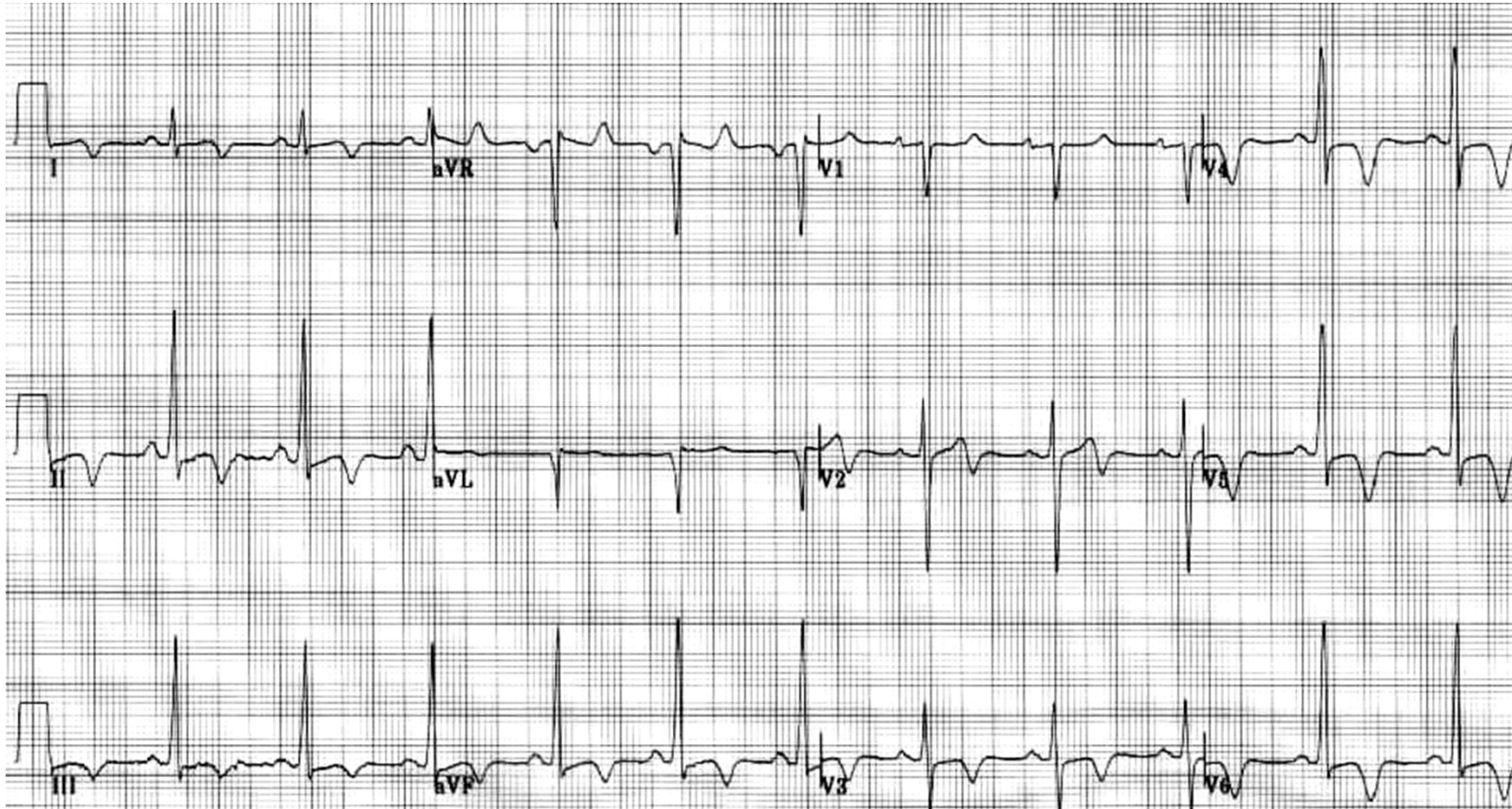
# 18 yo male, exertional syncope



# Hypertrophic Cardiomyopathy

- Younger patients
- Family history important
- ECG abnormalities in 90%
- May present as sudden death
- Chest pain, shortness of breath

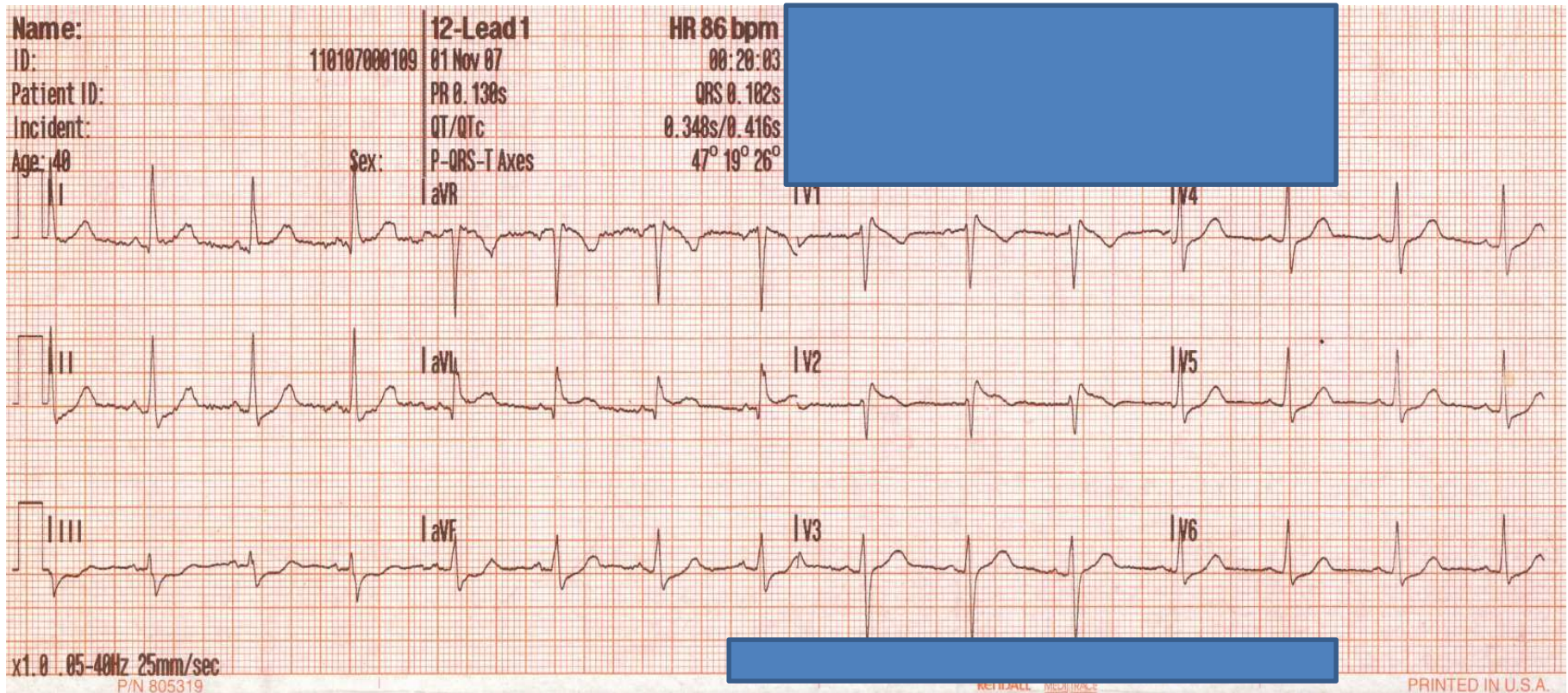
# HCM ECG



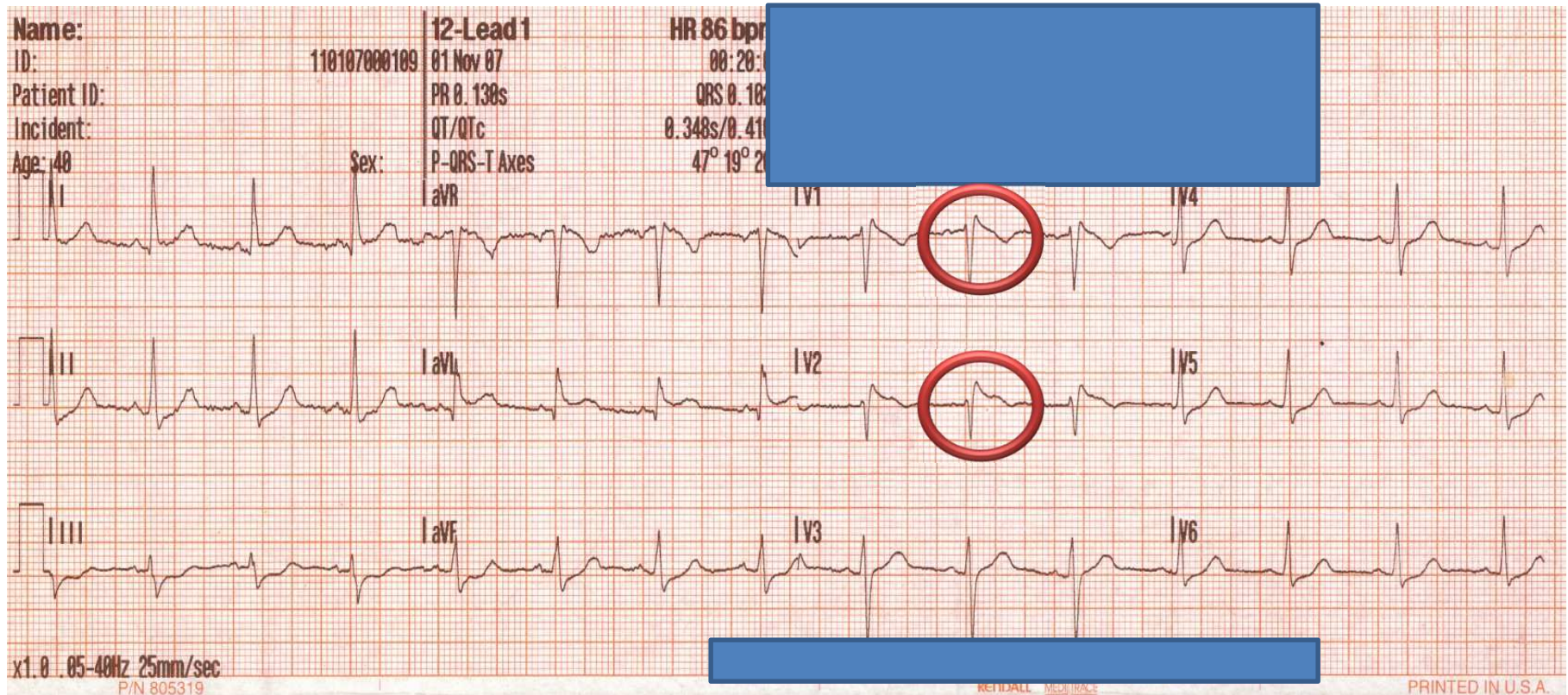
- LVH (high left ventricular voltage)
- T wave inversions
- Dysrhythmia
- ST segment changes



# 37 yo male, syncopal episode



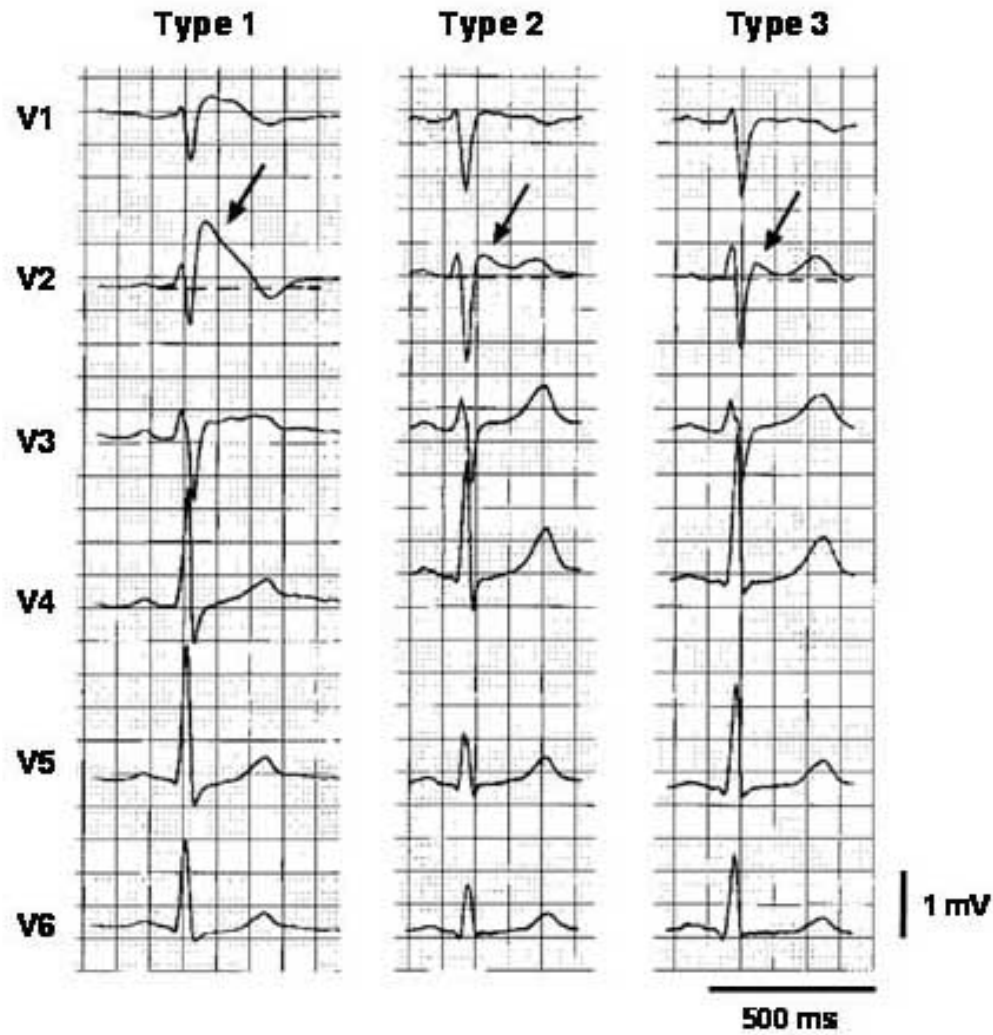
# SR, rate 86, Brugada Syndrome



# The Brugada Syndrome

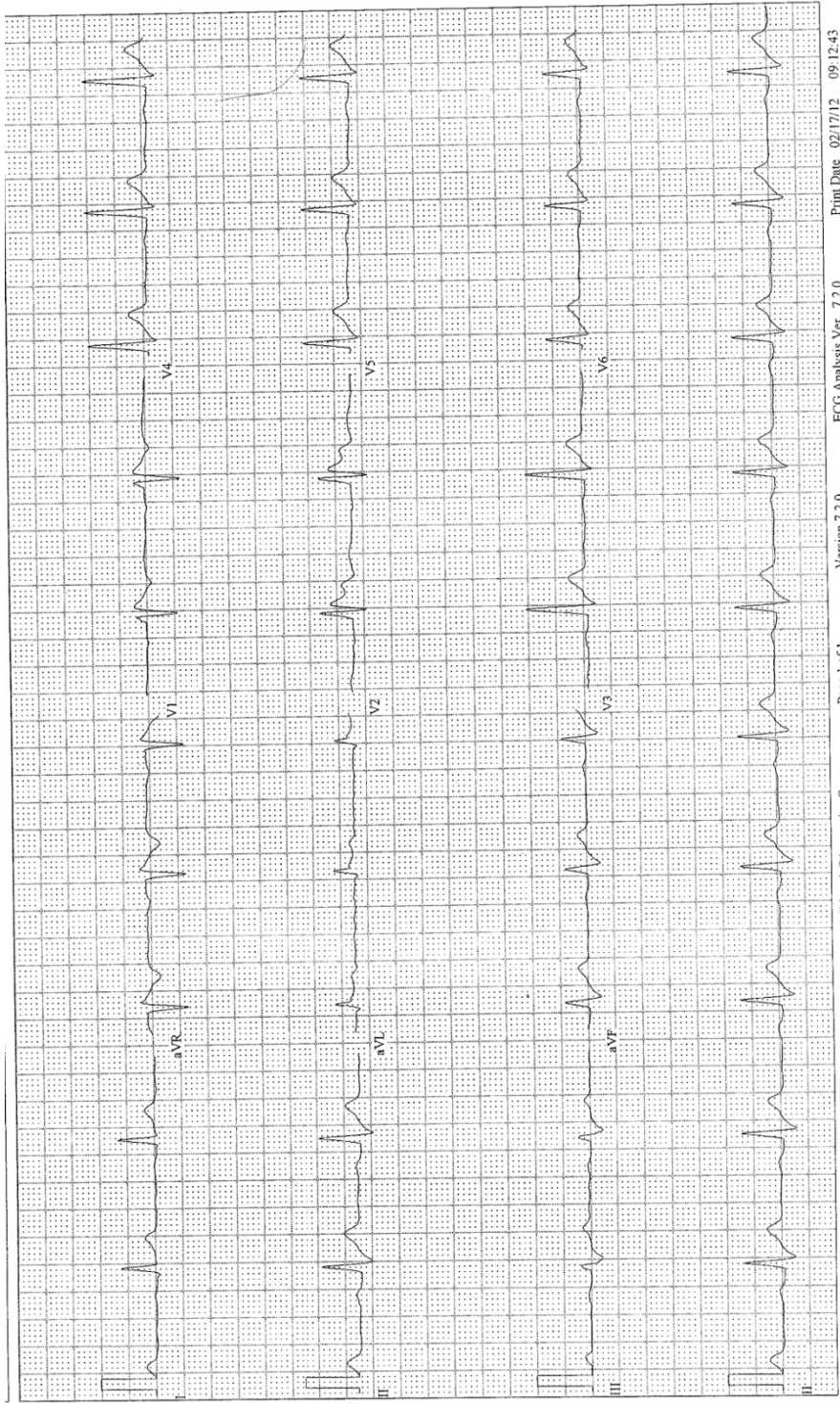
- Atypical STE in precordial leads
- Type 1 ECG pattern is diagnostic
- Young, predisposition to ventricular dysrhythmias
- “Channelopathy”
- Common males, asian descent, 30-50 years
- Syncope is presenting complaint

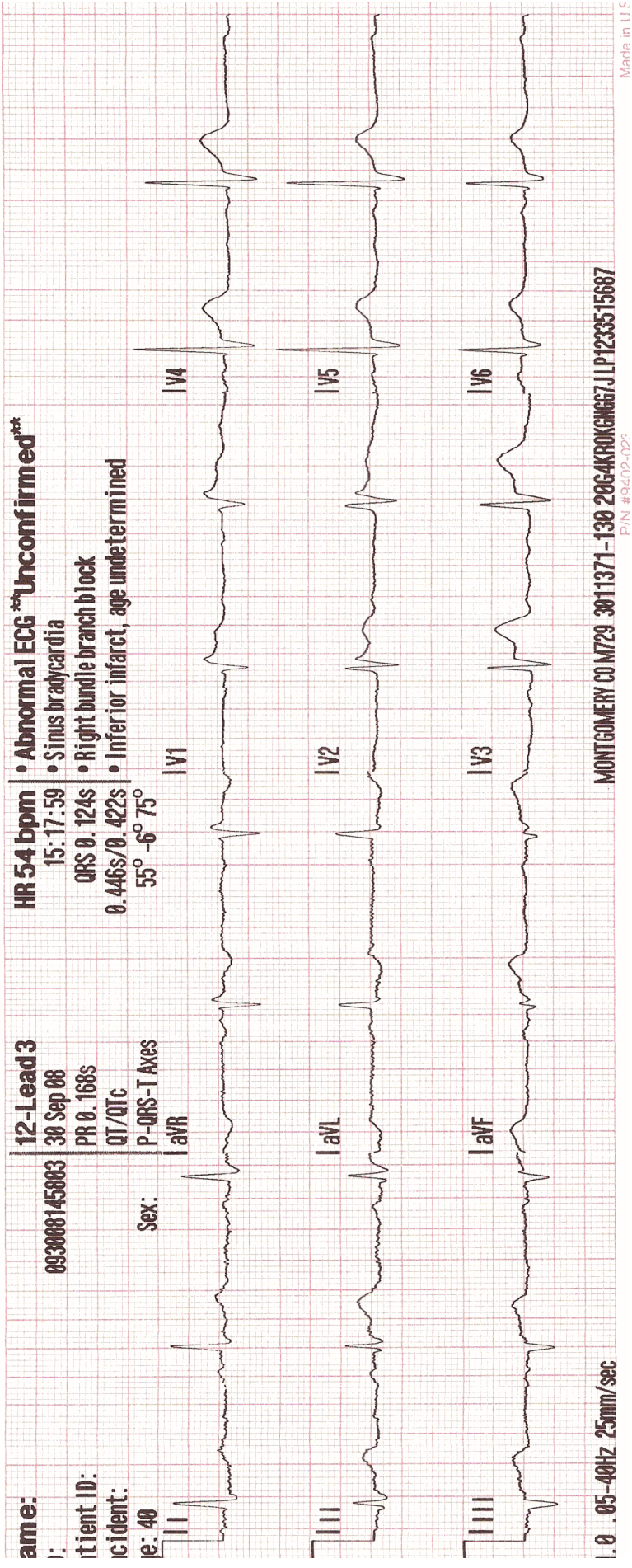
# The Brugada Syndrome



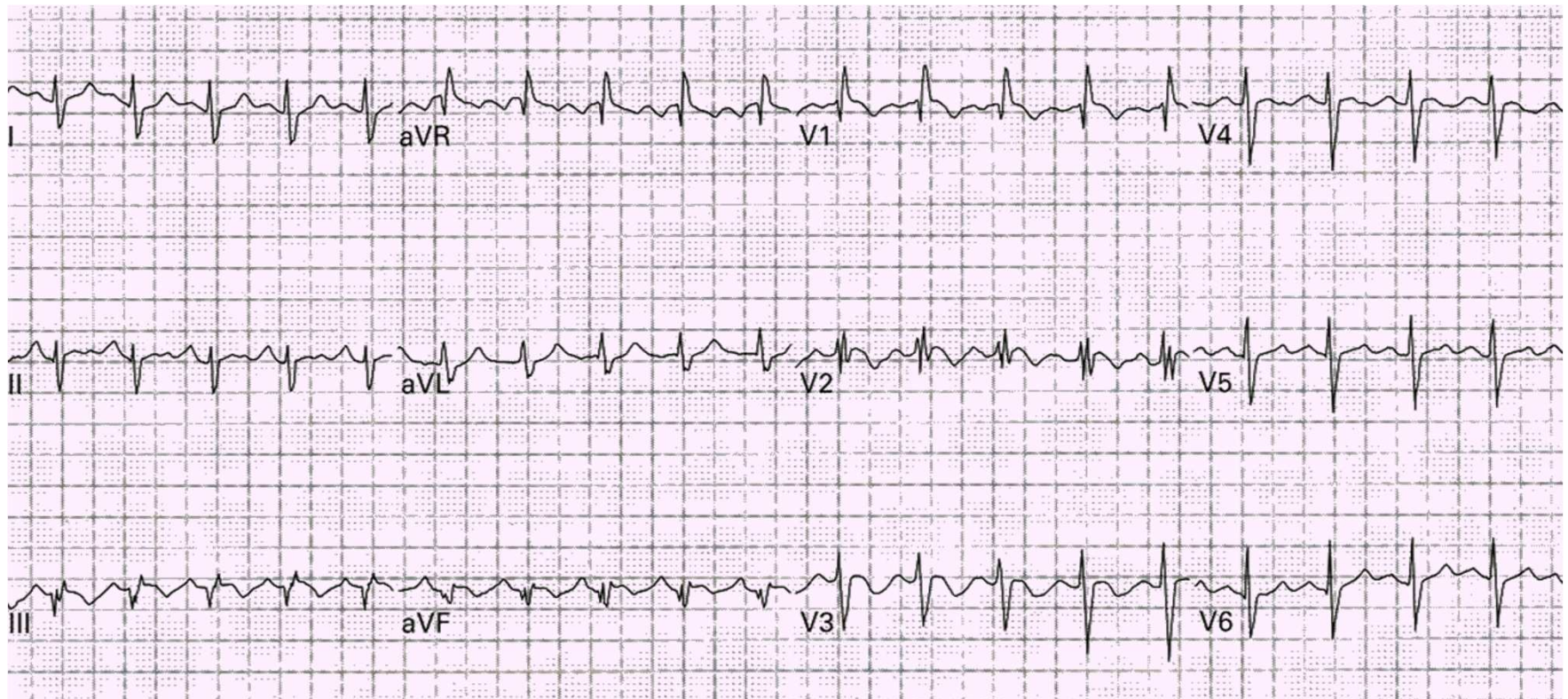
# Brugada Bottom Line

- Syncope
- Atypical STE
- Incomplete RBBB
- Type 1 STE and no symptoms ?



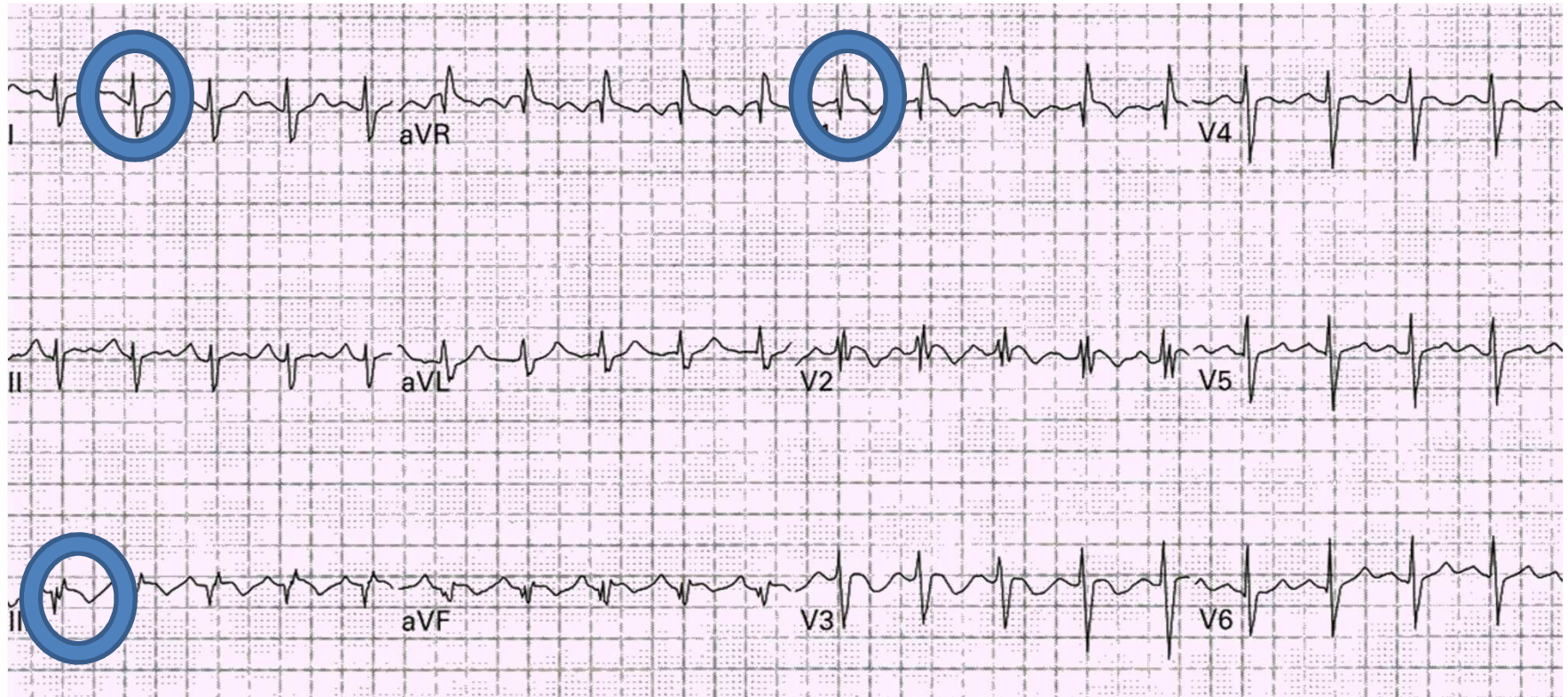


# 24 yo female, chest pain and dyspnea



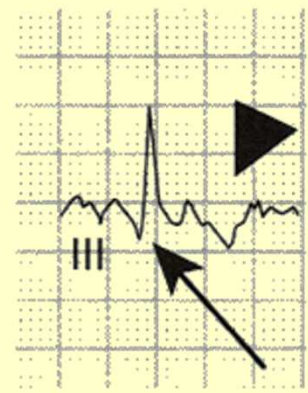
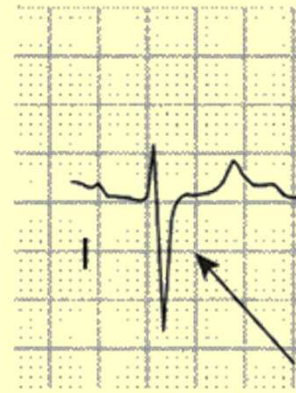


# 24 yo female, chest pain and dyspnea



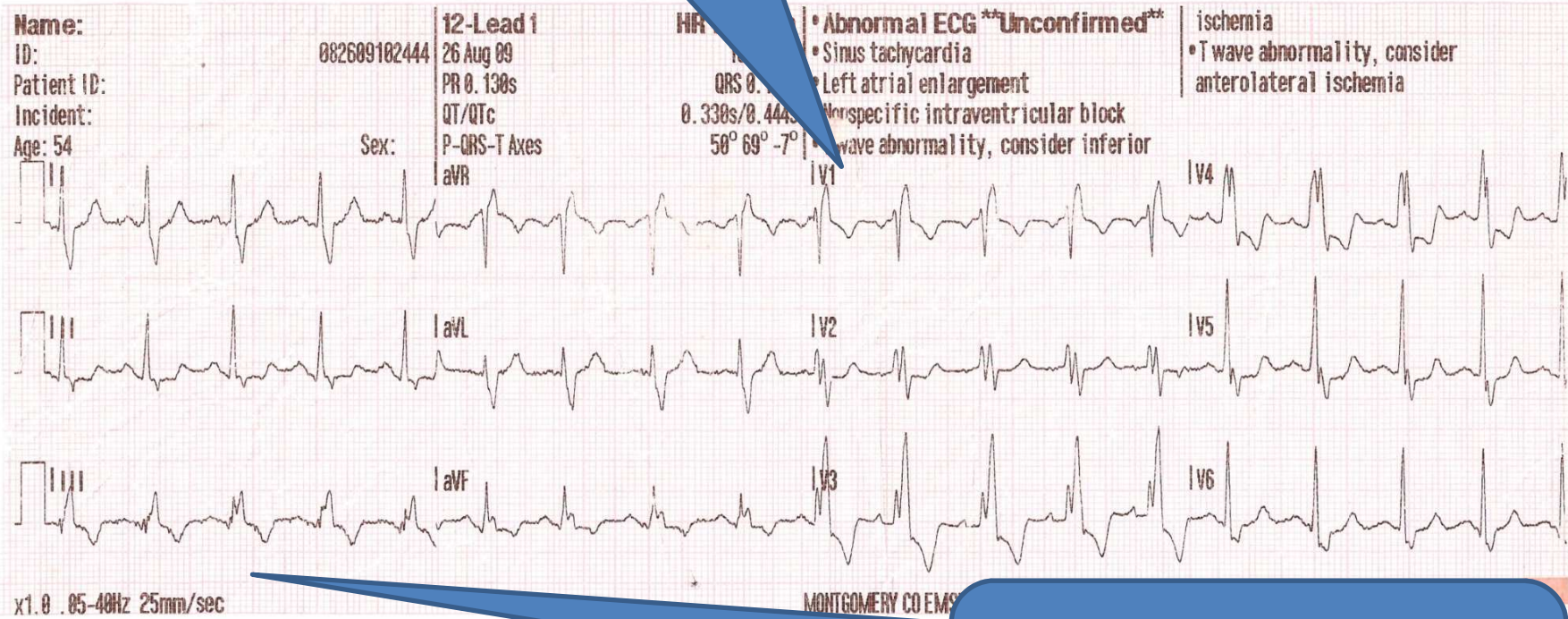
# ECG Features of Pulmonary Embolism

- Tachycardia
- Rightward axis
- Incomplete RBBB
- “Right heart strain”
- S1 Q3 T3

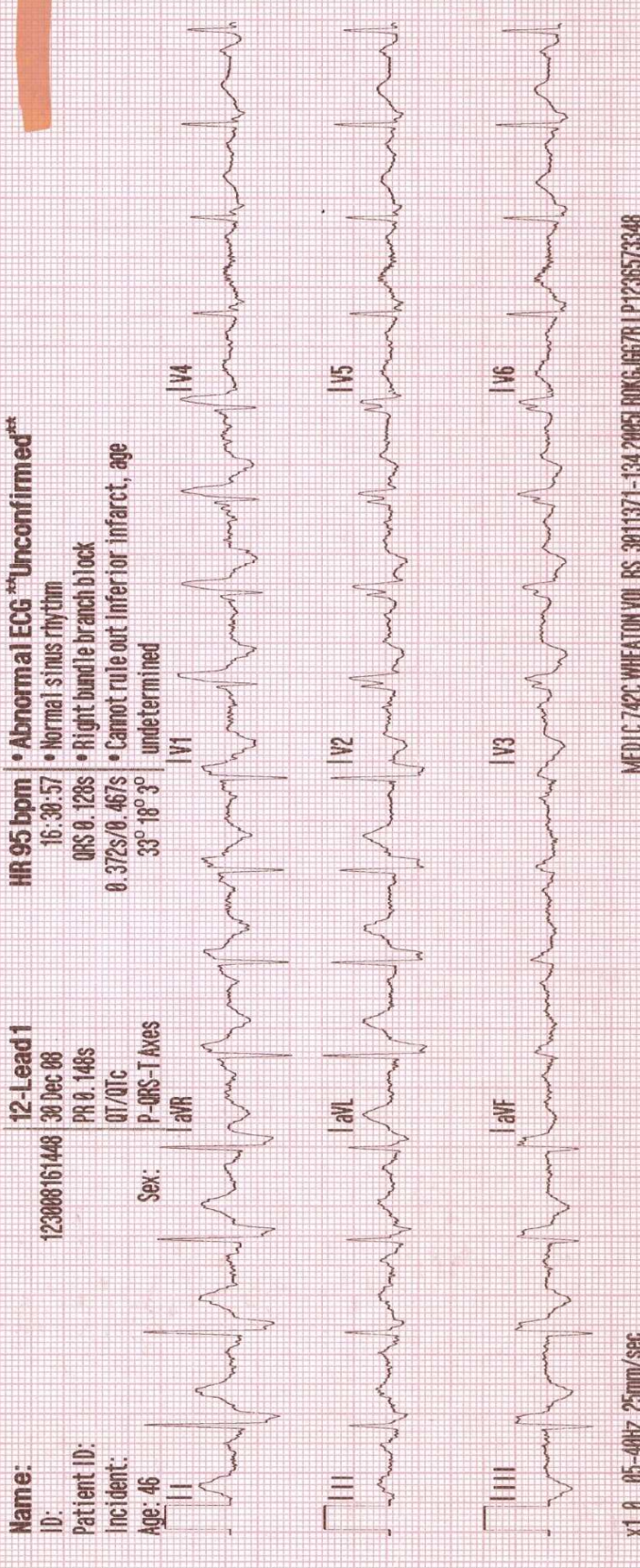


The classical S1-Q3-T3 pattern of PE:  
S-wave in lead I (small arrow), Q-wave in  
lead III (large arrow), and inverted T-wave  
in lead III (arrow head)

Incomplete RBBB



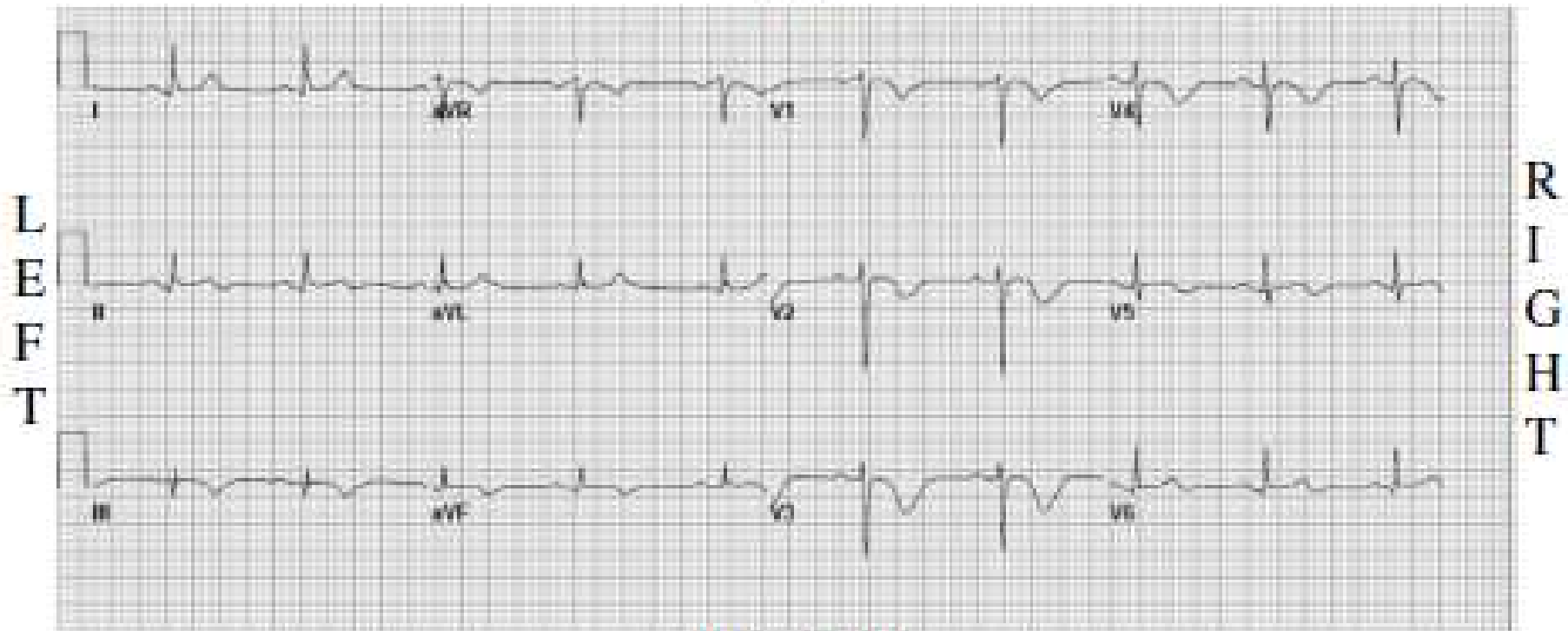
Sinus tachycardia



# ECG Features of Pulmonary Embolism

*E. Abarca et al / Journal of Electrocardiology xxi (2013) xxx-xxx*

TOP



BOTTOM

**SIMULTANEOUS T-WAVE INVERSIONS IN ANTERIOR AND INFERIOR LEADS:  
AN UNCOMMON SIGN OF PULMONARY EMBOLISM**

Michael D. Witting, MD, MS, Amal Mattu, MD, Robert Rogers, MD, and Christian Halvorson, BA

- **Unmatched case control study**
- **97 patients with PE**
- **89 with ACS**
- **105 with non cardiac chest pain**

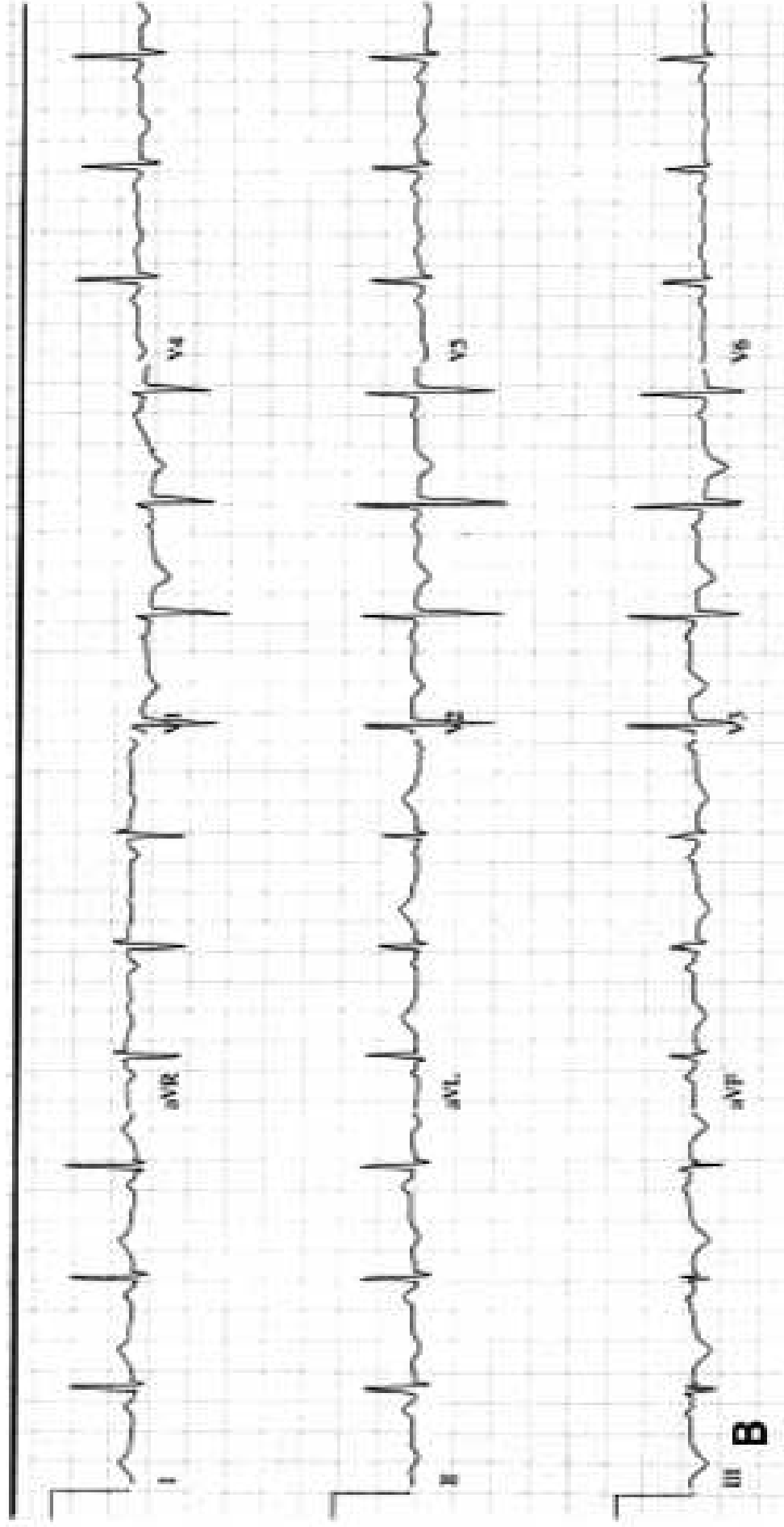
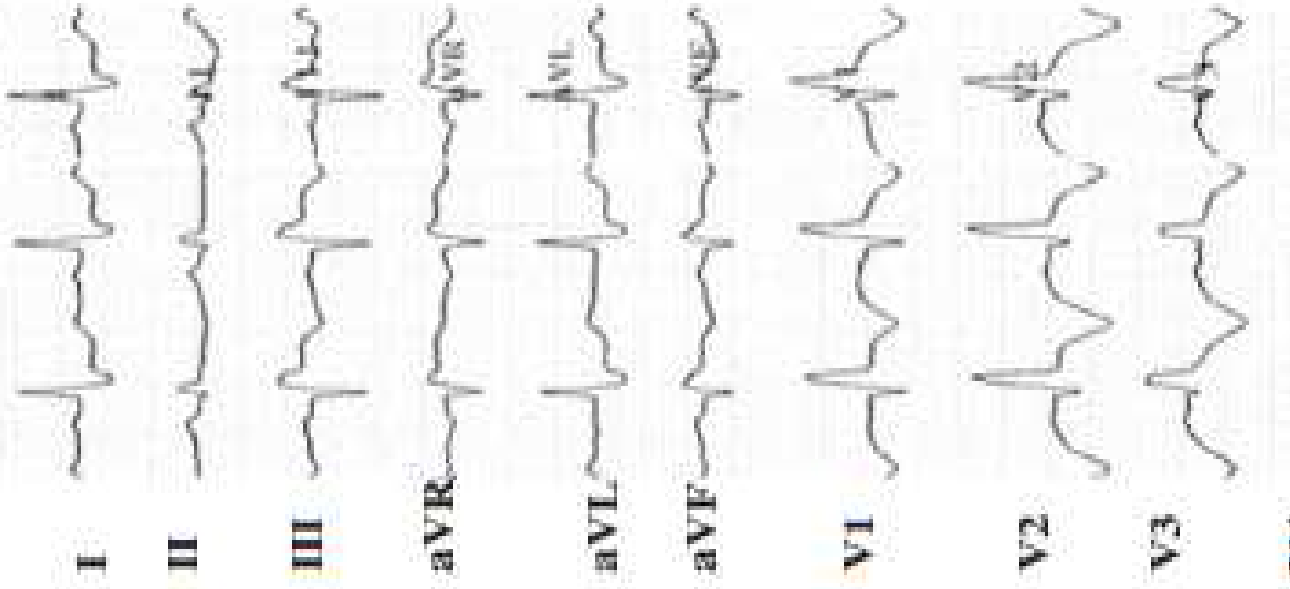


Figure 1. Simultaneous anterior and inferior T-wave inversions in 2 patients with pulmonary embolism. (A) The more sensitive pattern, 1-mm inversions in III and V<sub>1</sub>. (B) The more specific pattern, 2-mm inversions in III, aVF, V<sub>4</sub>, V<sub>2</sub>.

## SIMULTANEOUS T-WAVE INVERSIONS IN ANTERIOR AND INFERIOR LEADS: AN UNCOMMON SIGN OF PULMONARY EMBOLISM

Michael D. Witting, MD, MS, Amal Mattu, MD, Robert Rogers, MD, and Christian Halvorson, BA

**After deterioration**  
**BP 60/20mmHg**



**Case Report**

**A new electrocardiogram finding for massive pulmonary embolism: ST elevation in lead aVR with ST depression in leads I and V<sub>4</sub> to V<sub>6</sub><sup>☆</sup>**





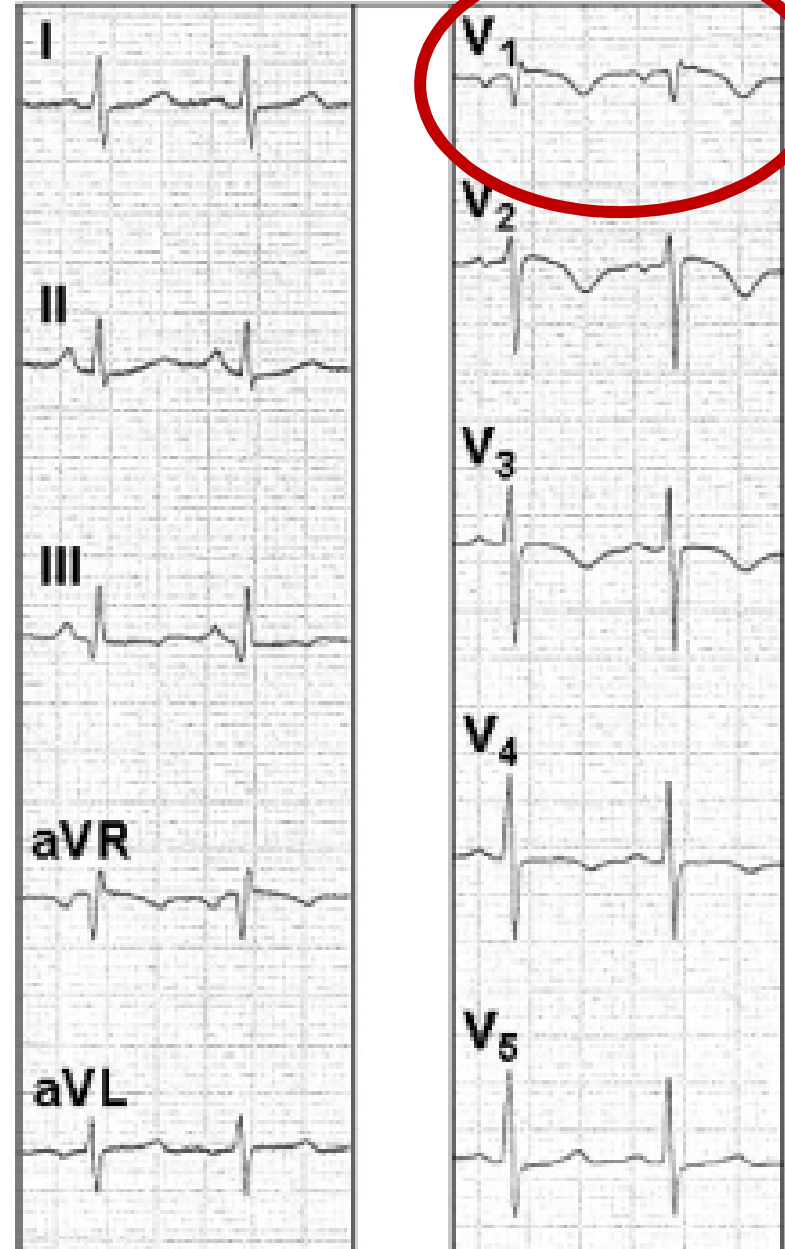
## QR in V1 – an ECG sign associated with right ventricular strain and adverse clinical outcome in pulmonary embolism

Nils Kucher\*, Nazan Walpoth, Kerstin Wustmann, Markus Novanu, Marc Gertsch

- ECGs from 151 patients suspected of having PE
- 75 patients with PE
- Troponin, echo, BNP measured in PE group
- Looked for ECG signs of right heart strain

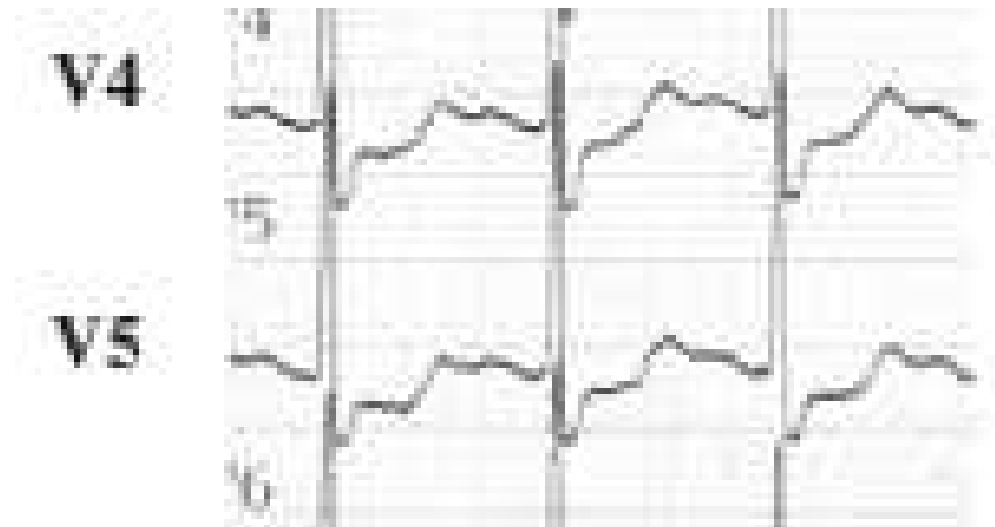
# The “Kucher” Sign

- Qr In V1 a predictor of poor outcome
- Most specific ECG finding

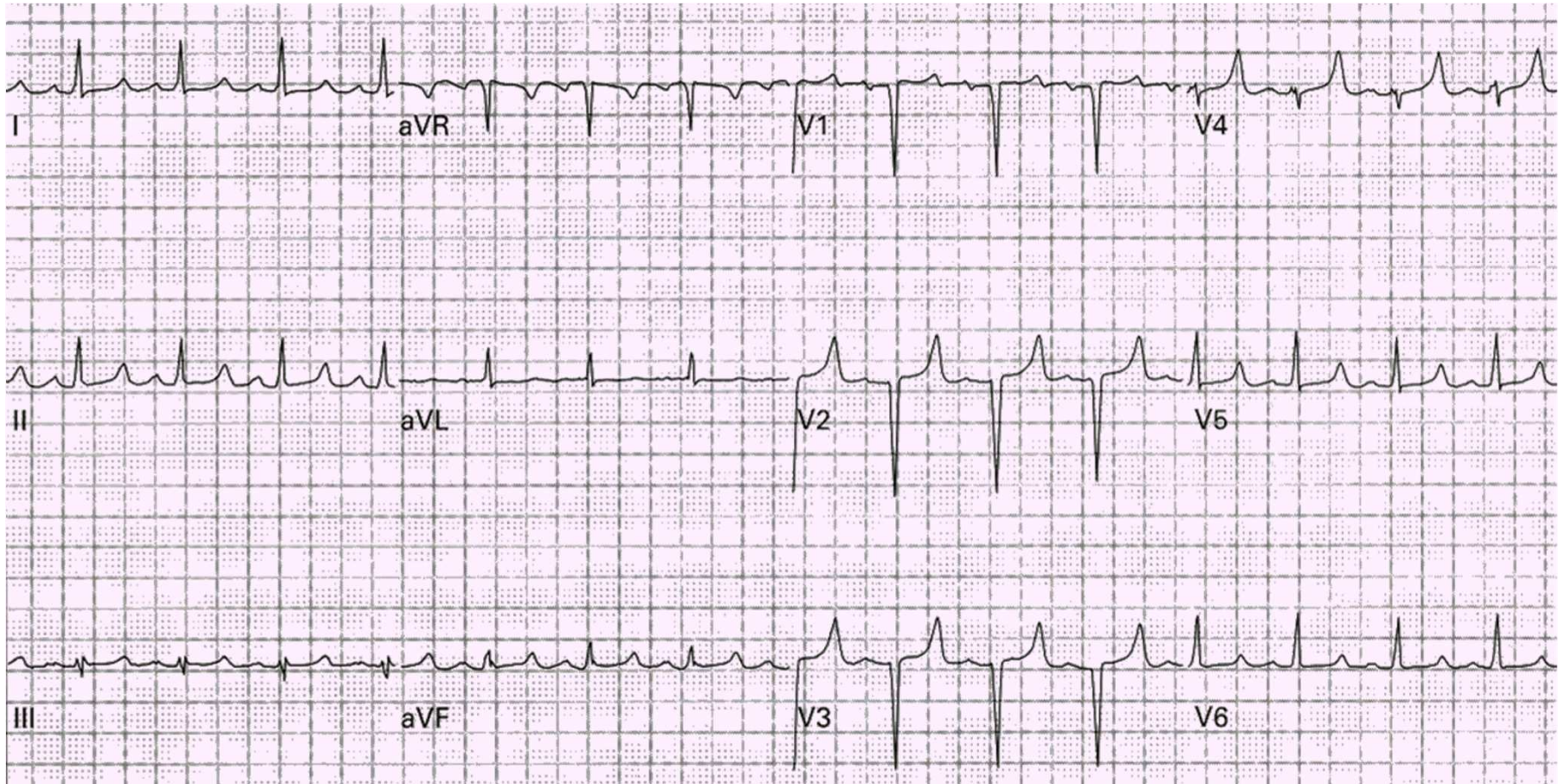


# Bottom Line Predictors of Badness

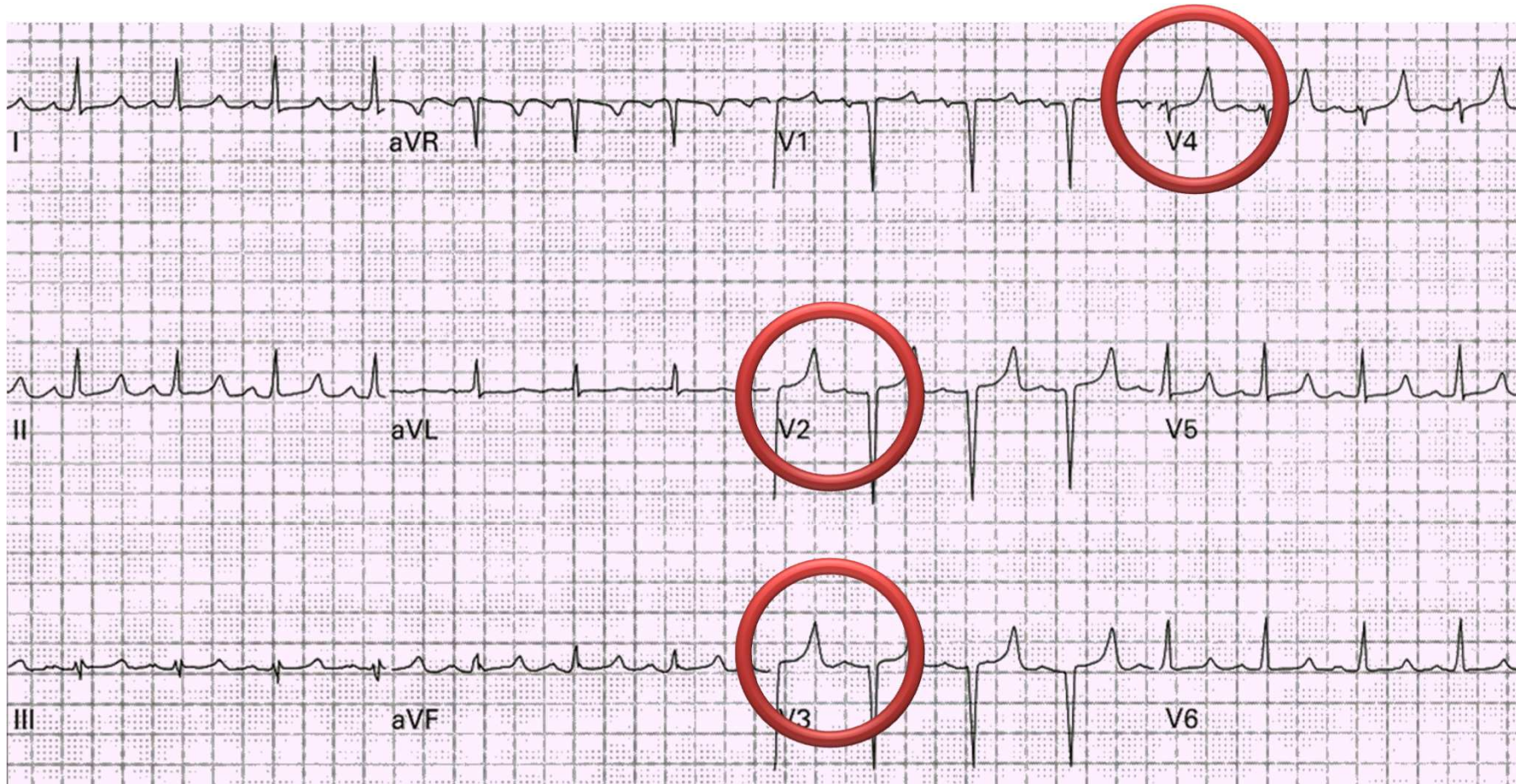
- TWI anteirololy
- RBBB
- STE in aVR
- qR in V1
- Tachycardia



# 26 yo female, ESRD, weakness

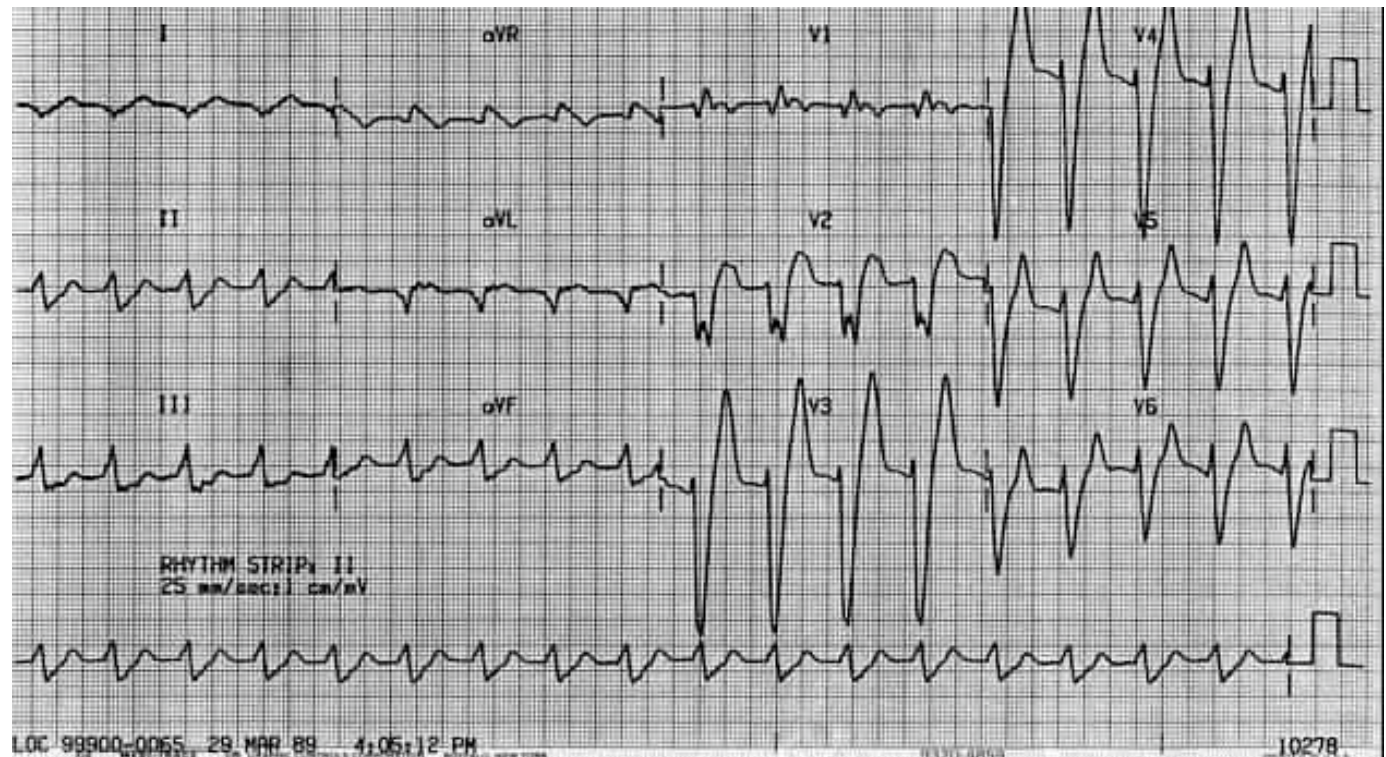


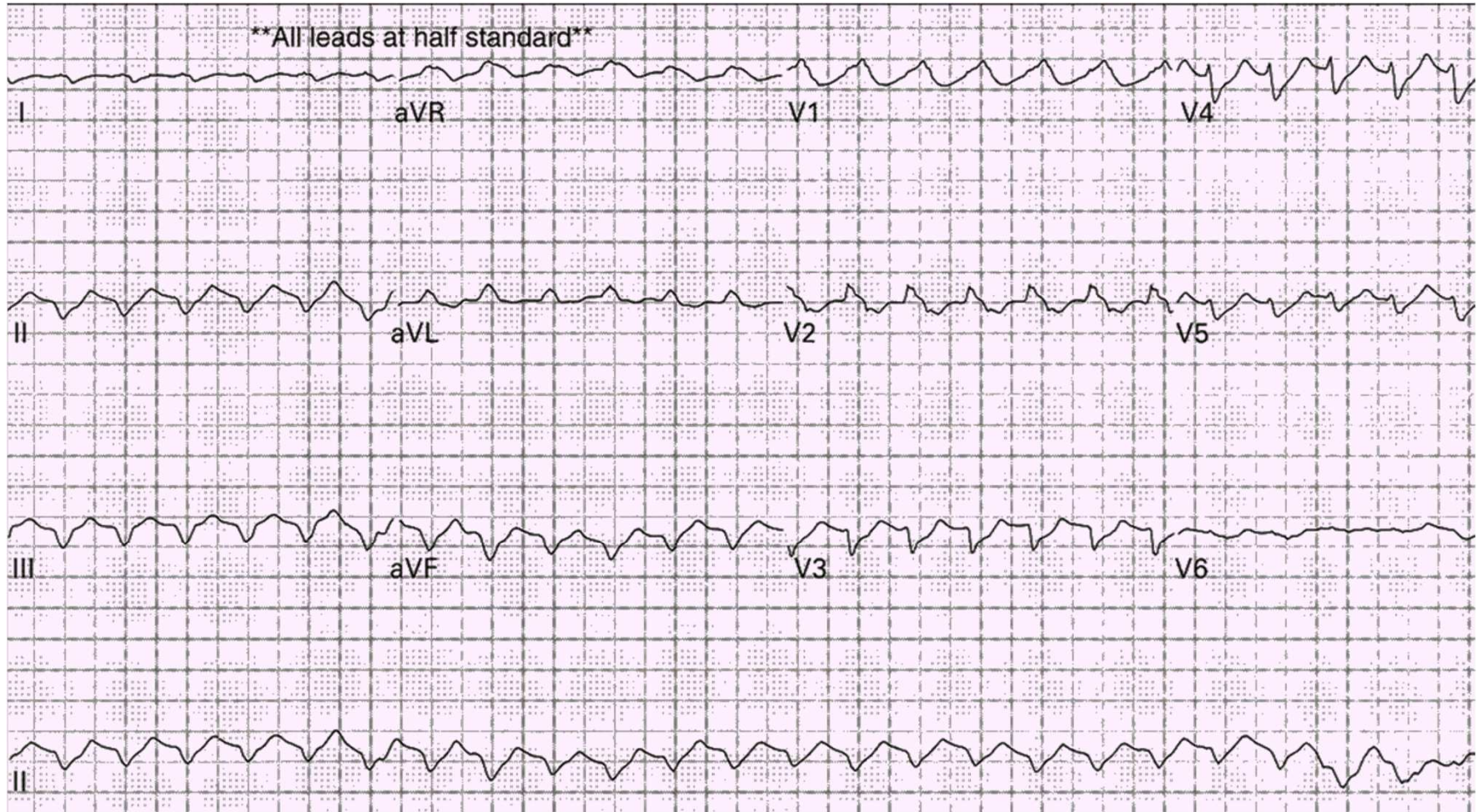
# SR, rate 90-100, Hyperkalemia



# Hyperkalemia

- Peaked T waves
- Widening of QRS
- Absence of P's
- Sinusoidal rhythm





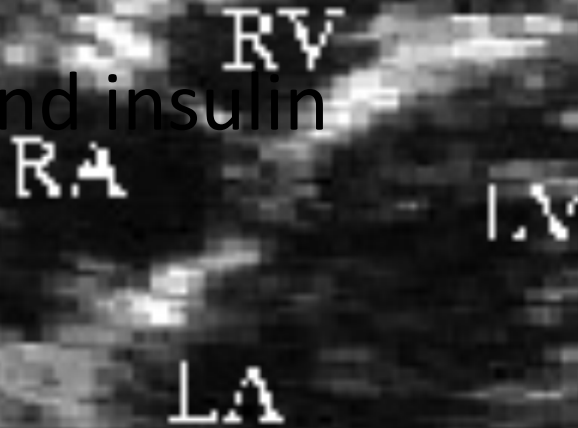
**Serum K+ 8.3 mEq/L**

# Treatment of Hyper-K

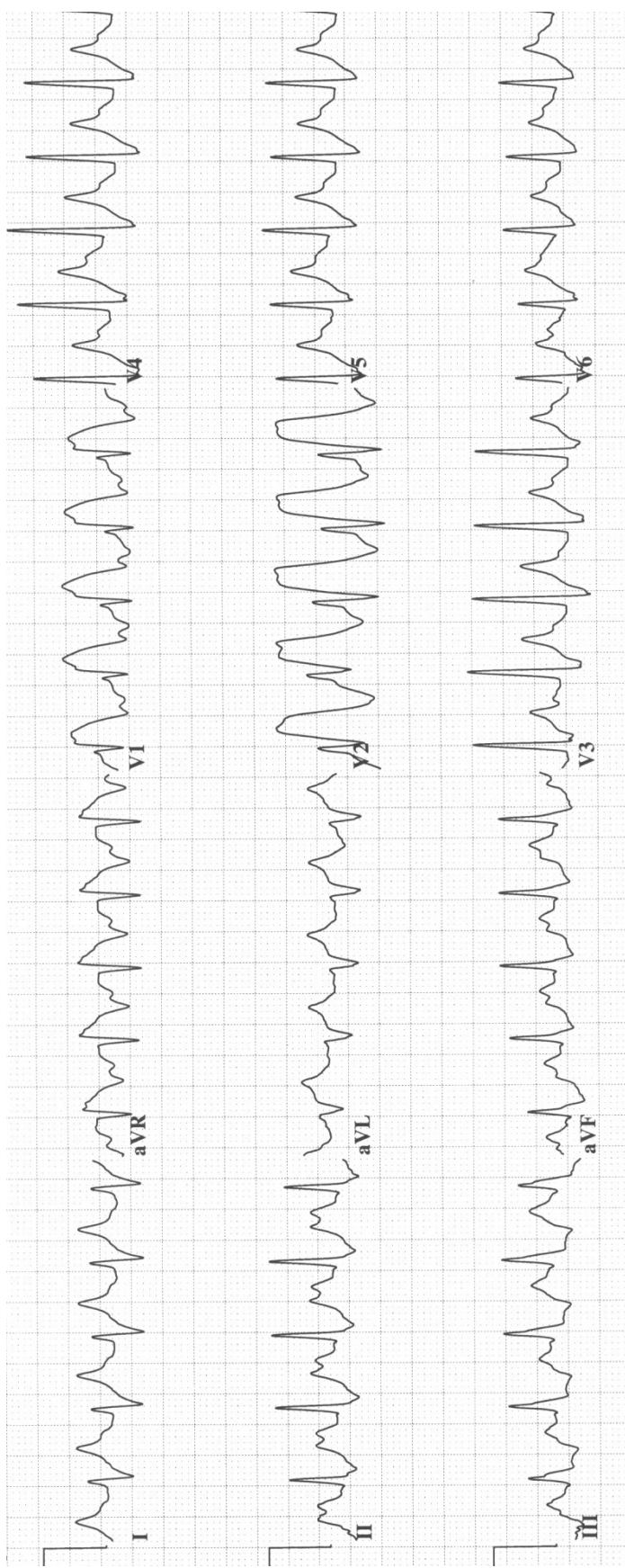
Calcium

Dextrose and insulin

- $\text{NaHCO}_3$
- Albuterol
- Binding resins
- Dialysis

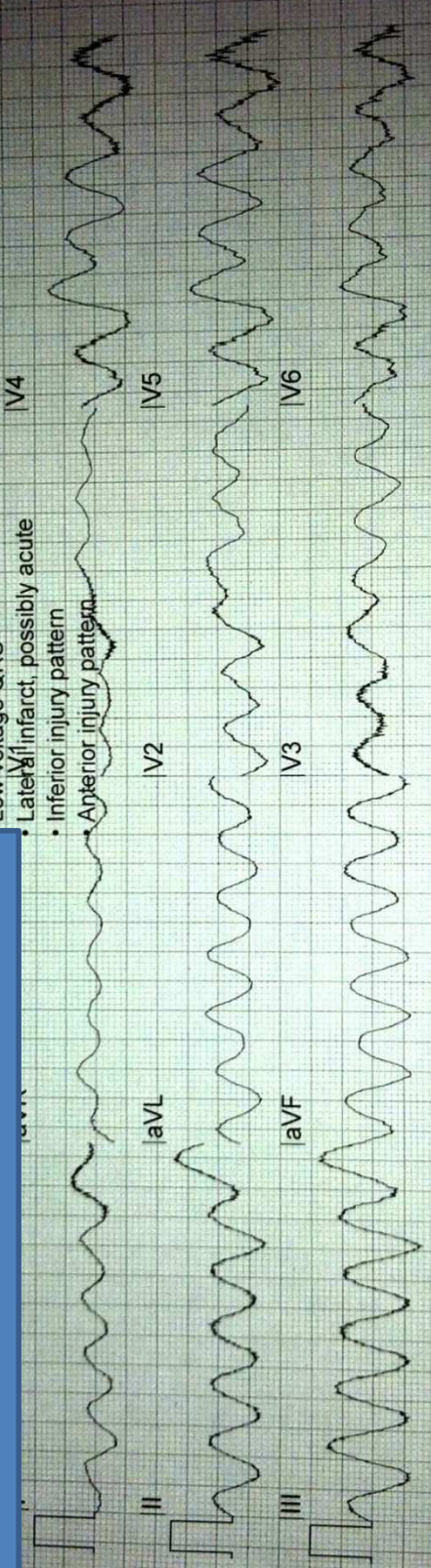






\*\*\* ACUTE MI SUSPECTED \*\*\*  
 Abnormal ECG \*\*Unconfirmed\*\*  
 Atrial fibrillation with rapid ventricular response with premature ventricular or  
 aberrantly conducted complexes

Low voltage QRS  
 • Lateral infarct, possibly acute  
 • Inferior injury pattern  
 • Anterior injury pattern

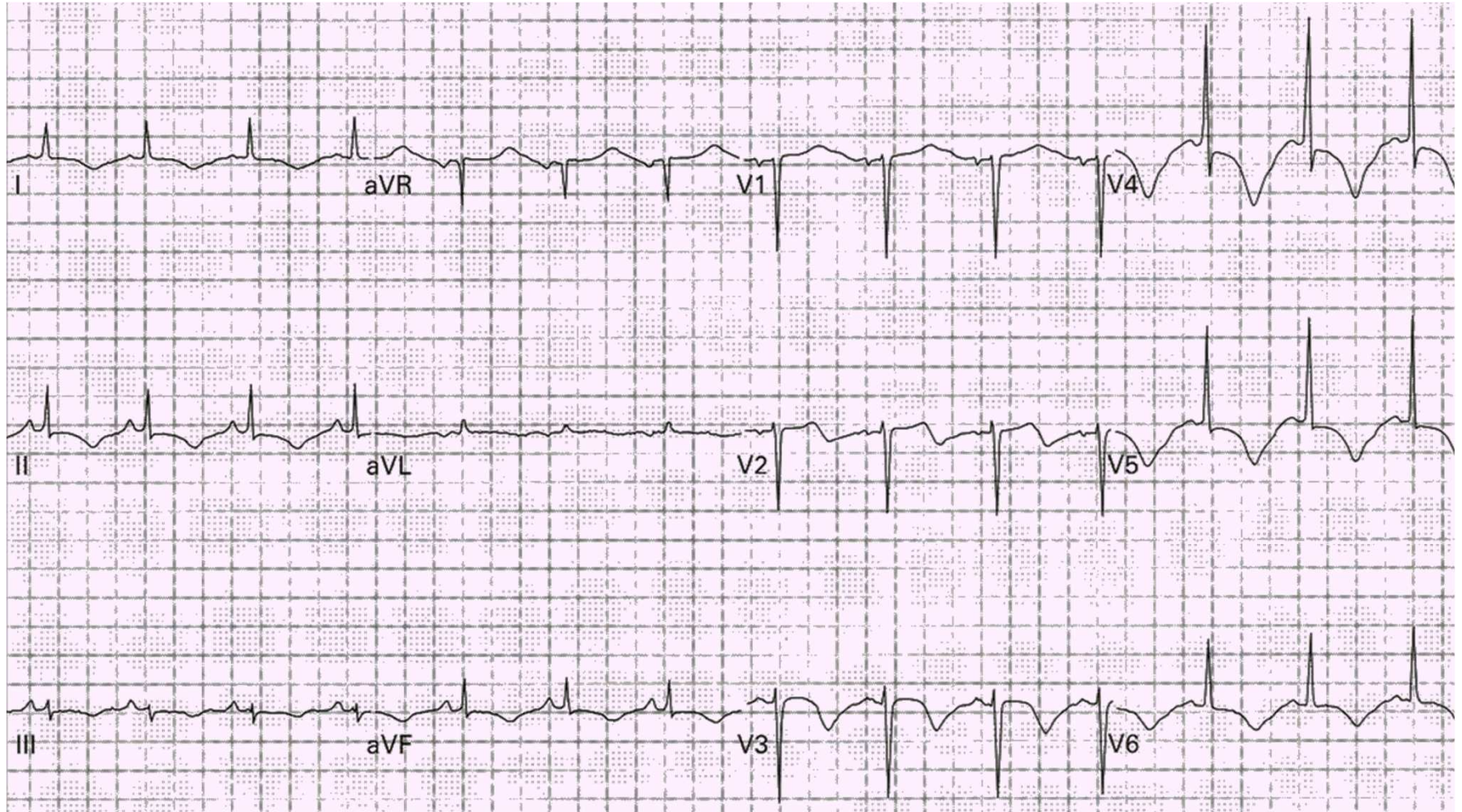


x1.0 05-150Hz 25mm/sec  
 Physio-Control, Inc. Comments  
 AMB591 000HDGAC 591 3011371-134 LP1236574607

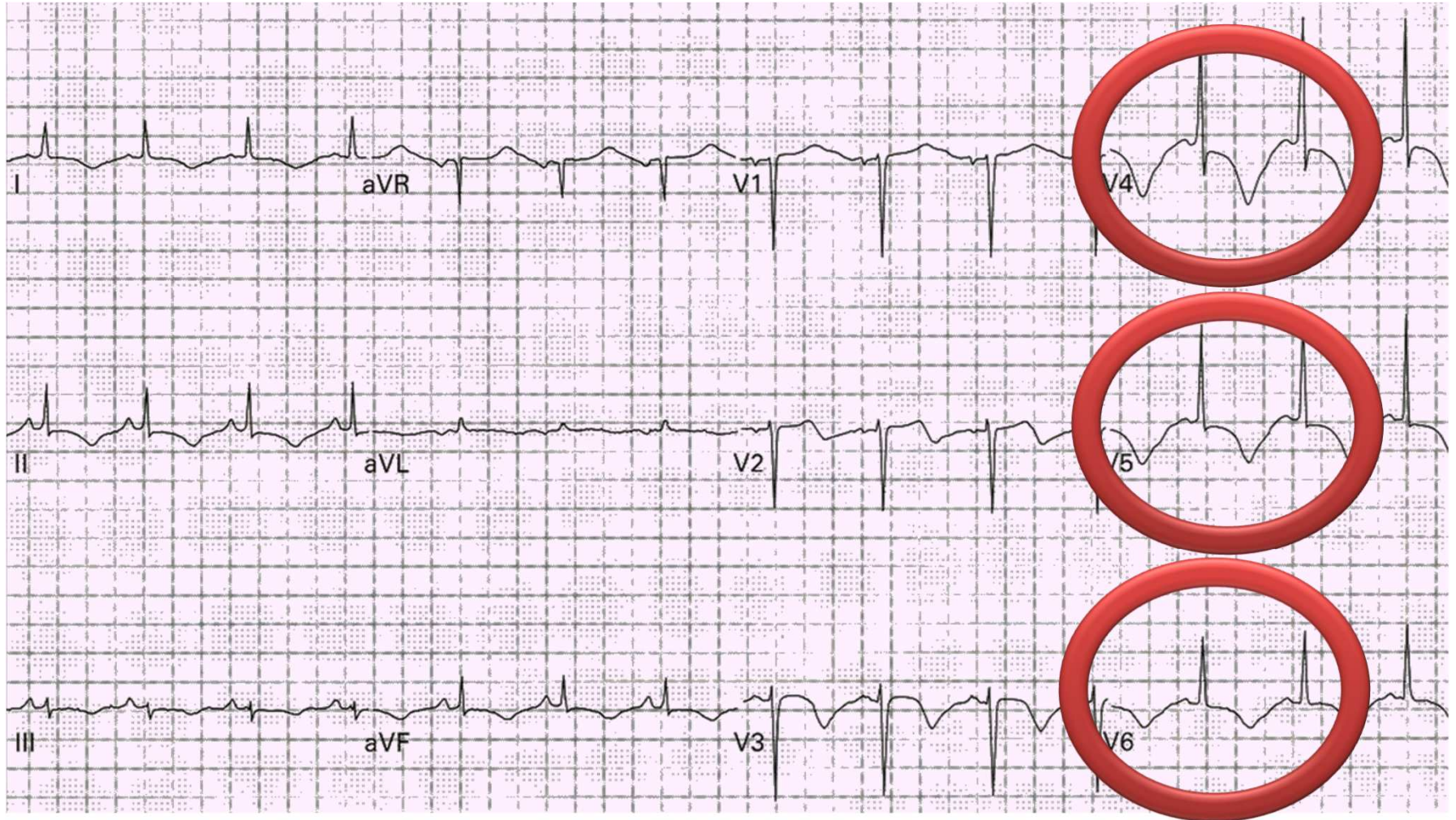
ST measurements are measured at the median point and are expressed in mm.

I	II	III	aVR	aVL	aVF	V1	V2	V3	V4	V5	V6
-0.98	4.98	5.95	-2.01	-3.47	5.46	-0.35	-0.35	3.75	4.83	4.73	4.39

# 60 yo female, found unconscious

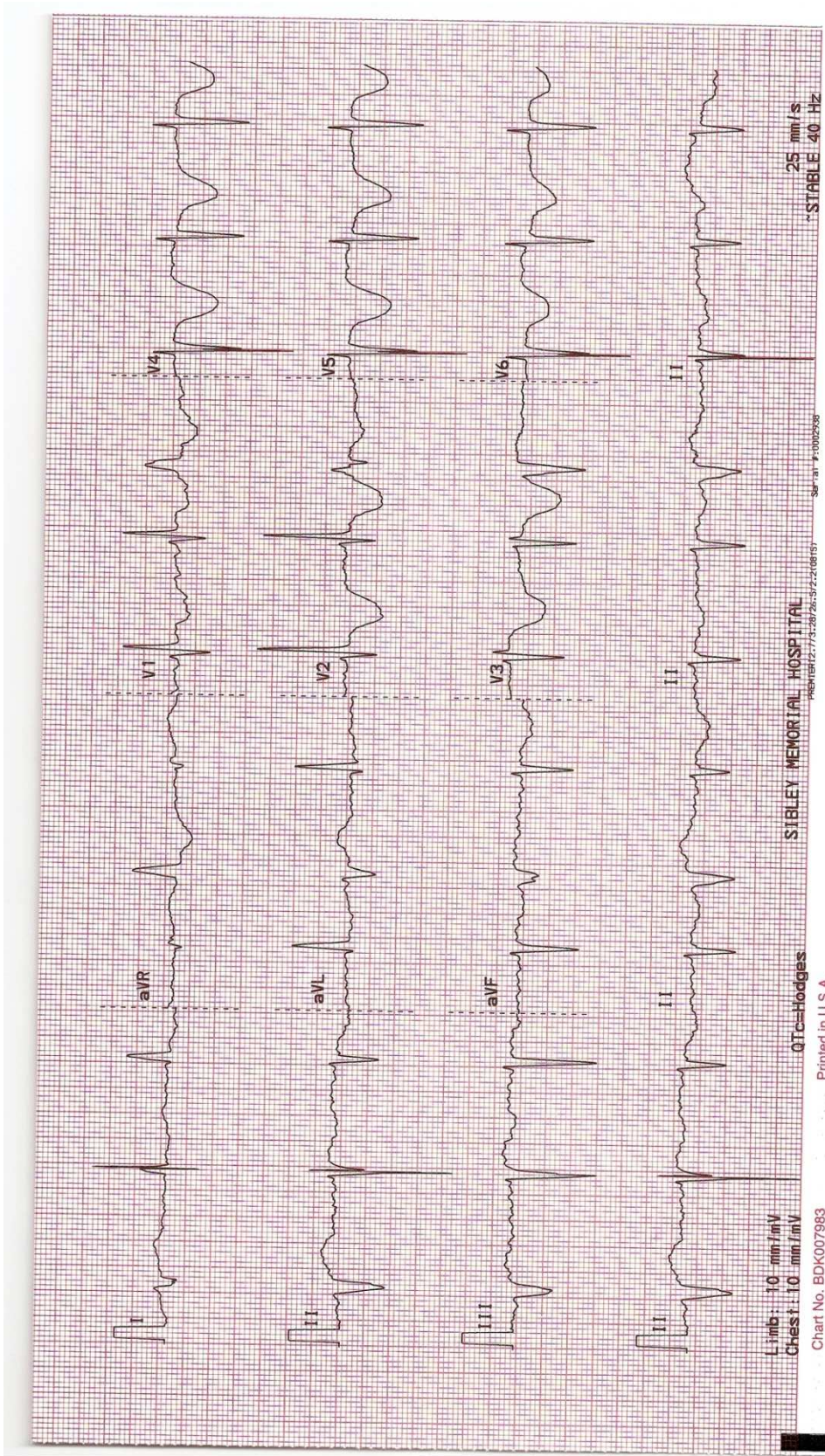


# Increased ICP vs AMI



# Diffuse T Wave Inversion

- Cerebral ischemia
- Increased ICP
- Cardiac ischemia
- + Troponins



# **Some more ECGs**

# A STEMI Equivalent

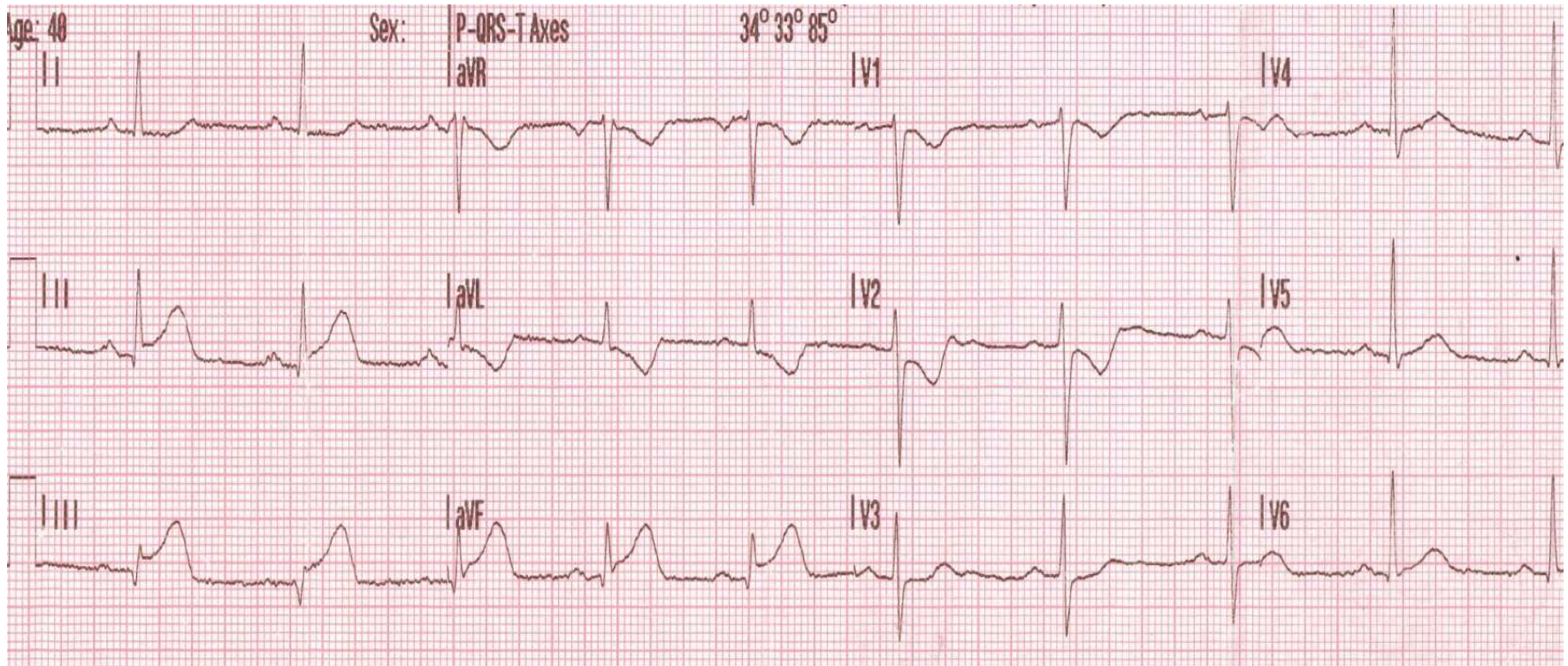
Rokos IC, French WJ, Mattu A, et al.

Appropriate cardiac cath lab activation:  
optimizing electrocardiogram interpretation  
and clinical decision-making for acute ST  
elevation myocardial infarction. ***Am Heart J.***

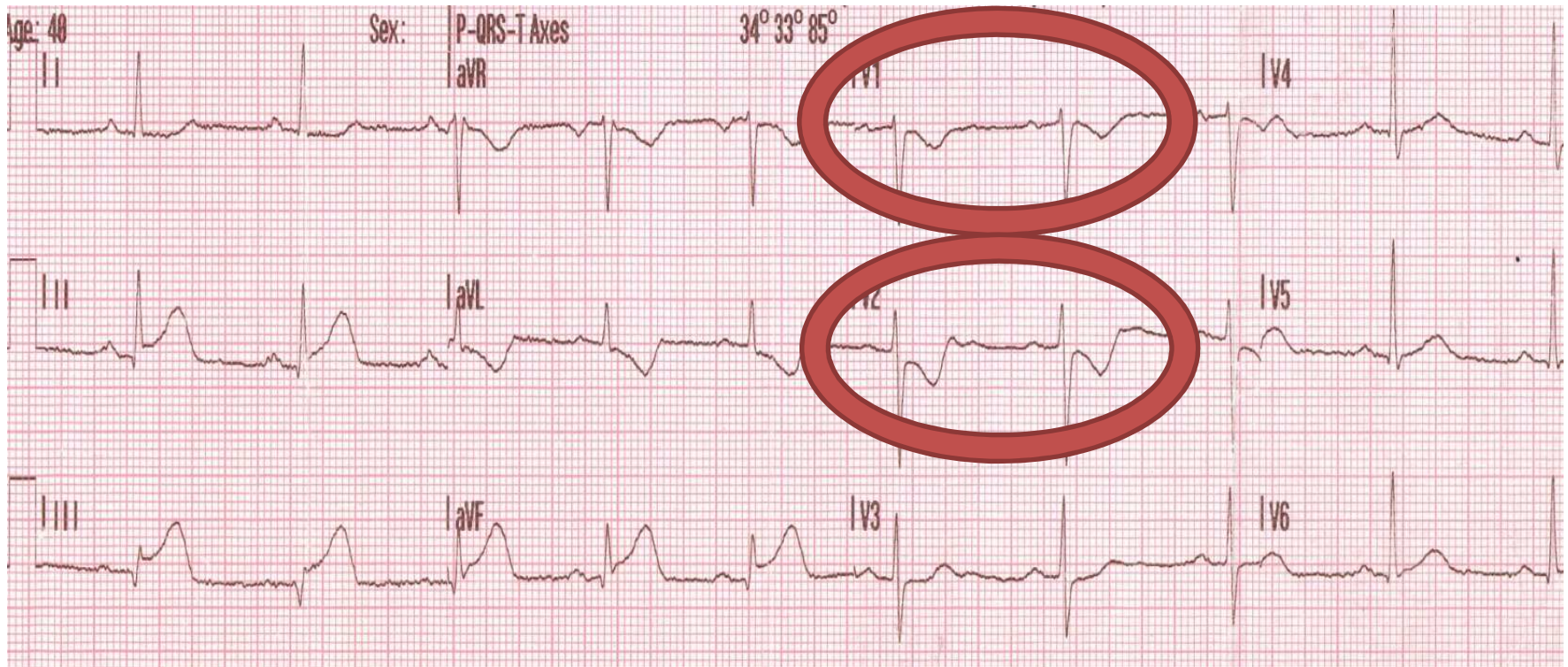
2010 Dec; 160(6):995-1003



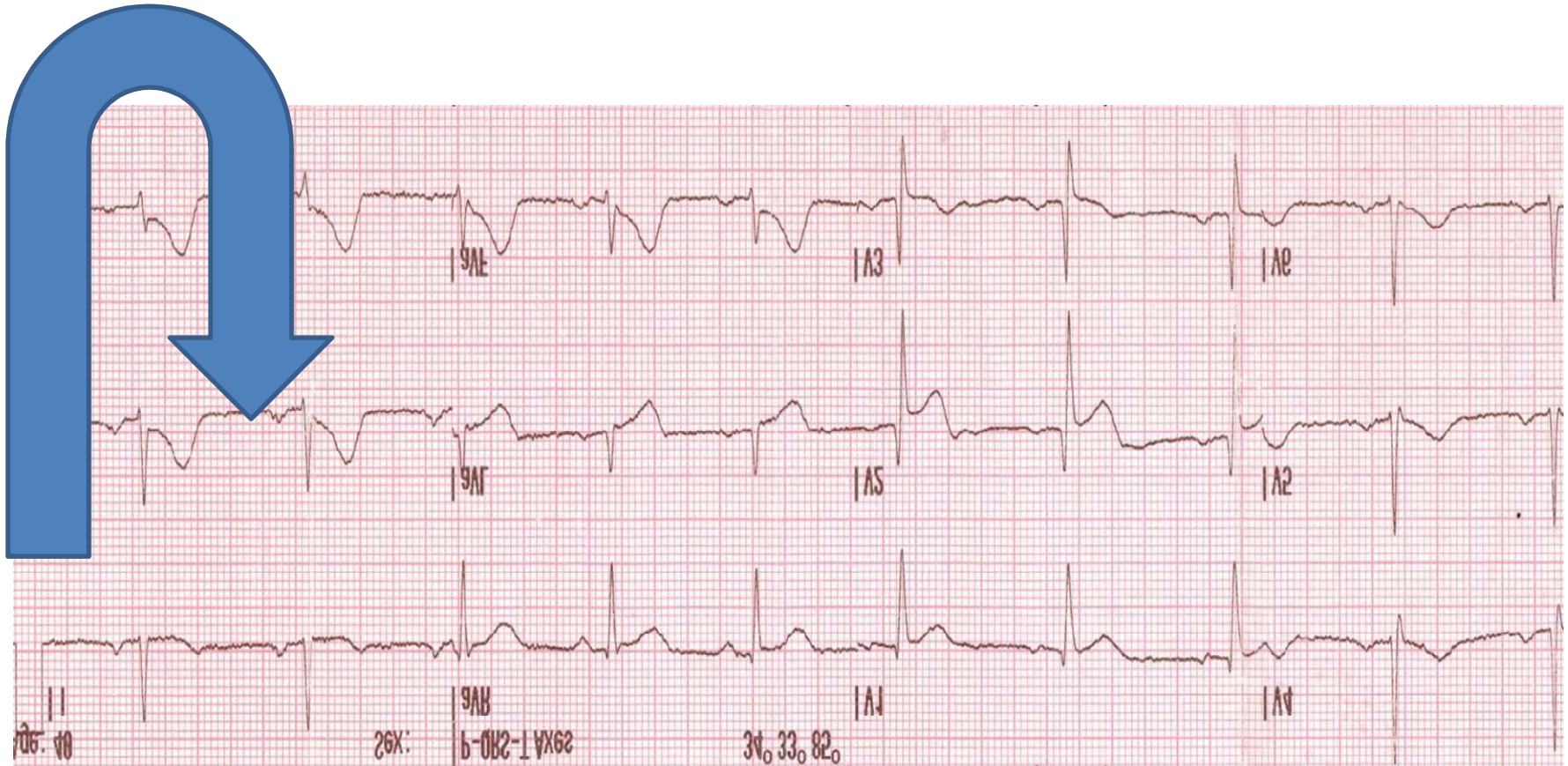
# 50 yo male, diaphoresis



# SR, Inferior Wall STEMI, Posterior Extension



# Flipped Around for Posterior Examination

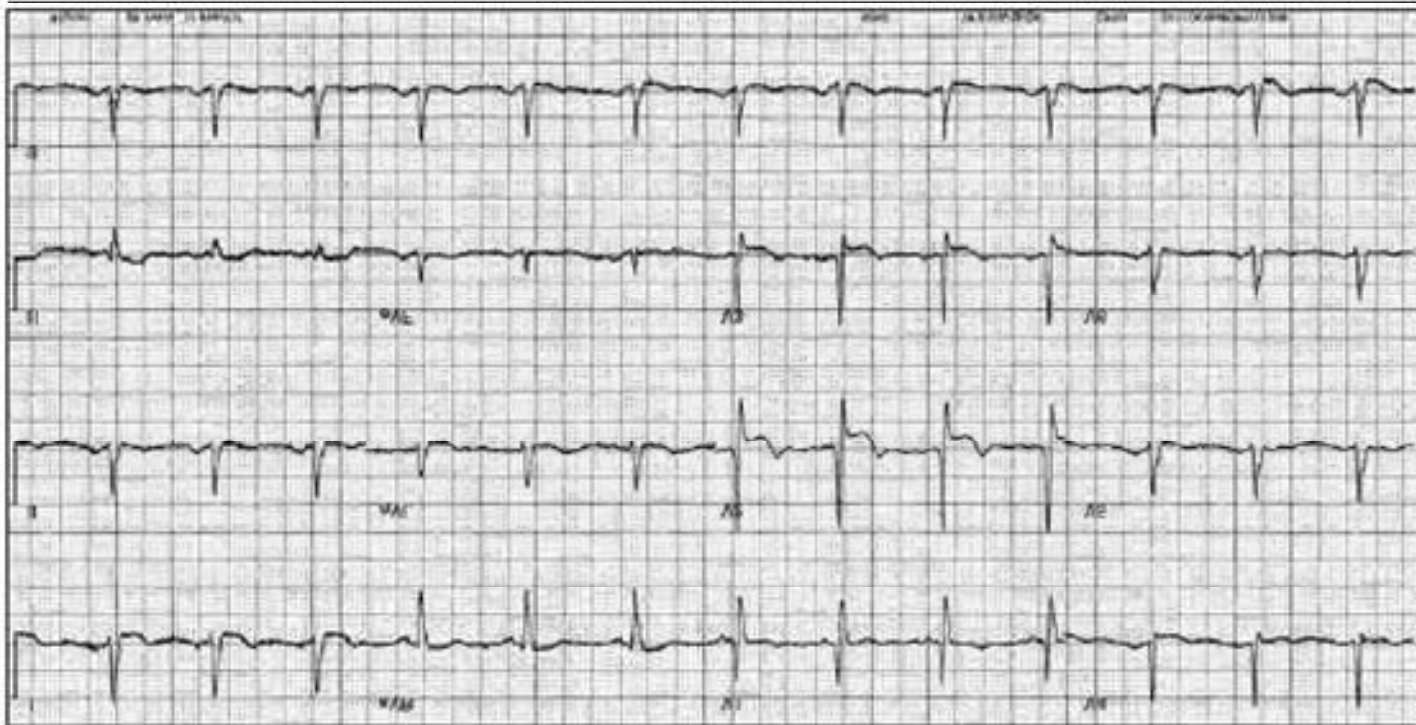


# Posterior Wall MI



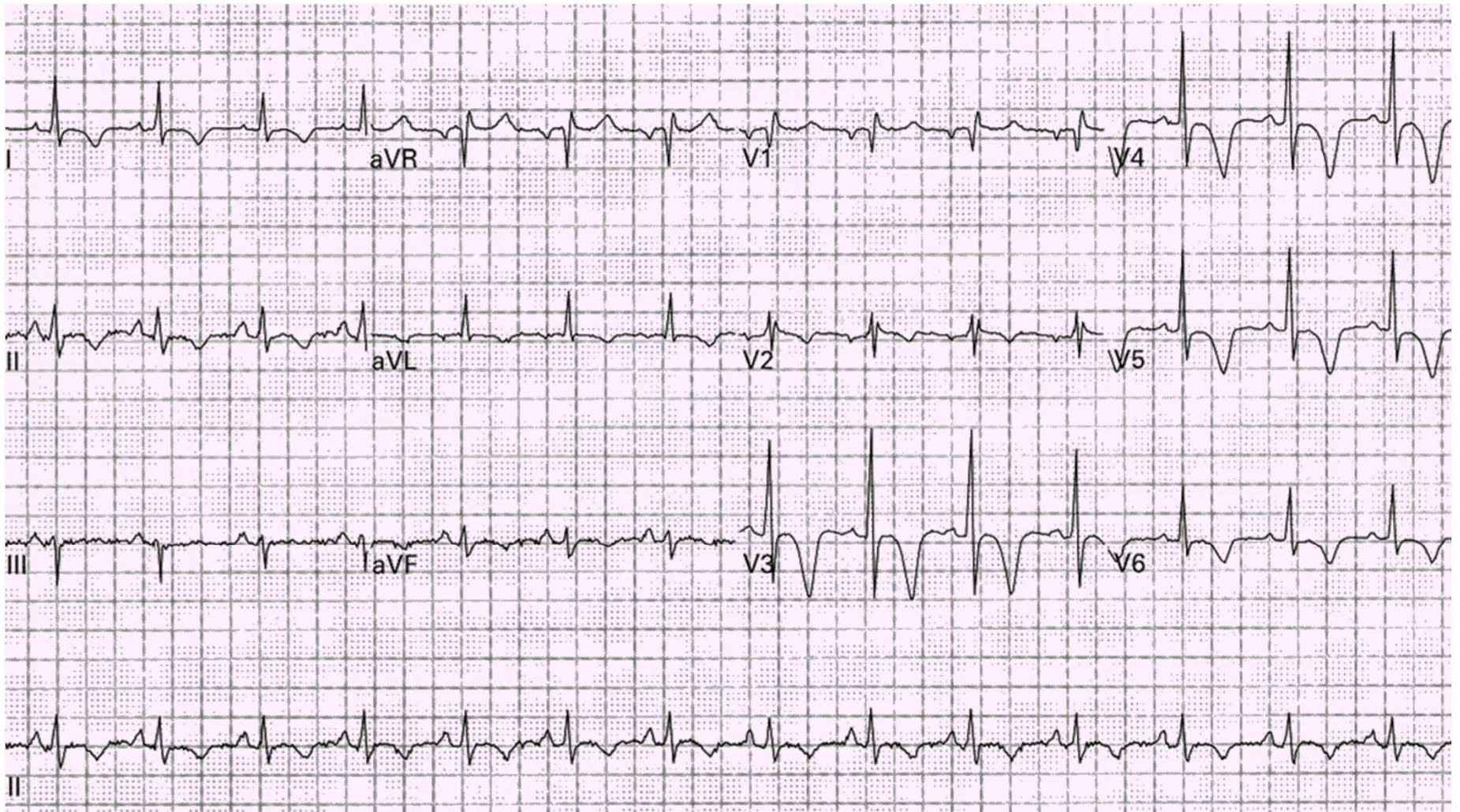
- ST depression
- Prominent R wave in precordial leads
- R/S ratio  $> 1$  in V2
- Coexistence of inferior/lateral changes

# Flipped Around

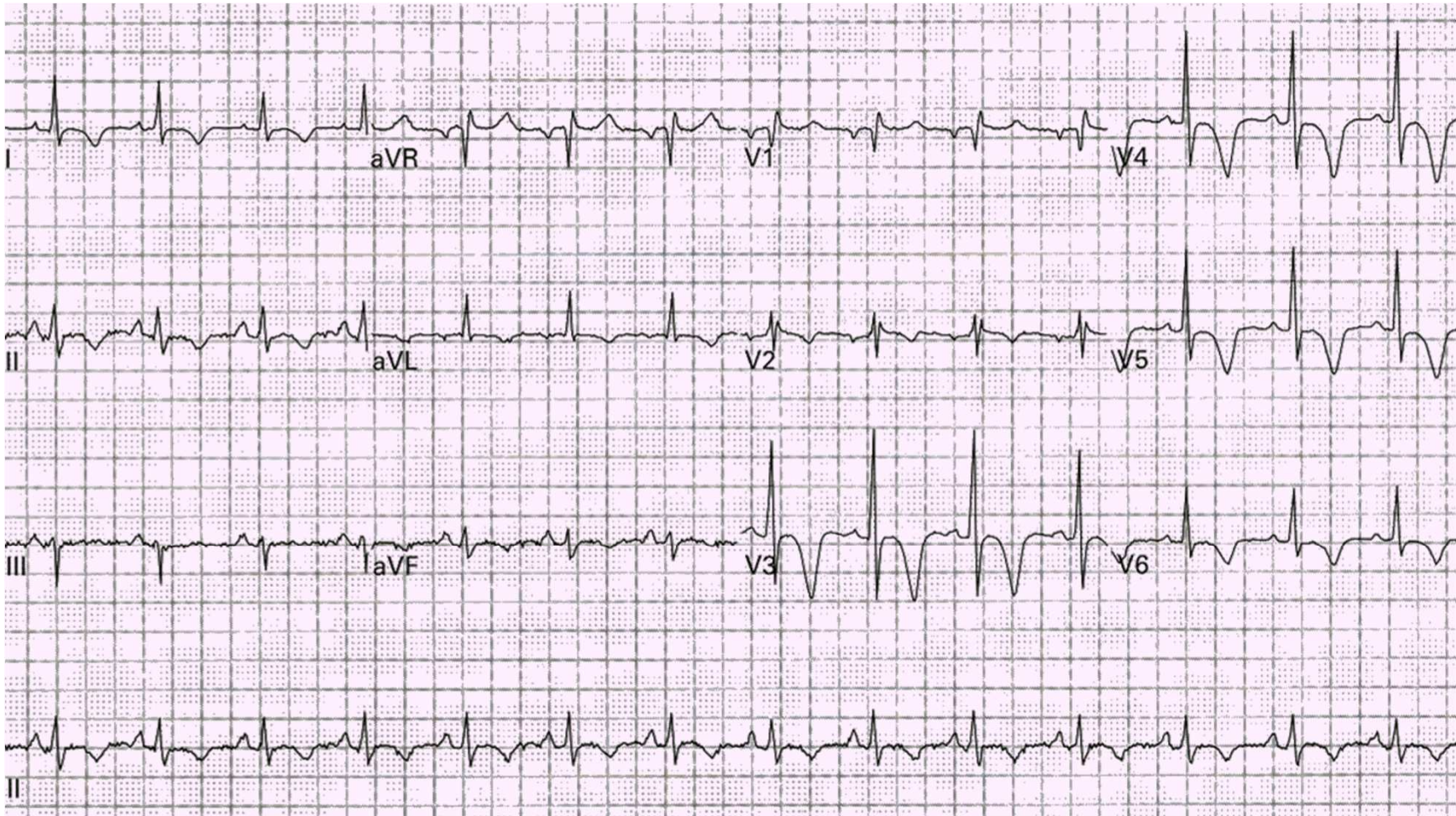


- ST depression
- Prominent R wave in precordial leads
- R/S ratio  $> 1$  in V2
- Coexistence of inferior/lateral changes

# 47 yo female, chest pain resolved following NTG



# SR, T wave inversion suggesting anterolateral ischemia



# Wellens Syndrome

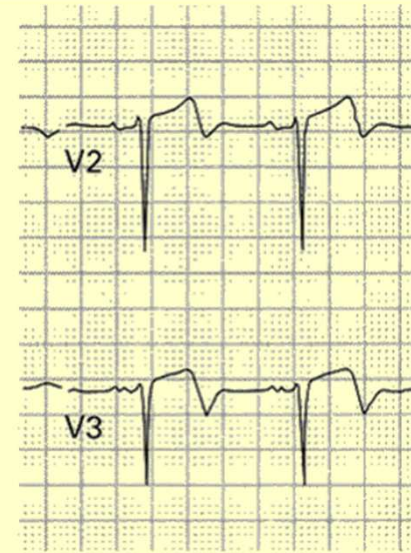
- T wave patterns in precordial leads
- Suggestive of proximal LAD lesion
- T wave inversion
- Biphaseic T wave
- Invasive approach preferred



# Wellens's Waves



Deeply inverted T-waves in the mid-precordial leads characteristic of Wellens' syndrome



The less common, biphasic T-wave pattern of Wellens' syndrome

- *T wave pattern often persists in pain free state*

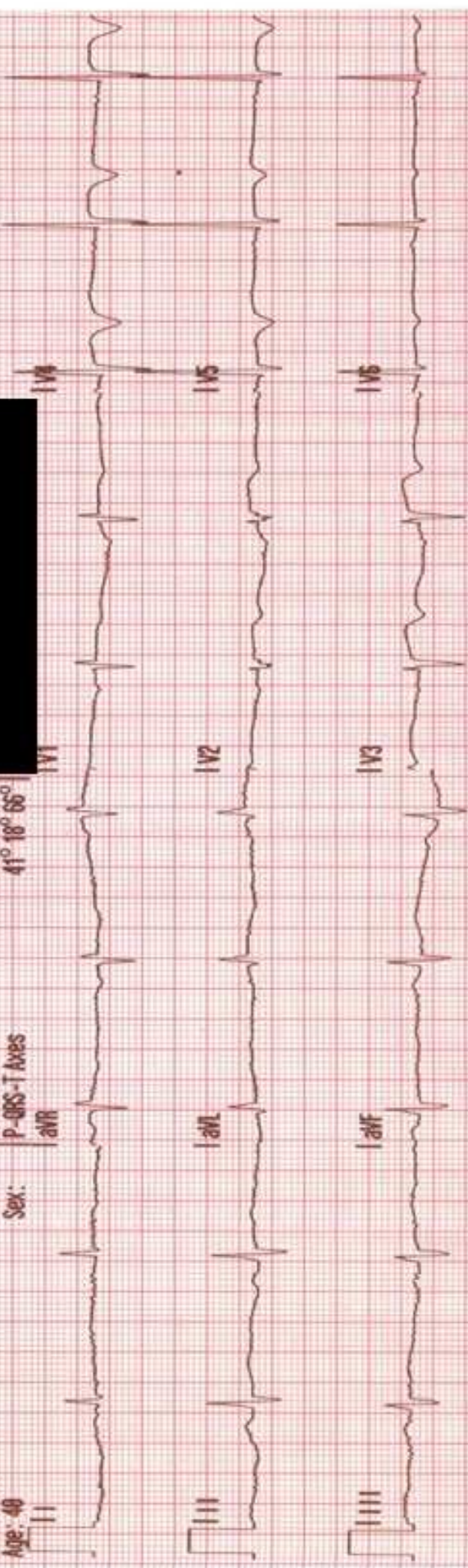
Abnormal ECG (Inconformed) ischemia

HR 61 bpm  
67:28:57  
QRS 0.888s  
0.468s/0.418s  
41° 18° 66°

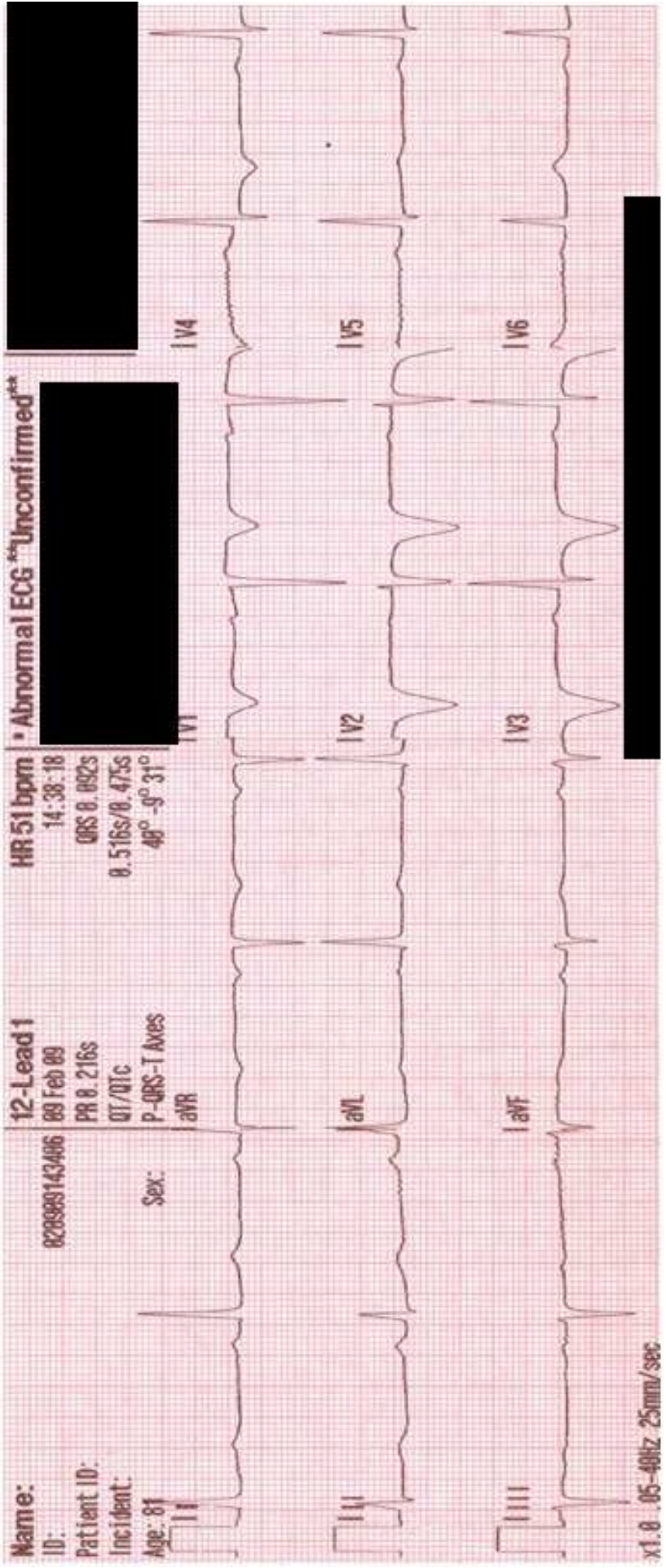
12-Lead 1  
11 Dec 07  
PR 0.144s  
QT/QTc  
P-QRS-T Axes  
aVR

121107072687  
Sex:

Name:  
ID:  
Patient ID:  
Incident:  
Age: 40



x1.0 .05-40Hz 25mm/sec



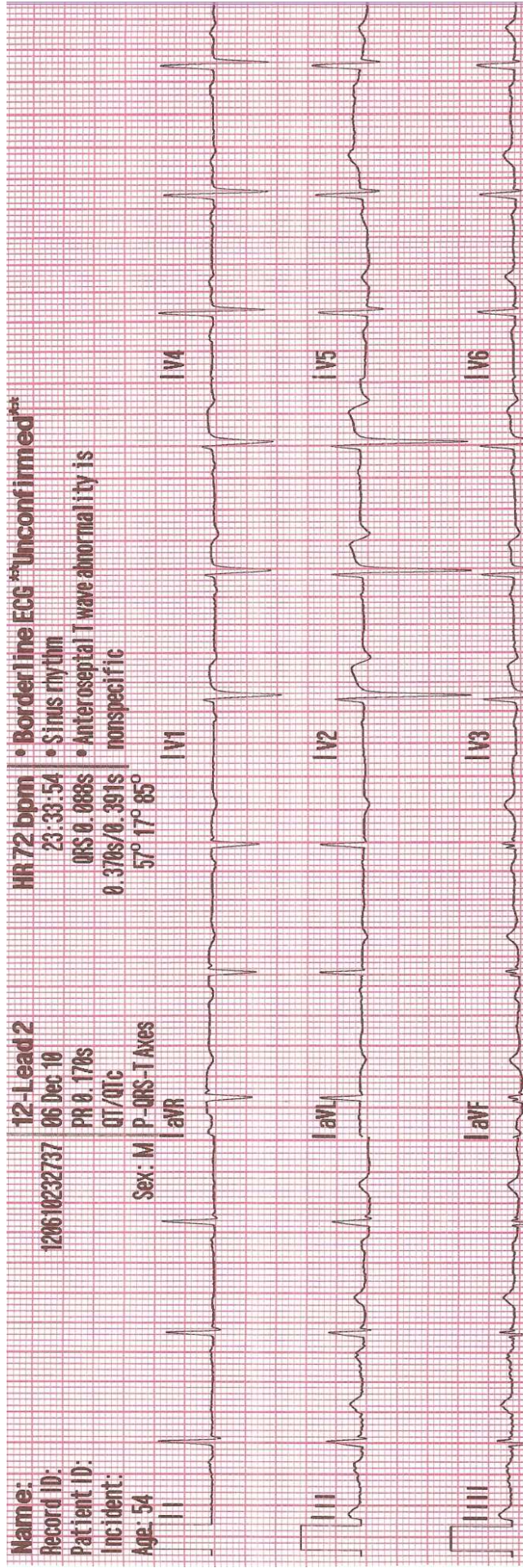
Name: [REDACTED]  
 ID: [REDACTED]  
 Patient ID: [REDACTED]  
 Incident: [REDACTED]  
 Age: 81  
 Sex: [REDACTED]

12-Lead 1  
 09 Feb 09  
 PR 0.16s  
 QT/QTc  
 P-QRS-T Axes  
 aVR

HR 51 bpm  
 14:38:18  
 QRS 0.08s  
 0.516s/0.475s  
 48° -9° 31°

Abnormal ECG <sup>ECG</sup> Unconfirmed <sup>ECG</sup>

x1.0 05-40Hz 25mm/sec



**Name:** 12-Lead 2  
**Record ID:** 120610232737  
**Patient ID:** 06 Dec 10  
**Incident:** PR 0.170s  
 QT/QTc 0.370s/0.391s  
 Sex: M P-QRS-T Axes 57° 17° 85°  
 Age: 54

**HR 72 bpm**  
 23:33:54  
 • Borderline ECG \*\*Unconfirmed\*\*  
 • Sinus rhythm  
 • Anteroseptal T wave abnormality is nonspecific

Name: *Walter S. Wang*

ID: 111689162231

Patient ID: 16 Nov 09

Incident: PR 0.154s

Age: 65 QT/QTc

Sex: P-QRS-T Axes

||| aVR

HR 60 bpm

16:26:52

QRS 0.072s

0.416s/0.416s

15° 3° 58°

||| I V1

12-Lead 2

Abnormal ECG \*\*\* Unconfirmed\*\*\*

Normal sinus rhythm

Possible inferior infarct, age undetermined

T wave abnormality, consider

anterolateral ischemia

||| II

||| aVL

||| V2

||| III

||| aVF

||| V3

||| IV

||| V4

||| V5

||| V6

||| V1

||| V2

||| V3

||| V4

||| V5

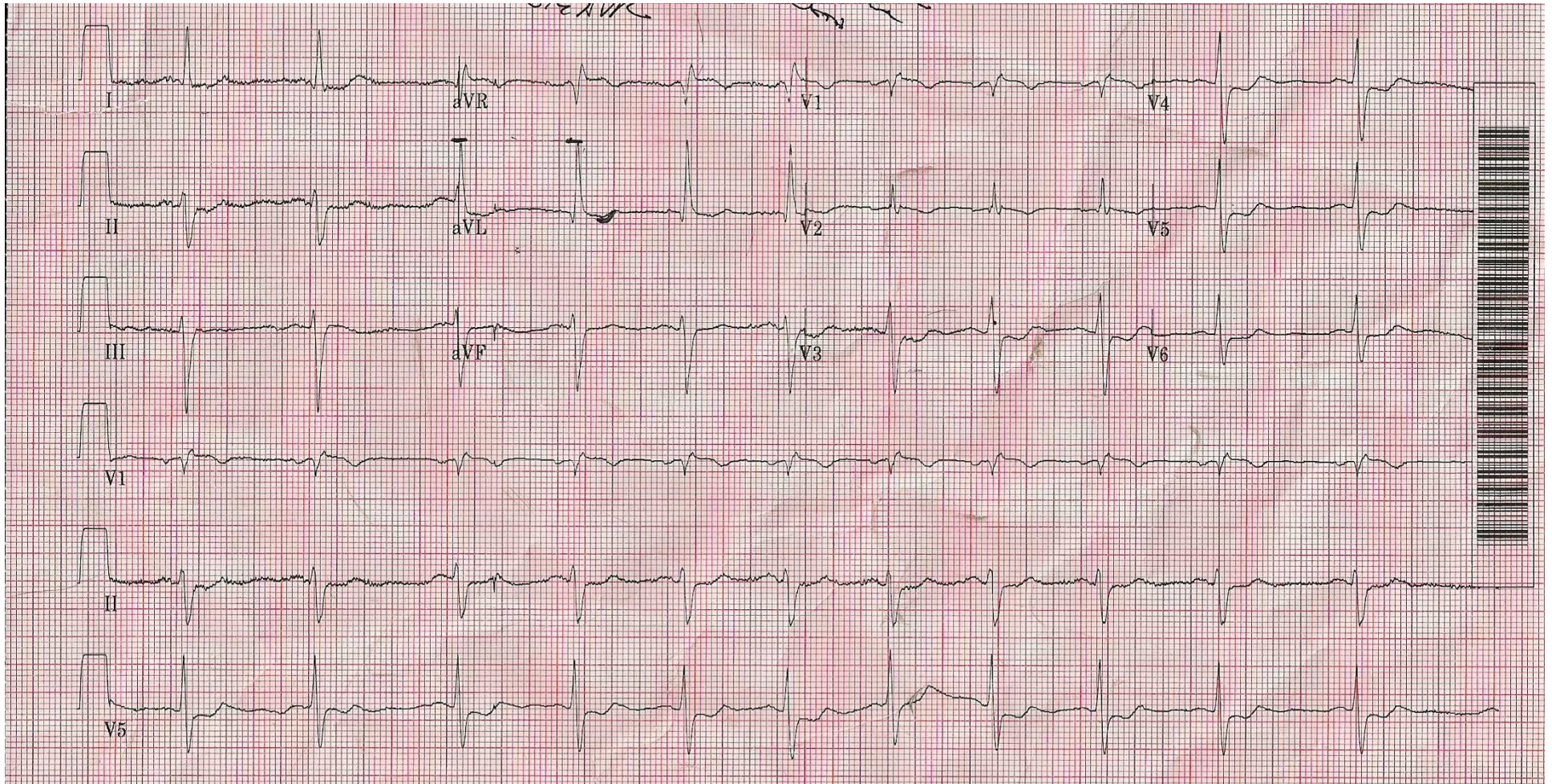
||| V6

05-40Hz 25mm/sec

04-02 BCCRS 3011371-130 2005L00KG.GG7R LP1231394019

MEDTRONIC PHYSIO-CONTROL

# The Forgotten 12th Lead



**Cath lab activation ?**

# The Forgotten 12th Lead



## **STE in aVR**

- Predictive of left main coronary obstruction
- Worsened outcomes
- Surgical revascularization
- Lower left ventricular ejection fraction



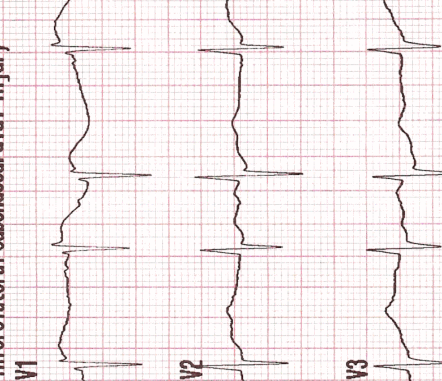
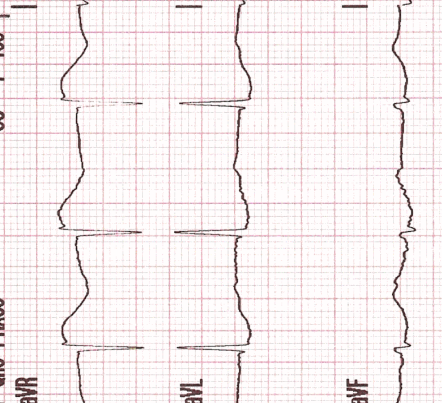
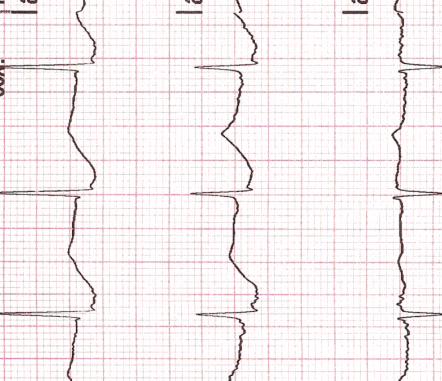
Name:  
ID:  
Patient ID:  
Incident:  
Age: 79  
Sex:

100300094957  
03 Oct 08  
PR 0.138s  
QT/QTc  
P-QRS-T Axes  
aVR

12-Lead 1

HR 87 bpm  
09:54:12  
QRS 0.076s  
0.348s/0.418s  
90° -1° 190°

• Abnormal ECG \*\*Unconfirmed\*\*  
• Normal sinus rhythm with occasional premature supraventricular complexes  
• Marked ST abnormality, possible inferolateral subendocardial injury



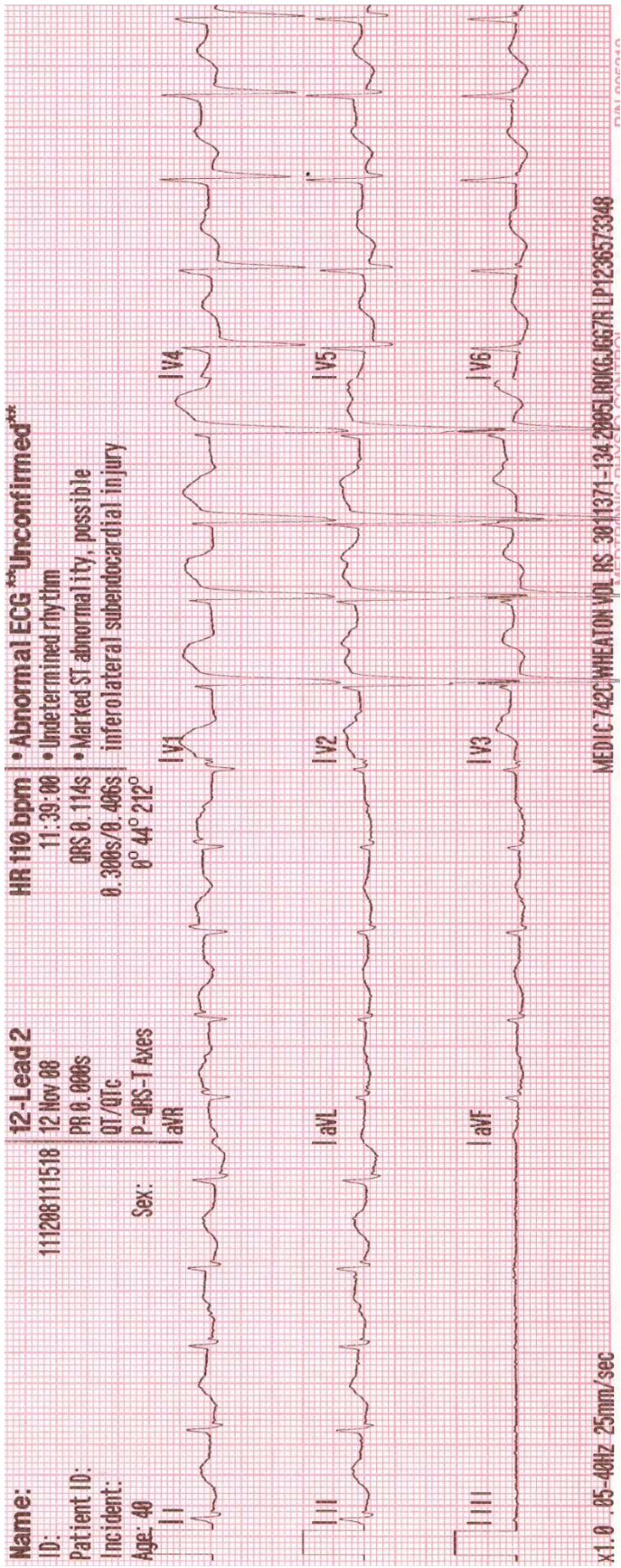
x1.0 .05-40Hz 25mm/sec

MONTGOMERY CO M729 3011371-130 206-KR0KNG667JLP233515687

9A508

P/N #9402-023

Made in U.S.A.

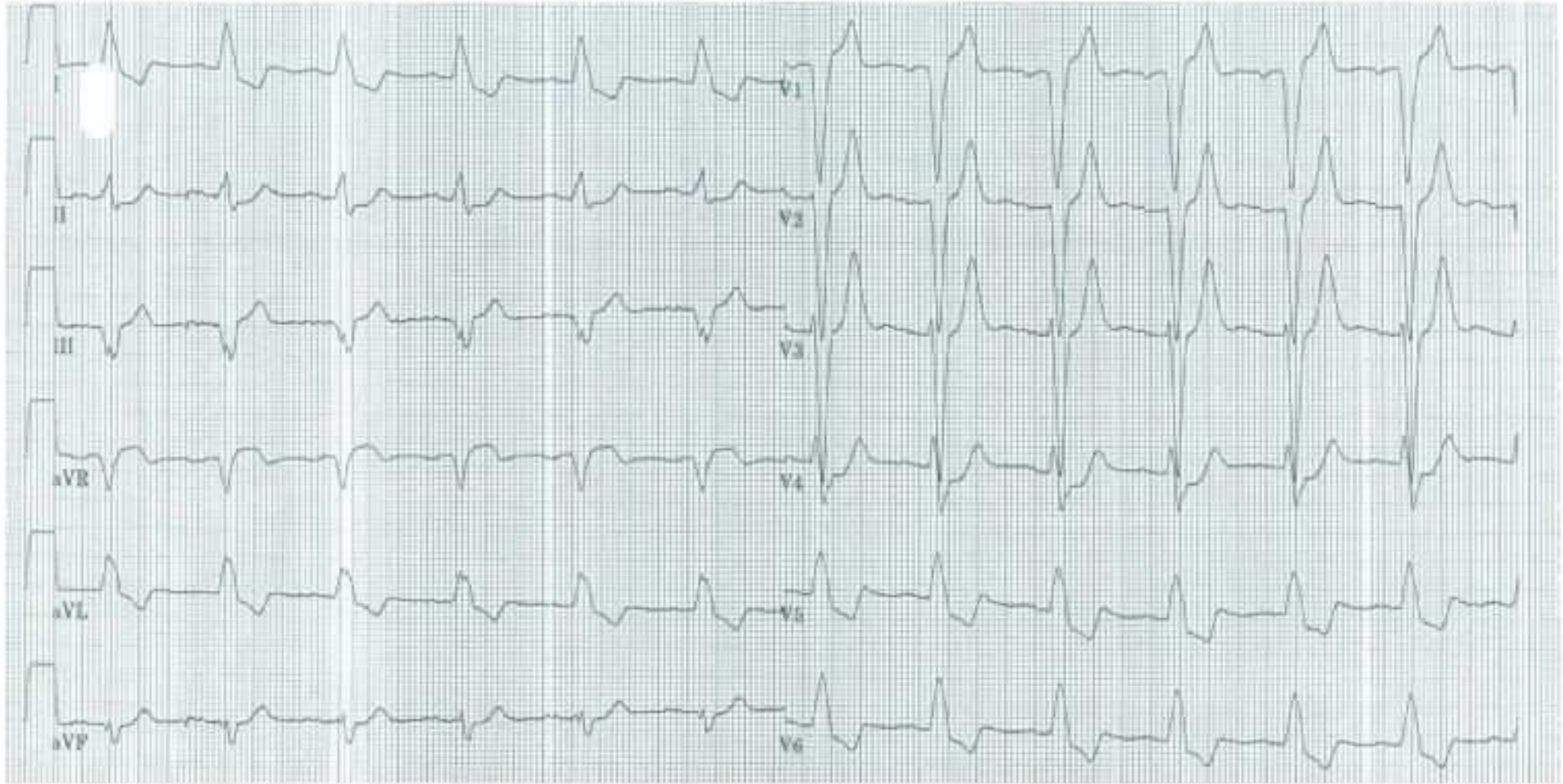


MEDIC 7420 WHEATON VOL RS 3011371-134 20051 ROKG.IGG7R LP1236573348

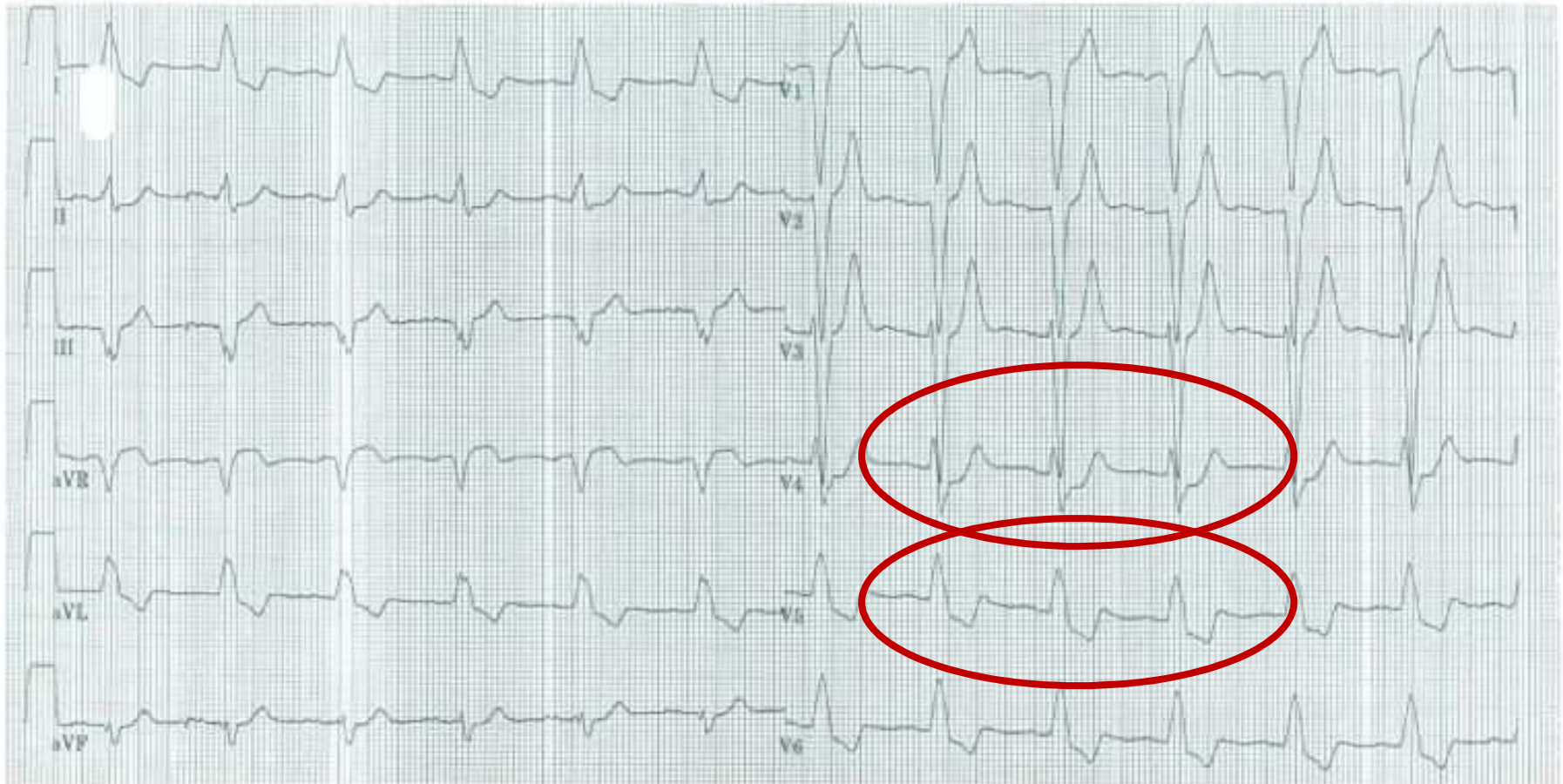
x1.0 .05-40Hz 25mm/sec

FINAL REPORT

# Dyspnea in a 73 yo male



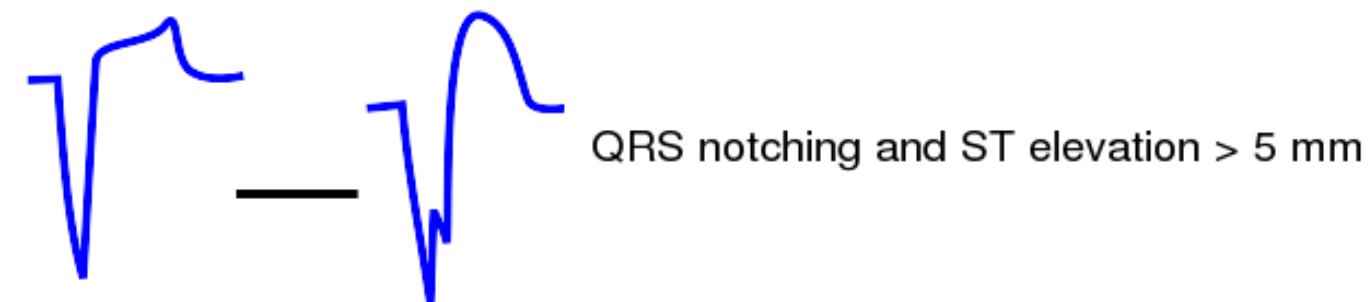
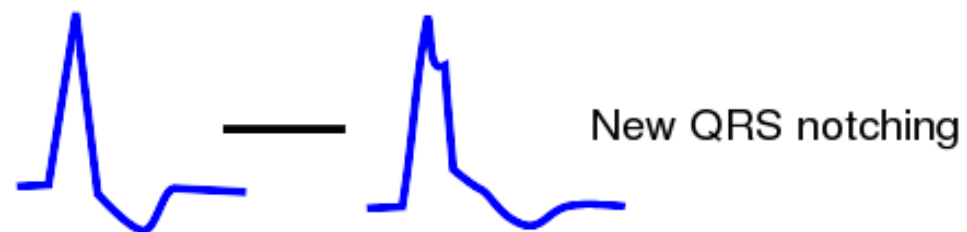
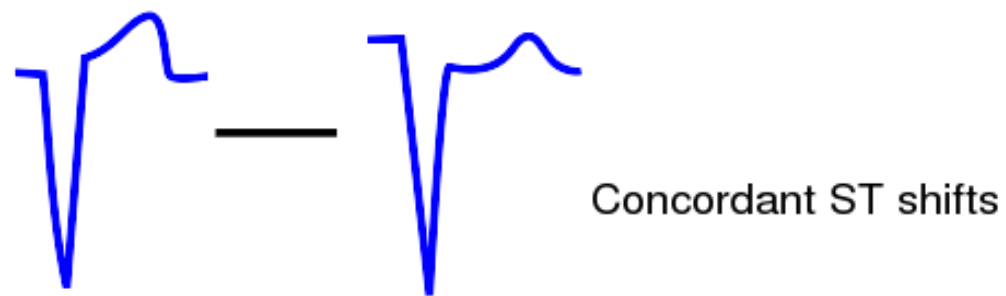
# LBBB and Ischemia



ECG PEDIA.ORG

...because all LBBB's go to the cath lab?

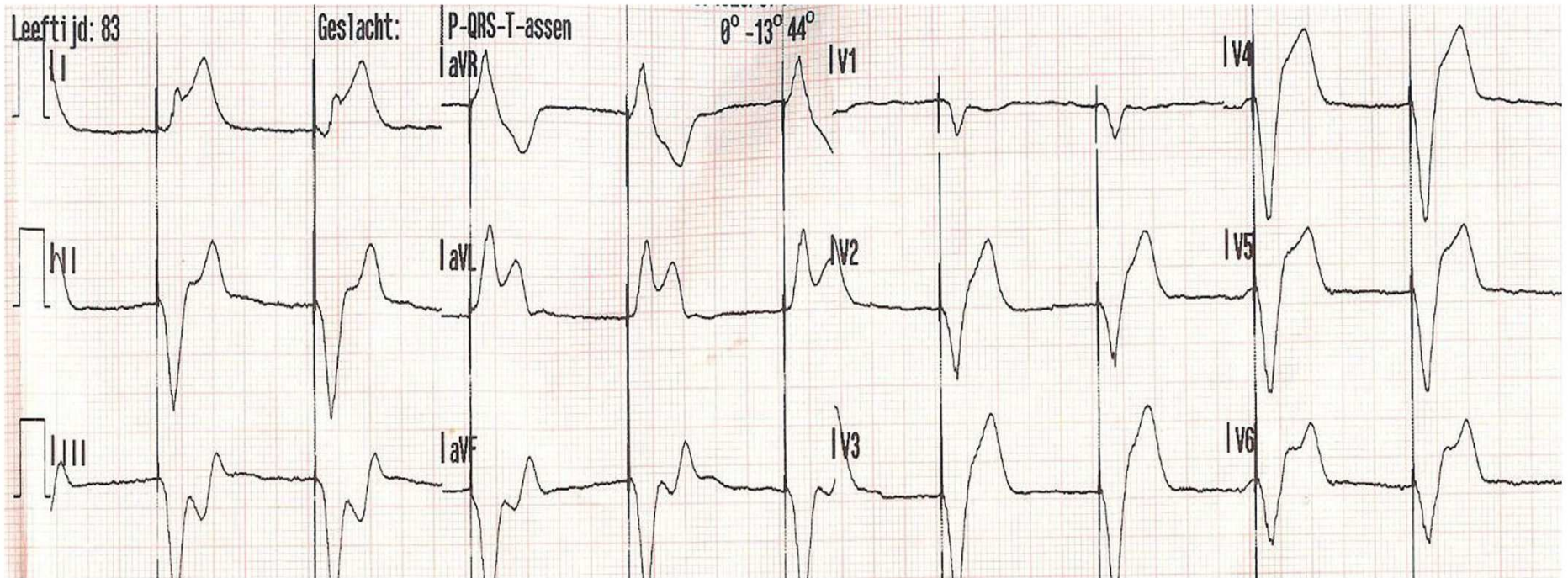
## Ischemia in LBTB



# Sgarbossa's Criteria

Finding	Score
Concordant STE > 1mm	5
ST depression > 1 mm in V1-V3	3
Inappropriately discordant STE > 5 mm	2

- Highly specific for AMI when score-sum > 3
- Not very sensitive
- Useful as a tool to stratify ECGs in the setting of suspected ischemia



Courtesy of M.M. Meuwissen, Amphia Breda, The Netherlands

## Which criteria does this particular ECG meet?

- Concordant STE
- Inappropriately discordant STE

# Summary of STEMI Equivalents

- Posterior wall MI “septal ST depression”
- STE in aVR
- The de Winter ST/T complex
- Sgarbossa and his LBBBs