Who's your PAPPA?
Getting to the source of ECGs that are scary, misleading or fake news.

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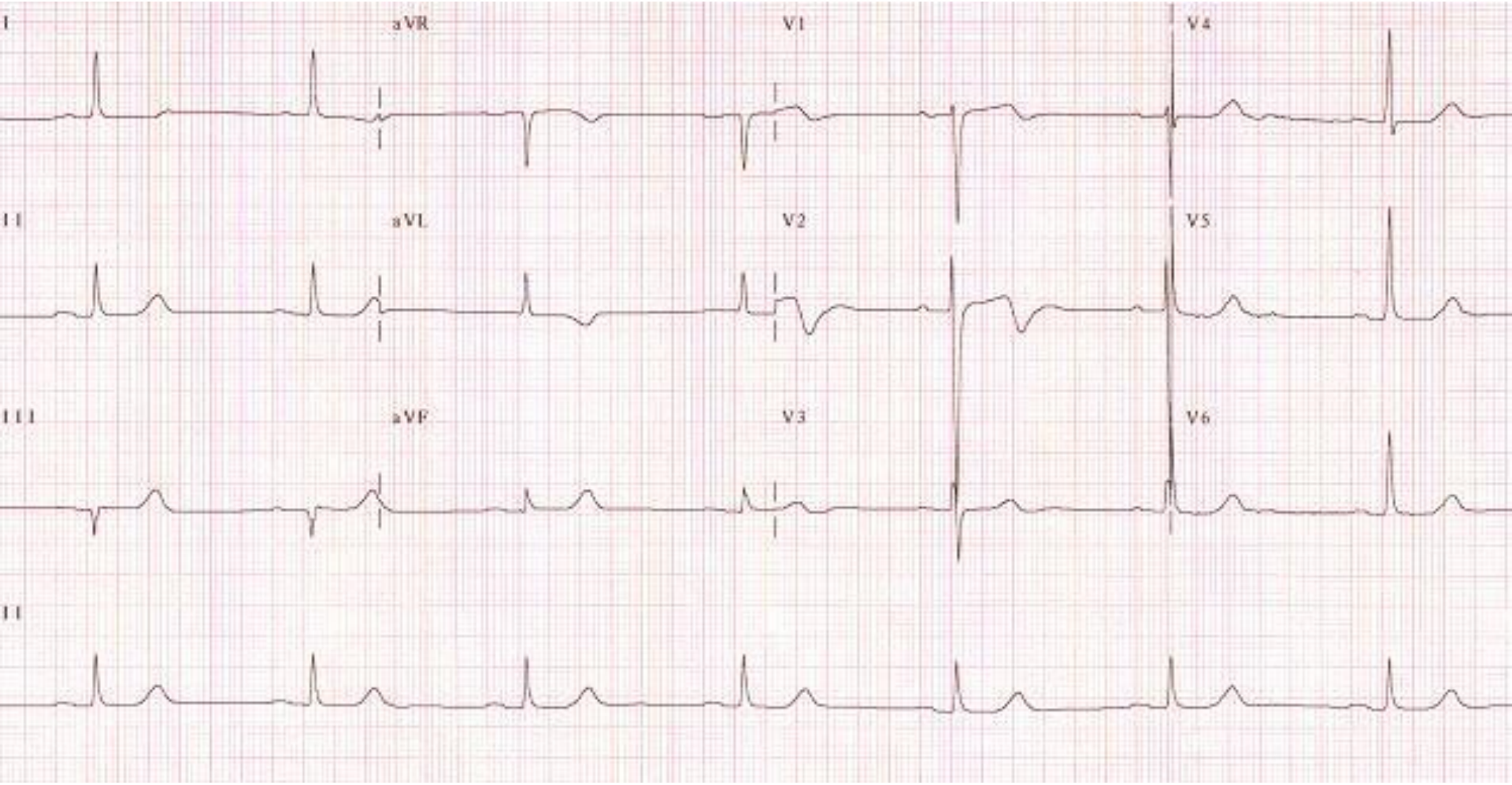
April 27, 2018

Road Map

- ECG patterns of high risk angina
- Using STEMI patterns to define extent and location of infarction
- ST segment elevation that is NOT a STEMI
- Monogenic arrhythmic tracings
- Q-T prolongation
- The ECG of the Century

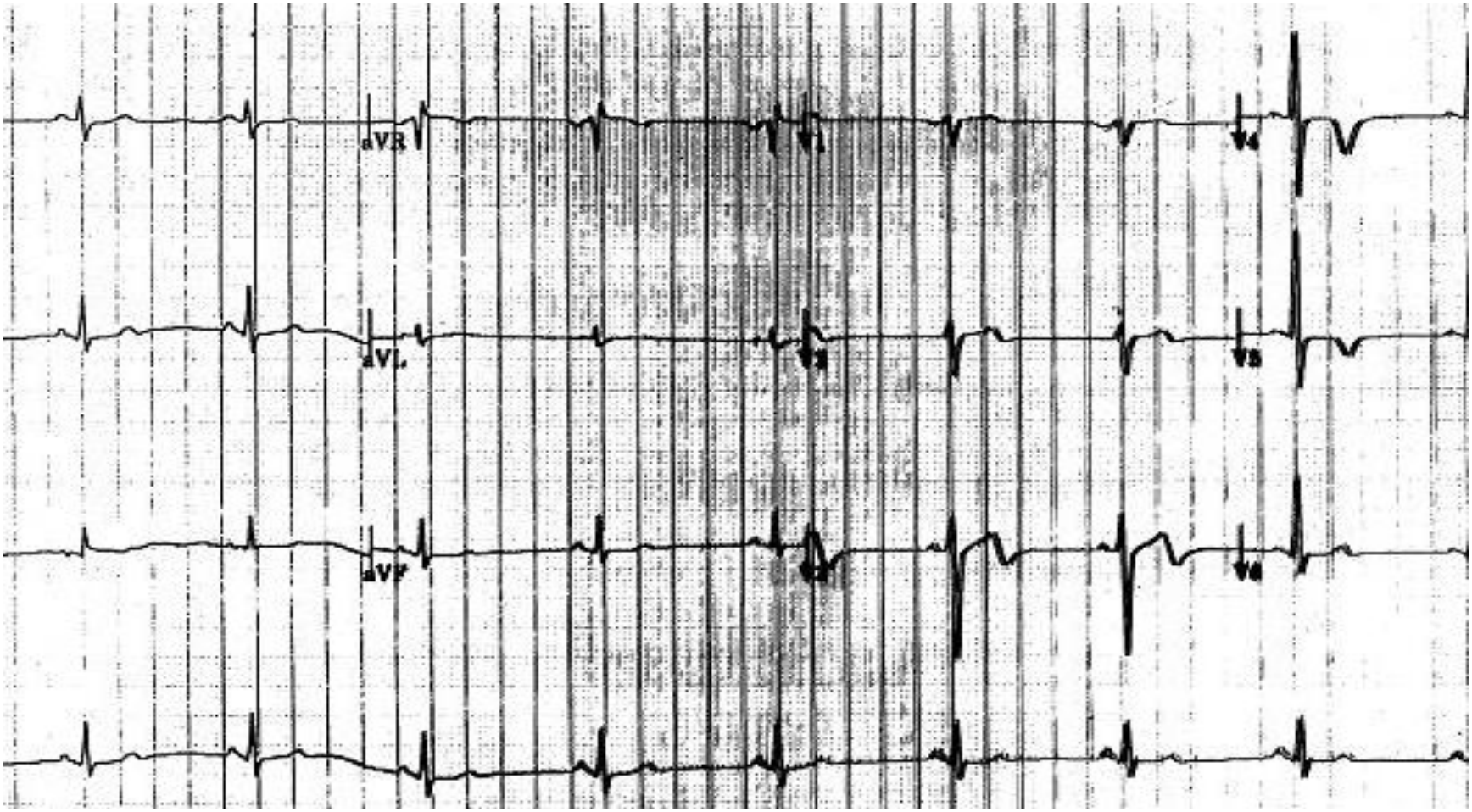
Tight LAD Stenosis



Tight LAD Stenosis

- ST-T changes in V2 and V3
- Little or no ST segment elevation
- T wave takes off from a straight or concave ST segment into a symmetrical and deeply inverted T wave
- The angle between the ST segment and the T wave is 60-90 degrees
- Seen during *pain free period*

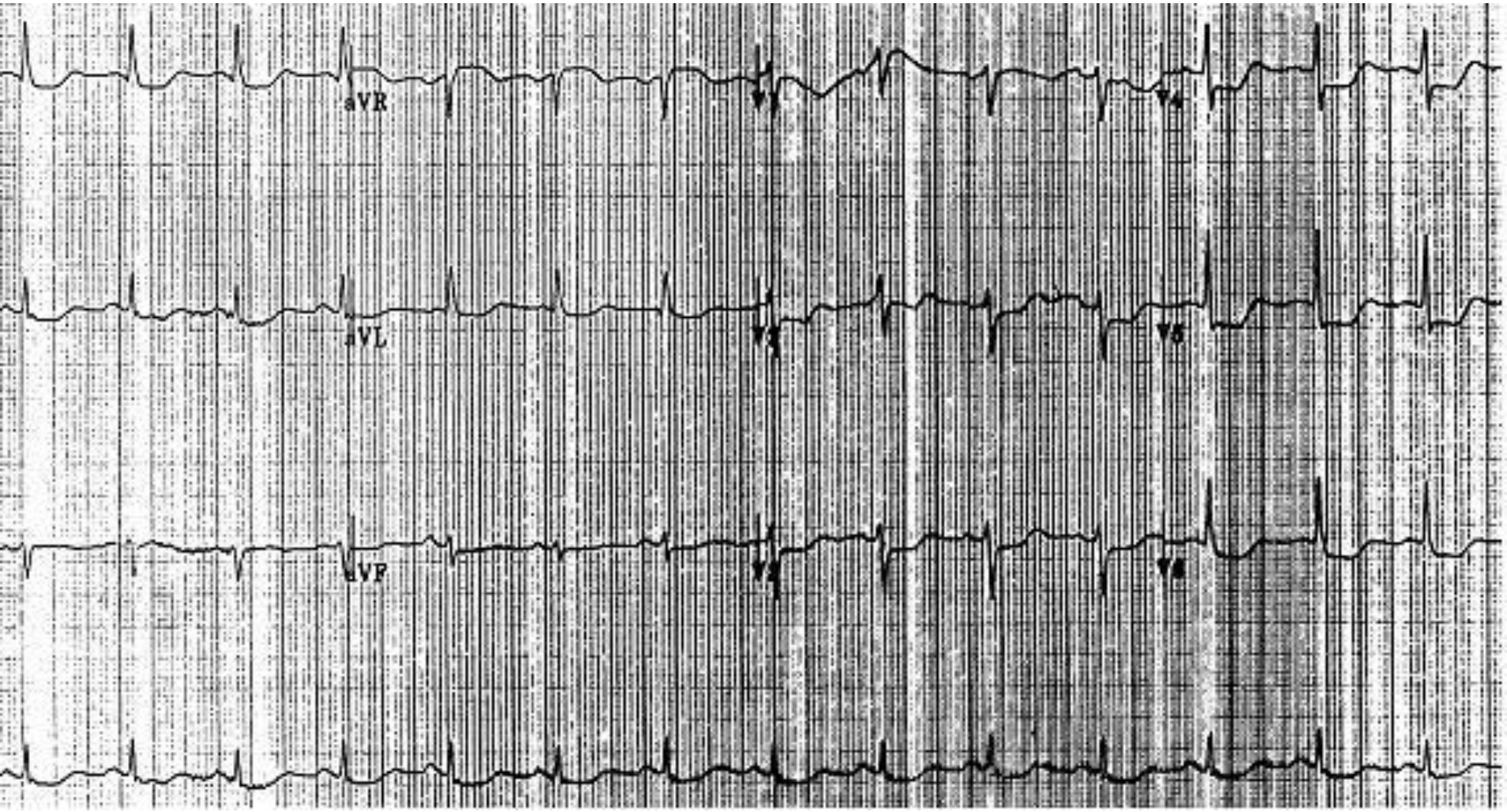
Tight LAD



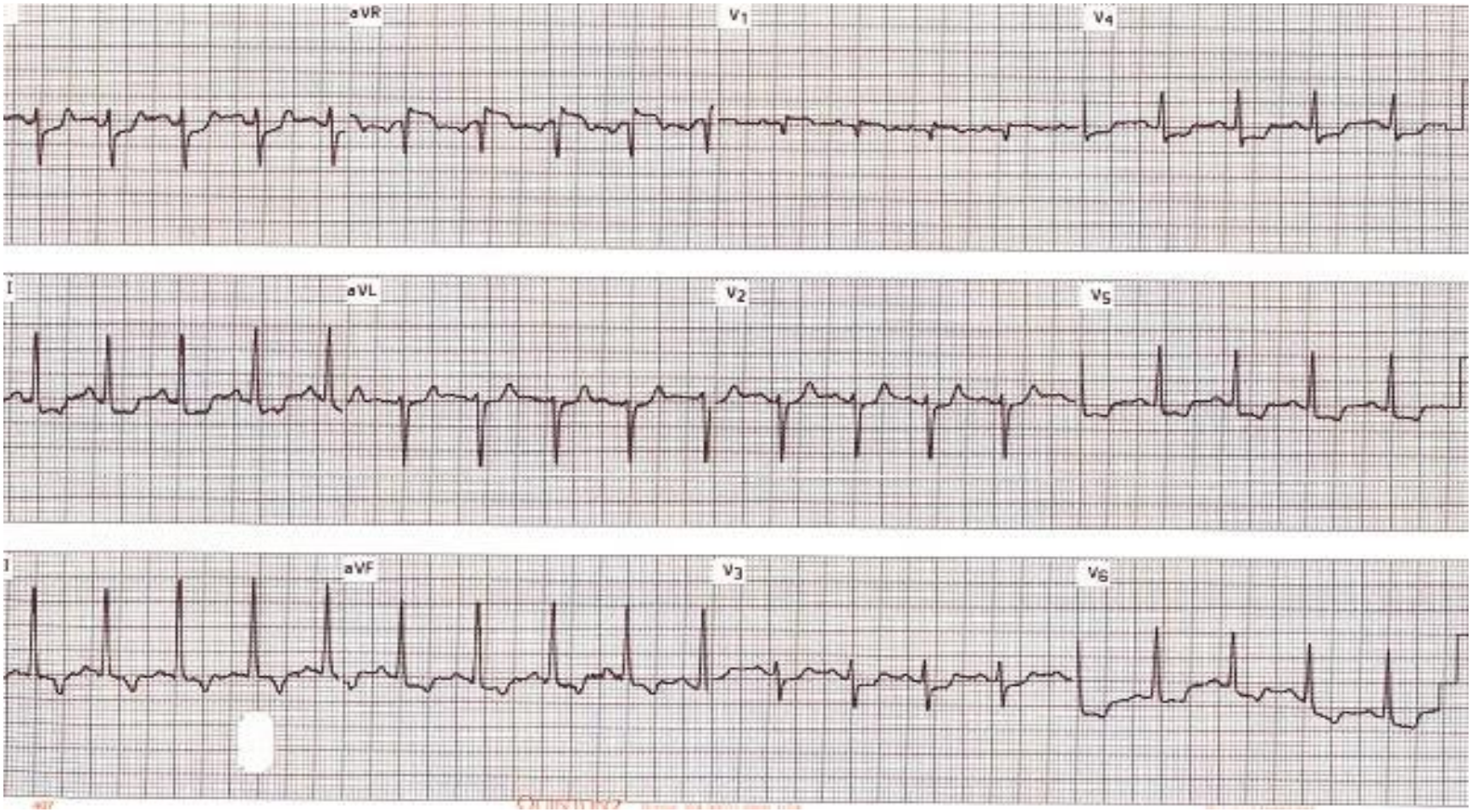
Severe Left Main Stenosis

- ST segment depression in 8 or more leads
- ST segment elevation in V1 and aVR
- 71% of patients with this pattern will have severe left main or three vessel disease.
- Note: 25% of patients with 90-99% left main have a NORMAL ECG when pain-free. The above ECG changes occur *during* an episode of pain

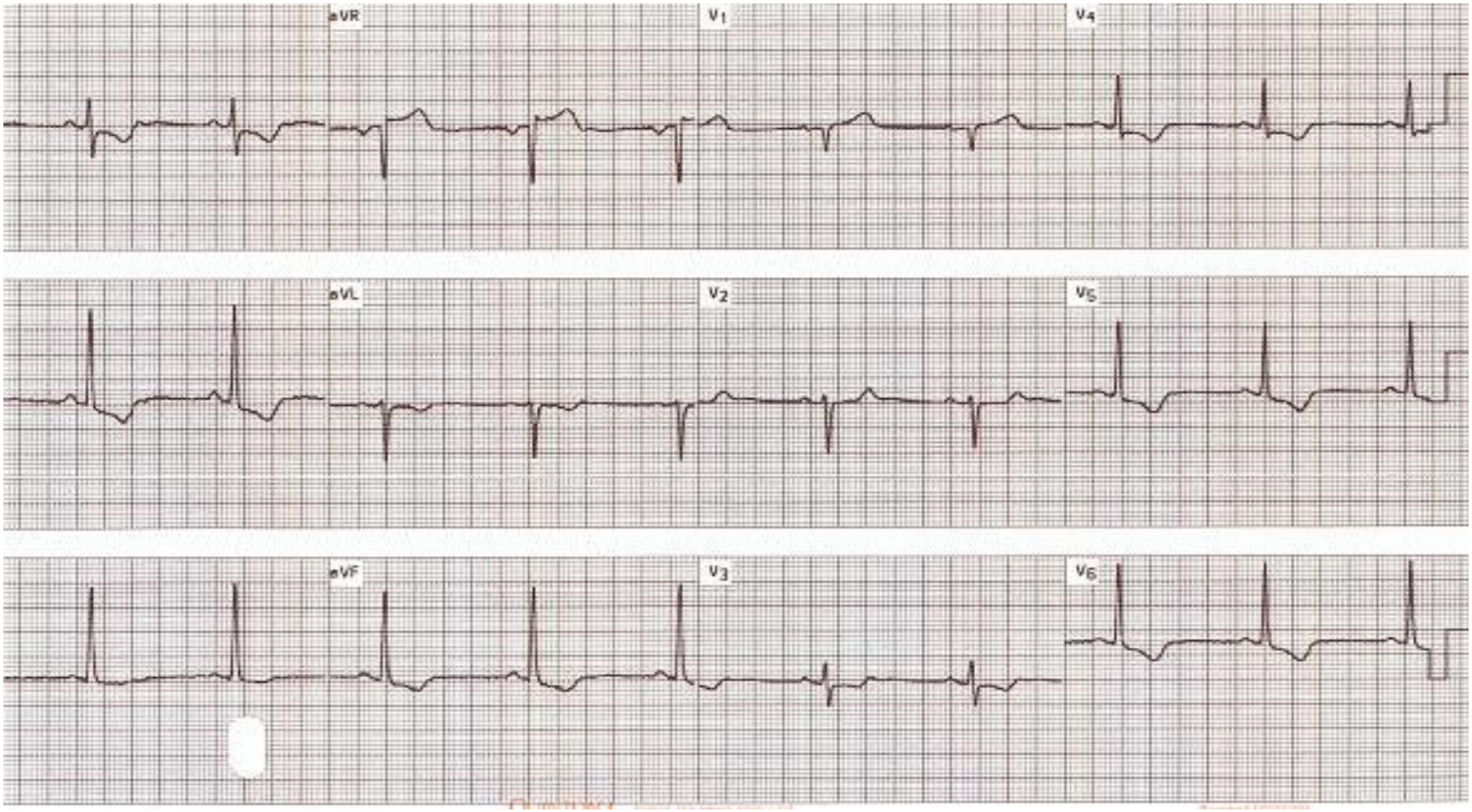
Severe Left Main Stenosis



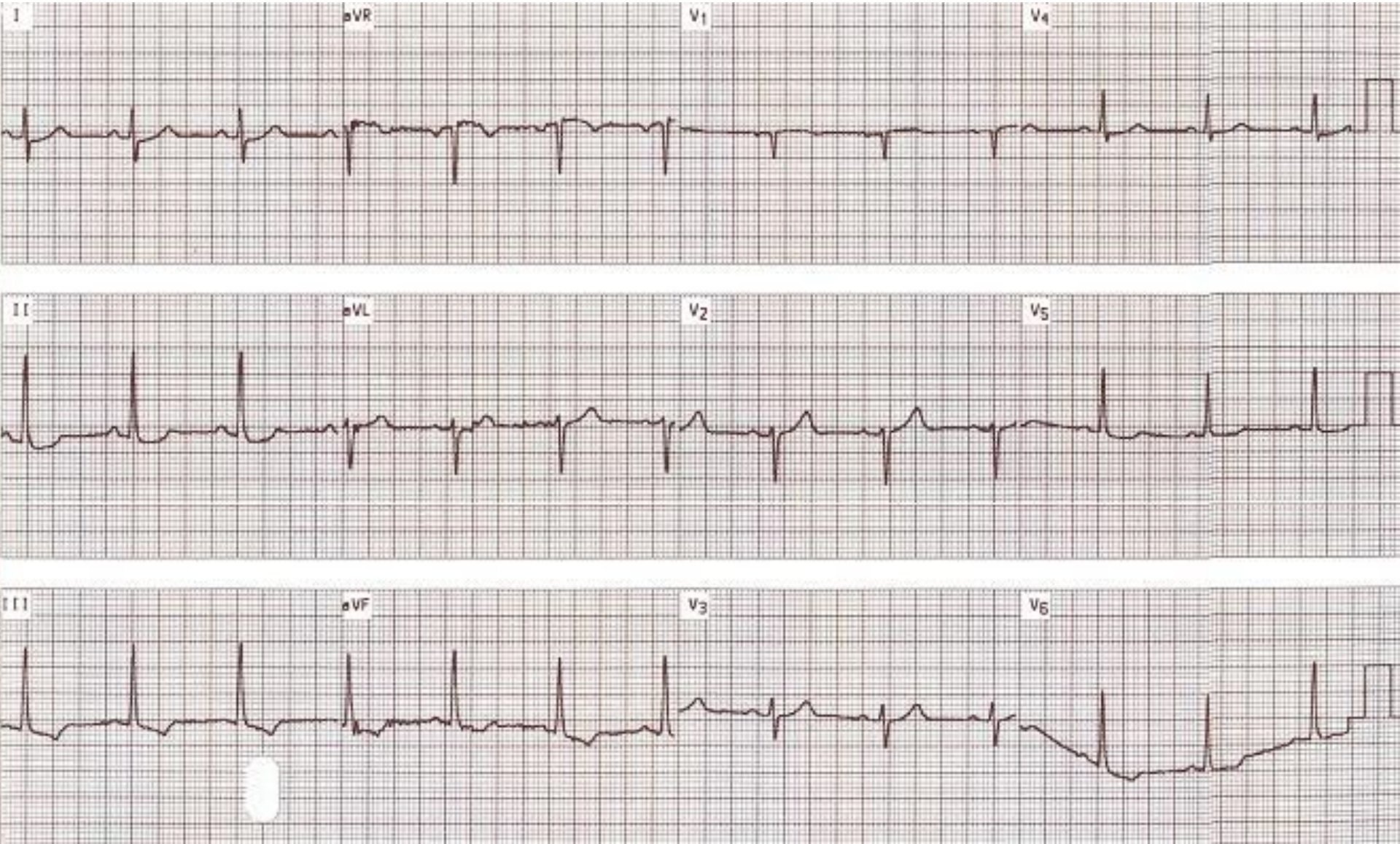
LMCA or 3 Vessel Disease?



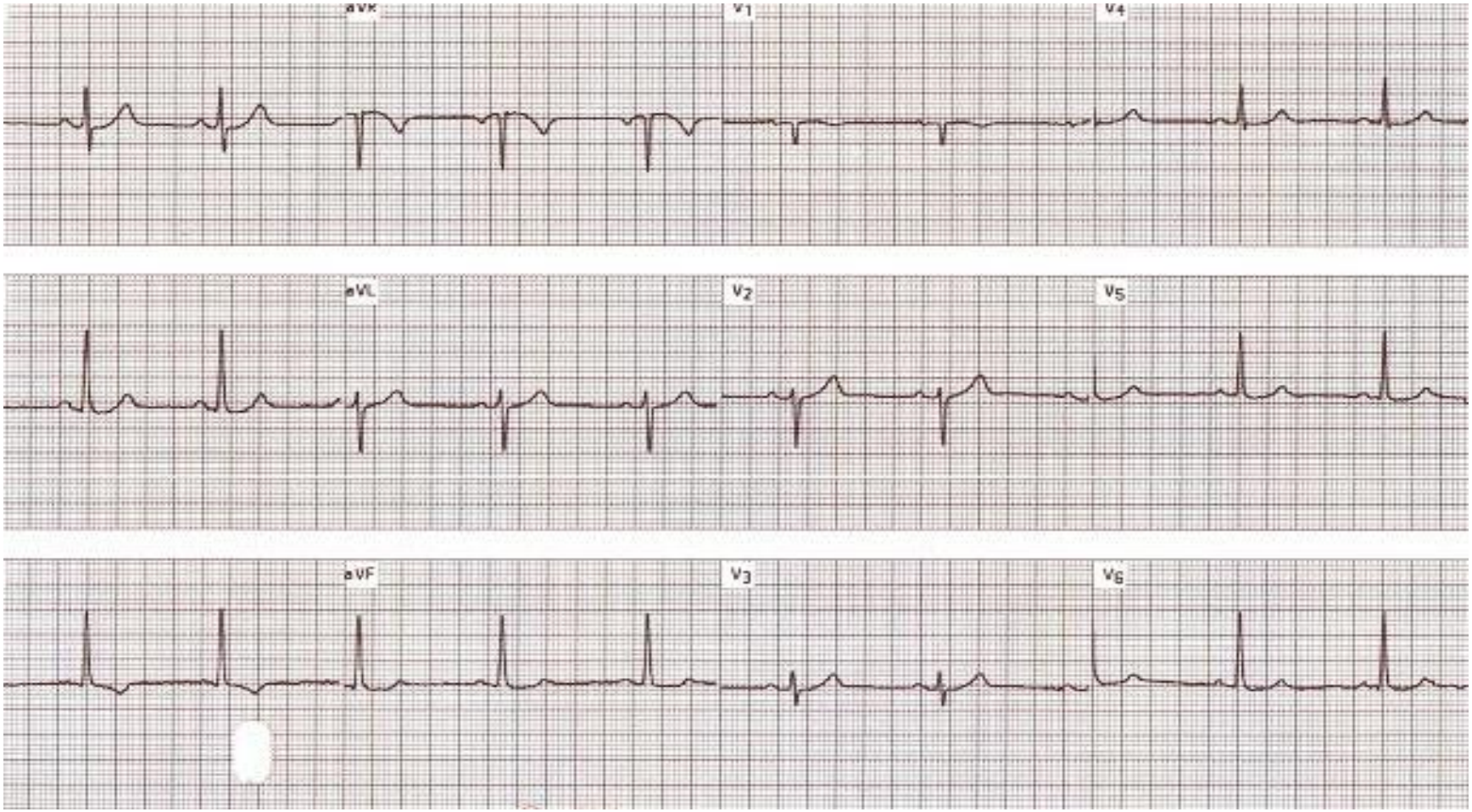
Resolution of diffuse ST segment depression



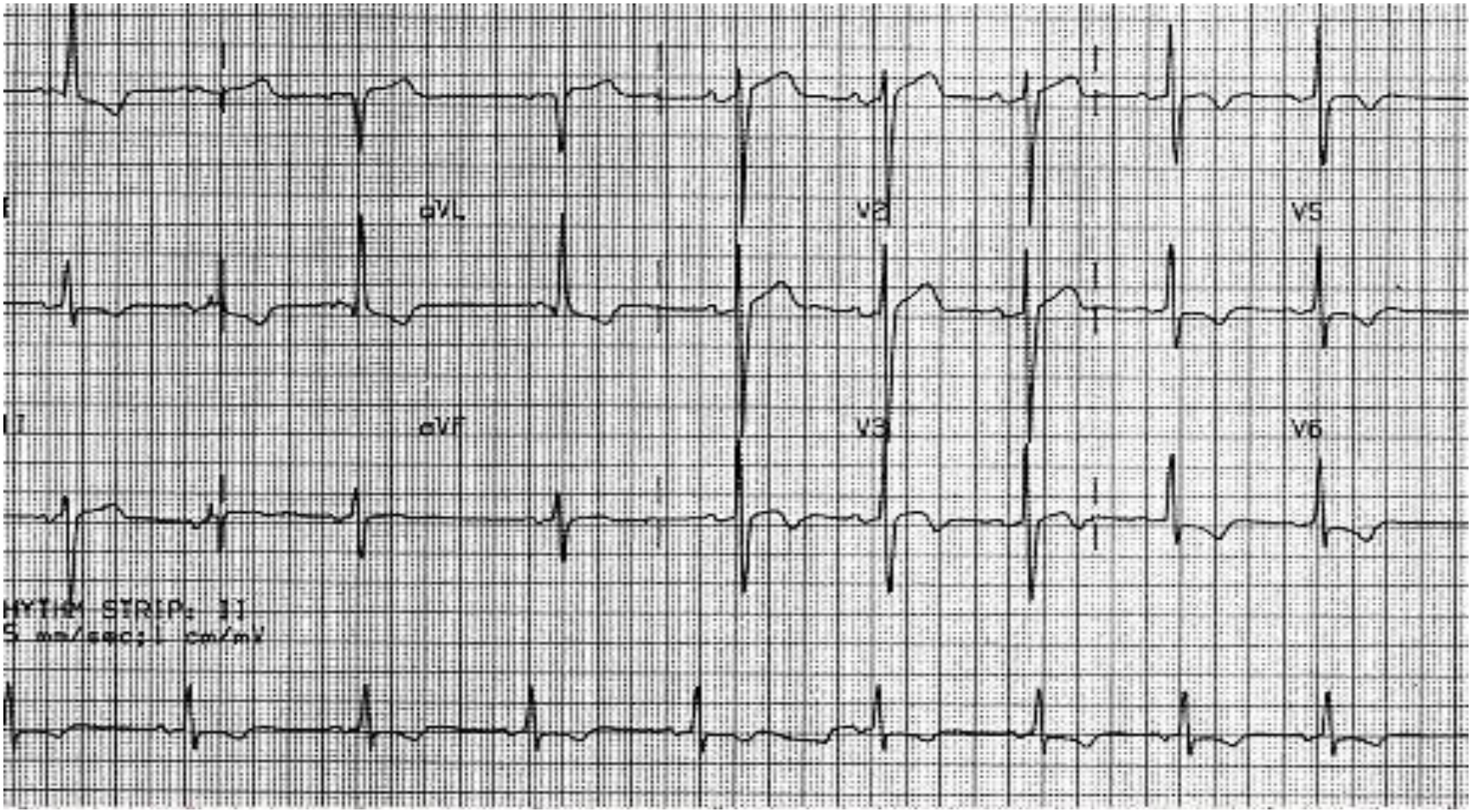
Resolution, cont'd



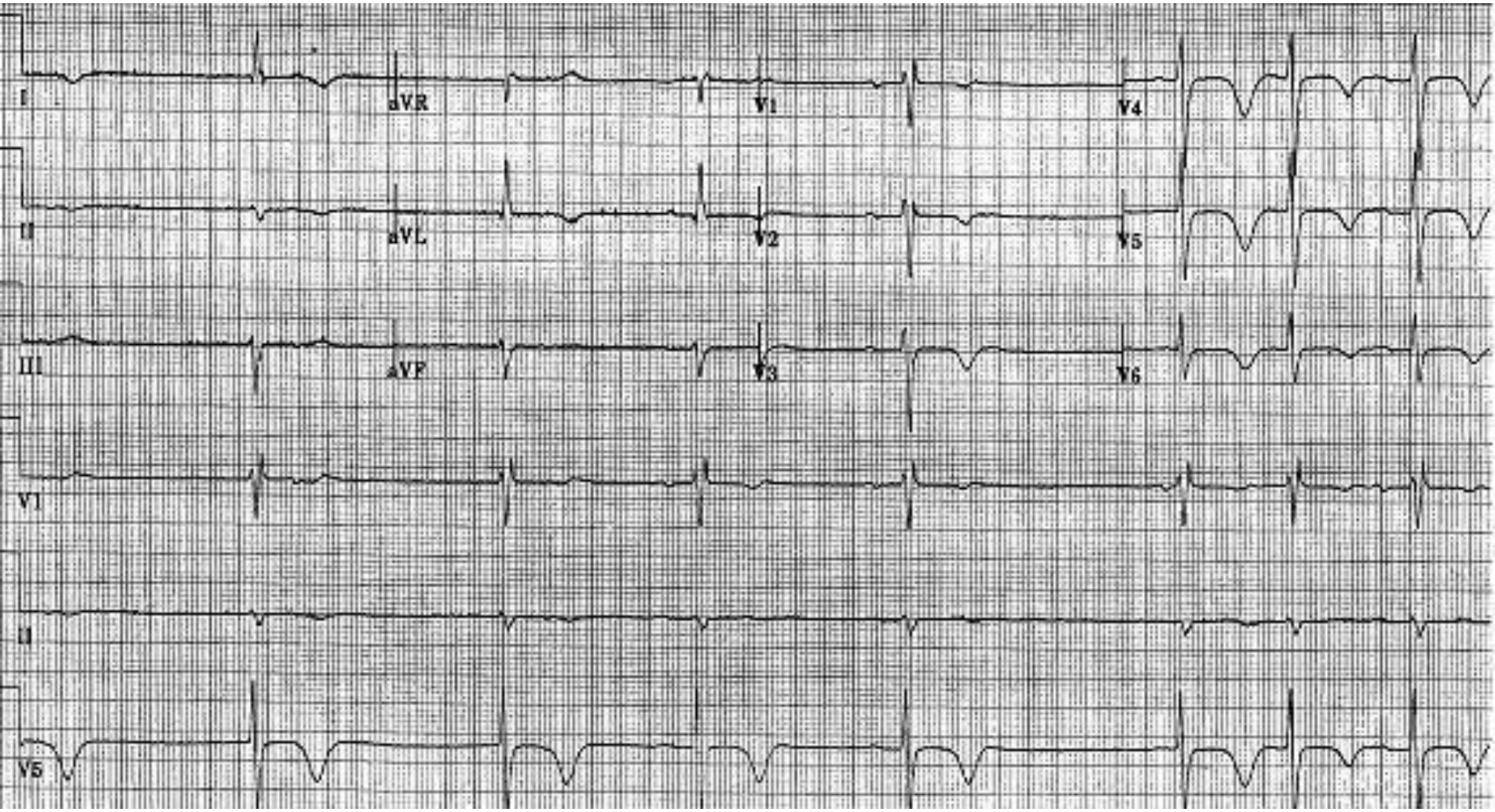
Resolution, cont'd



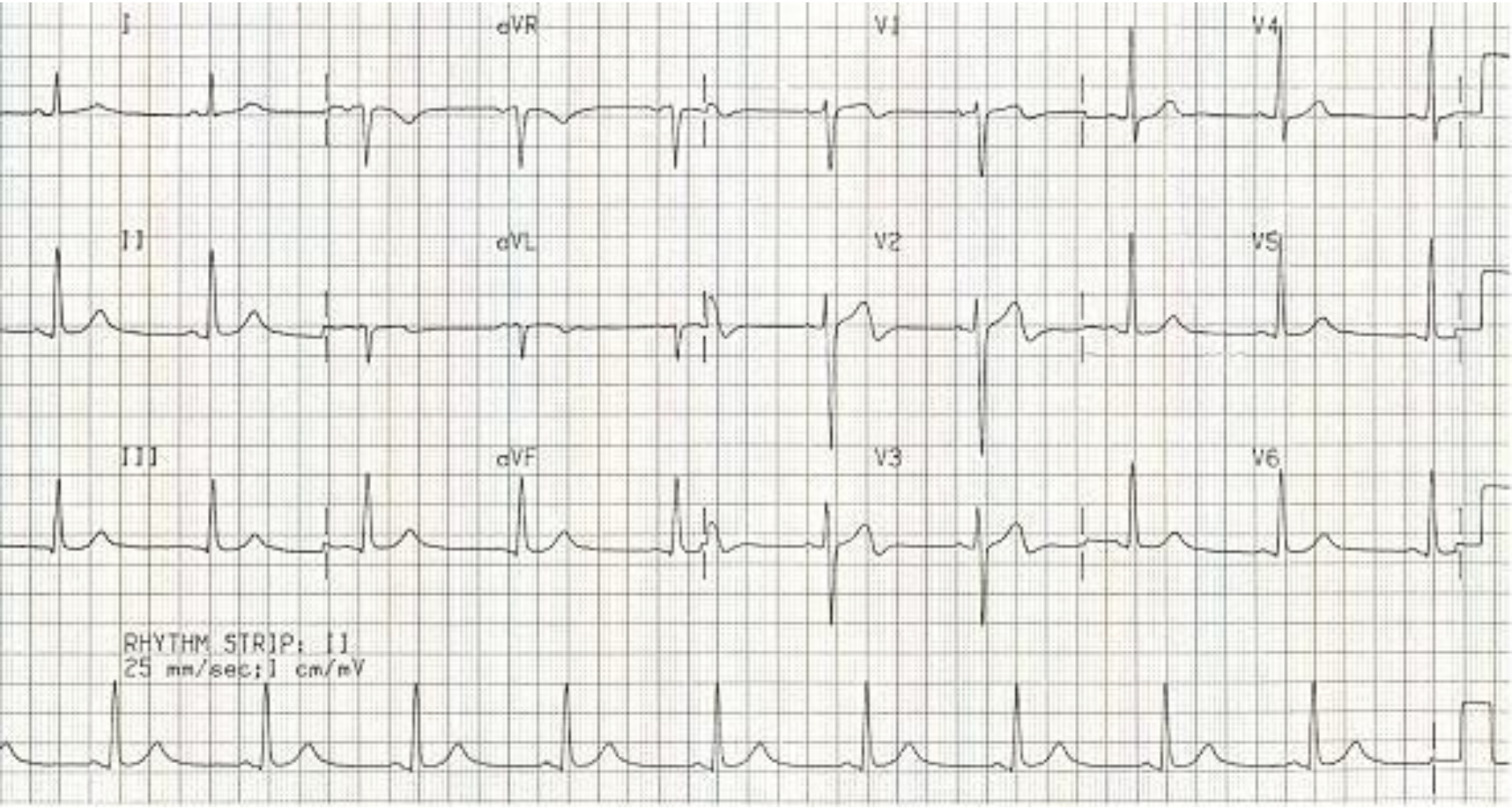
Let's practice what we know



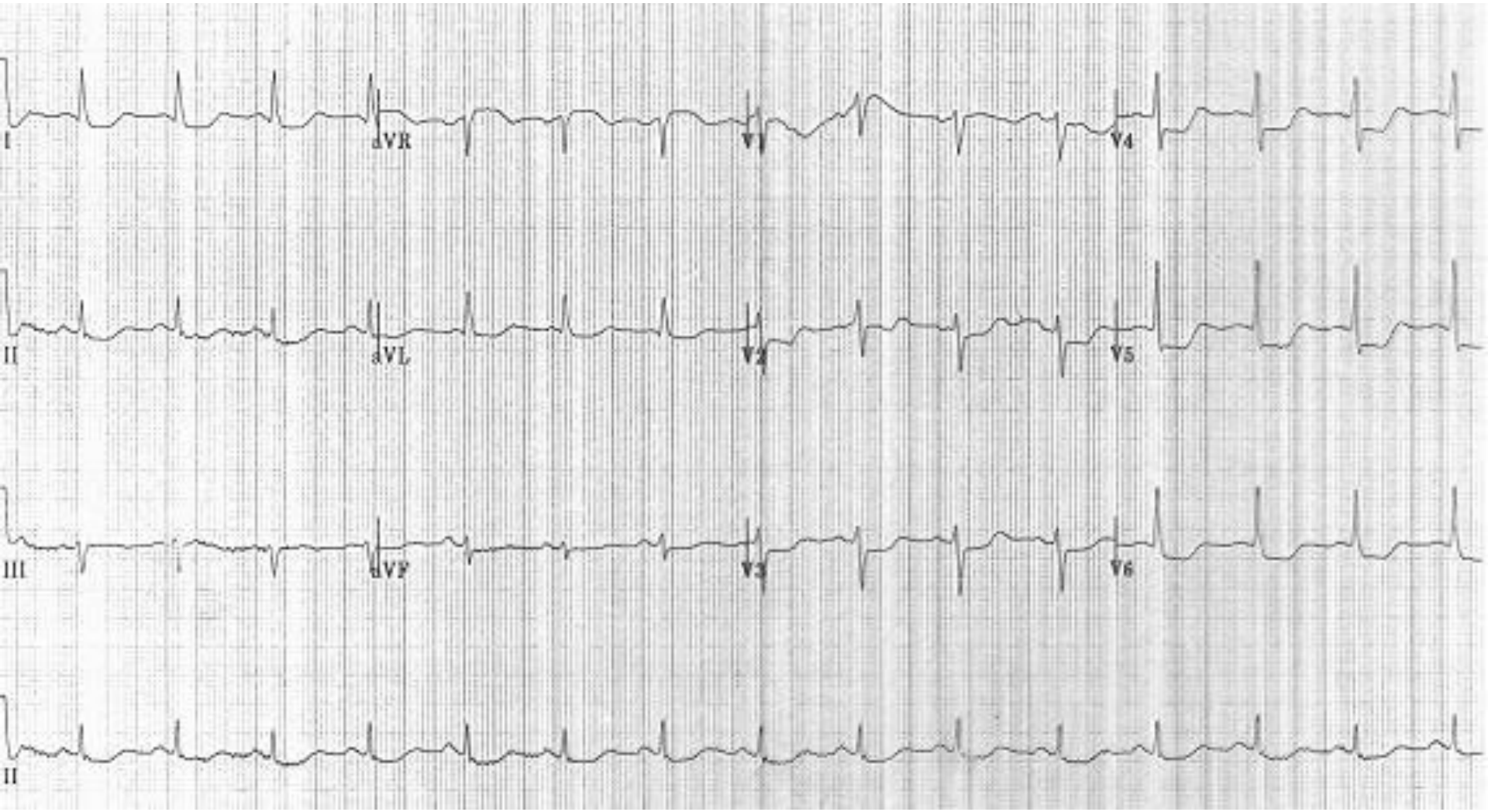
Tight LAD Stenosis?



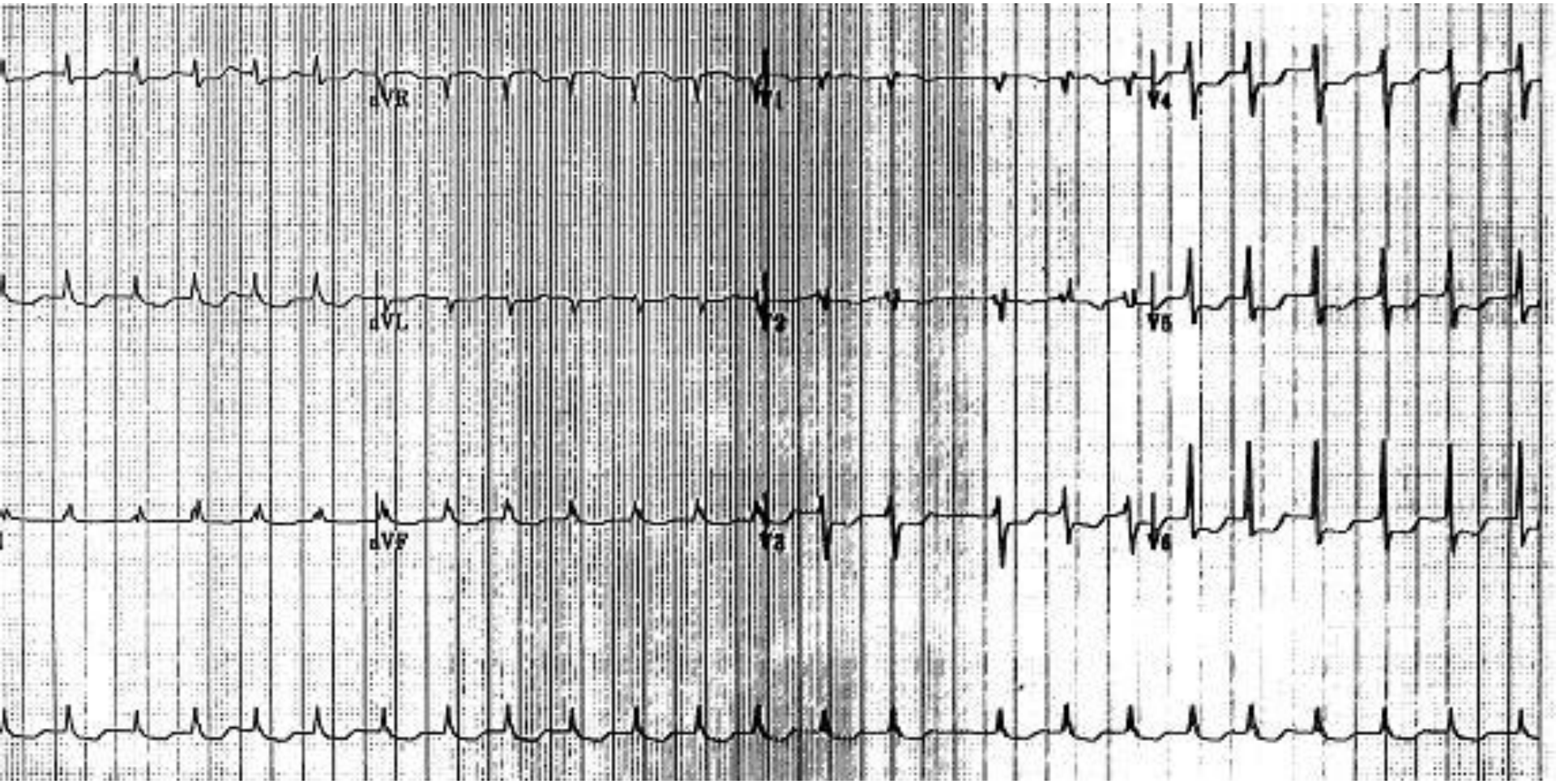
Tight LAD Stenosis?



High Grade Left Main?



High Grade Left Main?



Two ways to estimate myocardial infarction

- *Size:*
  - ST segment score
- *Proximal vessel location:*
  - ST segment vector

ST Segment Score

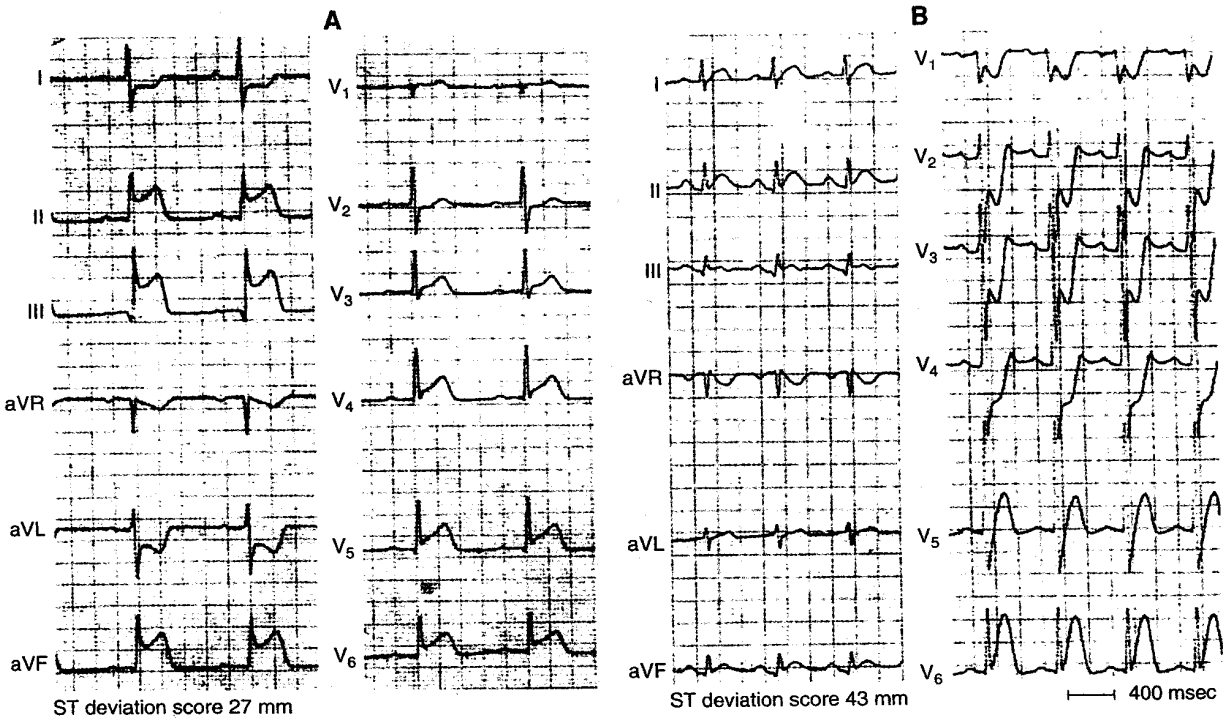


Figure 1-1 ST segment deviation score. **A,** In this patient with an acute inferolateral MI, by using all 12 leads, the total amount of ST-segment deviation measures 27 mm. **B,** This patient with an acute inferoposterolateral MI has an ST segment deviation score of 43 mm.

ST segment vector

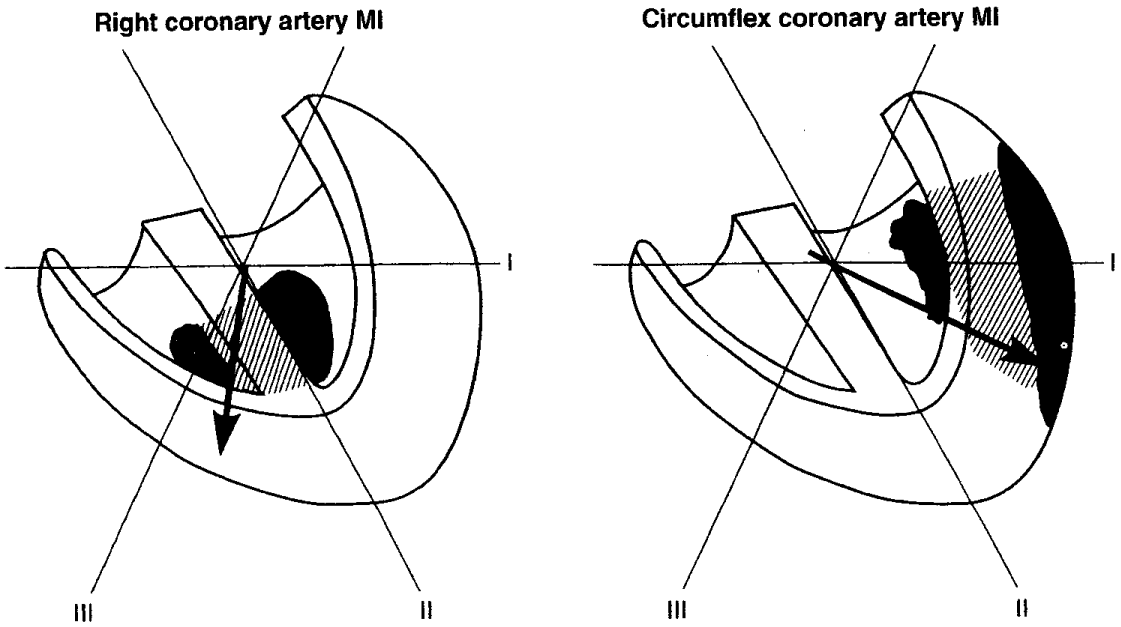
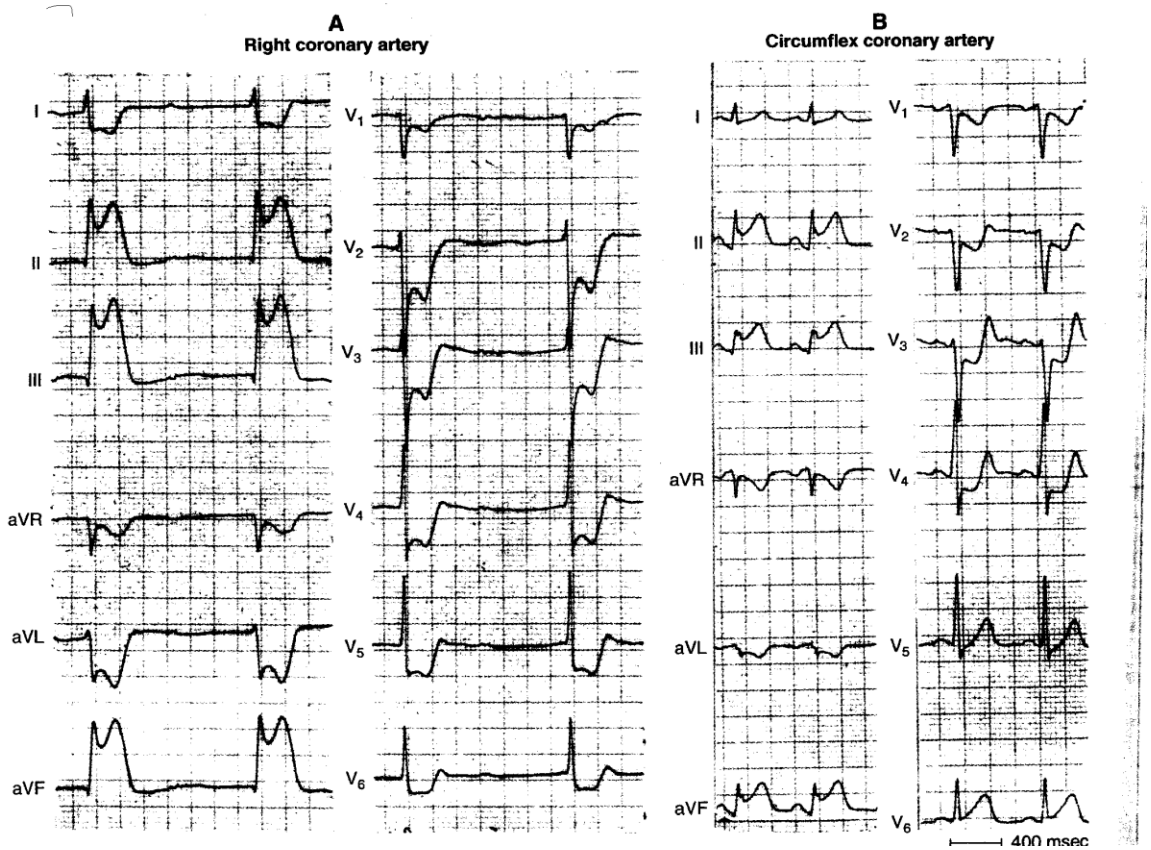
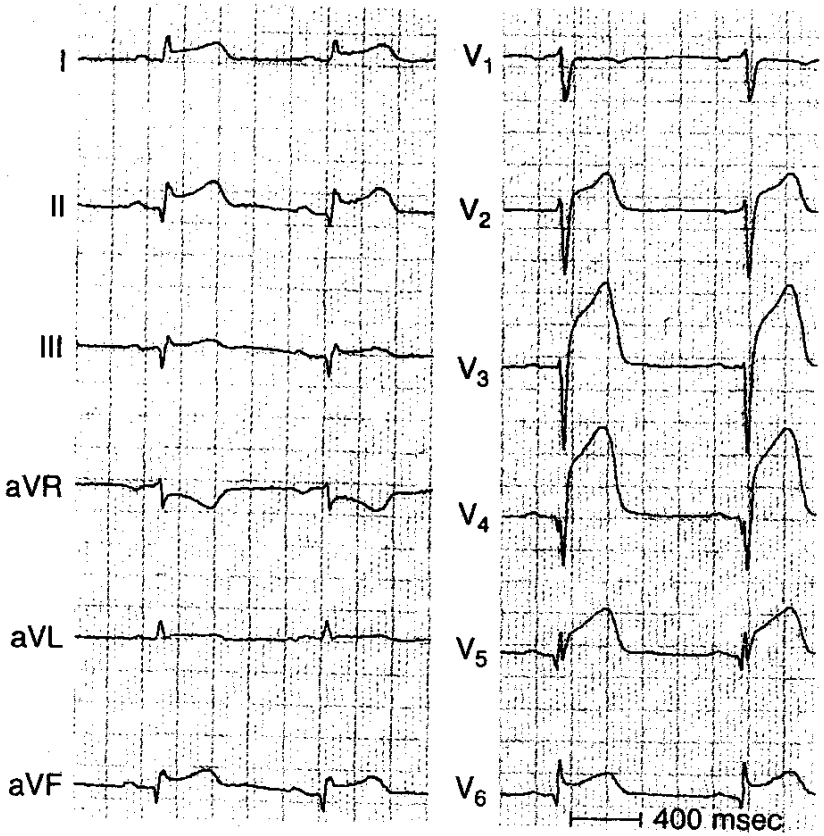


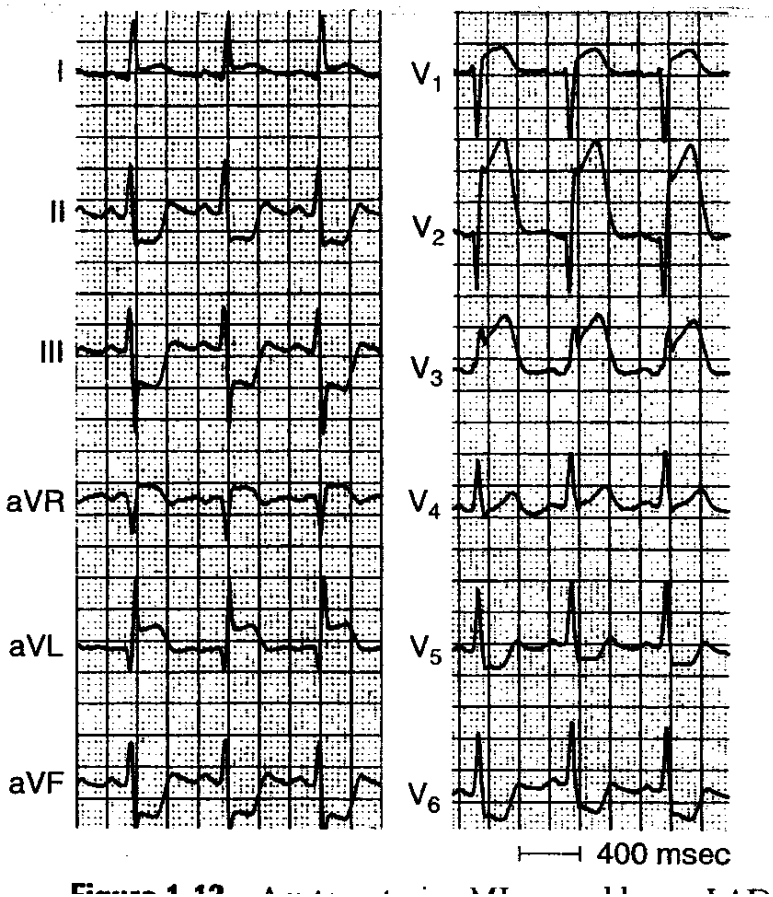
Figure 1-2 Behavior of the ST segment deviation vector in inferoposterior MI. As explained in the text, in RCA occlusion, the vector points inferiorly, to the right, and is closer to the lead III axis than to the lead II axis. In CX occlusion, the vector points to the left and is closer to the lead II axis than to lead III.

Inferior MI
RCA vs Circ

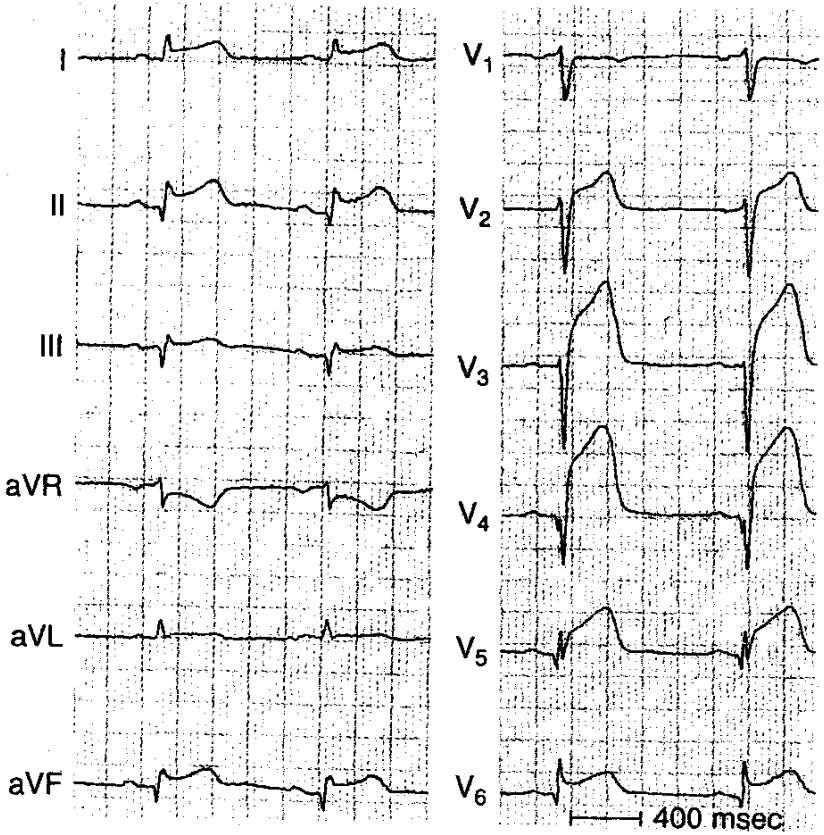


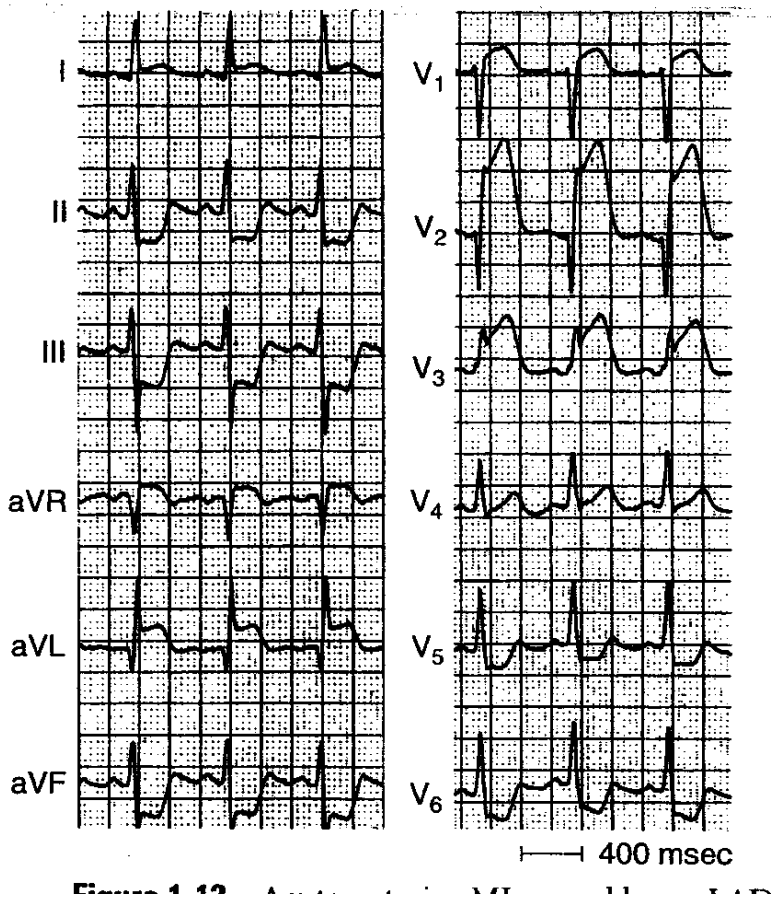
Which is the bigger MI?





Which is the more proximal LAD?

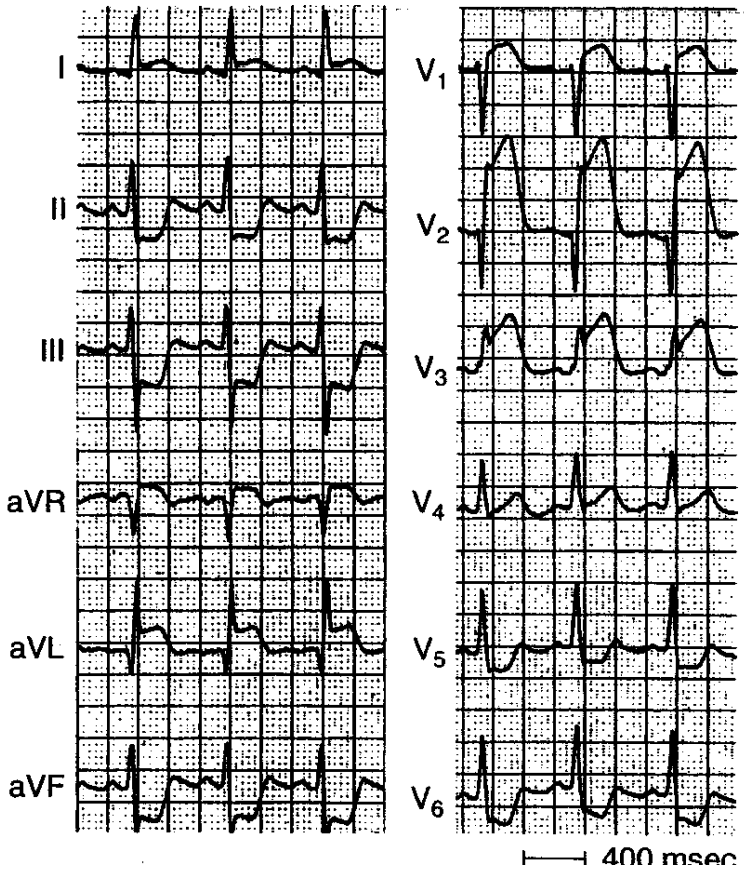


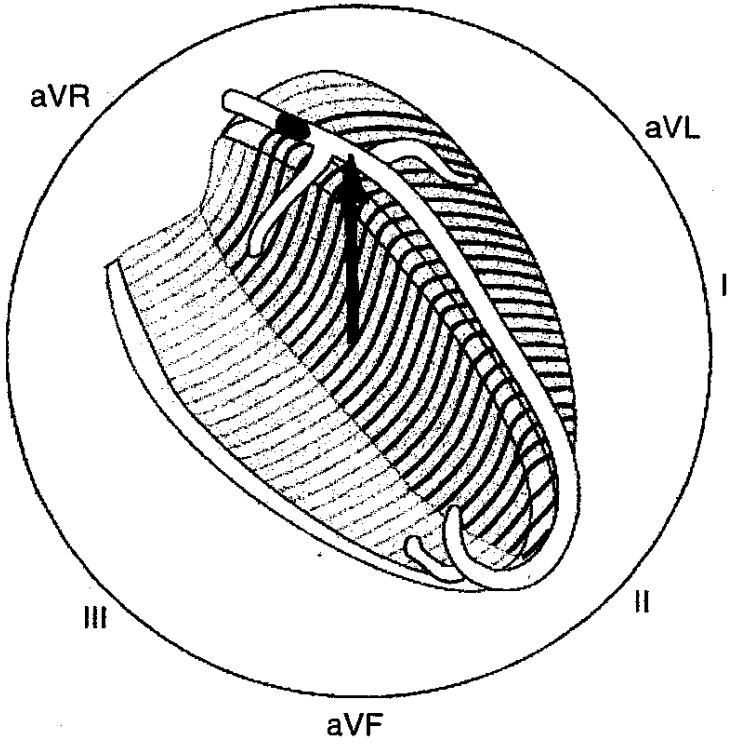


Which is the more proximal LAD?

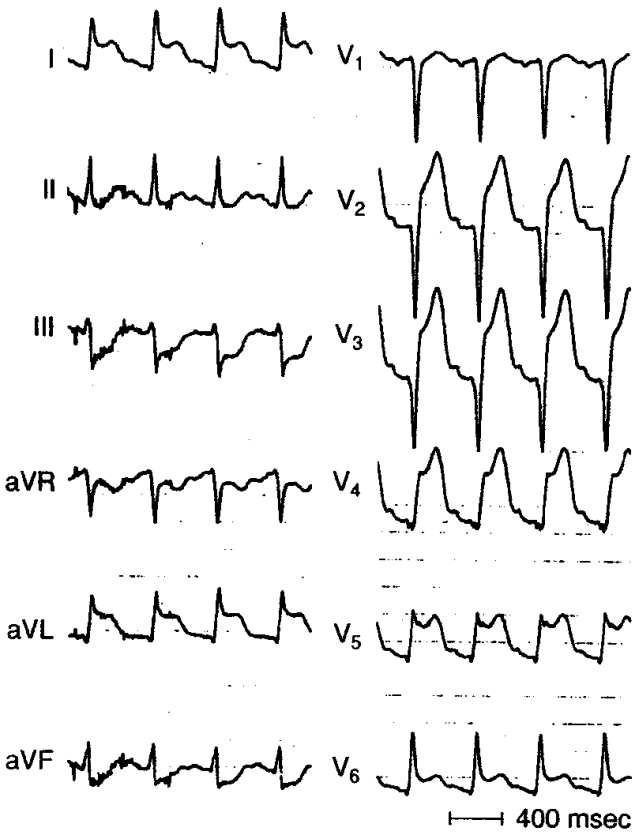
- Introducing the ST segment vector approach

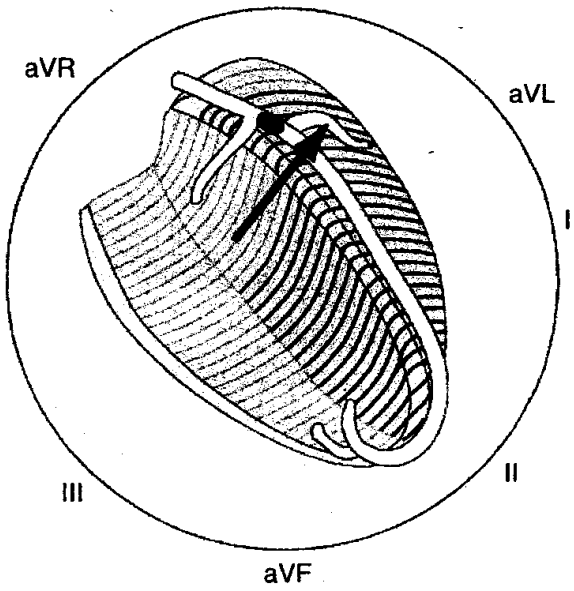
LAD before S_1 and diagonal



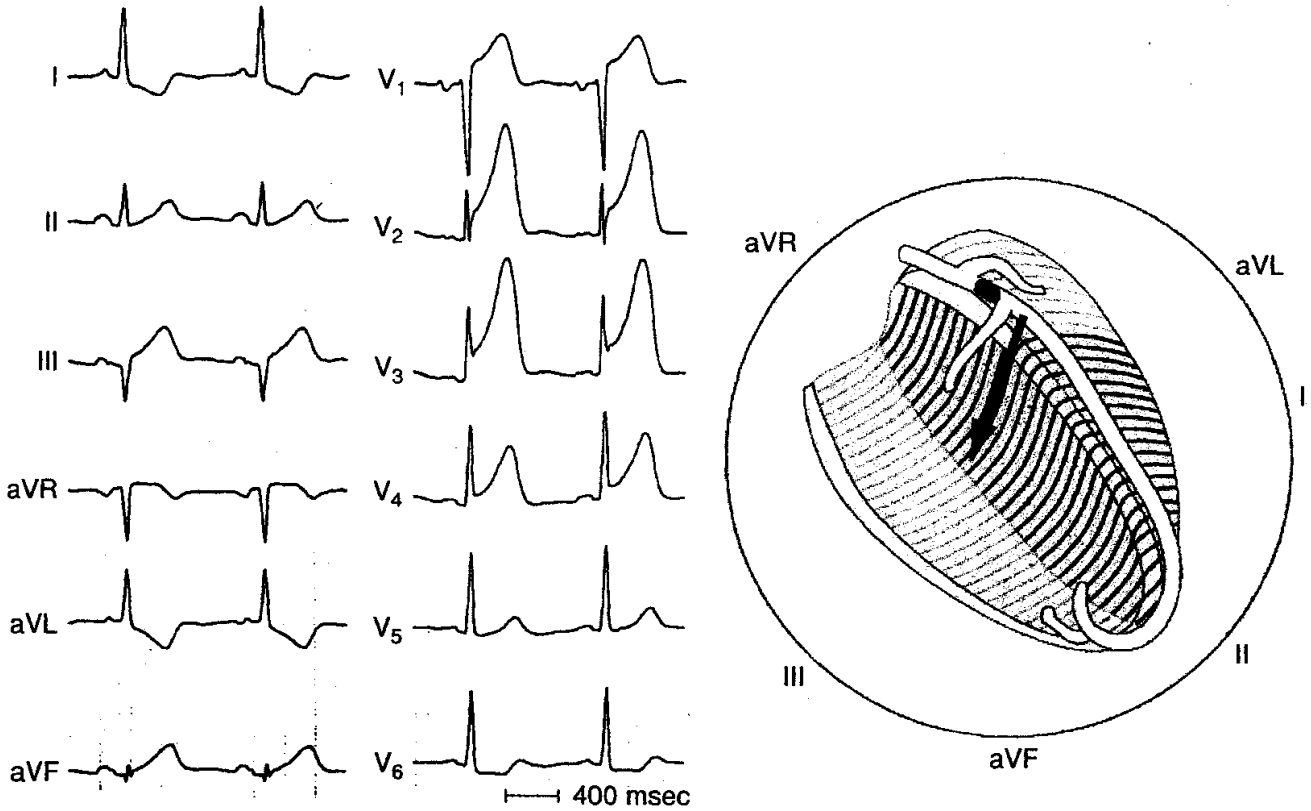


LAD after S_1 , before diagonal





LAD after diagonal, before S_1



LAD after S_1 and diagonal

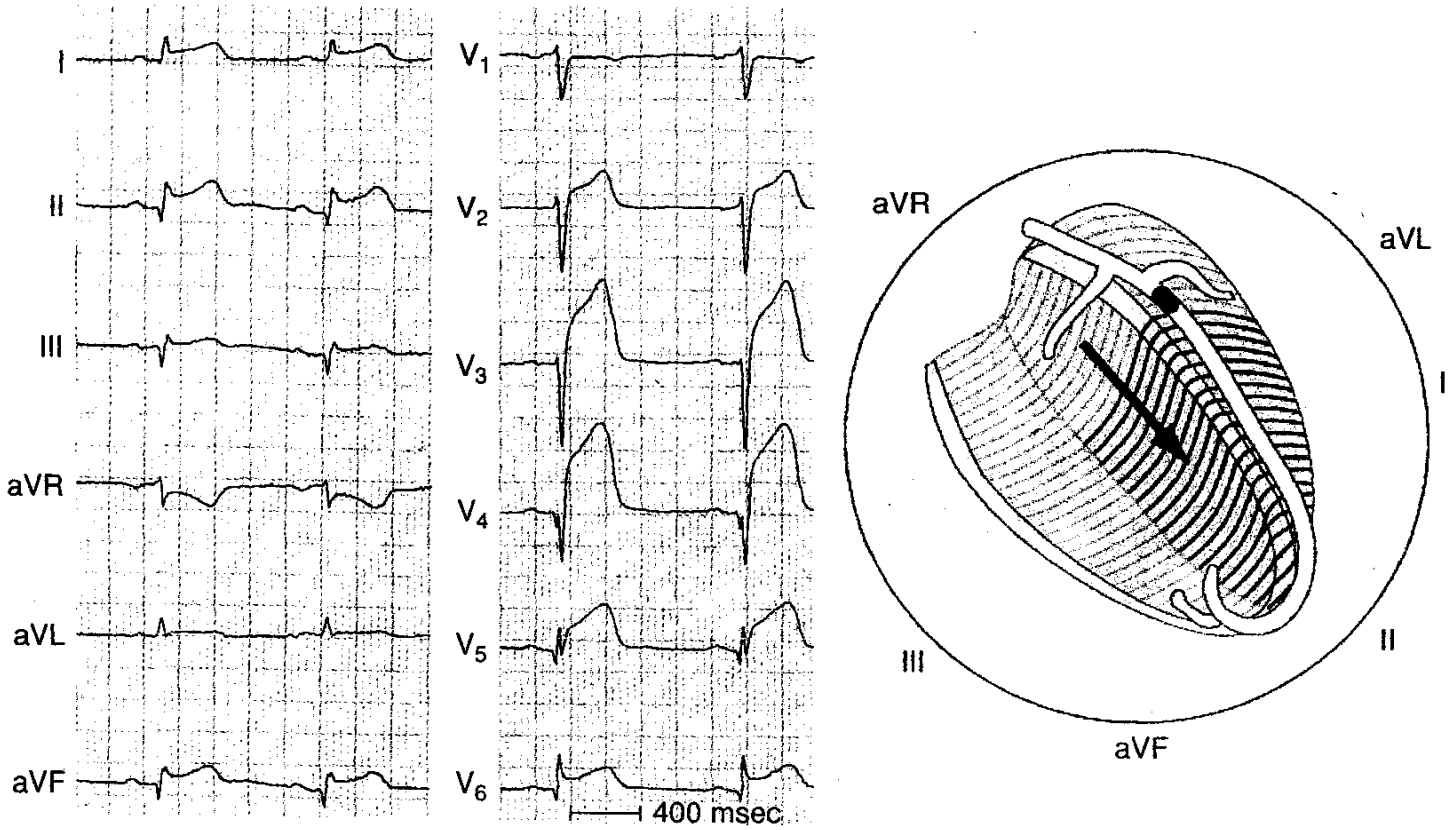
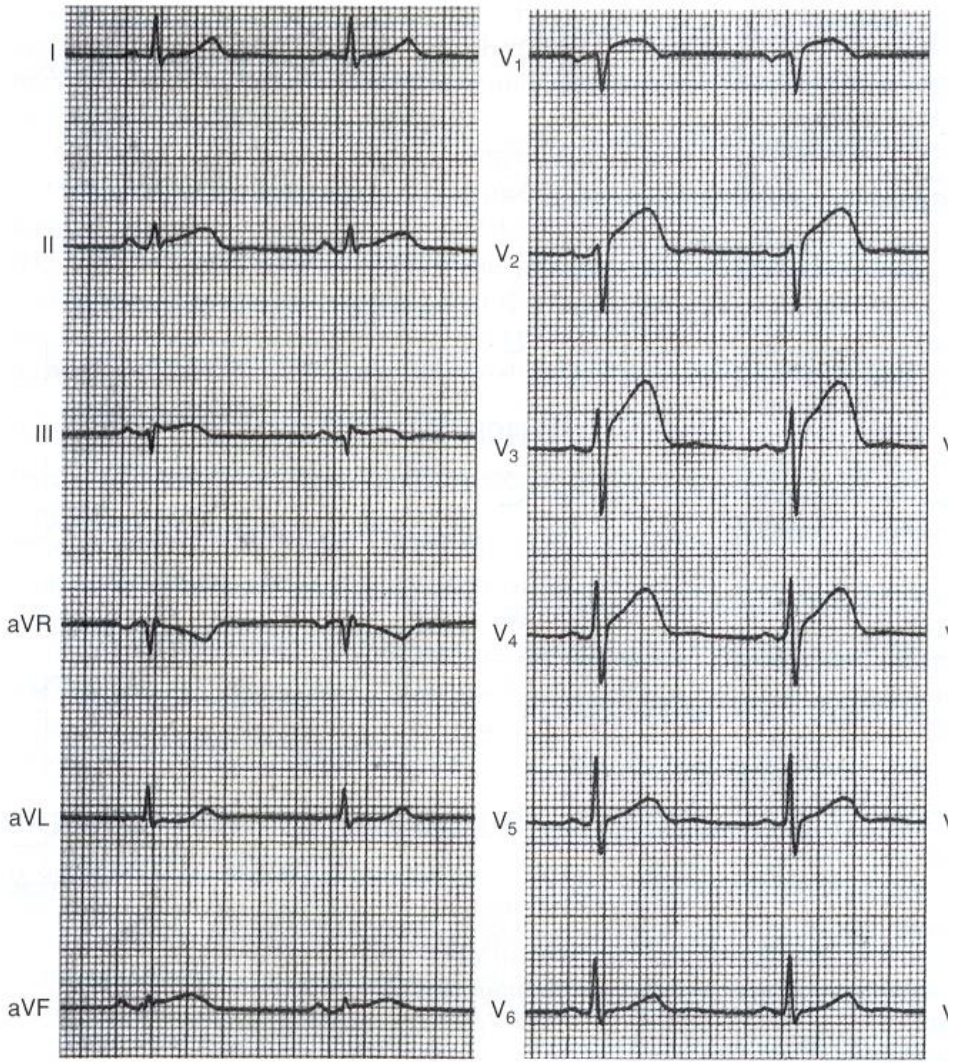
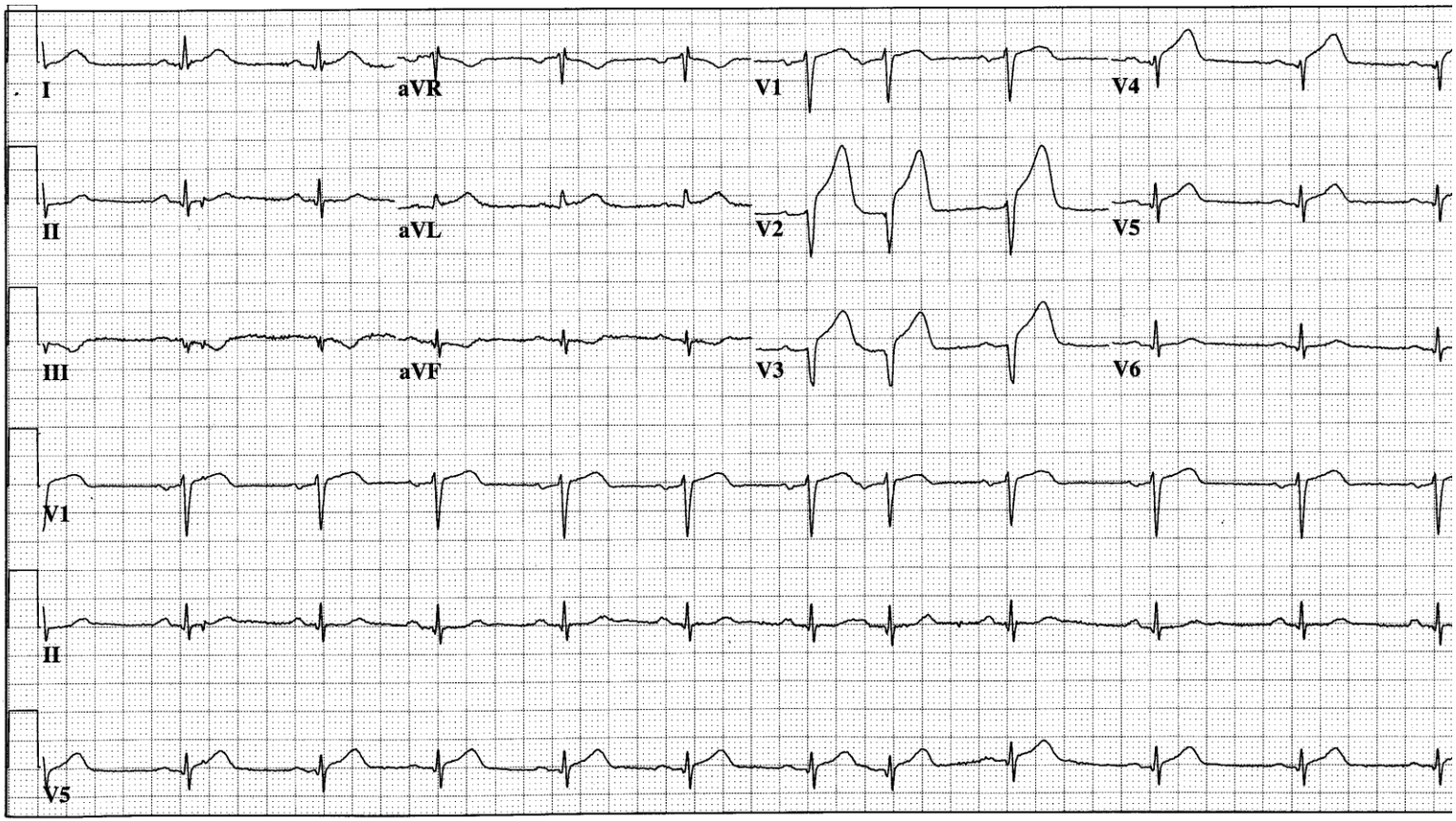


Figure 1-15 Acute anterior MI caused by a distal LAD occlusion. Because the ischemic area is

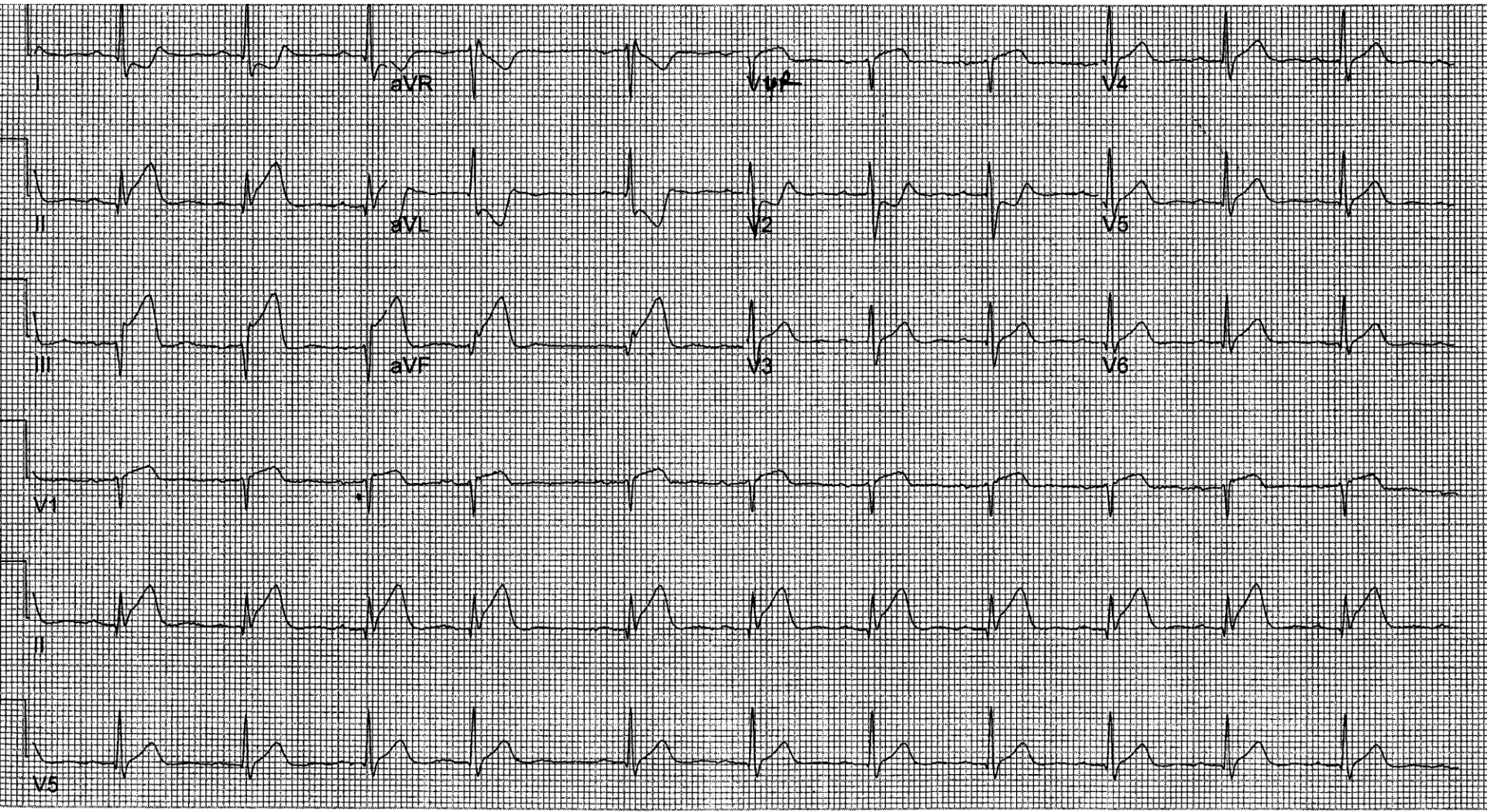
Just for fun…



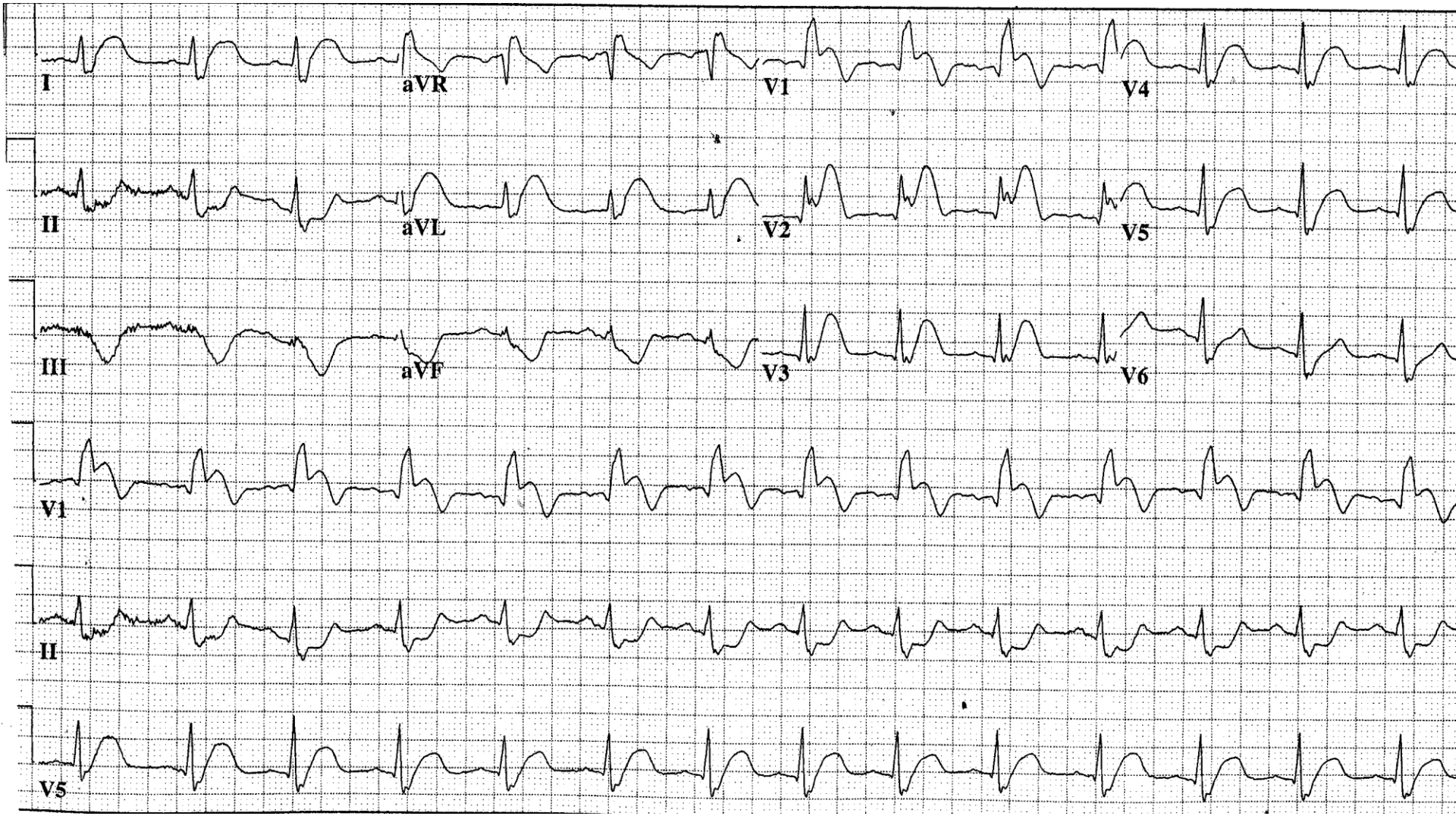
Just for fun…



RV MI?



Where's the occlusion?



LBBB, old or new – Call a STEMI?

Left bundle branch block

- Diagnosis of acute MI in presence of LBBB is problematic, since the ST segment is depressed or elevated from secondary changes (opposite from the major component of the QRS)

Left bundle branch block

- Proximal LAD septal perforators perfuse the right bundle and left anterior fascicle > 90% of the time
- RCA perfuses the left posterior fascicle > 90% of the time
- Disruption of the left bundle occurs at its origin, typically with fibrosis (Lenegre's disease) and occasionally with calcification (Lev's disease). This is a hinge point of the heart, related to cardiac dilatation and the central fibrous body of the heart.

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Right, But Not Left, Bundle Branch Block Is Associated With Large Anteroseptal Scar

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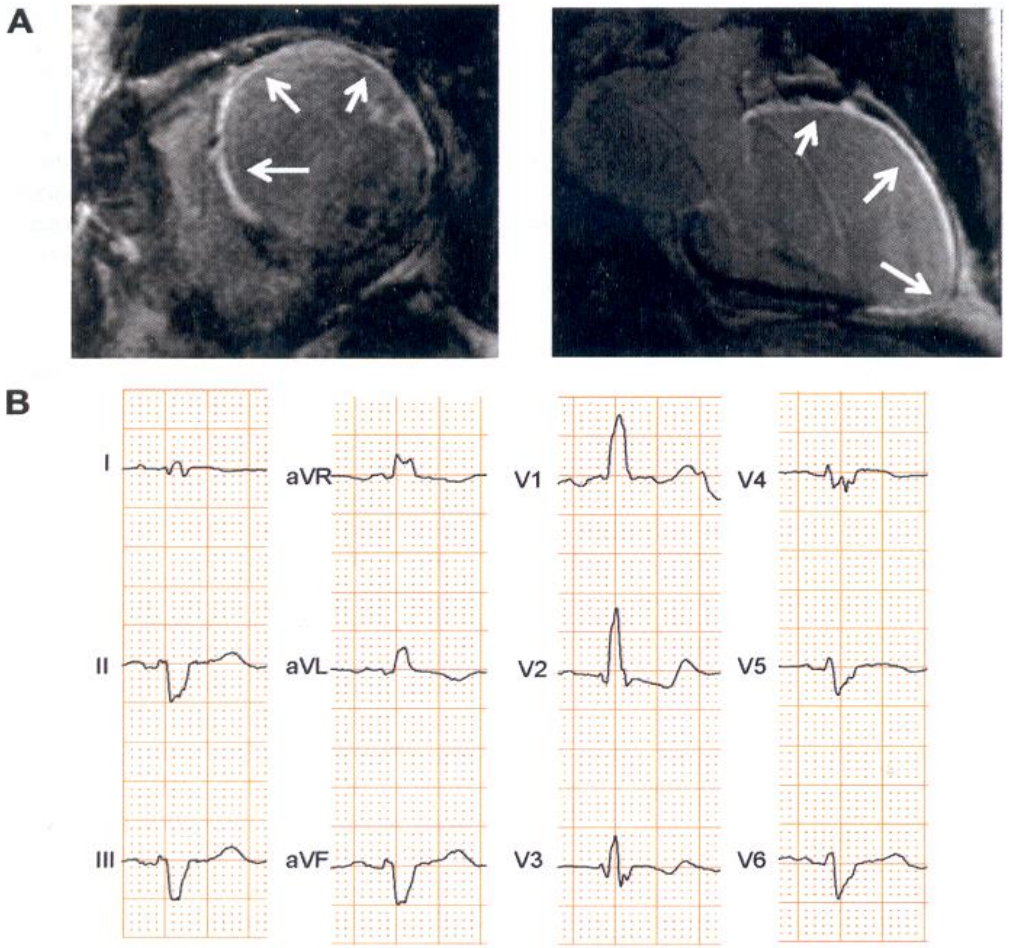
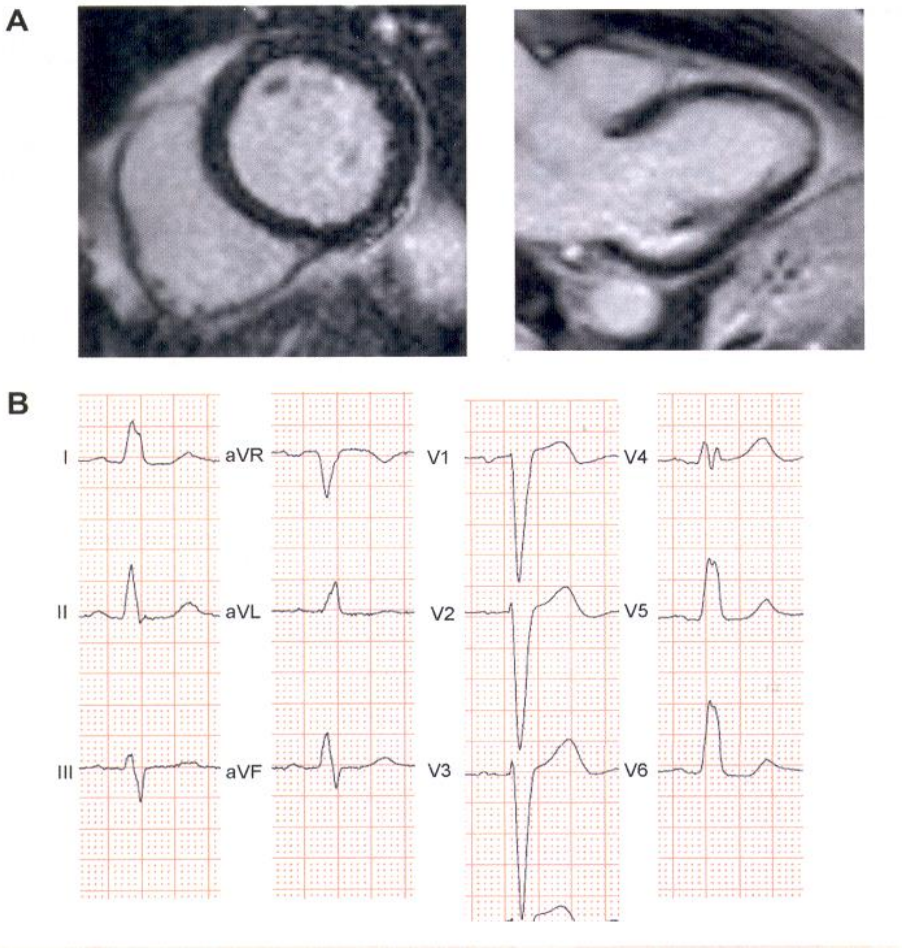
Silver Spring and Baltimore, Maryland; Durham, North Carolina; and Long Beach, California

Myocardial scar with RBBB



Non-ischemic CM and LBBB



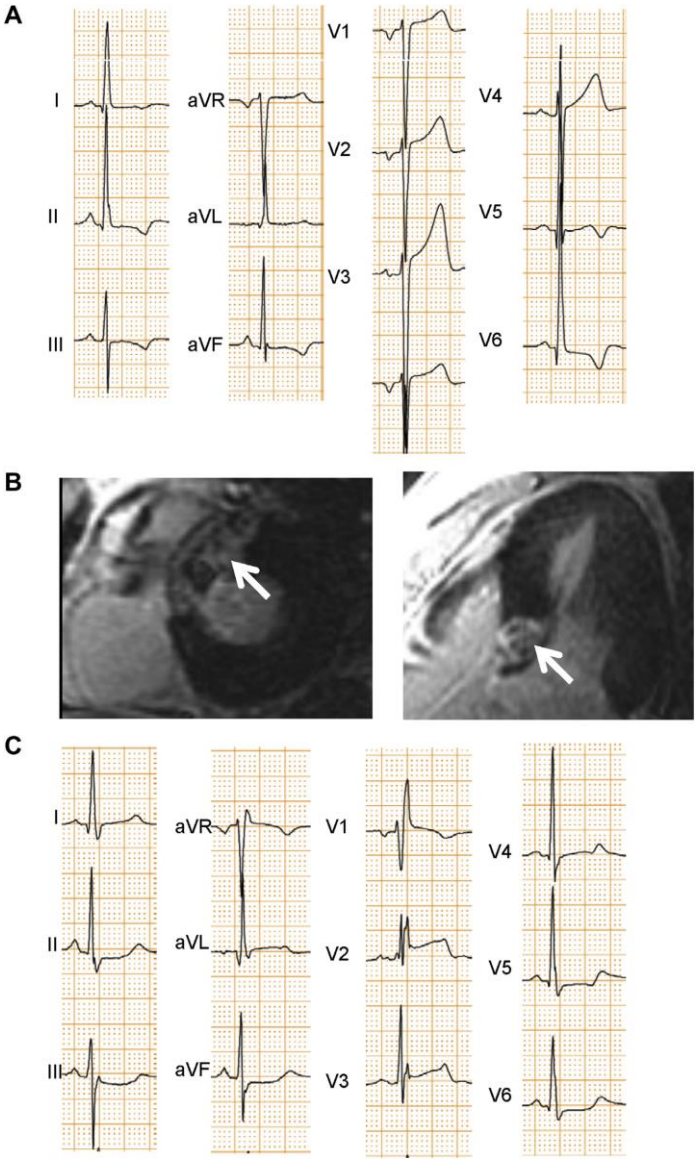
BBB and scar

- 233 patients with cardiac MR before AICD
- LV EF 24 %
- Ischemic heart disease
  - RBBB 79 %
  - LBBB 29 %

Bundle branch block and anterior MI: a novel approach

- 20 patients with hypertrophic cardiomyopathy and normal QRS duration
- Alcohol septal ablation of the LAD septal perforator
  - 15/20 developed RBBB
  - None developed LBBB

Alcohol ablation and CMR-LGE



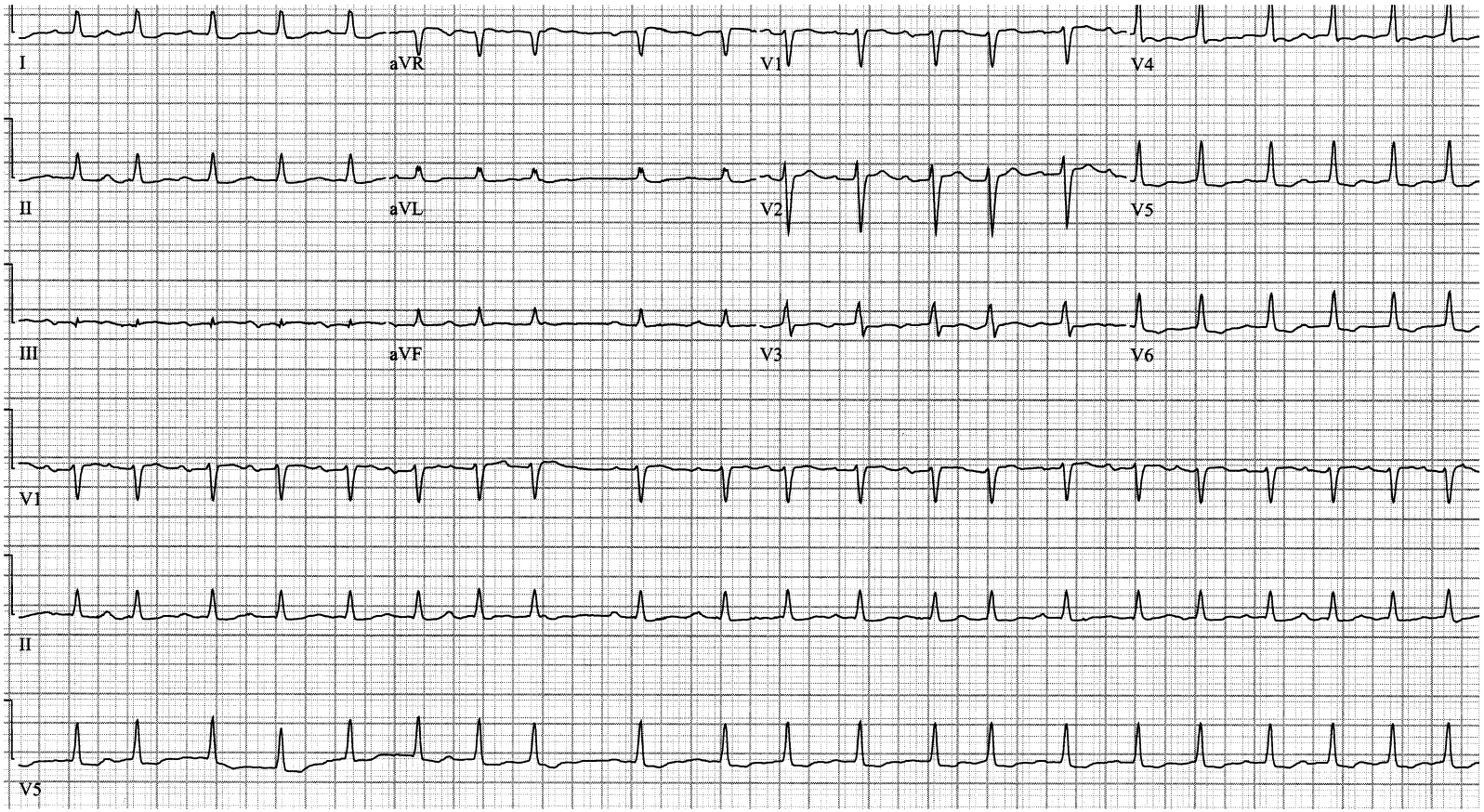
Implications of this…

- Re-synchronization therapy for dilated cardiomyopathy
  - It doesn't help about 30% of the time
  - Patients with LBBB get the most benefit compared to patients with RBBB

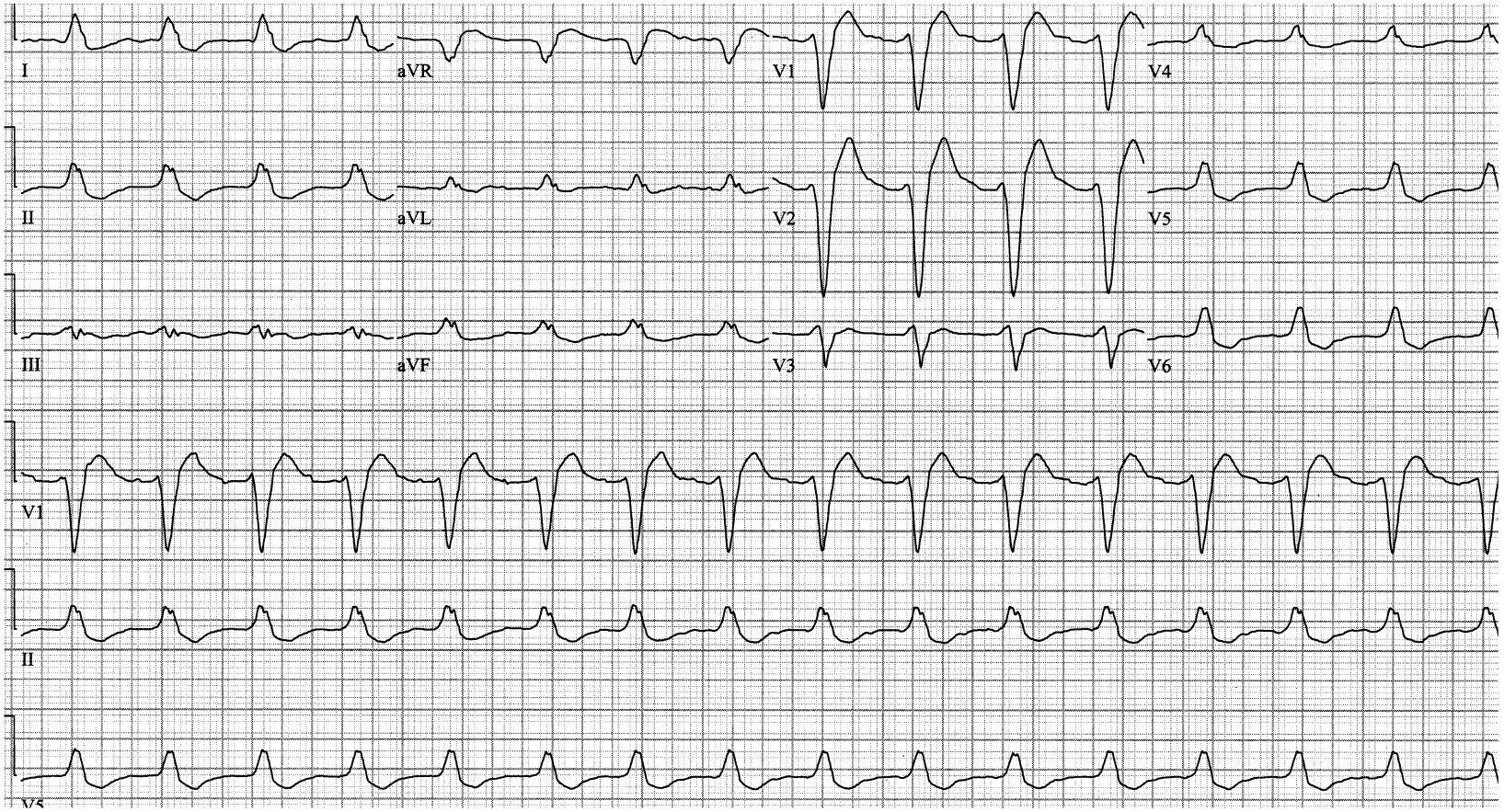
Implications of this…

- Possible STEMI
  - Distinctly rare for LAD occlusion alone to cause LBBB
  - LBBB due to MI would require LAD + RCA
  - LBBB is more likely due to mechanical stress from dilated LV
  - The actual LBBB pattern with MI would be taller R waves in V_1 – V_3, not Q wave or rS.

Patient No. 2, Feb 7, 2015



Patient No. 2, Feb 10, 2015



Implications of this…

- Even if LBBB were a marker of anterior MI, what the LBBB means is that the decision to call a STEMI is based on *clinical criteria*, not the EKG.
- (Consider LVH or a pacemade rhythm, by analogy.)
- A stat echo could be part of that clinical assessment

ST-segment elevation in conditions other than AMI

NEJM 2003: 349; 2128 - 35

- Normal ST-segment elevation and normal variants
- LBBB
- Acute pericarditis & myocarditis
- Hyperkalemia
- Brugada and RVCM
- Pulmonary embolism

Here is a more extensive look at context

1. 6014 healthy men in US Air Force, age 16-58
    - 91% had 1-3 mm ST segment elevation in 1 or more precordial leads; most pronounced in V2.
2. 529 normal men age 17 to 24
    - ST segment elevation of at least 1 mm in V1-V4 in 93%

NEJM 2003; 349:2128-35

In contrast:

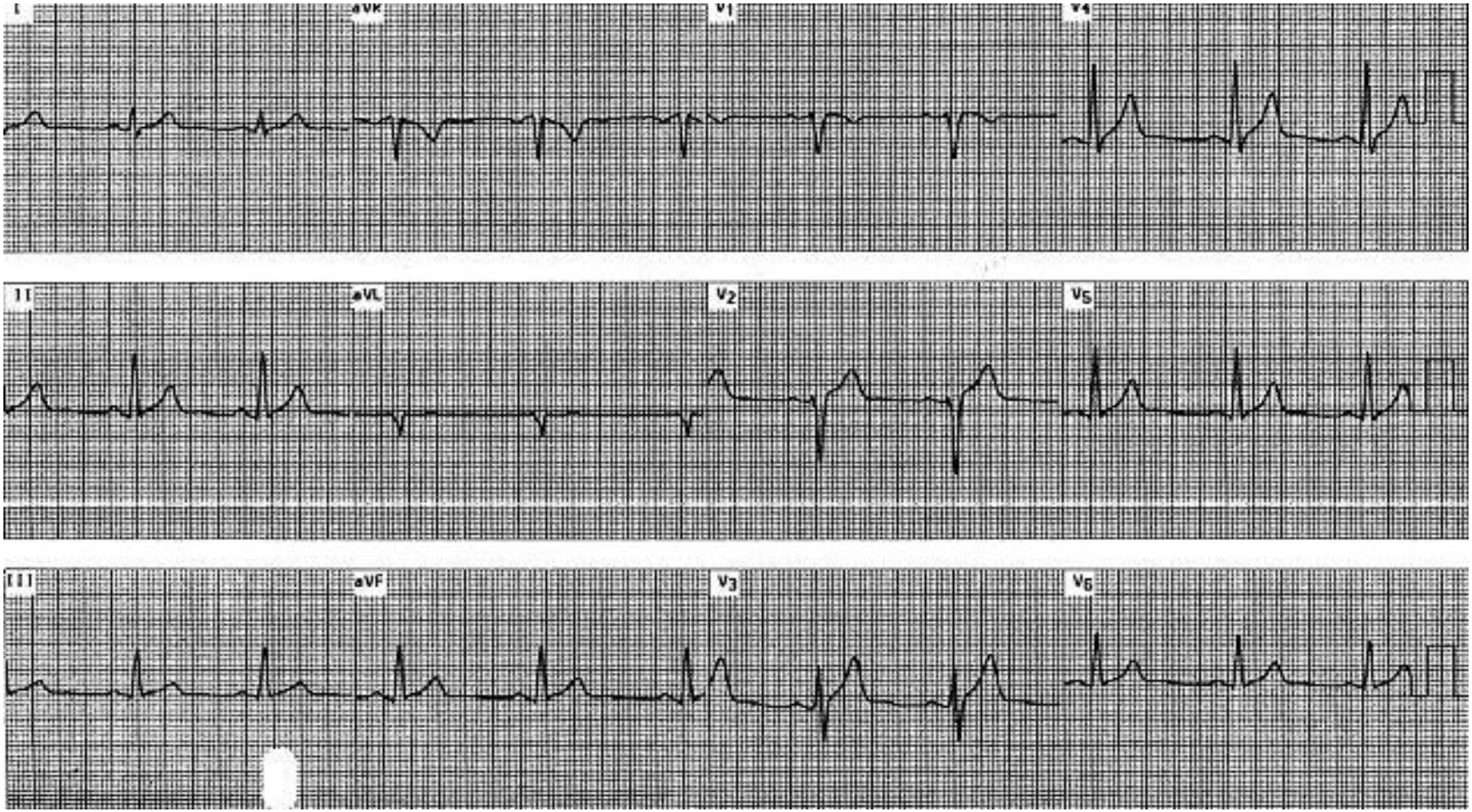
About 20% of normal electrocardiograms from women had ST segment elevation of 1 mm or more; this prevalence was unchanged regardless of age.

Normal Finding

- Precordial ST segment elevation
  - 1 mm or more – male pattern
  - Less than 1 mm – female pattern
- ST segment is concave
- The deeper the S wave, the greater the ST segment elevation

- NEJM 2003; 349:2128-35

ST segment elevation



Other normal variations

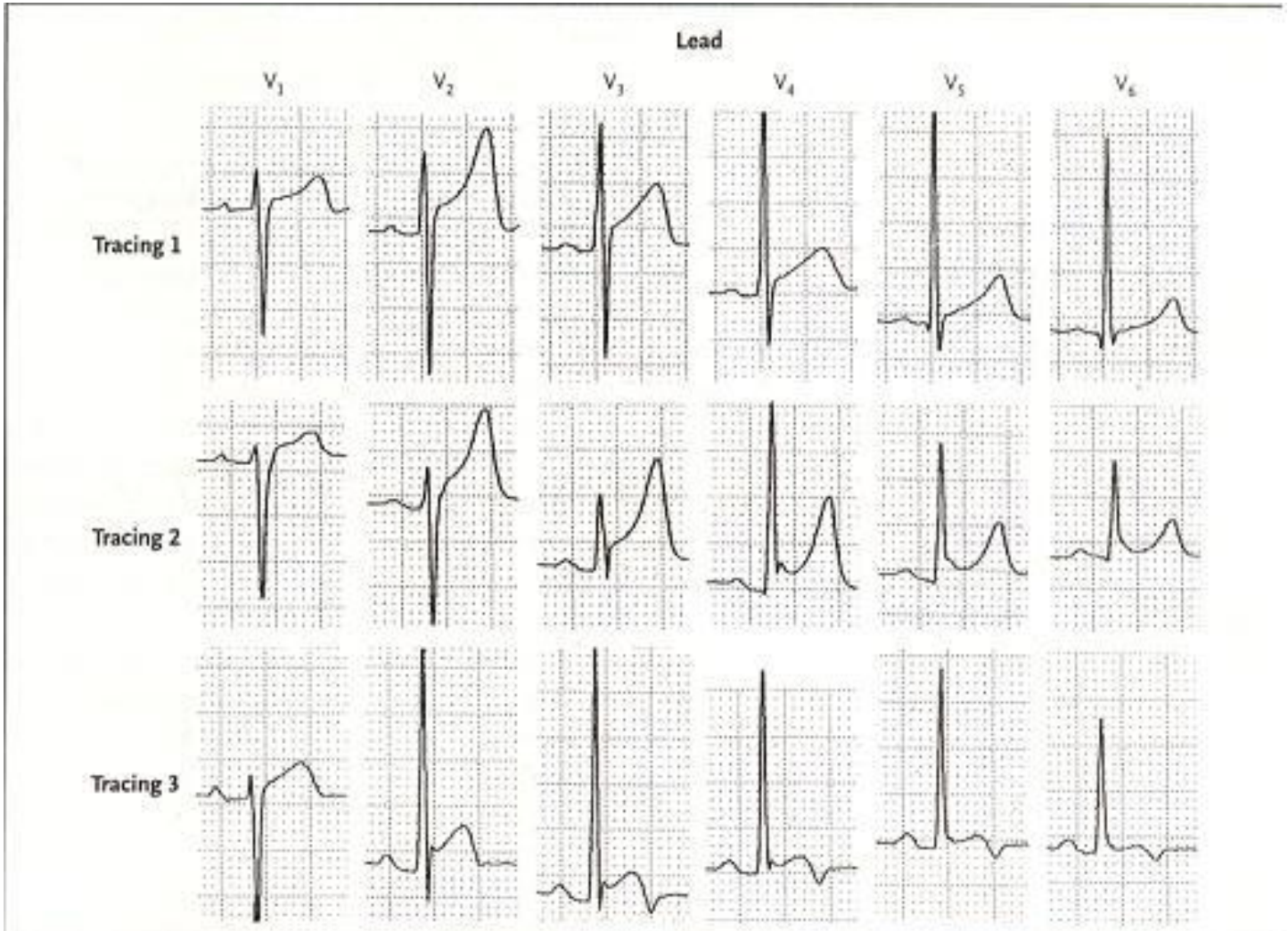


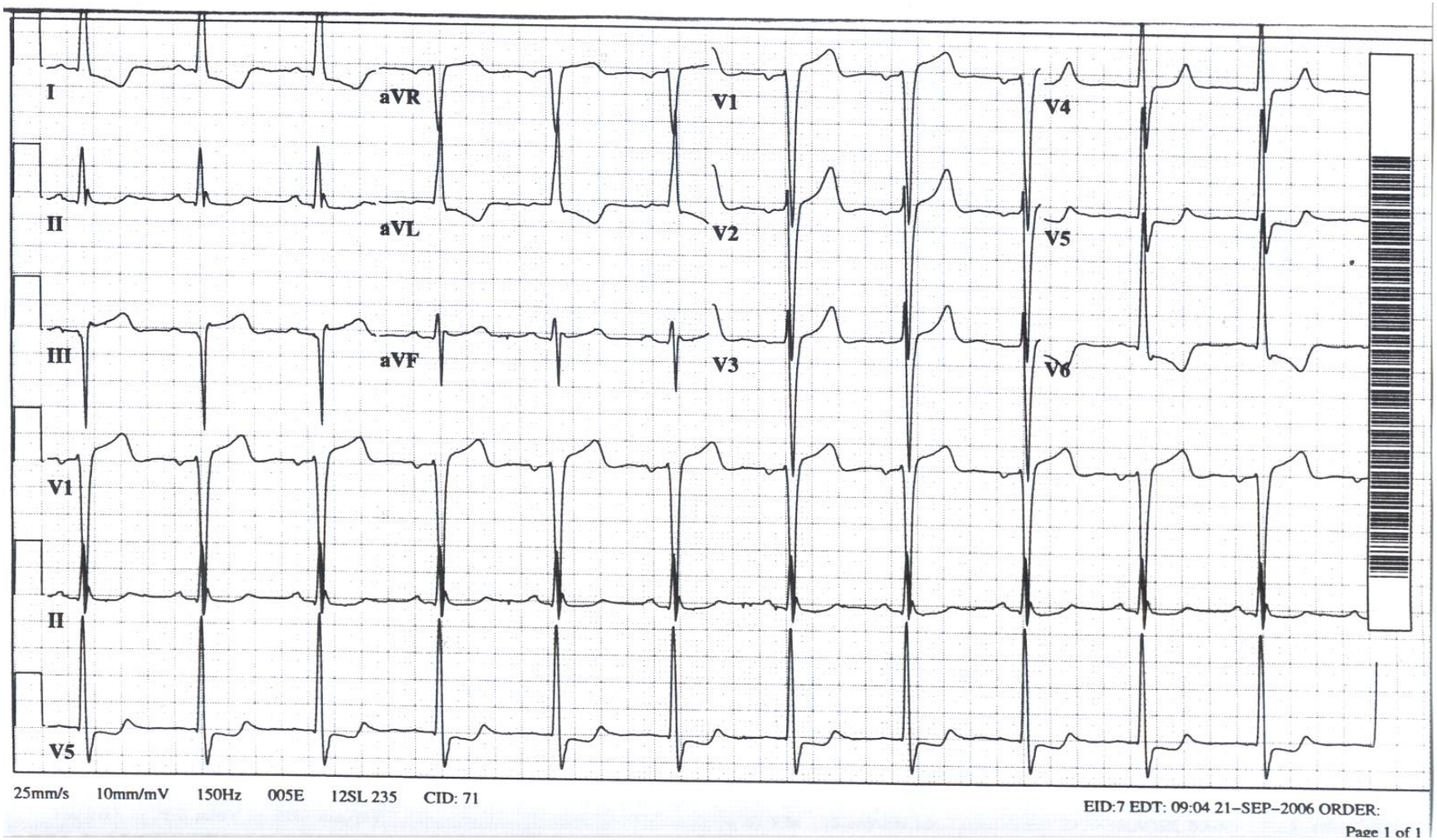
Figure 1. Electrocardiograms Showing Normal ST-Segment Elevation and Normal Variants.

Tracing 1 shows normal ST-segment elevation. Approximately 90 percent of healthy young men have ST-segment elevation of 1 to 3 mm in one or more precordial leads. The ST segment is concave. Tracing 2 shows the early-repolarization pattern, with a notch at the J point in V_4. The ST segment is concave, and the T waves are relatively tall. Tracing 3 shows a normal variant that is characterized by terminal T-wave inversion. The QT interval tends to be short, and the ST segment is coved.

Left ventricular hypertrophy

- ST and T waves are oriented opposite from the QRS
- The ST segment in V2 is typically concave.

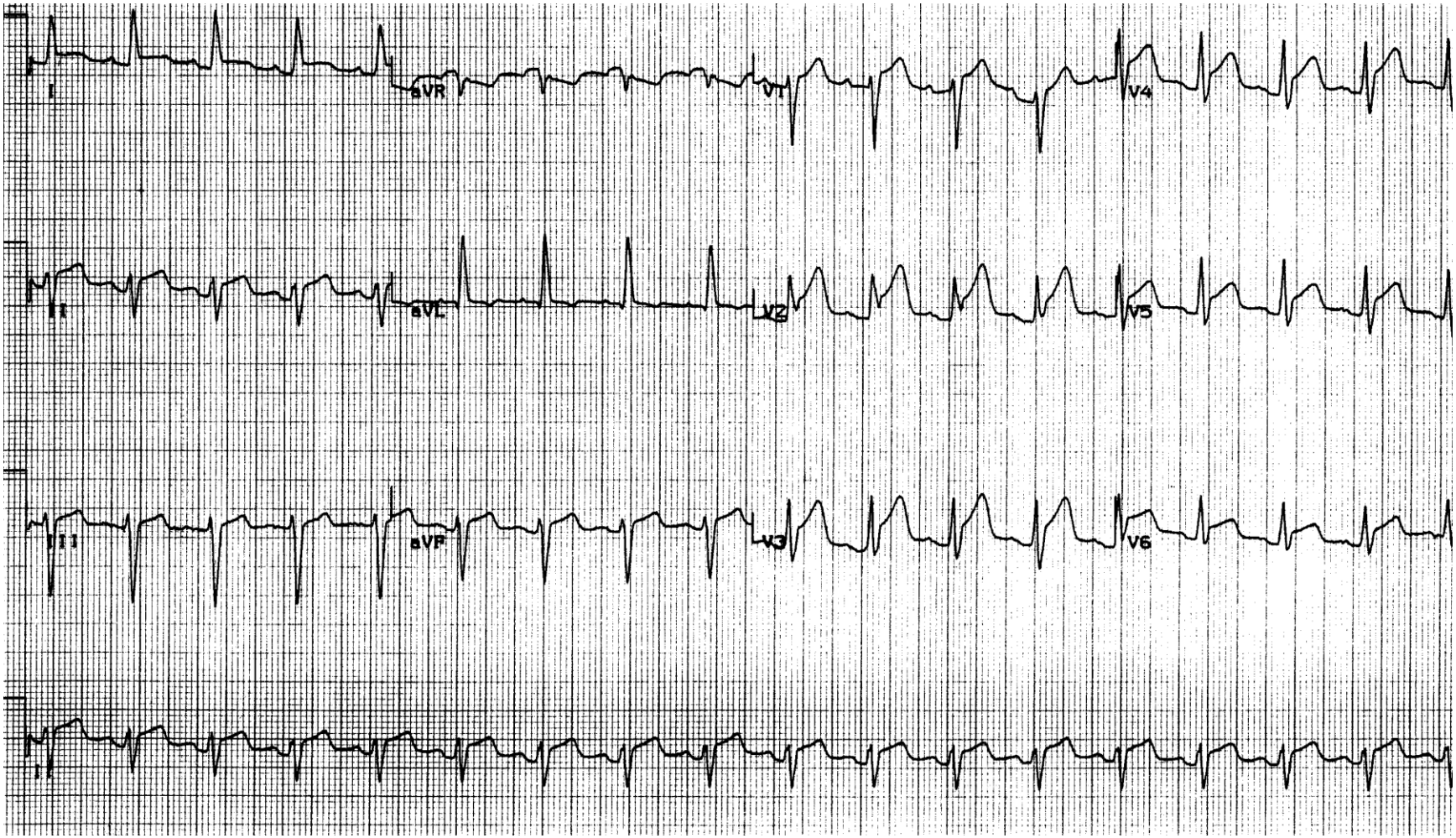
Left ventricular hypertrophy



Acute pericarditis

- ST segment elevated in limb leads as well as precordial leads. More than 1 coronary artery distribution
- PR segment is depressed
- ST segment is more prominent in lead 2 than lead 3. Reciprocal depression in aVR.

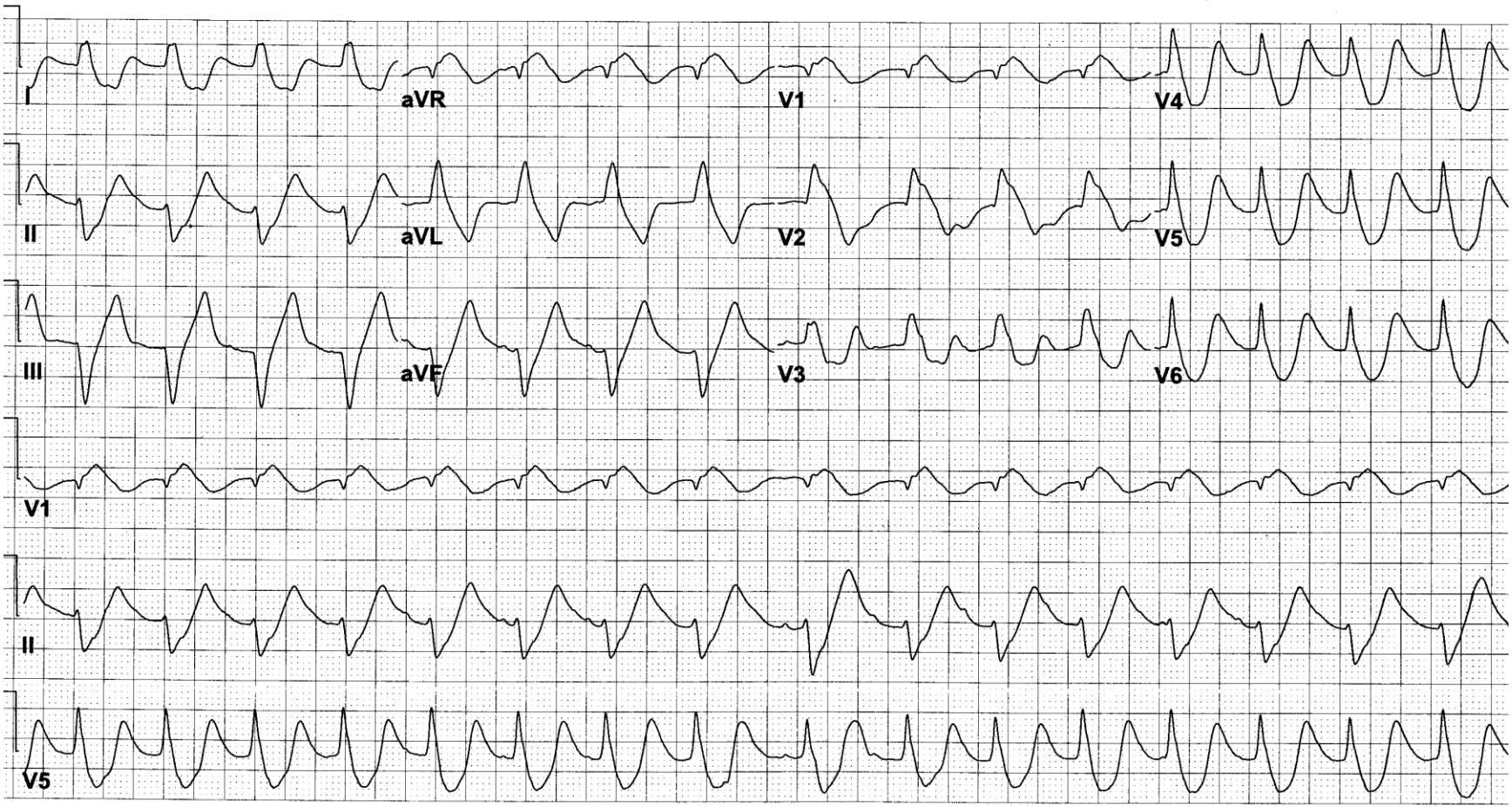
Acute pericarditis



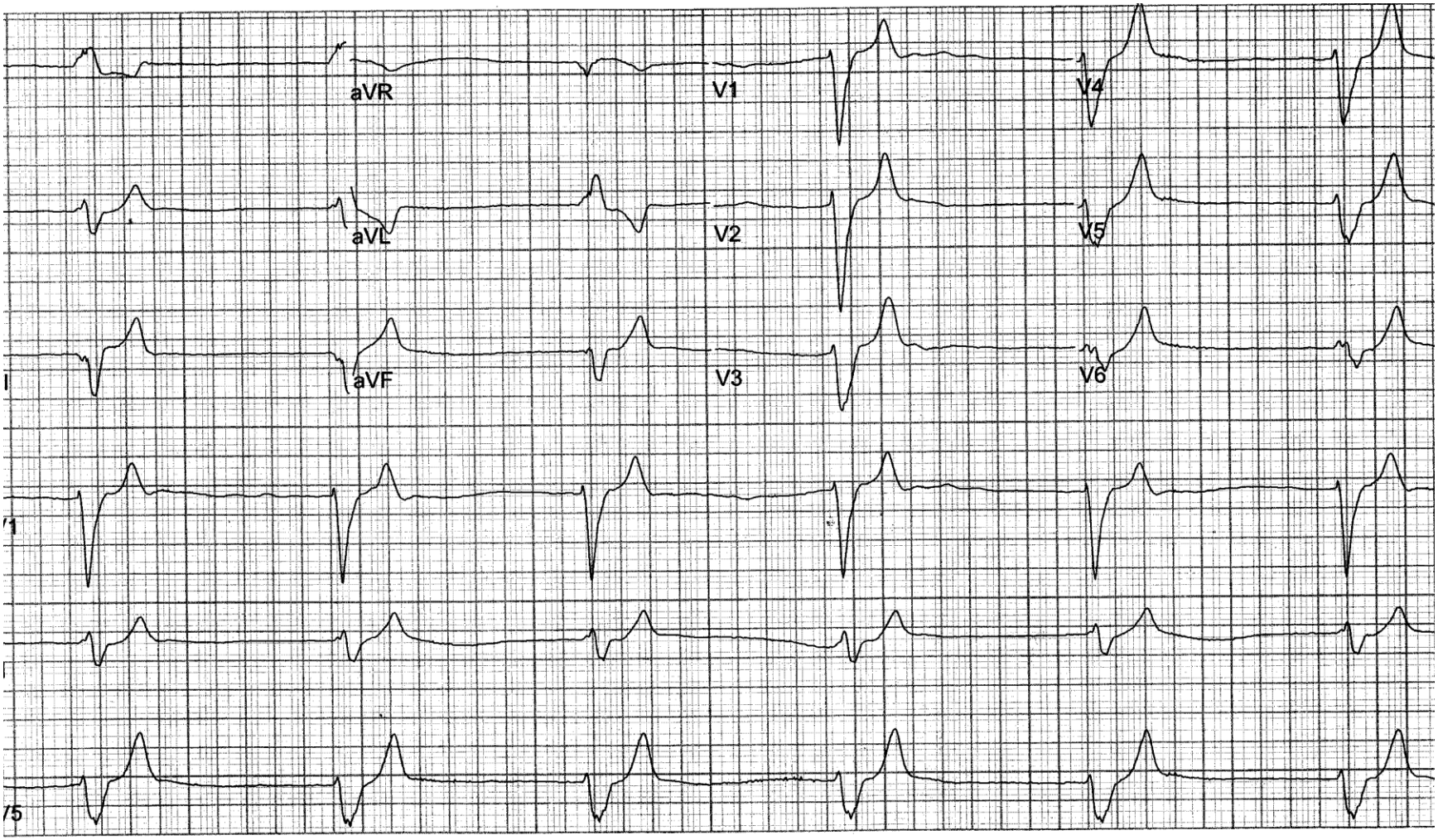
Hyperkalemia

- Wide QRS
- Tall, pointed T waves
- Low amplitude P waves
- ST segment elevation. May be downsloping.

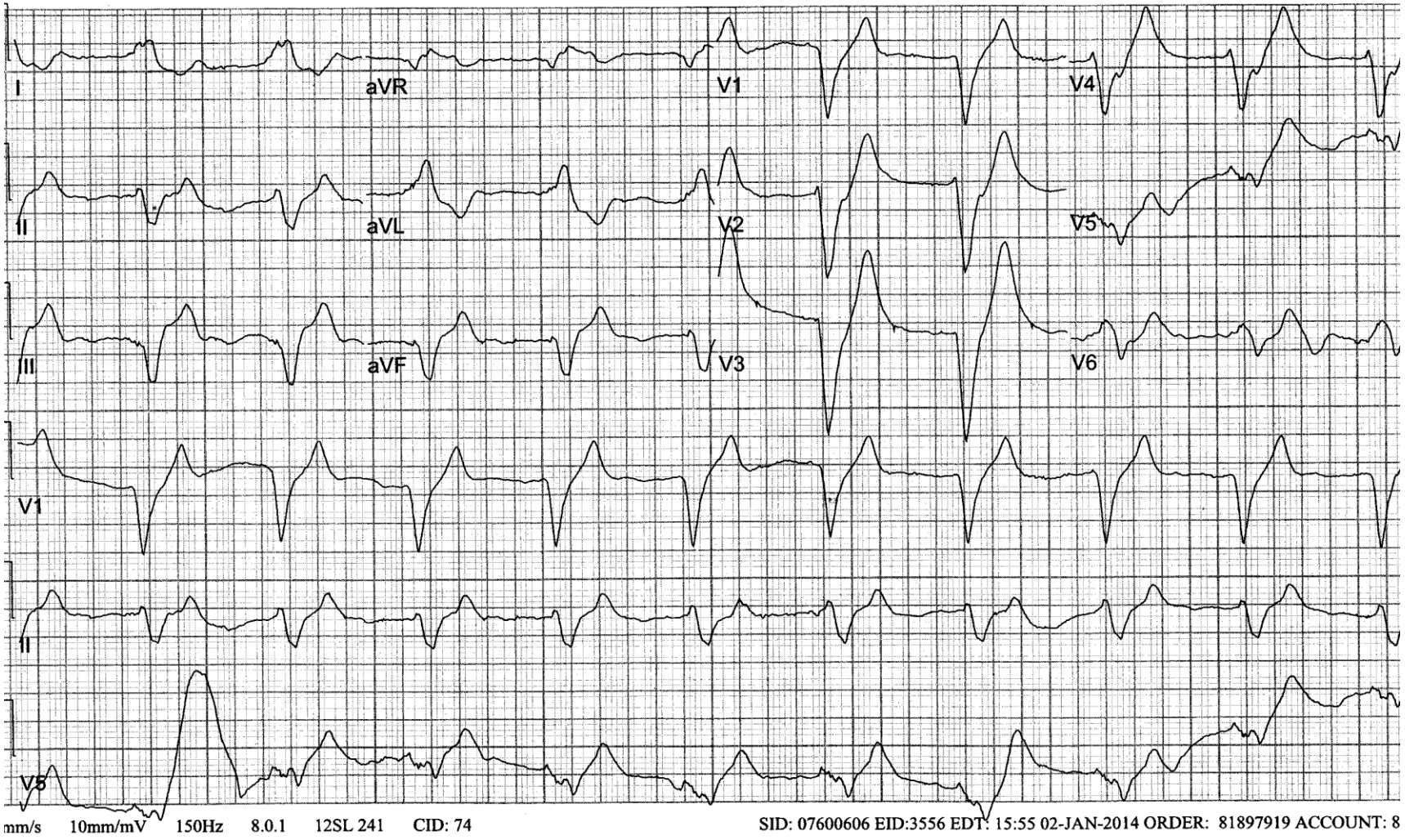
Hyperkalemia



What's wrong with this picture? The ED called a STEMI because of new LBBB. Cardiology cancelled because it wasn't new after all.



45 minutes later. What would you do now?



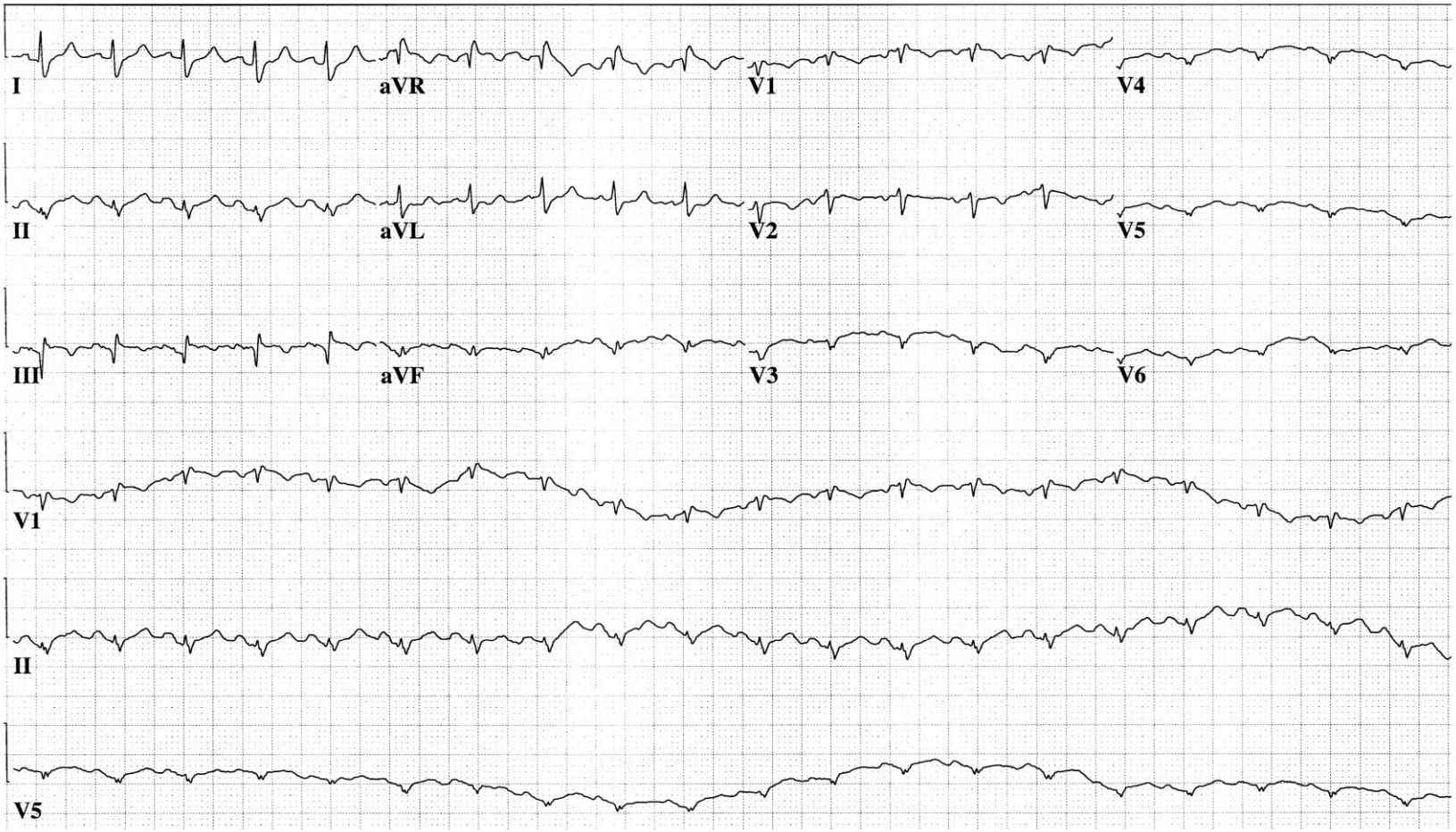
Arrhythmogenic RV cardiomyopathy

- ECG may be similar to Brugada.
- CT shows replacement of RV myocardial tissue by fibrofatty tissue.

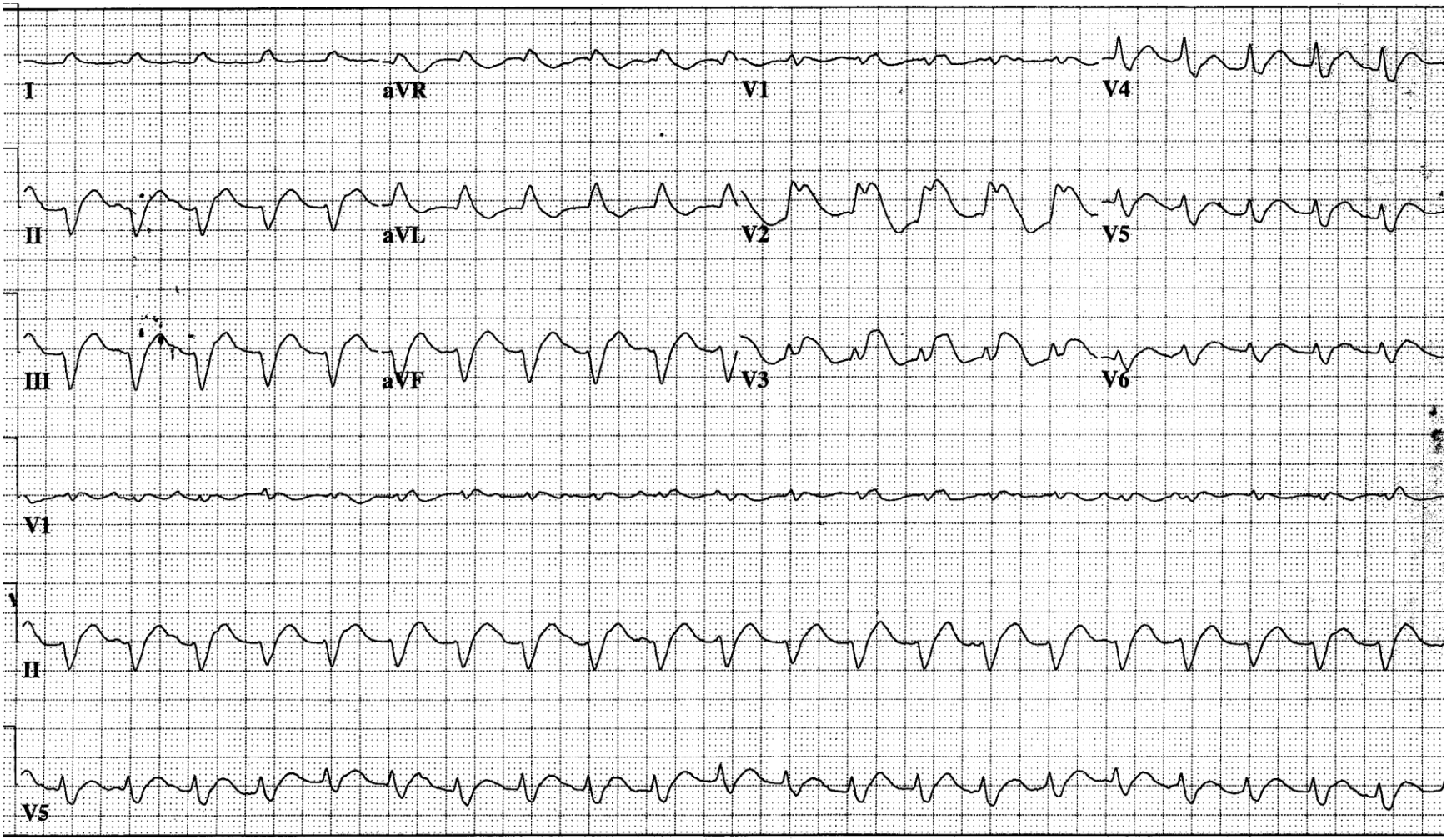
Pulmonary embolism

- T wave inversion right precordial leads
- S1Q3T3 pattern
- Sinus tachycardia
- Complete or incomplete RBBB
- ST segment elevation and T wave inversion in the anterior or inferior leads

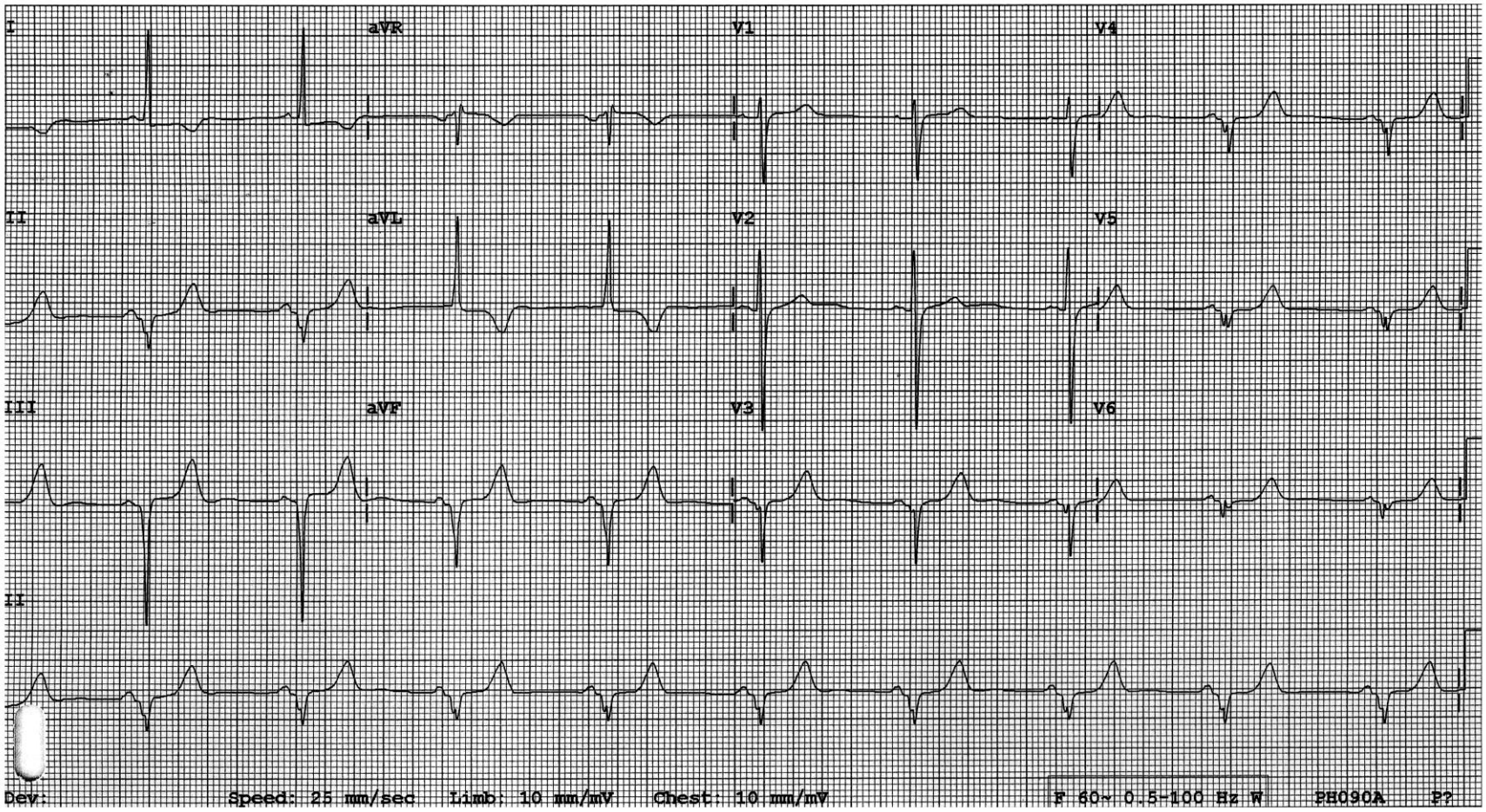
Pulmonary Embolism. 58 yr old female after abdominal surgery



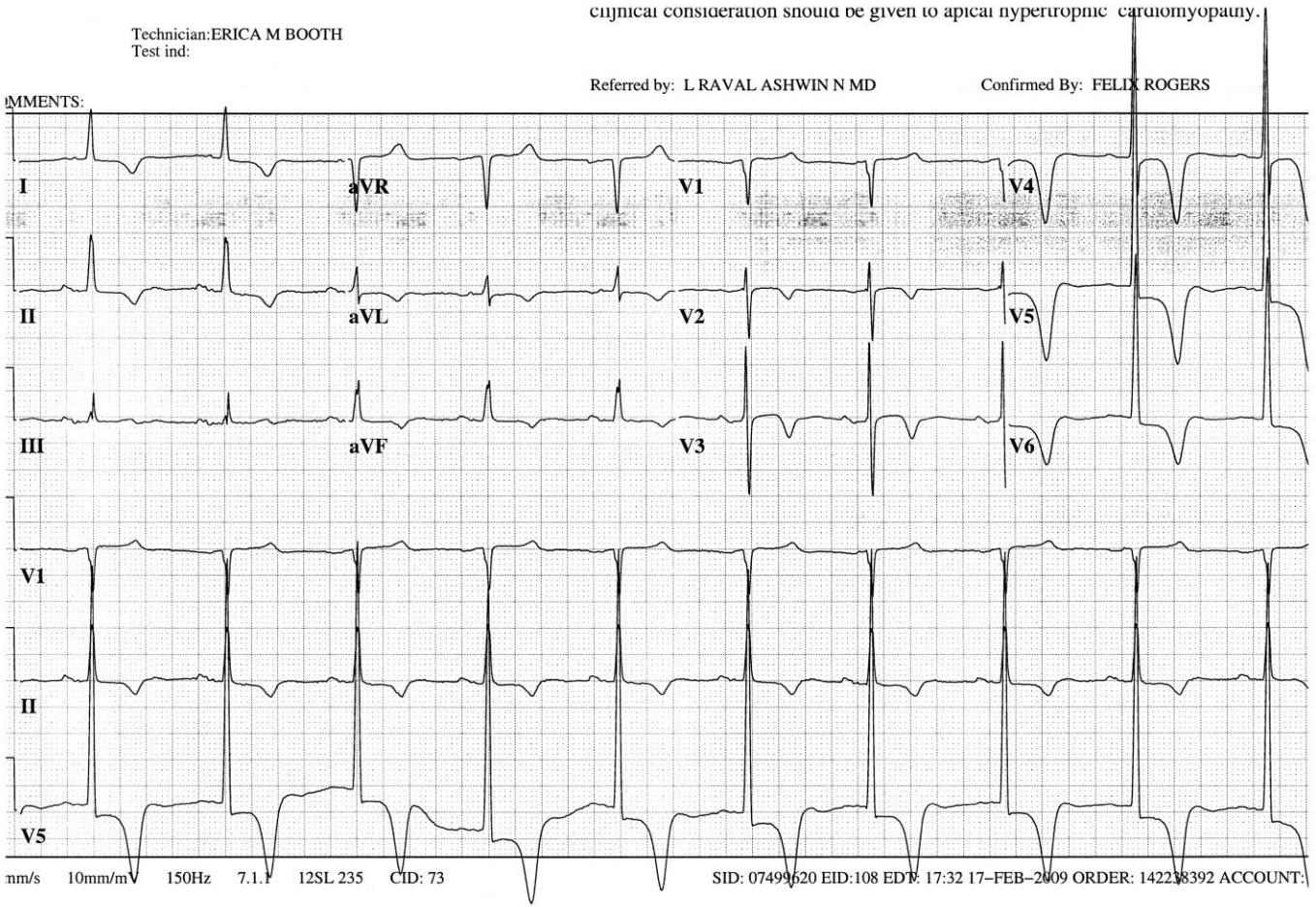
Pulmonary embolism



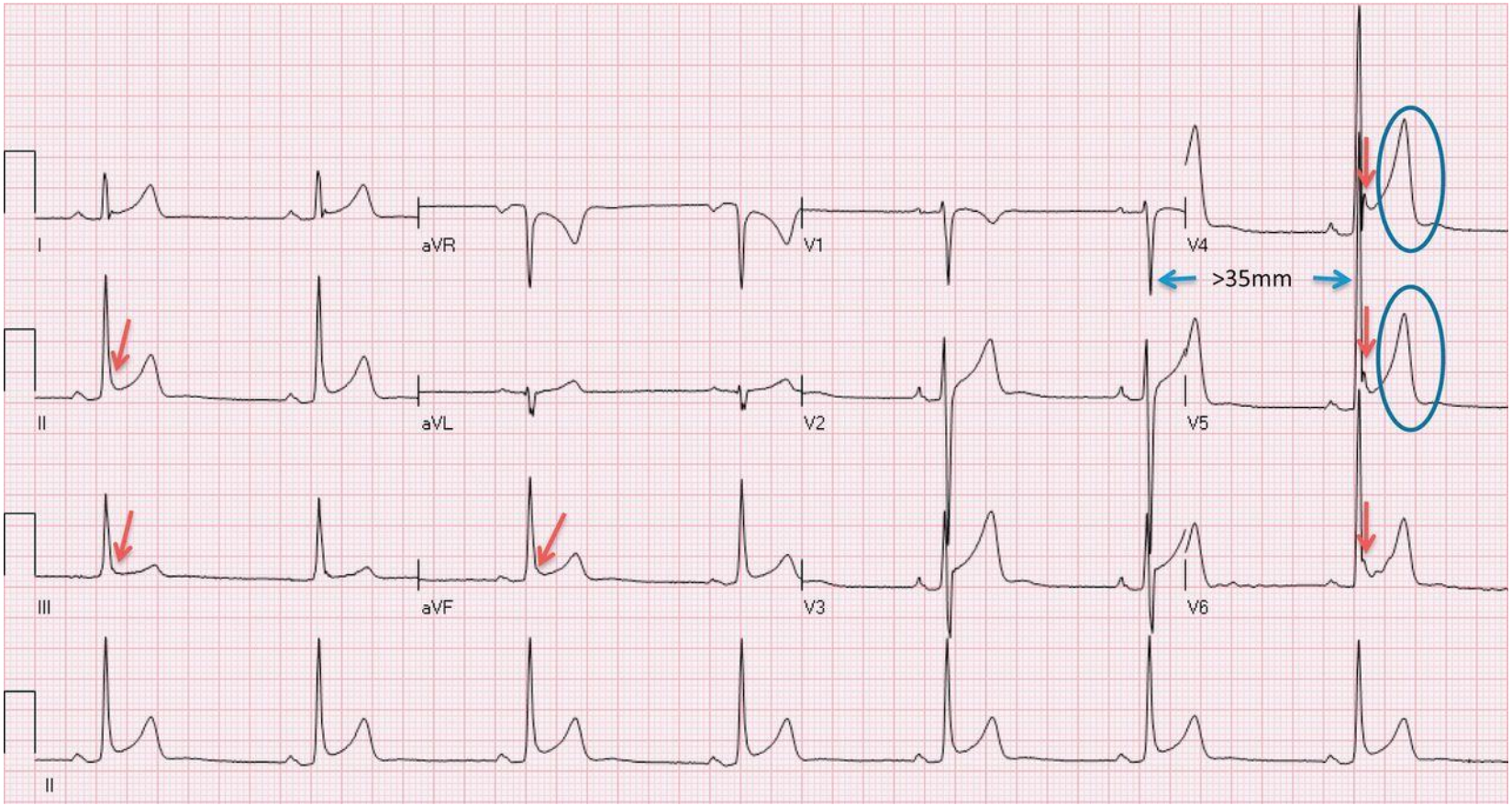
Hypertrophic heart disease. Active 56 y/o female with very atypical CP.



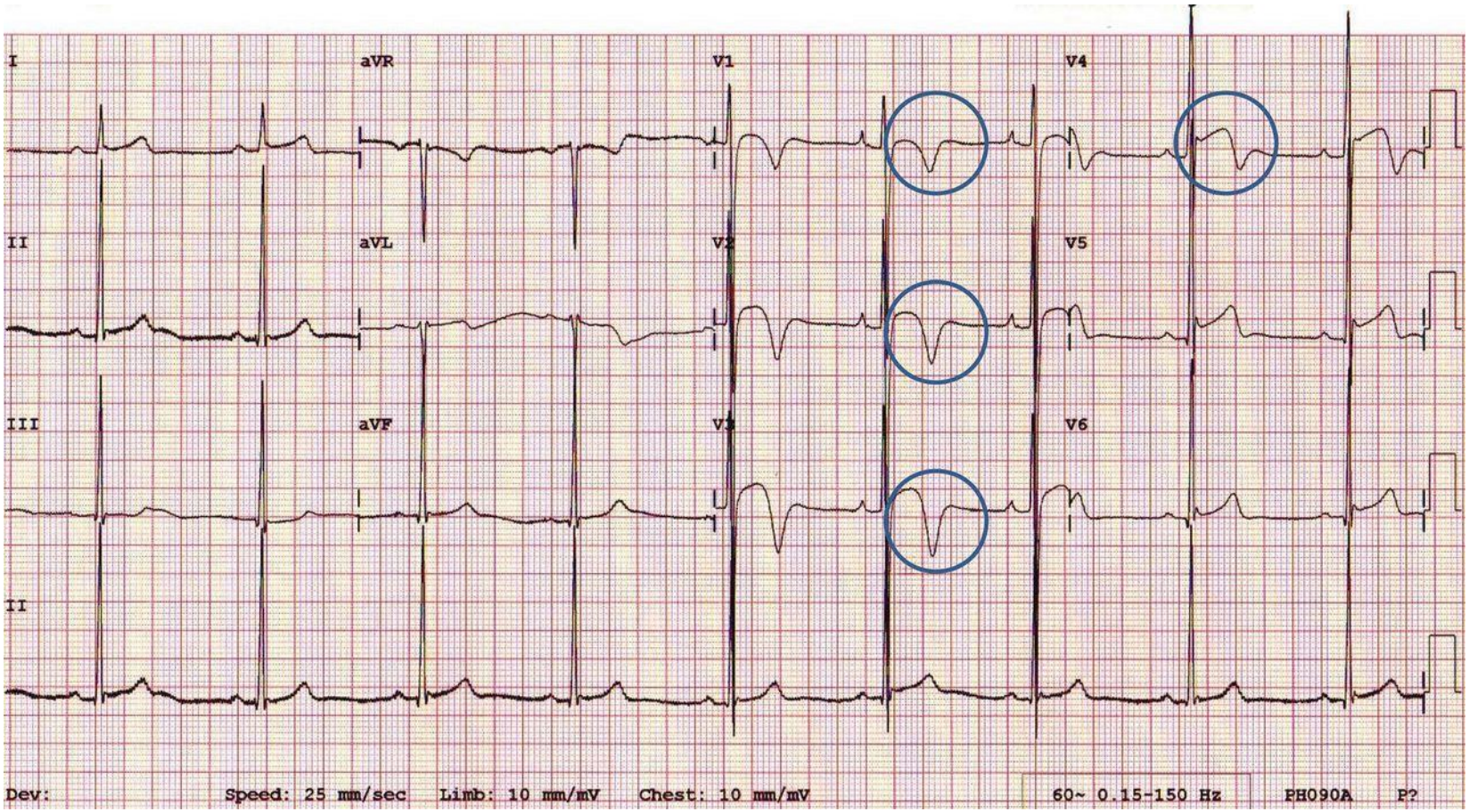
Apical hypertrophic cardiomyopathy



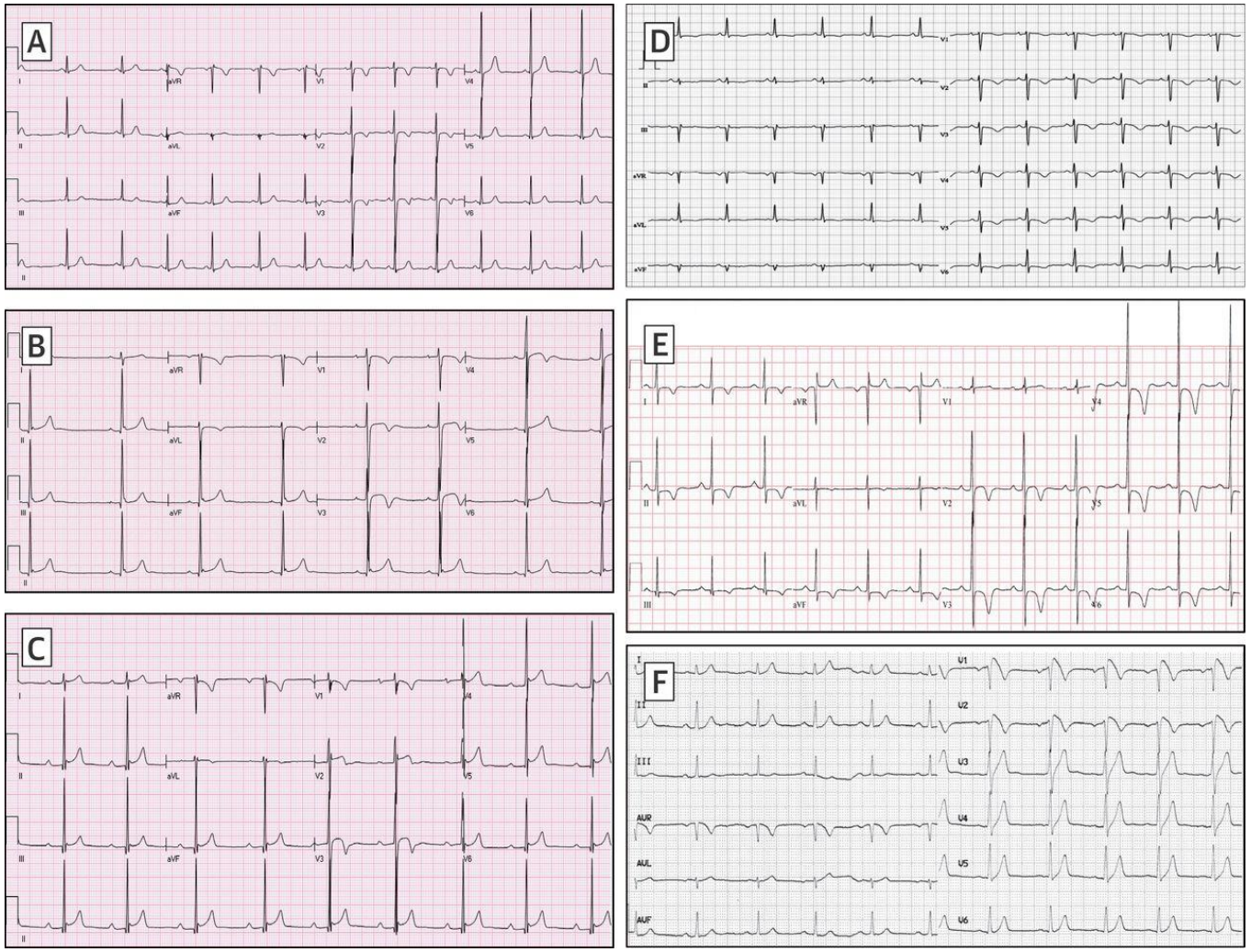
Athlete’s ECGs



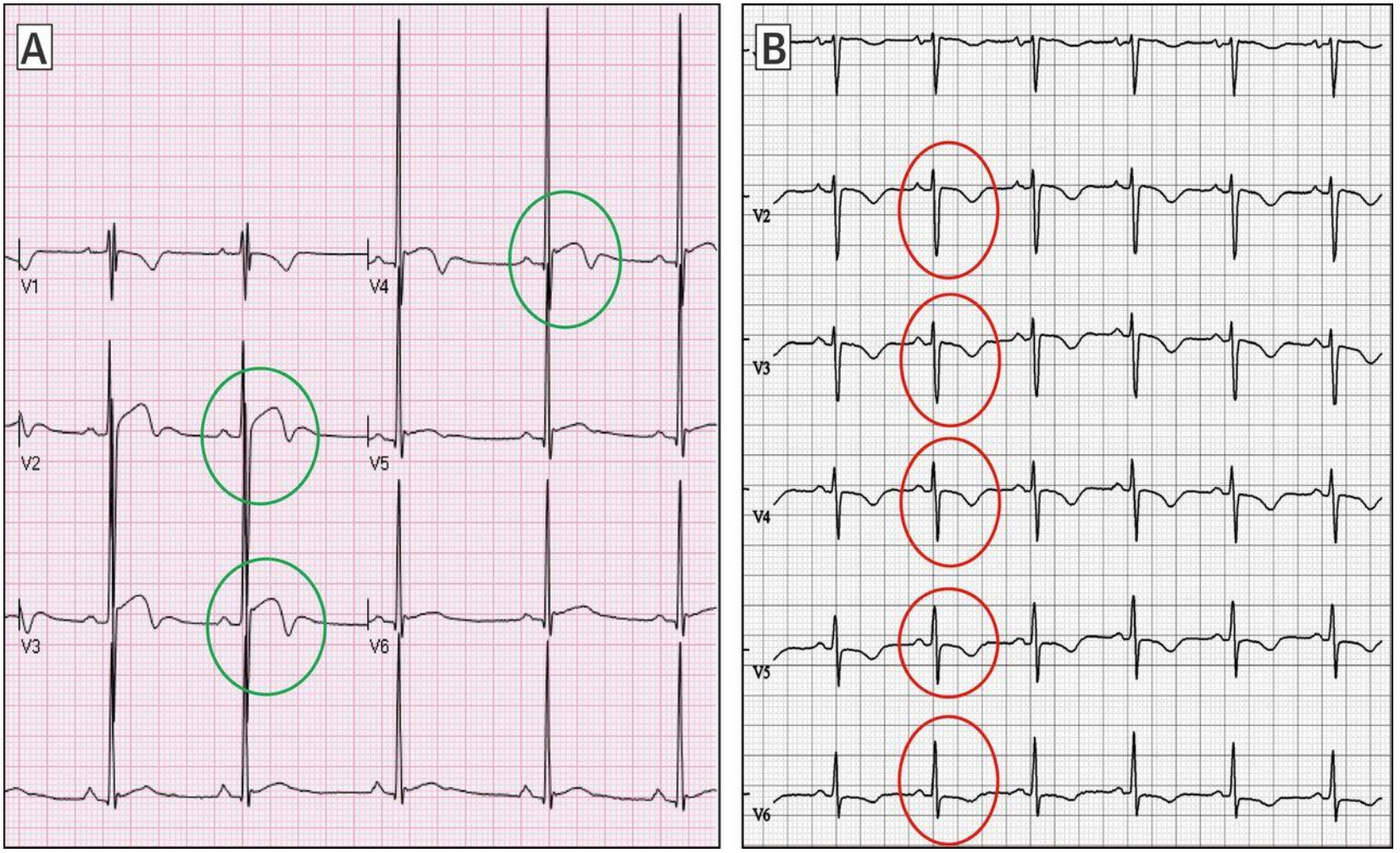
Sanjay Sharma et al. JACC 2017;69:1057-1075



Sanjay Sharma et al. JACC 2017;69:1057-1075



Sanjay Sharma et al. JACC 2017;69:1057-1075

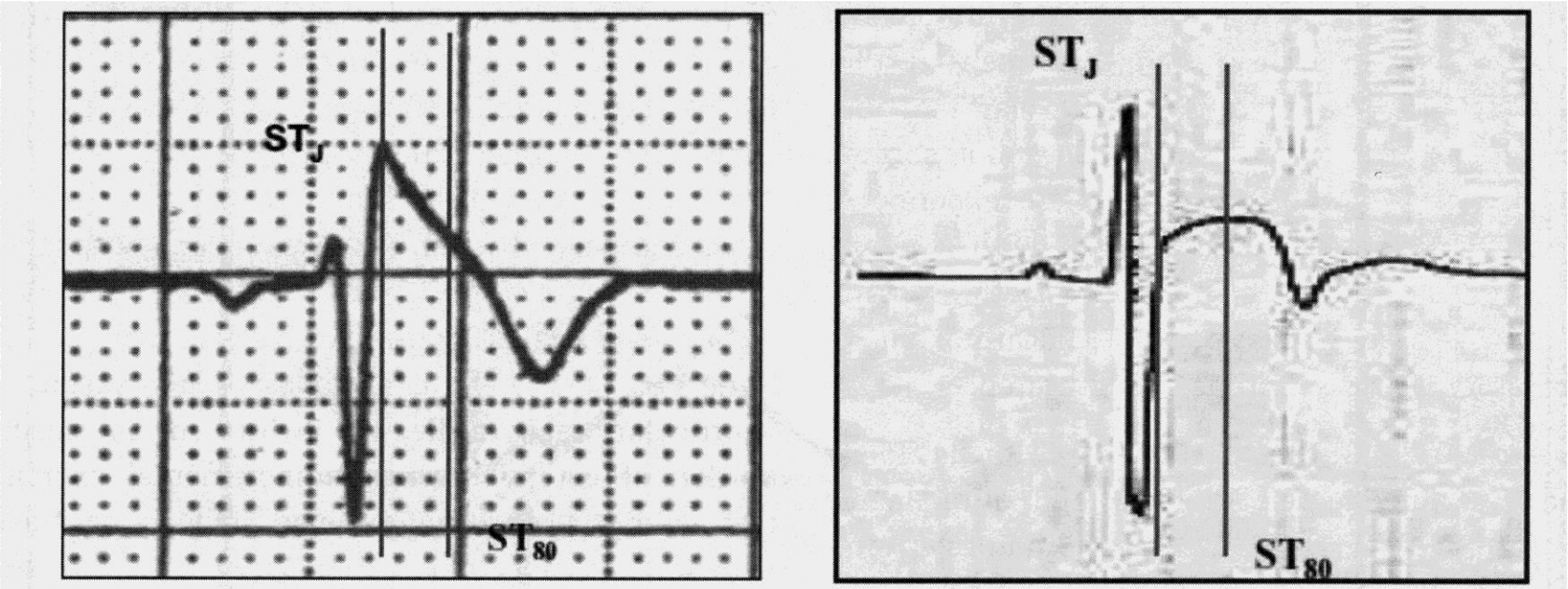


Sanjay Sharma et al. JACC 2017;69:1057-1075

Brugada syndrome

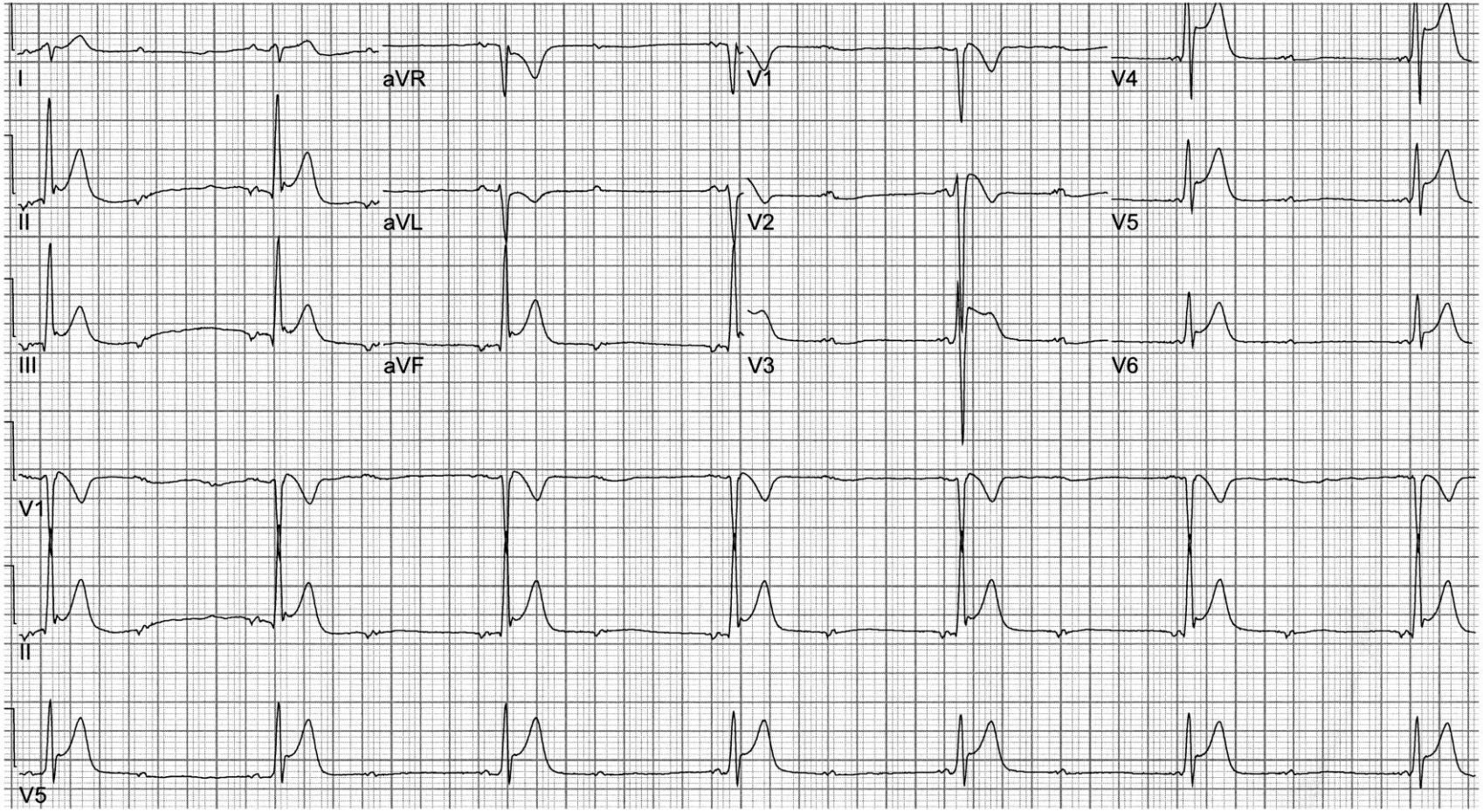
- RBBB pattern with ST segment elevation
- 40-60% of idiopathic V Fib
- Linked to mutations of sodium-channel gene. Loss of action potential dome in RV epicardium, not endocardium.

Brugada vs Early Repolarization

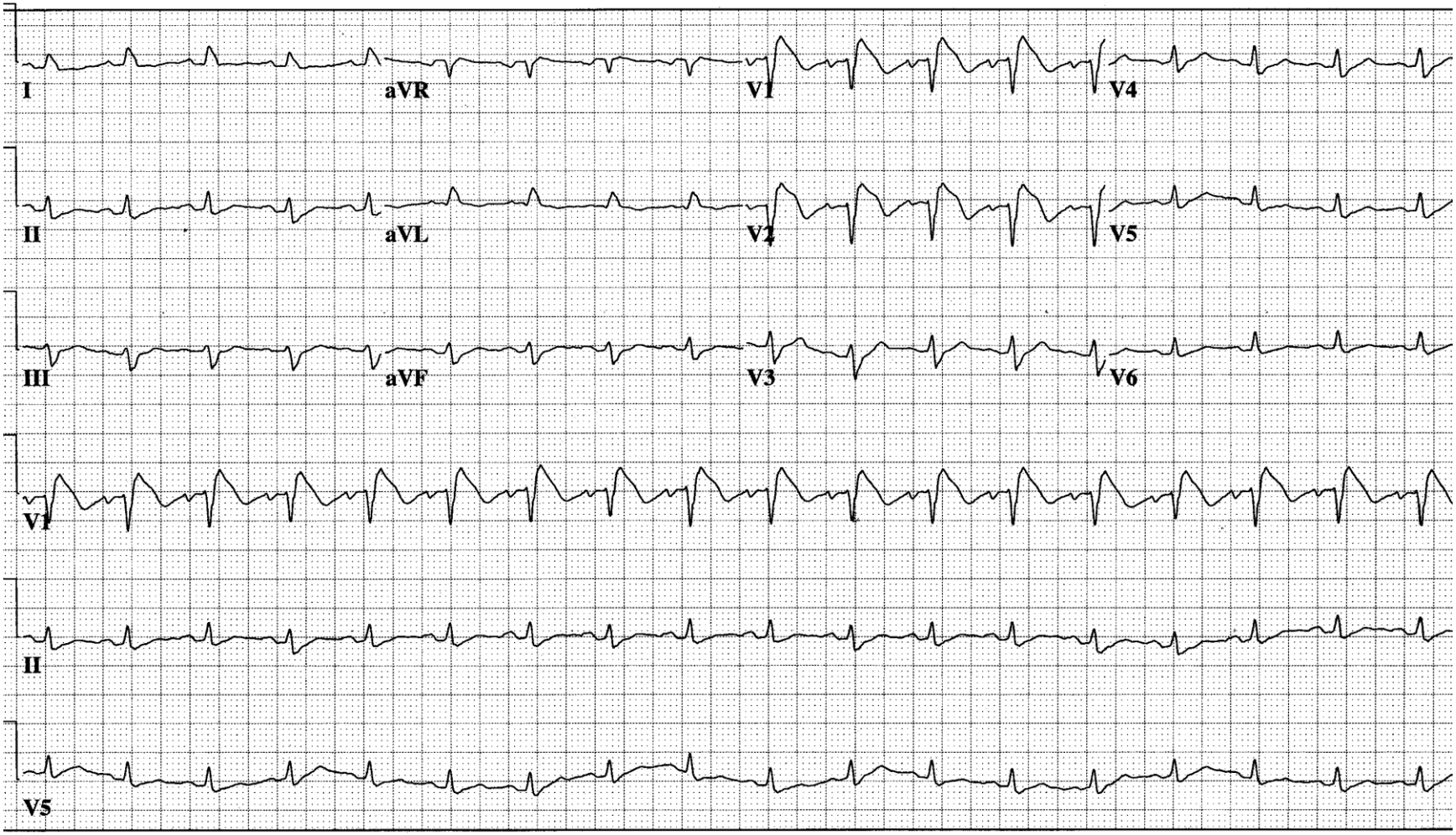


Brugada Type 1 electrocardiogram **(left)** should be distinguished from early repolarization with 'convex' ST-segment elevation in a trained athlete **(right)**. **Vertical lines** mark the J-point (STJ) and the point 80 ms after the J-point (ST80), where the amplitudes of the ST-segment elevation are calculated. The 'downsloping' ST-segment elevation in Brugada pattern is characterized by a STJ/ST80 ratio >1. Early repolarization patterns in an athlete show an initial 'upsloping' ST-segment elevation with STJ/ST80 ratio <1.

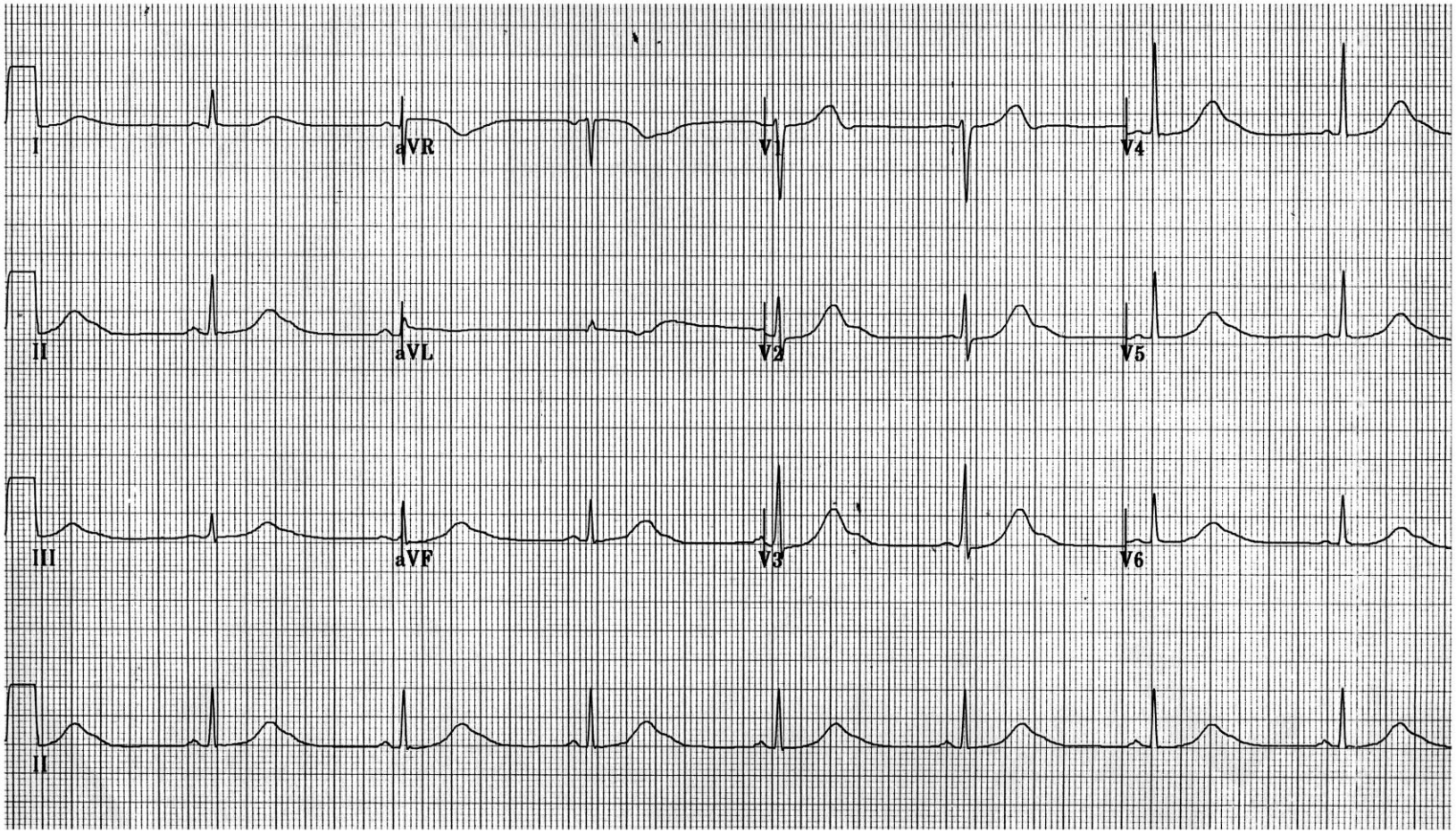
39 y/o found face down in a bar.



Brugada

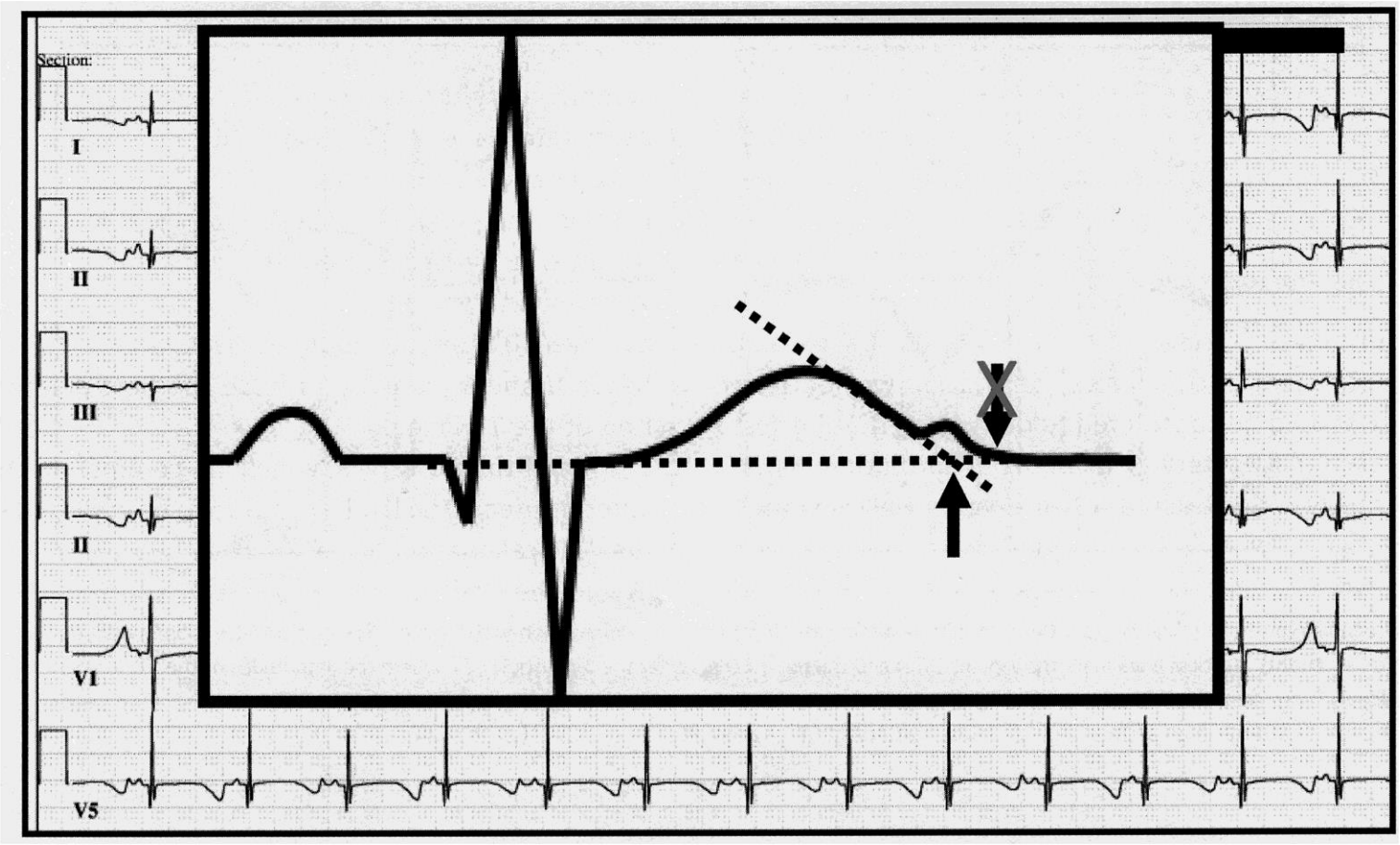


What's the Q-T interval?



Q-T prolongation

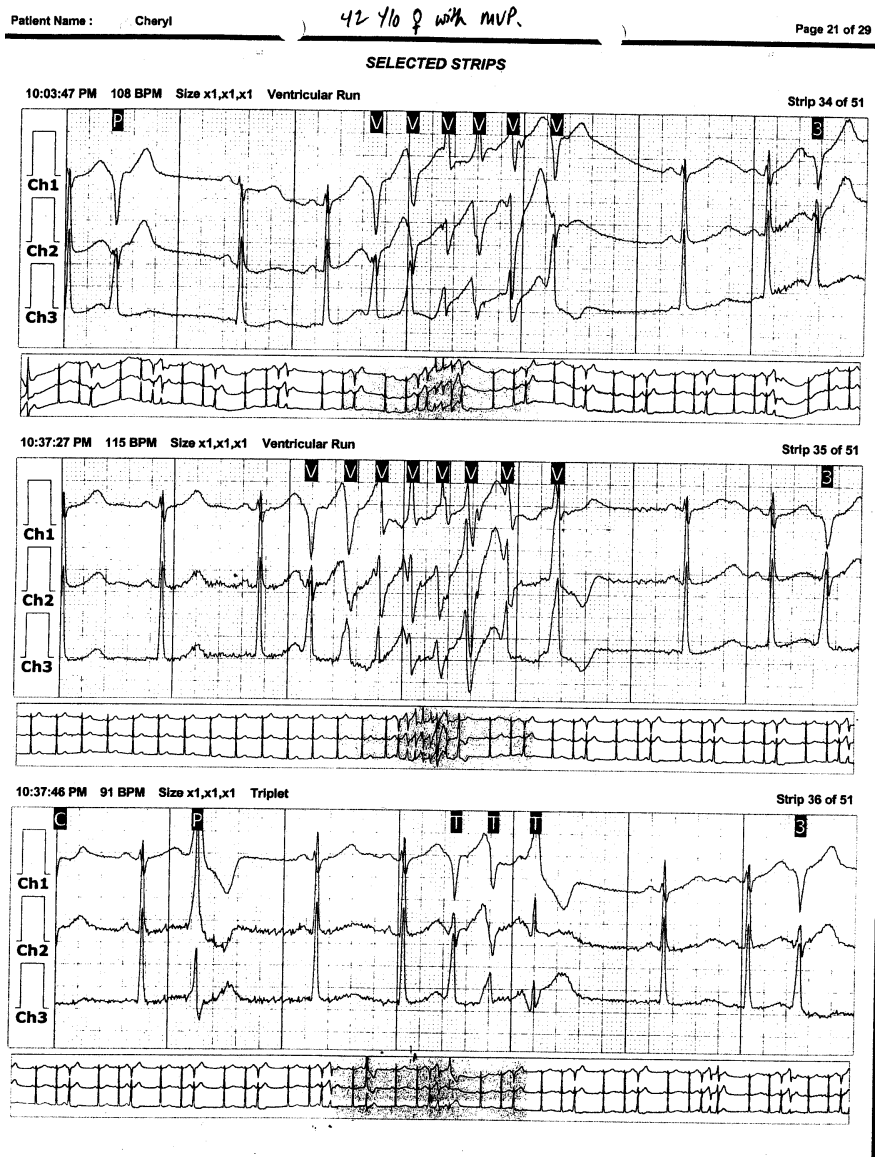
"Teach the Tangent" or "Avoid-the-Tail." Sharma, et al. *JACC* Feb 28, 2017: 1057-75



Dr. Henry Cuthbert Bazett

$$QTc = \frac{\text{QT interval in seconds}}{\sqrt{\text{cardiac cycle in seconds}}} = \frac{QT}{\sqrt{RR}}$$

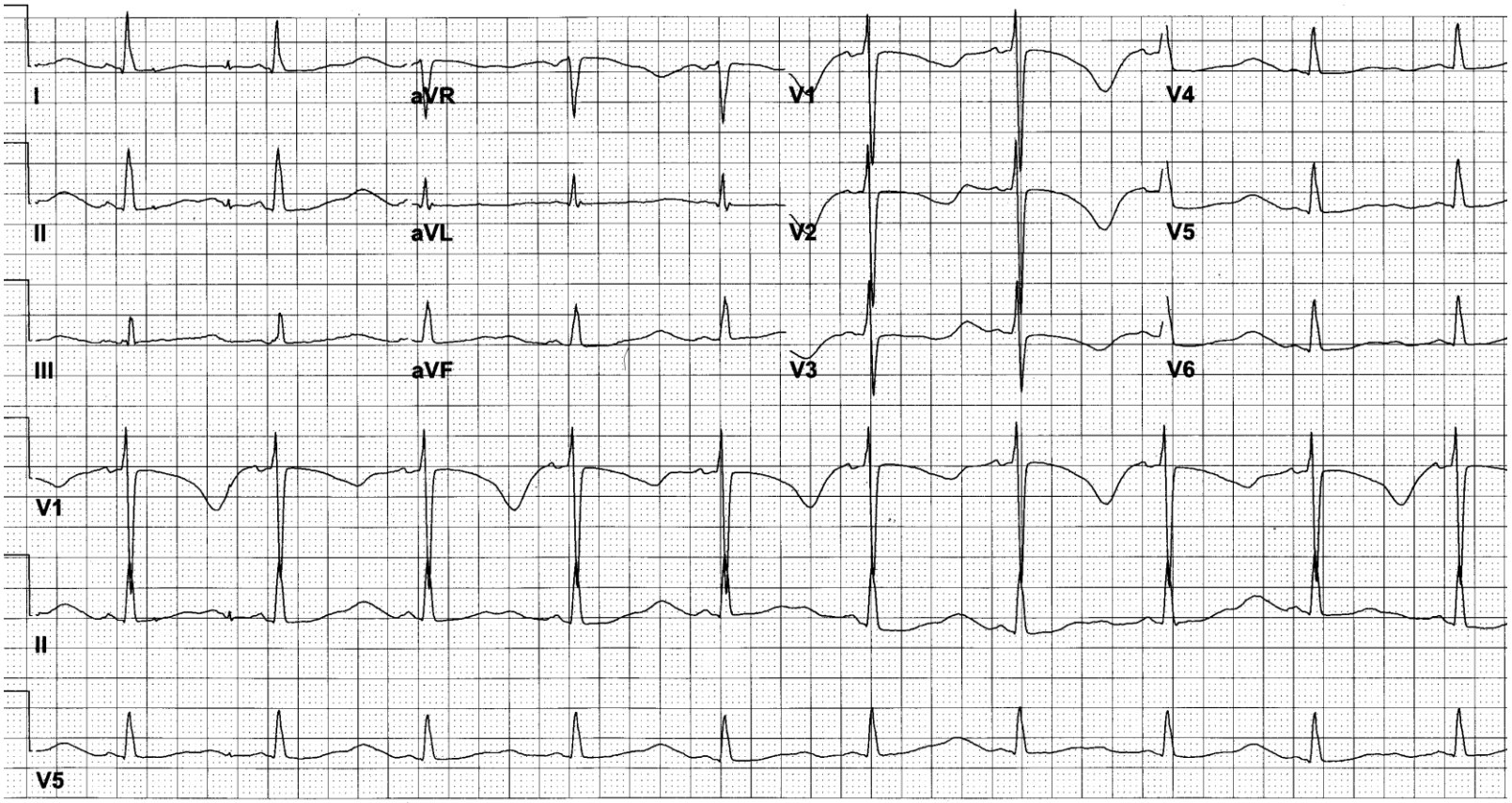
Patient No. 3


Patient Name : Cheryl
42 y/o ♀ with MVP.
Page 21 of 29
SELECTED STRIPS
10:03:47 PM 108 BPM Size x1,x1,x1 Ventricular Run
Strip 34 of 51
Ch1
Ch2
Ch3
10:37:27 PM 115 BPM Size x1,x1,x1 Ventricular Run
Strip 35 of 51
Ch1
Ch2
Ch3
10:37:46 PM 91 BPM Size x1,x1,x1 Triplet
Strip 36 of 51
Ch1
Ch2
Ch3

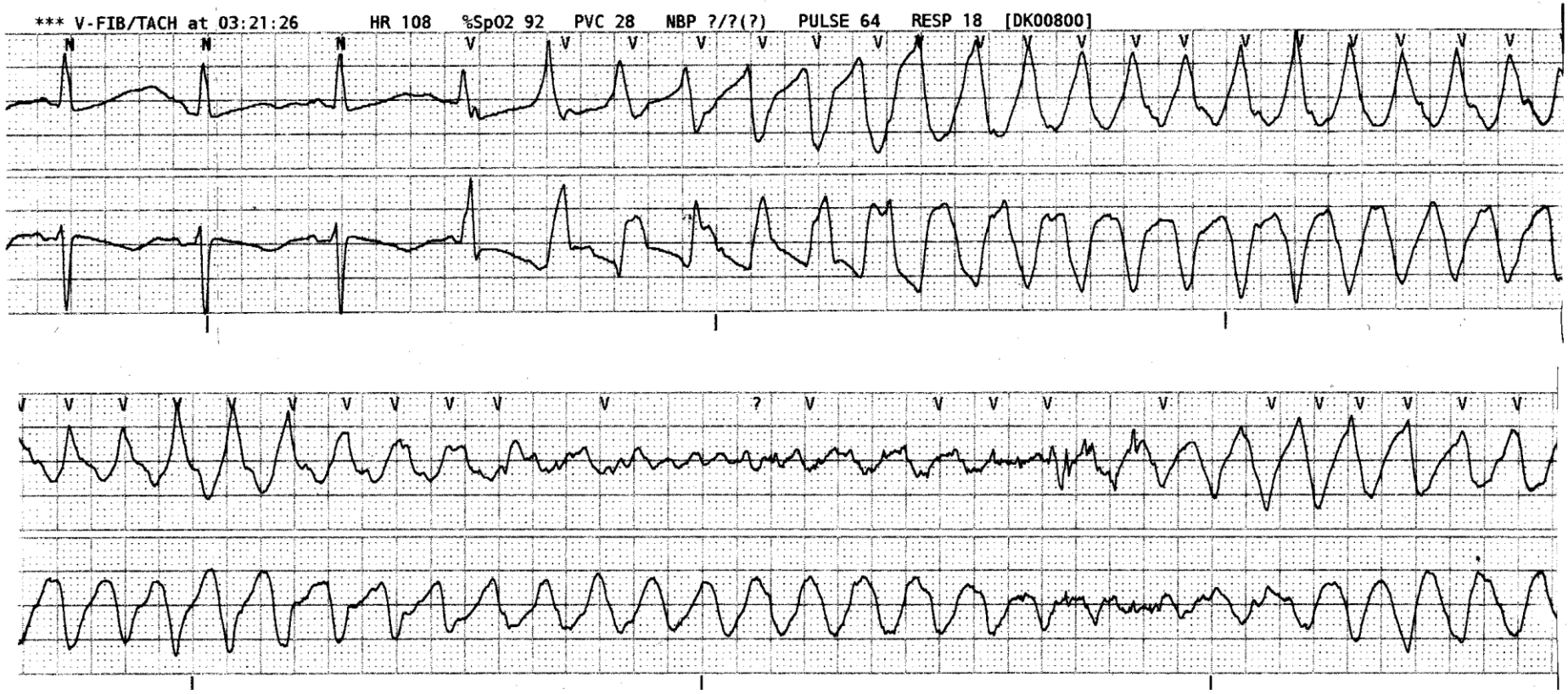
Case presentation

- EB is a 61 year old woman who presented to HFWH on July 29 after a syncopal spell.
- She started hemodialysis in January, had liver failure in February and was started on citalopram in March.
- She began to get confused 6 weeks later, and then had major mental status changes 6 days PTA.

EB, after cardiac arrest in emergency room

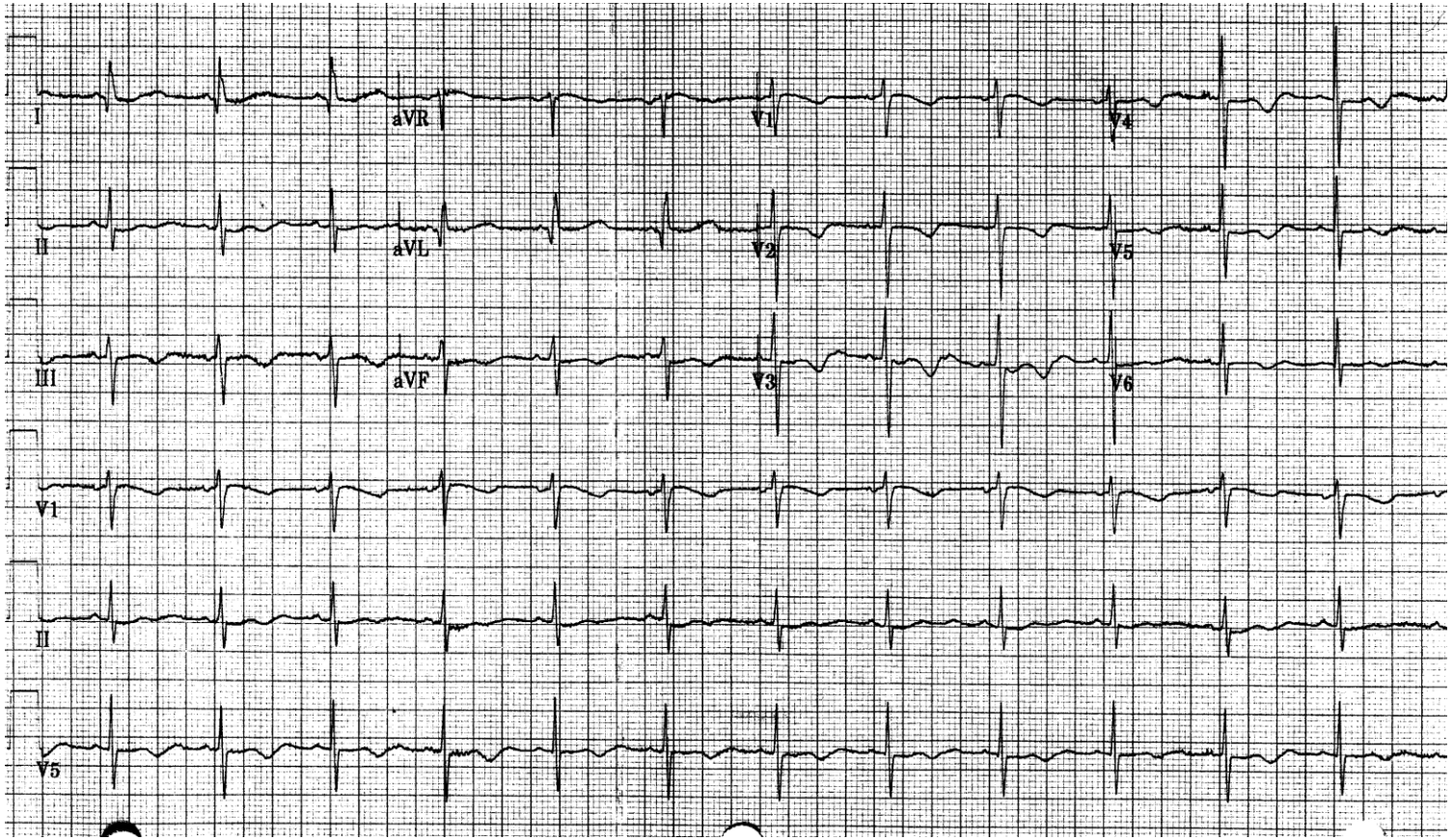


Then she did this several times:

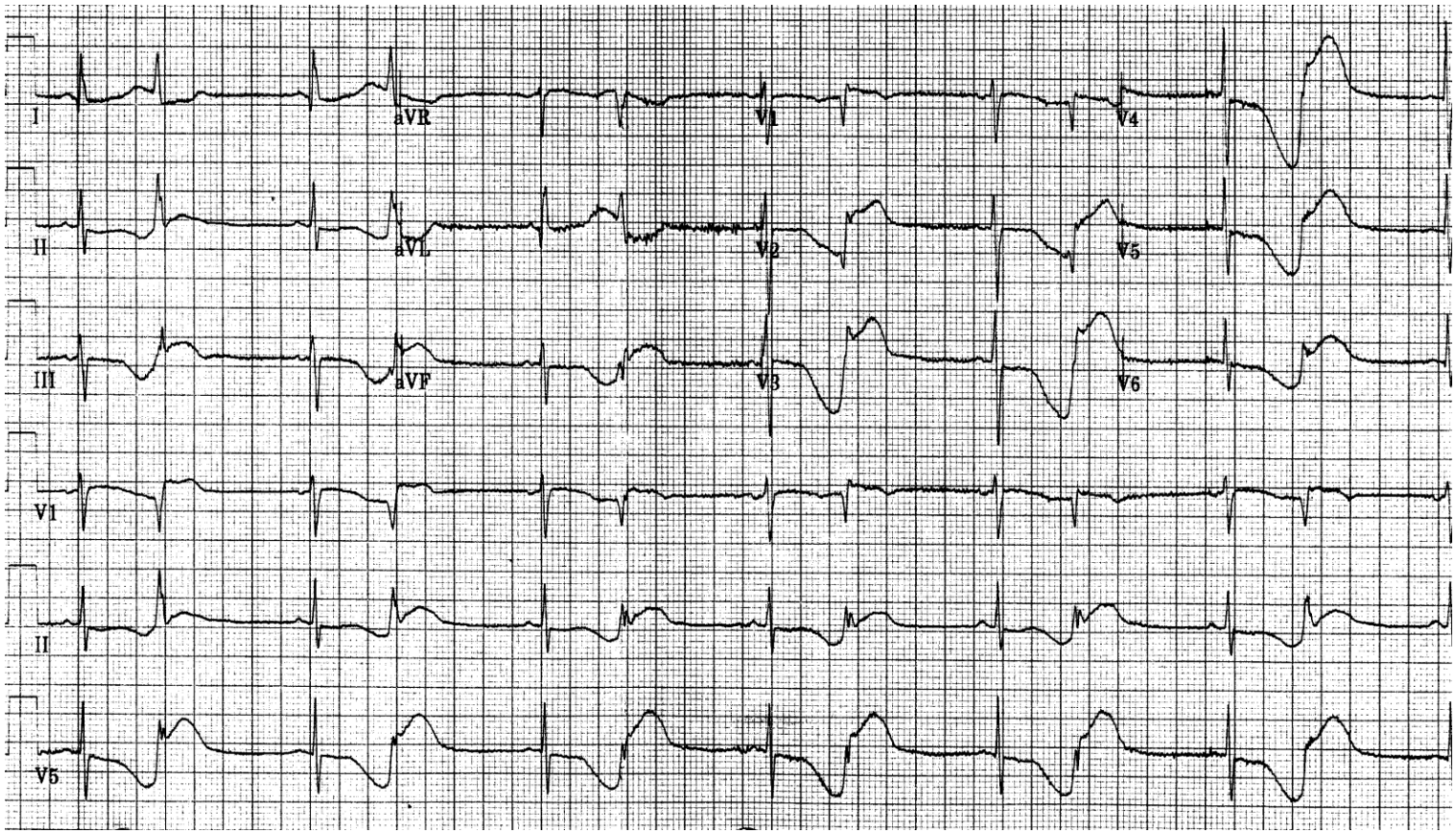


The EKG of the Century

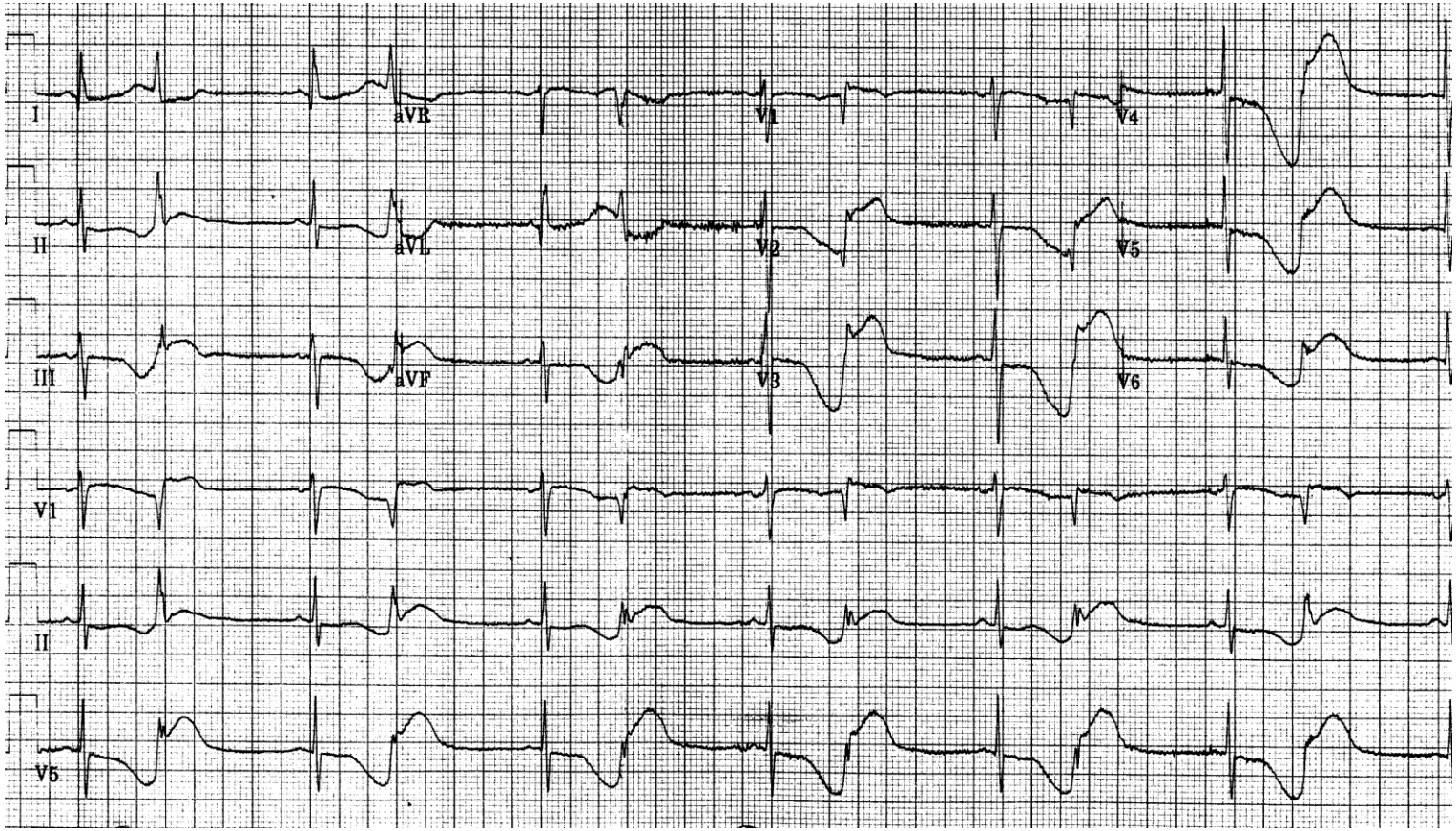
Patient C.L.
Feb 7, 2012. 4:43 PM



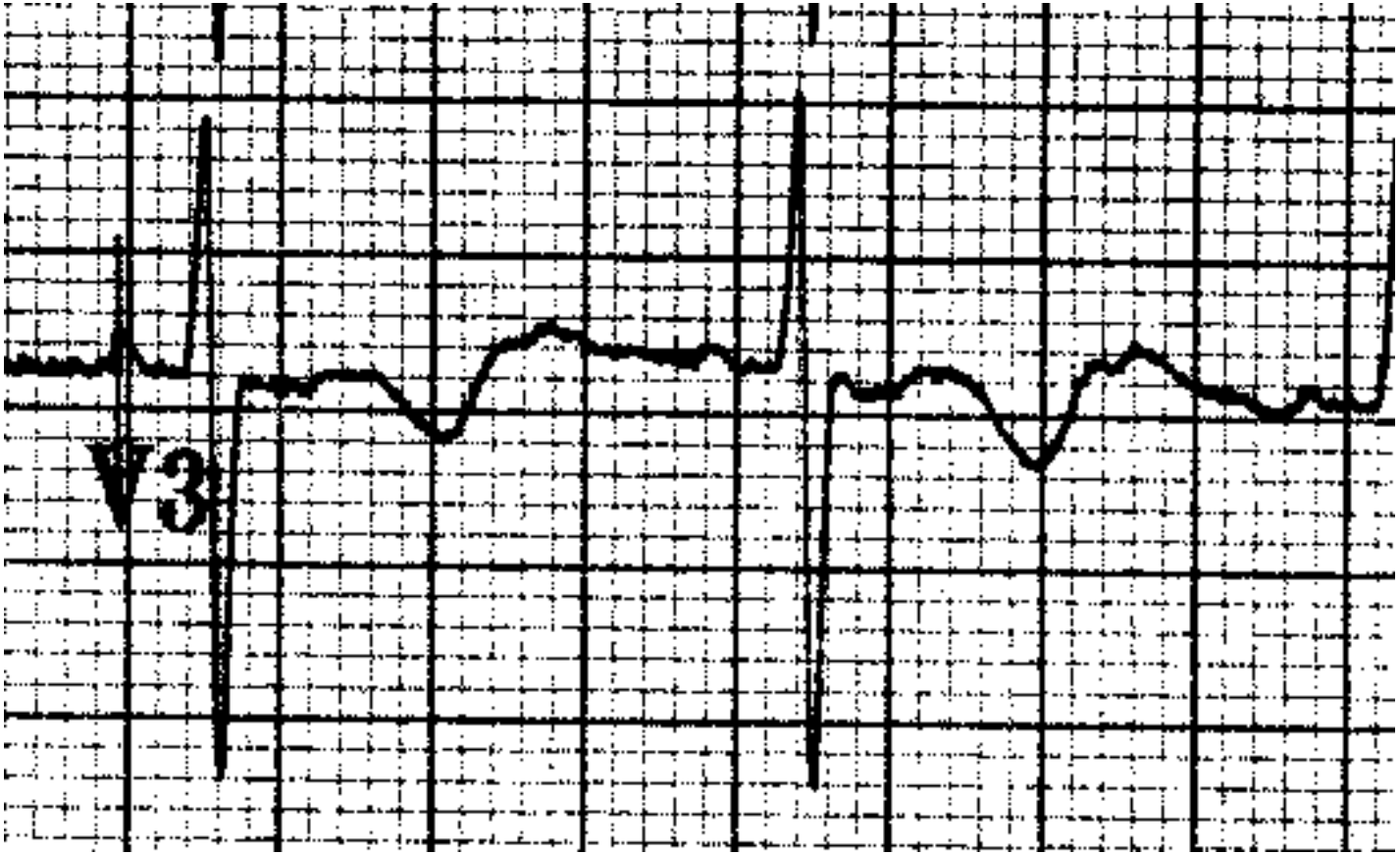
Patient C.L.
A few seconds later



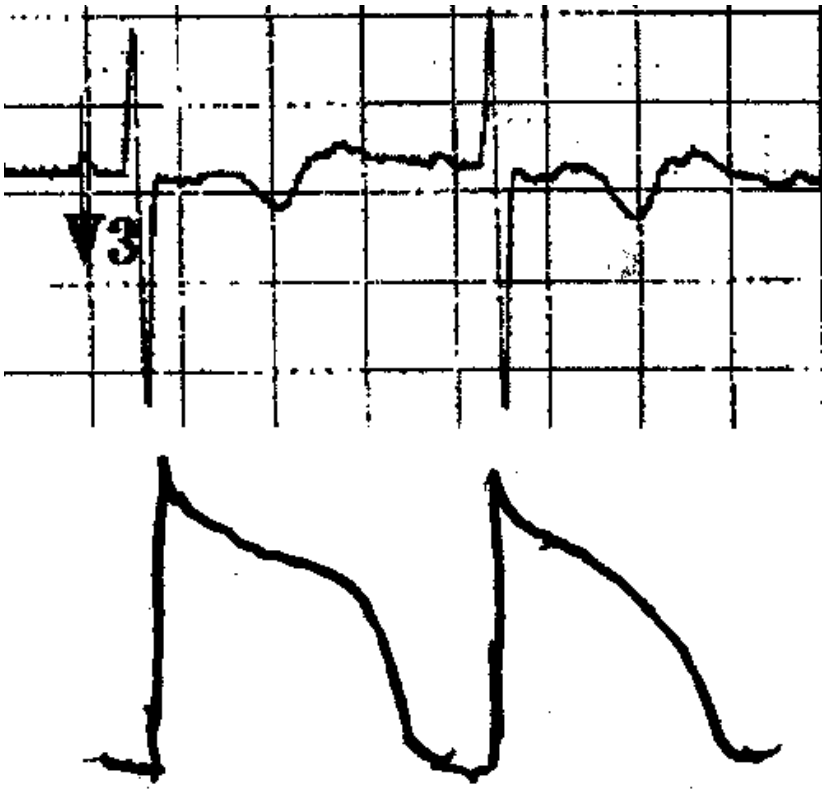
Patient C.L.
STEMI alternans?



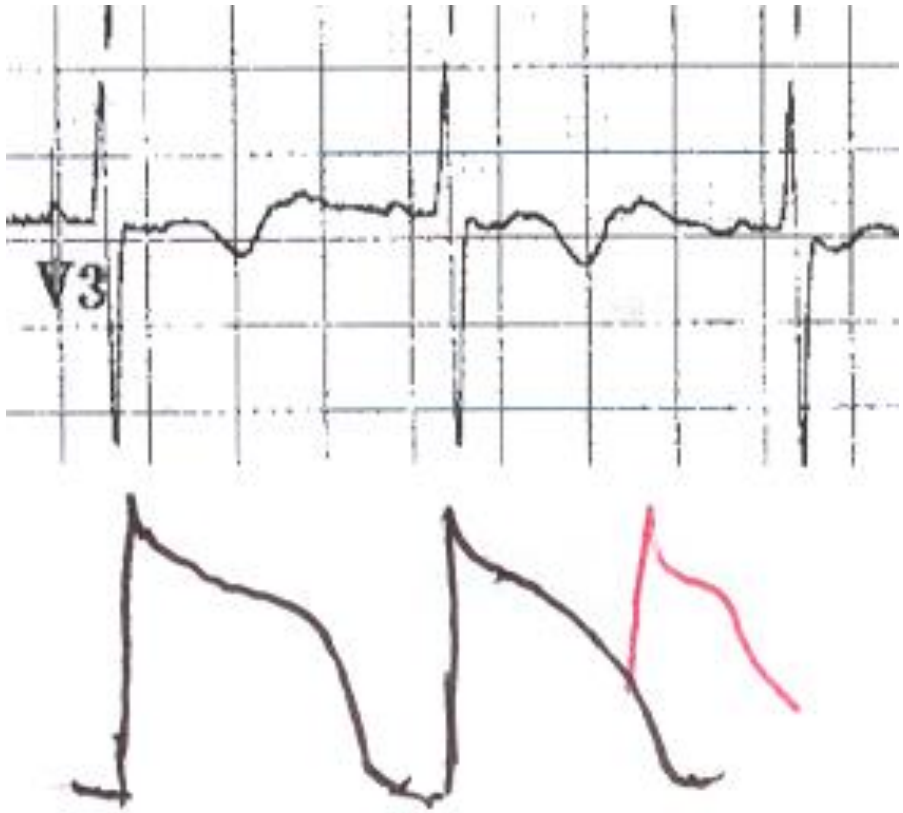
EKG without ectopy



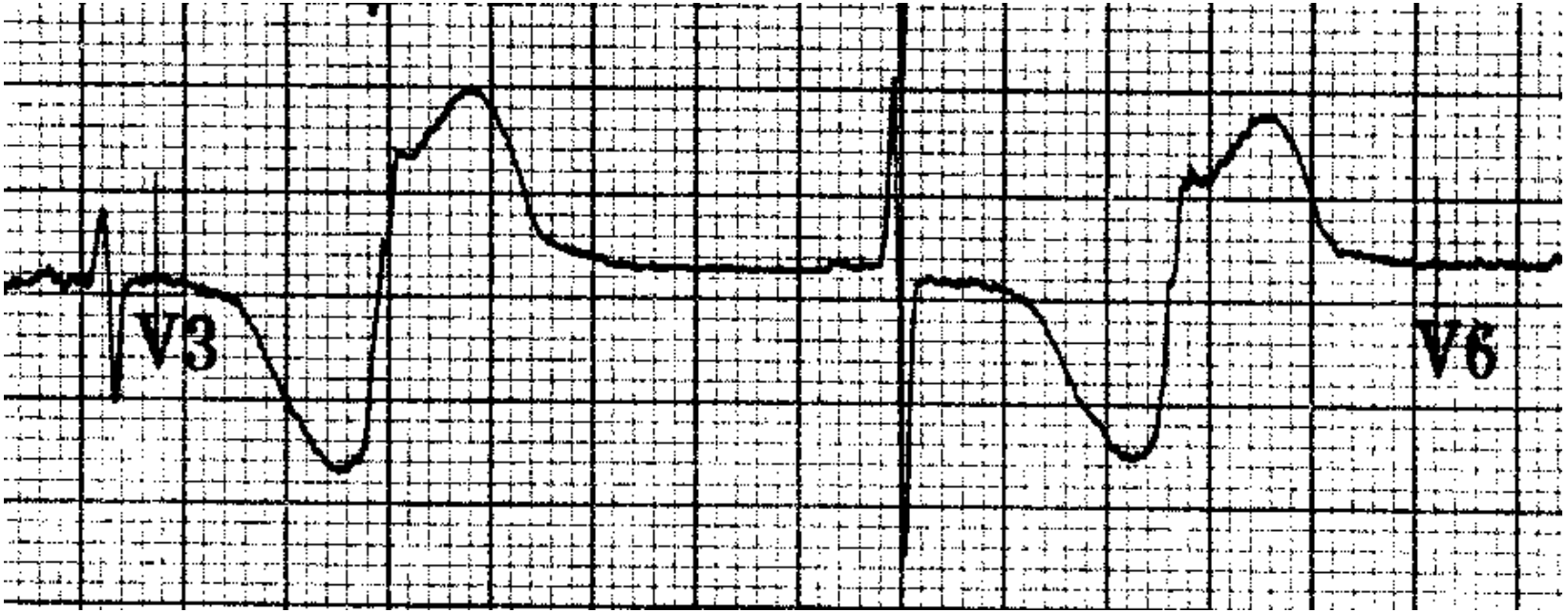
EKG without ectopy superimposed action potential



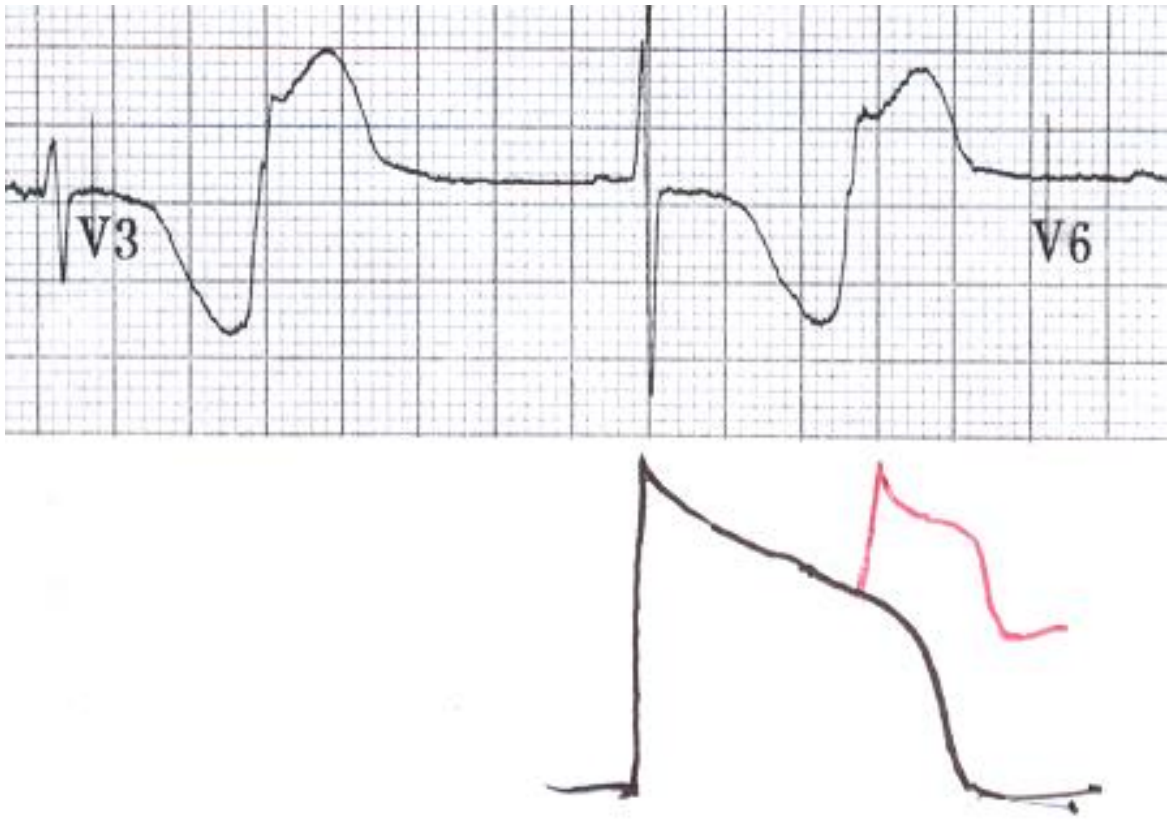
EKG with ectopy on superimposed action potential



EKG with ectopy



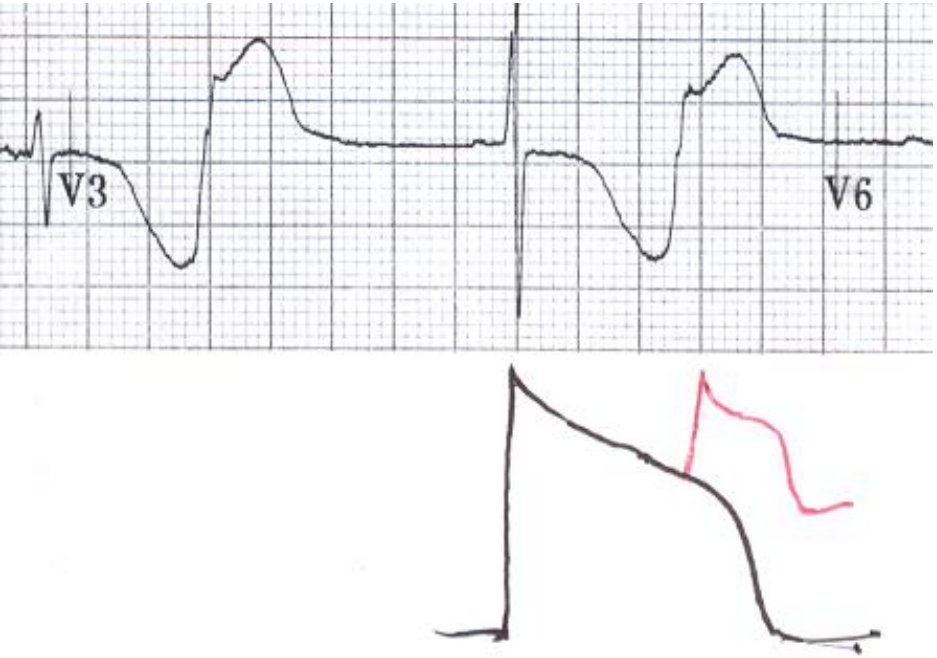
EKG with ectopy action potential

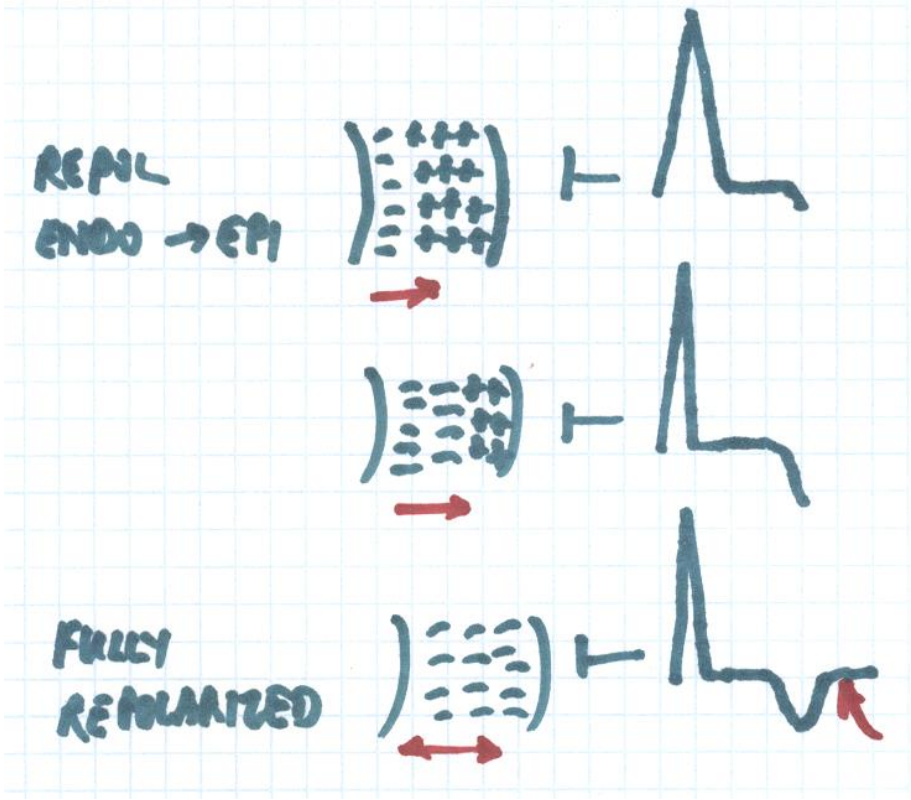


Summary

- Refine your knowledge of high risk angina
- Assess STEMI re infarct size, location of occlusion
- Abandon the idea that LBBB is a STEMI
- ST elevation, but not MI
- Athletes
- Brugada
- Prolonged Q-T

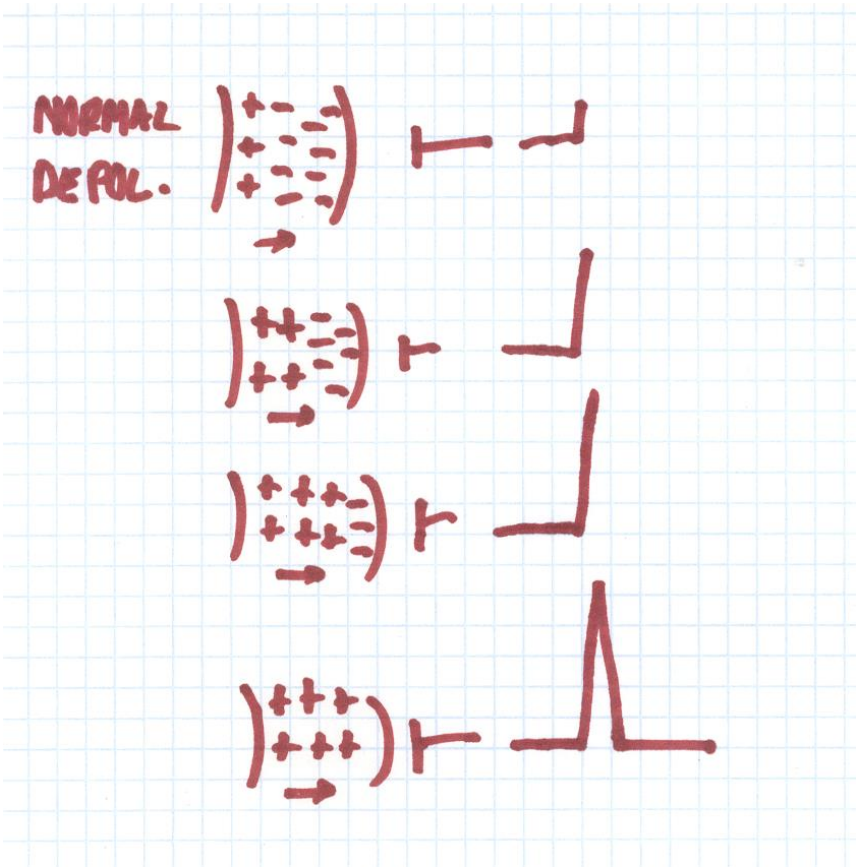
EKG with ectopy
action potential



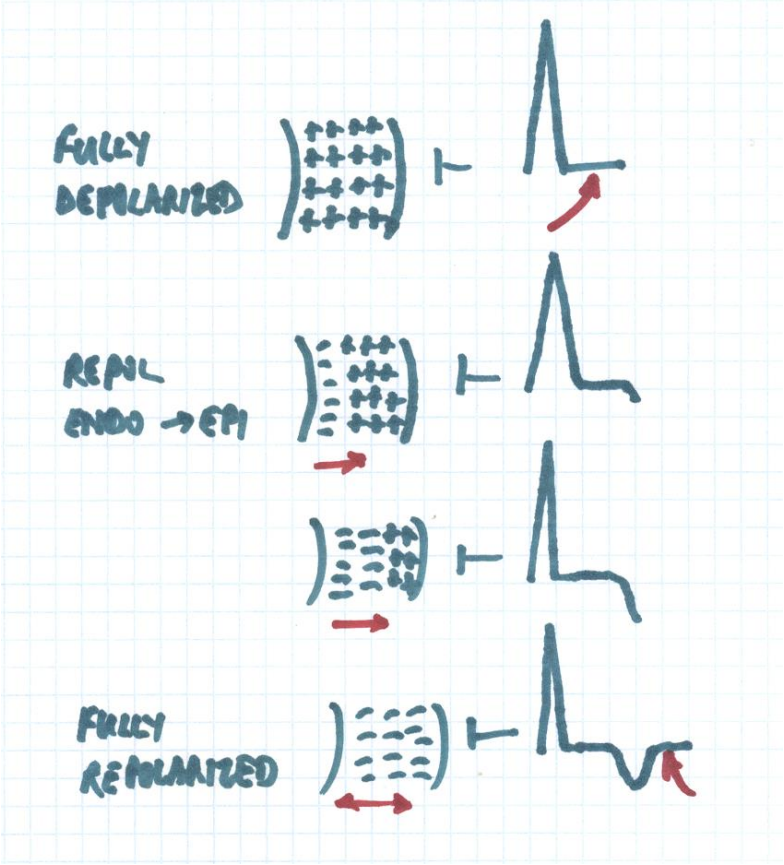


A slab of LV at rest

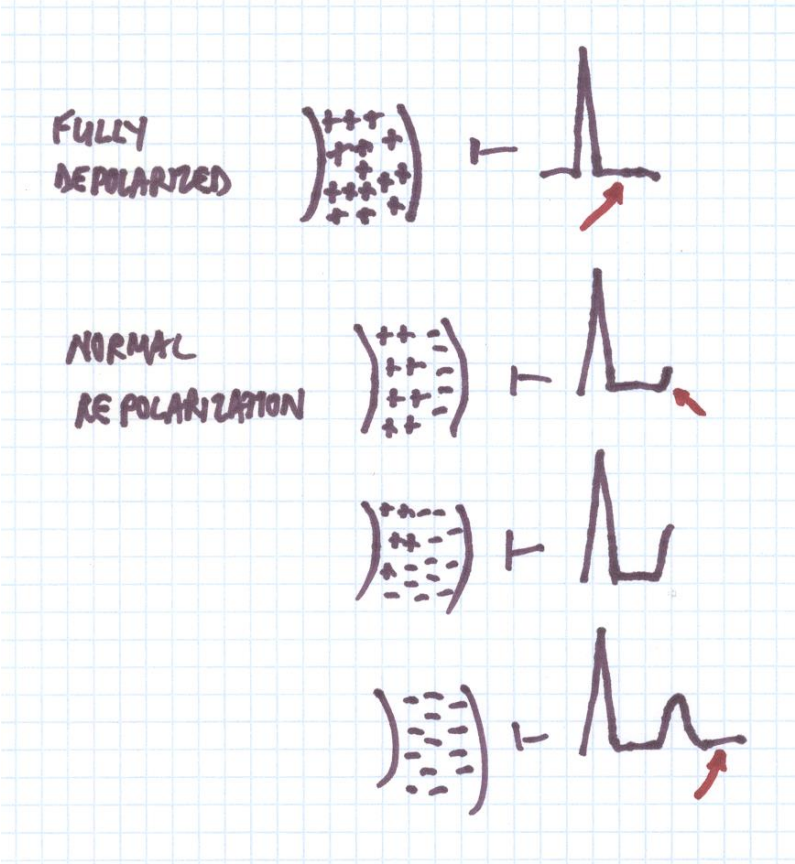
Normal depolarization



Depolarization
subendo to subepicardium



Depolarization subepicardium to subendo



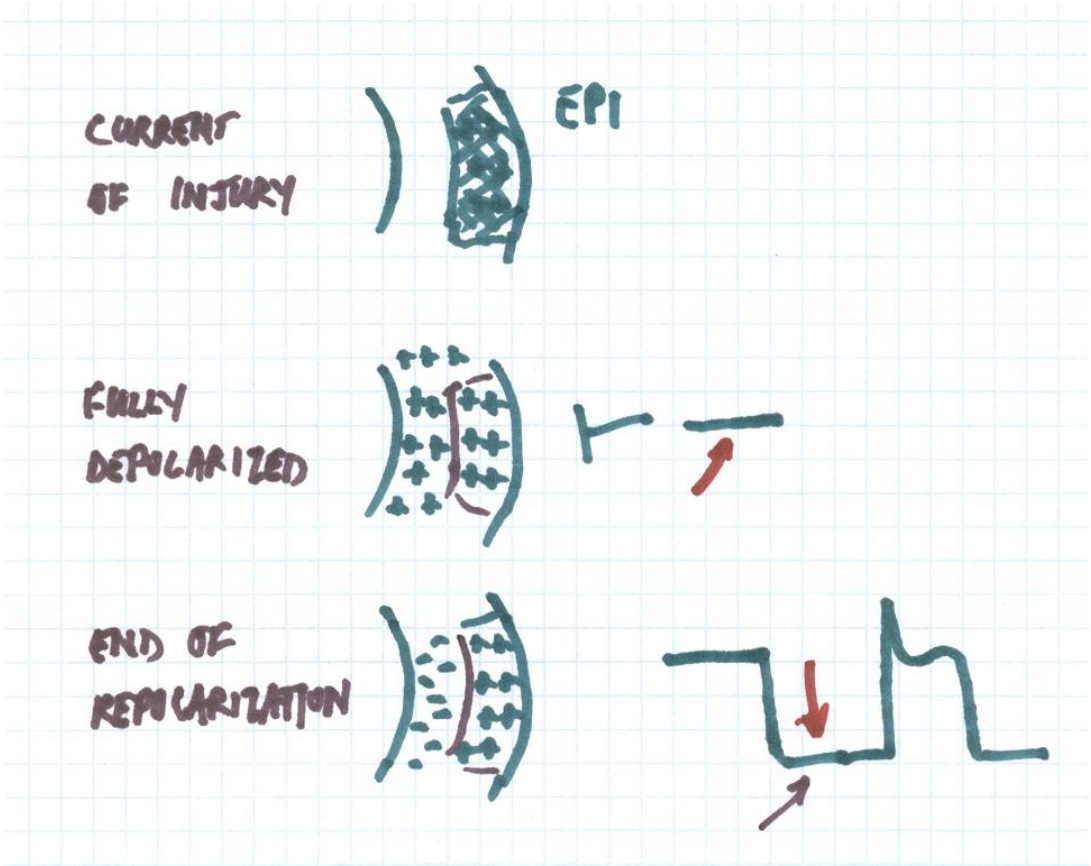
Primary T wave changes

- NORMAL QRS
- Subepicardial ischemia causes a delay in the repolarization
- The wavefront of repolarization proceeds from subendocardium to subepicardium

Injury patterns

- Subendocardial injury
- Subepicardial injury

Subepicardial injury



How our patient combines both

Patient C.L.
A few seconds later