Intermediate ECG Interpretation

James J. Jones, PhD, PA-C
Branch Chief, Interservice Physician Assistant Program

Cardiology Professor
Active Duty Lieutenant Colonel (Promotable)

Disclosure of Financial Relationships

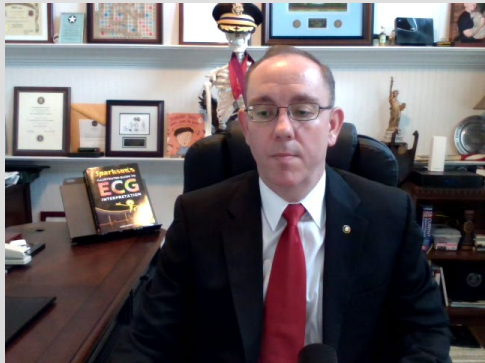
- I have no affiliation or financial interest to disclose.
- This talk is my opinion and in no way represents the policy or opinions of the White House, US Army, or the Department of Defense.

Course Description:

- This session will include conduction abnormalities, probability of supraventricular versus ventricular tachycardia, and describe clinical significance. Discussion will include the clinical significance of electrical deflections on ECG, ECG changes in relation to physiological events, QRS axis shifts in relation to various disease states, ECG patterns for presence of myocardial ischemia, injury and infarction, presence of conduction abnormalities indicating bundle branch blocks probability of supraventricular (SVT) vs. ventricular tachycardia (VT), and causes, clinical presentation and treatments for QT prolonga

Learning Objectives:

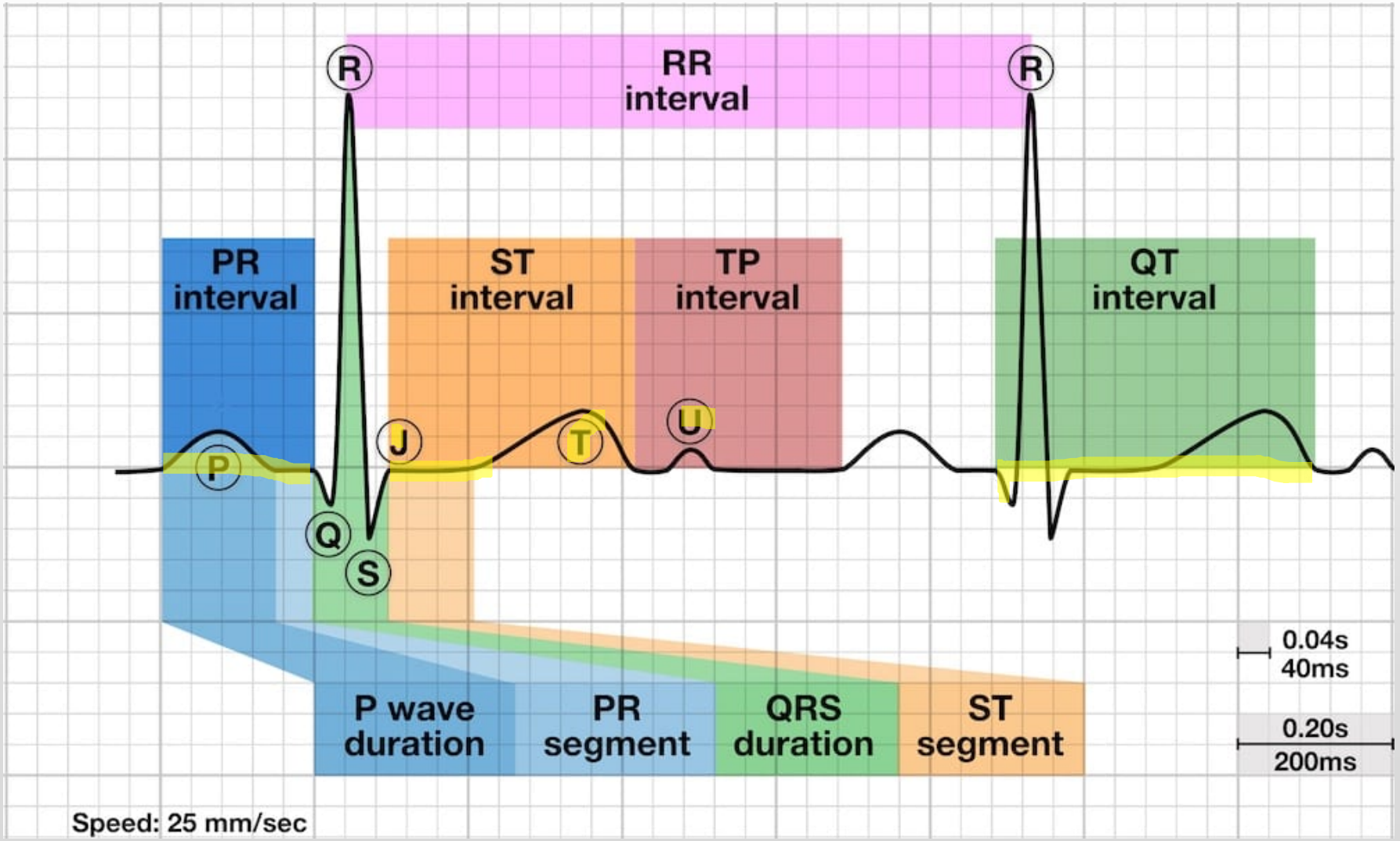
- At the end of this session, participants should be able to:
  - Describe clinical significance of electrical deflections on ECG
  - Review ECG changes in relation to physiological events
  - Analyze QRS axis shifts in relation to various disease states
  - Evaluate ECG patterns for presence of myocardial ischemia, injury and infarction
  - Determine the presence of conduction abnormalities indicating bundle branch blocks



Systematic approach to ECG Interpretation

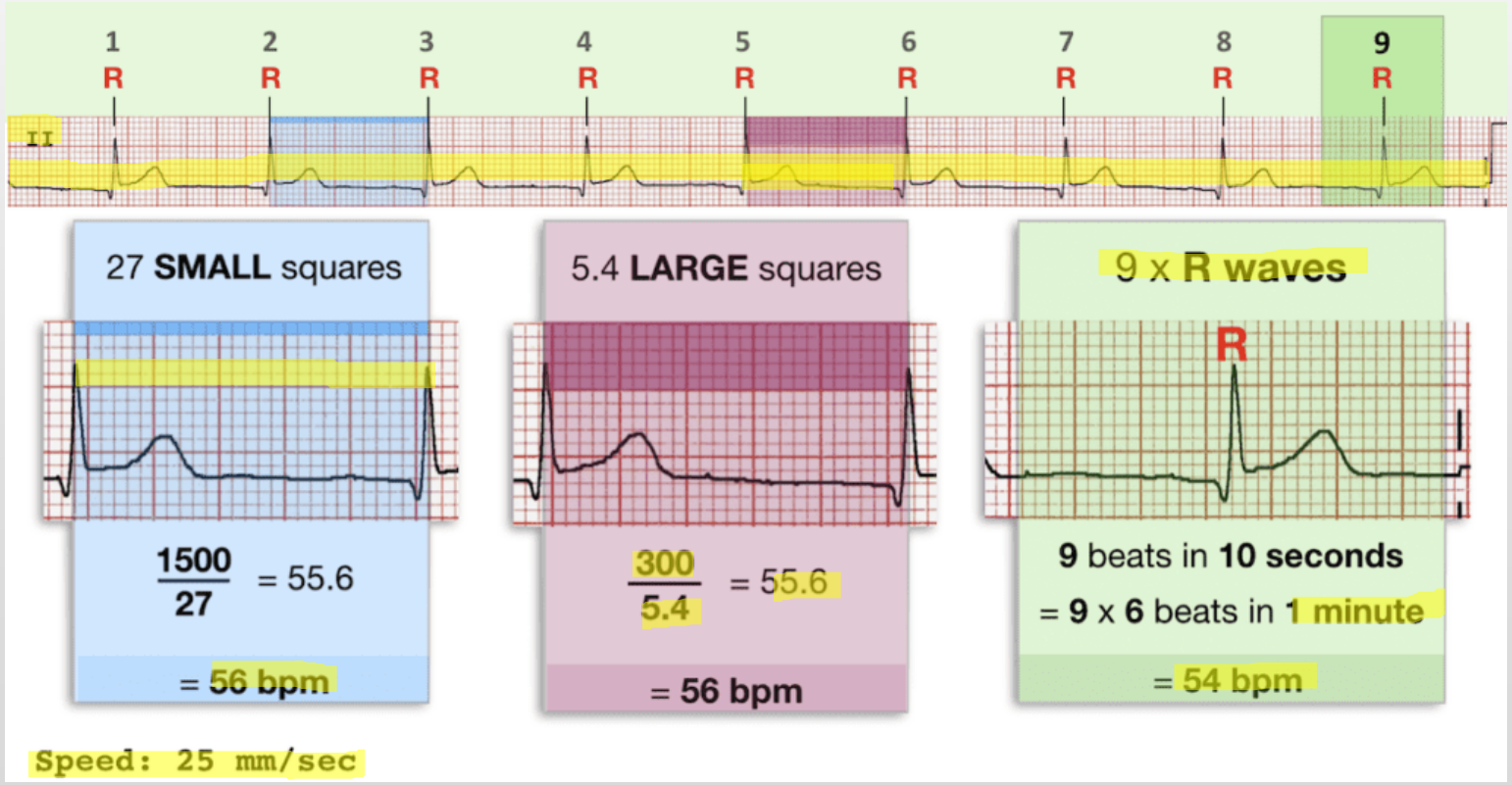
- Step 1. Assess the Rate and Rhythm
- Step 2. Assess the QRS axis and QRS morphology
- Step 3. Assess the ST segments, T Waves, and Interval

Review of deflections on ECG



Step 1: What is the Rate and Rhythm?

- Normal 60 – 100/min
- Tachycardia or bradycardia (SA node) vs –arrhythmia (not SA node)
- Method: 300/RR interval (large squares) or number of QRS complexes x 6 (if 25mm/s)



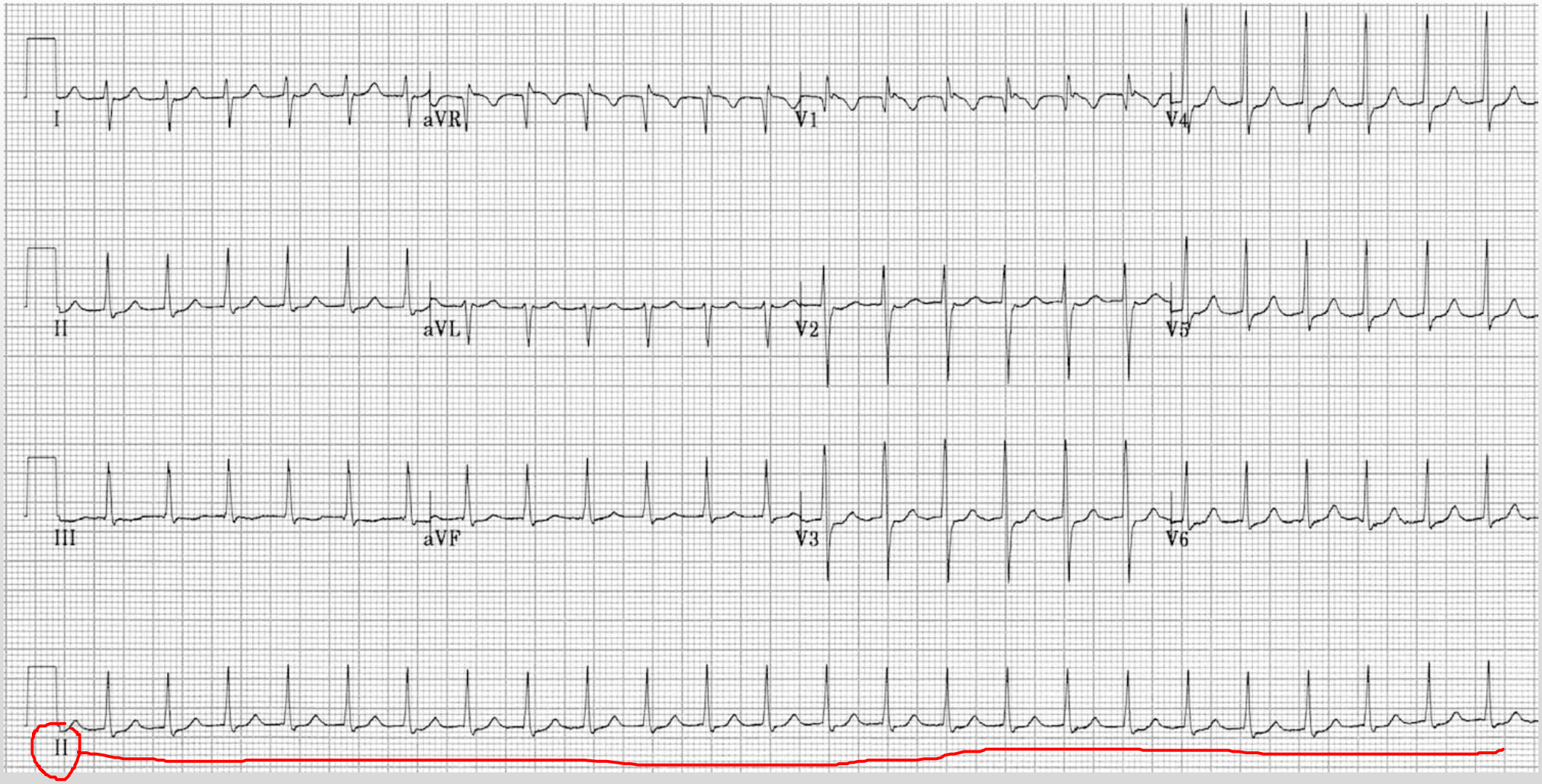
Step 1 (Assess the Rate and Rhythm)

- Determine if the rate is normal, tachycardiac, or bradycardic

- For adults, normal resting heart rate (60-100).

- Clinic pearls:
  - Maximum sinus rate = 220 - patient age
  - A rate of 140-150 bpm suggest possibility of atrial flutter with 2:1 AV block

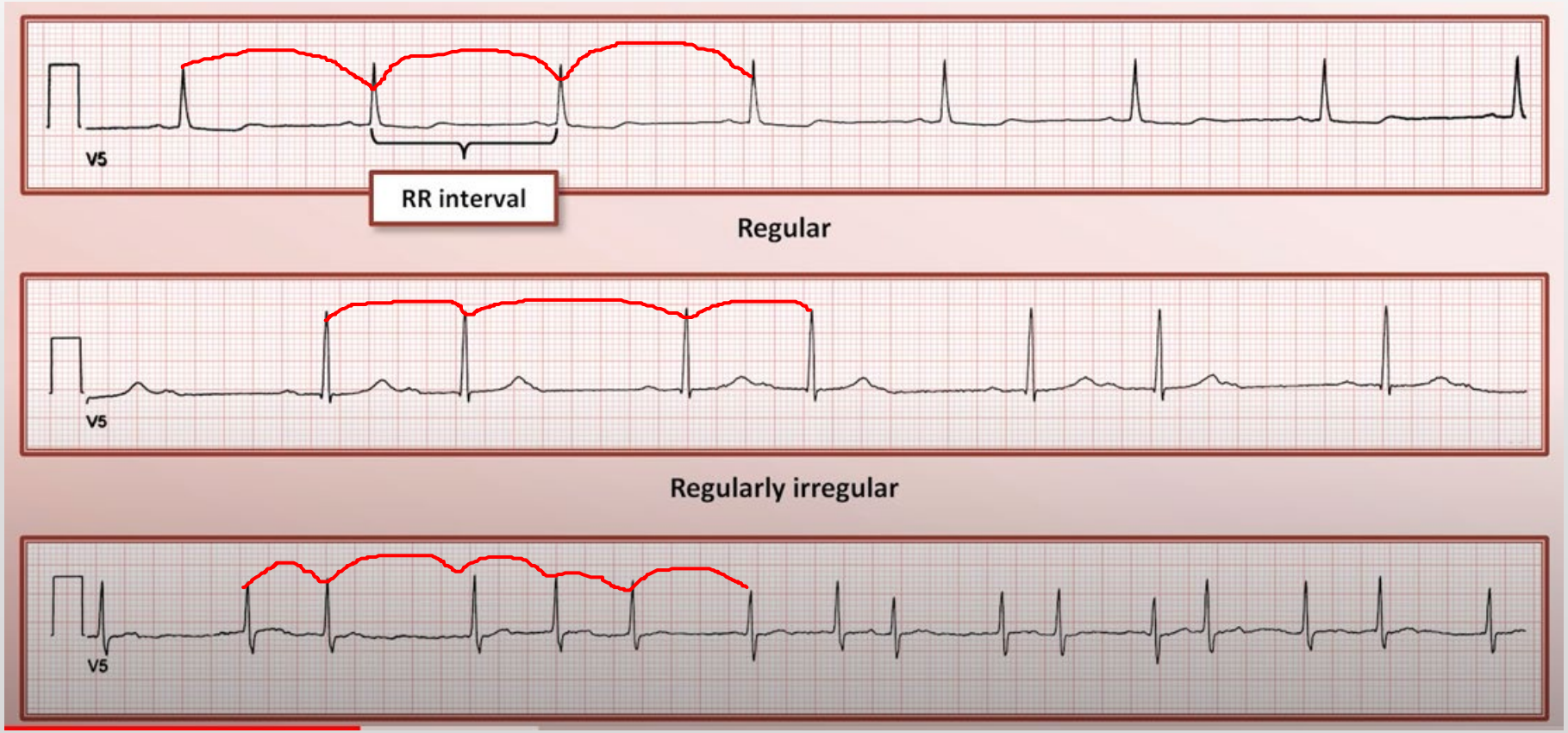
Example: What is the Rate? Count the R Waves in Lead II. 24 X 6 = 144!



Step 1: What is the ventricular rhythm? Assess the Rate and Rhythm

Pattern of QRS complexes

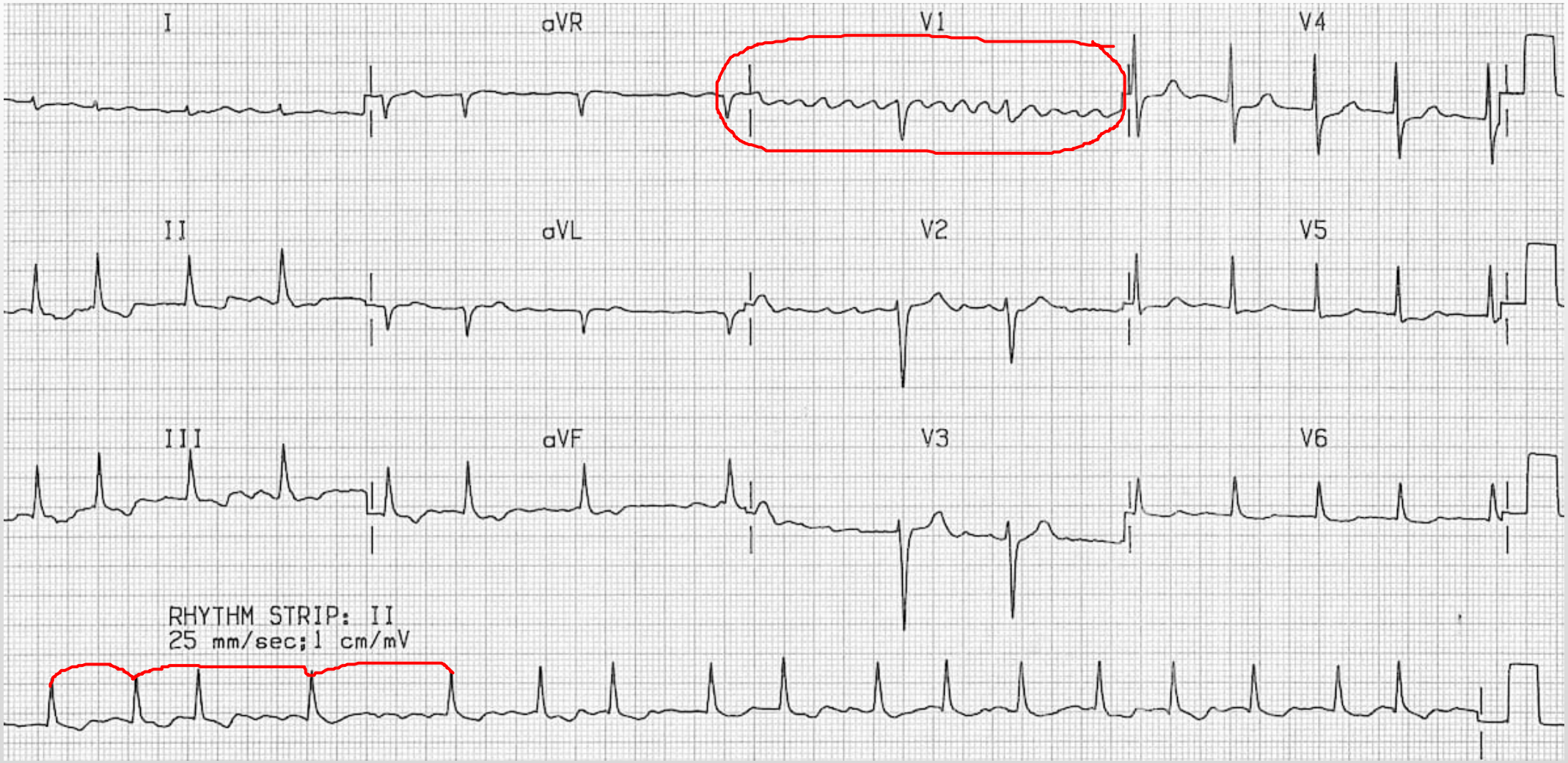
- Regular or irregular? Is it regularly irregular or irregularly irregular?



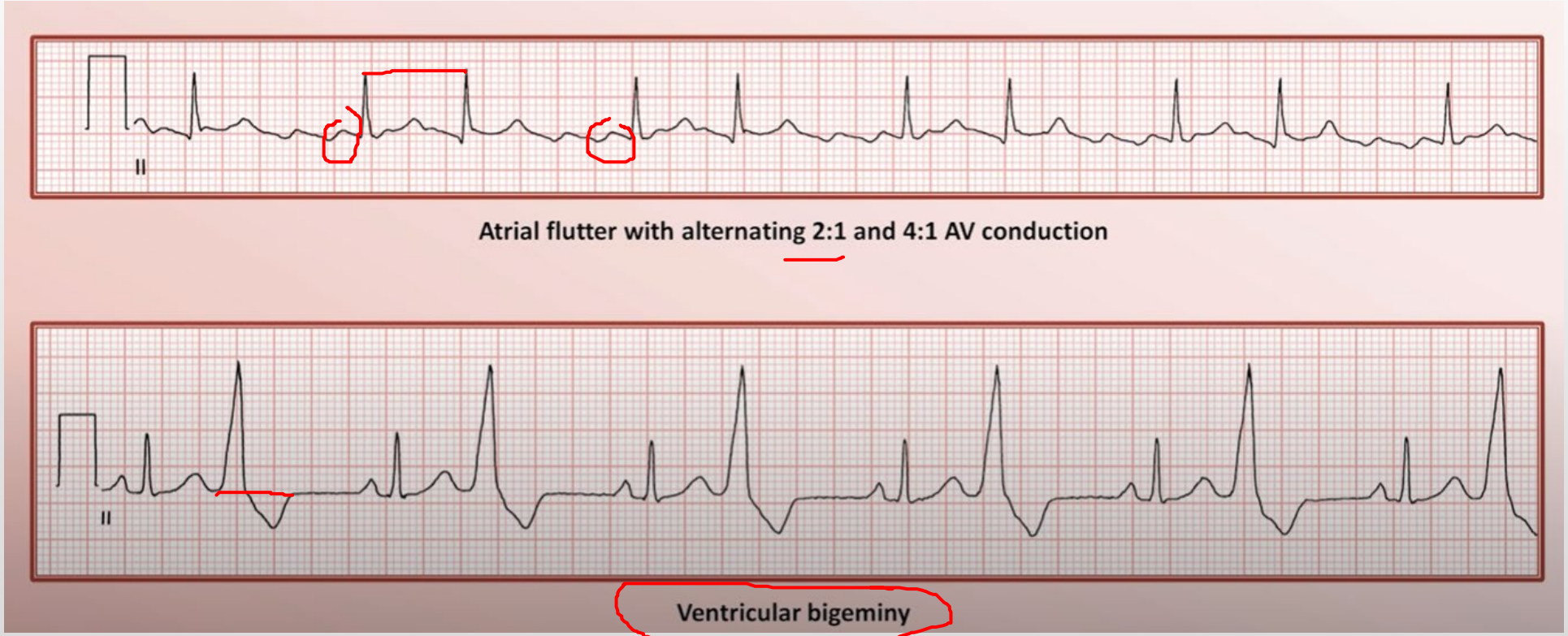
Regularly Irregular vs Irregulary Irregular
Step 1: Assess the Rate and Rhythm

	Regularly Irregular			Irregularly Irregular		
	Bradycardia	Normal Rate	Tachycardia	Bradycardia	Normal Rate	Tachycardia
Sinus Arrhythmia				X	X	X
Atrial Fibrillation				X	X	X
Atrial Flutter			X (2:1 alt. with 4:1 conduction, net HR ≈ 100 bpm)	X (uncommon)	X	X
Multifocal atrial tachycardia						X
2nd degree AV block, type 1	X	X	X			
2nd degree AV block, type 2				X	X	
Atrial / ventricular bigeminy/trigeminy	X (uncommon)	X	X			

Example: Irregularly Irregular -Is this?
Atrial Fibrillation, Atrial Flutter, Multifocal Atrial Tachycardia



Is the Rate and Rhythm coming from Atria or the Ventricles?



Step 1: Assess the Rhythm (QRS Complex)

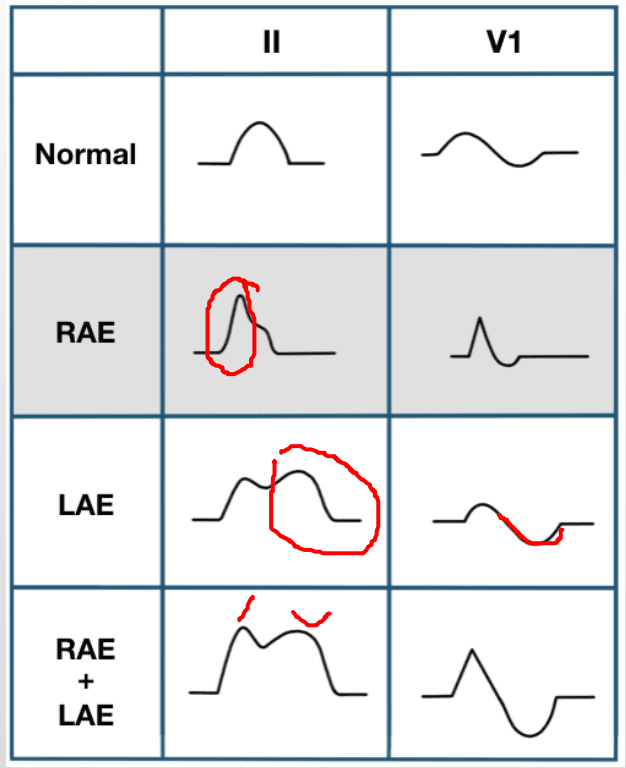
- Is the QRS Narrow or Wide?

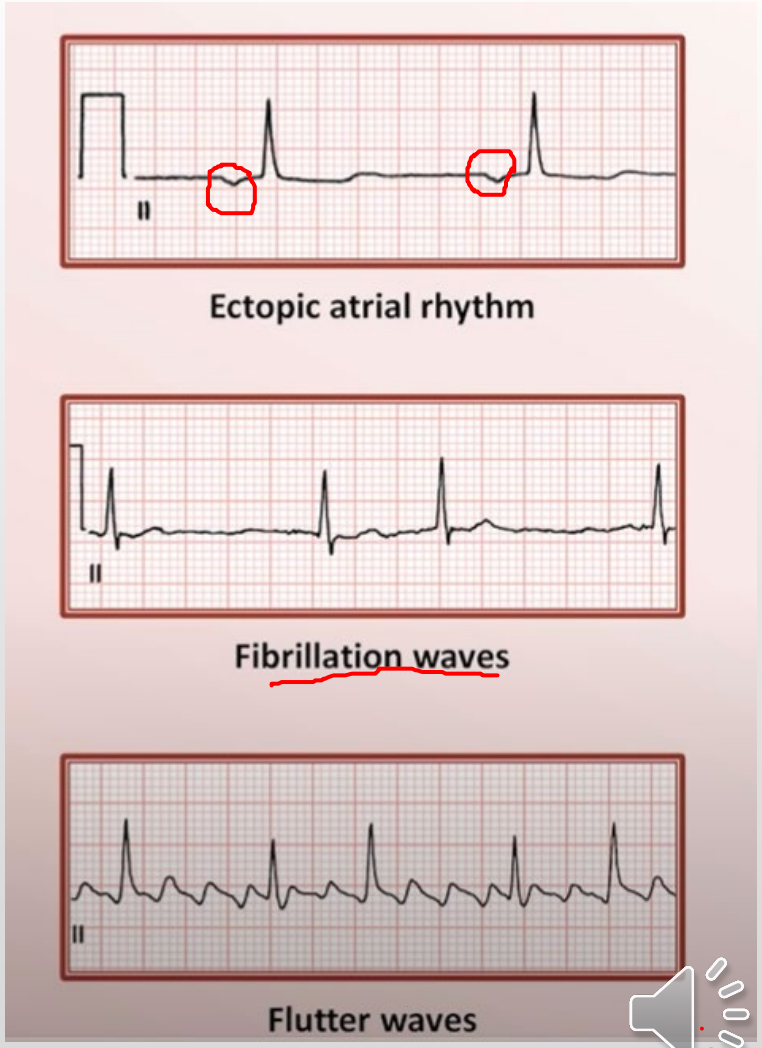
Wide Complex Etiologies:

- Bundle Branch Block
- Ventricular Rhythm
- Left Ventricular Hypertrophy
- Pacemaker
- Drugs – i.e Class Ia and 1c antiarrhythmics
- Wolf-Parkinson-White pattern
- Profound Hyperkalemia

Step 1: Assess the Rhythm – P Waves

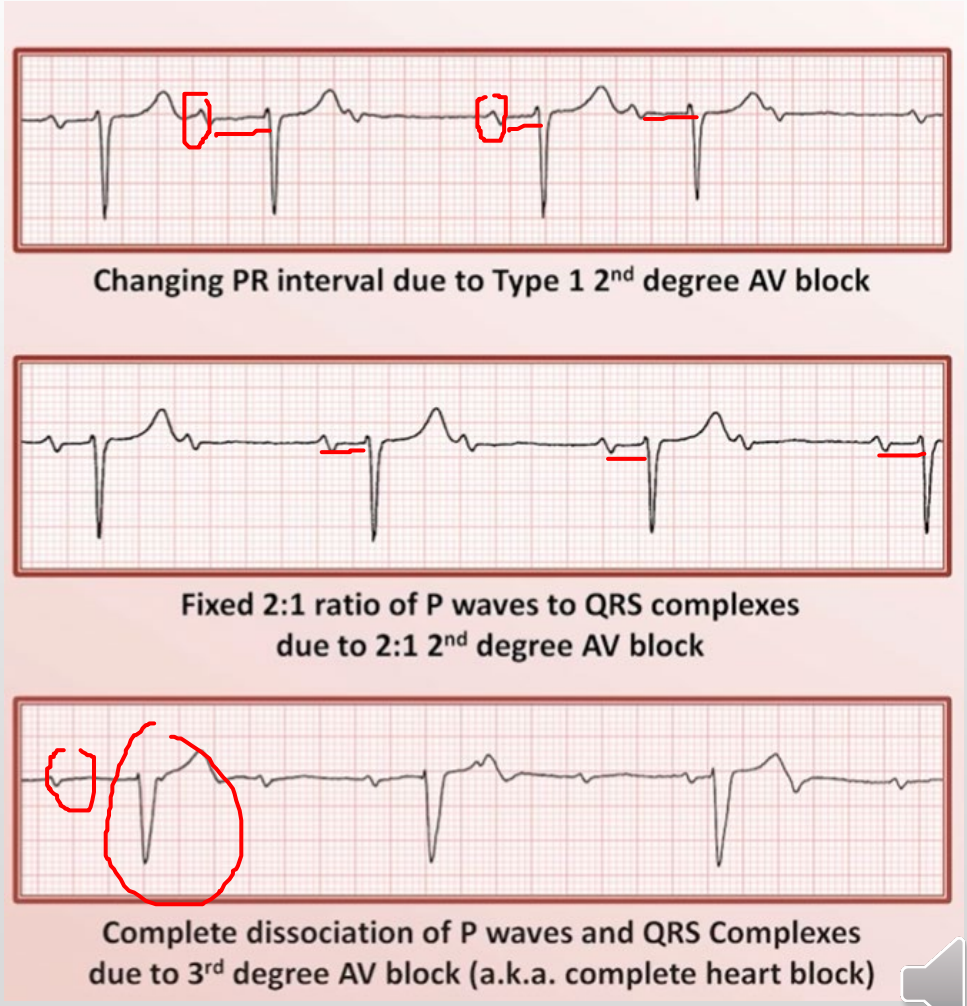
- Are there P waves?
- What is their morphology?
  - Sinus P waves should be up right in 1 and down in AVR
  - Is their atrial enlargement?
- No P Waves? Are there fibrillation or flutter Waves?





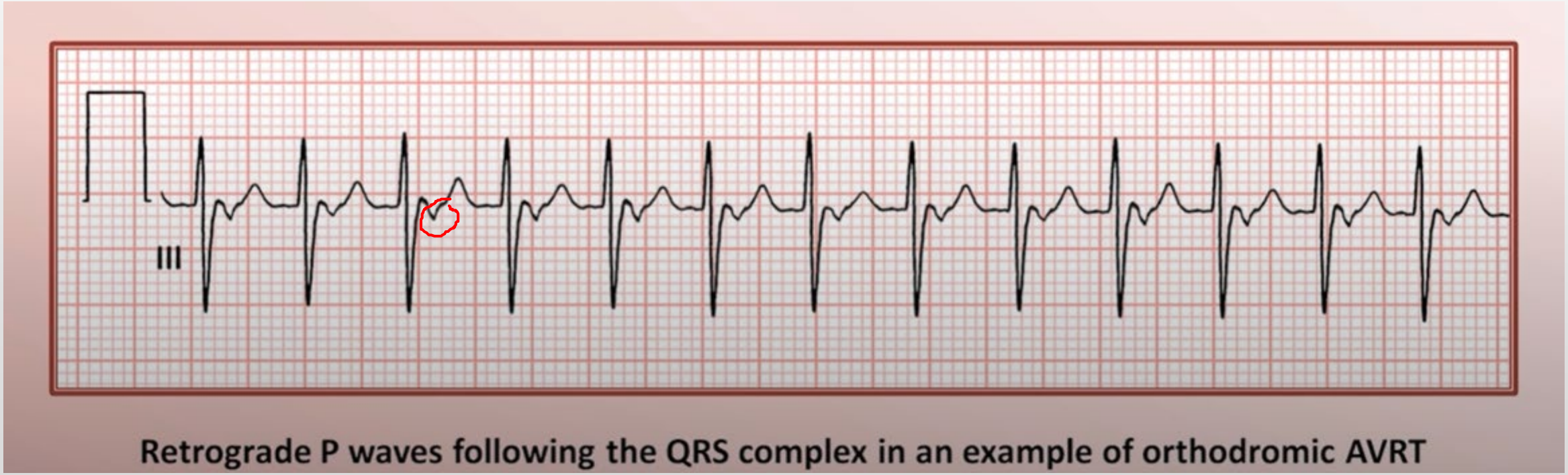
Step 1: Relationship between Atrial and Ventricular activity

- Does the PR interval change?
- Is there a 1:1 relationship between P waves & QRS complexes?
- Is there any association between them?



Final Step 1: (Where is the P Wave?)

- Do the P waves come before or after the QRS complex?



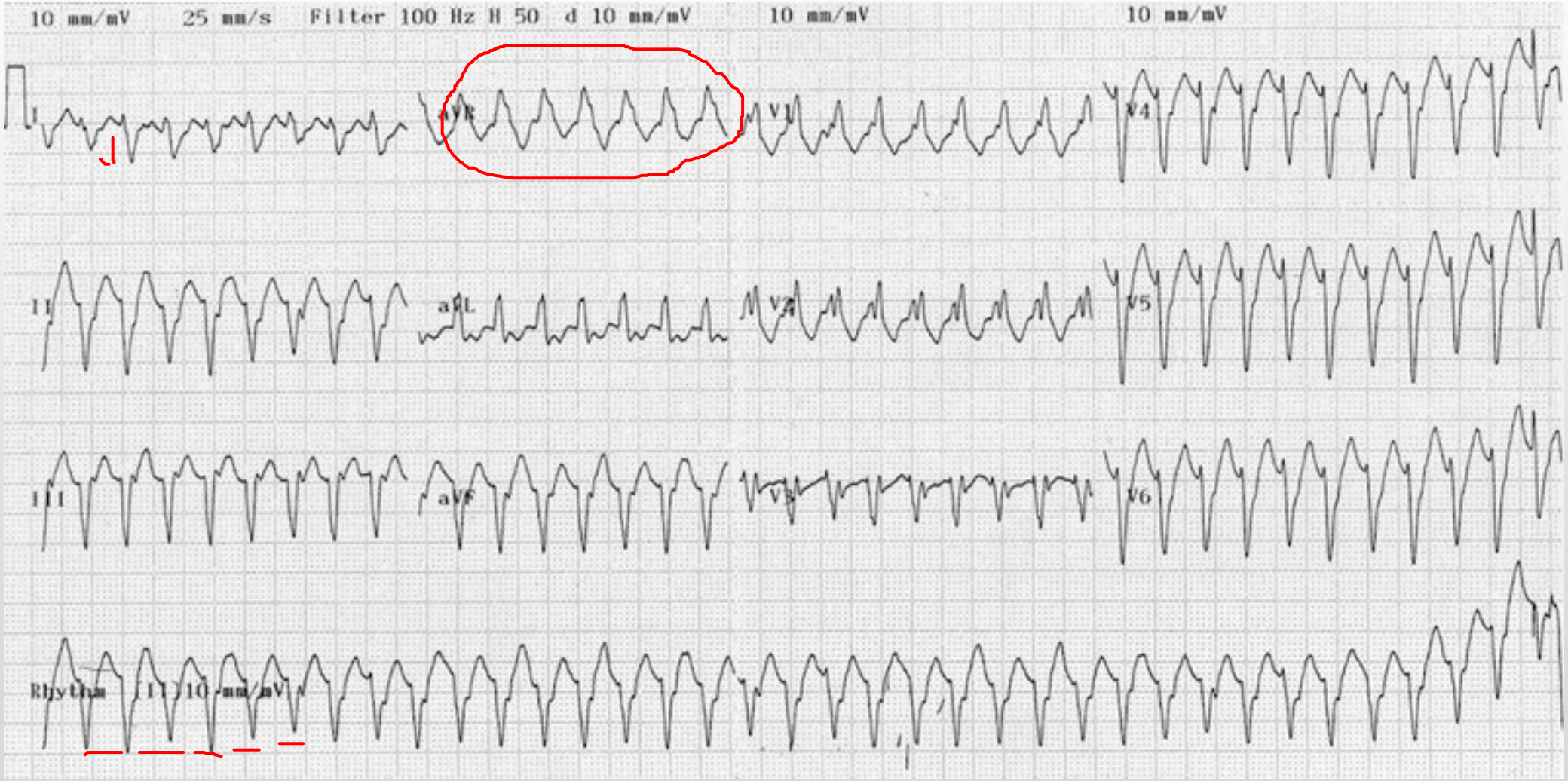
Retrograde P waves following the QRS complex in an example of orthodromic AVRT

Step 1: Distinguish VT from SVT?

Electrocardiographic features that increase the likelihood of VT:

- Absence of typical RBBB or LBBB morphology
- Extreme axis deviation ("northwest axis") — QRS is positive in aVR and negative in I + aVF.
- Very broad complexes (>160ms)
- AV dissociation (P and QRS complexes at different rates)
- Capture beats — occur when the sinoatrial node transiently 'captures' the ventricles, in the midst of AV dissociation, to produce a QRS complex of normal duration.
- Fusion beats — occur when a sinus and ventricular beat coincides to produce a hybrid complex.
- Positive or negative concordance throughout the precordial (chest) leads, i.e. leads V1-6 show entirely positive (R) or entirely negative (QS) complexes, with no RS complexes seen.
- Brugada sign – The distance from the onset of the QRS complex to the nadir of the S-wave is > 100ms

Monomorphic Ventricular Tachycardia!



Step 1: Summary

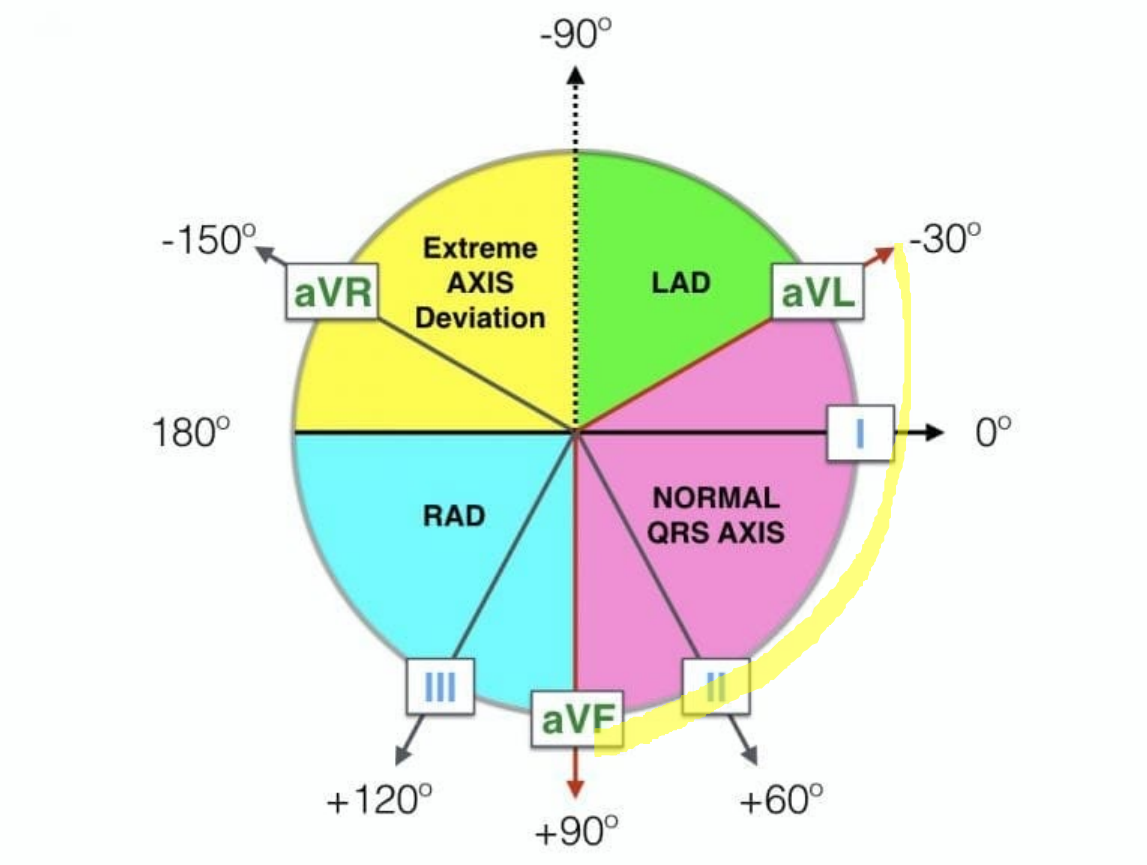
- 1). Measure the rate
- 2). Determine if rhythm is regular, regularly irregular, or irregularly irregular
- 3). Determine if QRS complex is narrow or wide
- 4). Evaluate the atrial activity
- 5). Identify the relationship between atrial & ventricular activity

Step 2: Asses the QRS Axis and Morphology

- Determine the QRS axis

Etiologies of RAD

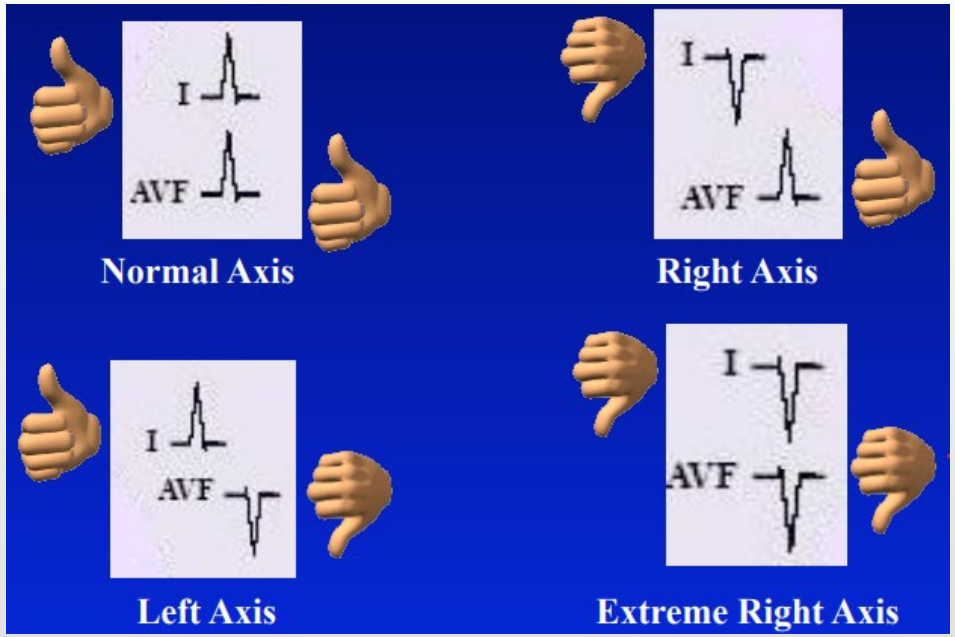
- Normal variant in children and young, thin adults
- Right ventricular hypertrophy
- COPD without RVH
- Left posterior fascicular block
- Lateral wall MI
- Ectopic ventricular rhythm
- WPW pattern



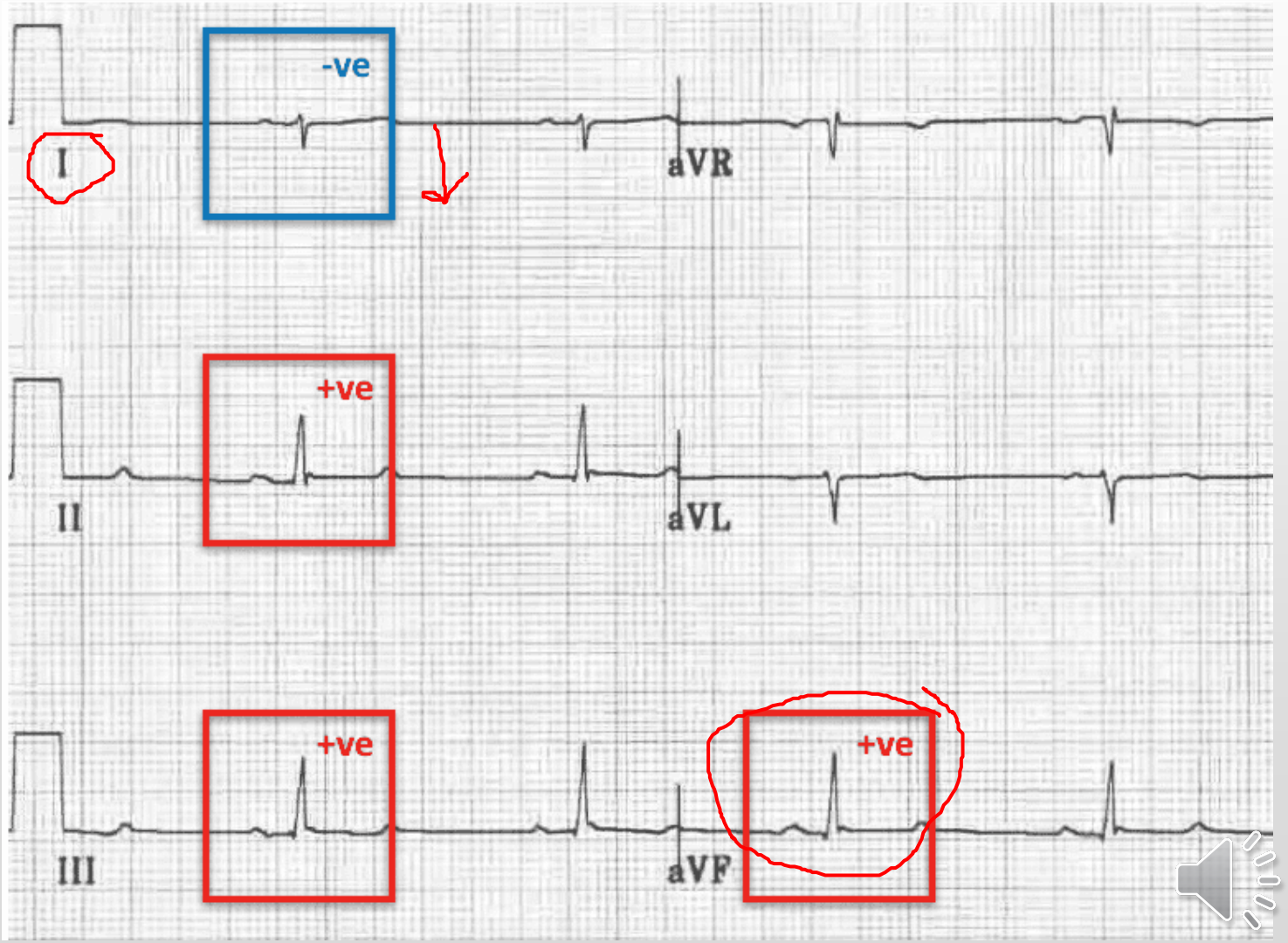
Etiologies of LAD

- Normal variant in older, obese adults
- Left ventricular hypertrophy
- Elevated diaphragm (e.g. ascites, pregnancy)
- Left anterior fascicular block
- Inferior wall MI
- Ectopic ventricular rhythm
- WPW pattern

Axis: Look at leads I and AVF

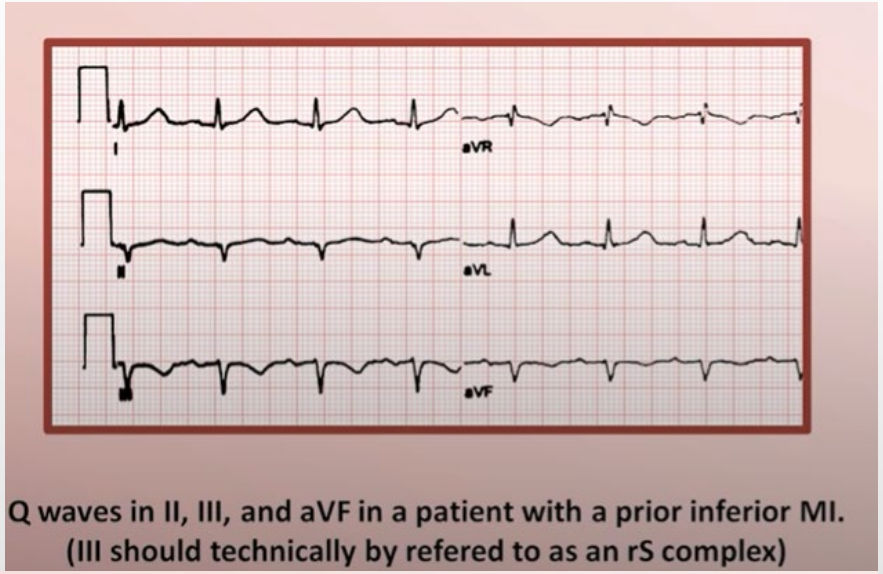


RAD: leads II, III and aVF are POSITIVE; Leads I and aVL are NEGATIVE

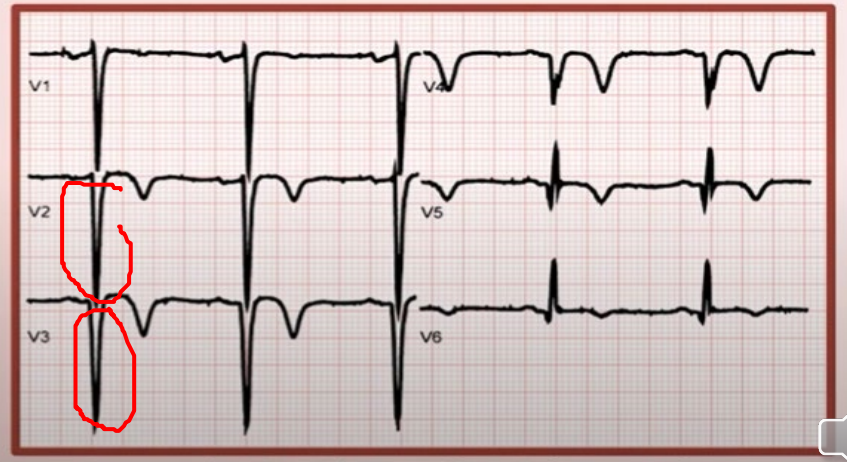


Step 2: Assess the QRS axis and Morphology

- Q waves are considered pathological if:
- > 40 ms (1 mm) wide
- > 2 mm deep
- > 25% of depth of QRS complex
- Seen in leads V1-3
- Pathological Q waves usually indicate current or prior myocardial infarction.

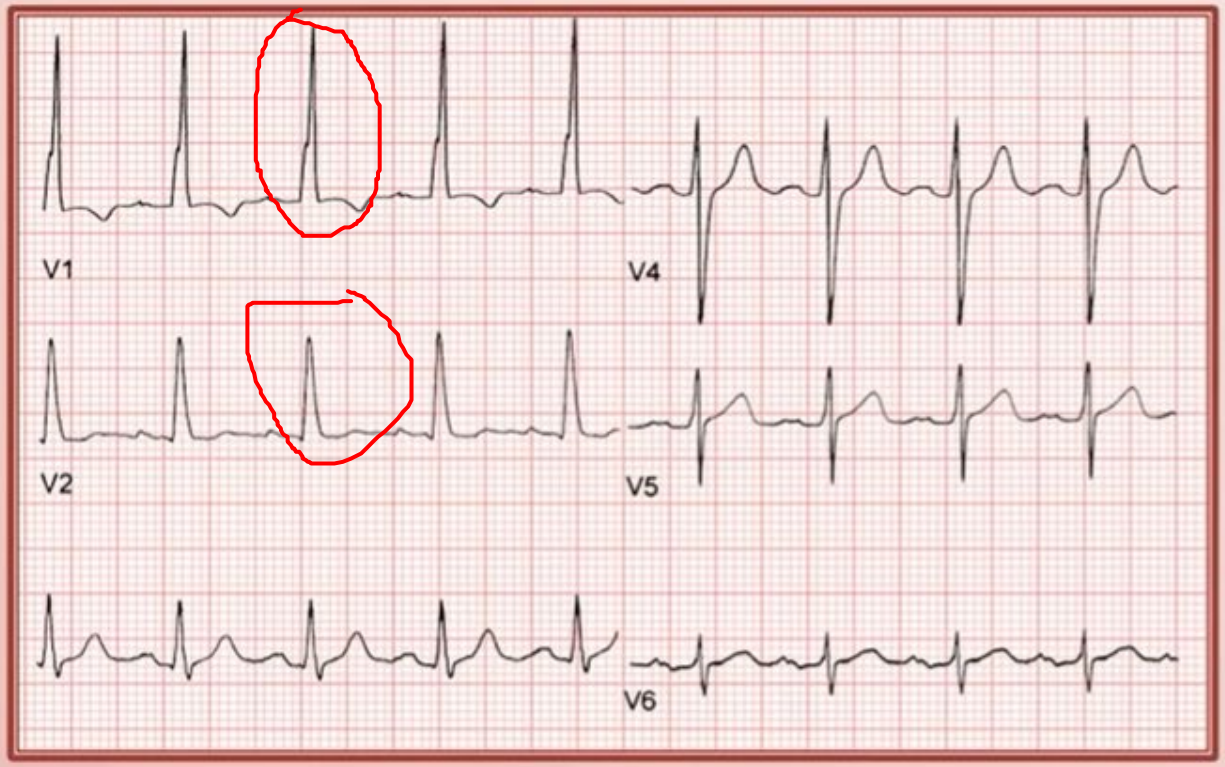


Q waves in II, III, and aVF in a patient with a prior inferior MI. (III should technically by refered to as an rS complex)

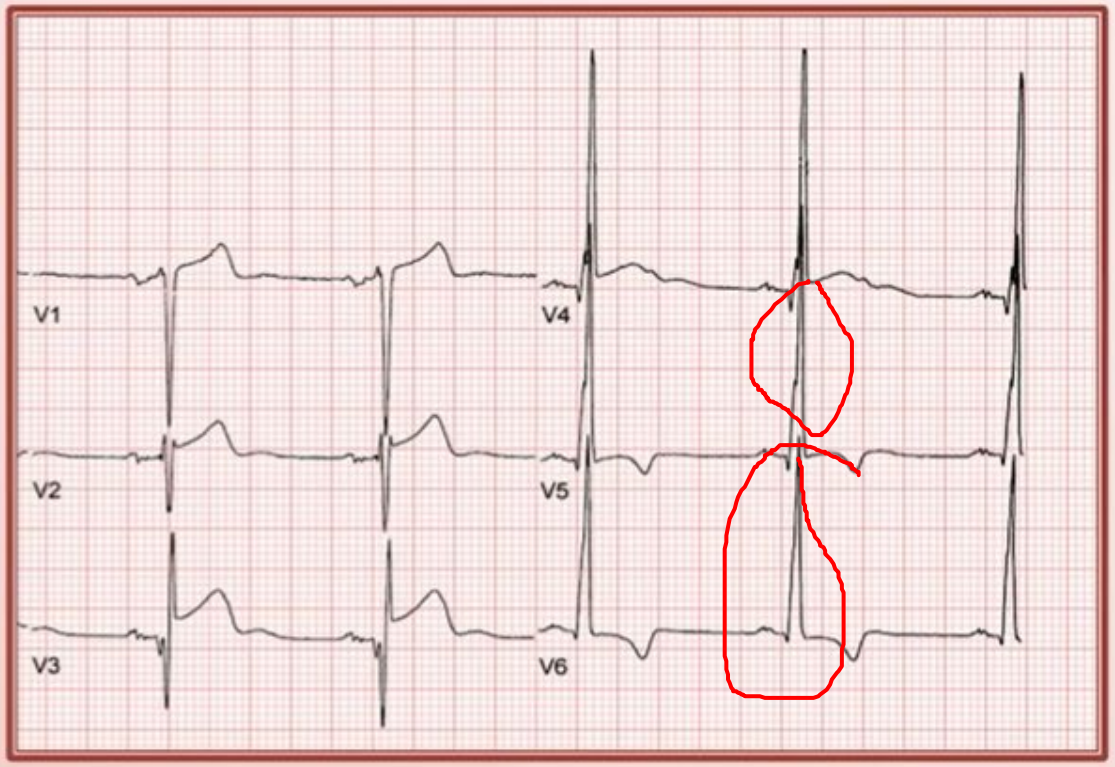


Q waves in V2-V6 in a patient 3 days out from a massive anterolateral STEMI

Is there Right Ventricular Hypertrophy or Left Ventricular Hypertrophy?

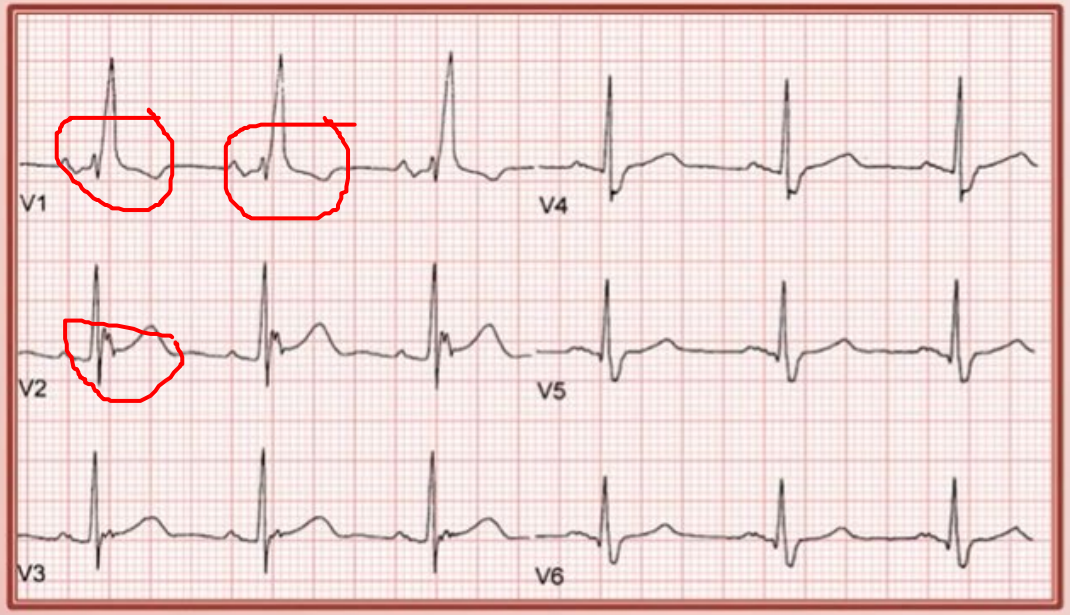


Typical example of RVH with tall R waves in V1 and V2.

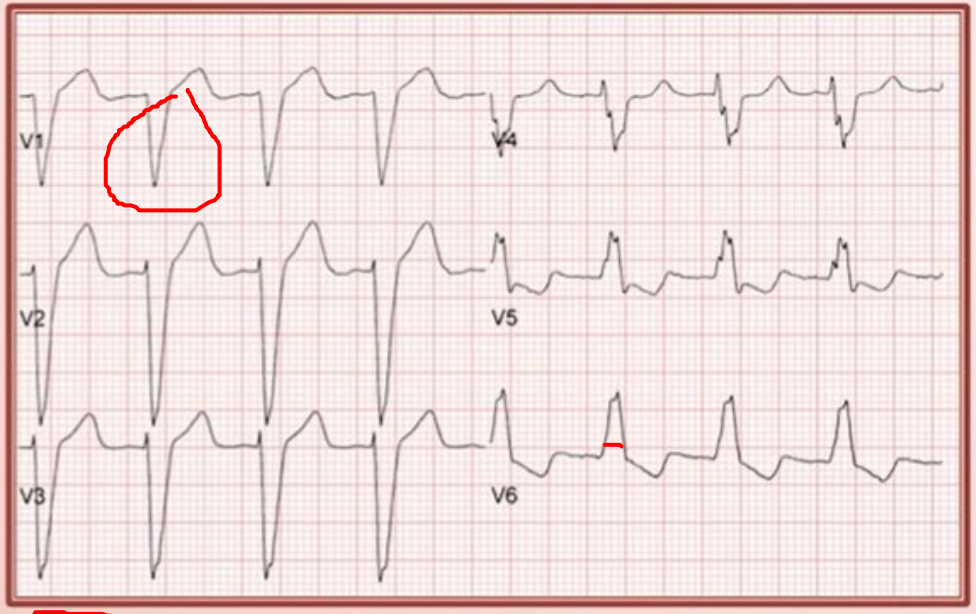


Typical example of LVH with tall R waves in V5 and V6.

Is there a Right or Left Bundle Branch Block



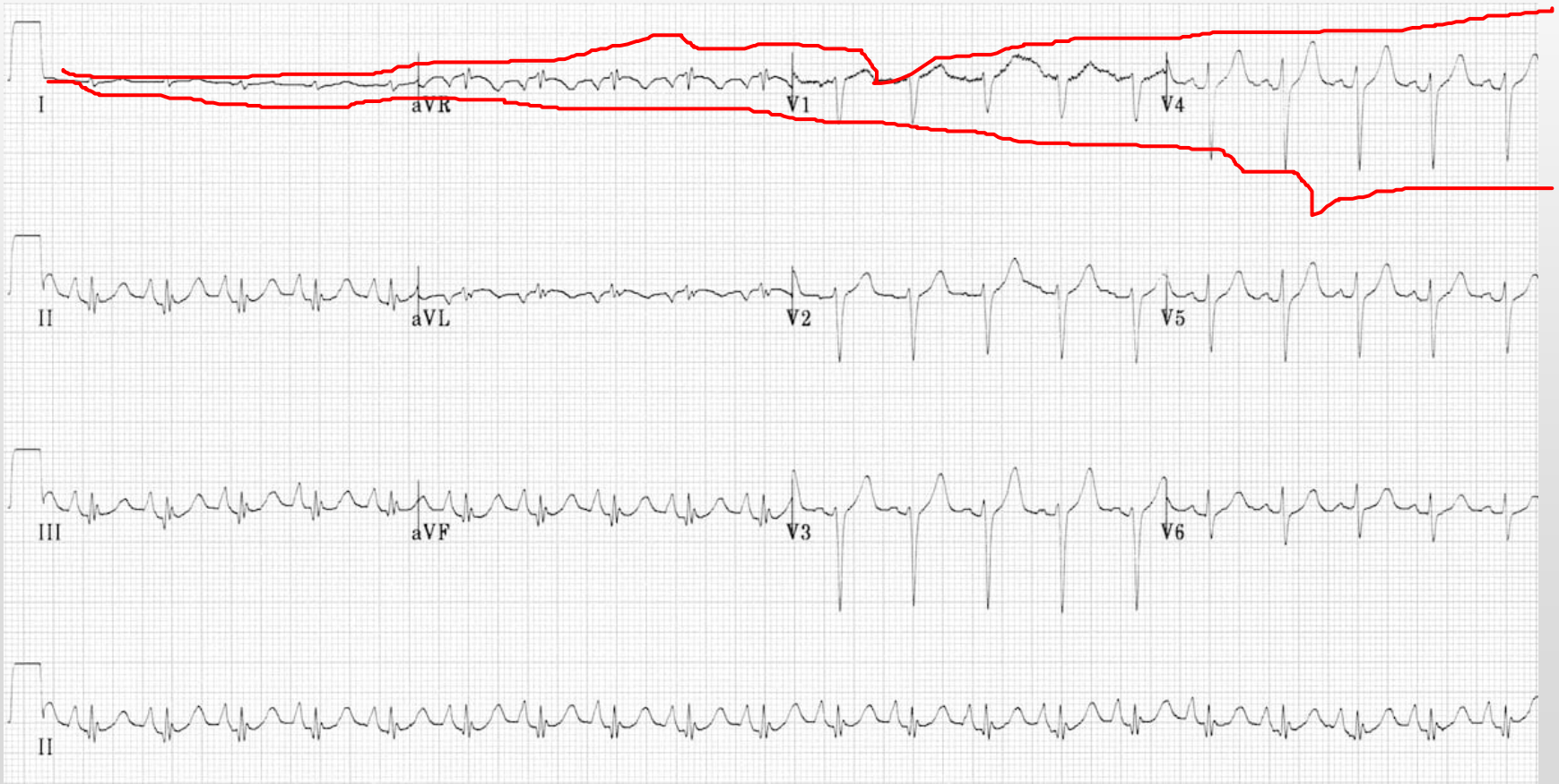
RBBB with tall, RsR' complex in V1 and prolonged S in V6.



LBBB with deep QS complex in V1 and broad R in V6.

Examine low voltage QRS

- Look for low voltage:

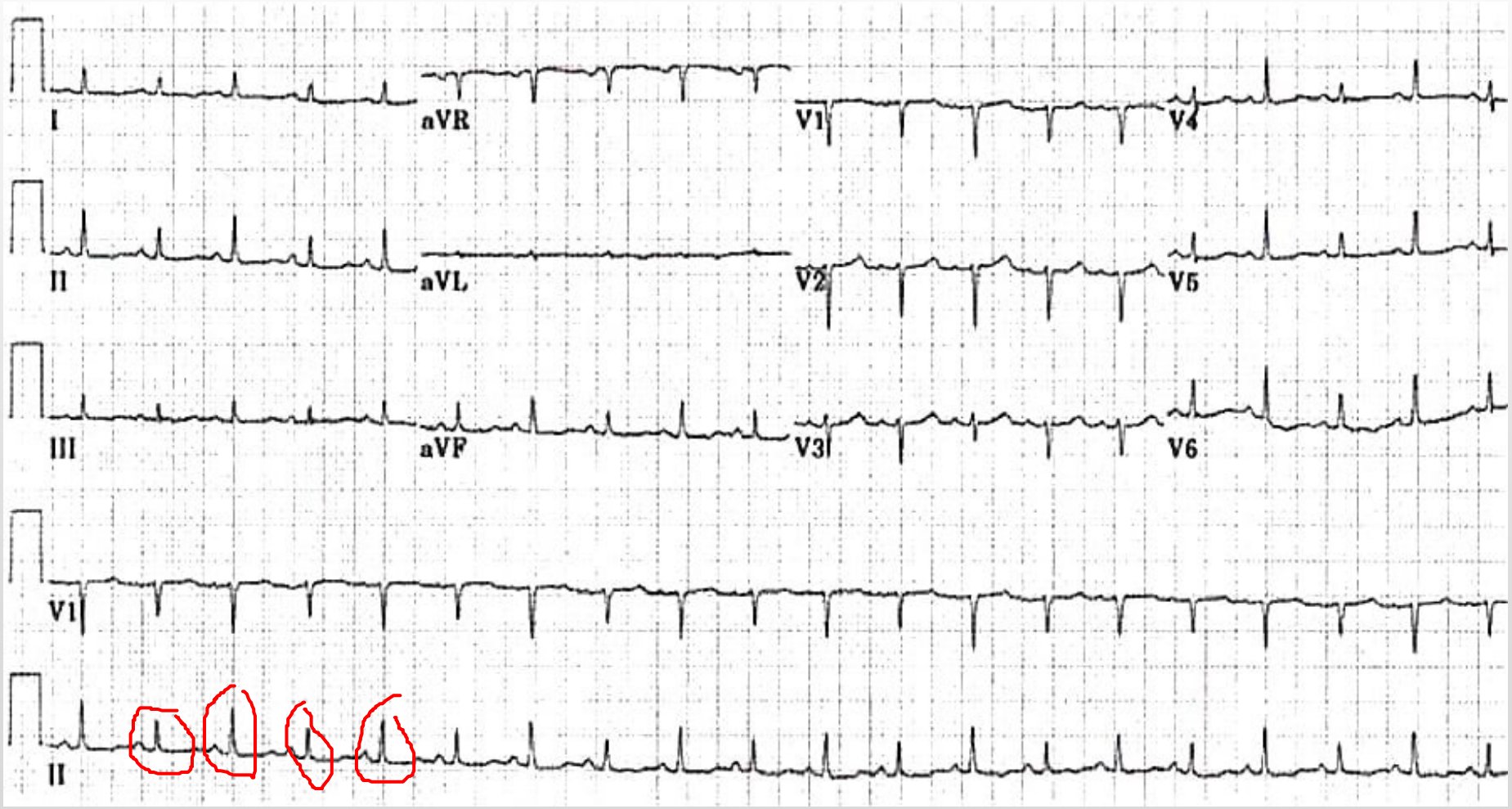


Etiologies of Low Voltage

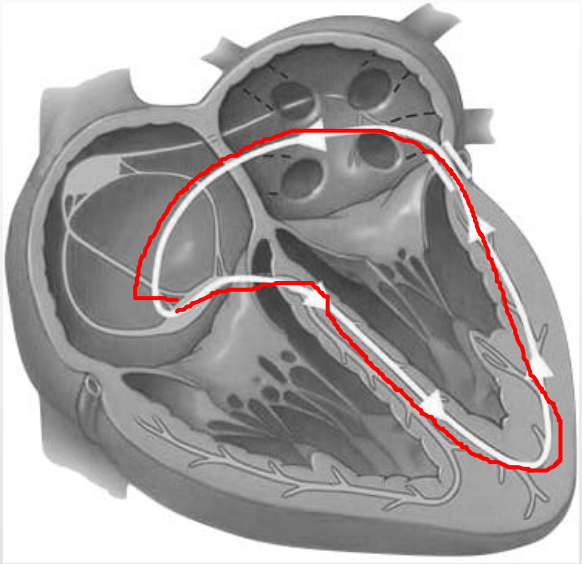
- Obesity
- COPD
- Pleural or pericardial effusion
- Myocardial infiltration (e.g. amyloidosis, sarcoidosis)
- Hypothyroidism

Look for Electrical Alternans

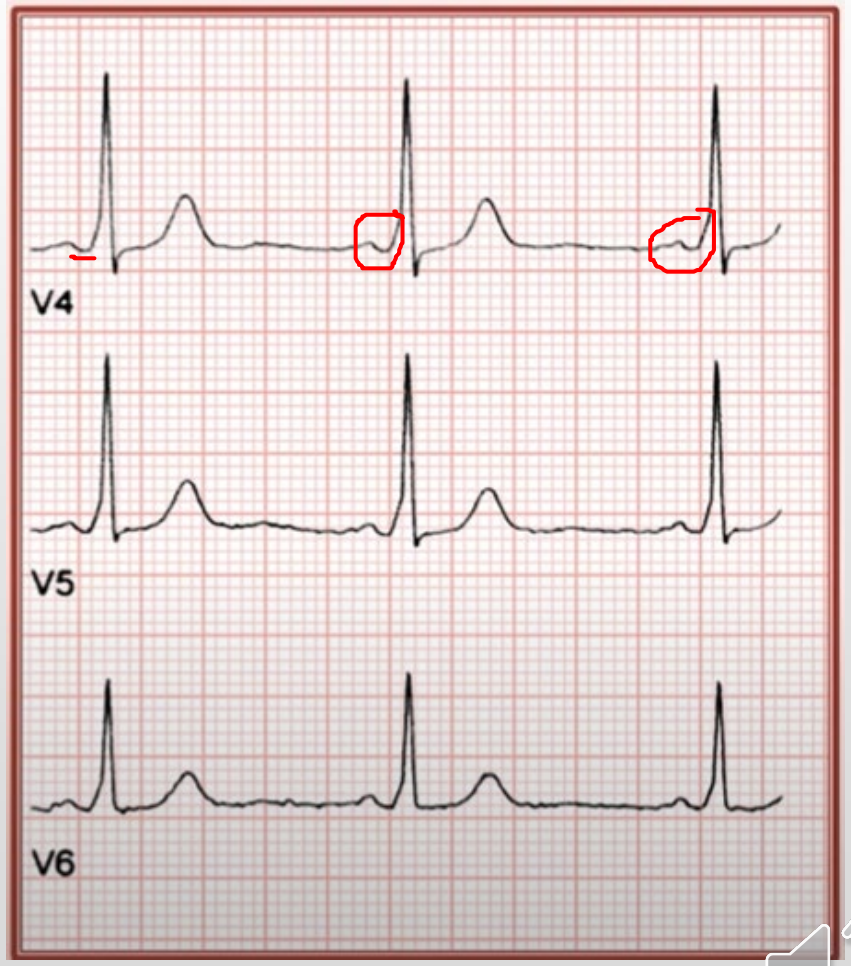
May indicate pericardial effusion



Finally, look for Delta Waves! (AV Re-entry Tachycardia)



PR interval <120ms
Delta wave – slurring slow rise of initial portion of the QRS
QRS prolongation >110ms
ST Segment and T wave discordant changes – i.e. in the opposite direction to the major component of the QRS complex



Step 3: Assess the ST Segments, T Waves, and QT Interval

Examine the ST segments.

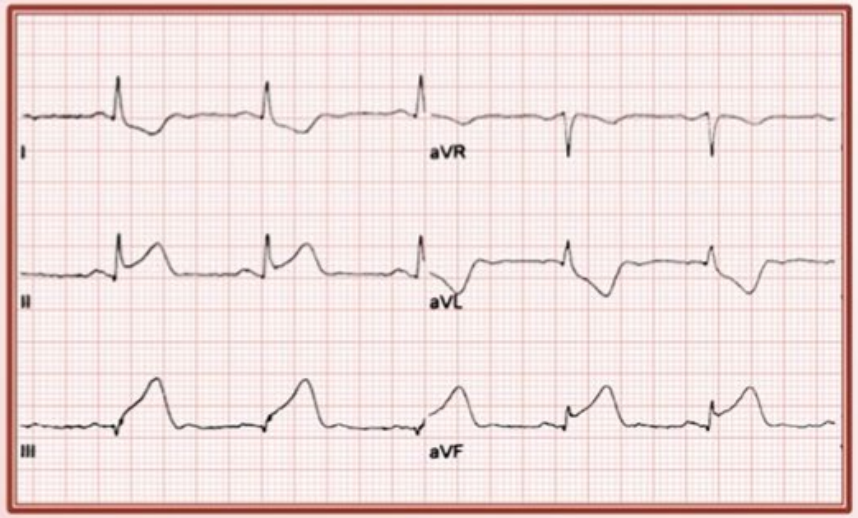
Etiologies of ST Elevation

- ST elevation MI
- LBBB
- LVH
- Normal variant (a.k.a. "early repolarization")

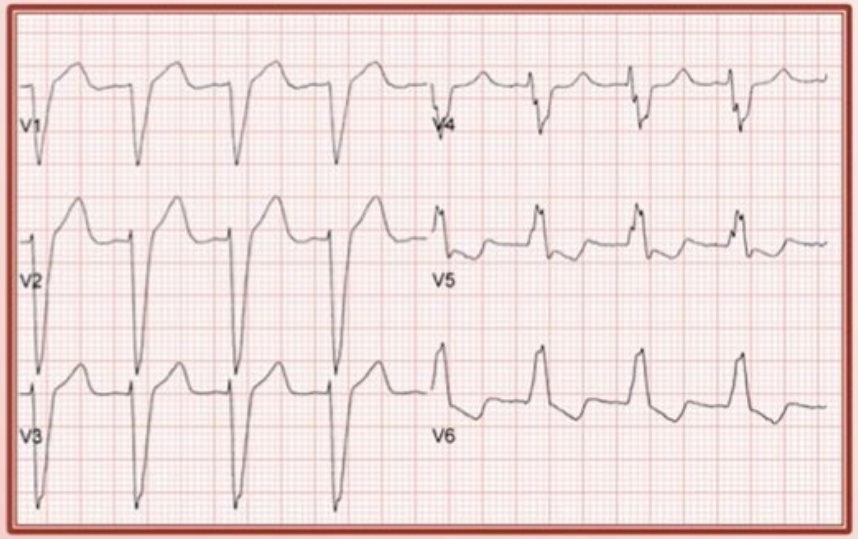
Usually limited to V1-V3

- Pericarditis
- LV aneurysm
- Vasospasm
- Severe hyperkalemia
- Hypothermia
- Brugada syndrome
- Takotsubo cardiomyopathy

Acute inferior STEMI



LBBB

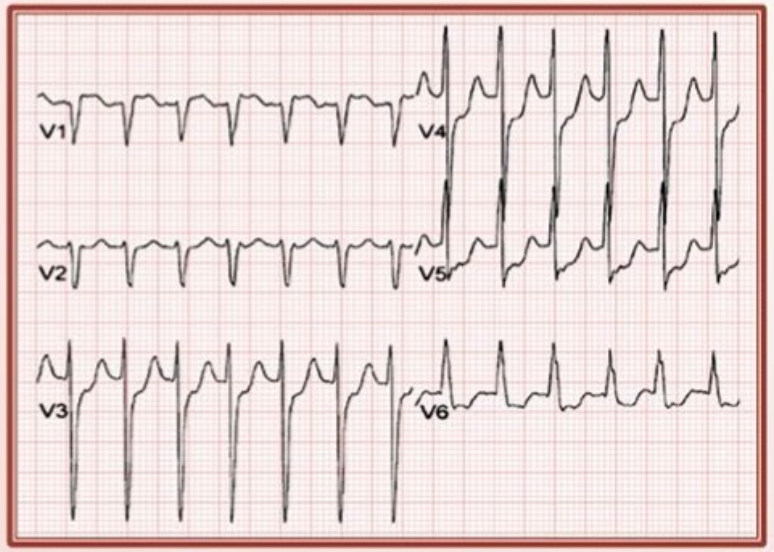


ST Segment Depression
Step 3: Assess the ST Segments, T Waves, and QT Interval

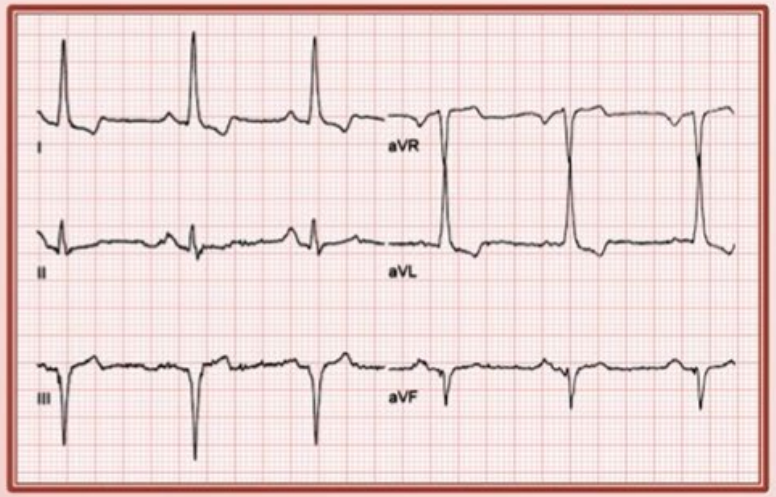
. **Examine the ST segments.**

Etiologies of ST Depression	
• Ischemia / infarction	*Primary repolarization abnormality*
• Tachycardia	
• Digoxin	
• Hypokalemia	
• RBBB/LBBB/IVCD	*Secondary repolarization abnormality*
• RVH/LVH ("strain pattern")	

Tachycardia
(AVNRT)

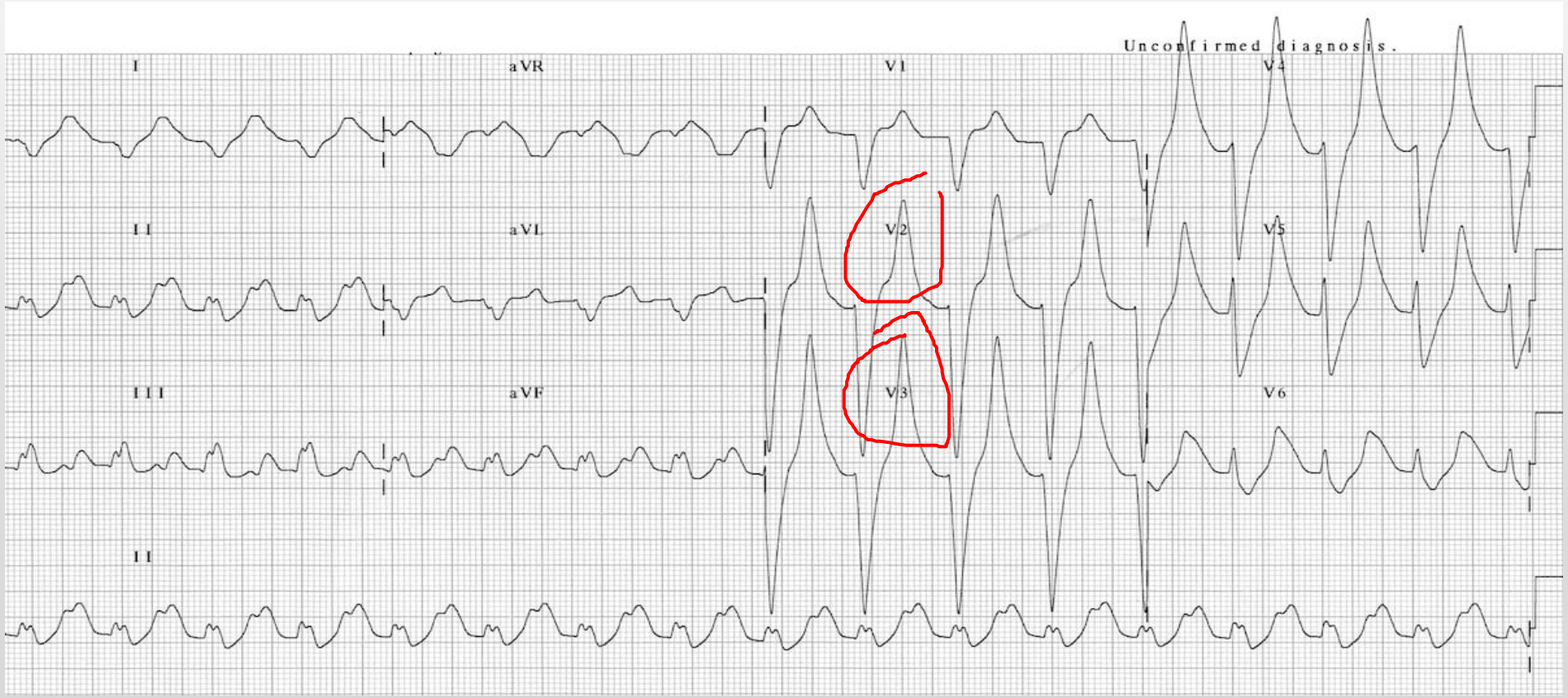


LVH



Peaked T Waves
Step 3: Assess the ST Segments, T Waves, and QT Interval

- Suggest Hyperkalemia
- Prominent T Waves may also indicate an Early STEMI (Hyperacute T Wave)



Prolonged QT Interval
Step 3: Assess the ST Segments, T Waves, and QT Interval

- QT Interval and correction for HR (QTc). Should be < ½ RR interval

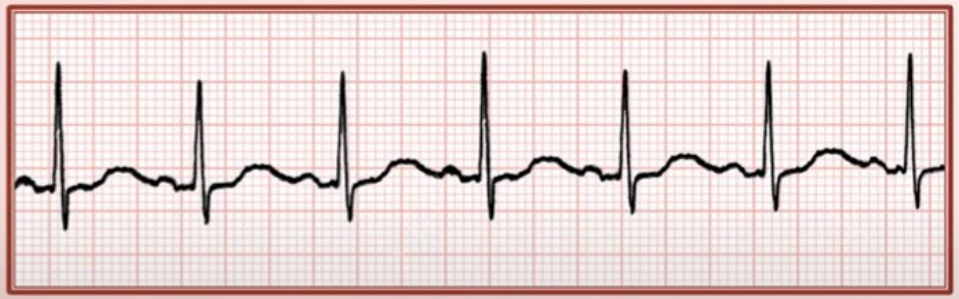
Etiologies of Prolonged QT

- Congenital long QT syndrome
- Medications (e.g. class Ia, Ic, & III antiarrhythmics, antipsychotics, antidepressants, antiemetics, quinolones, macrolides)
- Hypocalcemia
- Hypothyroidism
- Hypothermia
- Hypokalemia?

Treatment:

Most patients (even those without symptoms) are treated with a beta-blocker. Other medications may be used to shorten the Q-T interval.

Unstable patients require emergent cardioversion



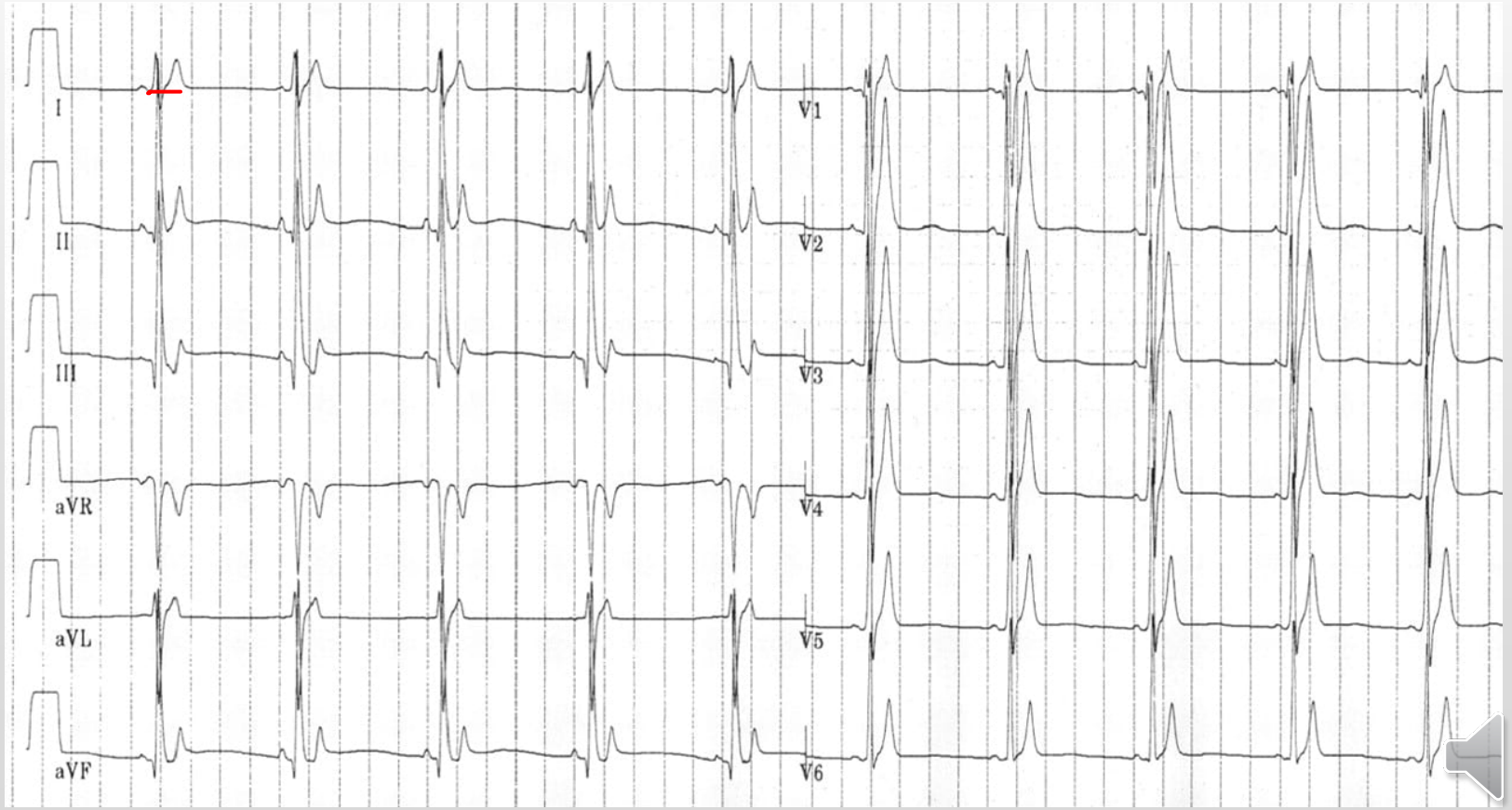
QTc = 540ms, secondary to azithromycin

Short QT Interval < 350 ms

- A very short QT Interval is pathological and important to identify!

Etiologies of Short QT

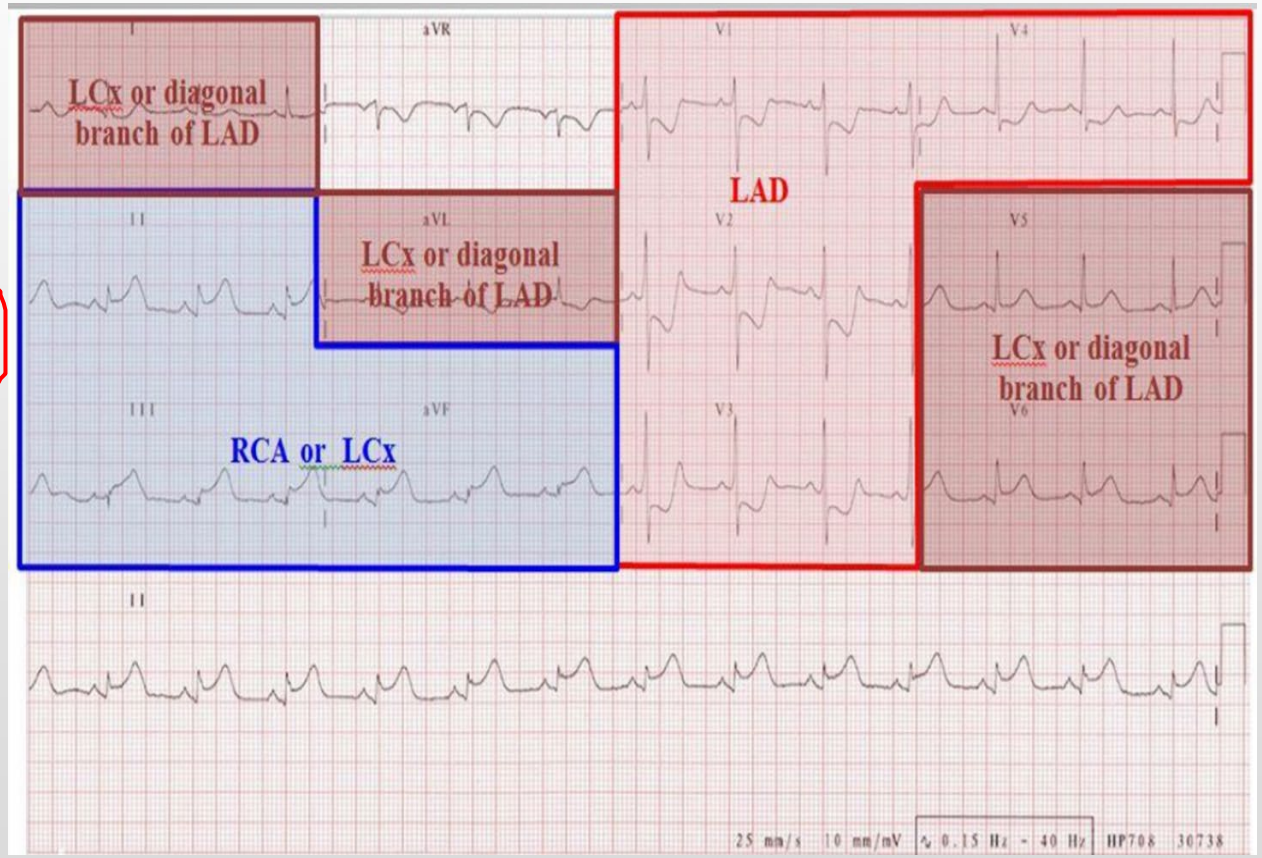
- Hypercalcemia
- Congenital Short QT Syndrome



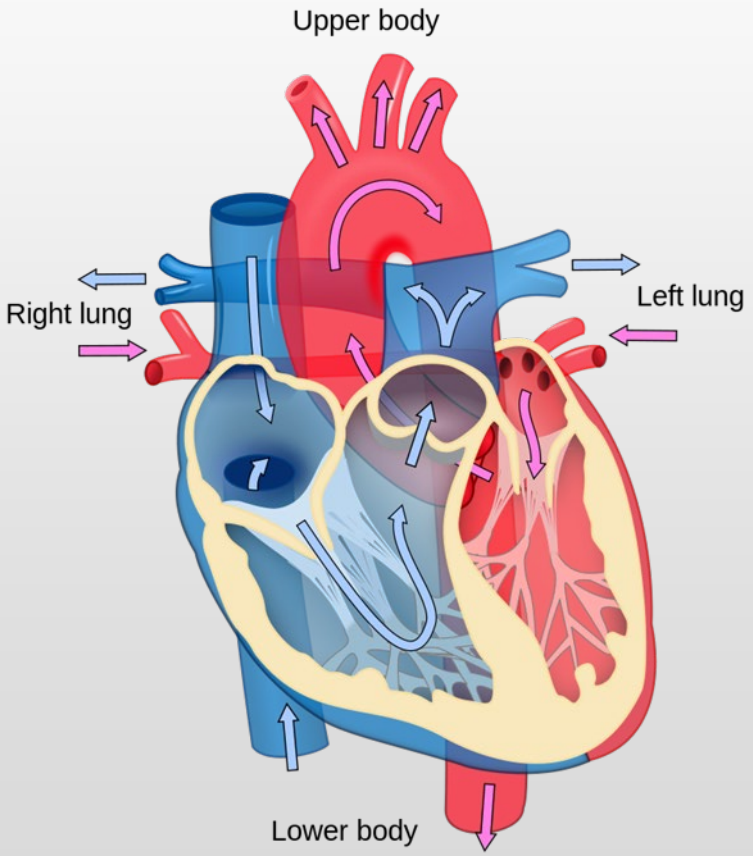
ECG and Relationship to Coronary Vessels

I Lateral	aVR	V1 Septal	V4 Anterior
II Inferior	aVL Lateral	V2 Septal	V5 Lateral
III Inferior	aVF Inferior	V3 Anterior	V6 Lateral

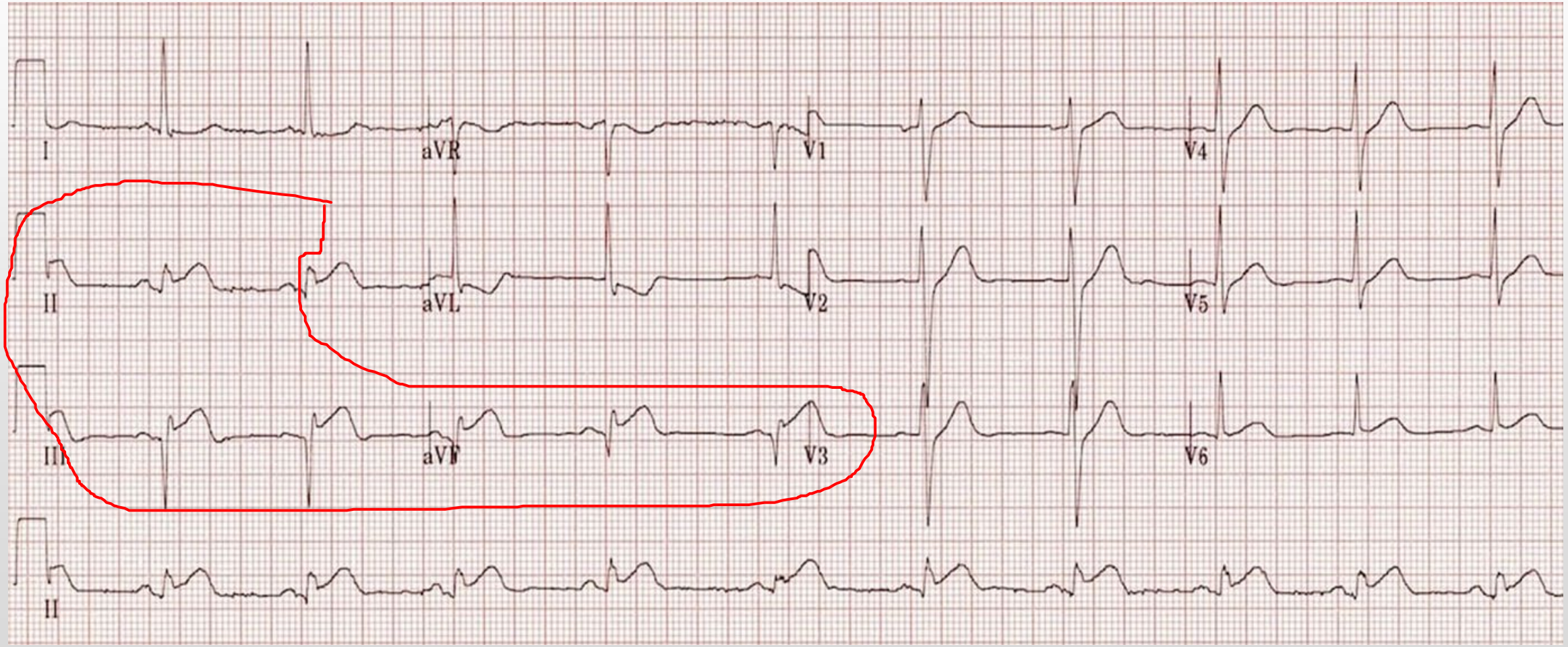
SITE	FACING	RECIPROCAL
SEPTAL	V1, V2	NONE
ANTERIOR	V3, V4	NONE
ANTEROSEPTAL	V1, V2, V3, V4	NONE
LATERAL	I, aVL, V5, V6	II, III, aVF
ANTEROLATERAL	I, aVL, V3, V4, V5, V6	II, III, aVF
INFERIOR	II, III, aVF	I, aVL
POSTERIOR	NONE	V1, V2, V3, V4



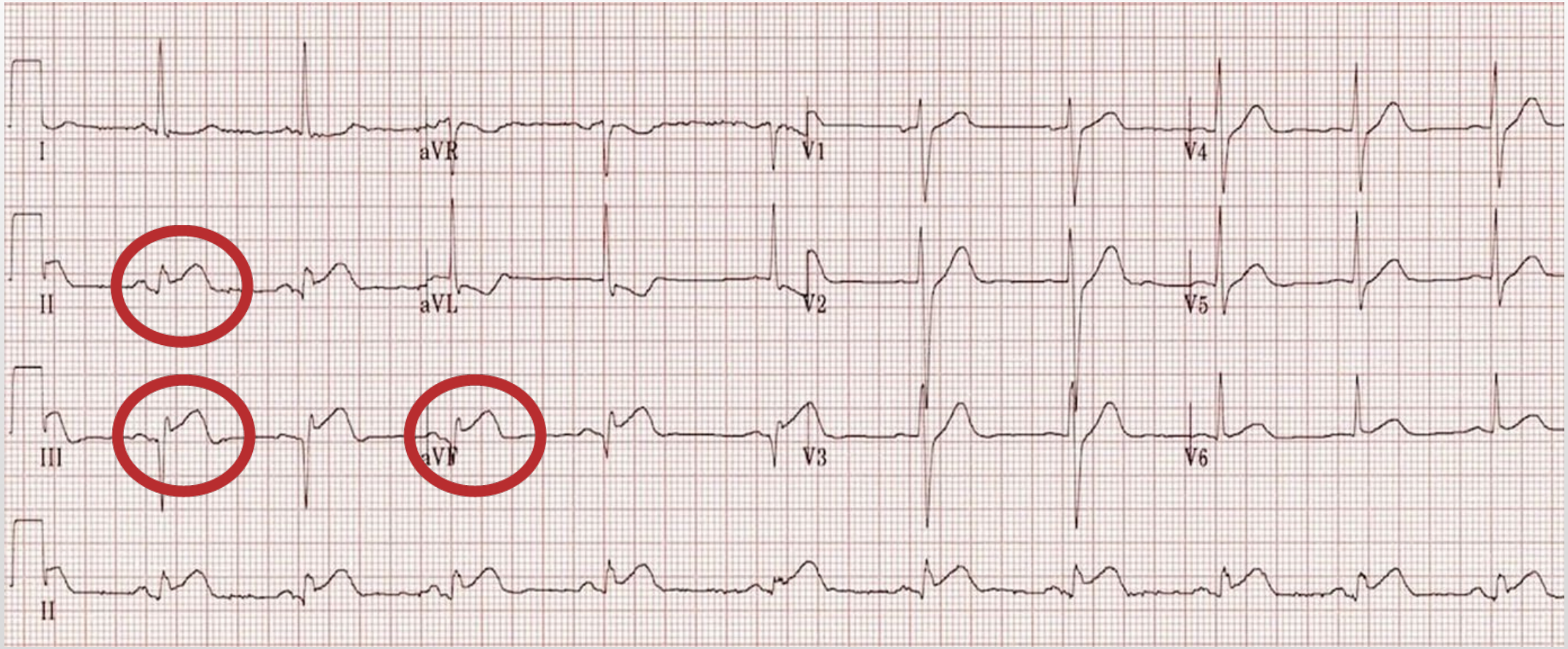
Clinical Case Presentations



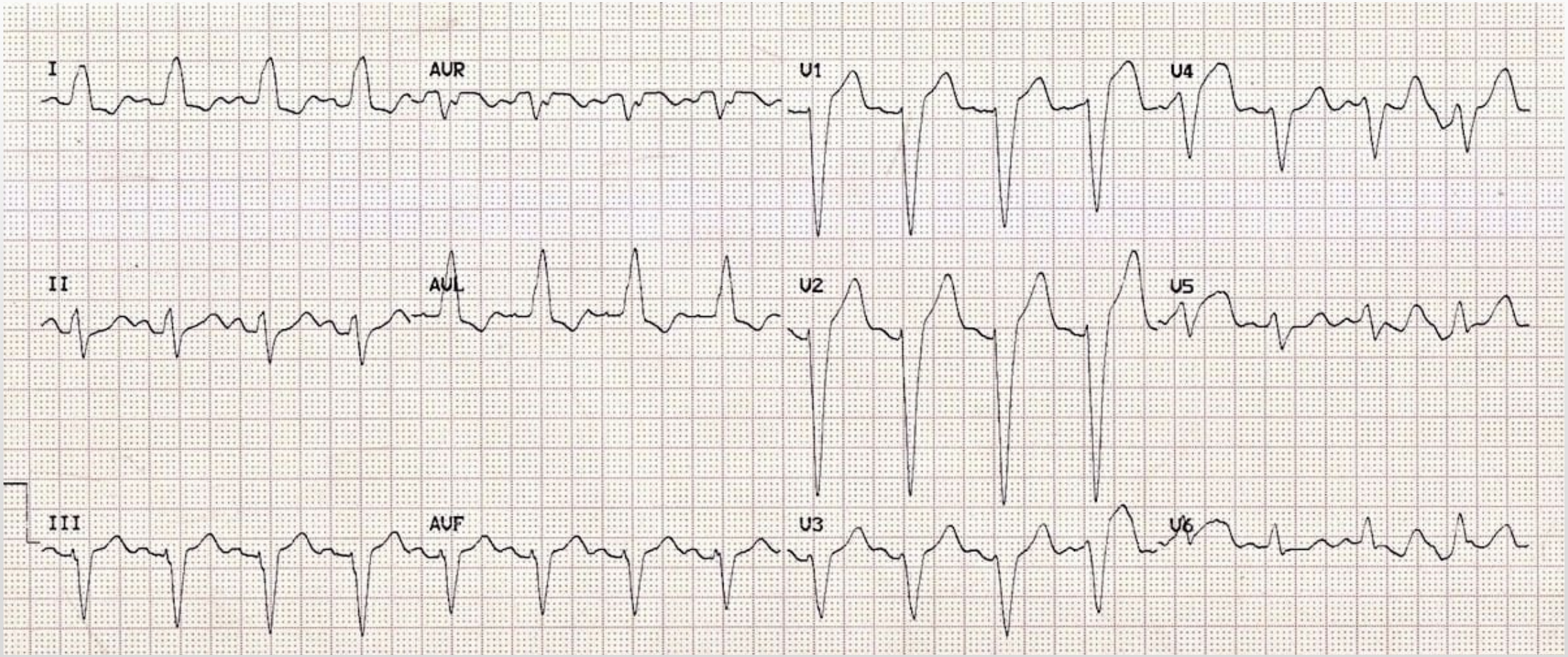
55-year-old male presents with Dyspnea and Diaphoresis? What is the diagnosis?



Inferior Wall MI

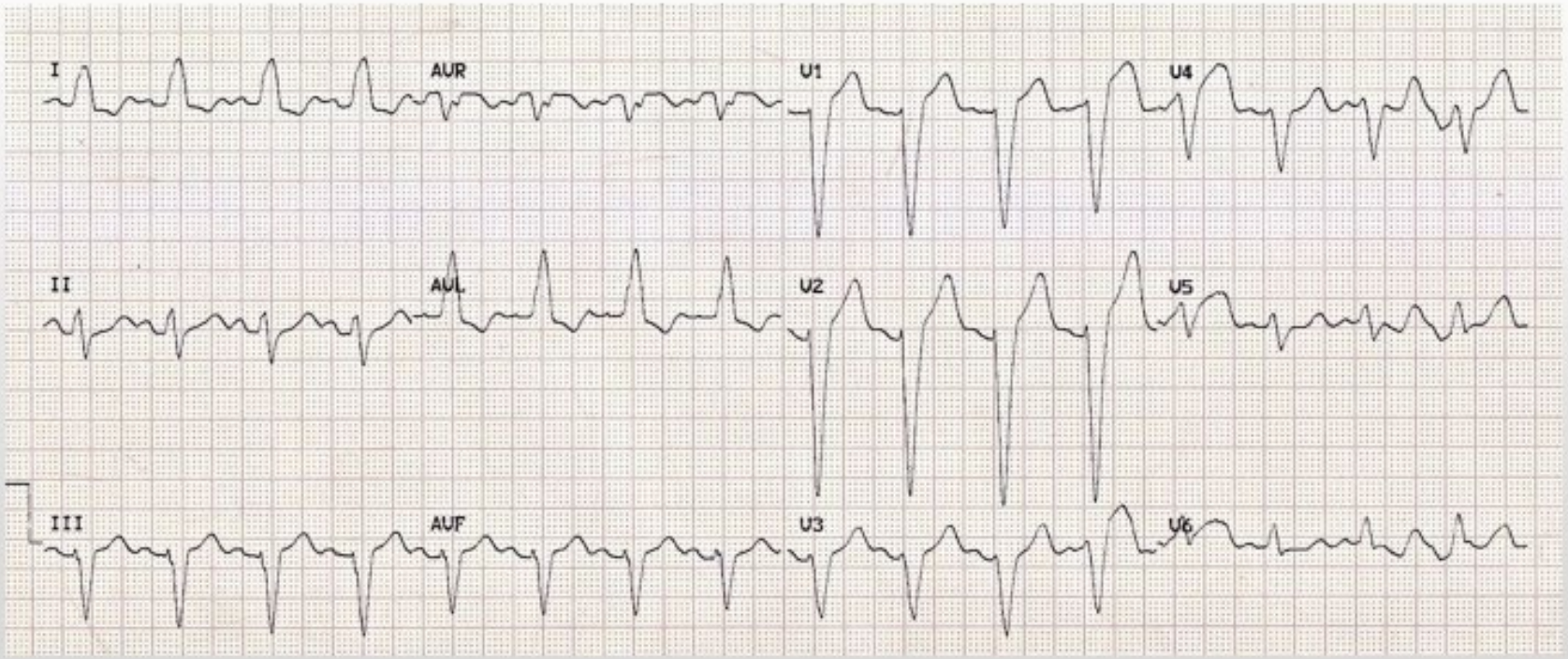


48-year-old woman presents with Dyspnea and Fatigue. You order an EKG. What is your Diagnosis?

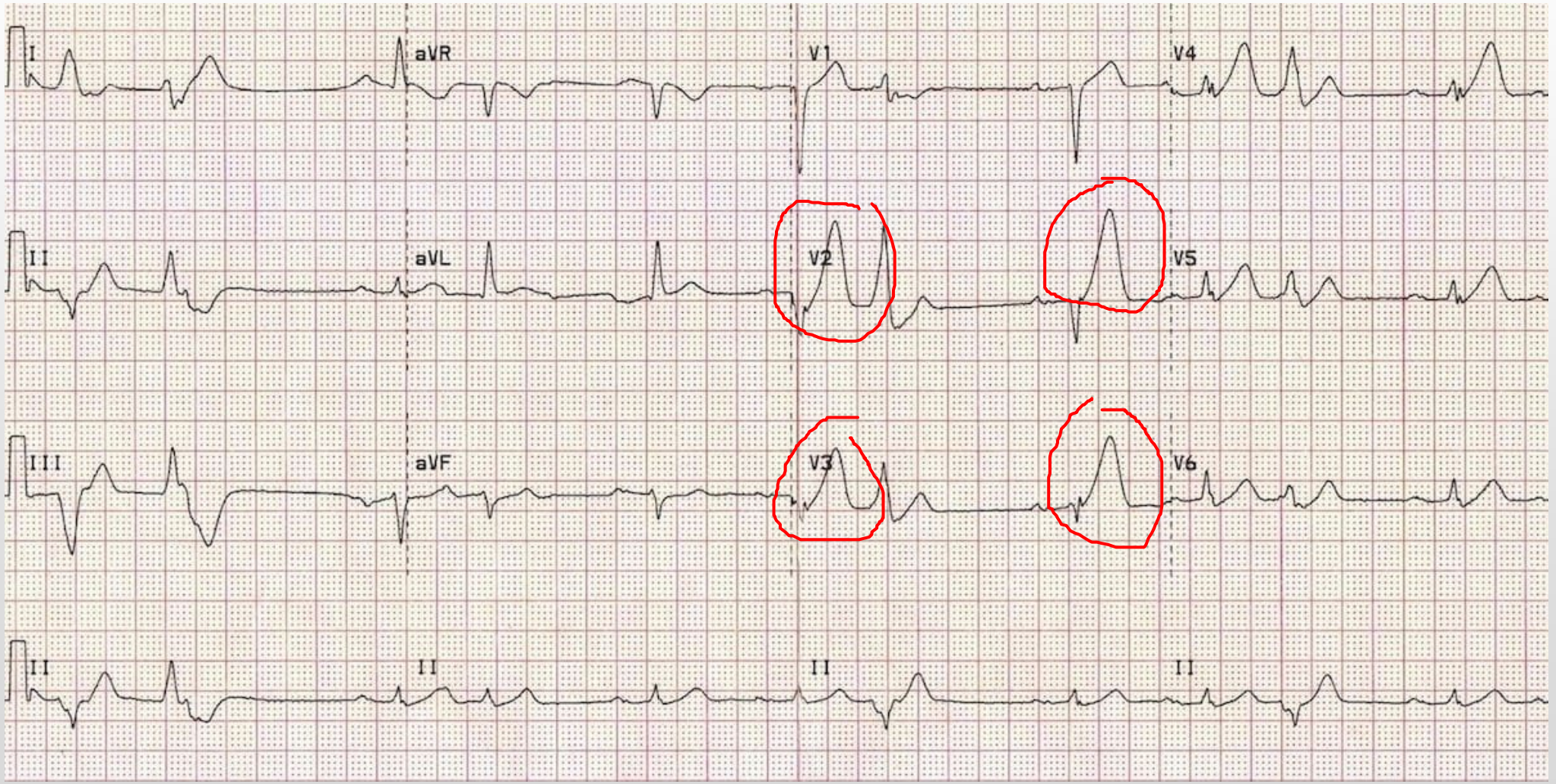


Left Bundle Branch Block – Treat as a STEMI!

48-year-old woman presents with Dyspnea and Fatigue.
You order an EKG. What is your Diagnosis?



62-year-old man presents with chest pain and shortness of breath. What is your diagnosis?

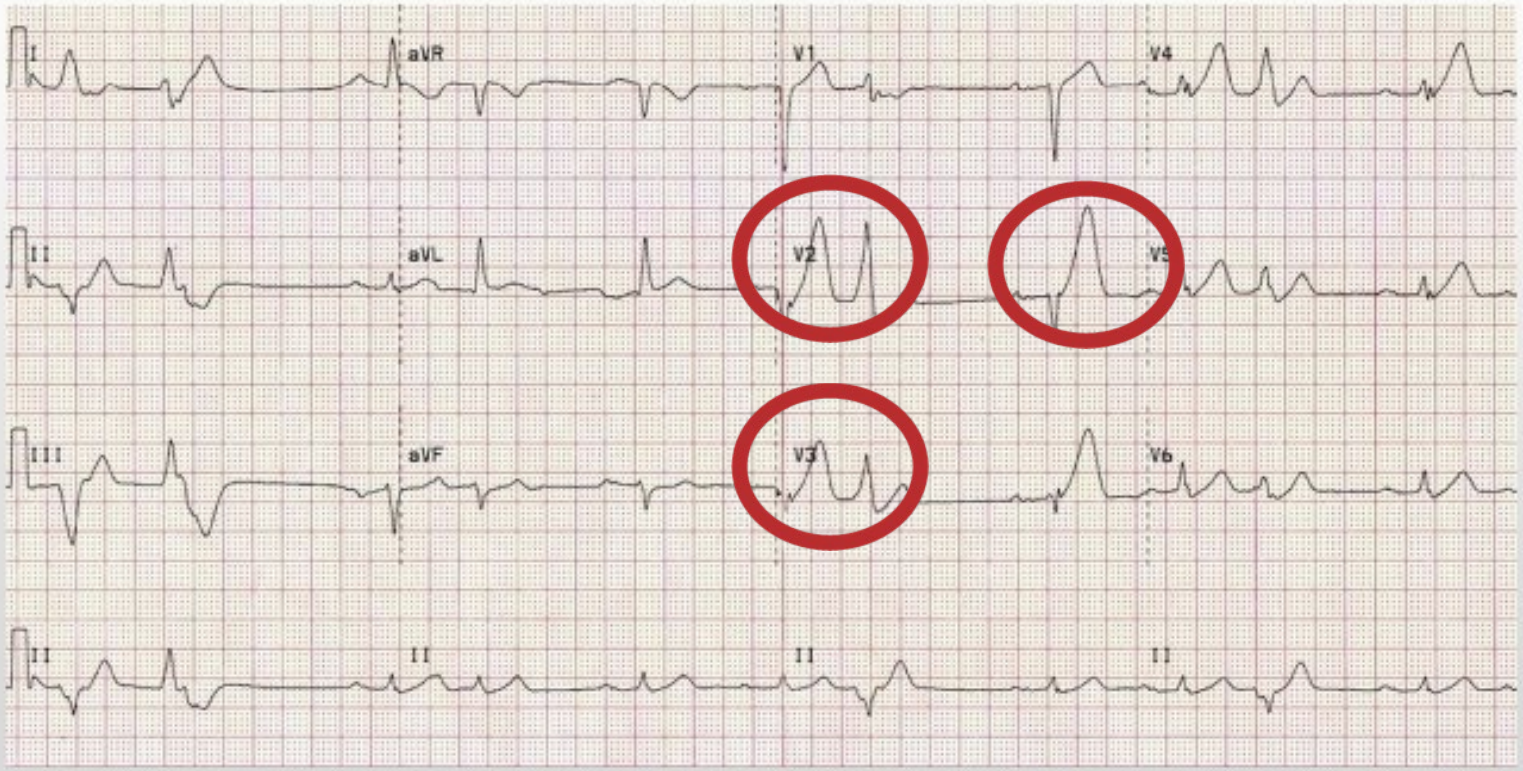


Hyperacute Anterior STEMI

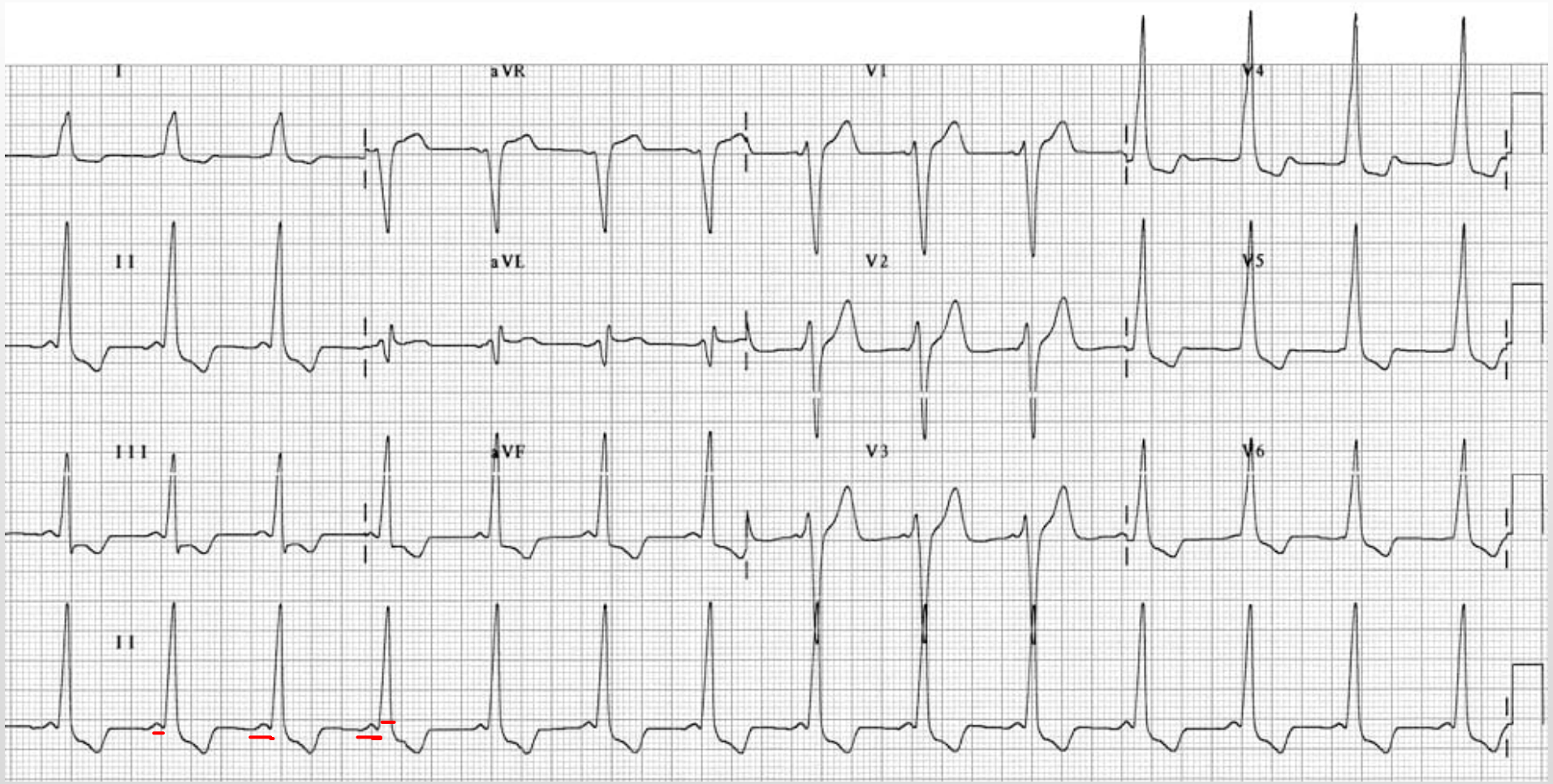
There are hyperacute T-waves in V2-6

The rhythm is sinus with 1st degree AV block.

62 year old man presents with chest pain and shortness of breath. What is your diagnosis?

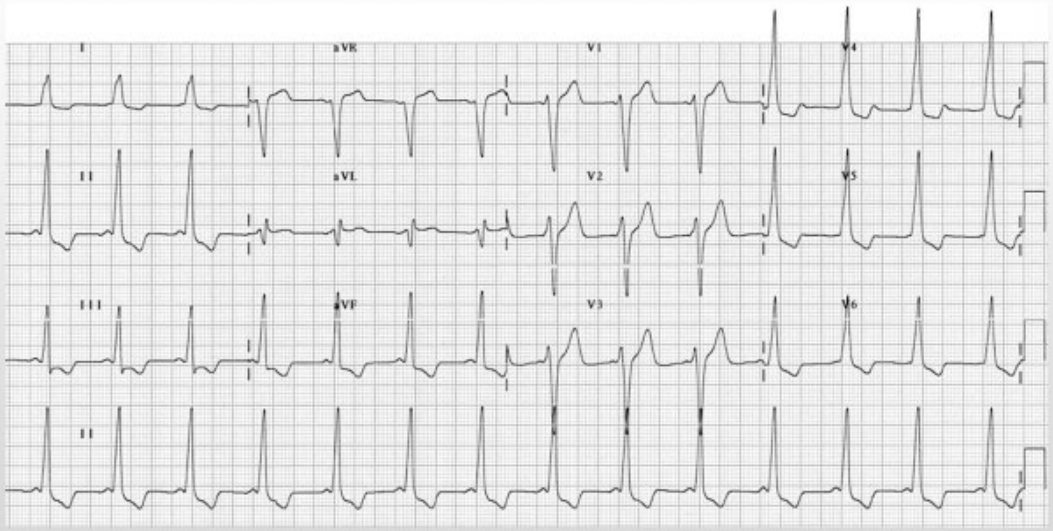


18-year-old presents for routine Physical Exam. You order an EKG for entry into military service.



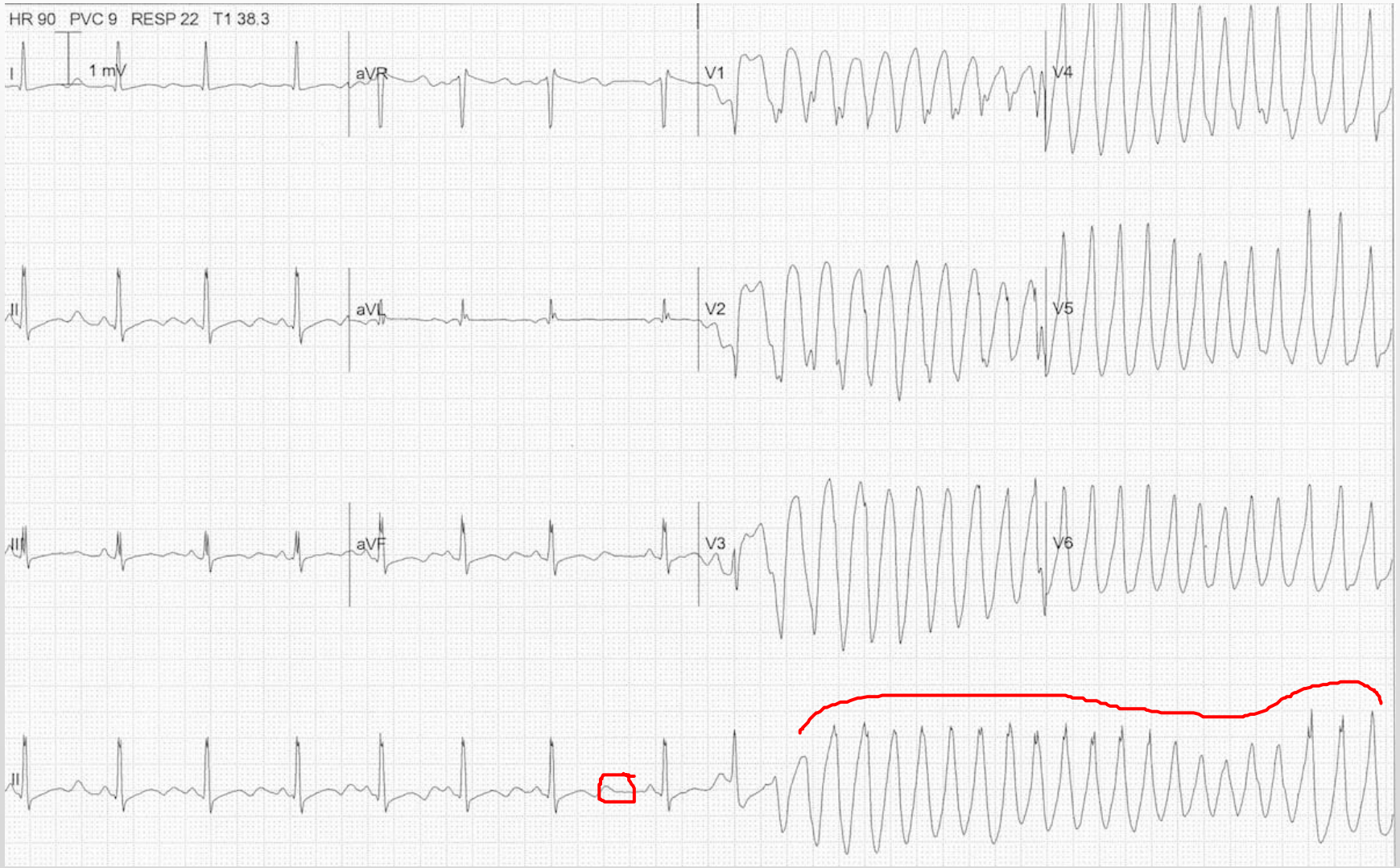
Wolf-Parkinson-White (WPW)

18 year old presents for routine Physical Exam.
You order an EKG for entry into military service.



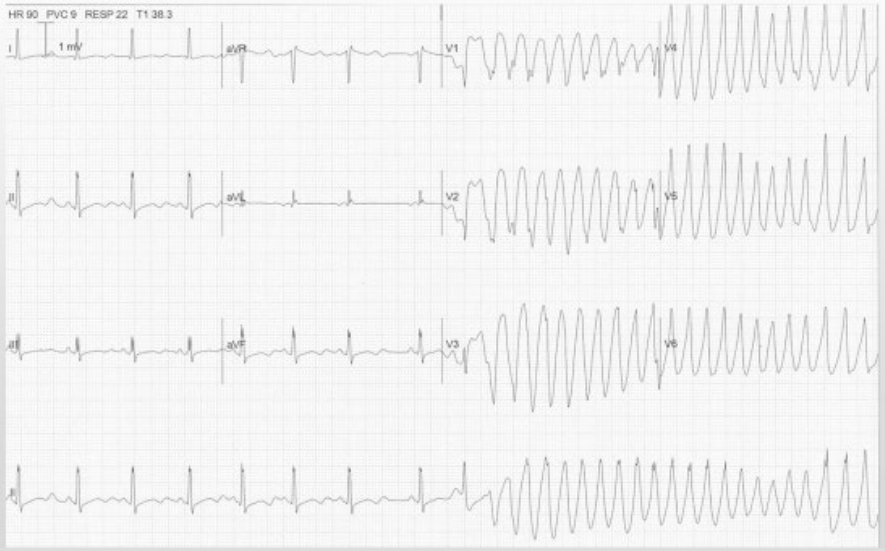
- Sinus rhythm with very short PR interval (< 120 ms)
- Broad QRS complexes with a slurred upstroke to the QRS complexes — the delta wave.
- Dominant S wave in V1 — this pattern is known as “Type B” WPW and indicates a right-sided accessory pathway.

42-year-old male presents for hypertension. His PA started him on HCTZ 25 mg po 6 weeks ago. He has experienced significant fatigue. You order an EKG:



Torsades de Pointes:

42-year-old male presents for hypertension. His PA started him on HCTZ 25 mg po 6 weeks ago. He has experienced significant fatigue. You order an EKG:



TdP secondary to hypokalaemia:

- Sinus rhythm with inverted T waves, prominent U waves and a long Q-U interval due to severe hypokalaemia (K+ 1.7)
- A premature atrial complex (beat #9 of the rhythm strip) lands on the end of the T wave, causing 'R on T' phenomenon and initiating a paroxysm of polymorphic VT.
- Because of the preceding long QU interval, this can be diagnosed as TdP.

References:

- "ECG Library • LITFL • ECG Library Basics". 2020. Life In The Fast Lane • LITFL • Medical Blog. https://litfl.com/ecg-library/.
- "Sparkson's Illustrated Guide To ECG Interpretation Paperback – March 1, 2018". Jore Muniz, PA-C 2018.
- " Pathophysiology Of Heart Disease: A Collaborative Project Of Medical Students And Faculty, 6E | Medical Education | Health Library ". 2020. *Meded.Lwwhealthlibrary.Com*. https://meded.lwwhealthlibrary.com/book.aspx?bookid=1573.
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Contact Information

- James J. Jones, PhD, PA-C
- Email: jamesjonespa@gmail.com
- Cell: 571-282-8669

- THANK YOU!
- Stay Safe and I look forward to seeing you at AAPA next year!