



# The University Of Hong Kong

## Practical Guide for ECG Interpretation

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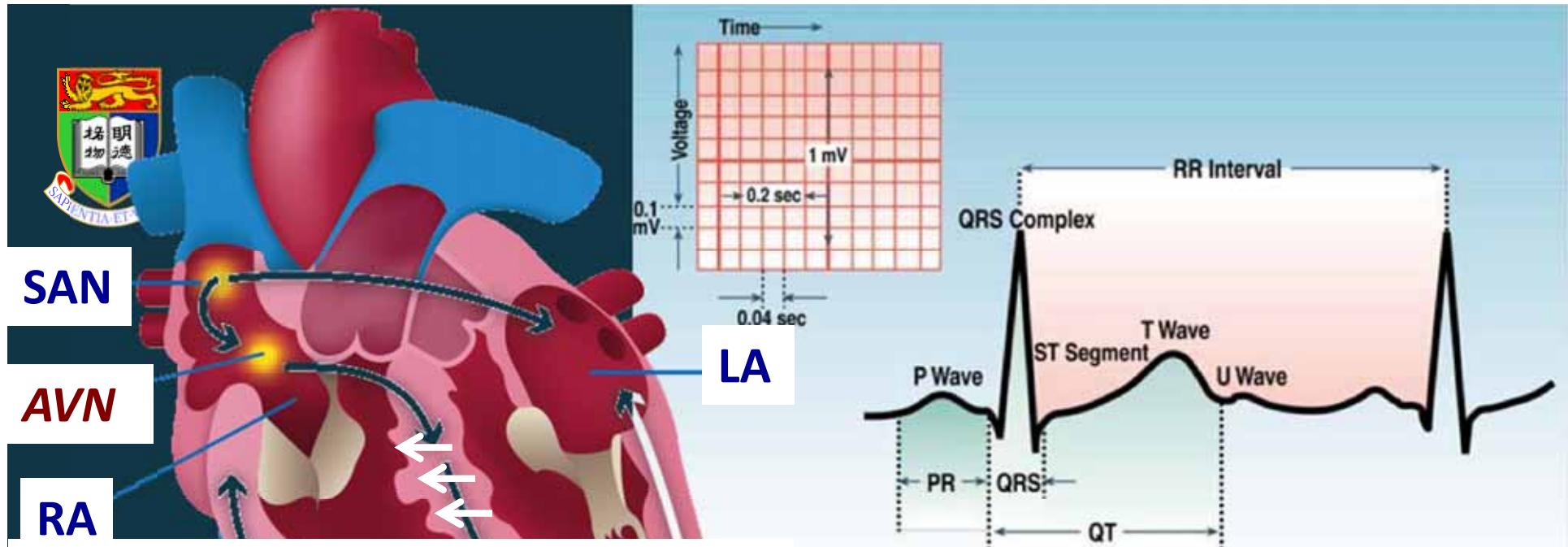
# Outline

- Basic principals of ECG acquisition
- Normal electrical conduction
- Systematic ECG analysis
- Examples
  - *Differential diagnosis WILL NOT be covered in this lecture*



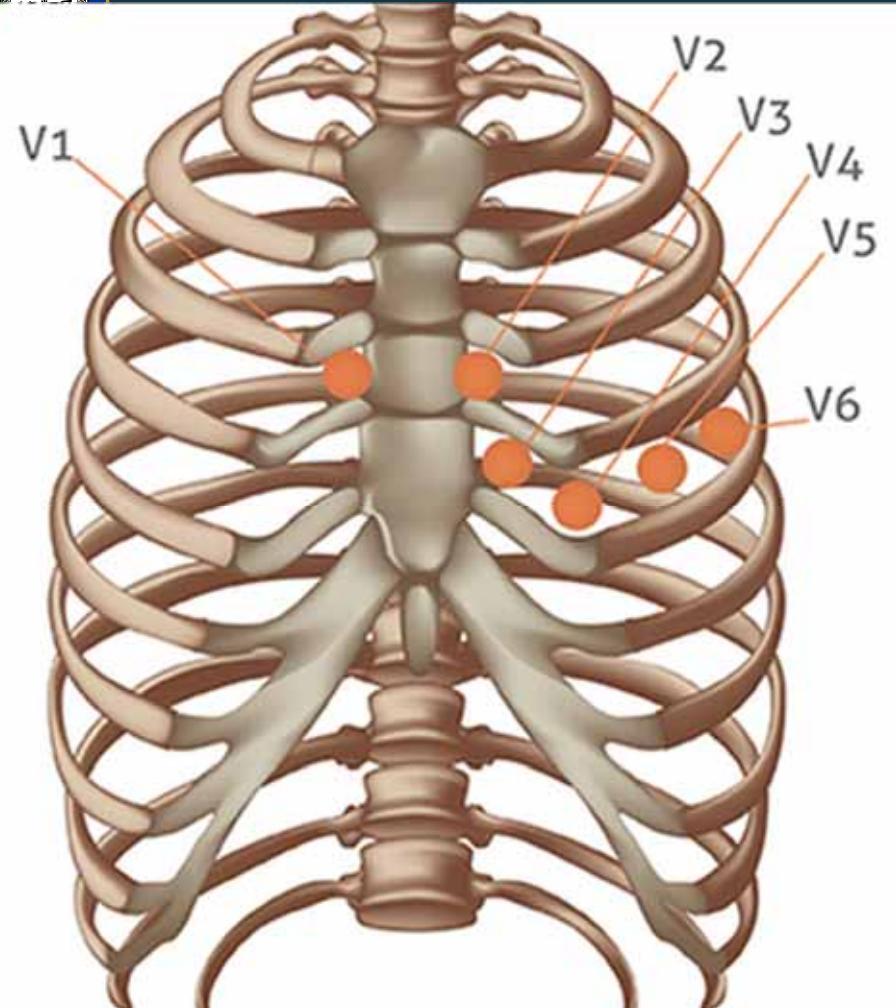
# Standard 12-lead Electrocardiogram

- Recording of the heart's electrical activity from electrodes on the body surface
- *Direction of electrical waveform*
  - Anything moving away from the lead: -ve
  - Anything moving towards the lead: +ve
- *Amplitude of electrogram*
  - The larger the muscle, the larger the amplitude
  - The farther away the lead from the heart, the smaller the amplitude

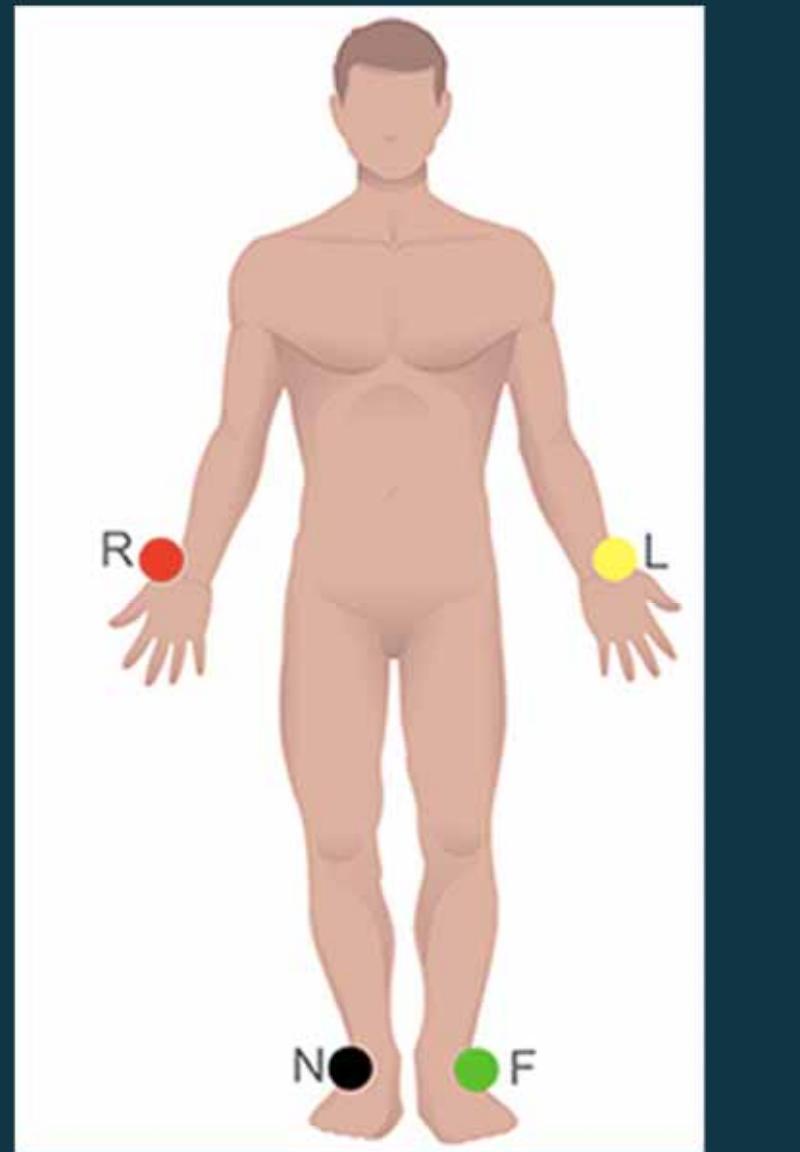


- P wave
  - Duration: <0.12s (*can't be too short!*)
  - Amplitude <2.5mm
- PR
  - Duration 0.12 – 0.20s
- QRS
  - Duration 0.06 – 0.10s, definitely not >0.12s if the inter-/intra-ventricular conduction is intact

**AHA/ACCF/HRS Recommendations 2009  
Collob MH et al. JACC 2011**



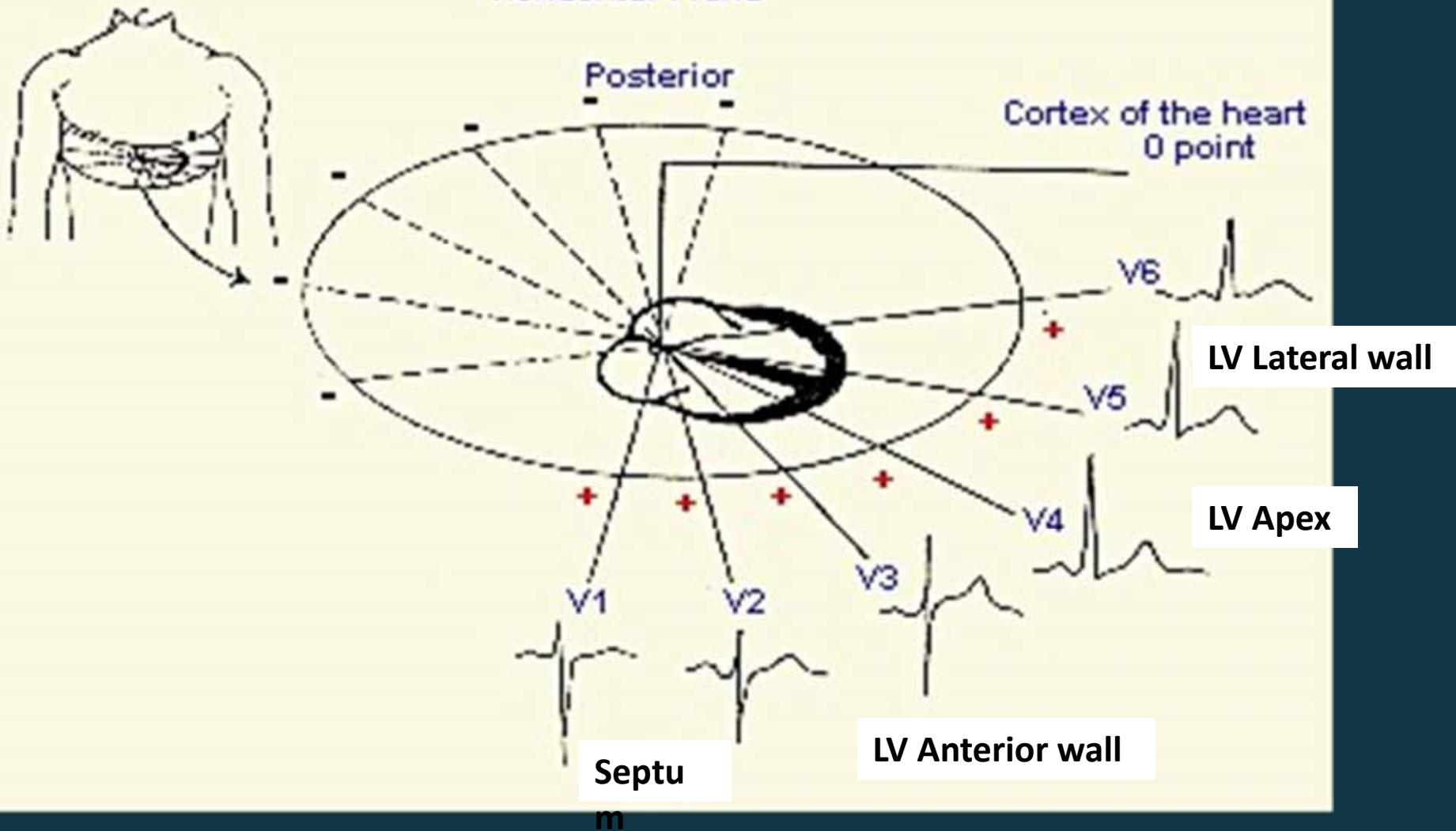
**Chest Leads/Augmented leads -  
Unipolar**



**Limb Leads - Bipolar**



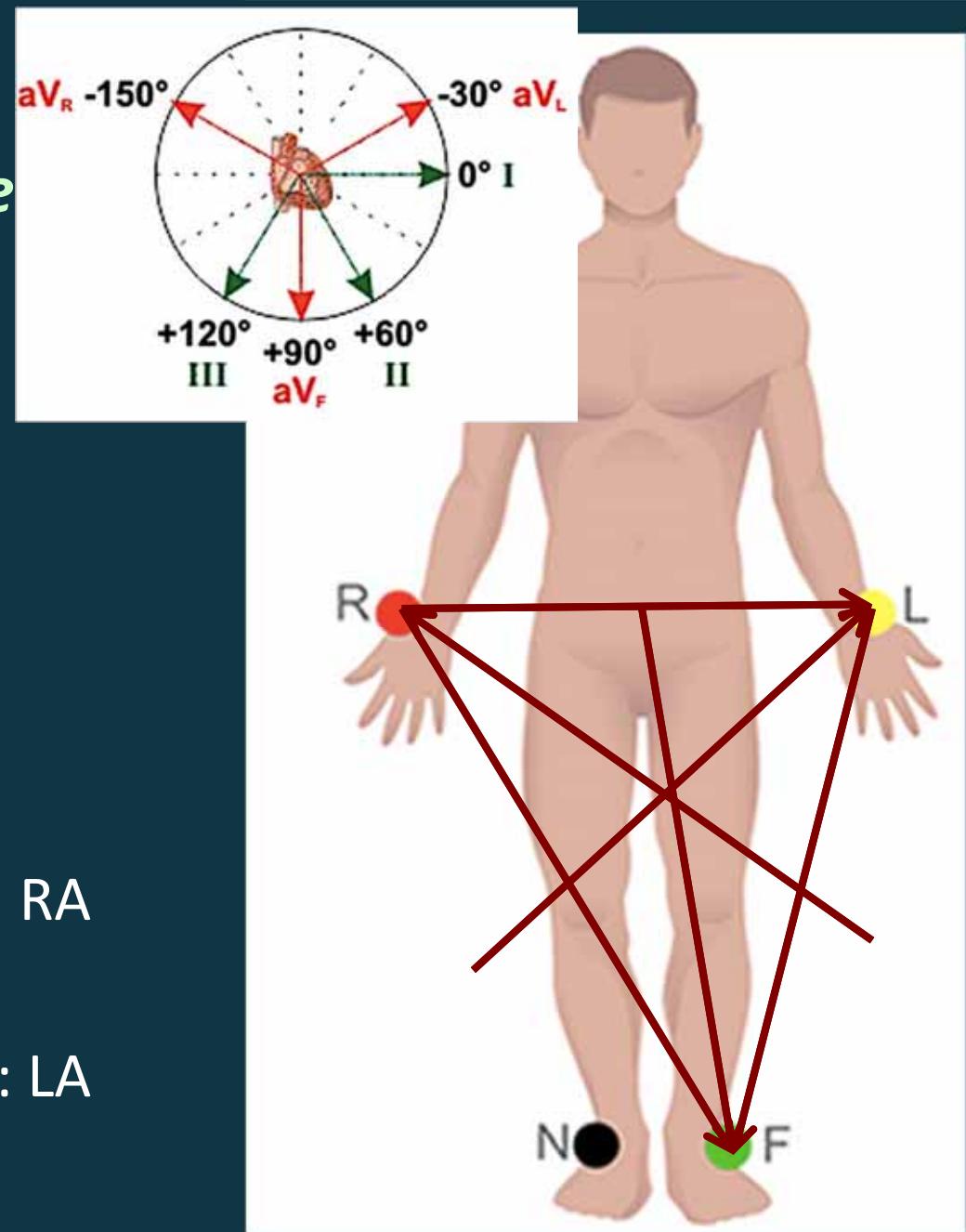
### Horizontal Plane

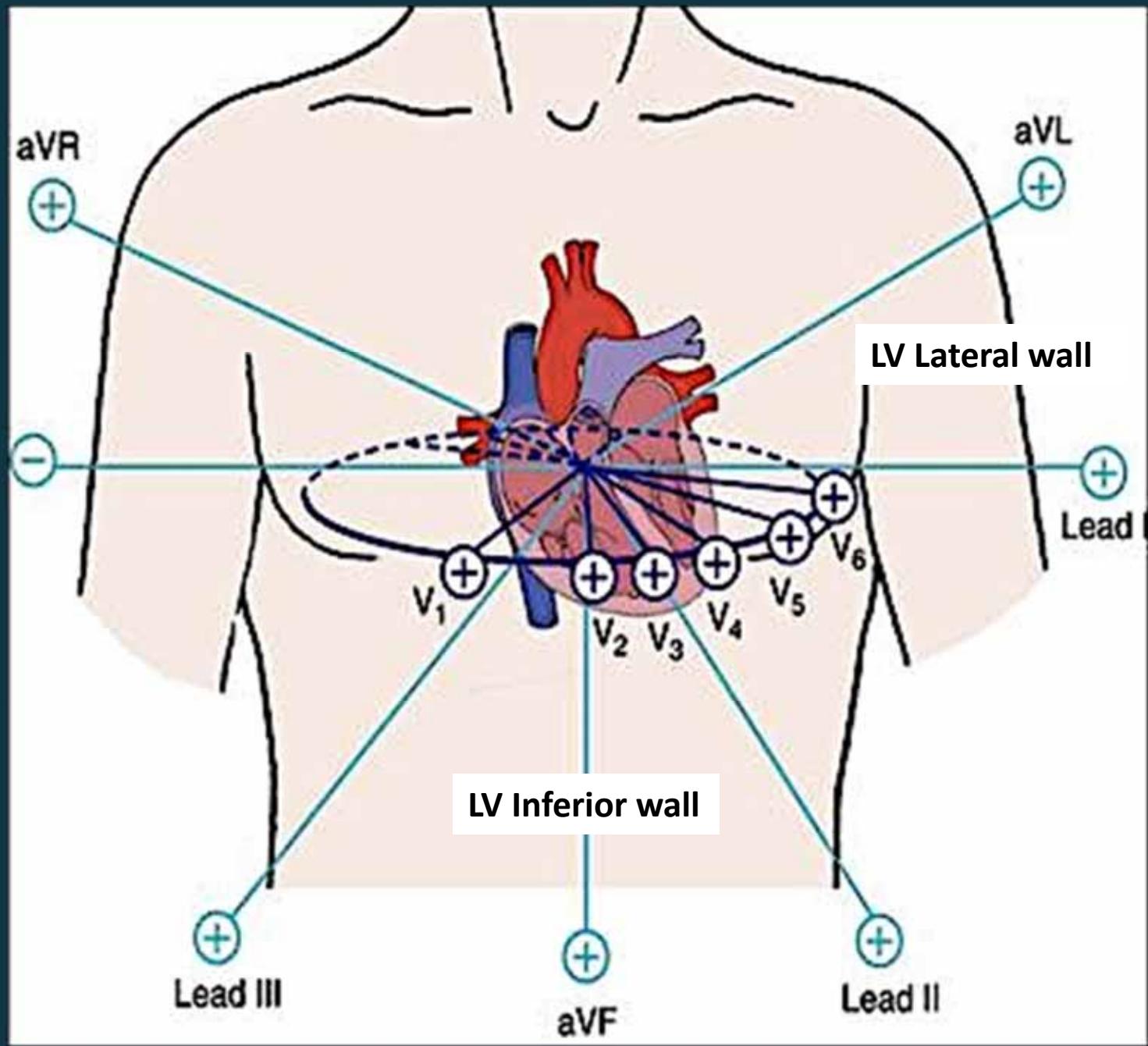




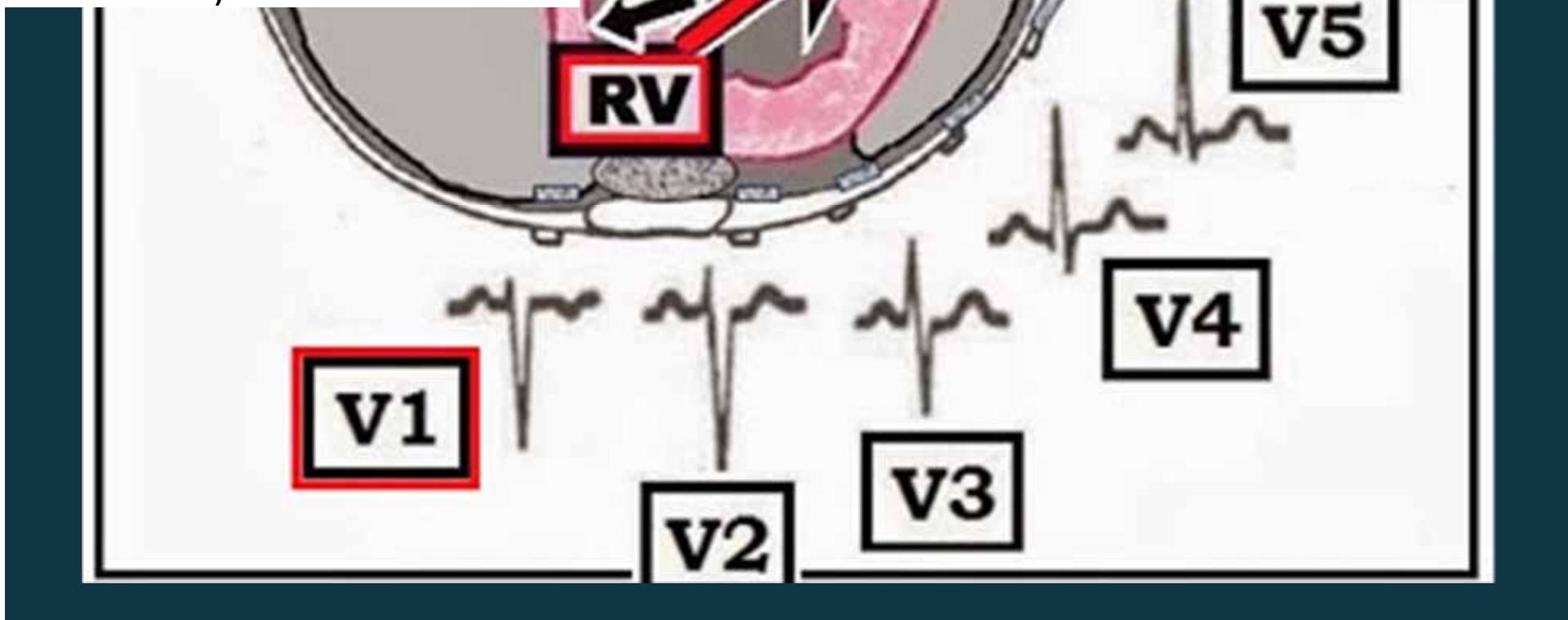
# Limb Leads

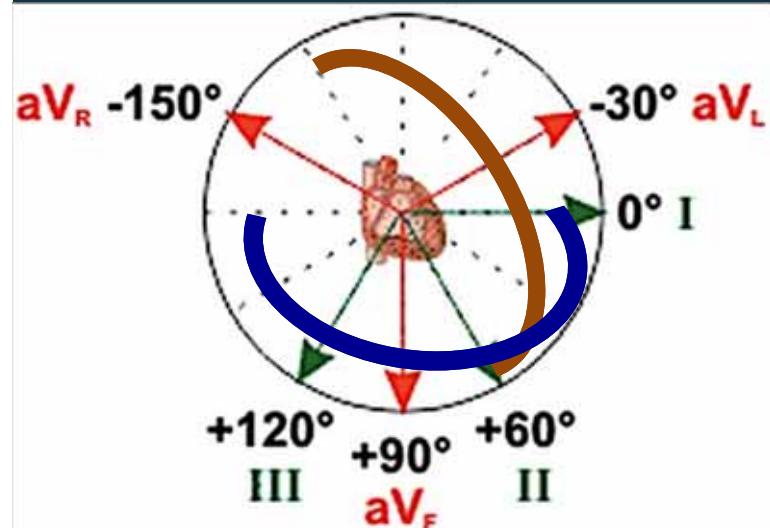
- **Bipolar = -ve to +ve**
- **Lead I**
  - -ve: RA / +ve: LA
- **Lead II**
  - -ve: RA / +ve: LL
- **Lead III**
  - -ve: LA / +ve: LL
- aVR (augmented)
  - -ve: LA + LL / +ve: RA
- aVL
  - -ve: RA + LL / +ve: LA
- aVF
  - -ve: LA + RA / +ve: LL



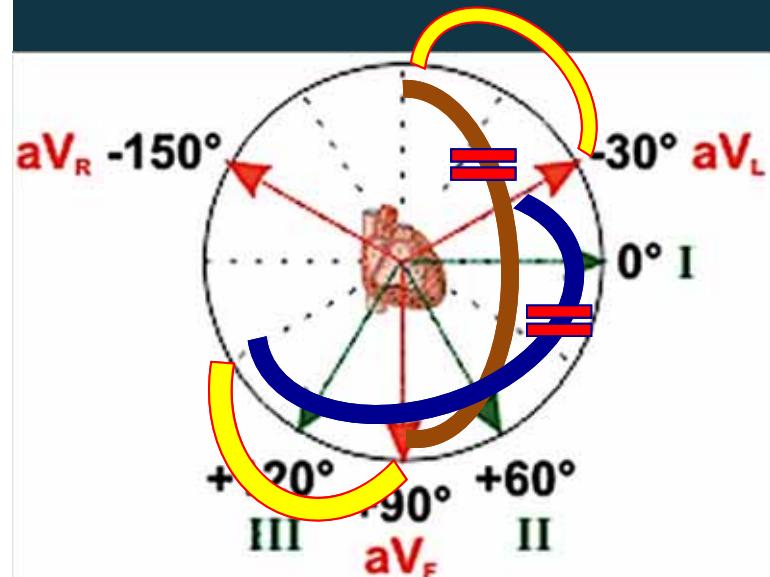


- Septal depolarization
  - Initial 20-30ms
  - q waves at V5, V6
  - r waves at V1, V2
- Ventricular depolarization
  - Next 70-80ms
  - Mainly right to left
  - Transition (from S>R to R>S) in V3 or V4



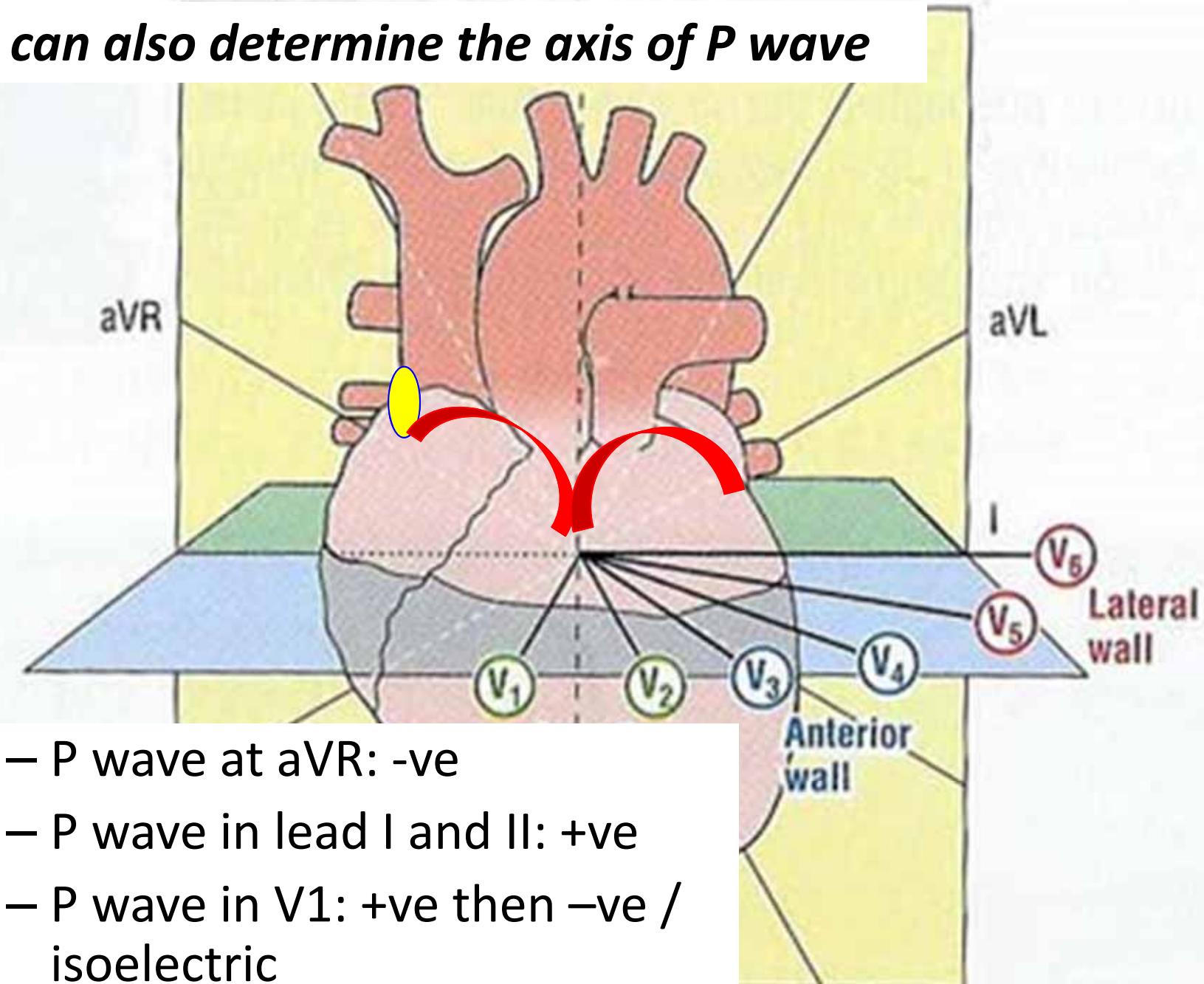


- **QRS Frontal Axis**
  - Average direction of ventricular depolarization (QRS) forces
- **Normal QRS Axis**
  - **-30° to +90°**
- **Calculation**
  - Sine cosine tangent... (???)
- **Simplified method of axis determination**
  - Any isoelectric limb (R=S) lead = 90° to the **Axis**
  - Any +ve (R>Q or S) limb lead = within 180° of the **Axis**
  - Any -ve (R<Q or S) limb lead = outside 180° of the **Axis**
  - **For normality to happen, lead I (+90°) and lead II (-30°) must be +ve or isoelectric**



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  - **For normality to happen, lead I (+90°) and lead II (-30°) must be +ve or isoelectric**
  - **If lead I is +ve but lead II is -ve...**
    - *Left axis deviation*
  - **If lead II is +ve but lead I is -ve...**
    - *Right axis deviation*

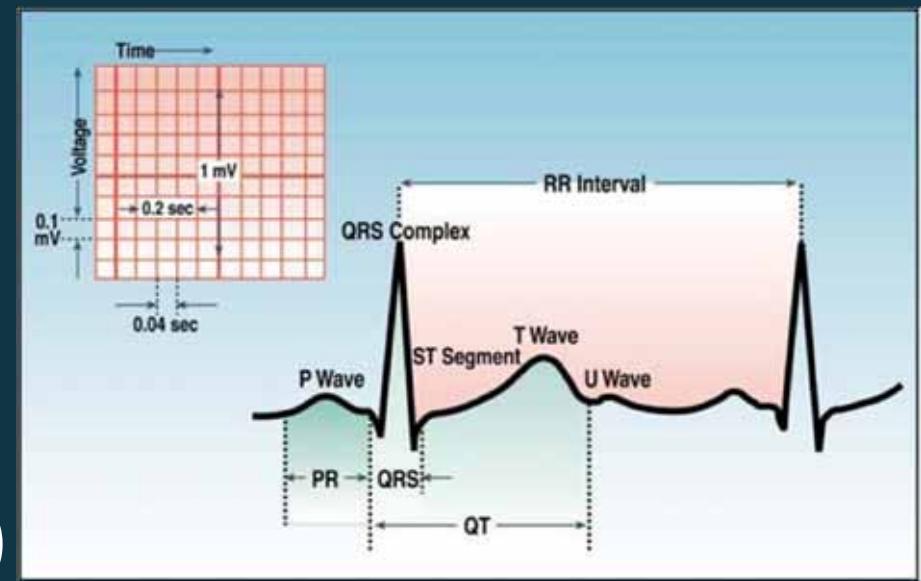
## We can also determine the axis of P wave

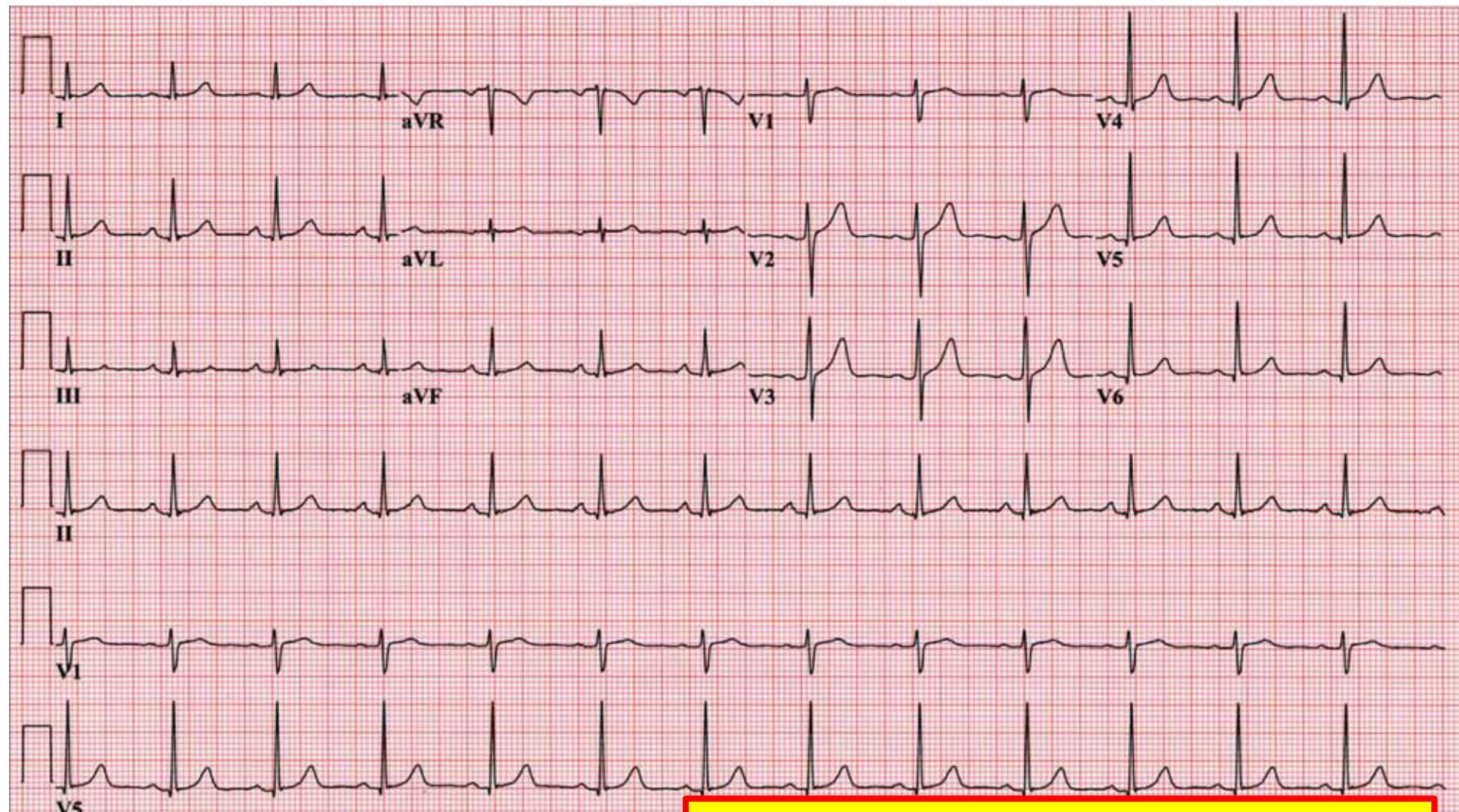


- P wave at aVR: -ve
- P wave in lead I and II: +ve
- P wave in V1: +ve then -ve / isoelectric

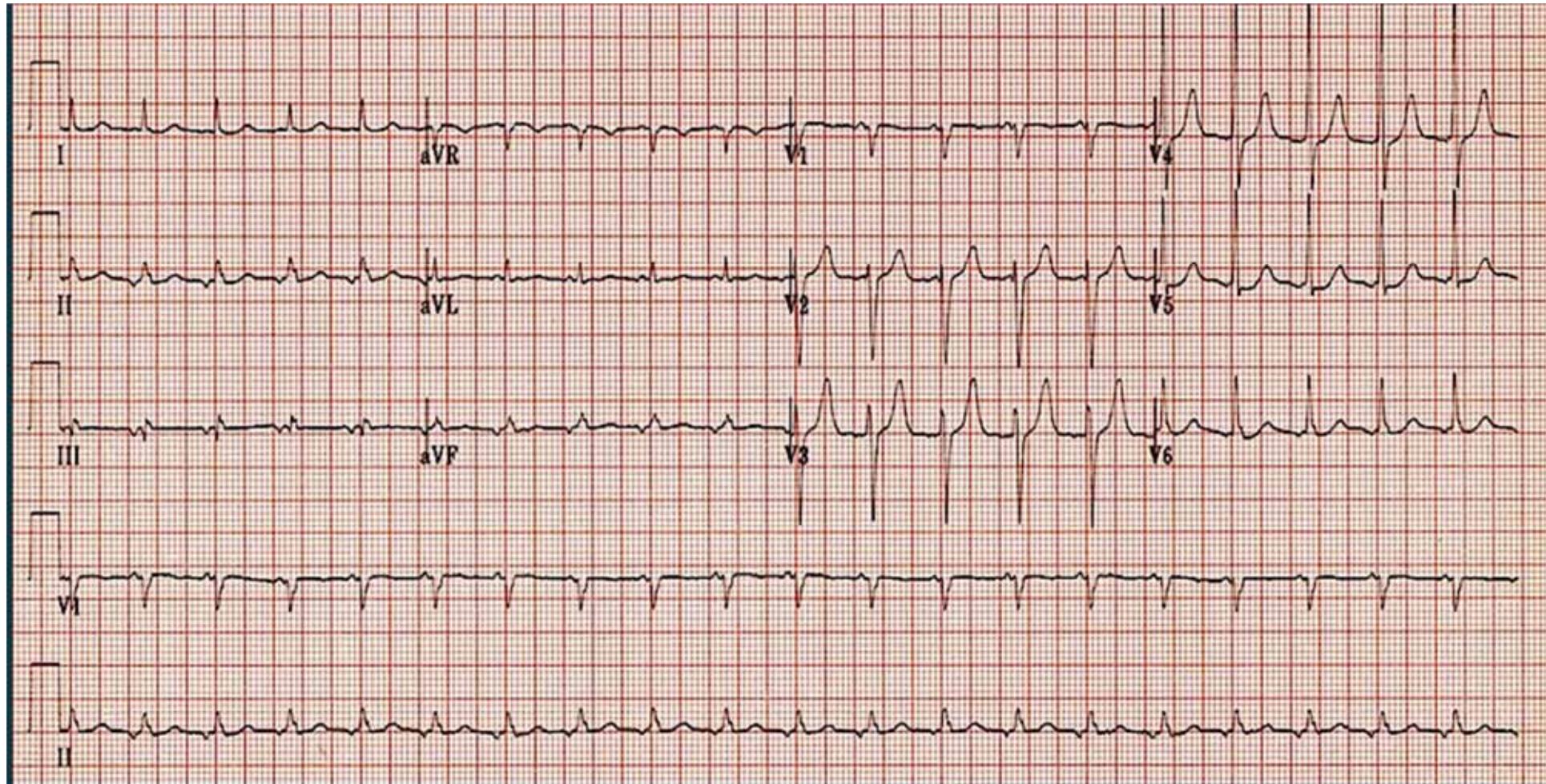
# Systematic ECG Analysis

- Measurements (Timing)
  - HR (regularity, rate)
  - PR; QRS; QT; Axis
- Rhythm (Atrial / Ventricular)
  - Atrial: sinus, atrial (**passive / active**)
  - Ventricular: responding to the atrium, not responding to the atrium (**junction / ventricular**)
- Conduction (AV node and HPS)
  - 1<sup>st</sup>, 2<sup>nd</sup>, 3<sup>rd</sup> degree AV block, inter- / intra-ventricular conduction delay
- Waveform (QRS)
  - Pathological Q wave, abnormal voltage, abnormal ST segment, abnormal T wave, prominent or inverted U wave
- Interpretation





**Impression: Normal ECG**



***Impression: Supraventricular  
Tachycardia (Atrial Tachycardia)***



# Supraventricular Tachycardia

- Atrial Tachycardia
- AV Nodal Reentrant Tachycardia
- AV Reentrant Tachycardia (Accessory Pathway)
- Junctional Tachycardia
- *(Sinus Nodal Reentrant Tachycardia)*

ACC/AHA/ESC Guideline 2003

Regular narrow QRS-complex tachycardia

## Vagal maneuvers / Adenosine

No change in rate

- Inadequate dose/delivery
- Consider VT (fascicular or high septal origin)

Gradual slowing  
then reacceleration  
of rate

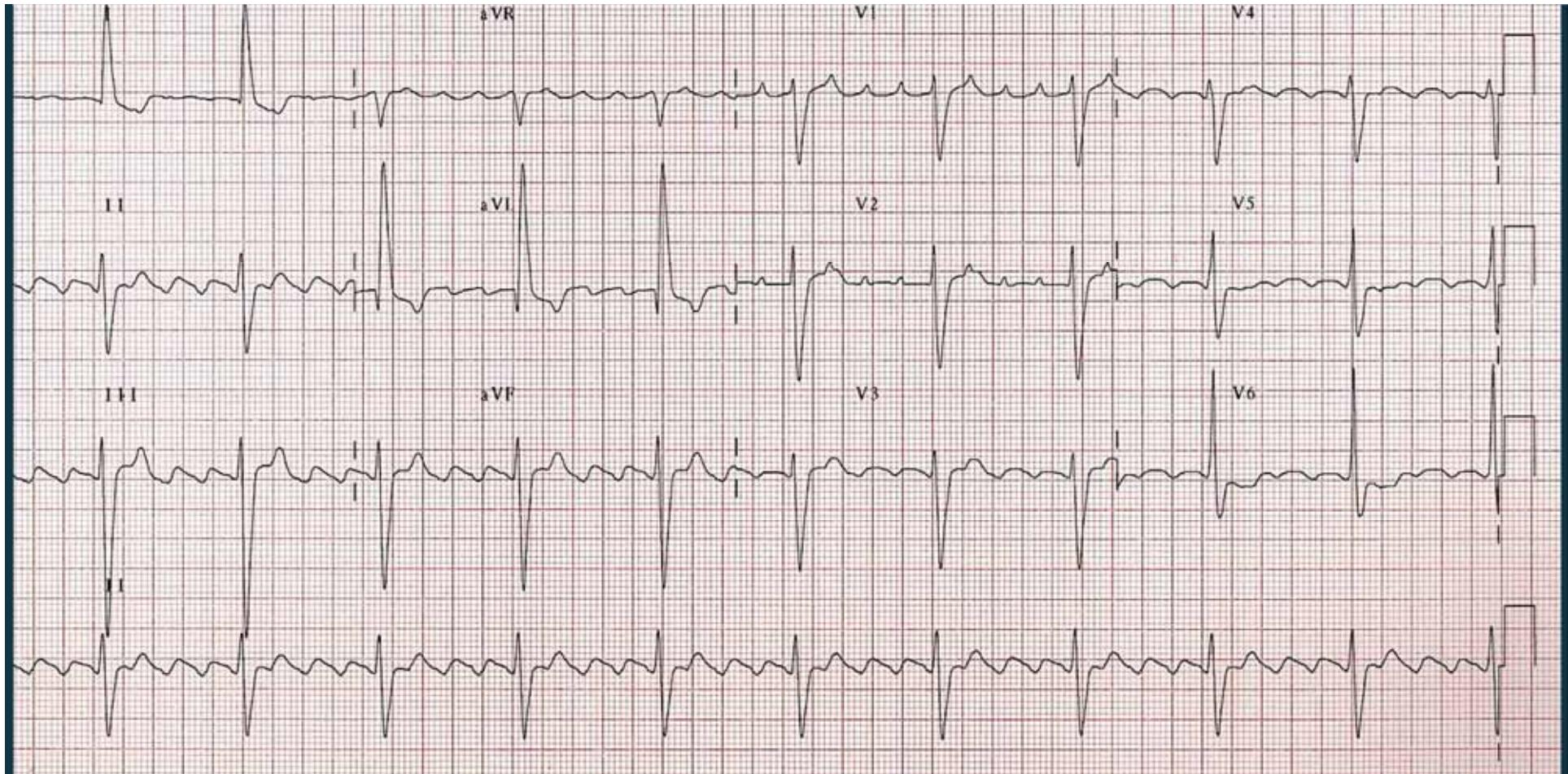
- Sinus tachycardia
- Focal AT
- Nonparoxysmal junctional tachycardia

Sudden  
termination

- AVNRT
- AVRT
- Sinus node re-entry
- Focal AT

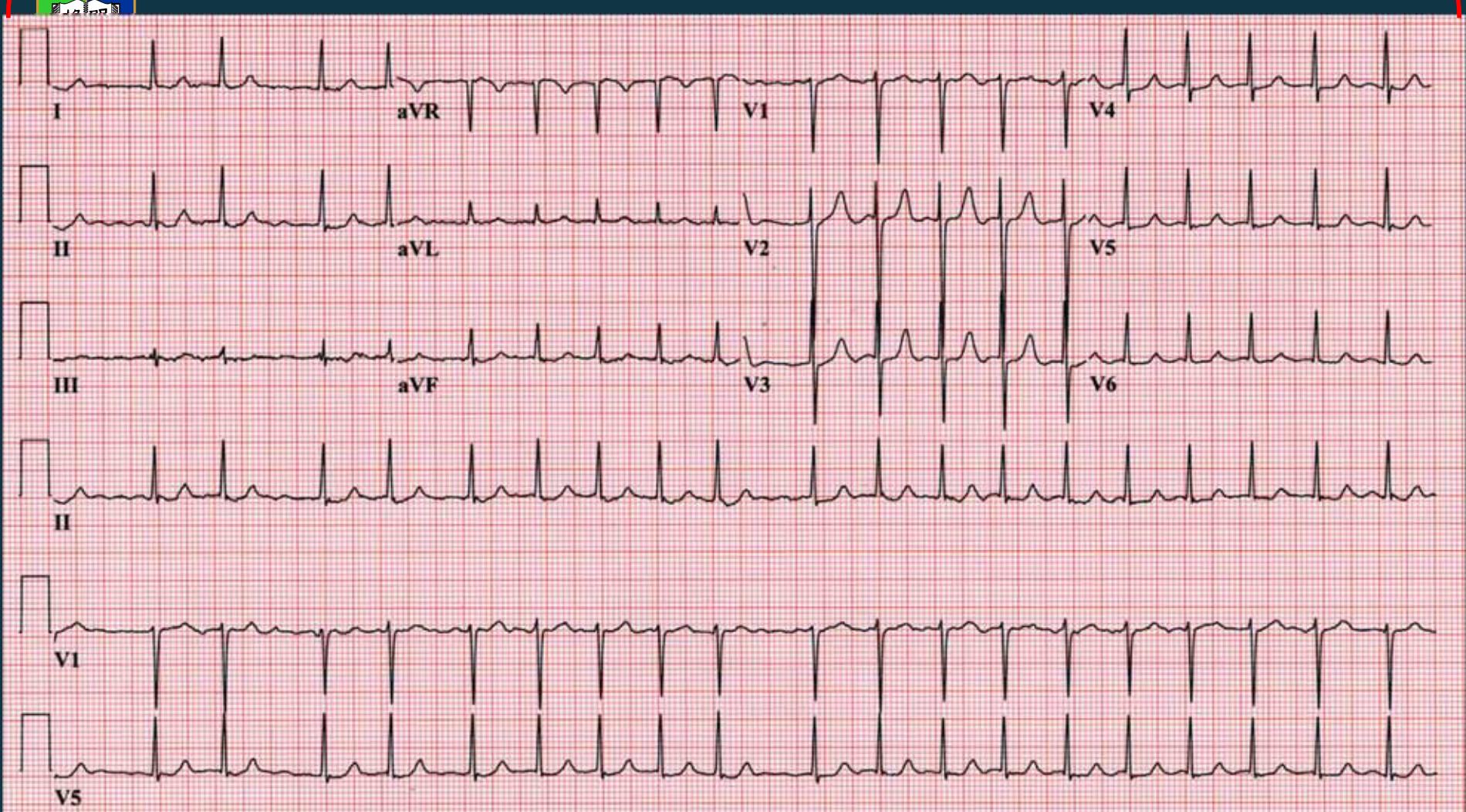
Persisting atrial tachycardia with  
transient high-grade AV block

- Atrial flutter
- AT

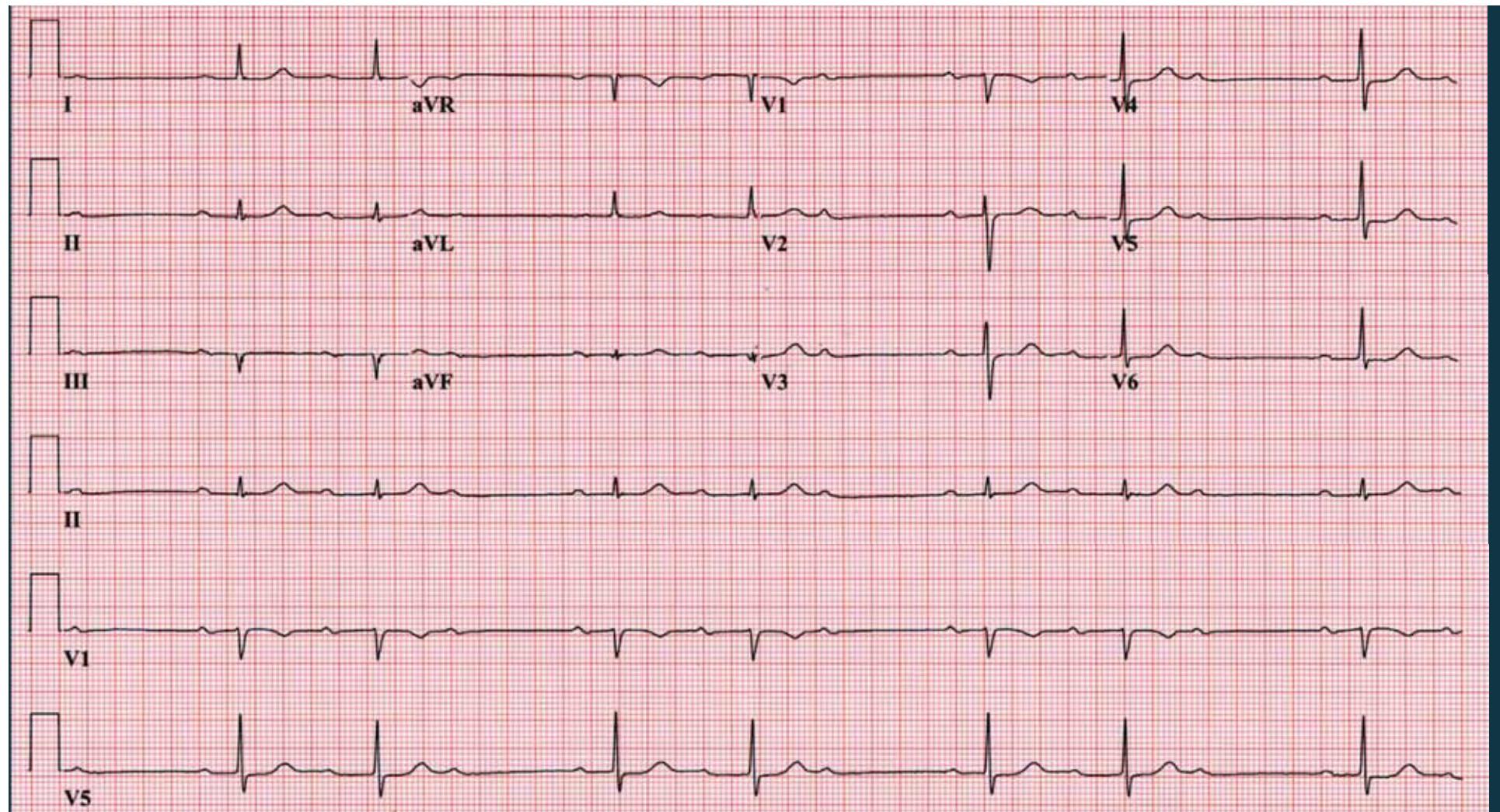


***Impression: Atrial Flutter with  
4:1 AV Conduction***

50 squares x 0.2 = 10s



***Impression: Fast Atrial fibrillation***

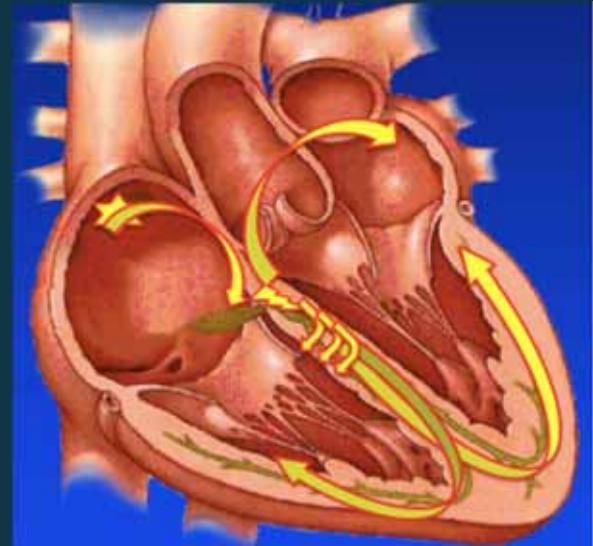


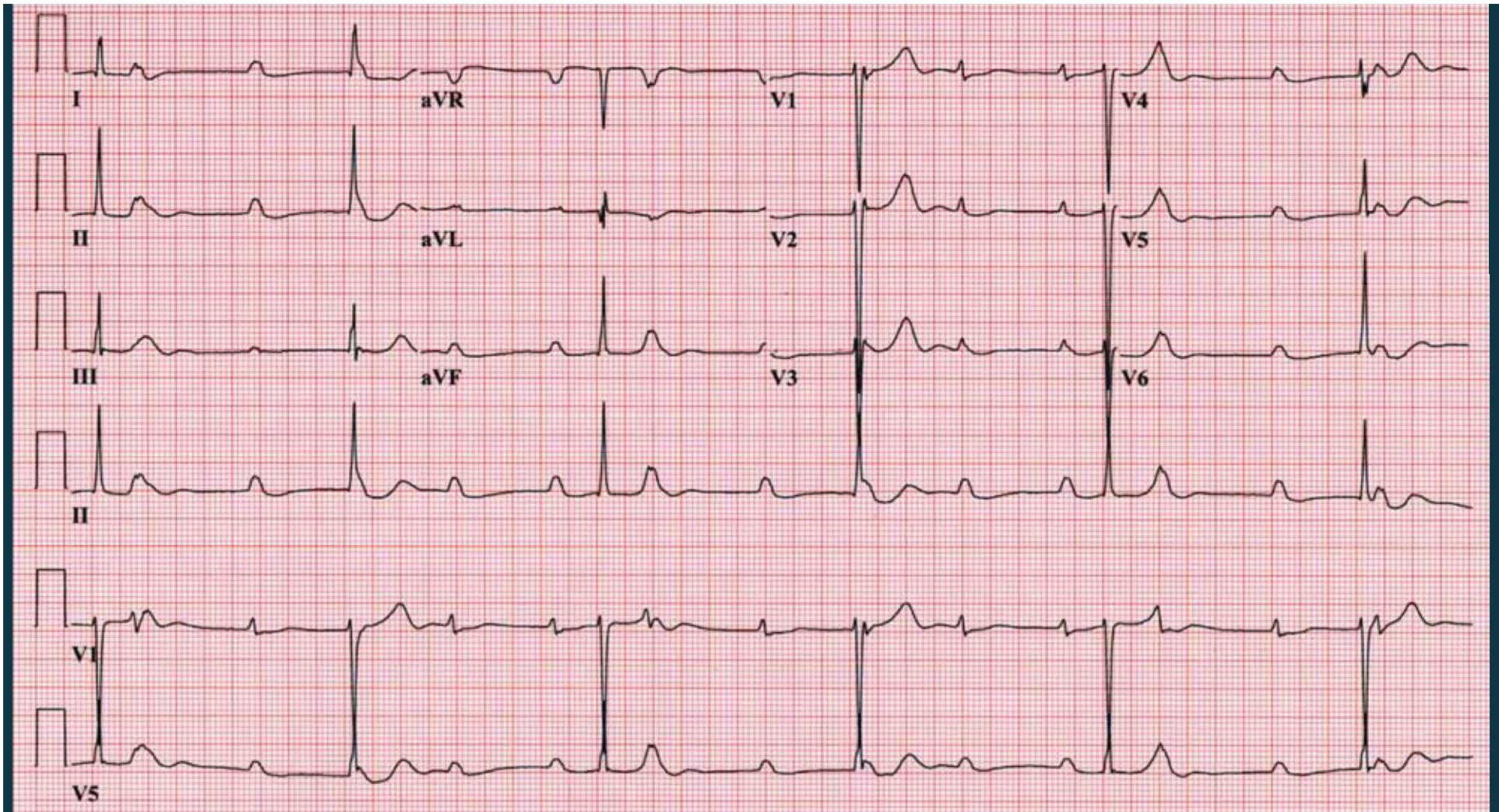
**Impression: Wenckebach AV Block**



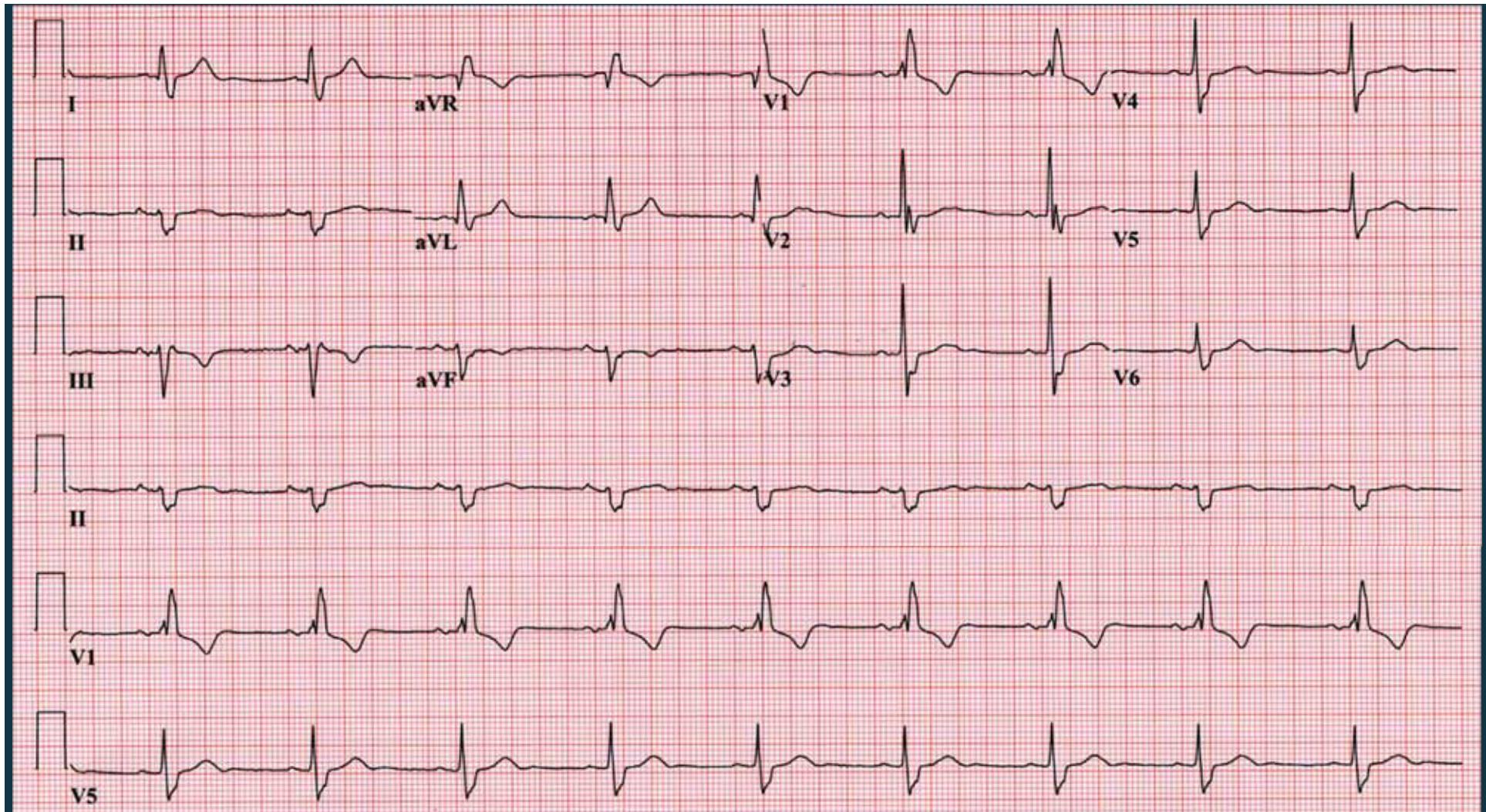
# AV block

- 1<sup>st</sup> Degree AV Block
  - PR >0.20s
  - Most common site of prolongation: AV node
- 2<sup>nd</sup> Degree AV Block
  - Mobitz type I (Wenckebach): Progressive prolongation of PR intervals until a non-conducted P wave occurs
  - Mobitz type II: Fixed PR intervals followed by a non-conducted P wave
- 3<sup>rd</sup> Degree AV Block
  - P and QRS are dissociated from each other





***Impression: Complete AV Block***



***Impression: RBBB + LAD  
(Bifascicular Block)***

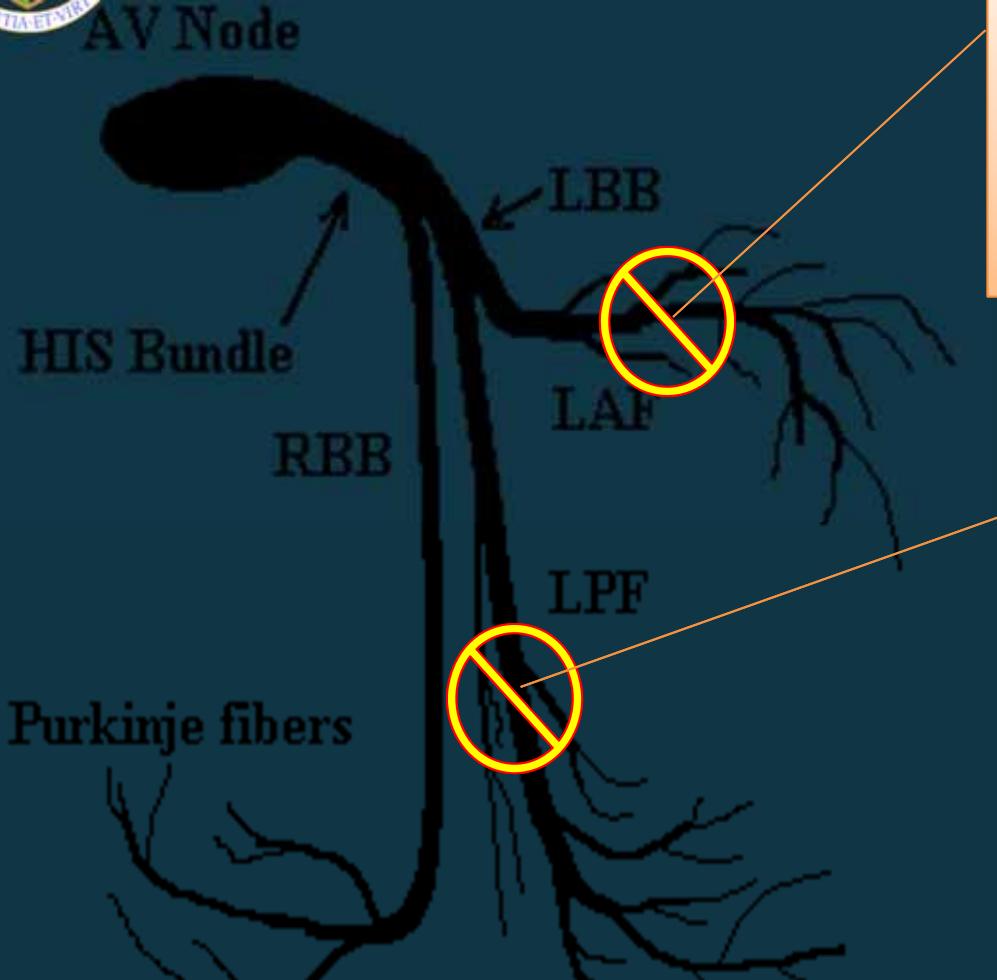


# Inter-ventricular Conduction Delay

- **RBBB**
  - QRS  $\geq 0.12s$
  - rsR' or rSR' in V1 with R' wider than r wave
  - Deep S wave in lead I and V6 with S wider than R or  $\geq 0.04s$
- **LBBB**
  - QRS  $\geq 0.12s$
  - QS pattern in V1 (small r wave can occasionally be seen)
  - Broad notched slurred R wave in I, aVL, V5 and V6 with onset to peak (R wave peak time)  $> 0.06s$
- Appropriate T wave discordance with BBB
  - T wave should deflect opposite to the terminal portion of the QRS
- Positive concordance can be normal



# Fascicular Block



***Left Axis Deviation***

qR in I & aVL

R wave peak time in aVL

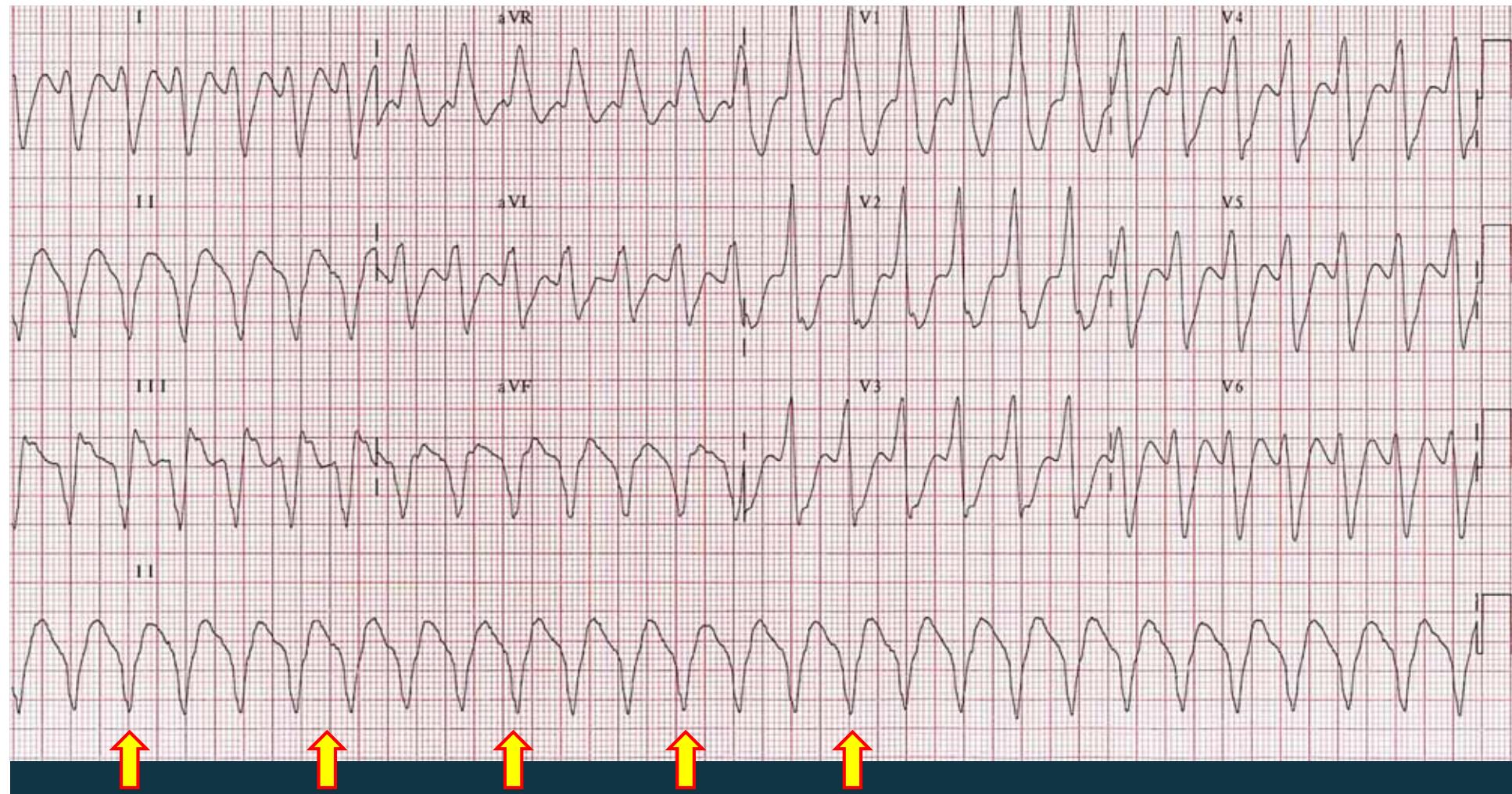
$\geq 0.045s$

***Right Axis Deviation***

rS in I & aVL

qR in III & aVF

***RBBB + LAFB / LPFB = Bifascicular Block***



***Impression: Monomorphic Ventricular Tachycardia***



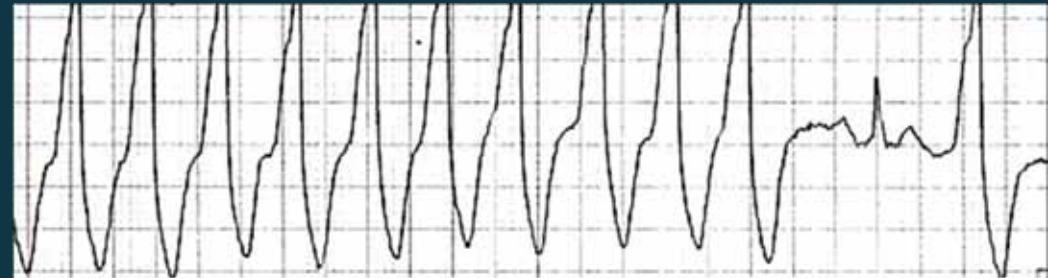
# Differential Diagnosis of Wide Complex Tachycardia

- Ventricular tachycardia
- Supraventricular tachycardia with aberrant conduction (RBBB, LBBB)
- Supraventricular tachycardia with anterograde accessory pathway conduction

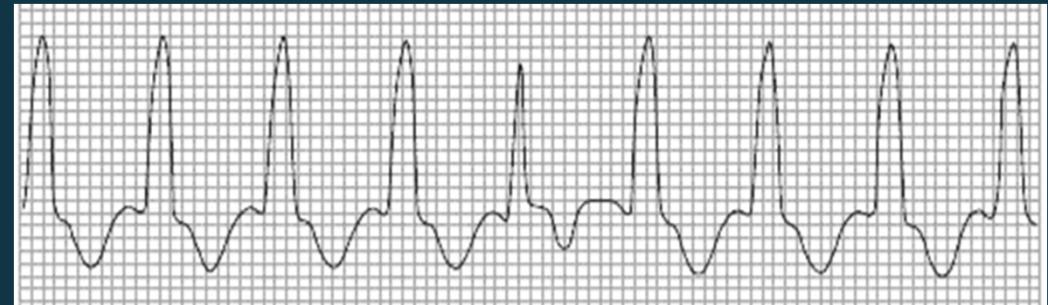


# Features of VT

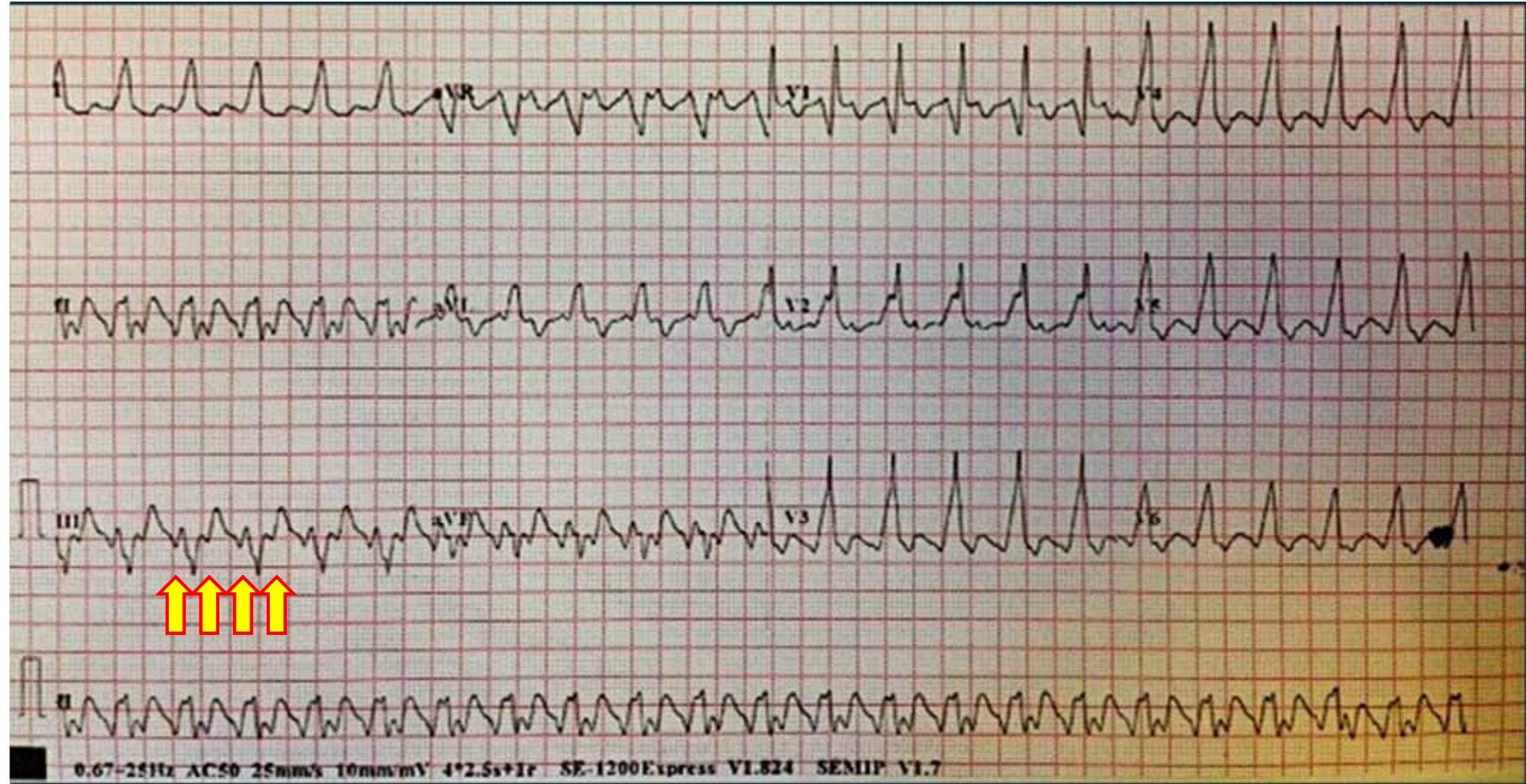
- *AV dissociation*
- *Capture Beat*



- *Fusion Beat*

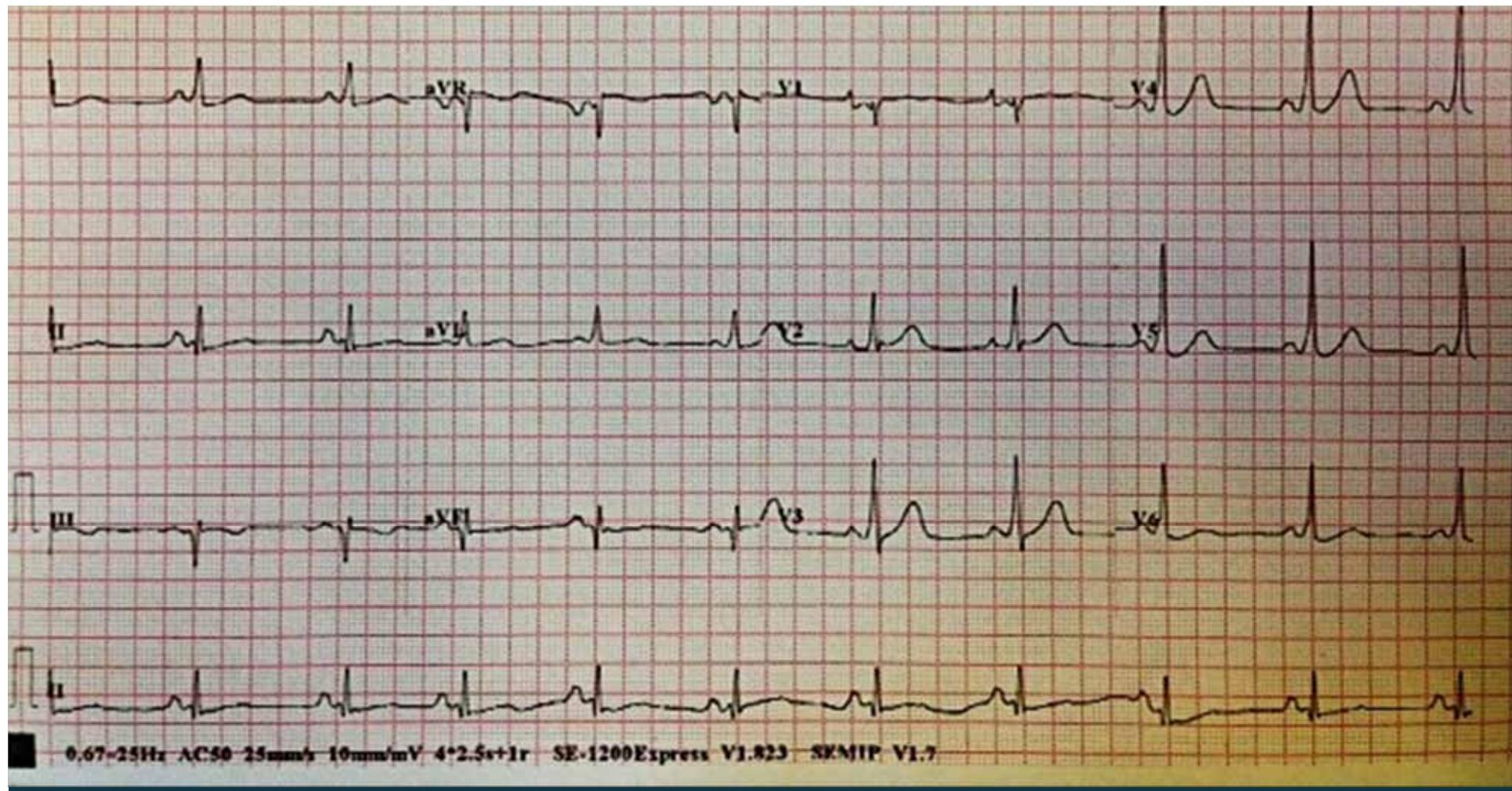


- *Negative concordance over precordial leads*
- History of structural heart disease
- PVC of similar morphology

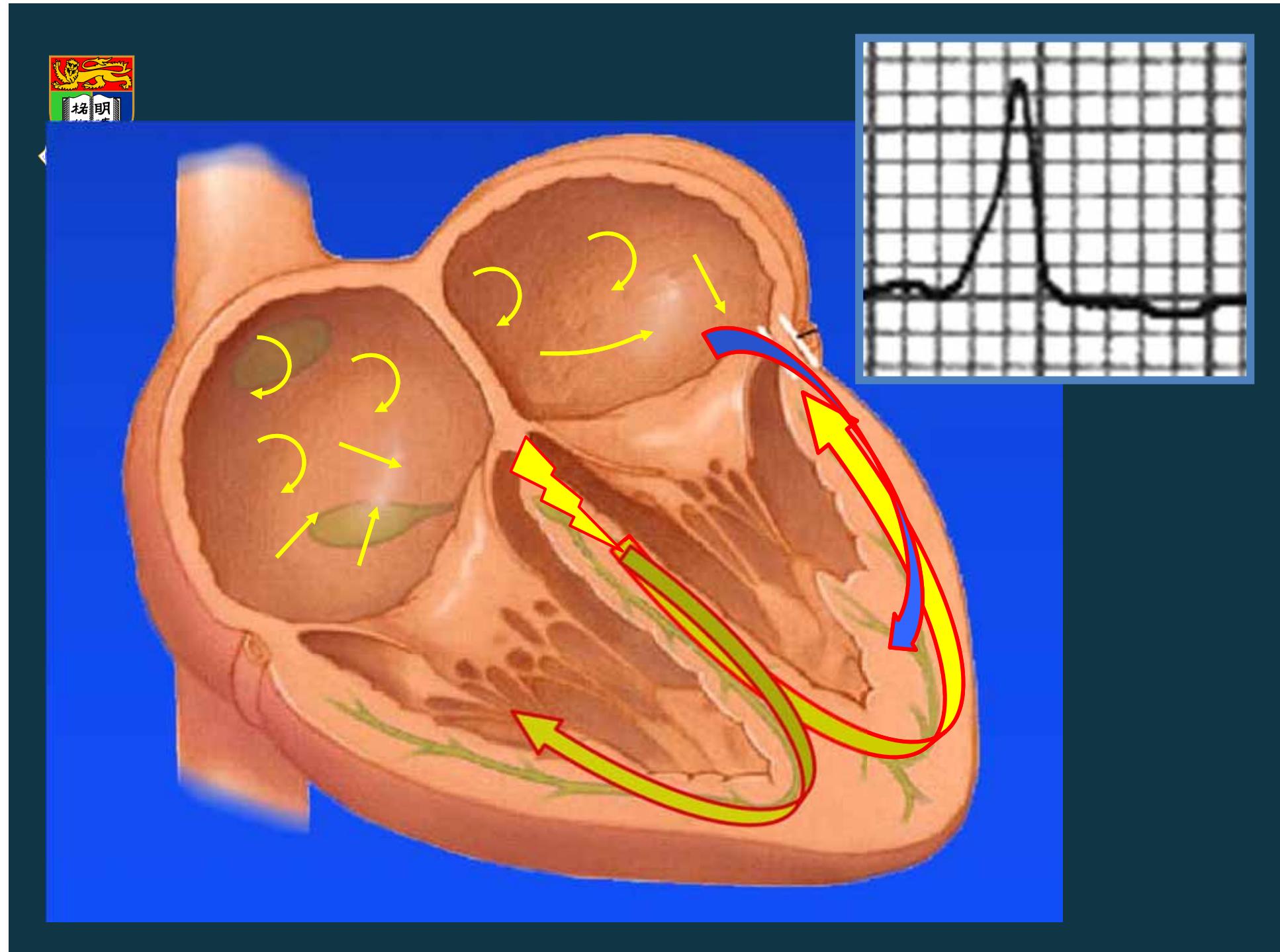


***Impression: Nothing support VT***

***Definitely not aberrancy***

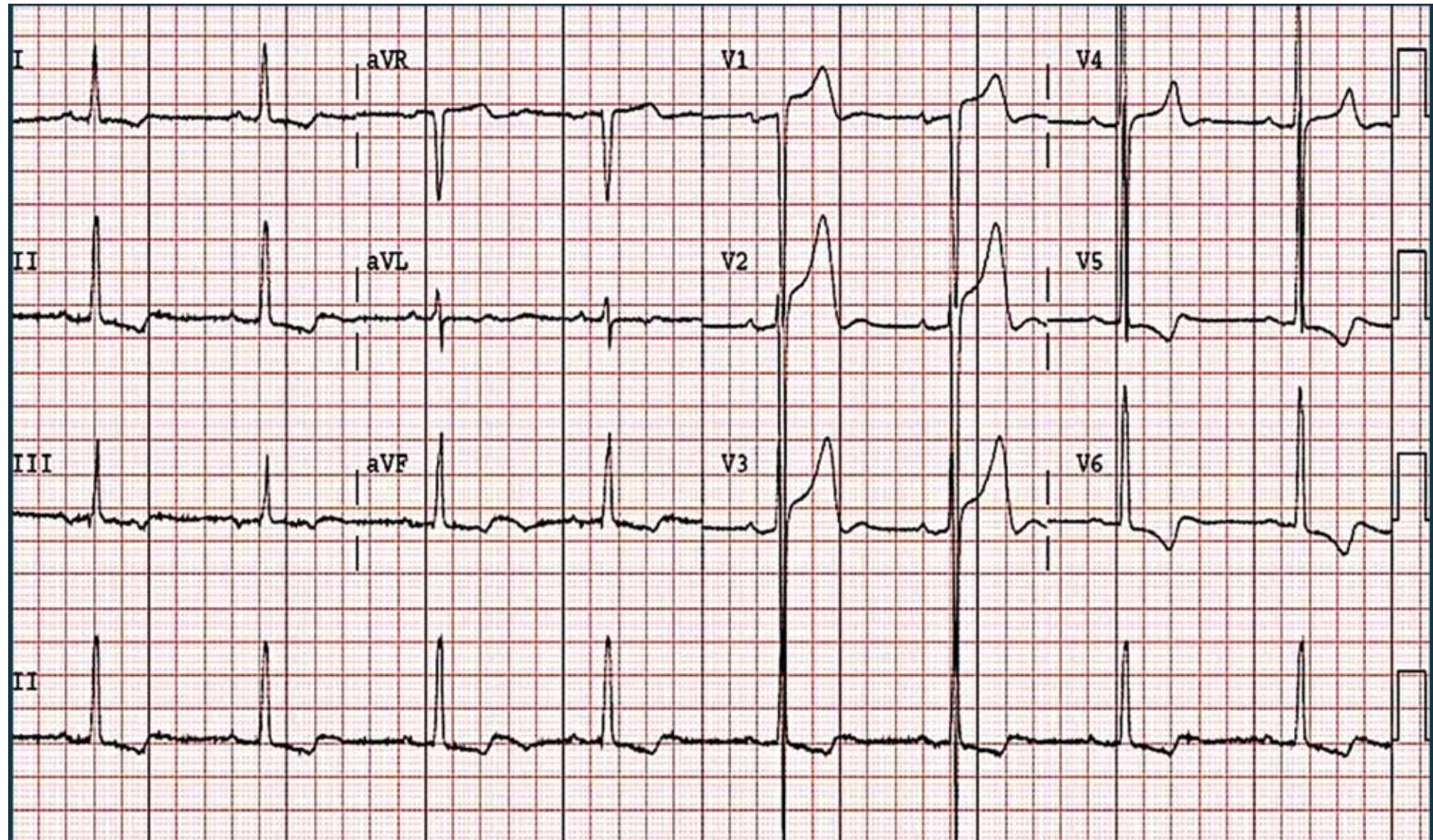


**Impression:**  
**Wolff Parkinson White Syndrome**





***Impression: Torsade de Pointes***

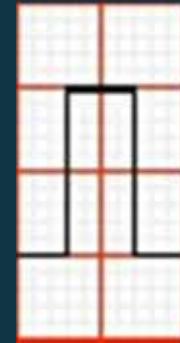


***Impression: Left Ventricular Hypertrophy  
with strain pattern***



# Commonly Used Criteria for LVH

- S in V3 + R in aVL >28mm in M, >20mm in F
- R in aVL  $\geq$ 11mm
- R in I + S in III >25mm
- R in aVF >20mm
- S in aVR >14mm
- S in V1 + R in V5/V6  $\geq$ 35mm
- *R + S in any leads >45mm*
- *Associated with LAE, LAD, ST/T abnormalities  
(Appropriate Discordance)*



– 1mm = 0.1mV



# Commonly used criteria for RVH

- Tall R waves in RV leads, deep S waves in LV leads
  - $R \text{ in } V1 + S \text{ in } V5/V6 > 10 \text{ mm}$
  - $R/S \text{ ratio in } V1 > 1$
  - $R > 7 \text{ mm}, S < 2 \text{ mm} \text{ or } rSR' \text{ with } R' > 10 \text{ mm}$
- RAD
- Incomplete RBBB pattern
- ST/T abnormalities (Appropriate Discordance)

–  $1 \text{ mm} = 0.1 \text{ mV}$

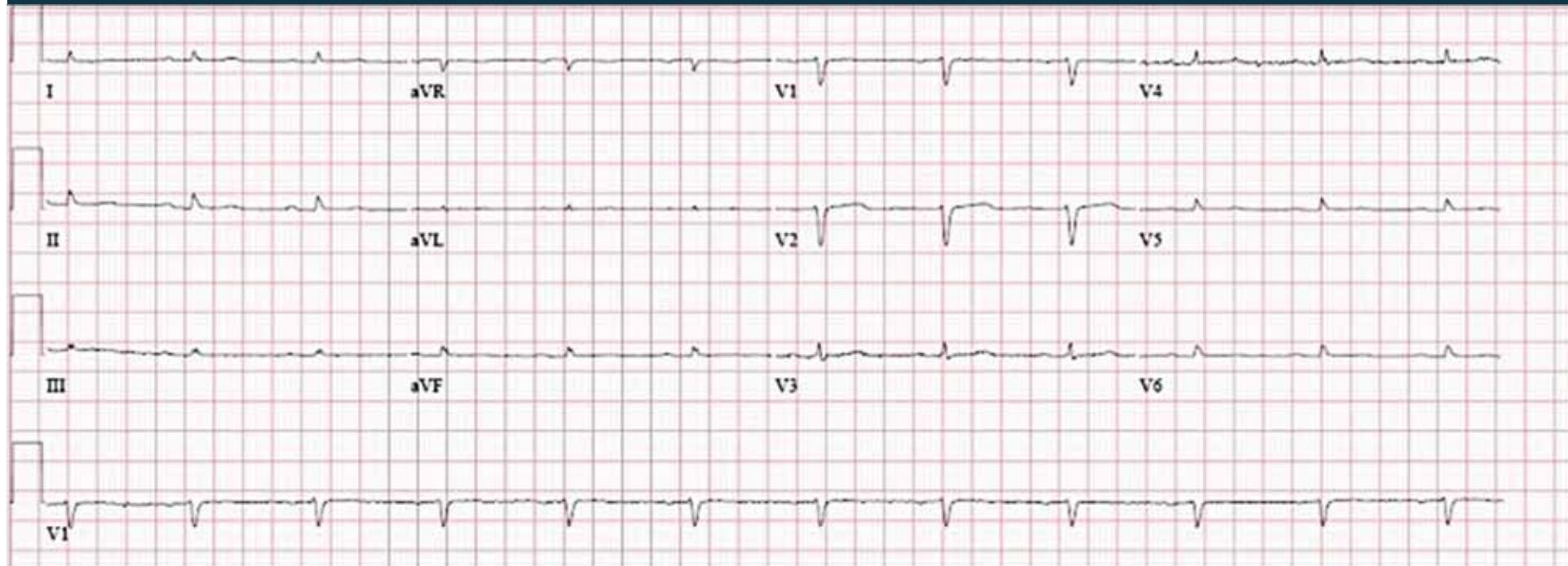


# ECG Criteria for Low Voltage

- Peripheral Voltage
  - All leads  $\leq 5\text{mm}$
- Precordial Voltage
  - All leads  $\leq 10\text{mm}$
- Sokolow-Lyon Index
  - S wave in V1 + R wave in V5/V6  $\leq 15\text{mm}$



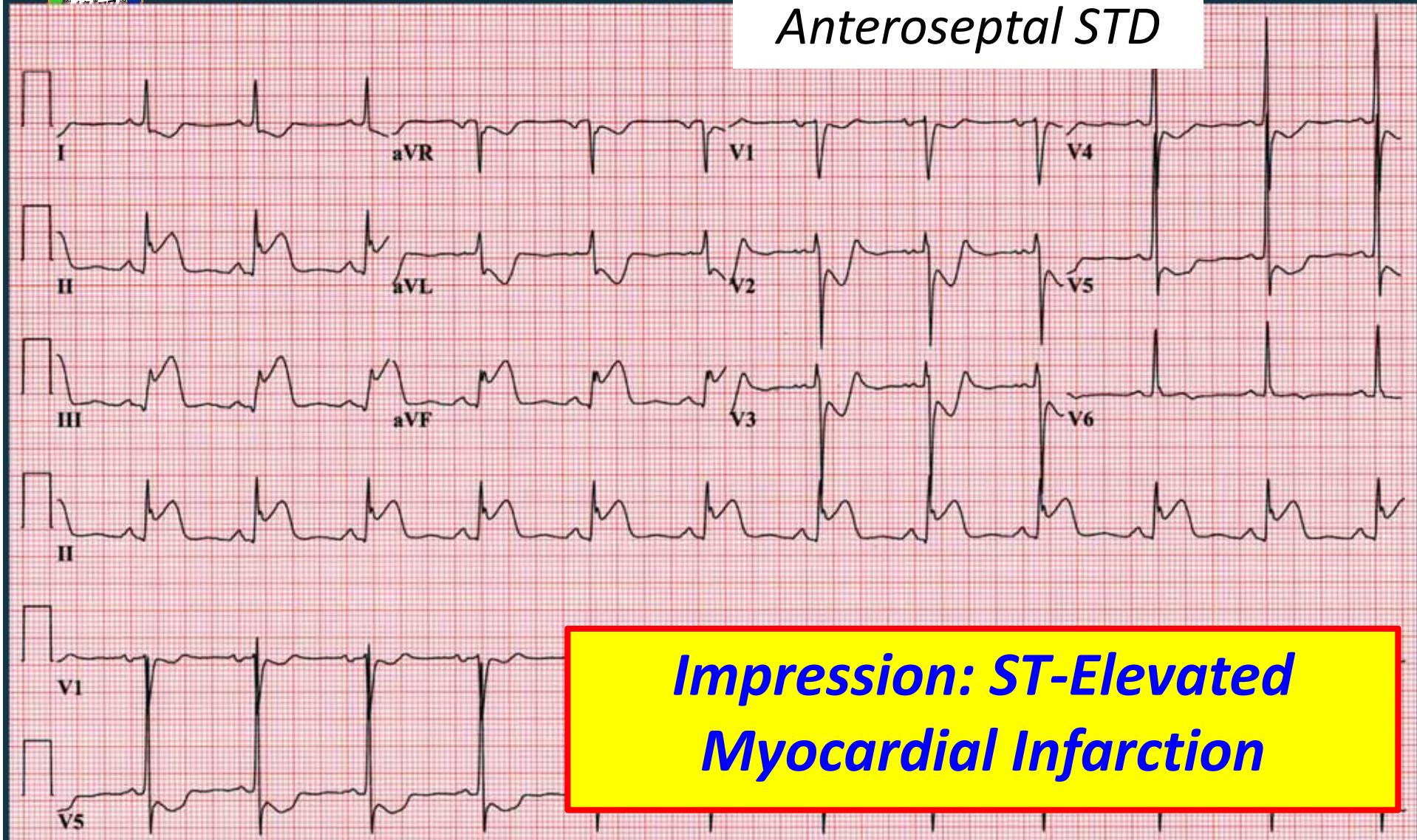
# Example of Low Voltage ECG





*Inferior Concave Downwards STE*

*Anteroseptal STD*



***Impression: ST-Elevated  
Myocardial Infarction***



# ST Elevation

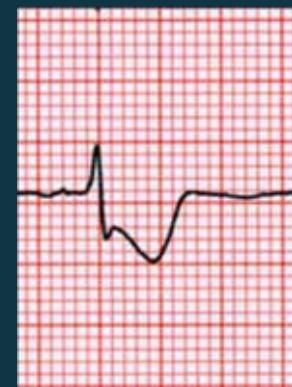
- Threshold for J-point elevation at V2-3
  - 0.2mV for men  $\geq$ 40 years old
  - 0.25mV for men  $<$ 40 years old
  - 0.15mV for women
- Threshold for J-point elevation at other leads
  - 0.1mV
- 2 contiguous leads
  - II, III, aVF; aVL, I, V6; V1-6
- Normal J-point elevation (early repolarization)
  - Rapidly upsloping or normal ST segment





# ST depression

- Threshold for J point depression
  - -0.05mV in V2 and V3
  - -0.1mV in all other leads
- Reciprocal J-point depression
  - Occurs in axis opposite in direction from that of the ST elevation
  - Lateral leads and inferior leads





# T wave abnormalities

- I, II, aVL, V2-V6
- Threshold for T wave inversion
  - -0.1 – -0.5mV
- Threshold for DEEP T wave inversion
  - -0.5 – -1mV
- Threshold for GIANT T wave inversion
  - <-1mV
- Peaked, symmetrical, biphasic, flat, noticed...

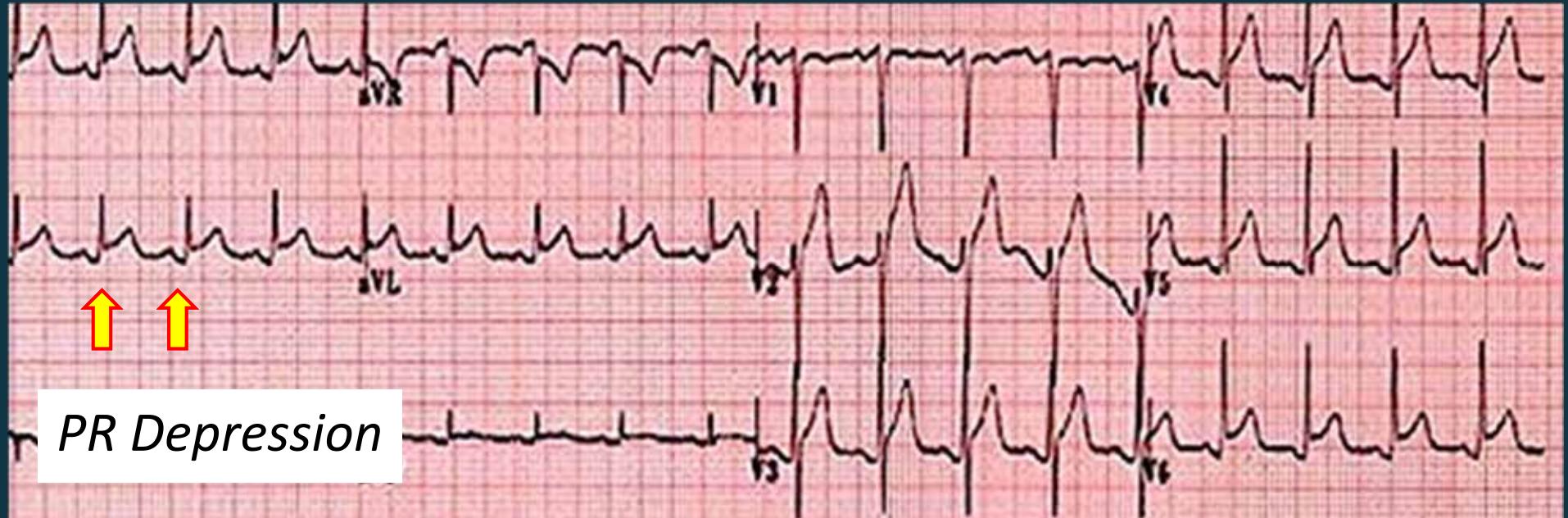


# Abnormal Q waves

Any Q-wave in leads V<sub>2</sub>–V<sub>3</sub>  $\geq 0.02$  s or QS complex in leads V<sub>2</sub> and V<sub>3</sub>

Q-wave  $\geq 0.03$  s and  $> 0.1$  mV deep or QS complex in leads I, II, aVL, aVF, or V<sub>4</sub>–V<sub>6</sub> in any two leads of a contiguous lead grouping (I, aVL, V<sub>6</sub>; V<sub>4</sub>–V<sub>6</sub>; II, III, and aVF)

R-wave  $\geq 0.04$  s in V<sub>1</sub>–V<sub>2</sub> and R/S  $\geq 1$  with a concordant positive T-wave in the absence of a conduction defect



PR Depression

Diffuse Concave Upwards STE

**Impression: Acute Pericarditis**