

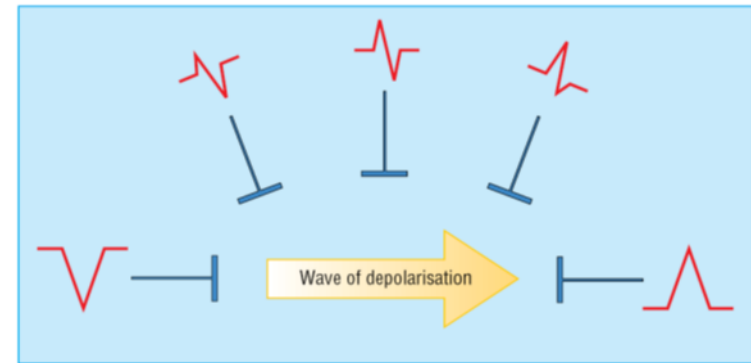
# Μαθήματα ΗΚΓ



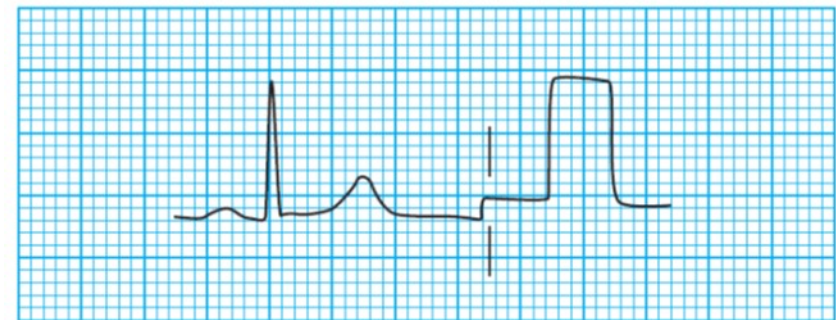
- Γ Λεβεντόπουλος
- Επιμελητής Α' Καρδιολογίας
- Μάρτιος 2021

Standard calibration  
25 mm/s  
0.1 mV/mm

Electrical impulse that travels **towards** the electrode produces an **upright** (“**positive**”) deflection relative to the isoelectric baseline

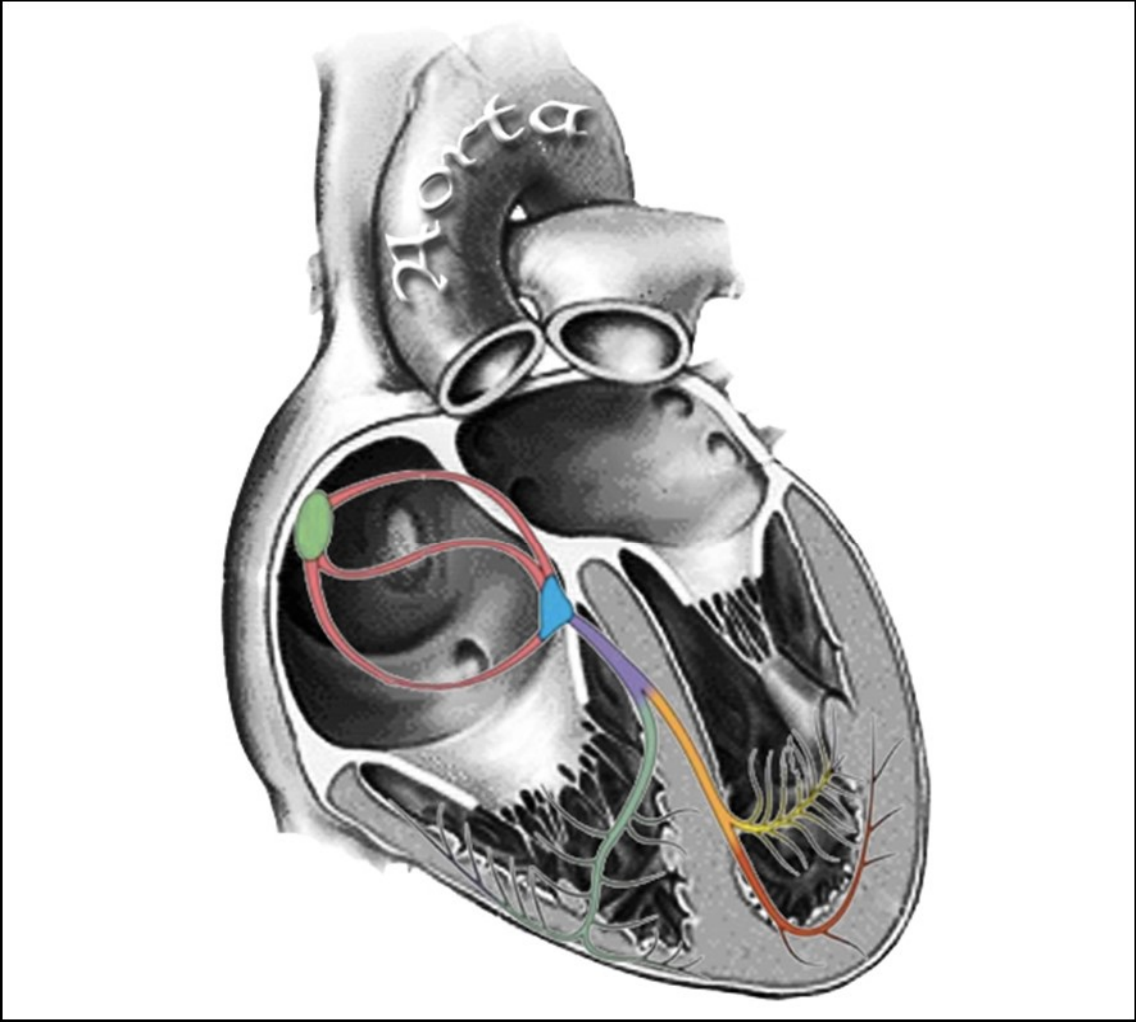


Wave of depolarisation. Shape of QRS complex in any lead depends on orientation of that lead to vector of depolarisation

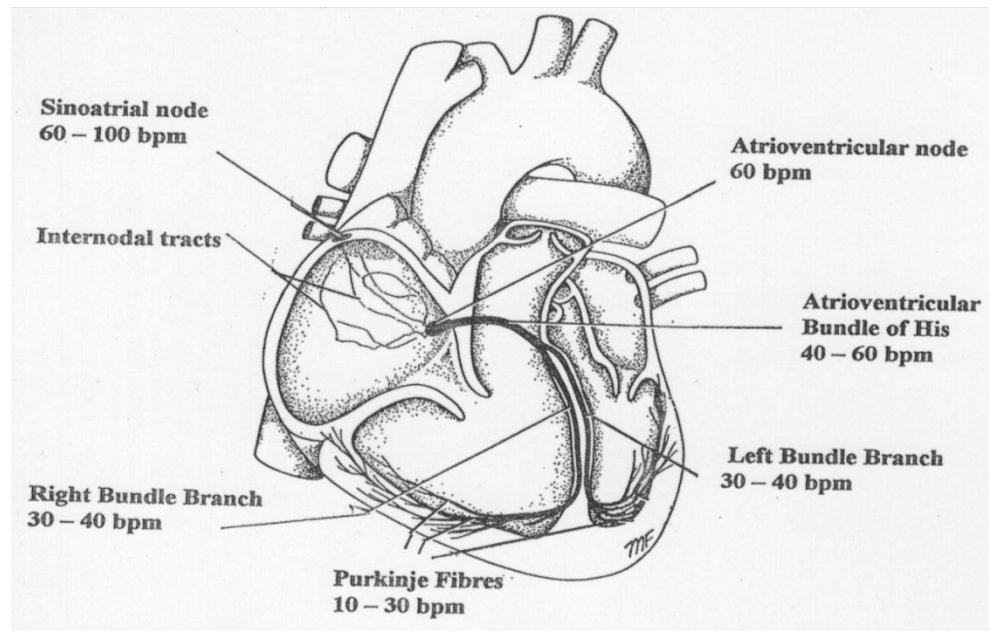
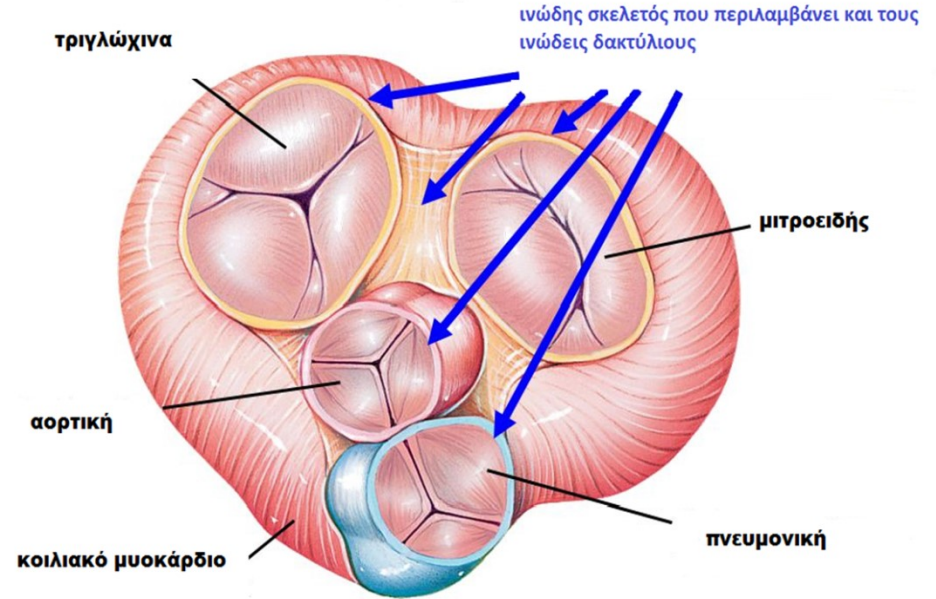
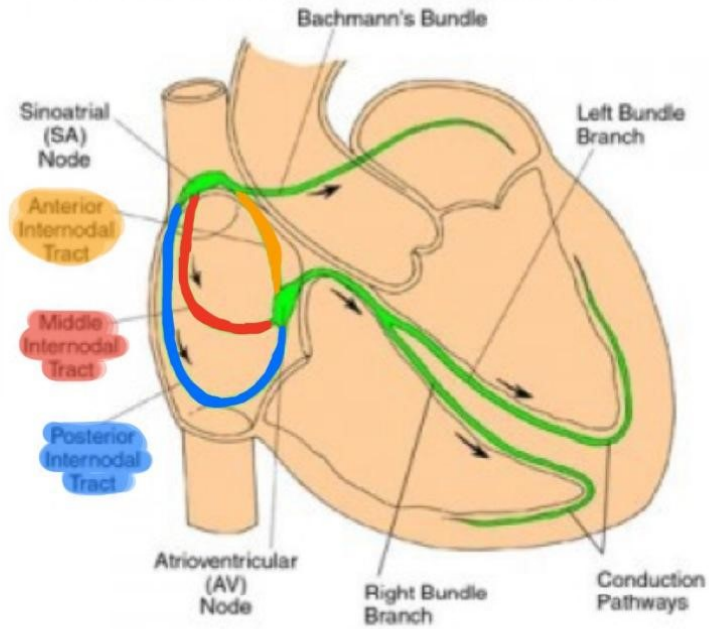


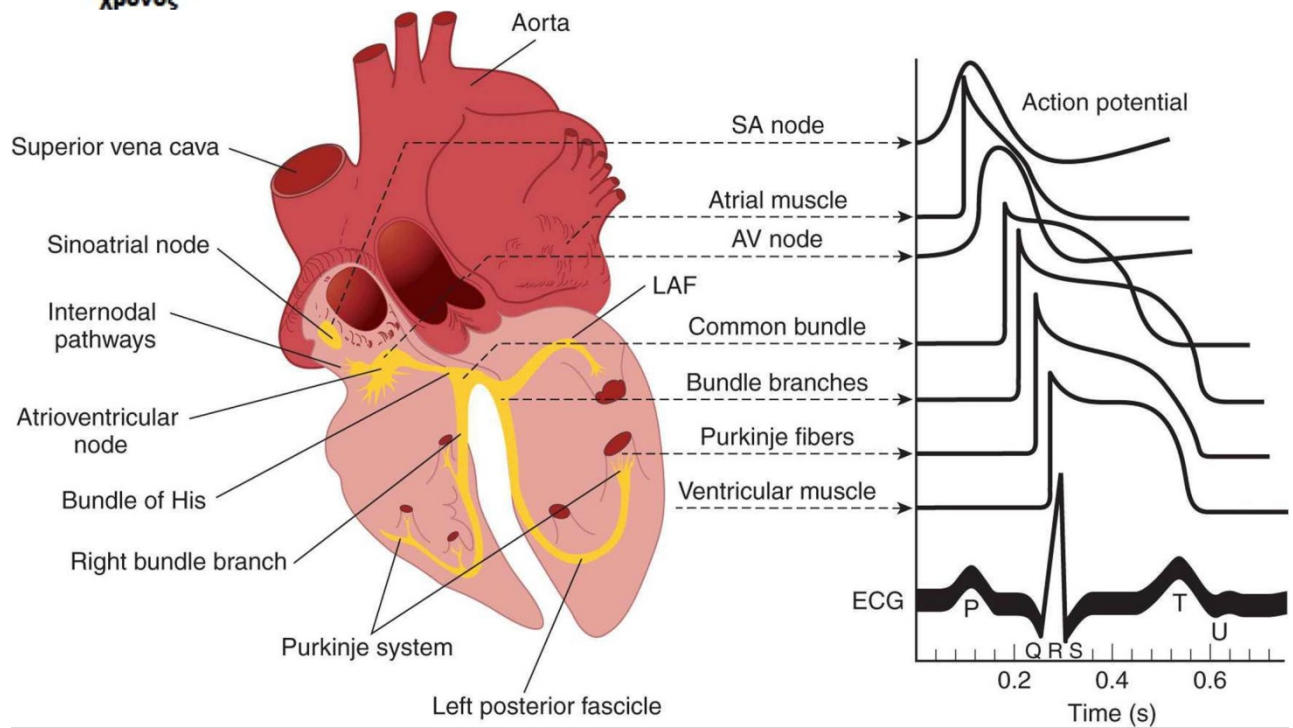
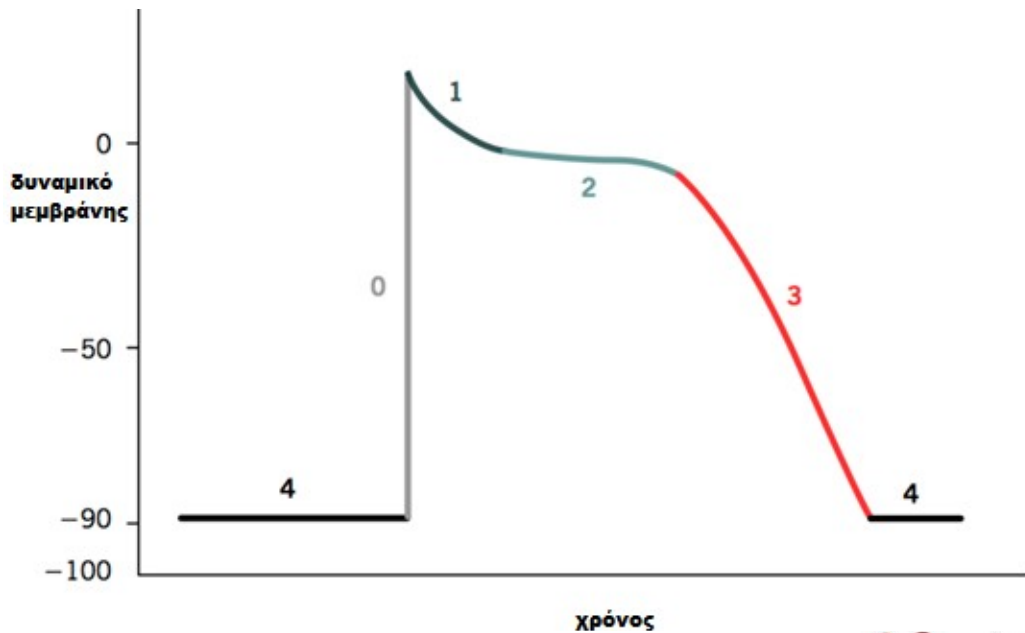
Speed : 25 mm/s    Gain : 10 mm/mV

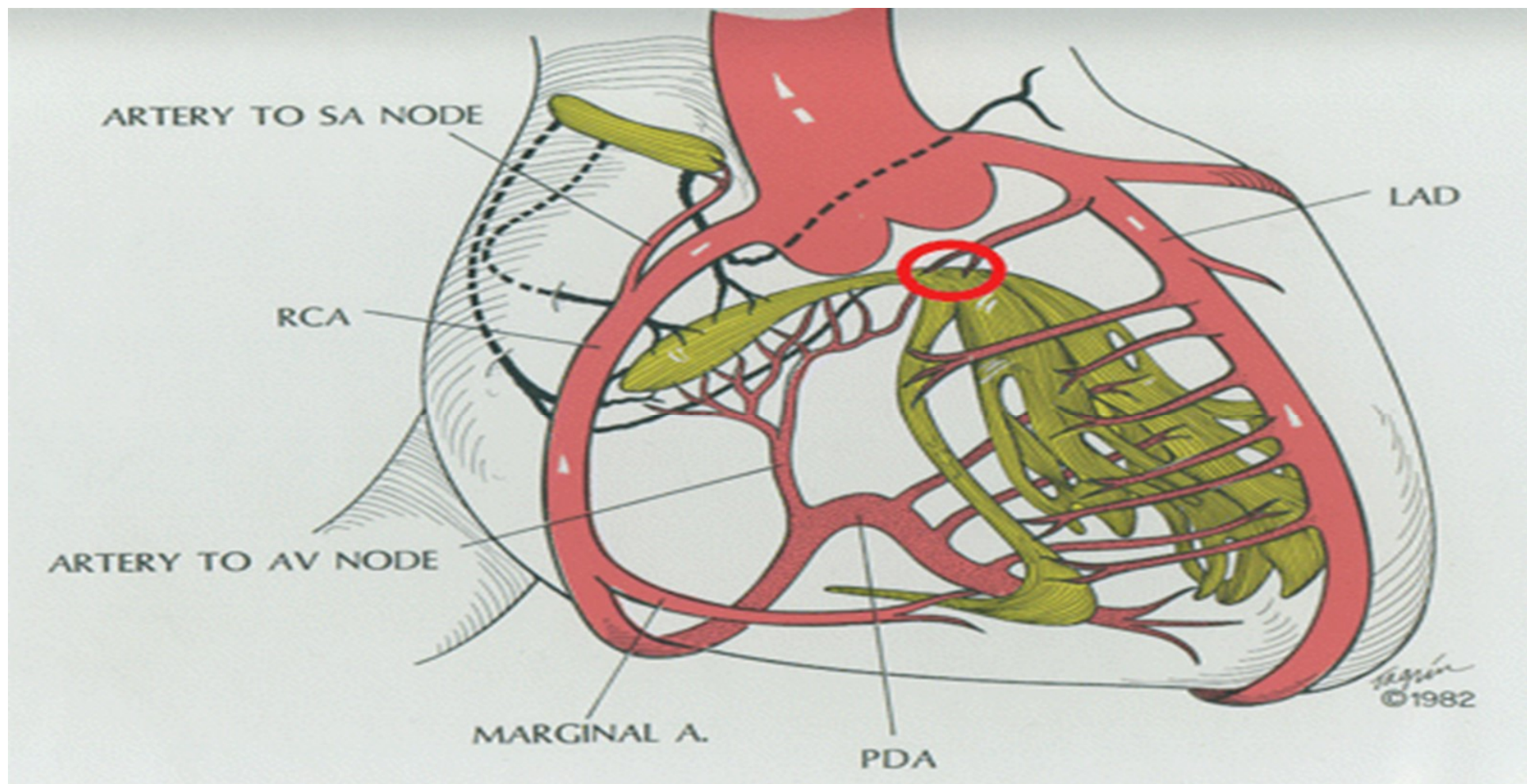
Standard calibration signal

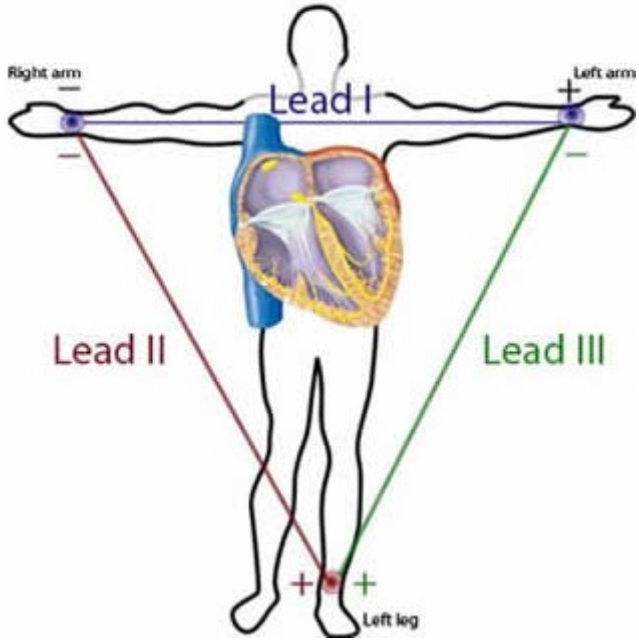
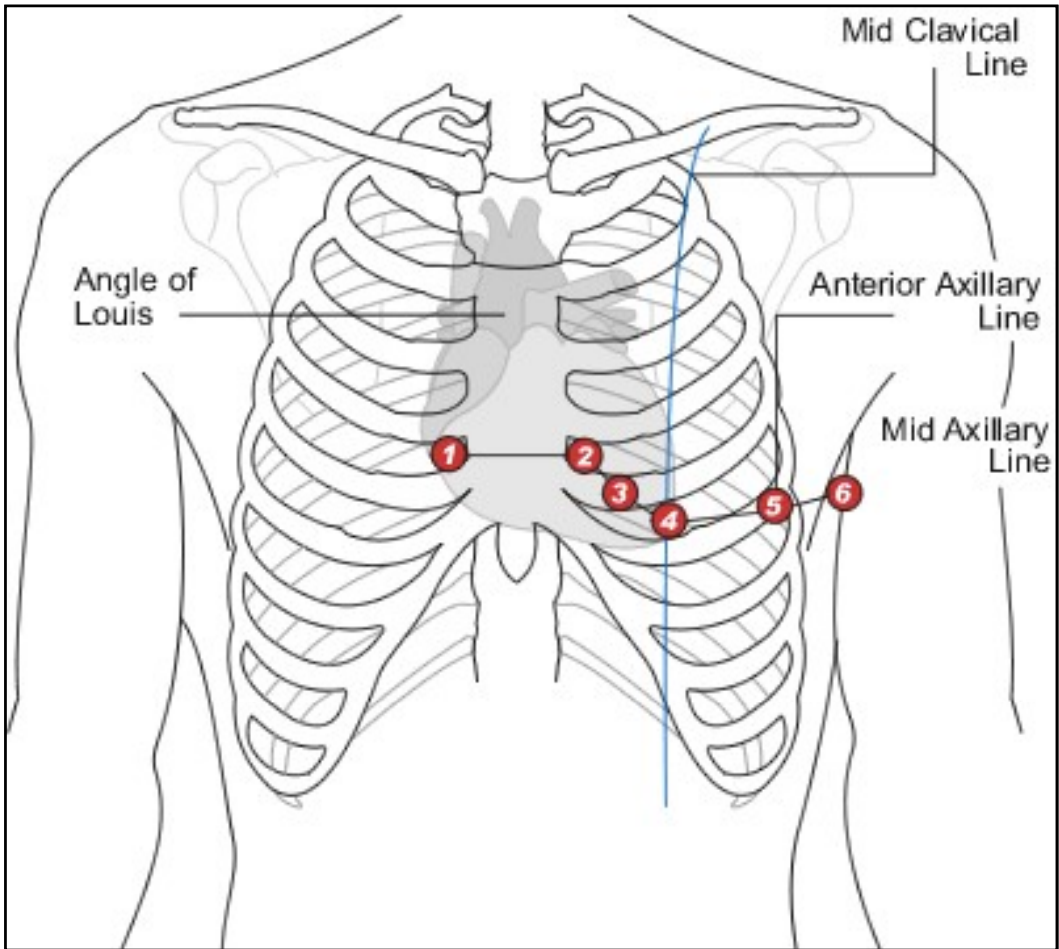


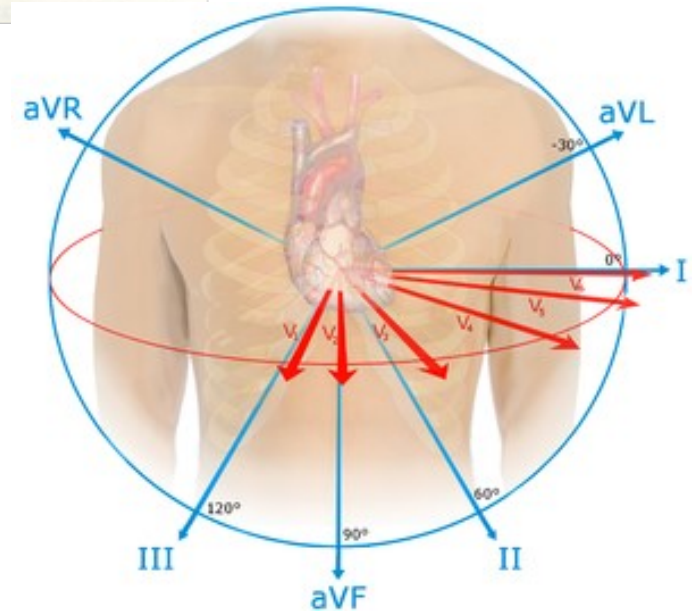
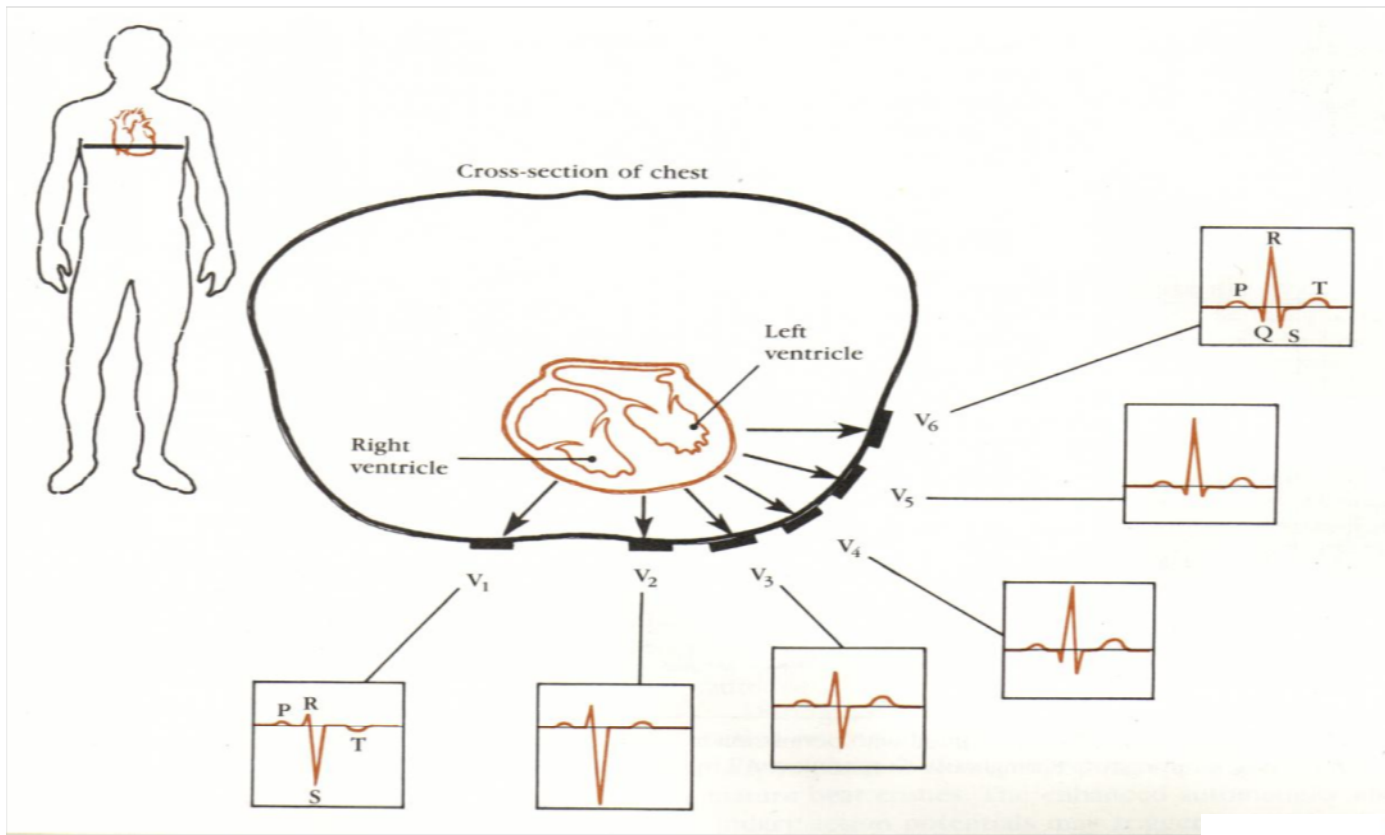
# The Electrical System of the Heart





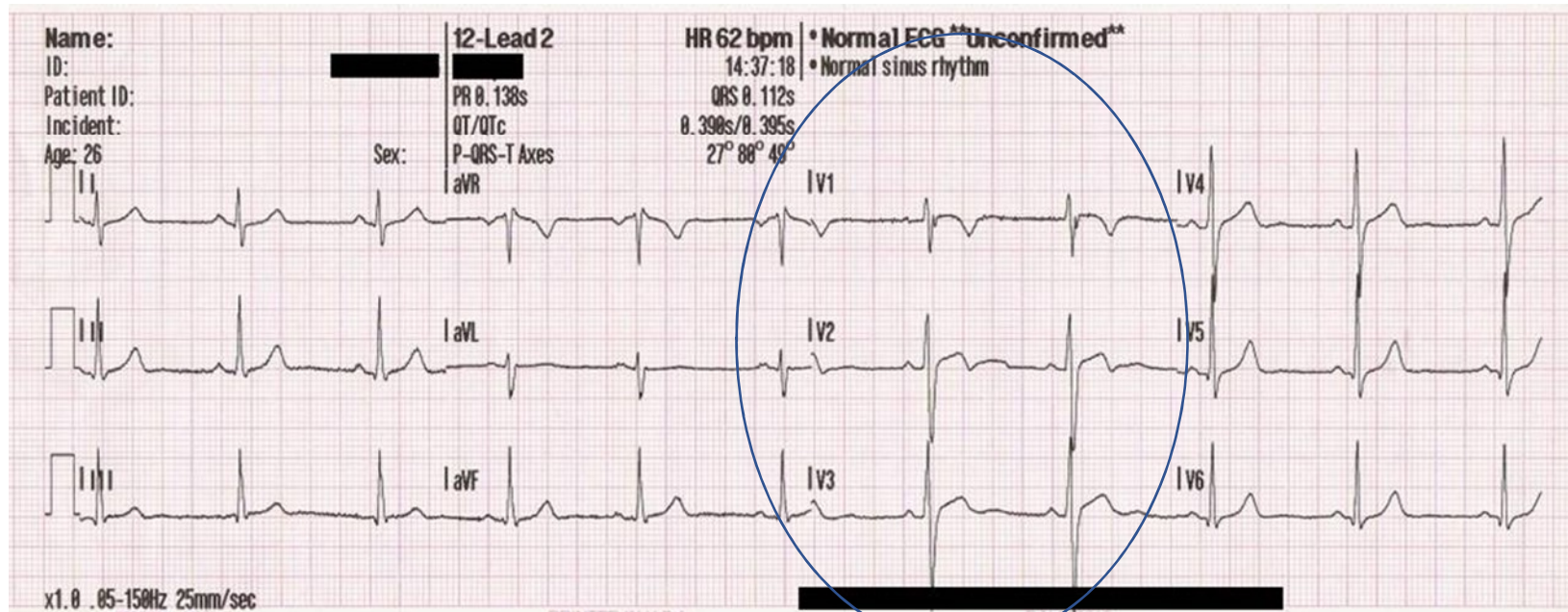
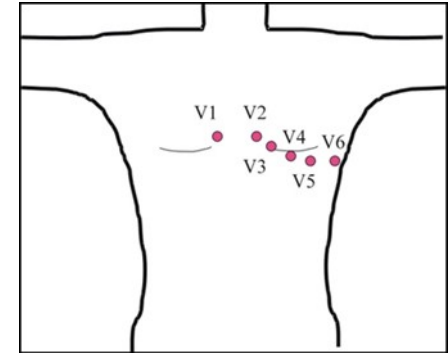




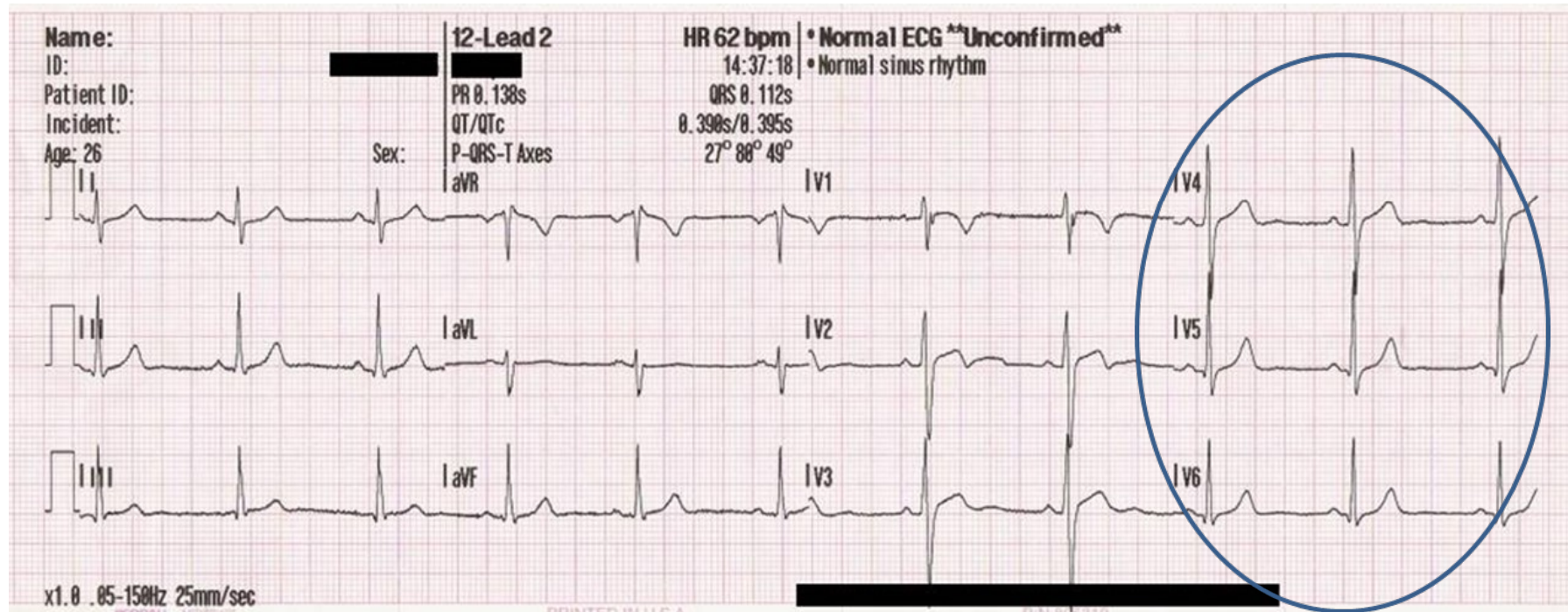
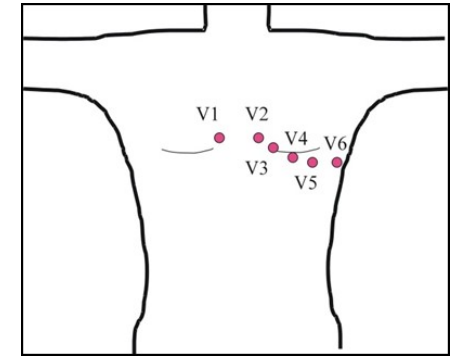




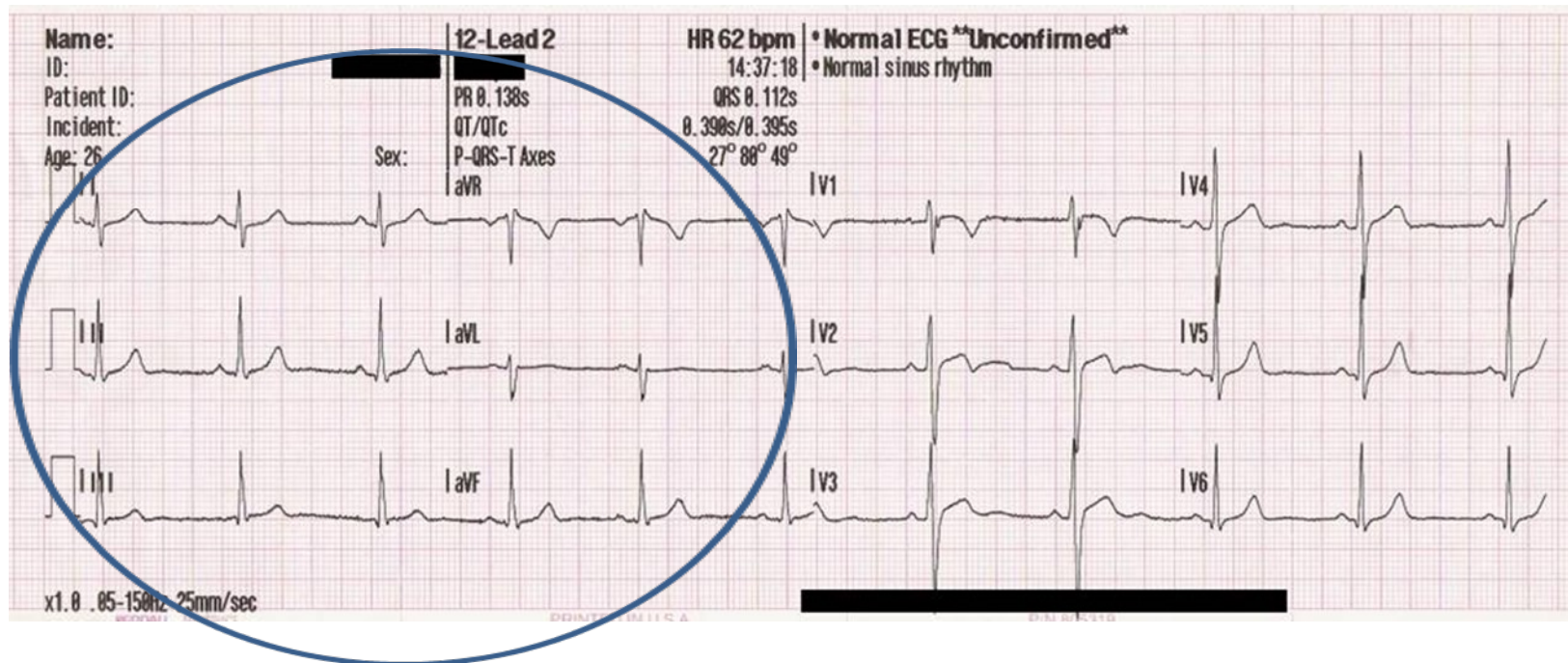
# Δεξιές προκάρδιες απαγωγές



# Αριστερές προκάρδιες απαγωγές



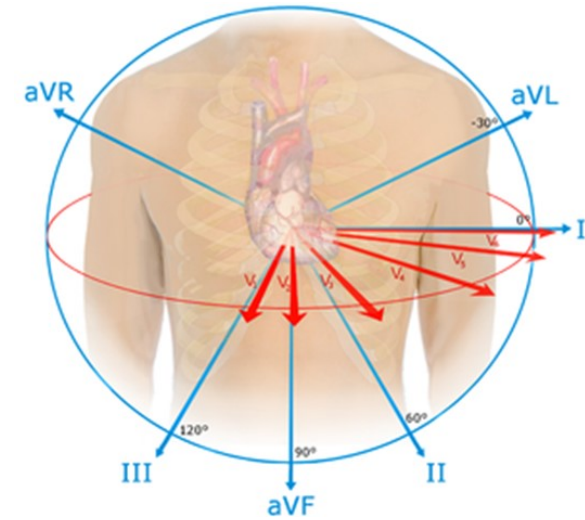
# Απαγωγές των άκρων



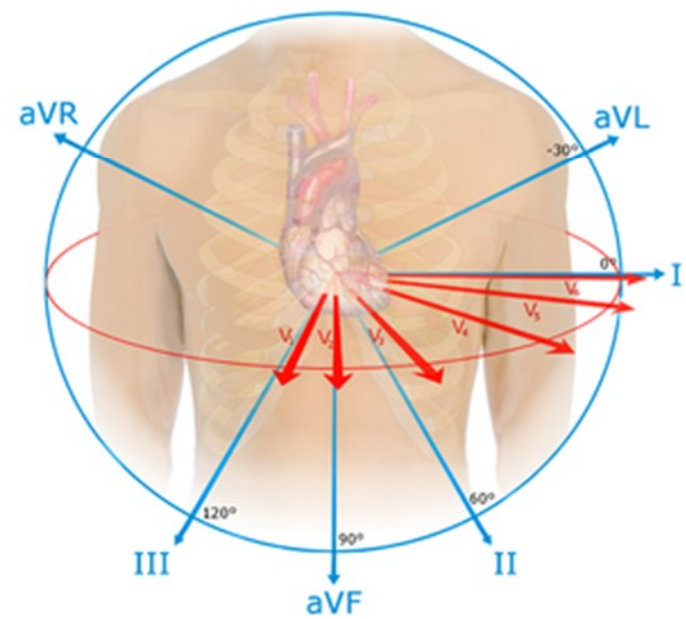
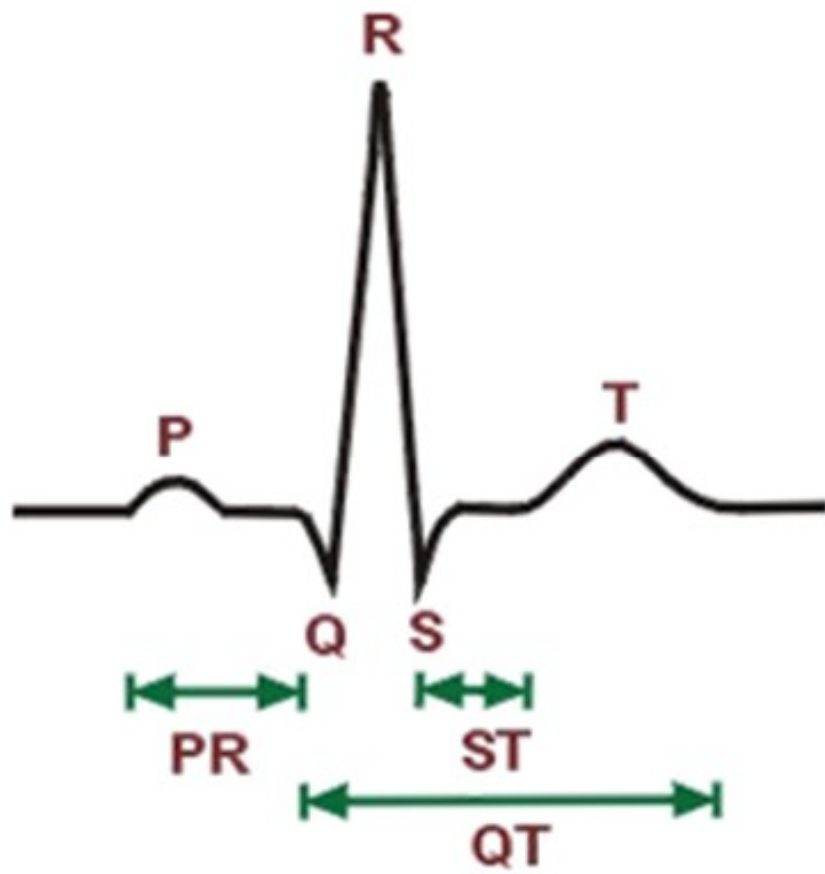
# 12 leads

Limb Leads		Precordial Leads	
Lead I	aVR	V1	V4
Lead II	aVL	V2	V5
Lead III	aVF	V3	V6

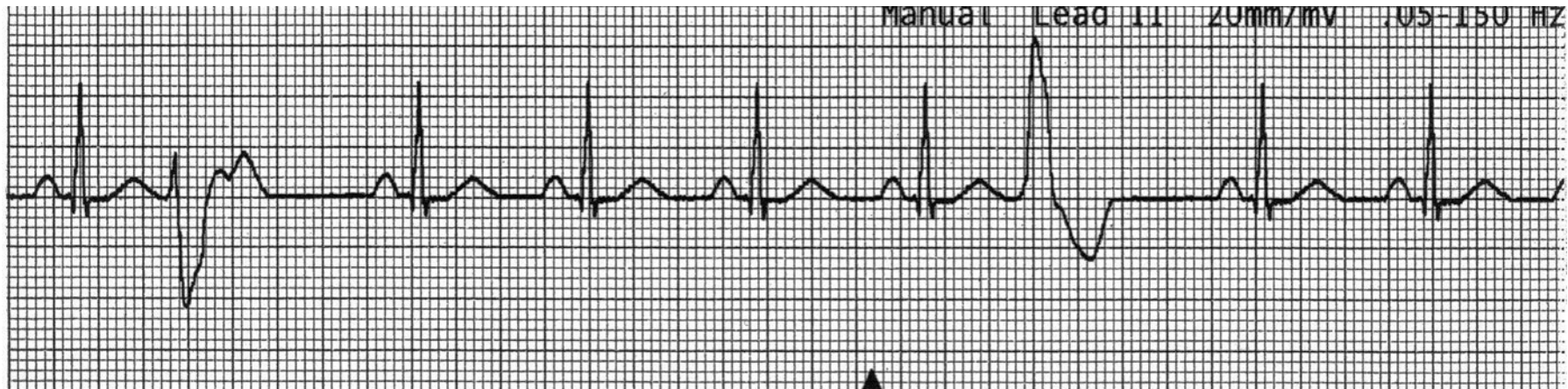
# Contiguous Leads



Lead I	aVR	V1	V4
Lead II	aVL	V2	V5
Lead III	aVF	V3	V6

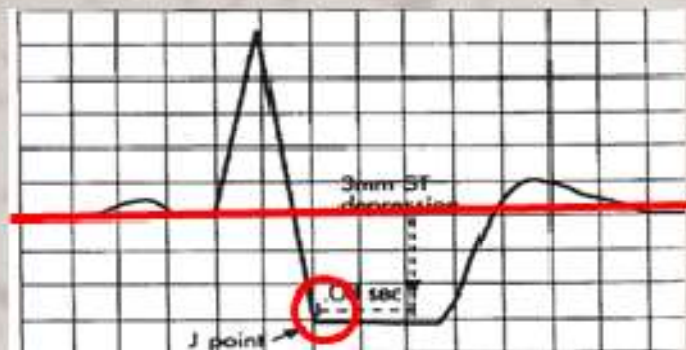
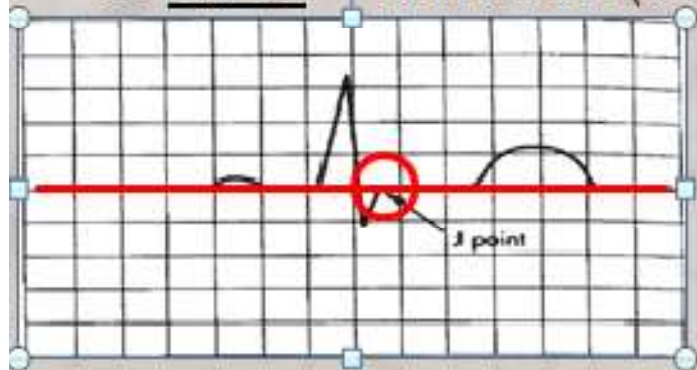


3. P wave = present, 1 per QRS, shape, duration, voltage.



4. P-R interval = length (0.12 - 0.2 sec = <1 big square), isoelectric.

5. QRS = duration (0.06 - 0.10 ), voltage, q or Q waves

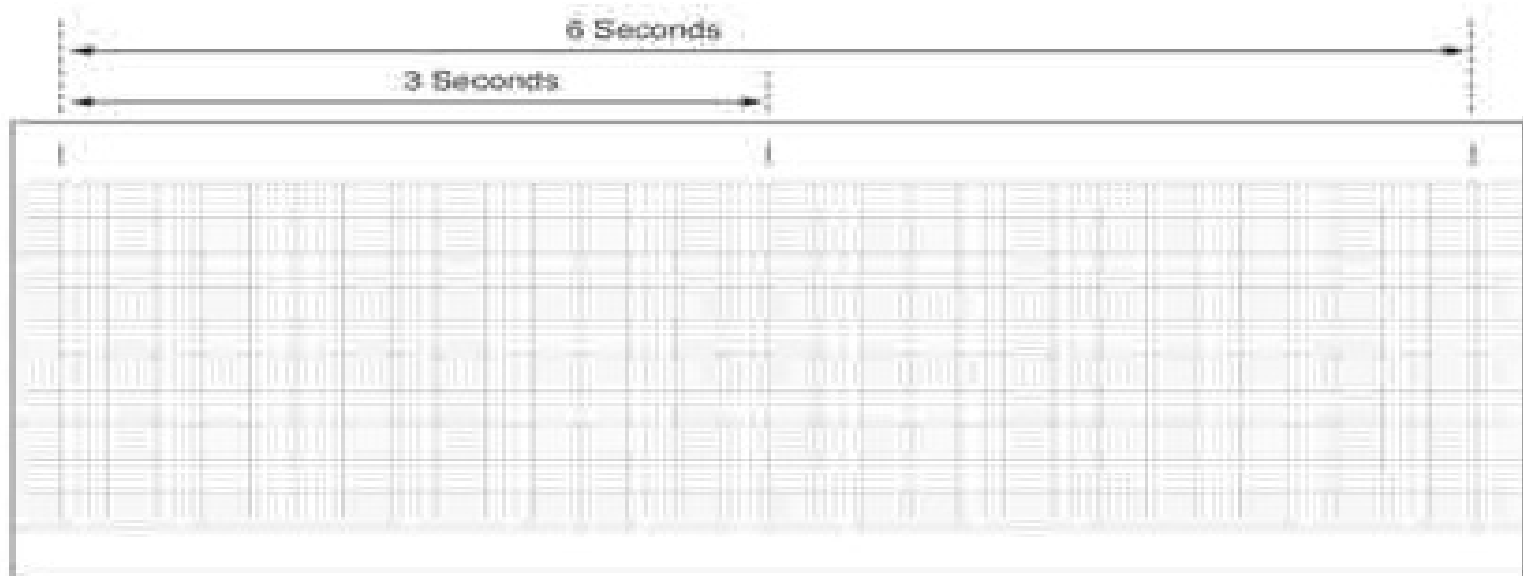
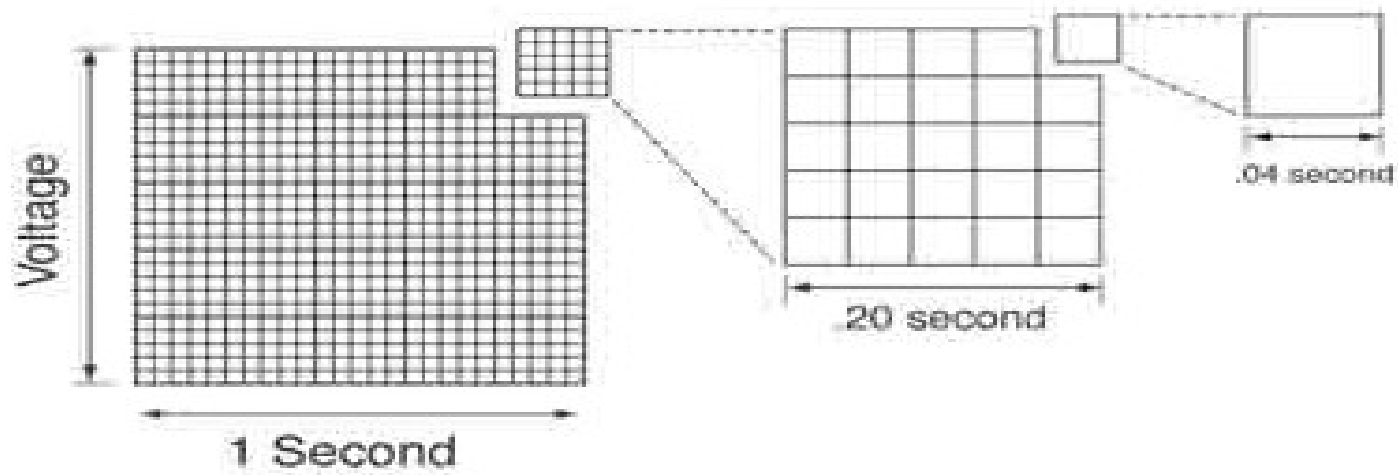


6. ST Segment = shape, isoelectric with PR segment



# The 6-Step Method

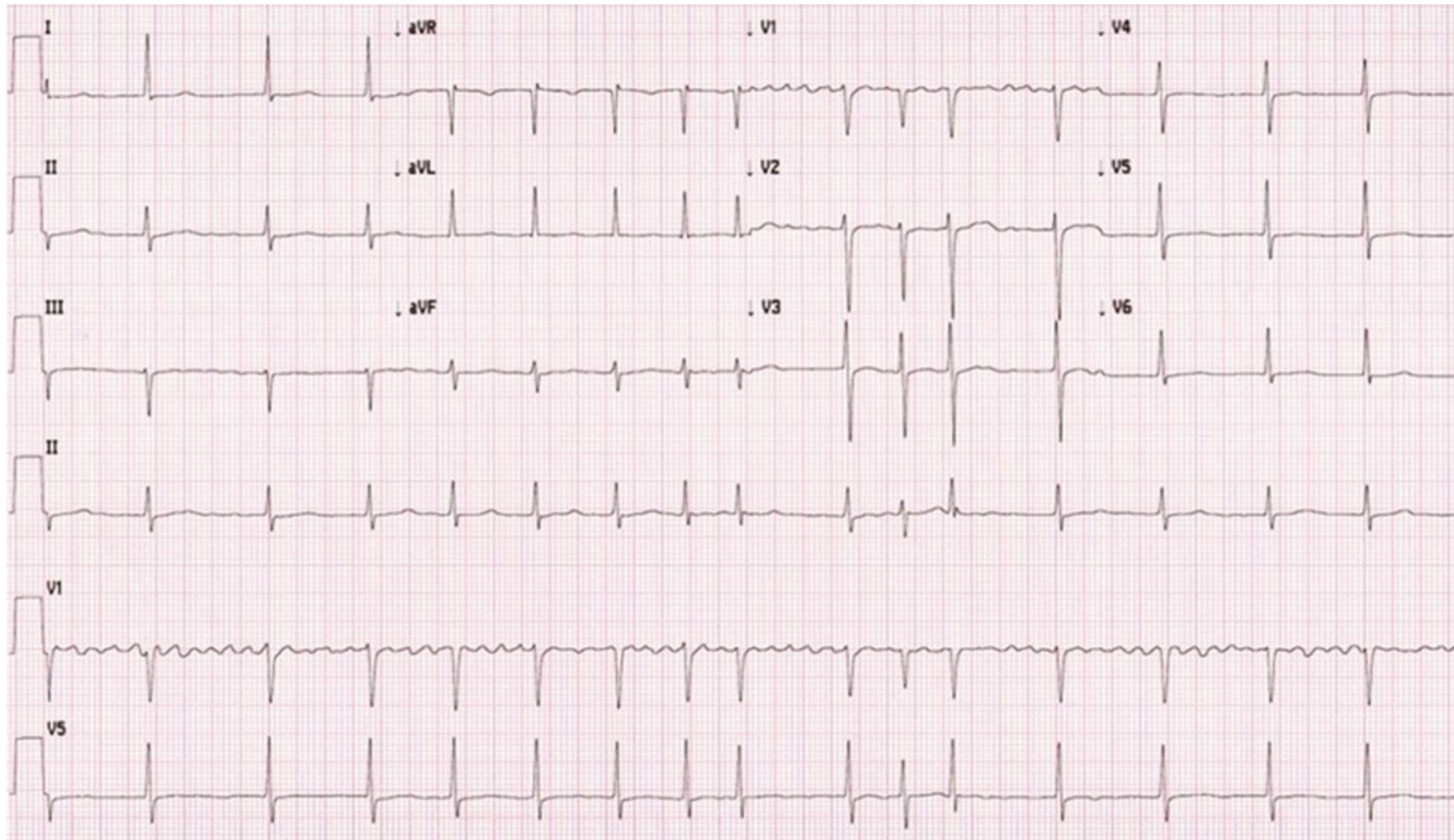
- 1. Rate & Rhythm
- 2. Axis Determination
- 3. Intervals
- 4. Morphology
- 5. STE-Mimics
- 6. Ischemia, Injury, & Infarct



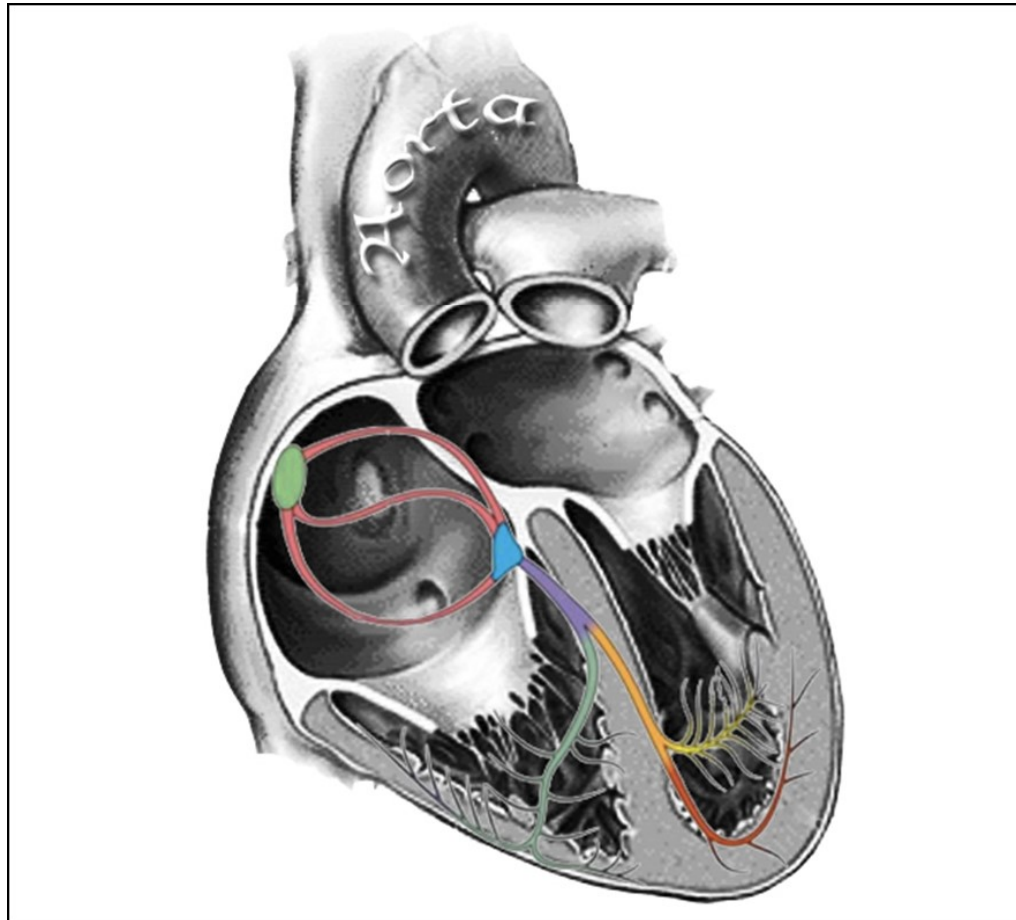
# Υπολογισμός συχνότητας

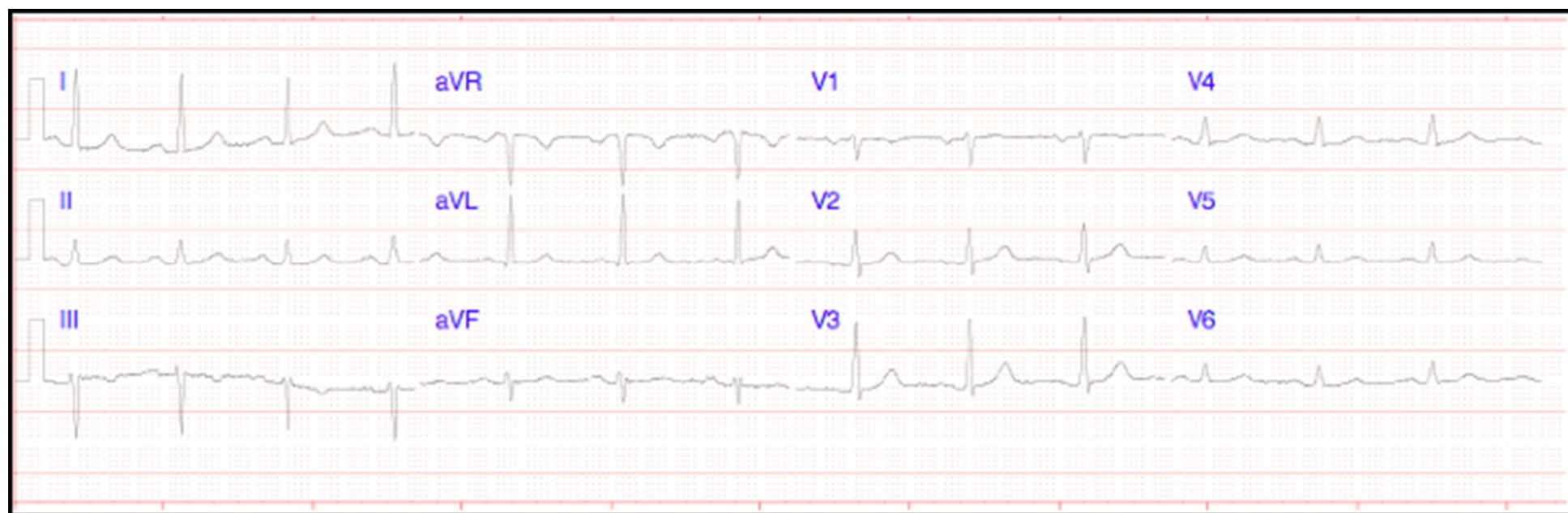


## Υπολογισμός συχνότητας βάσει της μακράς απαγωγής



# Φλεβοκομβικός ρυθμός





## Φλεβοκομβικός ρυθμός

- Rate: 60 - 100 bpm
- Rhythm: Regularly Regular
- P wave: Present
- P:QRS ratio: 1 to 1
- PR-interval: Normal
- QRS Width: < 120 ms (0.12 sec)



## Φλεβοκομβική αρρυθμία

- Rate: 60 - 100 bpm
- Rhythm: Varies with respiration
- P wave: Present
- P:QRS ratio: 1 to 1
- PR-interval: Normal
- QRS Width: < 120 ms (0.12 sec)





## Φλεβοκομβική βραδυκαρδία

- Rate: < 60 bpm
- Rhythm: Regularly-Regular
- P wave: Present
- P:QRS ratio: 1 to 1
- PR-interval: Normal
- QRS Width: < 120 ms (0.12 sec)



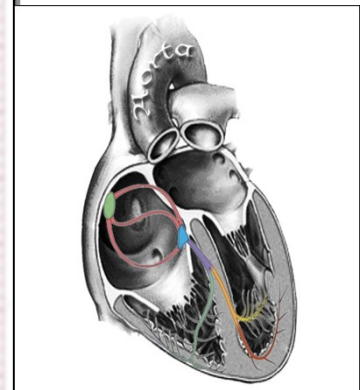
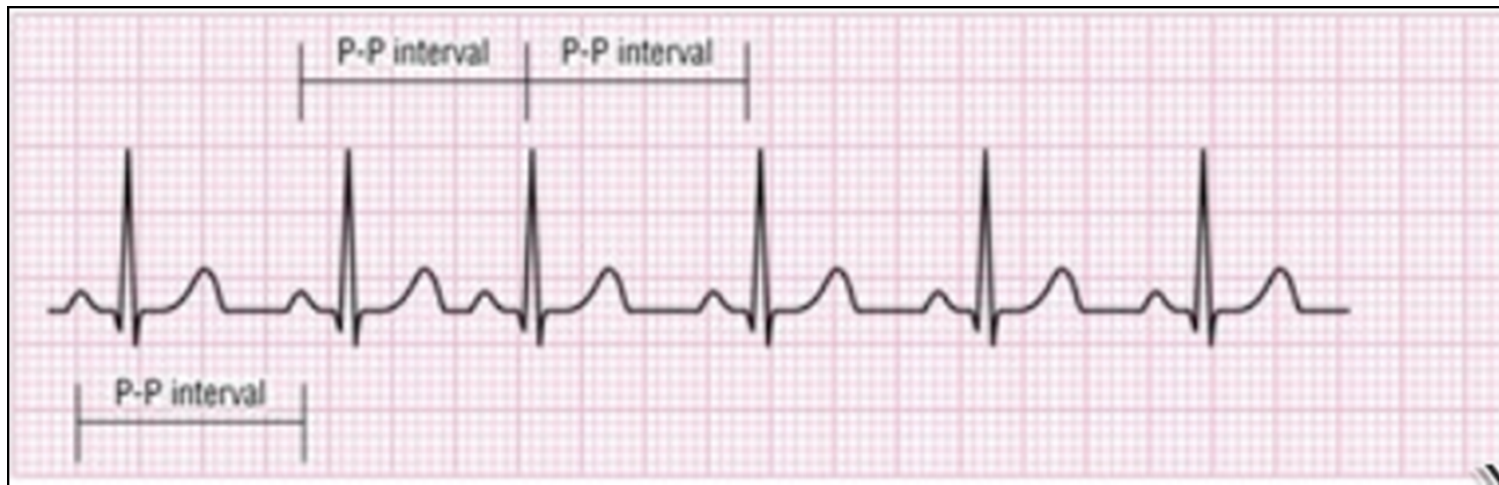
## Φλεβοκομβική παύση

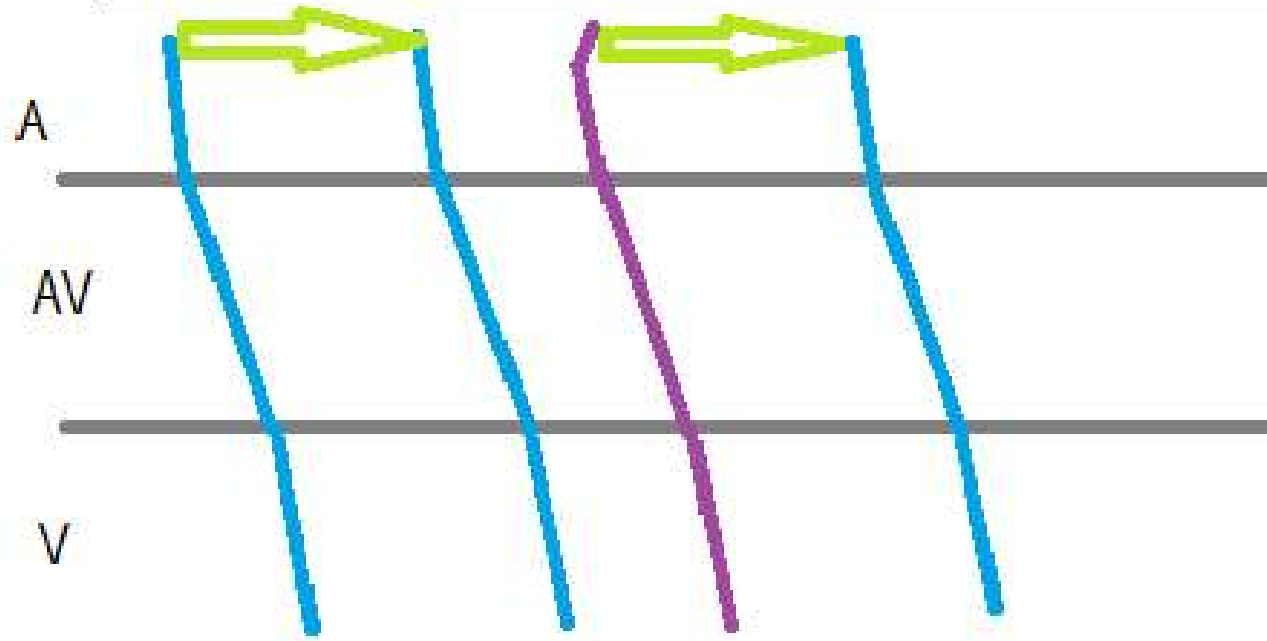
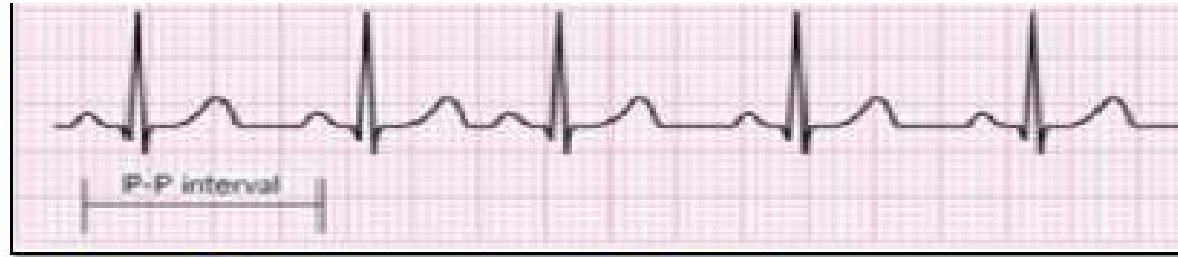
- Rate: Varies
- Rhythm: Irregular
- P wave: Present except for pause
- P:QRS ratio: 1 to 1
- PR-interval: Normal
- QRS Width: < 120 ms (0.12 sec)



## Πρώιμη κοιλιακή συστολή

- Rate: Determine underlined rate
- Rhythm: Irregular
- P wave: Present, may be different w/ PAC
- P:QRS ratio: 1 to 1
- PR-interval: Normal, may vary w/ PAC
- QRS Width: < 120 ms (0.12 sec)

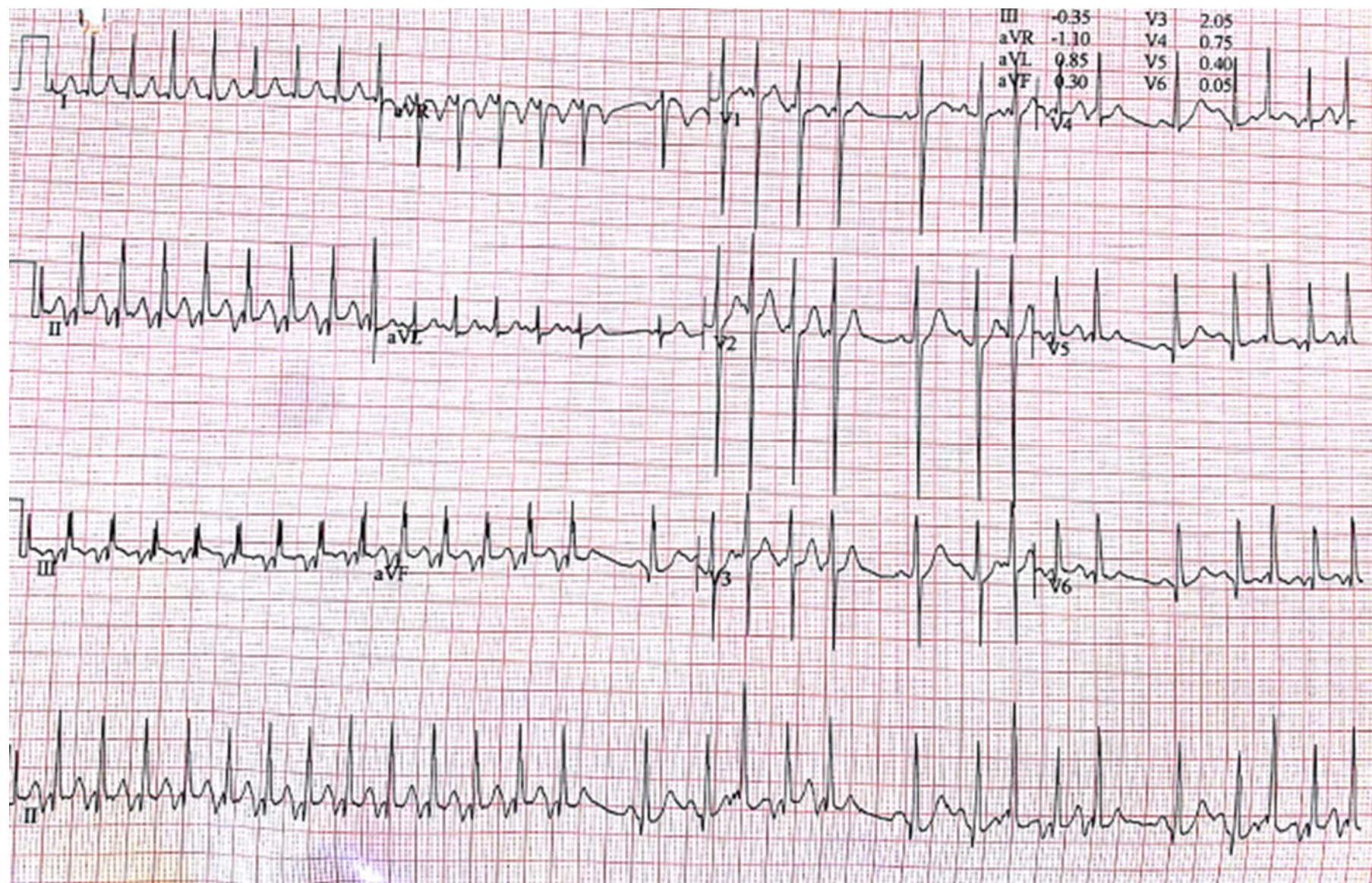




# Atrial tachycardia

- Rate: 100 - 180 bpm
- Rhythm: Regular
- P wave: Present, may be different w/ ectopy
- P:QRS ratio: 1 to 1
- PR-interval: Normal, different w/ ectopy
- QRS Width: < 120 ms (0.12 sec)

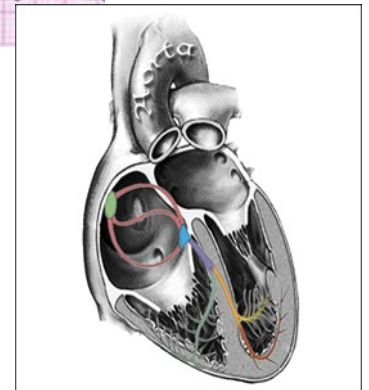
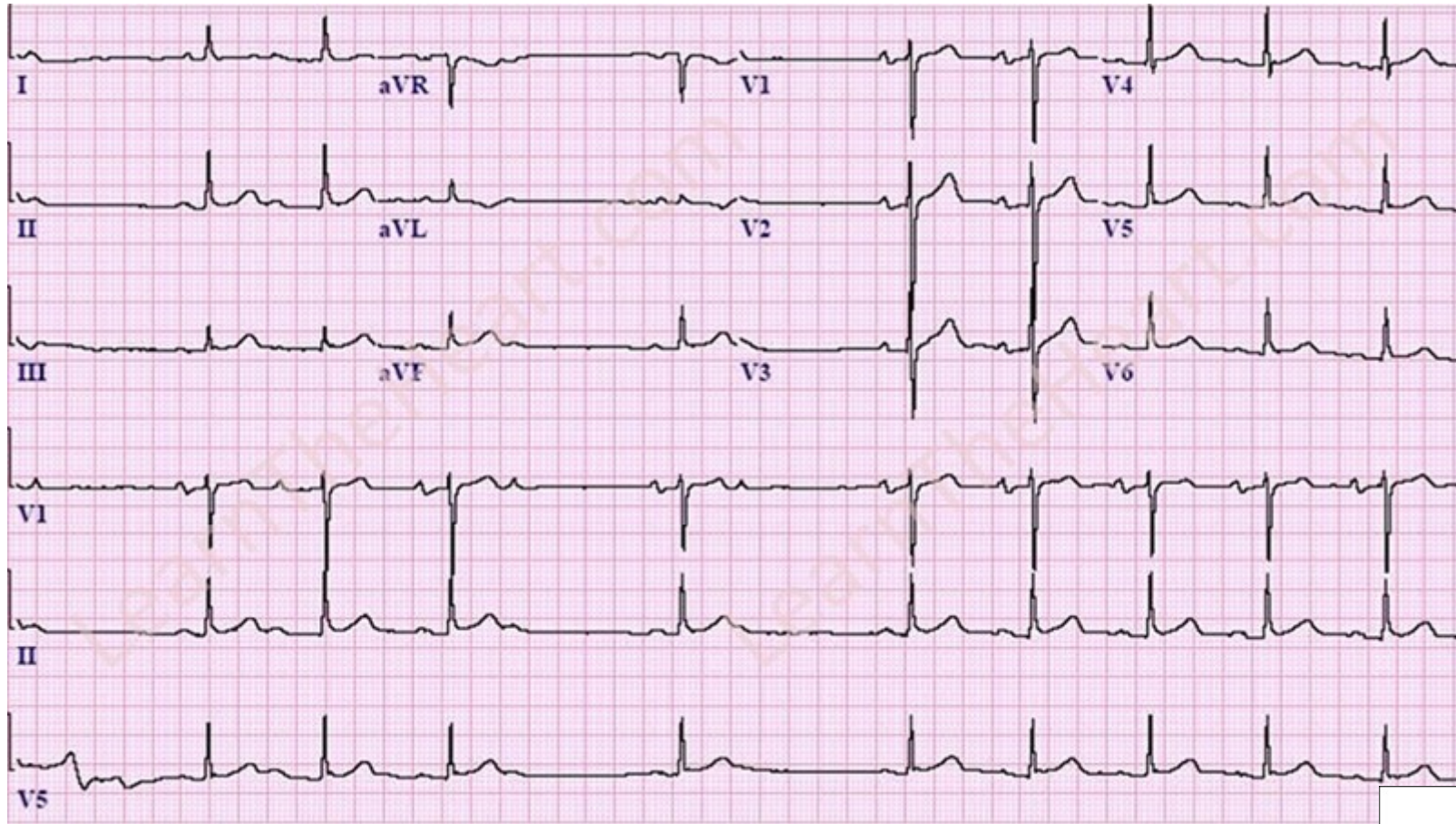




## Πλανώμενος βηματοδότης

- Rate: < 100 bpm
- Rhythm: Irregularly-Irregular
- P wave: At least 3 different morphologies
- P:QRS ratio: 1 to 1
- PR-interval: Variable
- QRS Width: < 120 ms (0.12 sec)

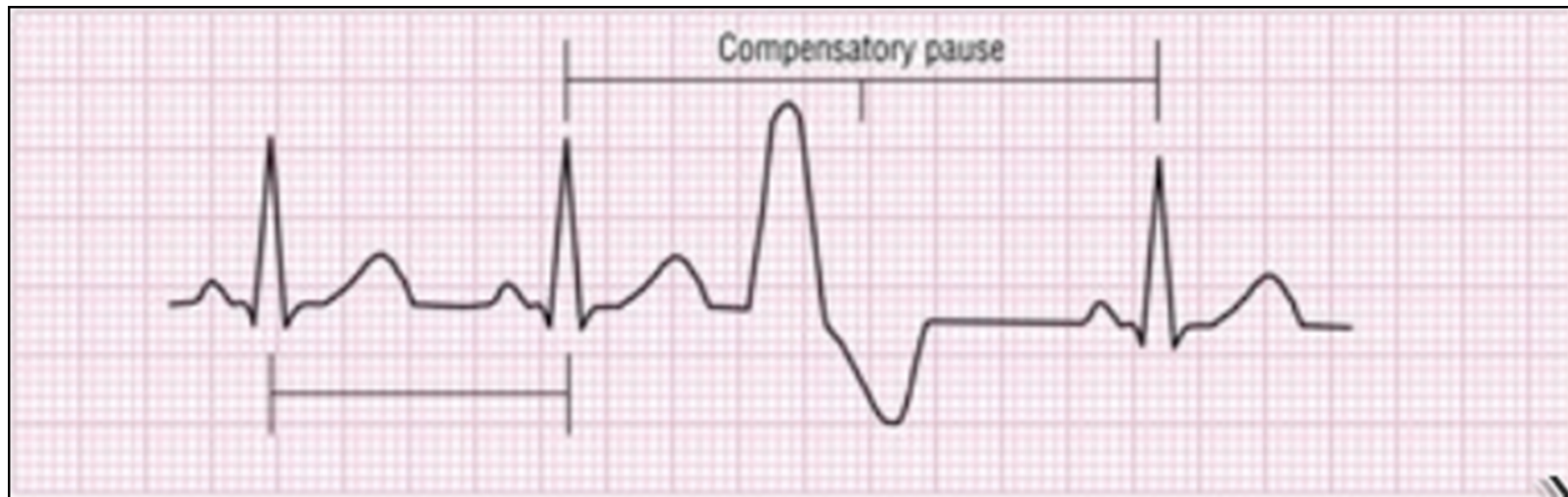


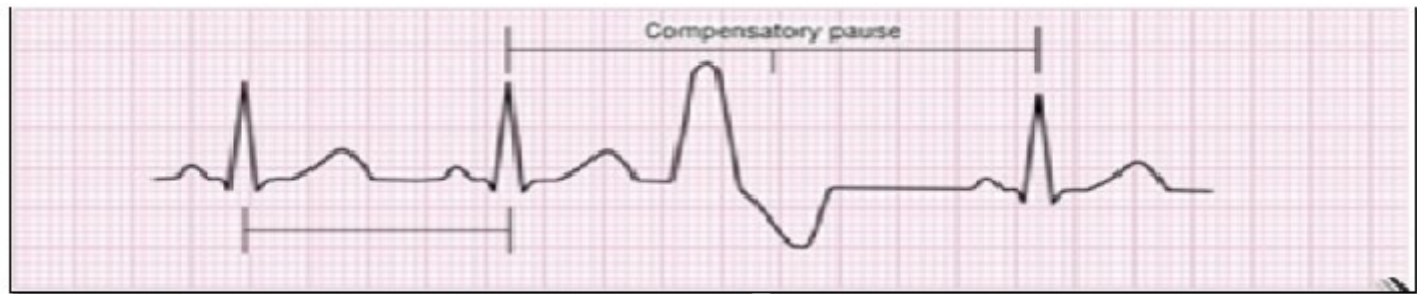




## Έκτακτη κοιλιακή συστολή

- Rate: Determine underlying rhythm
- Rhythm: Irregular
- P wave: None with PVC
- P:QRS ratio: None
- PR-interval: None
- QRS Width:  $> 120$  ms (0.12 sec) WIDE

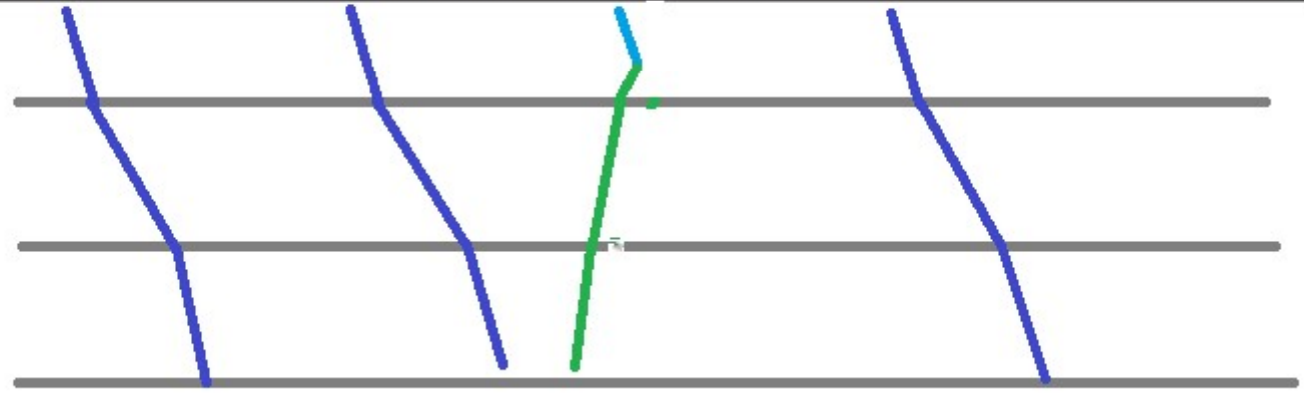




A

AV

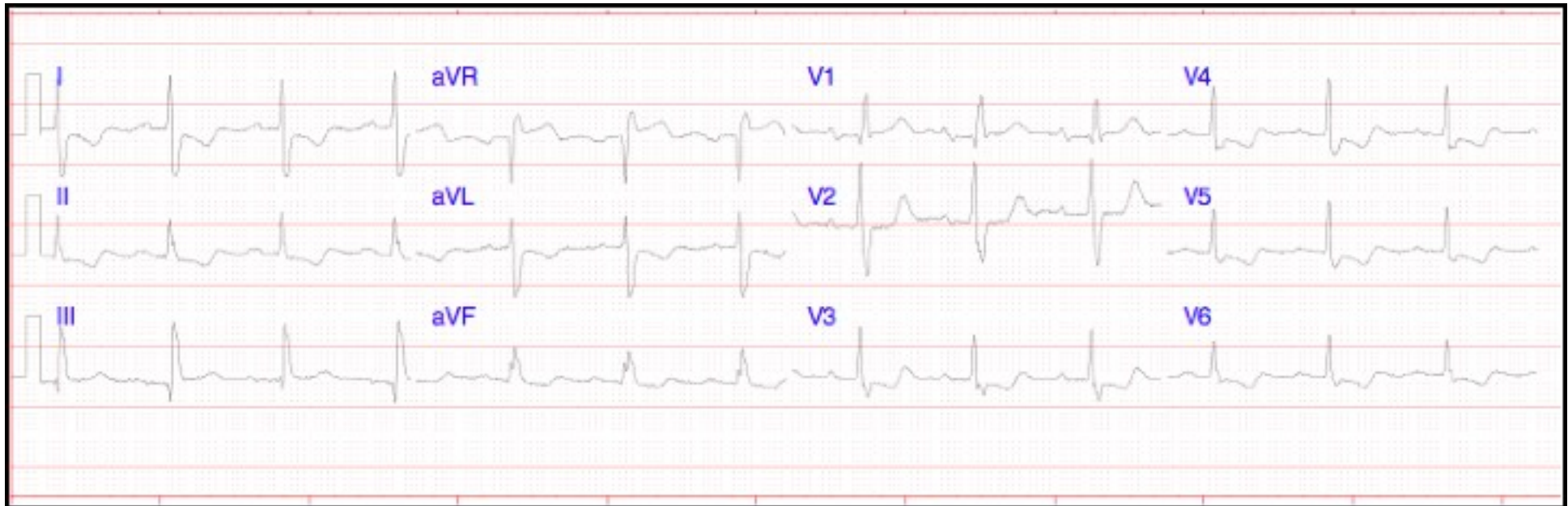
V

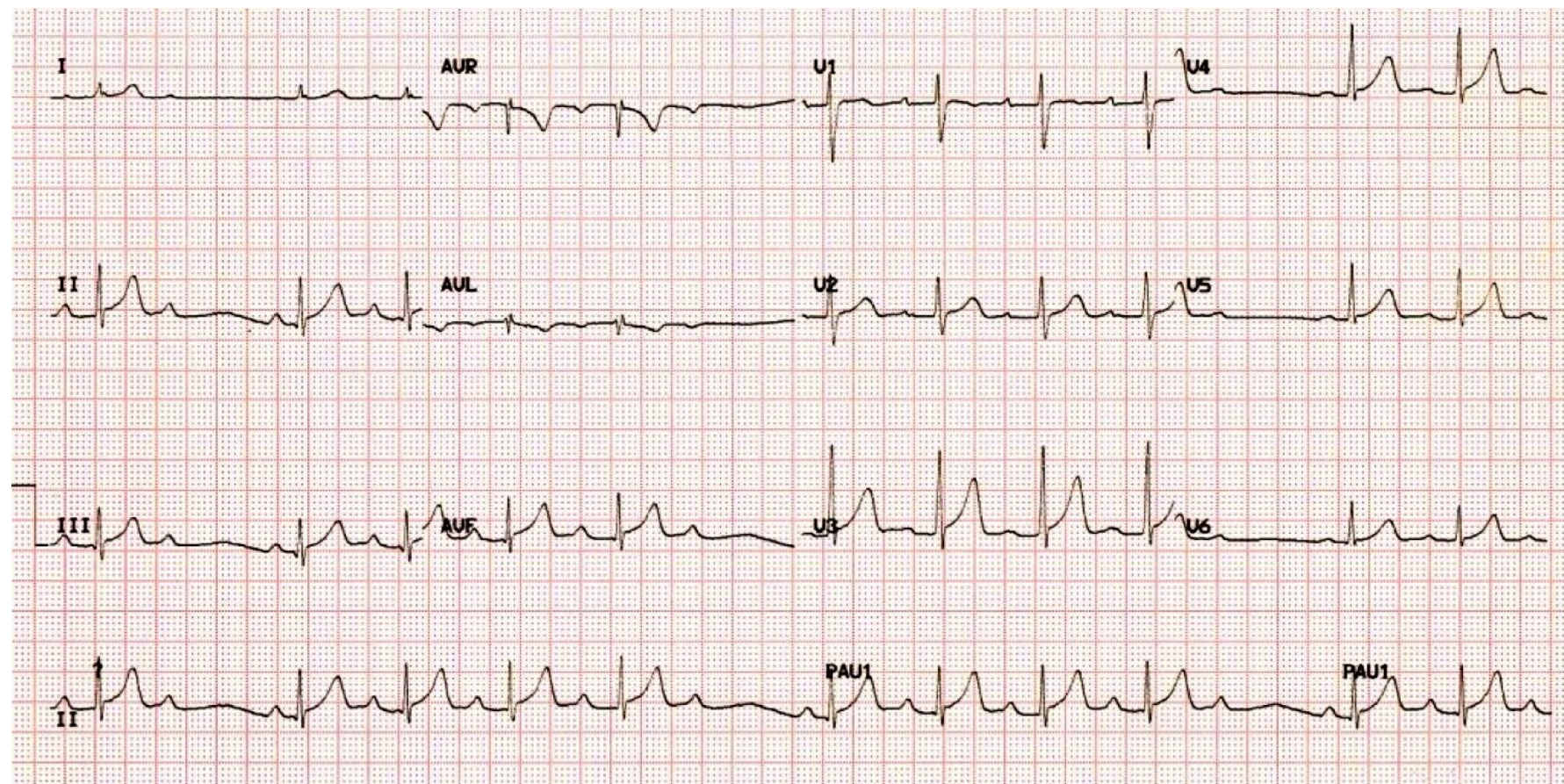


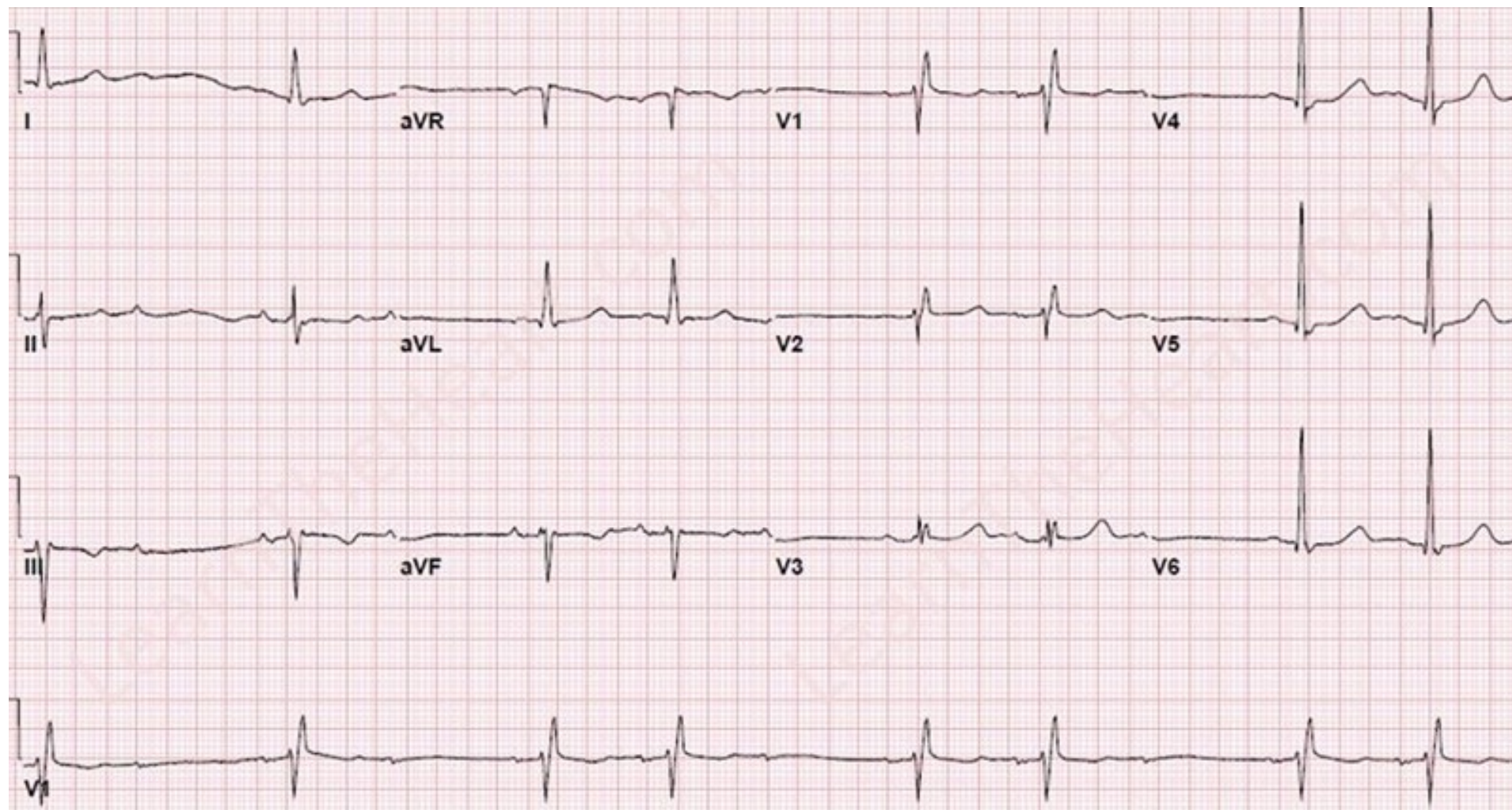
# Πρώιμη κοιλιακή συστολή

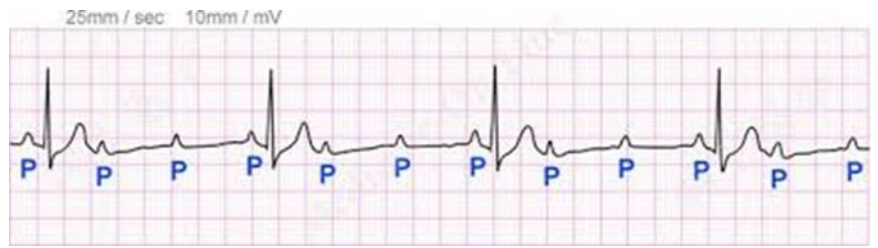
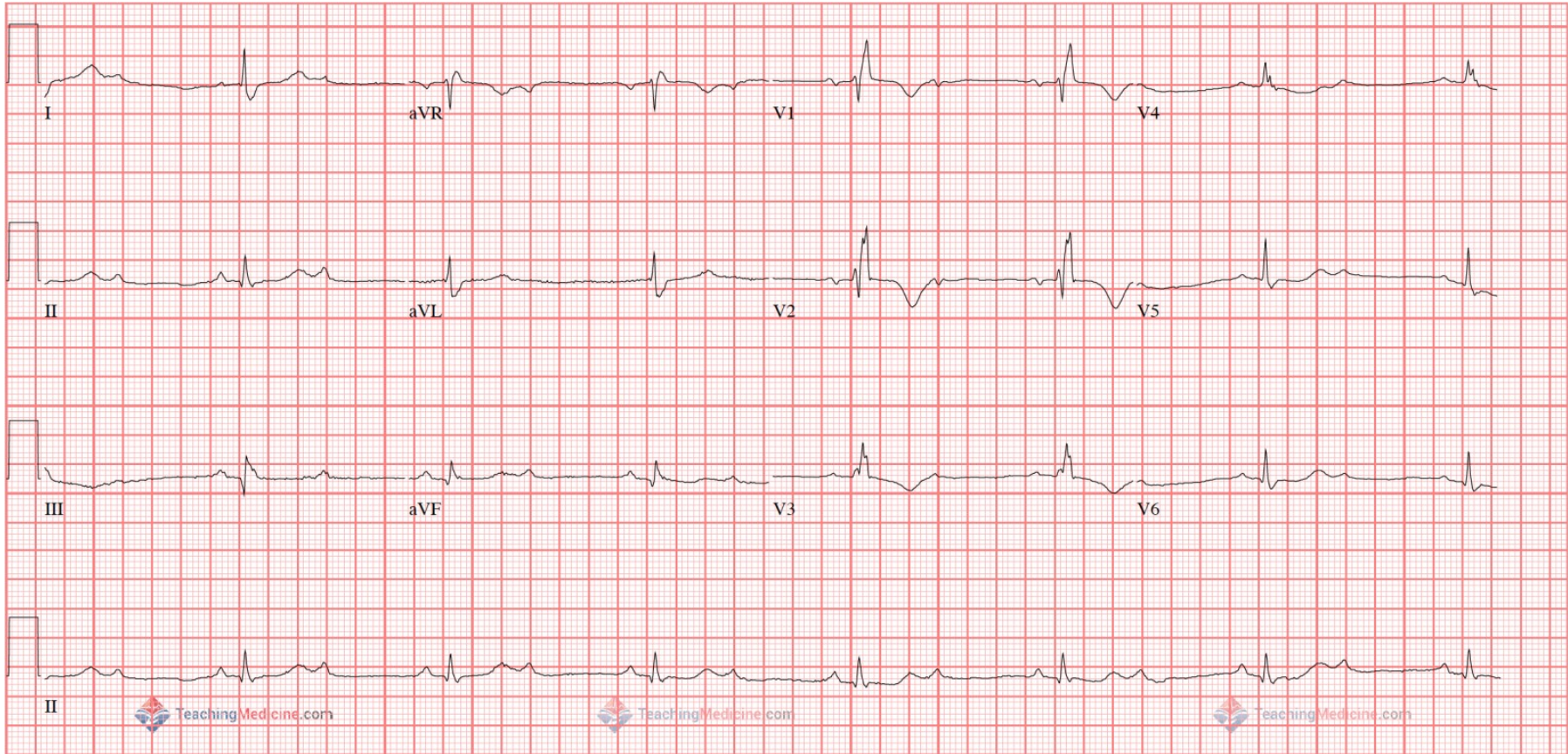
- Polymorphic
  - More than one one shape of QRS complex
- Multifocal
  - More than one focus or site of initial impulse.

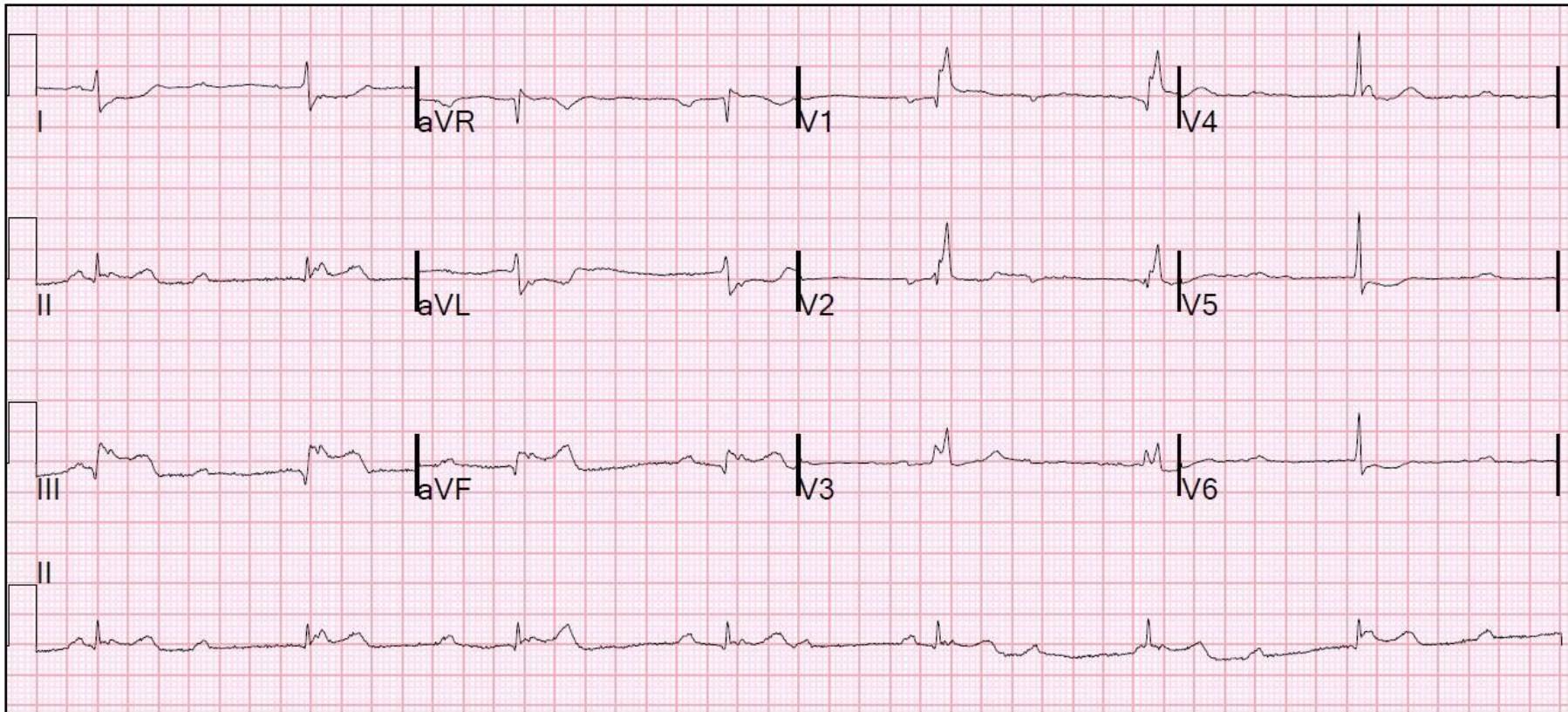
# 1<sup>ο</sup> βαθμού κολποκοιλιακός αποκλεισμός







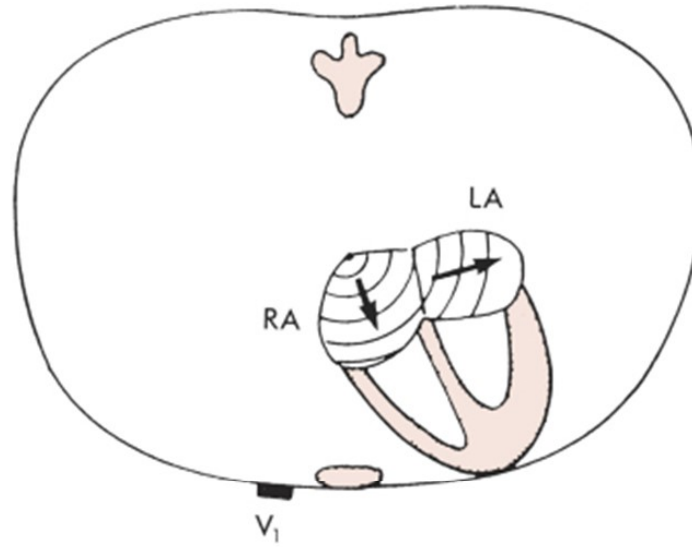








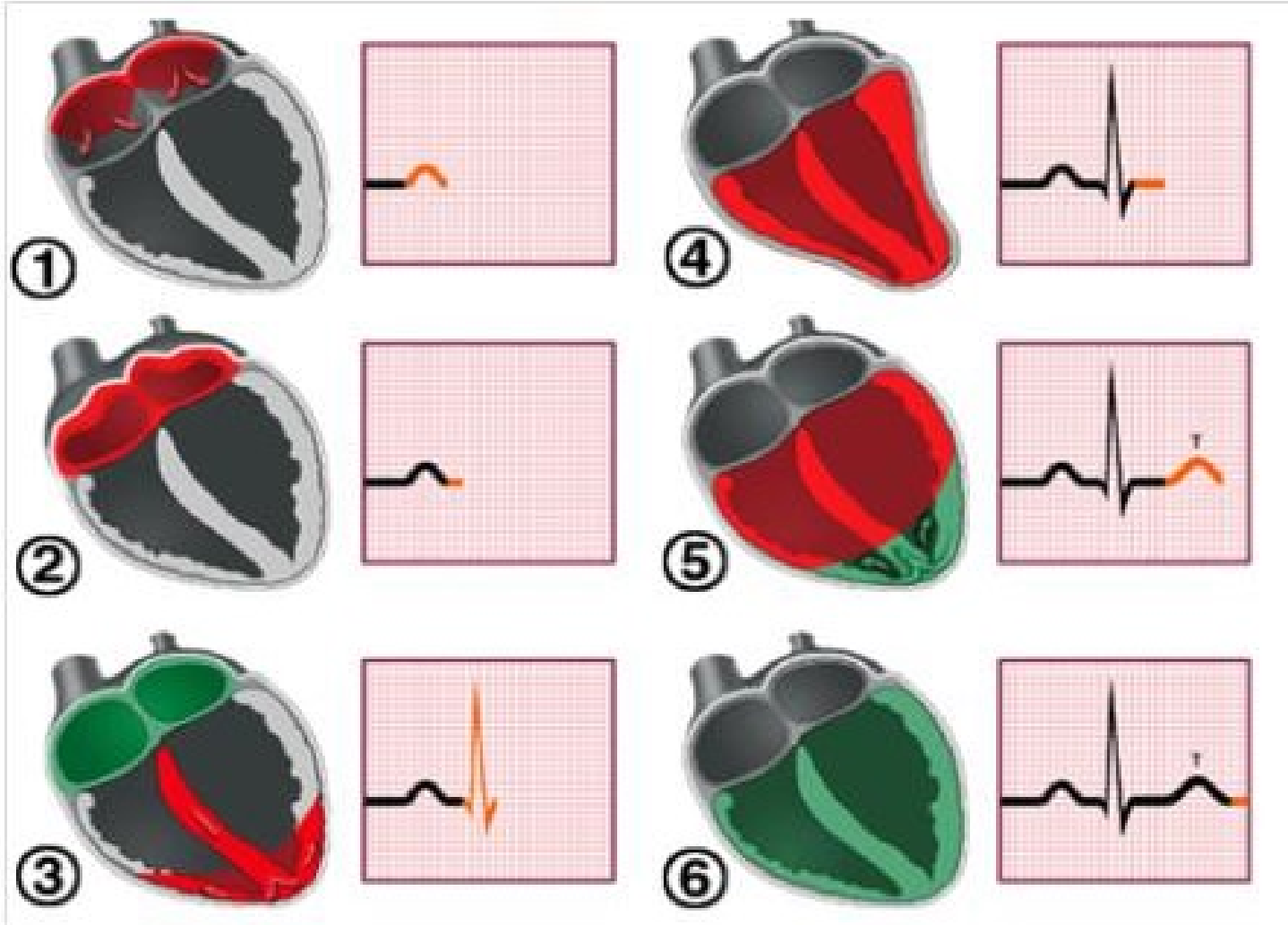
### Atrial Enlargement (Abnormality)



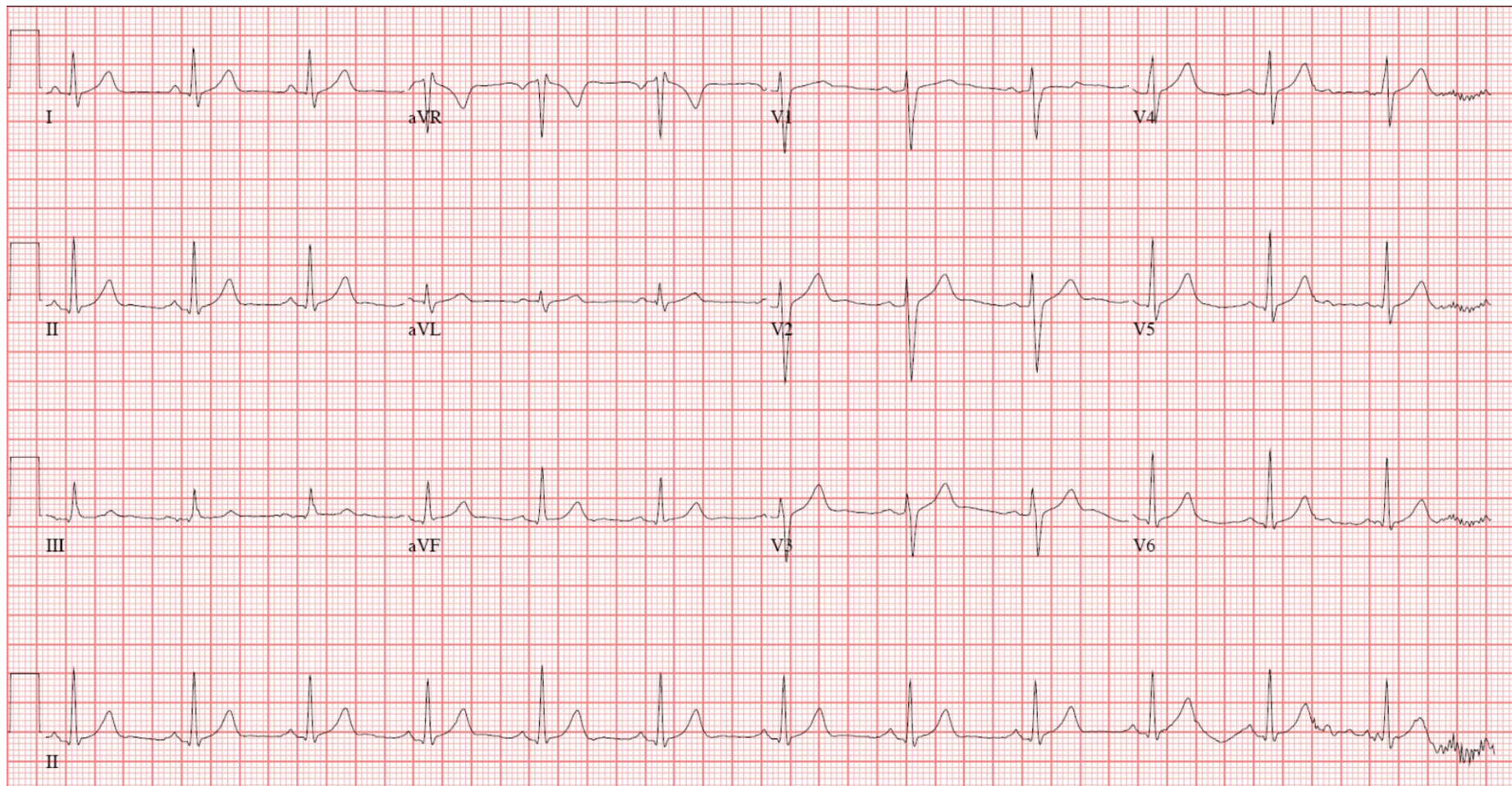
	Normal	Right	Left
II	<p>RA LA</p>	<p>RA LA</p>	<p>RA LA</p>
V <sub>1</sub>	<p>RA LA</p>	<p>RA LA</p>	<p>RA LA</p>



- Learn the basic concept behind electrical vectors.
- Learn the 6 step process to 12-lead ECG interpretation.
- Learn how to identify chamber enlargement.
- Learn how to differentiate between atrial & ventricular rhythms.
- Learn how to identify bundle branch blocks.
- Learn how to differentiate a STEMI from STE-Mimic
- Learn when to perform a right-sided or posterior 12-lead ECG.

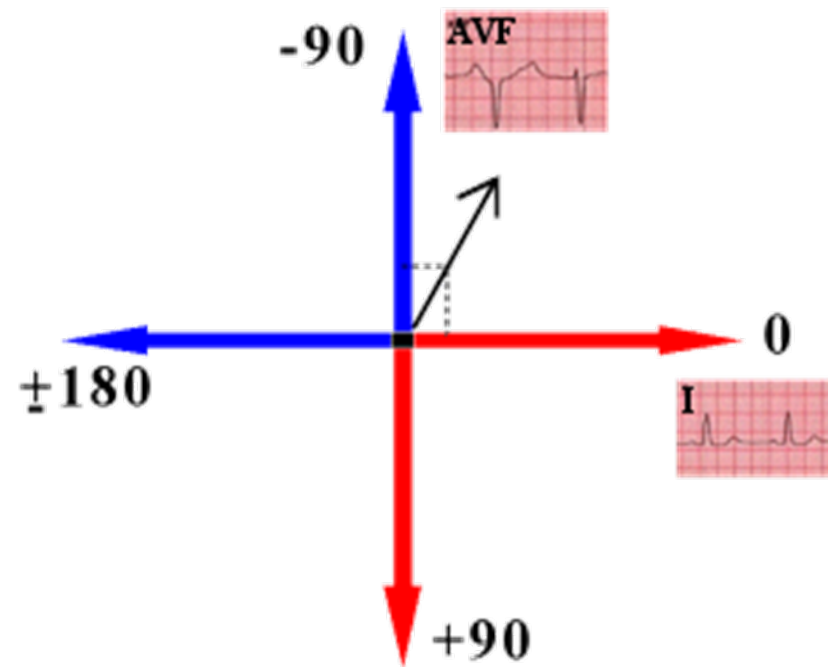


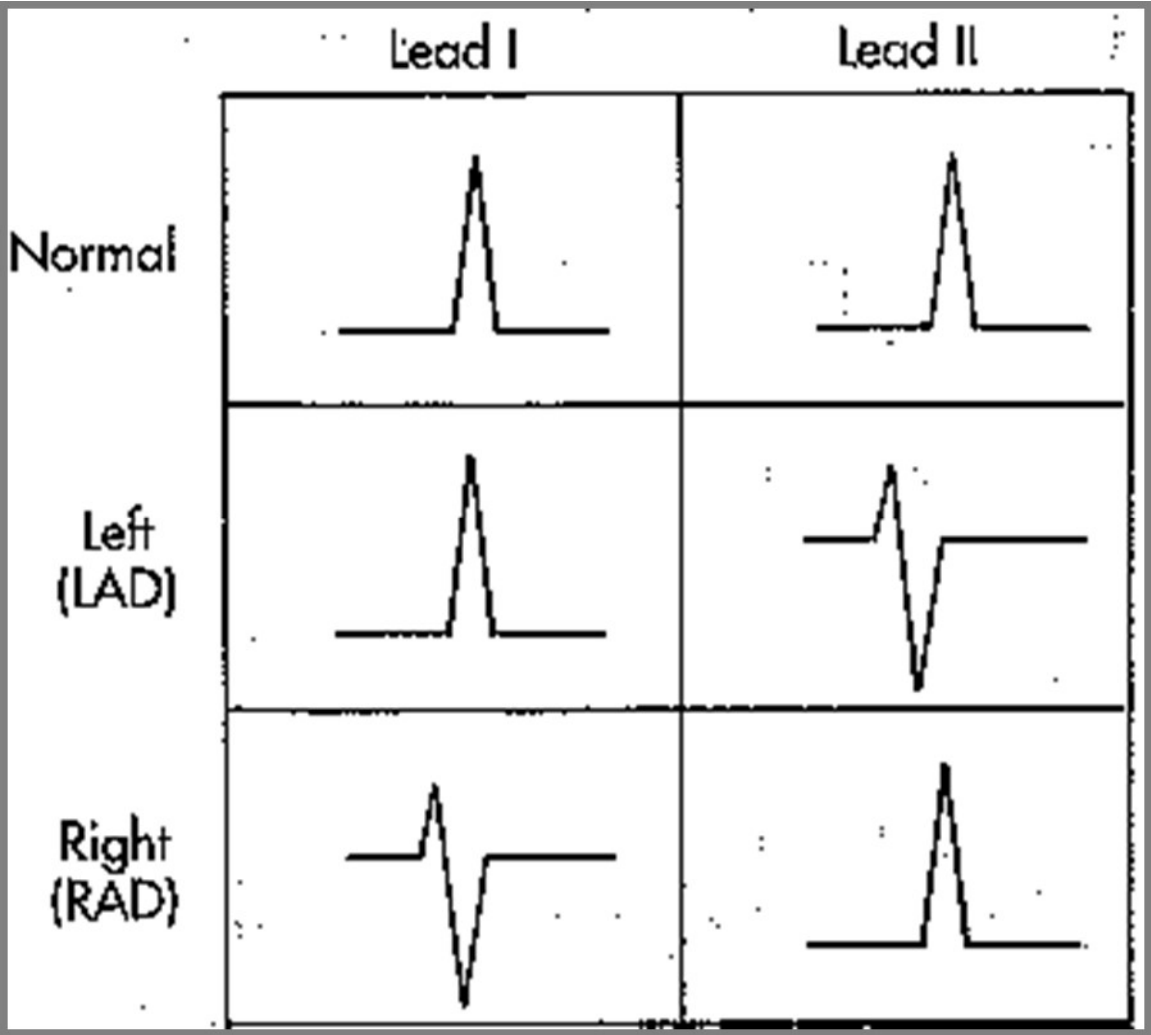
## Φυσιολογικό ΗΚΓ



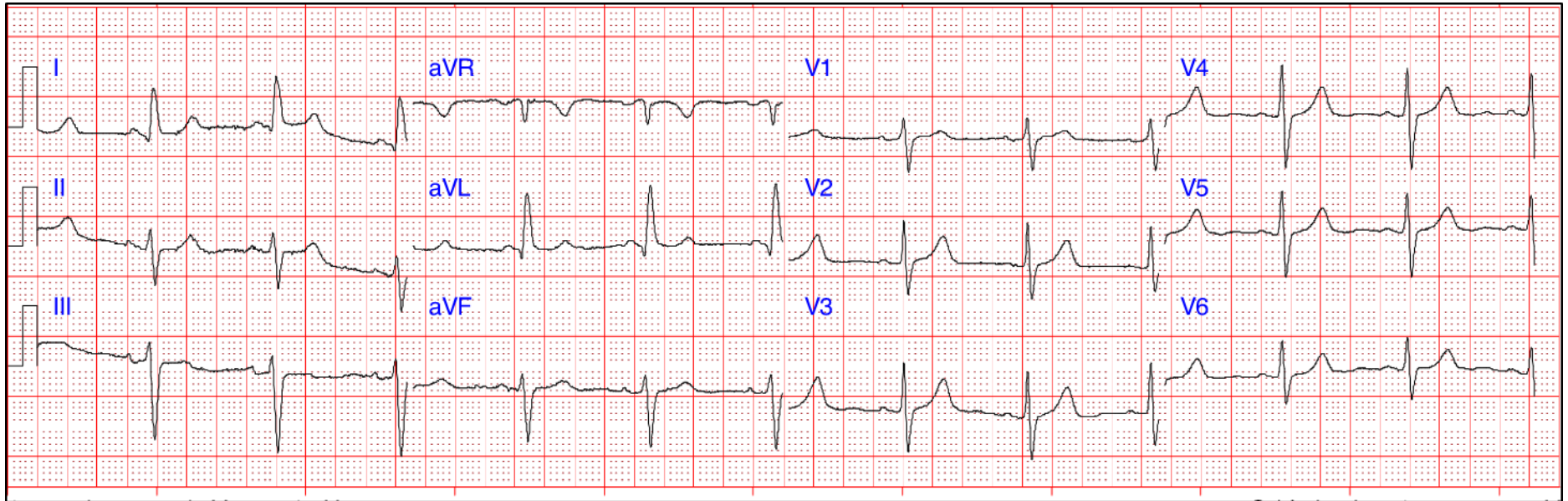
- 1. Rate & Rhythm
- 2. Axis Determination
- 3. Intervals
- 4. Morphology
- 5. STE-Mimics
- 6. Ischemia, Injury, & Infarct

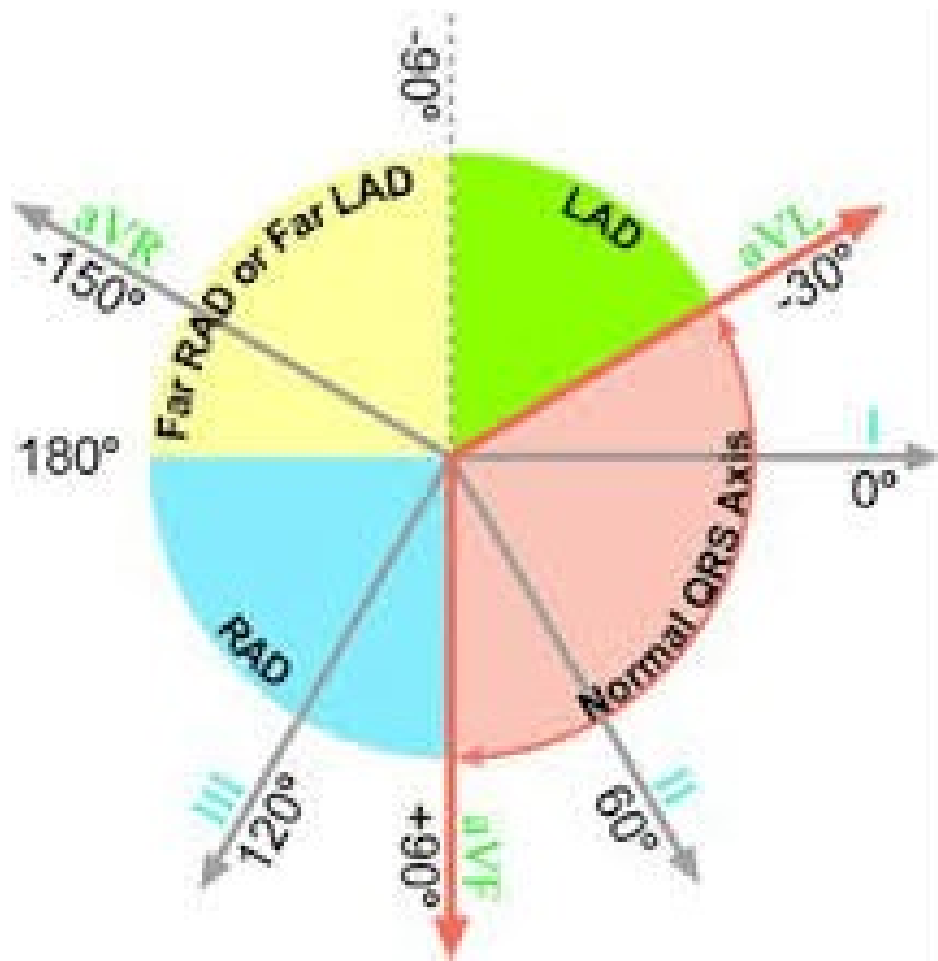
Αντιπροσωπεύει την κατεύθυνση της ηλεκτρικής δραστηριότητας στο μετωπιαίο άξονα

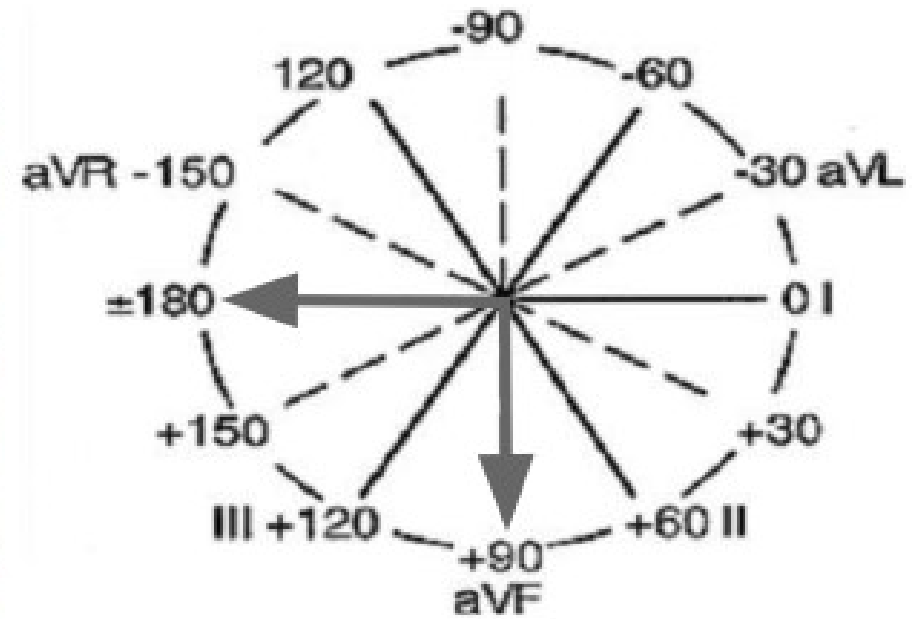
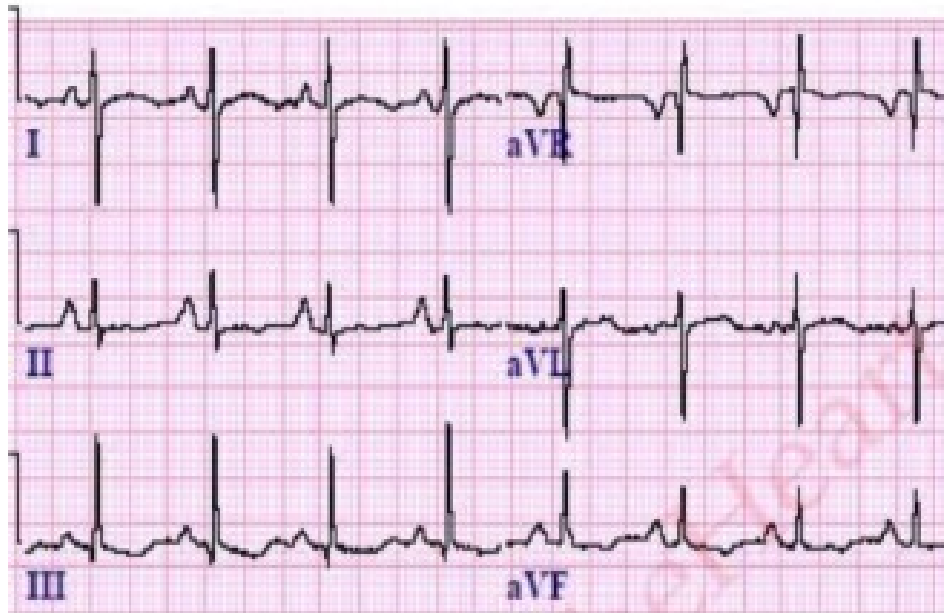












**Right Axis Deviation of the QRS Axis:  
Negative in Lead I and positive in lead aVF**

## Frontal Plane Axis

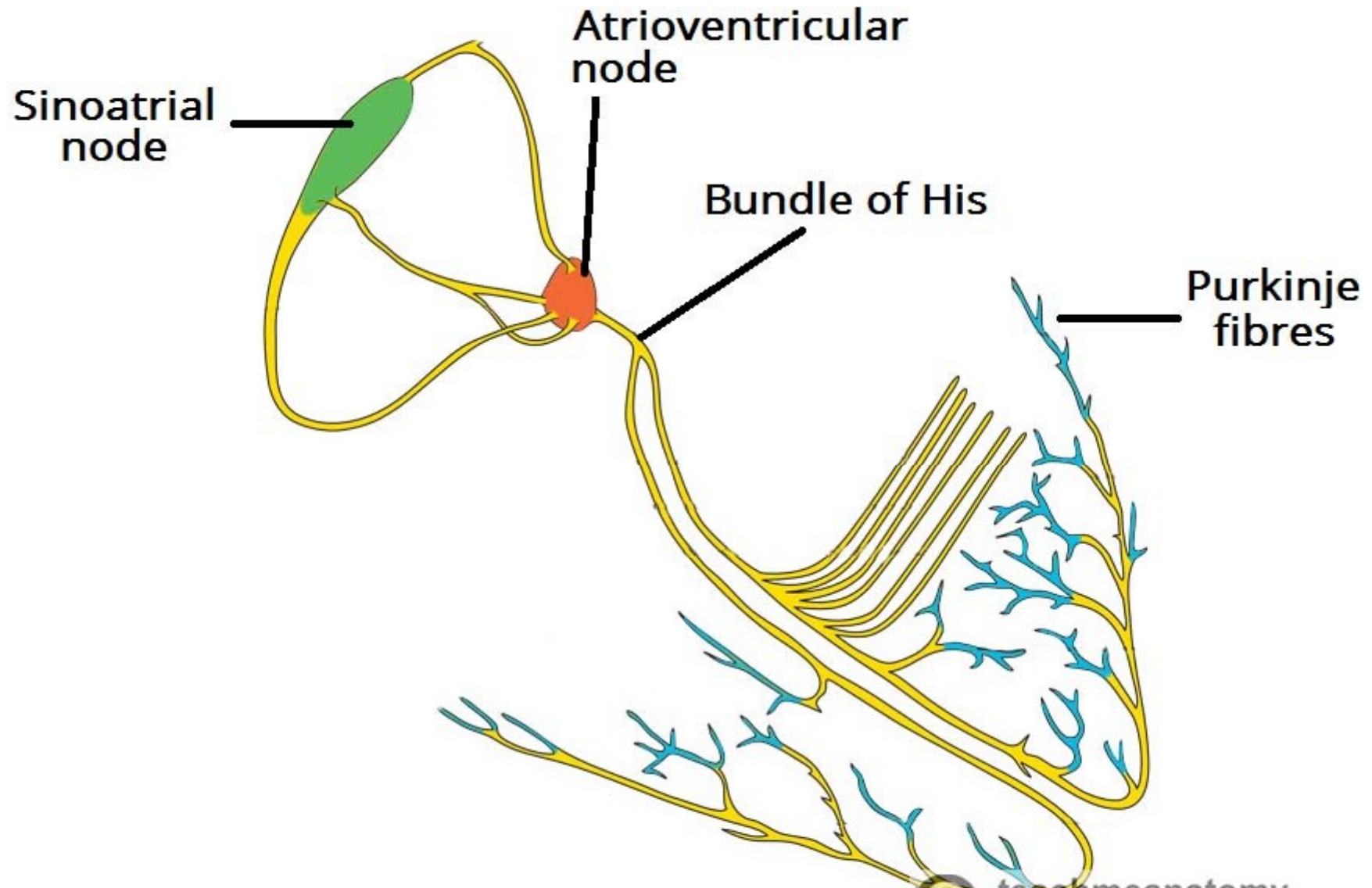
<p style="text-align: center;"><b>ERAD</b></p> <p style="text-align: center;">-90° to 180°</p>	<p style="text-align: center;">Right Axis Deviation</p> <p style="text-align: center;">90° to 180°</p>	<p style="text-align: center;">Pathological Left Axis Deviation</p> <p style="text-align: center;">-30° to -90°</p>
<ul style="list-style-type: none"> <li>• Ventricular Rhythm</li> <li>• Paced Rhythm</li> <li>• Dextrocardia</li> <li>• Electrolyte derangement</li> </ul>	<ul style="list-style-type: none"> <li>• May be normal</li> <li>• LPFB</li> <li>• Pulmonary disease</li> <li>• RVH</li> <li>• RBBB</li> <li>• WPW</li> <li>• Dextrocardia</li> <li>• Venrticular Rhythm</li> </ul>	<ul style="list-style-type: none"> <li>• Pregnancy</li> <li>• LAFB</li> <li>• WPW</li> <li>• Pulmonary disease</li> <li>• LBBB</li> <li>• Hyperkalemia</li> <li>• Q-waves, MI</li> </ul>

### **Left axis deviation**

Normal variant (diaphragm elevation)  
Left ventricular enlargement  
Inferior myocardial infarction  
Right-sided tension pneumothorax  
Ventricular pacemaker  
Left anterior hemiblock

### **Right axis deviation**

Normal variant (children)  
Right ventricular enlargement  
Lateral myocardial infarction  
Left-sided tension pneumothorax  
Pulmonary embolism  
Left posterior hemiblock

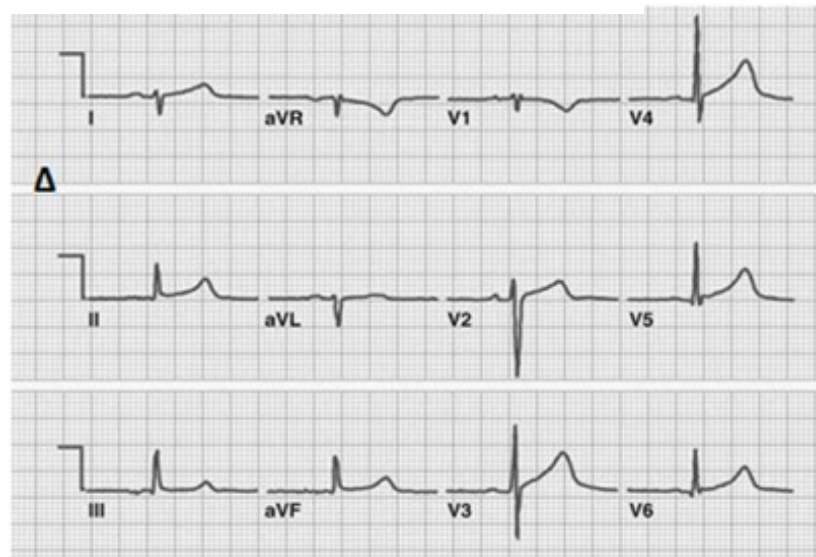
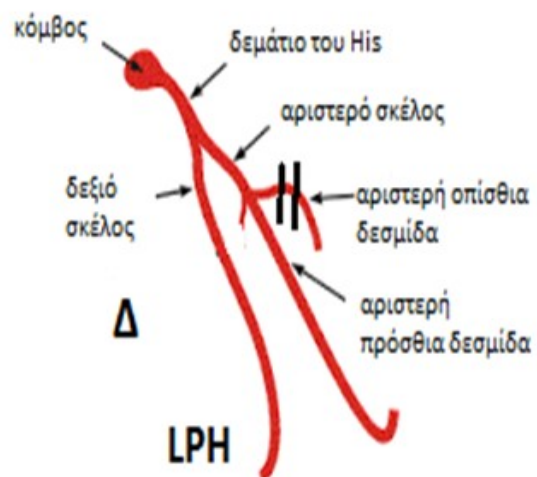
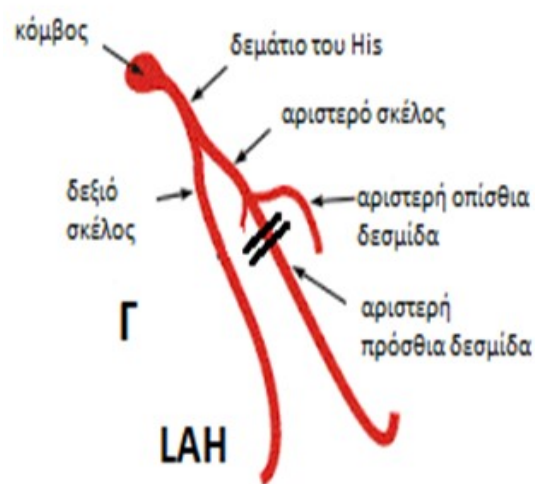


Sinoatrial node

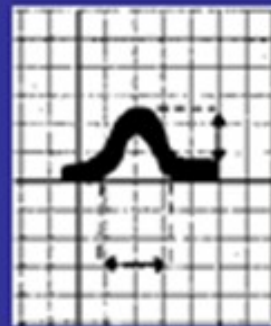
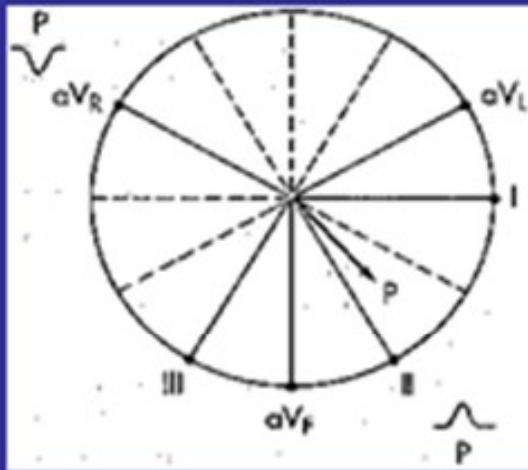
Atrioventricular node

Bundle of His

Purkinje fibres



# P wave

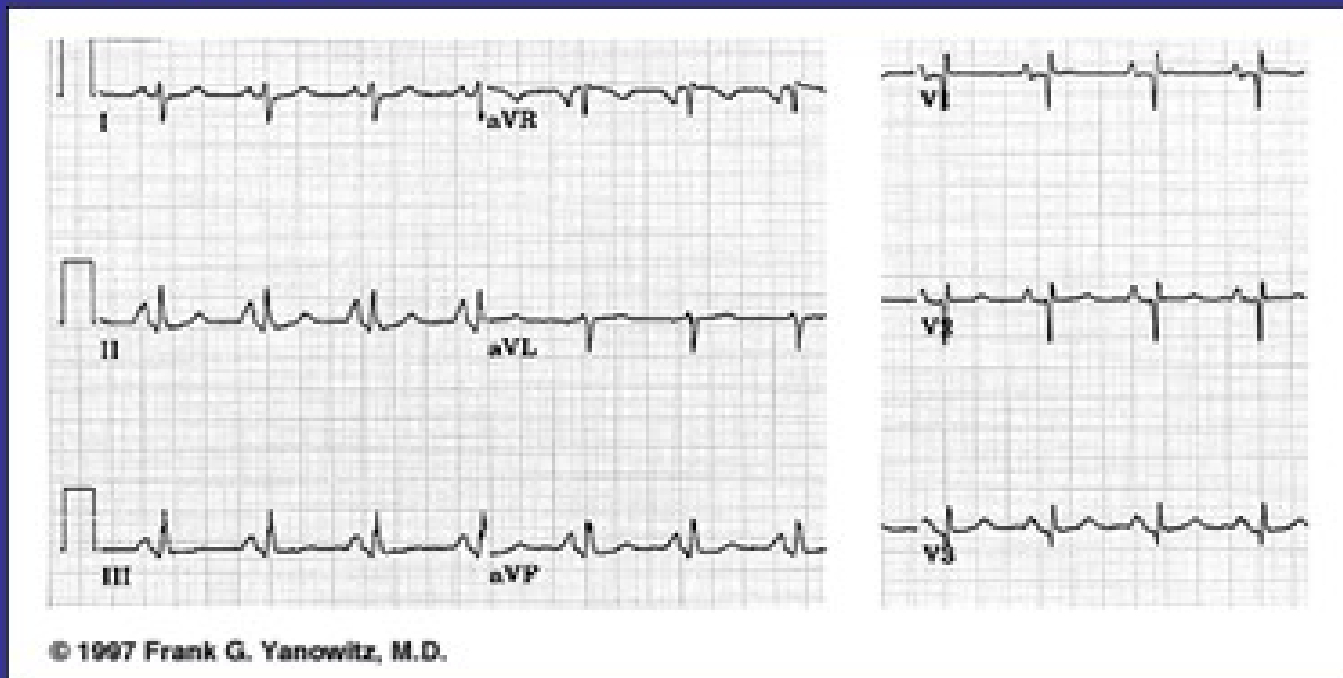


- Always positive in lead I and II in NSR
- Always negative in lead aVR in NSR
- < 3 small squares in duration
- < 2.5 small squares in amplitude
- Commonly biphasic in lead V1
- Best seen in leads II



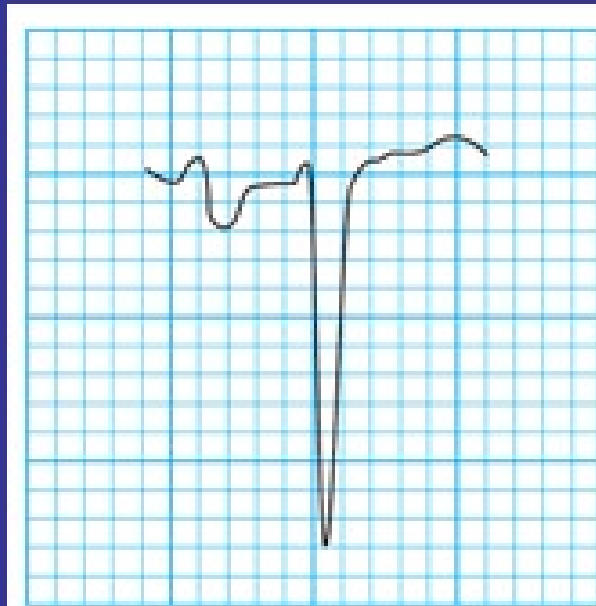
# Right Atrial Enlargement

- Tall ( $> 2.5$  mm), pointed P waves (P pulmonale)



# Left Atrial Enlargement

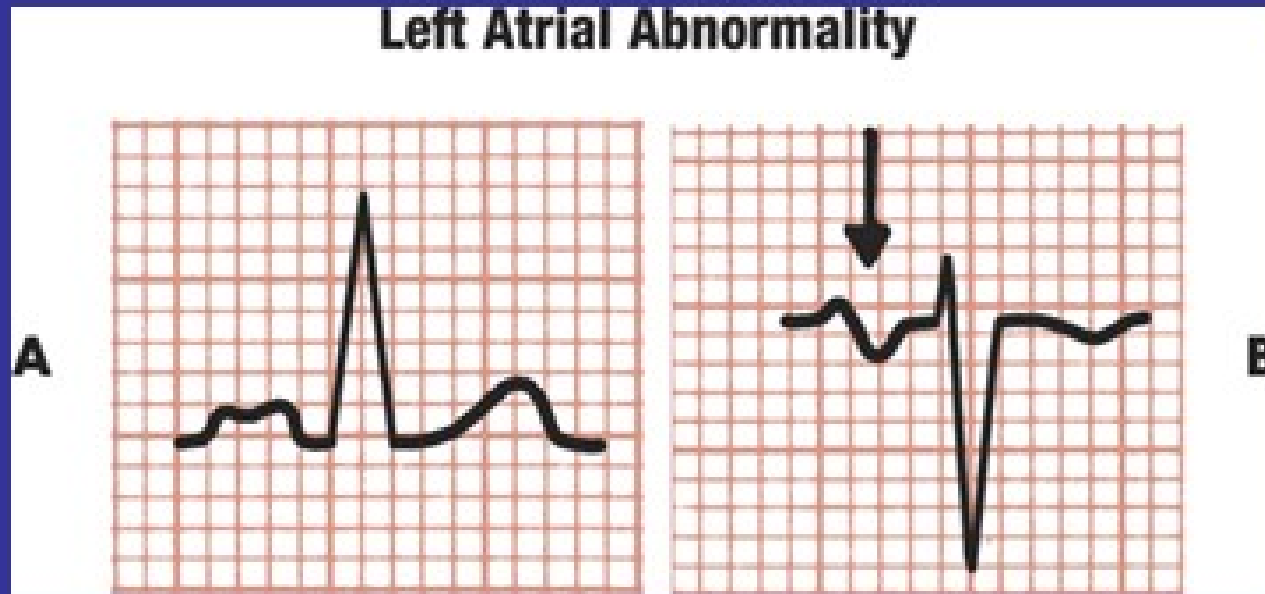
- Prominent terminal P negativity (biphasic) in lead V1 (i.e., "P-terminal force")  
duration >0.04s, depth >1 mm



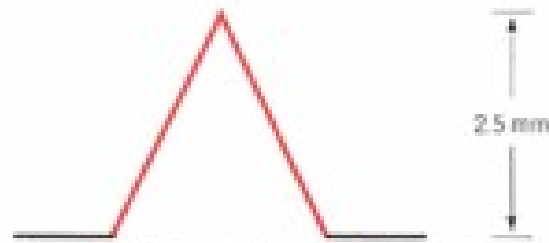
Biphasic P wave in V1. The large negative deflection indicates left atrial abnormality (enlarged to show detail)

# Left Atrial Enlargement

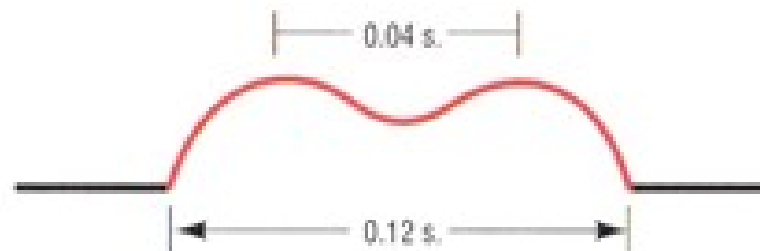
- Notched/bifid ('M' shaped) P wave (P 'mitrale') in limb leads with the inter-peak duration  $> 0.04s$  (1 mm)

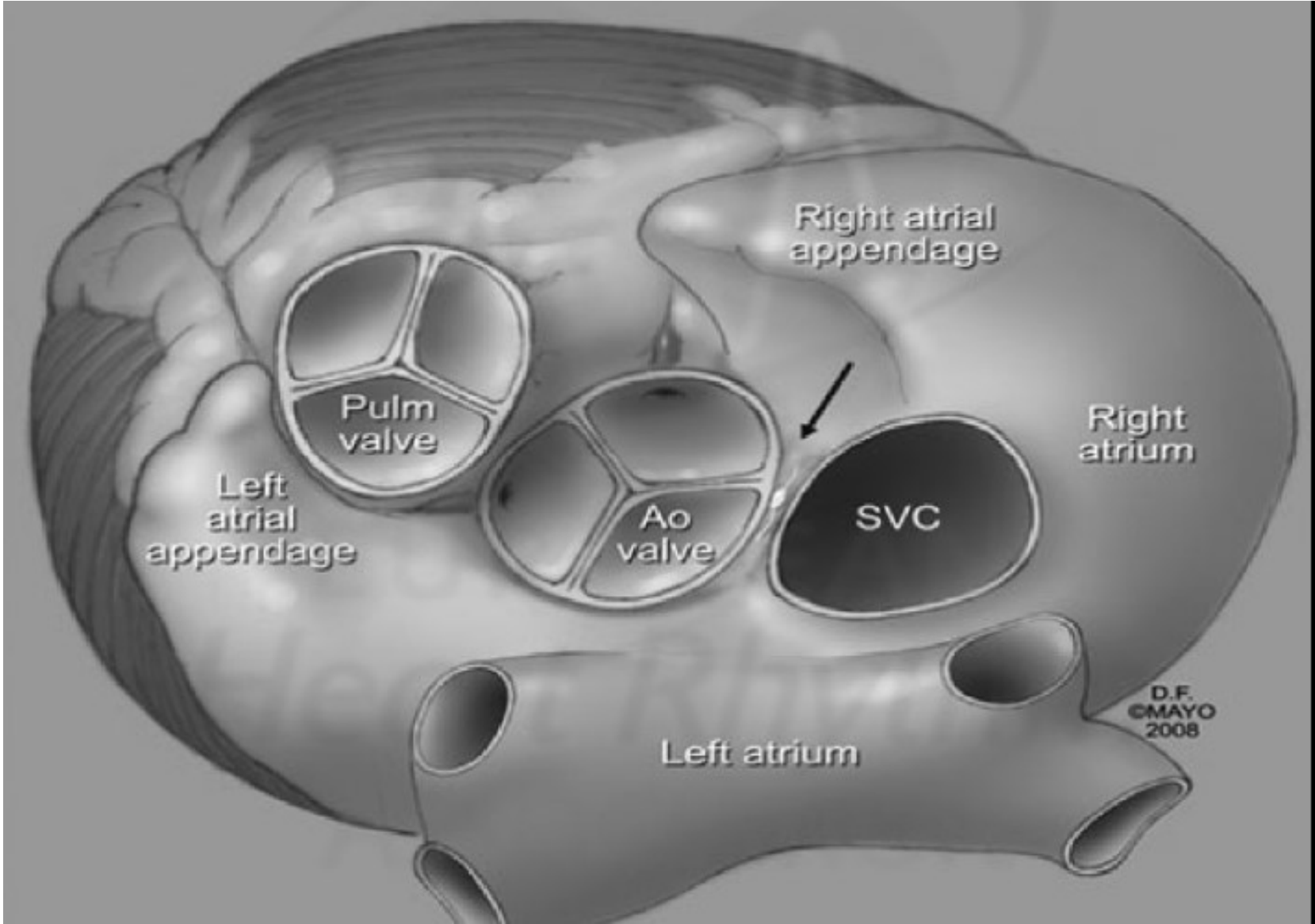


# P Pulmonale and P Mitrale

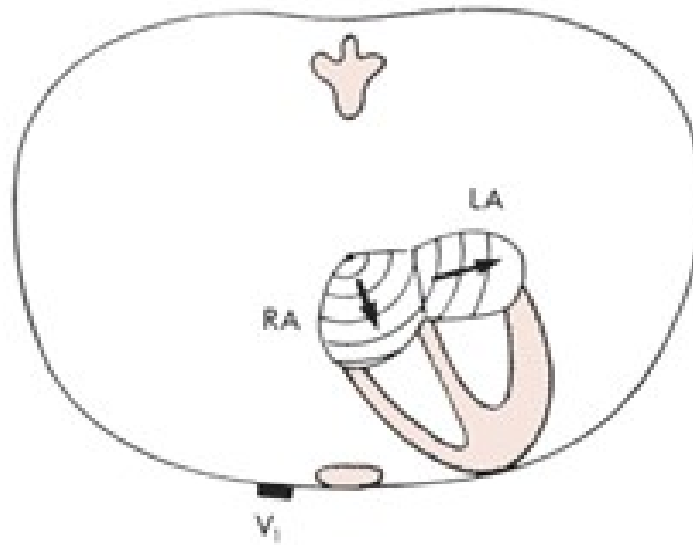


**Figure 12-4:** A peaked P wave taller than 2.5 mm in the limb leads indicates P-pulmonale.



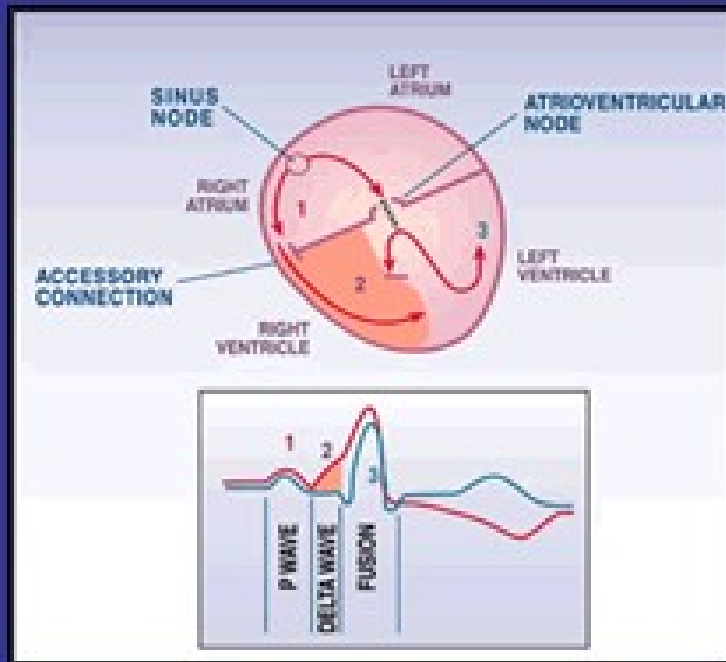


### Atrial Enlargement (Abnormality)



	Normal	Right	Left
II			
V <sub>1</sub>			

# Short PR Interval



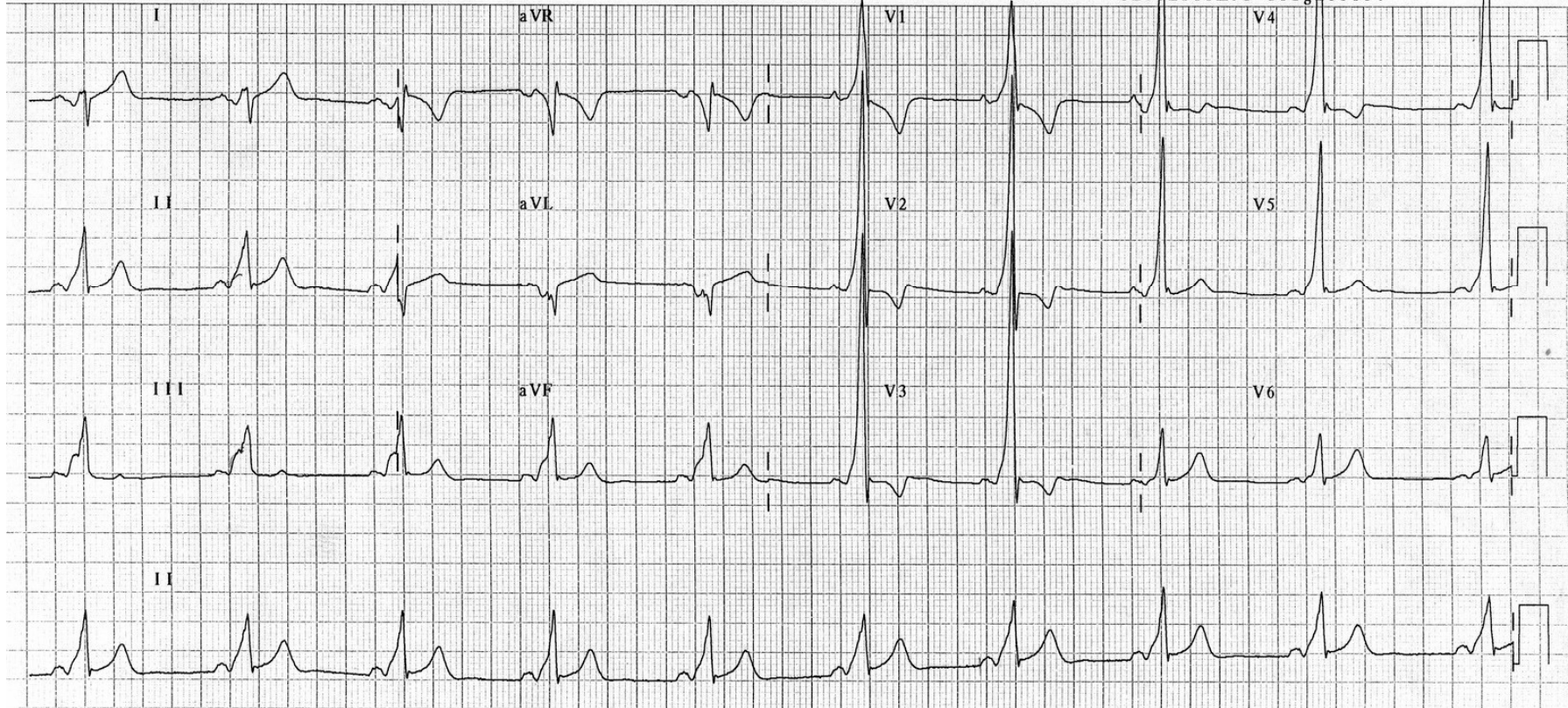
- WPW (Wolff-Parkinson-White) Syndrome
- Accessory pathway (Bundle of Kent) allows early activation of the ventricle (delta wave and short PR interval)

QTc 392

--Axis--  
P -40  
QRS 77  
T 15

- ABNORMAL ECG -

Unconfirmed diagnosis.

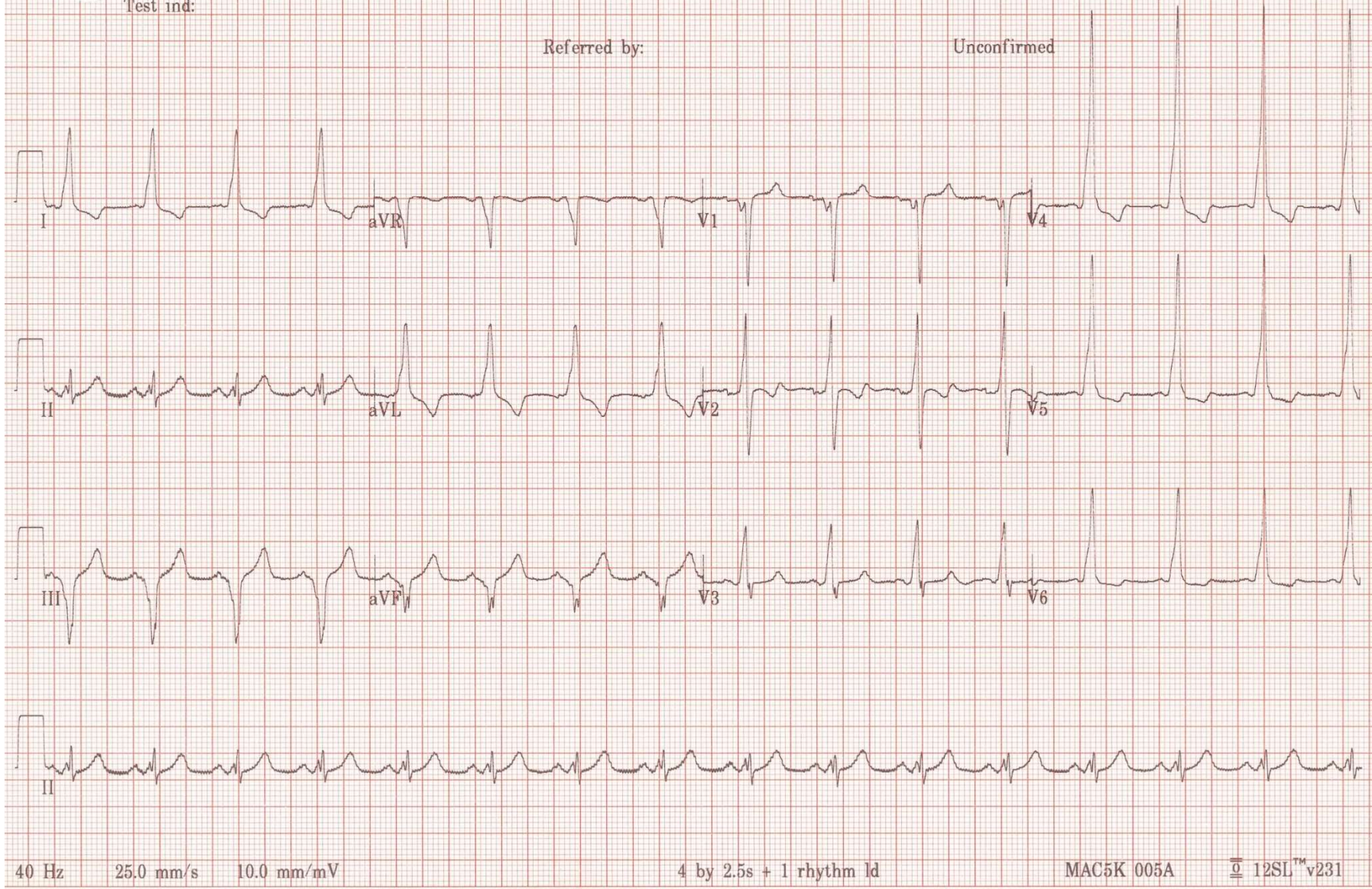




Technician:  
Test ind:

Referred by:

Unconfirmed



40 Hz

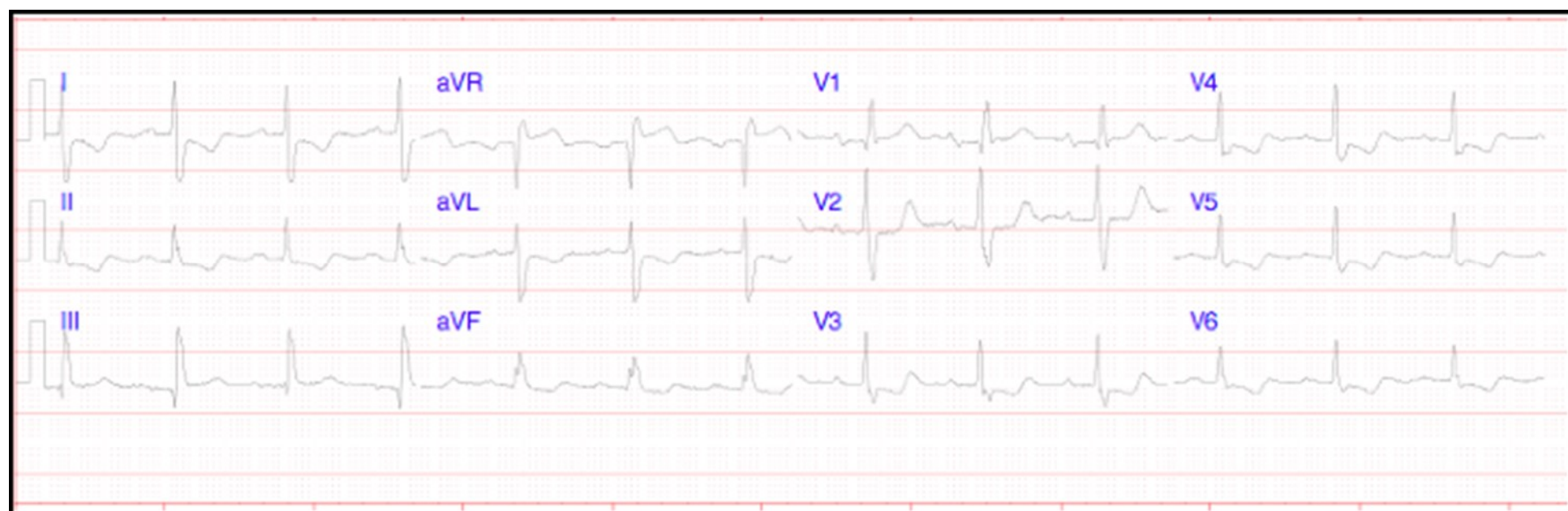
25.0 mm/s

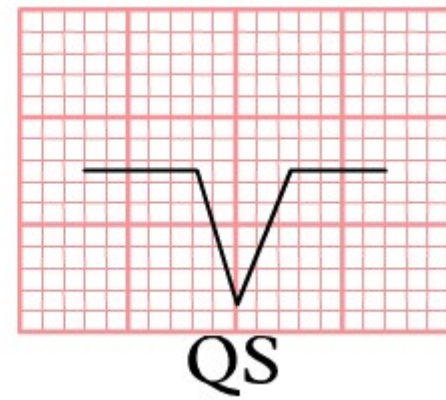
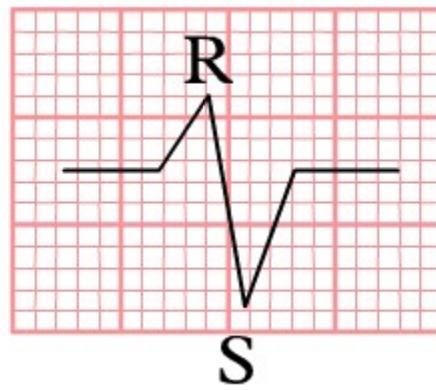
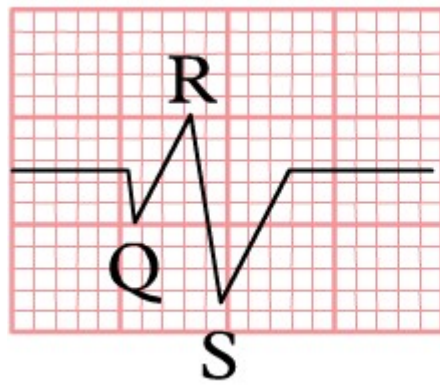
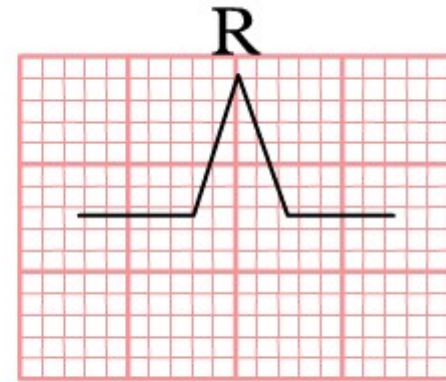
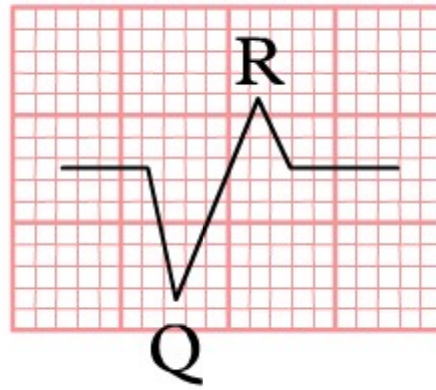
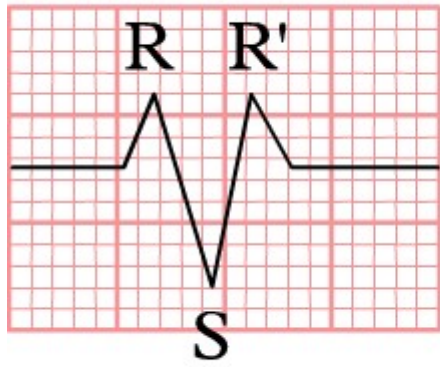
10.0 mm/mV

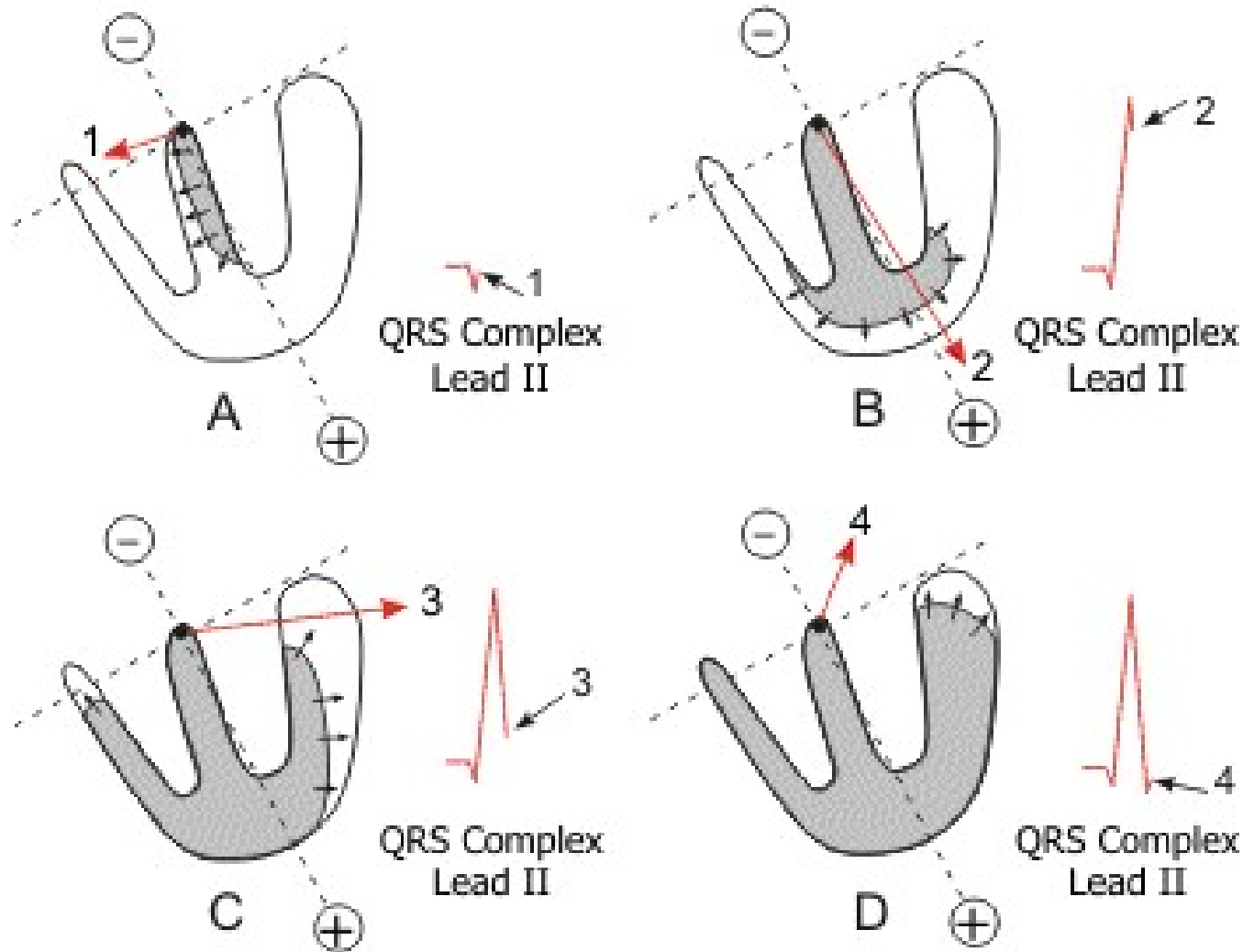
4 by 2.5s + 1 rhythm ld

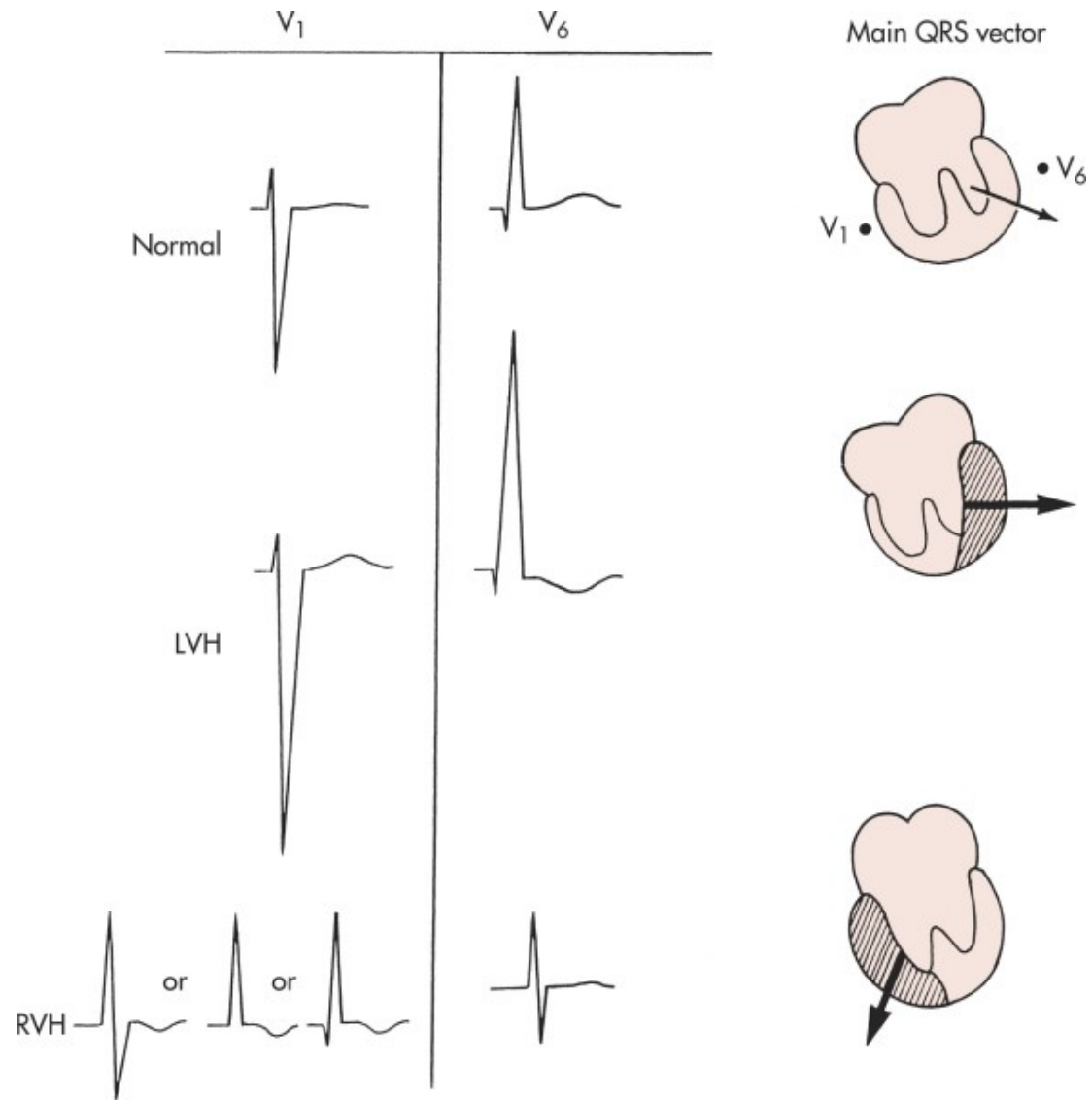
MAC5K 005A

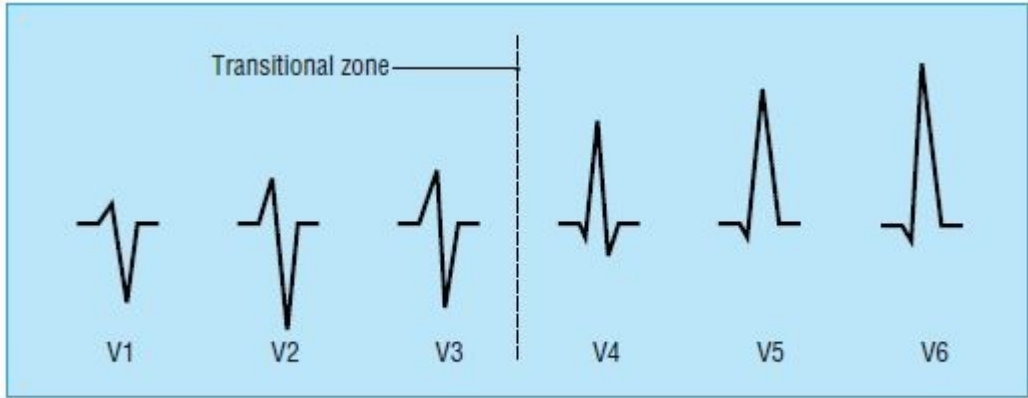
12SL™ v231



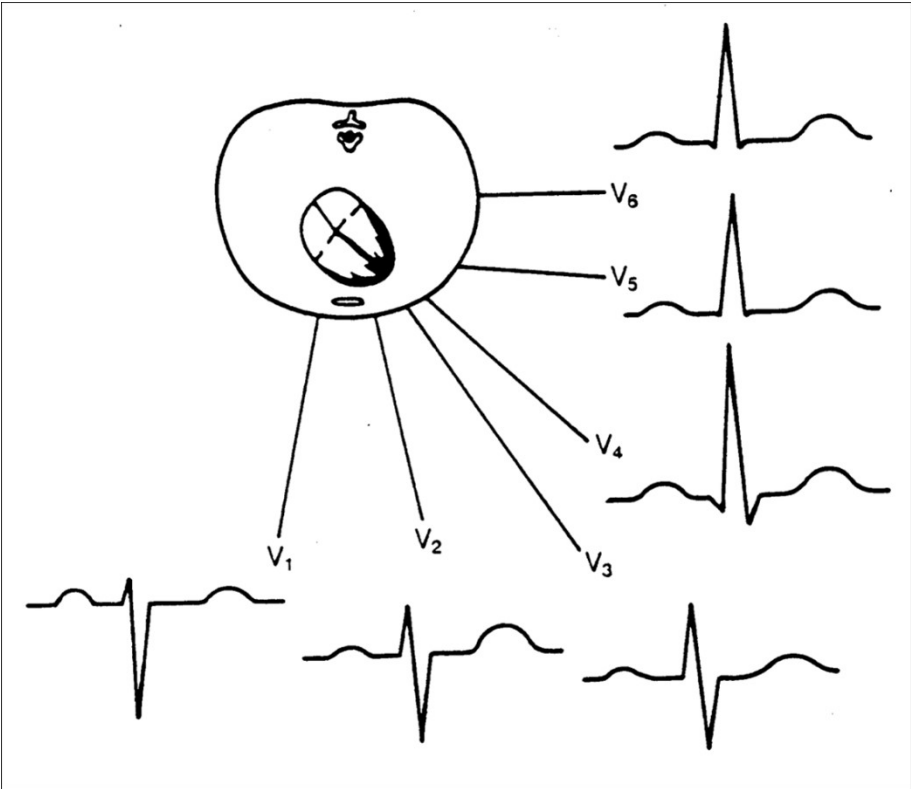




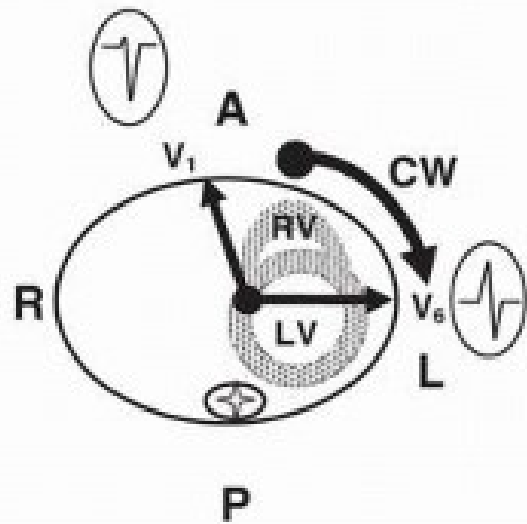




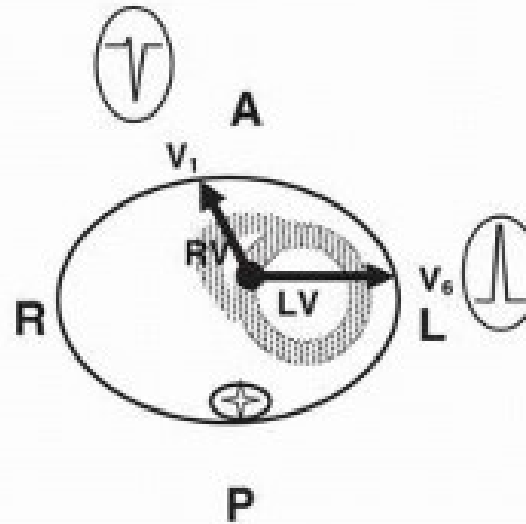
Typical change in morphology of QRS complex from leads V1 to V6



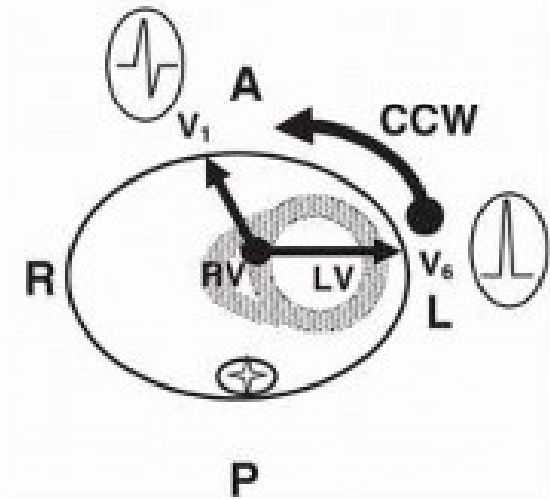
**A:** Clockwise Rotation



**B:** Normal Rotation



**C:** Counterclockwise Rotation

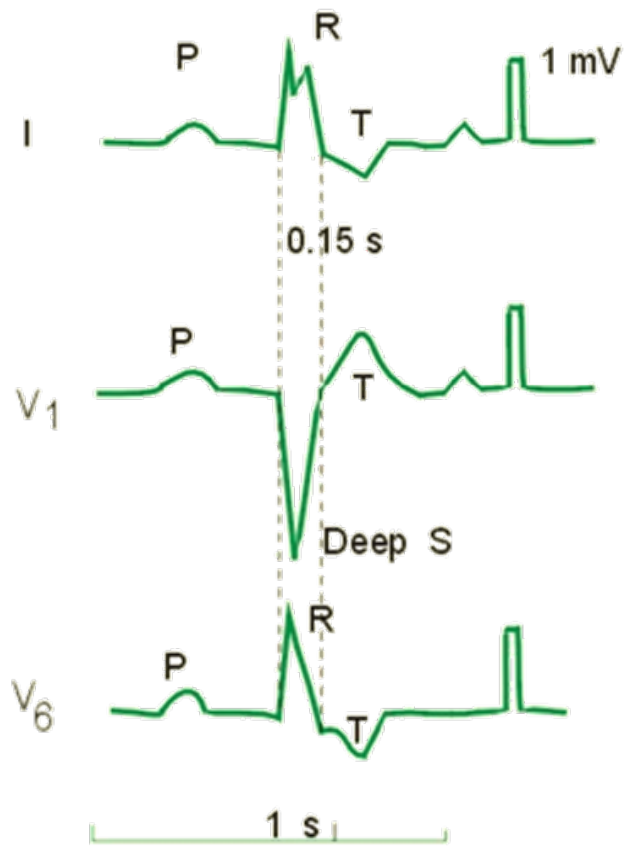


# Σκελικοί αποκλεισμοί

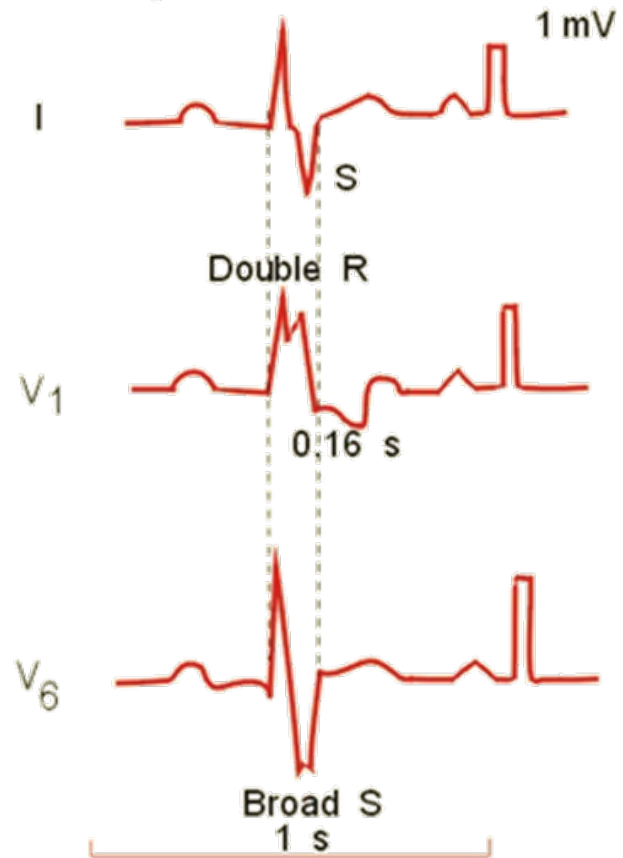
- QRS μεγαλύτερο από 0.12 secs
- αλλαγή του άξονα
- Δύσκολο να ερμηνευτεί το ΗΚΓ
- Δεξιός ή αριστερός
- Φυσιολογικό P κύμα
- Ακολουθείται από αρνητικό κύμα T όταν το QRS είναι καθ'υπεροχή θετικό



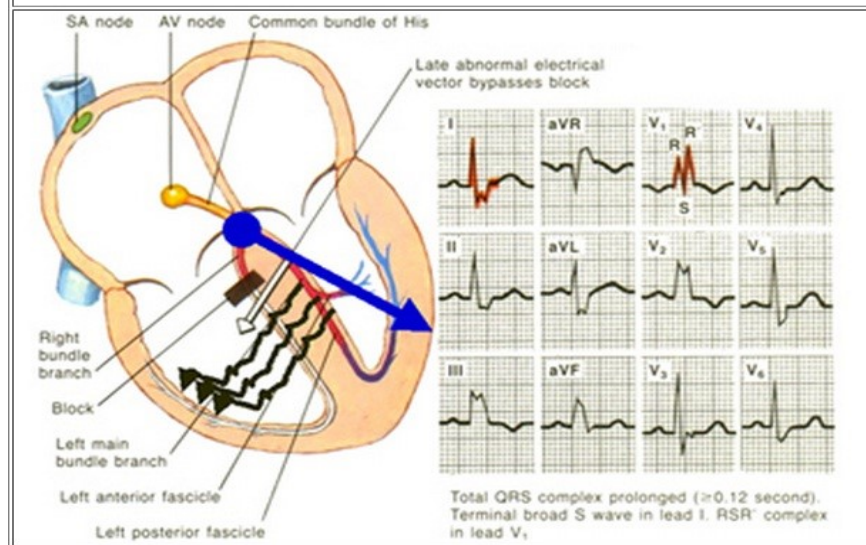
Left bundle branch block



Right bundle branch block

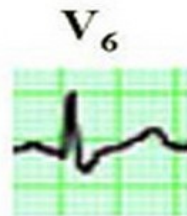


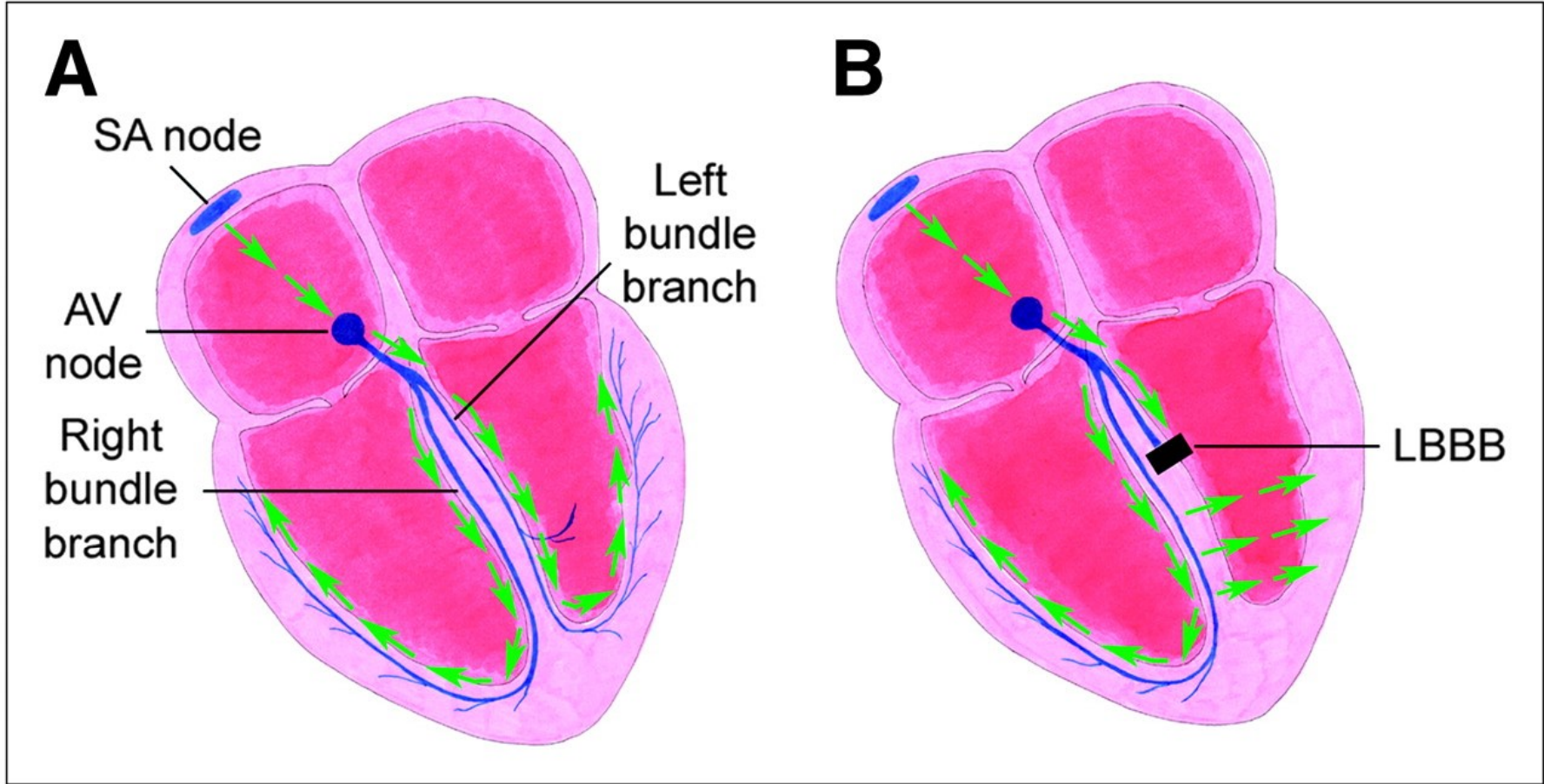
# Right Bundle Branch Block



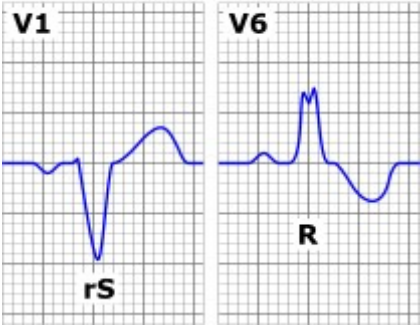
## RBBB Criteria (Check QRS 1st)

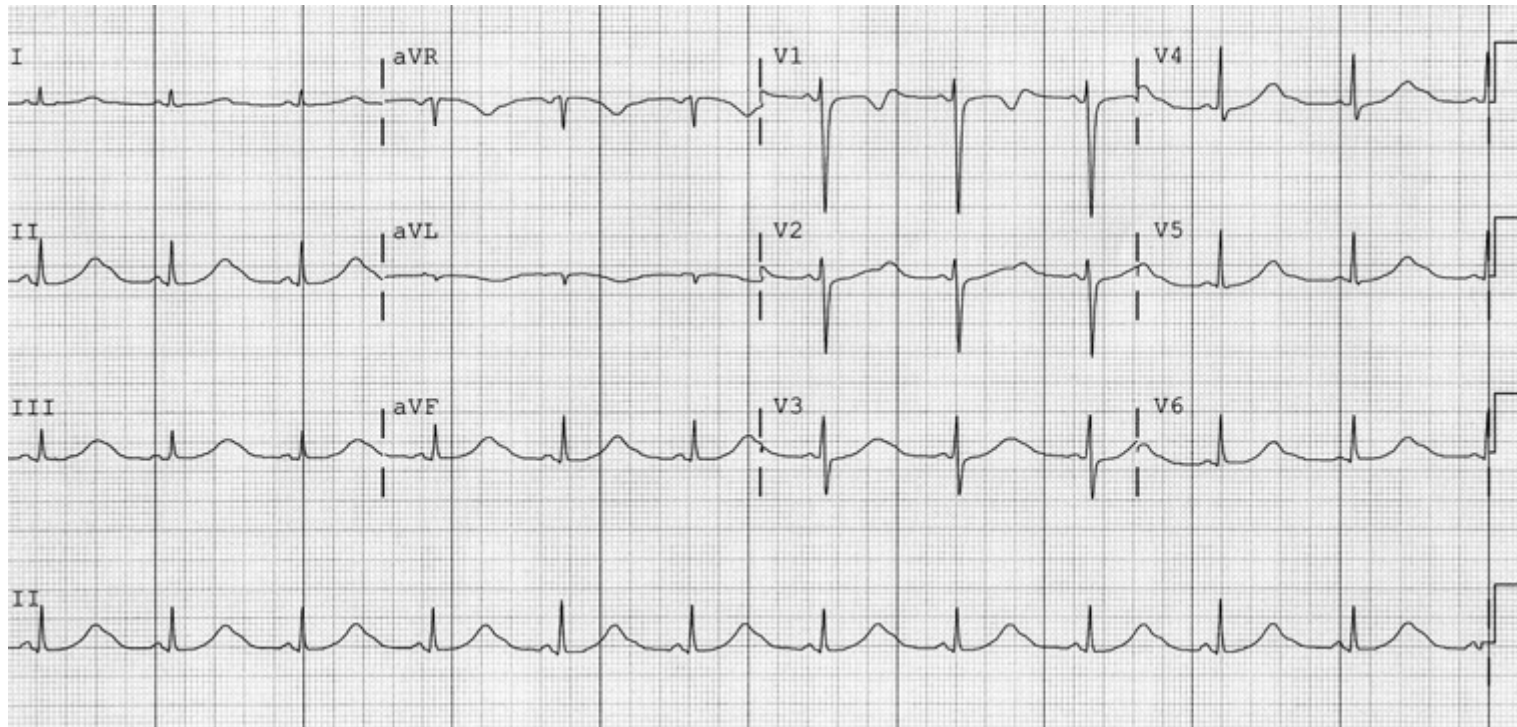
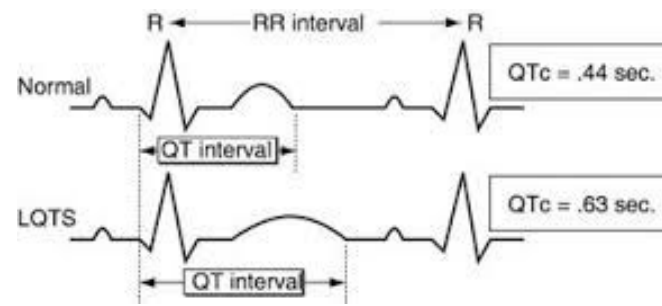
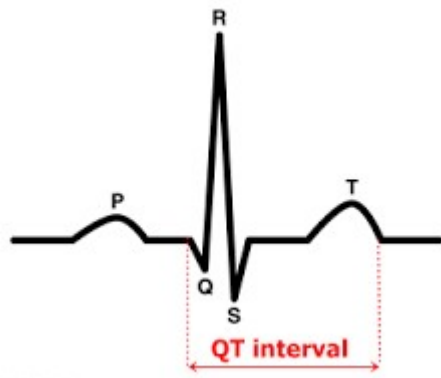
- ◆ Look in V<sub>1</sub> & V<sub>2</sub>
  - \* R, R' wave!
- ◆ Look in V<sub>5</sub>, V<sub>6</sub>, & Lead I
  - \* "slurred S wave"



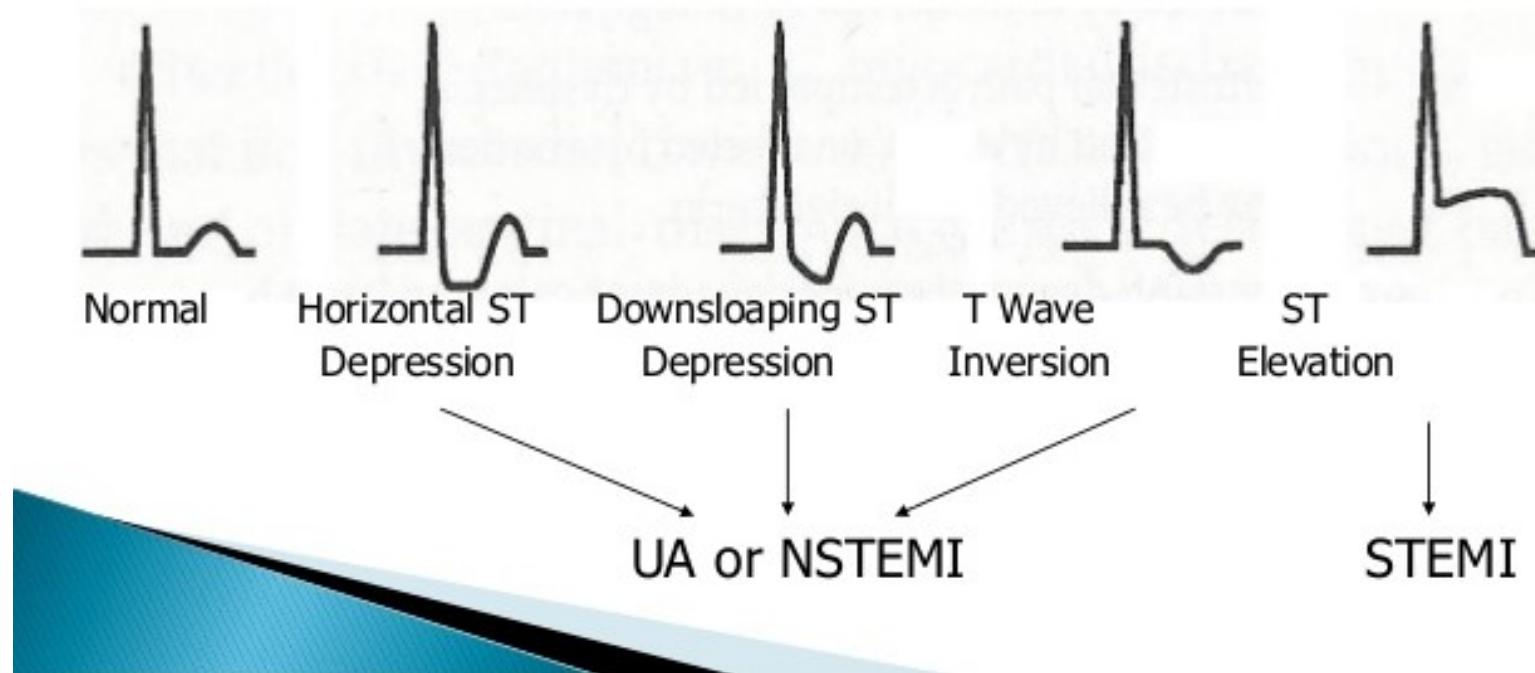


**Left bundle branch block characteristics**

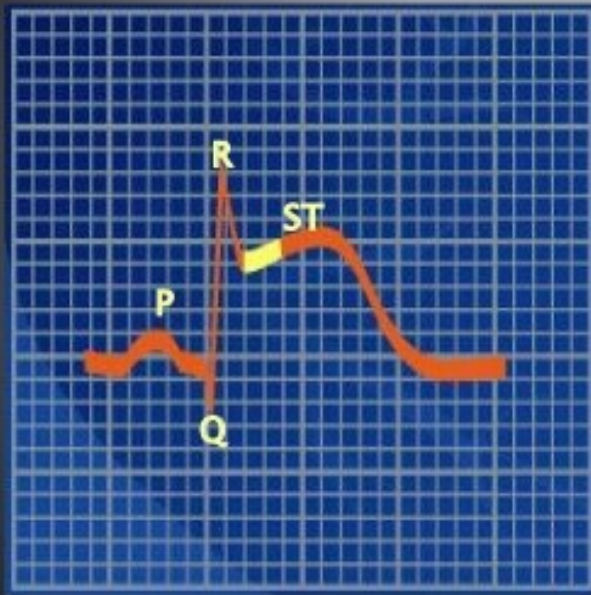




# ACS - ECG findings

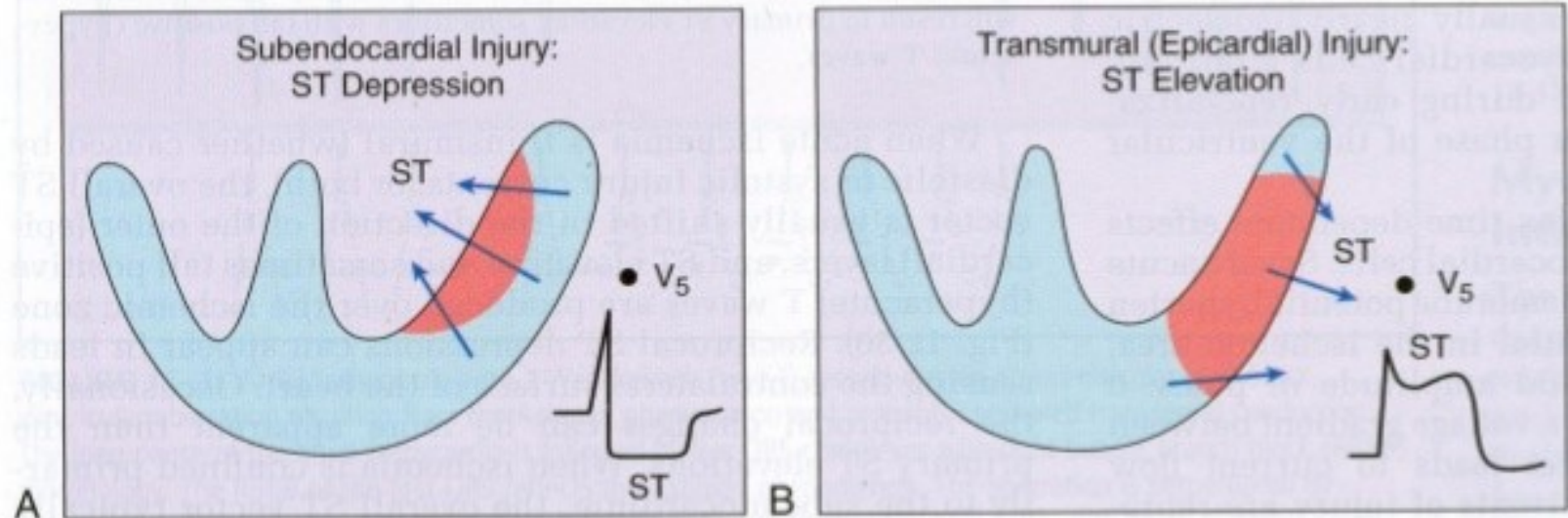


# ST elevation



- Occurs in the early stages
- Occurs in the leads facing the infarction

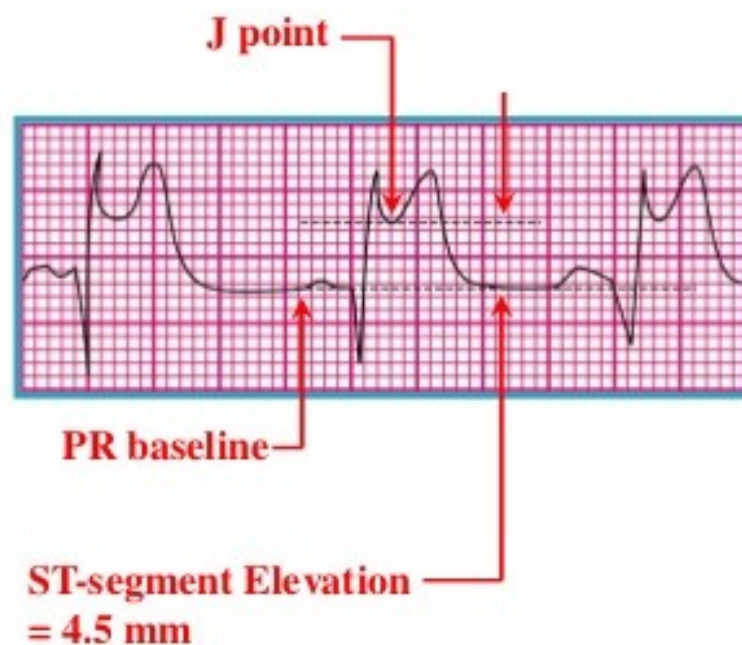
## Current of Injury Patterns



**FIGURE 12-36** Current of injury patterns with acute ischemia. **A**, With predominant subendocardial ischemia the resultant ST vector is directed toward the inner layer of the affected ventricle and the ventricular cavity. Overlying leads therefore record ST depression. **B**, With ischemia involving the outer ventricular layer (transmural or epicardial injury), the ST vector is directed outward. Overlying leads record ST elevation. Reciprocal ST depression can appear in contralateral leads.


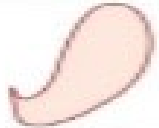

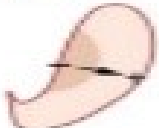








# Recognition of AMI

- Know what to look for—
  - ST elevation  $> 1$  mm
  - 2 contiguous leads
- Know where to look
  - I, AVL, V5, V6 = Lateral
  - V1 V2 V3 V4 = Anterior
  - II, III & AVF = Inferior



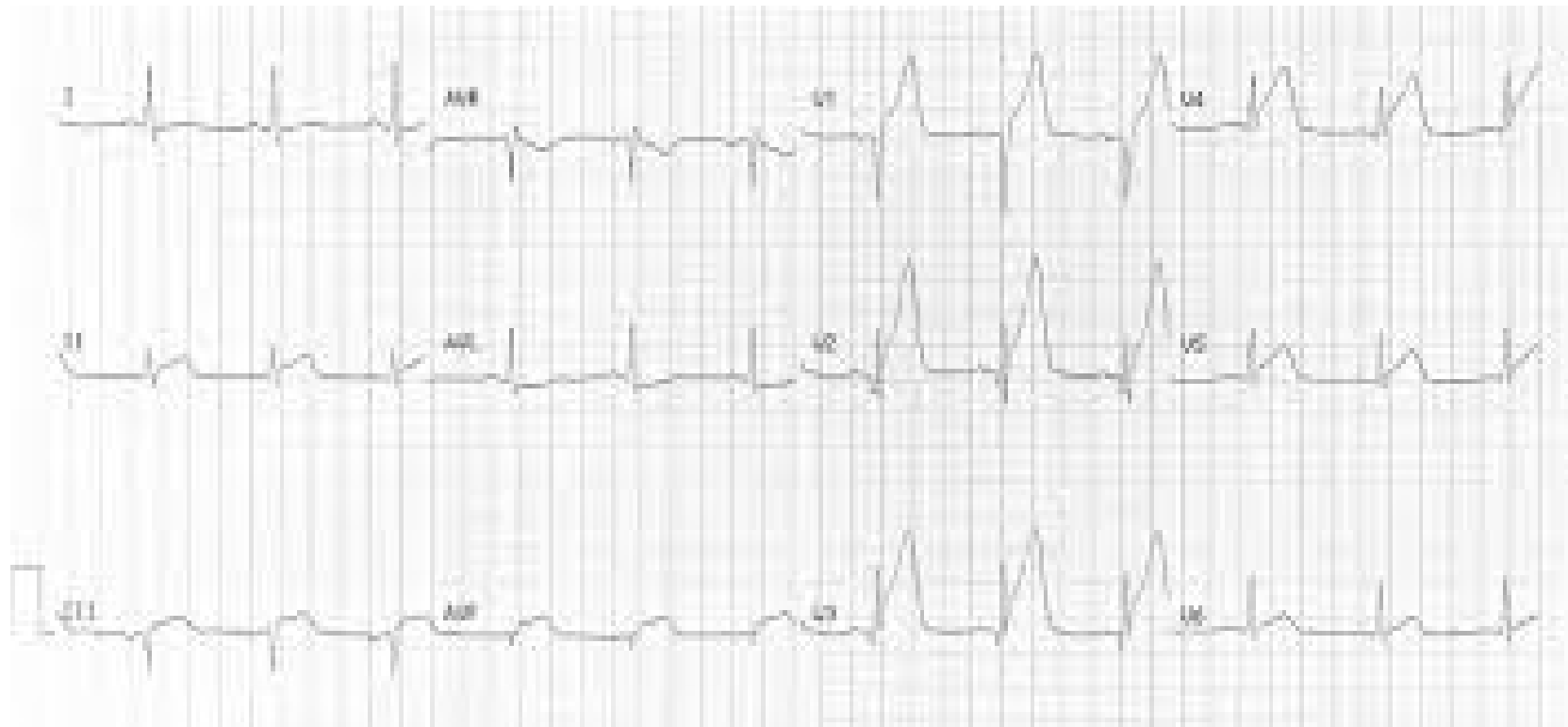


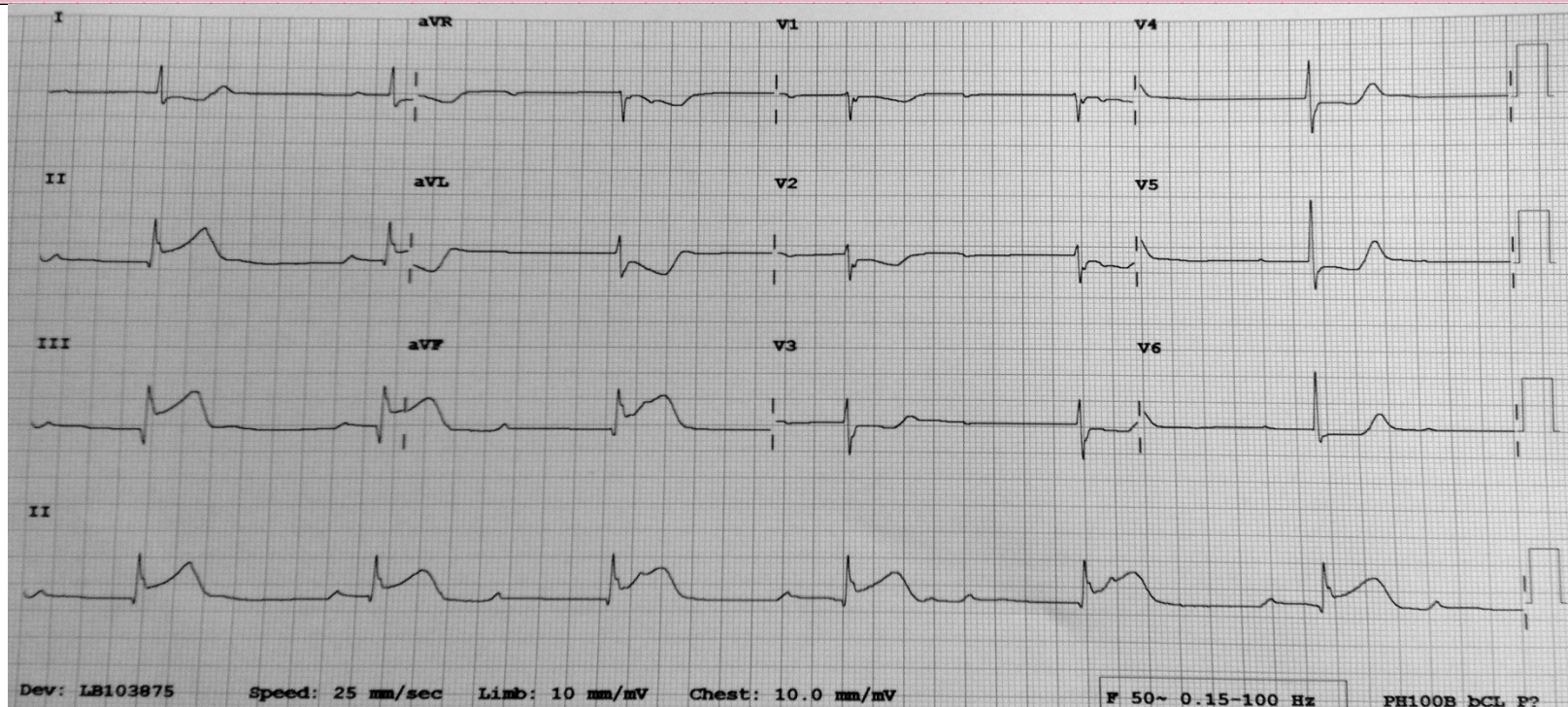
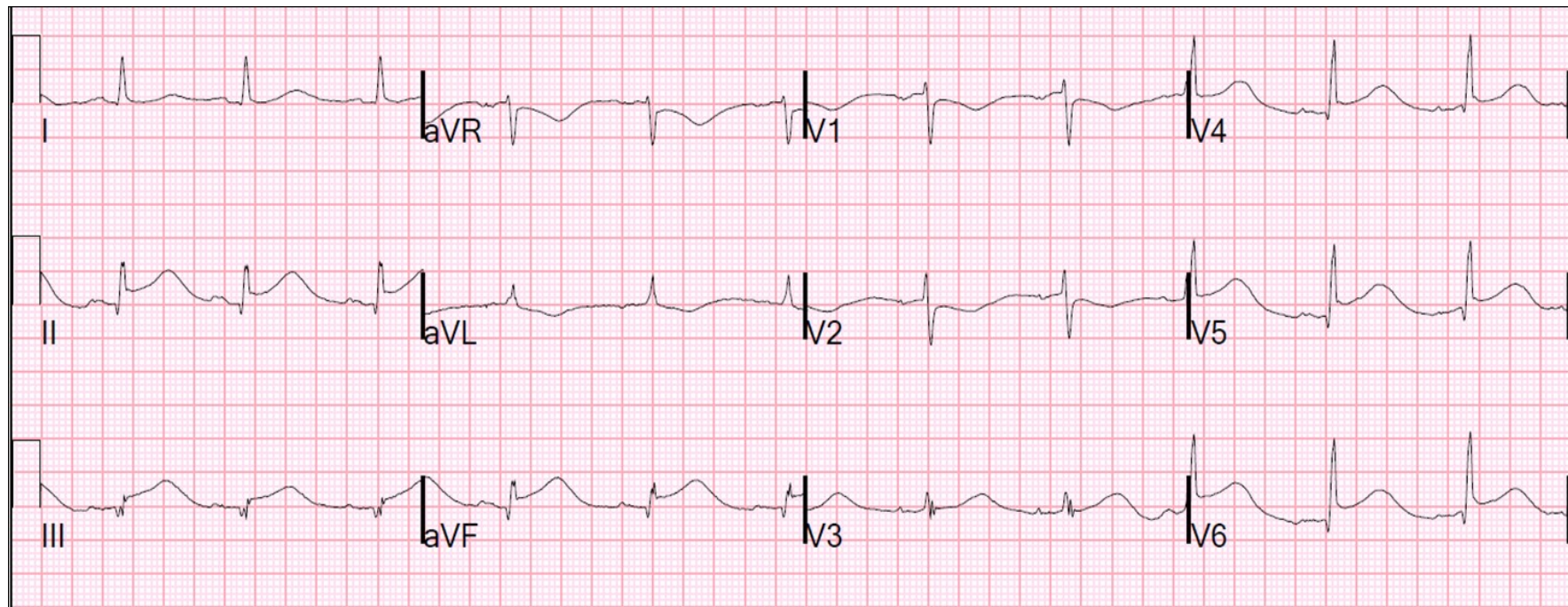
# Evolution of MI

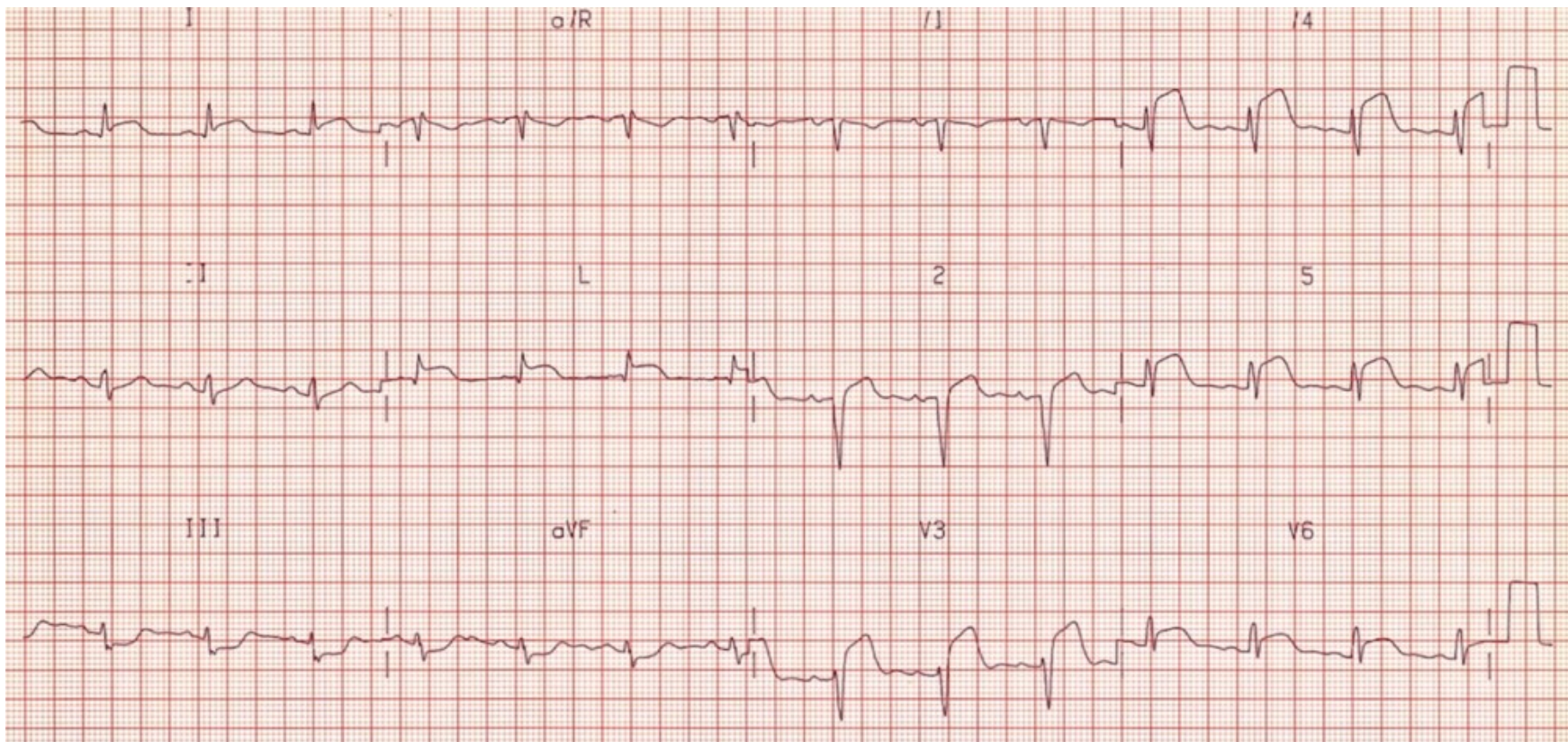
Time	V <sub>1</sub> -V <sub>2</sub>	LV involvement
Normal (basal)		 1
Seconds		 2
Minutes		 3
Hours		 4
Days		
Weeks		 5
1 Year		

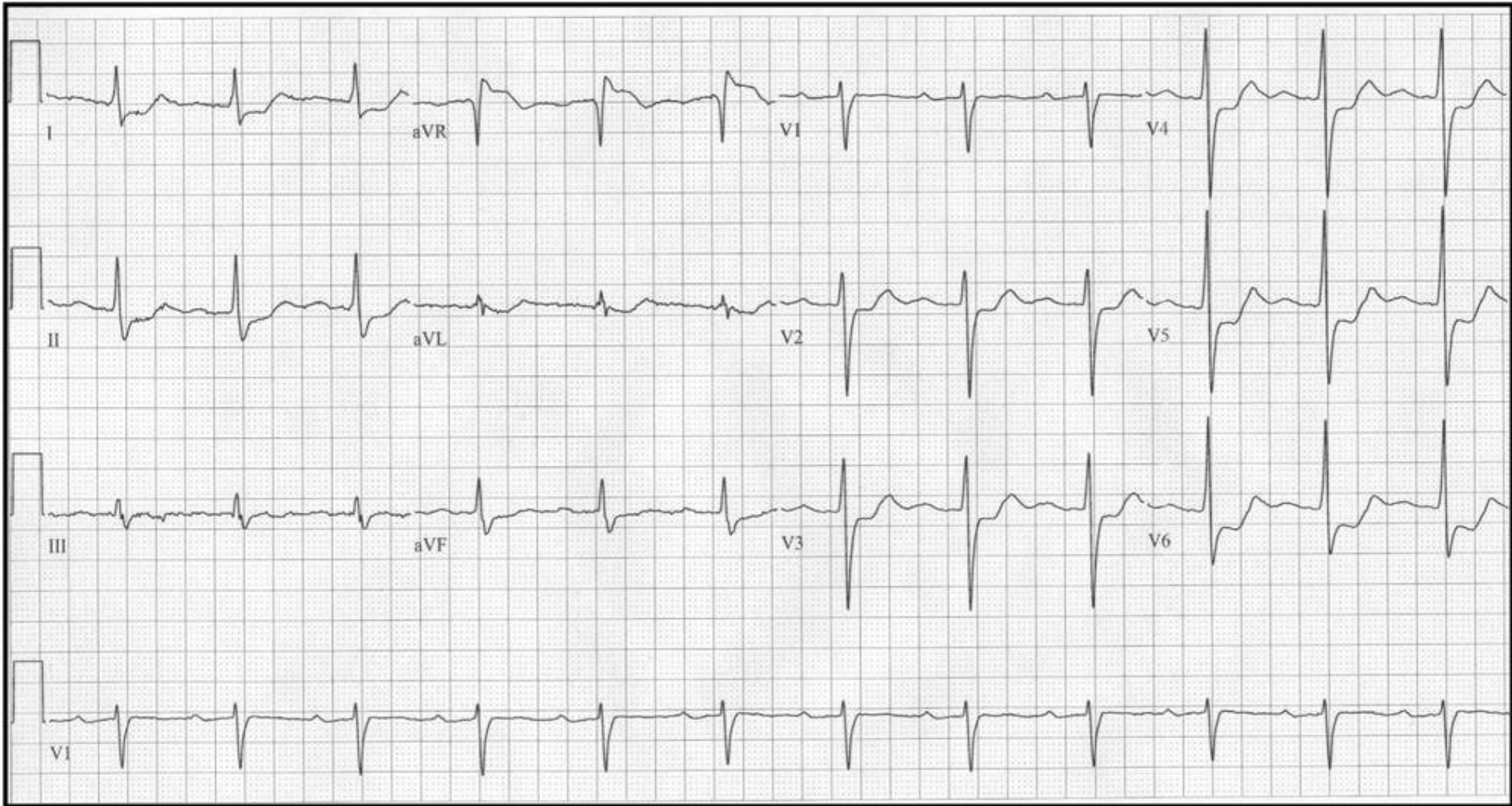
# Sequence of changes in evolving AMI

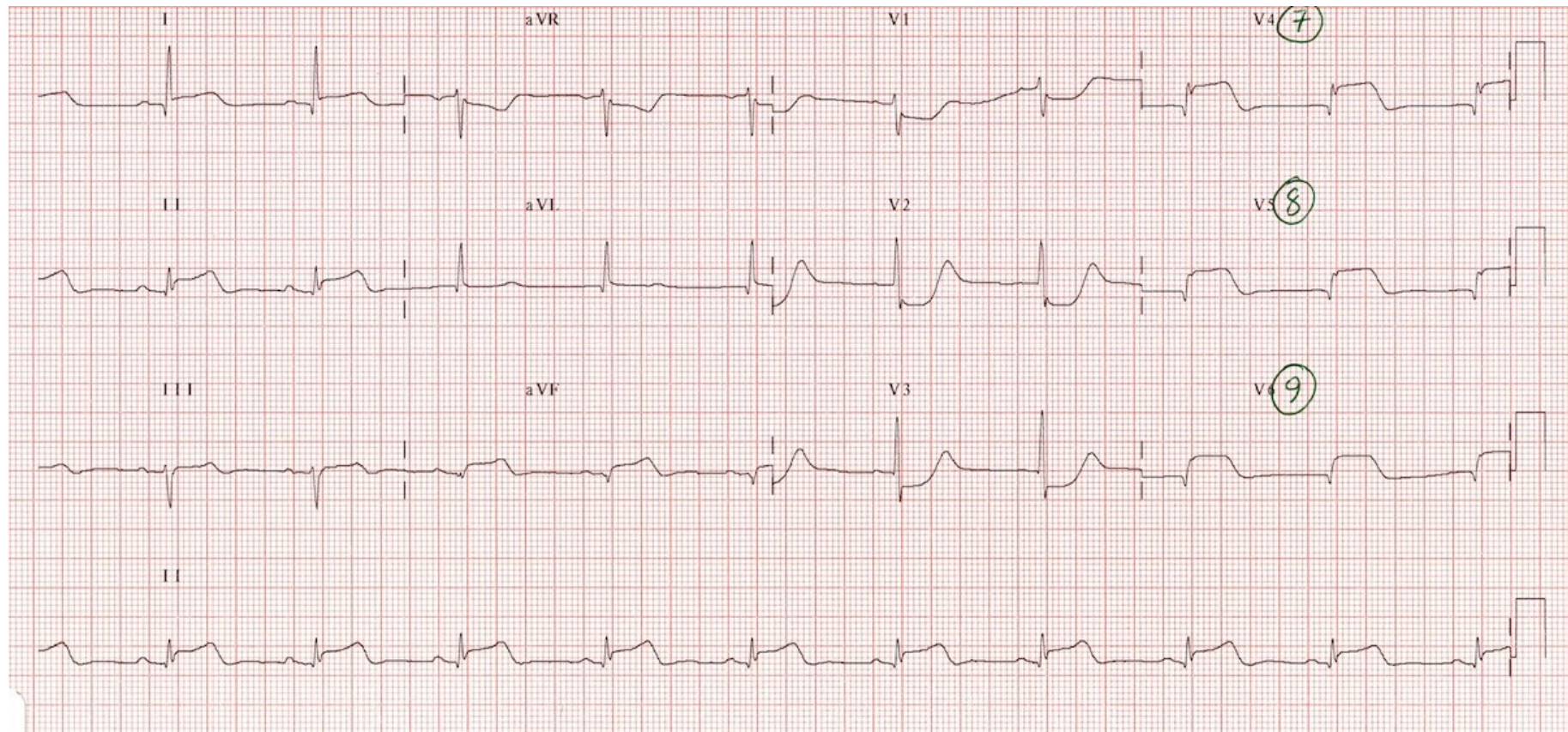












## Posterior ECG lead placement

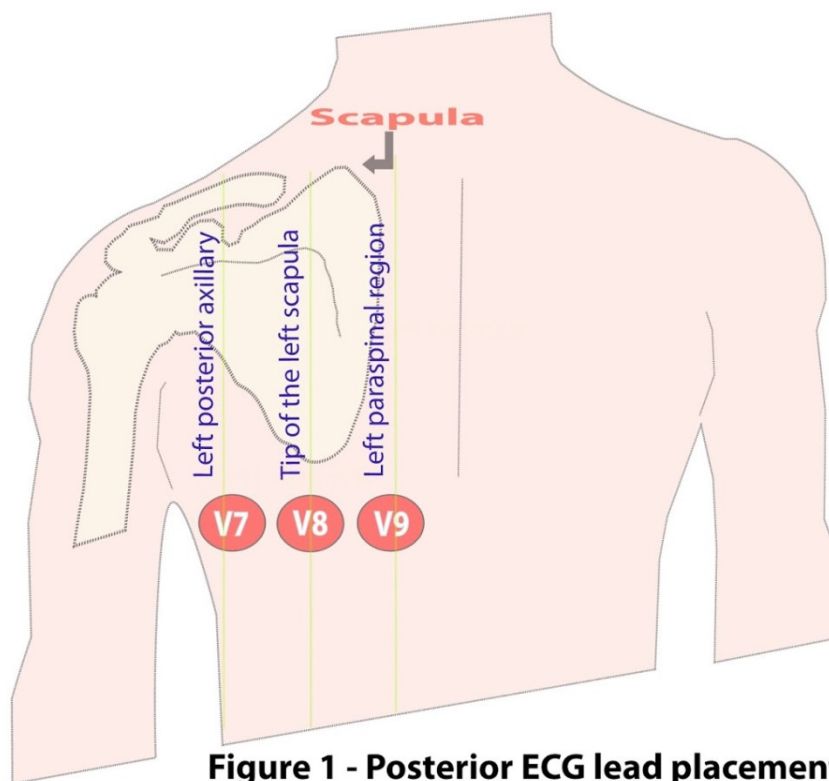


Figure 1 - Posterior ECG lead placement

### V7

Left posterior axillary line:  
in the same horizontal plane as V4-V6

### V8

Tip of the left midscapula:  
in the same horizontal plane as V7-V9

### V9

Left paraspinal region:  
in the same horizontal plane as V4-V6

### V1-V3

Should remain unchanged from standard 12-lead ECG

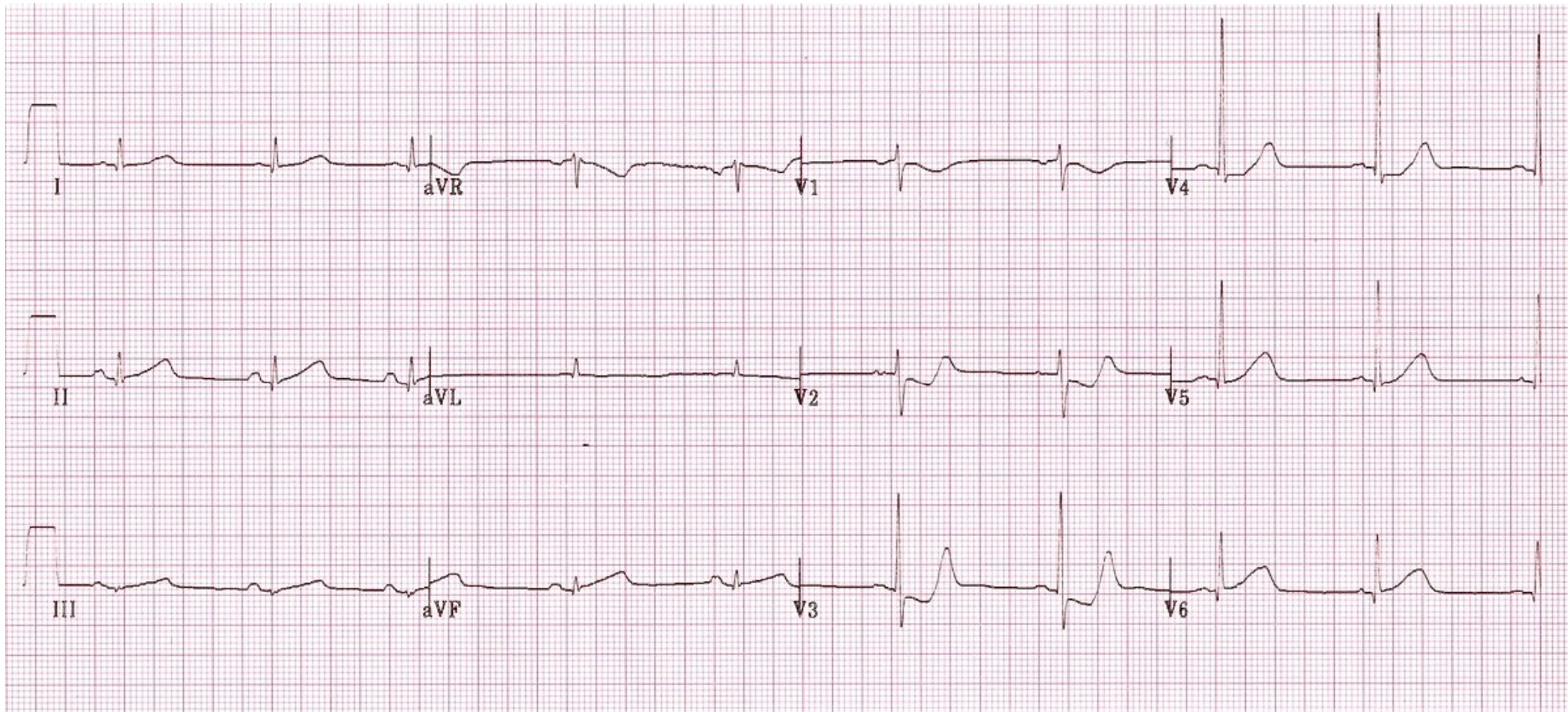
Posterior MI is suggestive by the following changes in V1-V3:

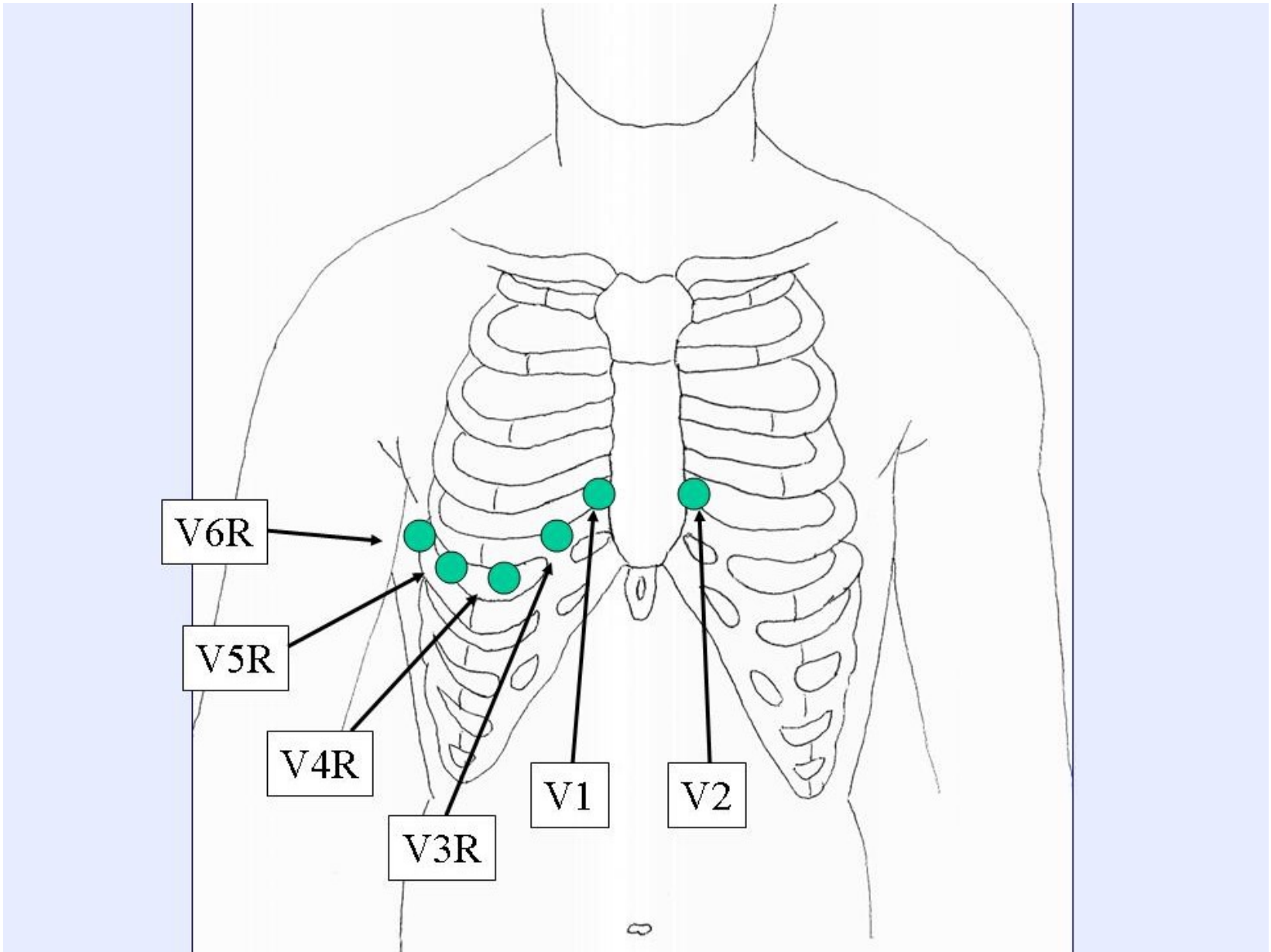
- \*Horizontal ST depression
- \*Tall, broad R waves (>30ms)
- \*Upright T waves
- \*Dominant R wave (R/S ratio >1) in V2

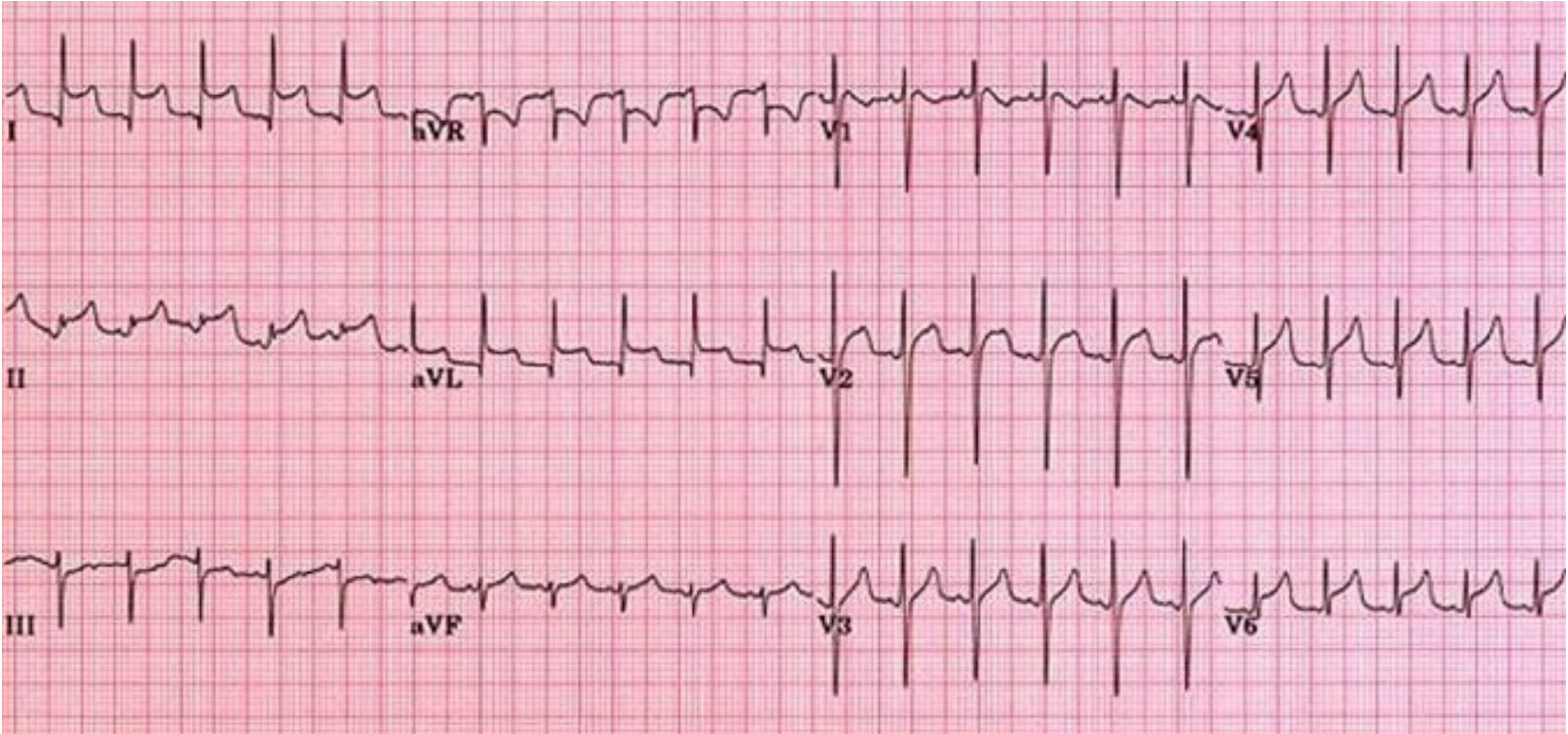
Please note that V6 is a good reference point for the horizontal placement of the posterior electrodes V7-9.

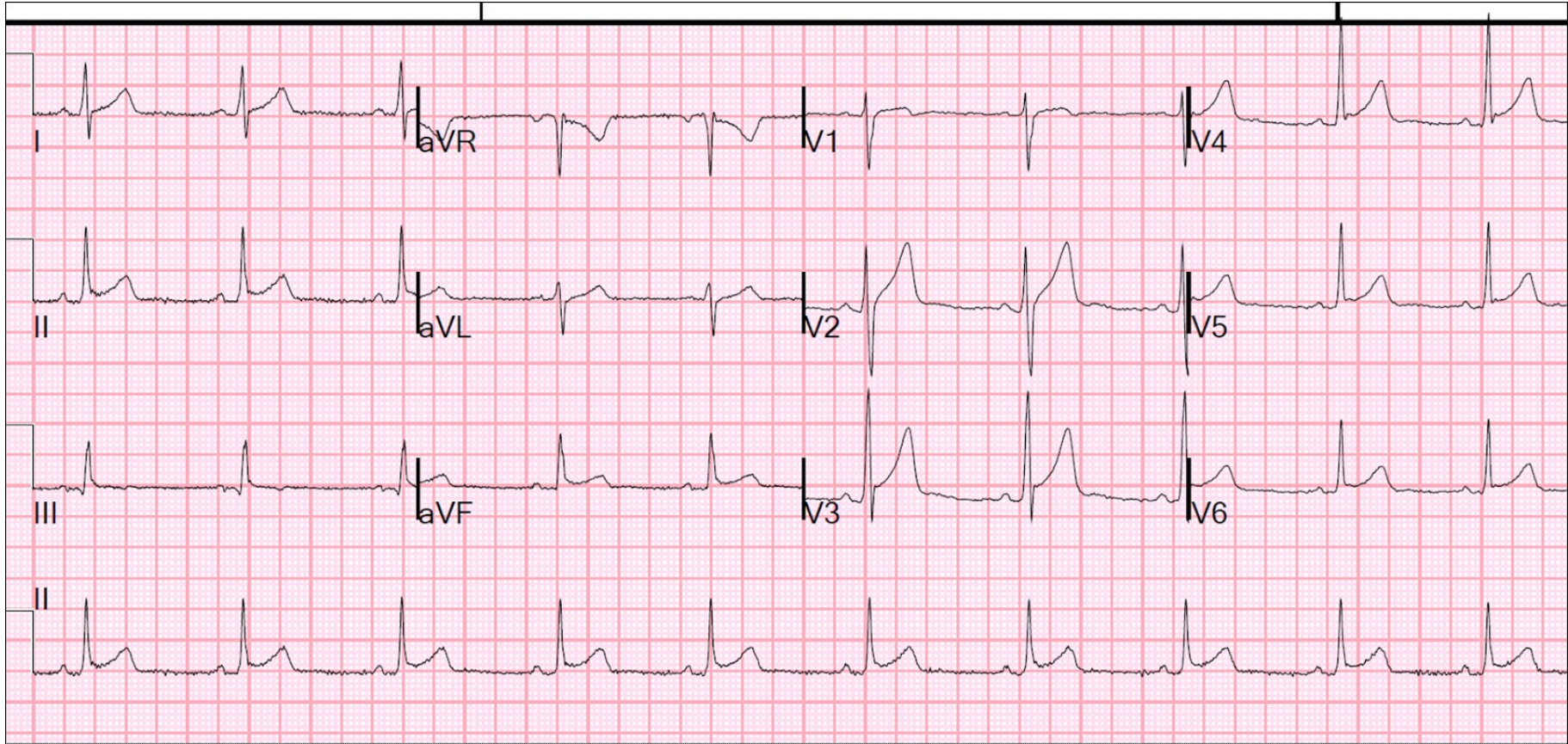
If you don't have access to a 15 or 18 lead ECG machine, then leave V1-3 in their normal position and use V4-6, these leads will then become V7-9.



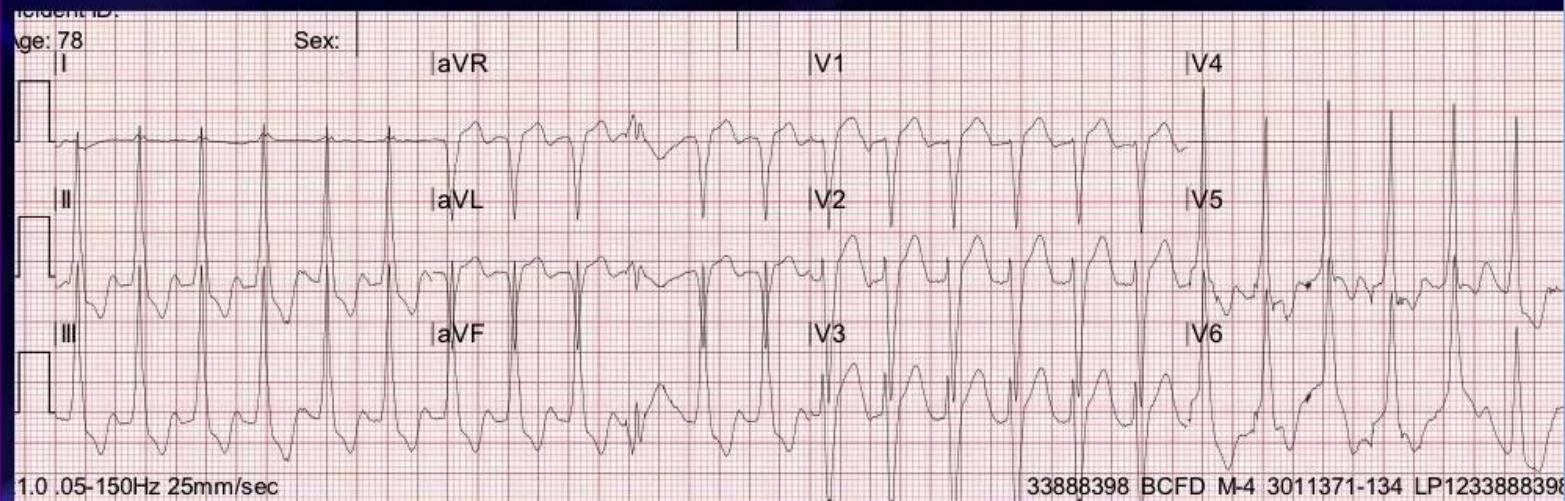




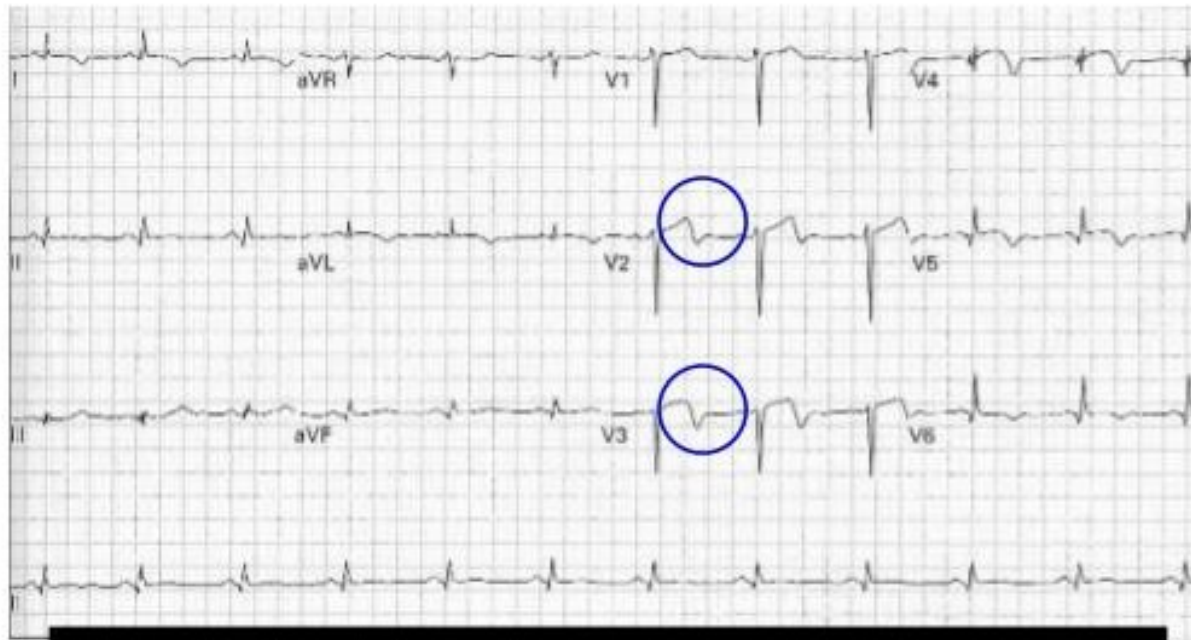




# LVH with strain



# Wellen's Sign



33, 54 year old man 24 hours after receiving thrombolytic therapy for acute myocardial infarction; currently asymptomatic

ST elevation and biphasic T wave in V2 and V3  
Sign of large proximal LAD lesion