

# Βασικές Αρχές Κλινικής Ηλεκτροκαρδιογραφίας

Λεωνίδας Ε. Πουλημένος, FESC

Επιμελητής Β΄



Καρδιολογική Κλινική «Ασκληπιείο» Βούλας  
Διευθυντής: Καθ. Αθανάσιος Ι. Μανώλης



# Ηλεκτροκαρδιογράφημα

- Πολύτιμο Εργαλείο
  - Άμεσο, Φθηνό, Εύκολο
  - Μη παρεμβατικό
- Όμως βασικά προβλήματα
  - Επικίνδυνο στα χέρια ημιμαθών
  - Πέρα από τις αρρυθμίες και τα STEMI μια πολύ «κακή» εξέταση ειδικά για screening
    - 75 % των πάνω από 70 γο έχουν ΗΚΓ παθολογία
    - Οι νεώτεροι ιδίως μπορούν να πάσχουν χωρίς ΗΚΓ ευρήματα
  - Σημασία στον ασθενή και τα συμπτώματά του
  - Δεν νοείται «θεραπεία» ενός κομματιού χαρτιού



# Einthoven



The Nobel Prize in Physiology or  
Medicine 1924

"for his discovery of the mechanism of the electrocardiogram"

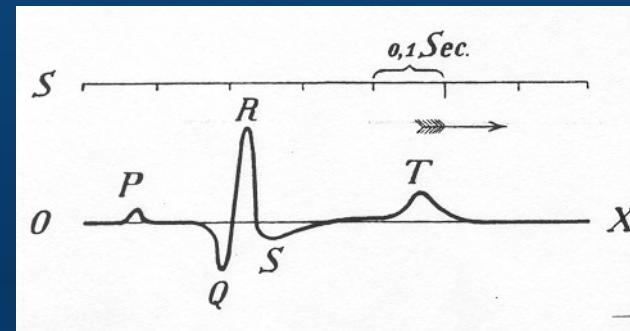


**Willem Einthoven**

the Netherlands

Leiden University  
Leiden, the Netherlands

b.1860  
(in Semarang, Java, then Dutch East Indies)  
d.1927

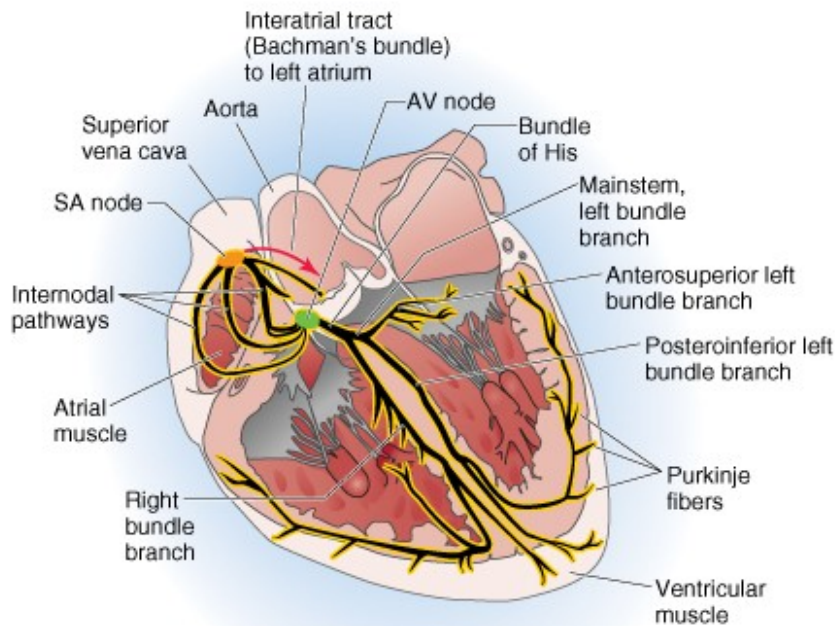


Όχι μόνο το παλαιότερο αλλά και το συχνότερο  
εργαστηριακό εργαλείο της καρδιολογίας.

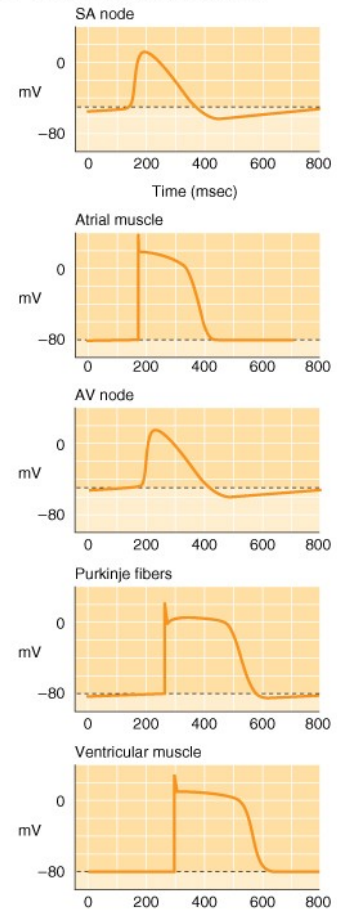


# Κυτταρικά δυναμικά ΕΝΕΡΓΕΙΑΣ

**A** CONDUCTION PATHWAYS THROUGH HEART

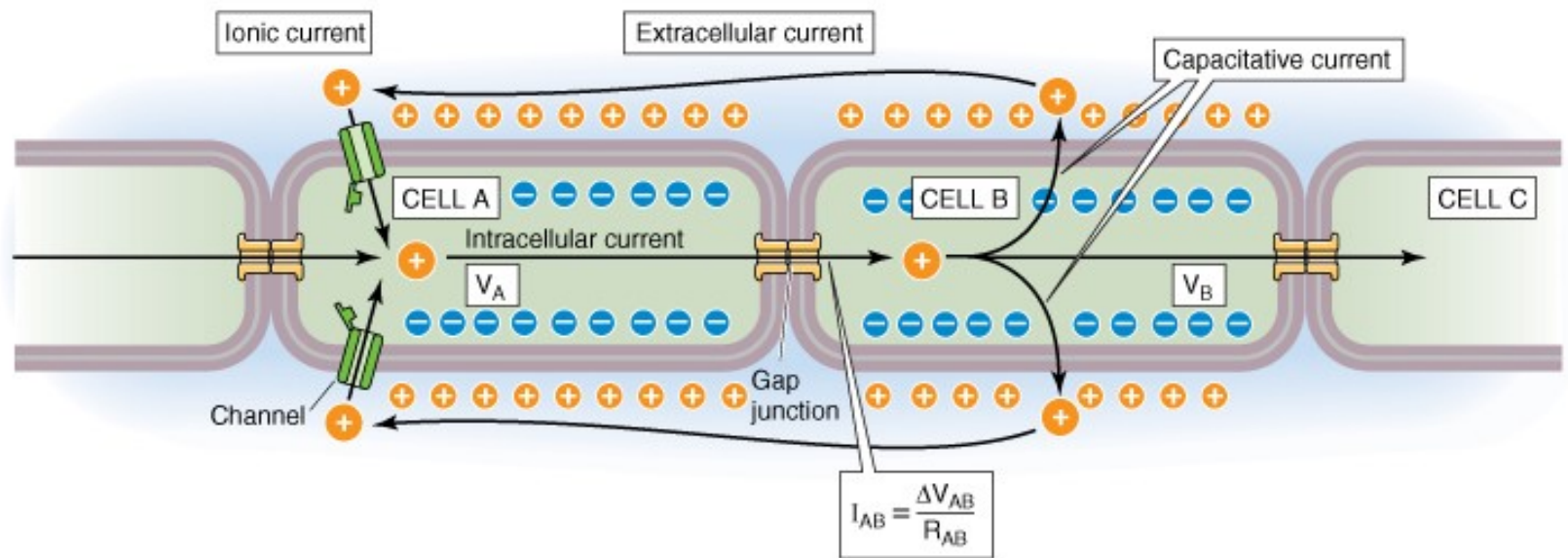


**B** CARDIAC ACTION POTENTIALS



# Διάδοση Δυναμικού Ενεργείας

## A CURRENT FLOW THROUGH GAP JUNCTIONS



© Elsevier Ltd. Boron & Boulpaep: Medical Physiology, Updated Edition [www.studentconsult.com](http://www.studentconsult.com)



# Στιγμαία Δυναμικά Μάζας Ιστού

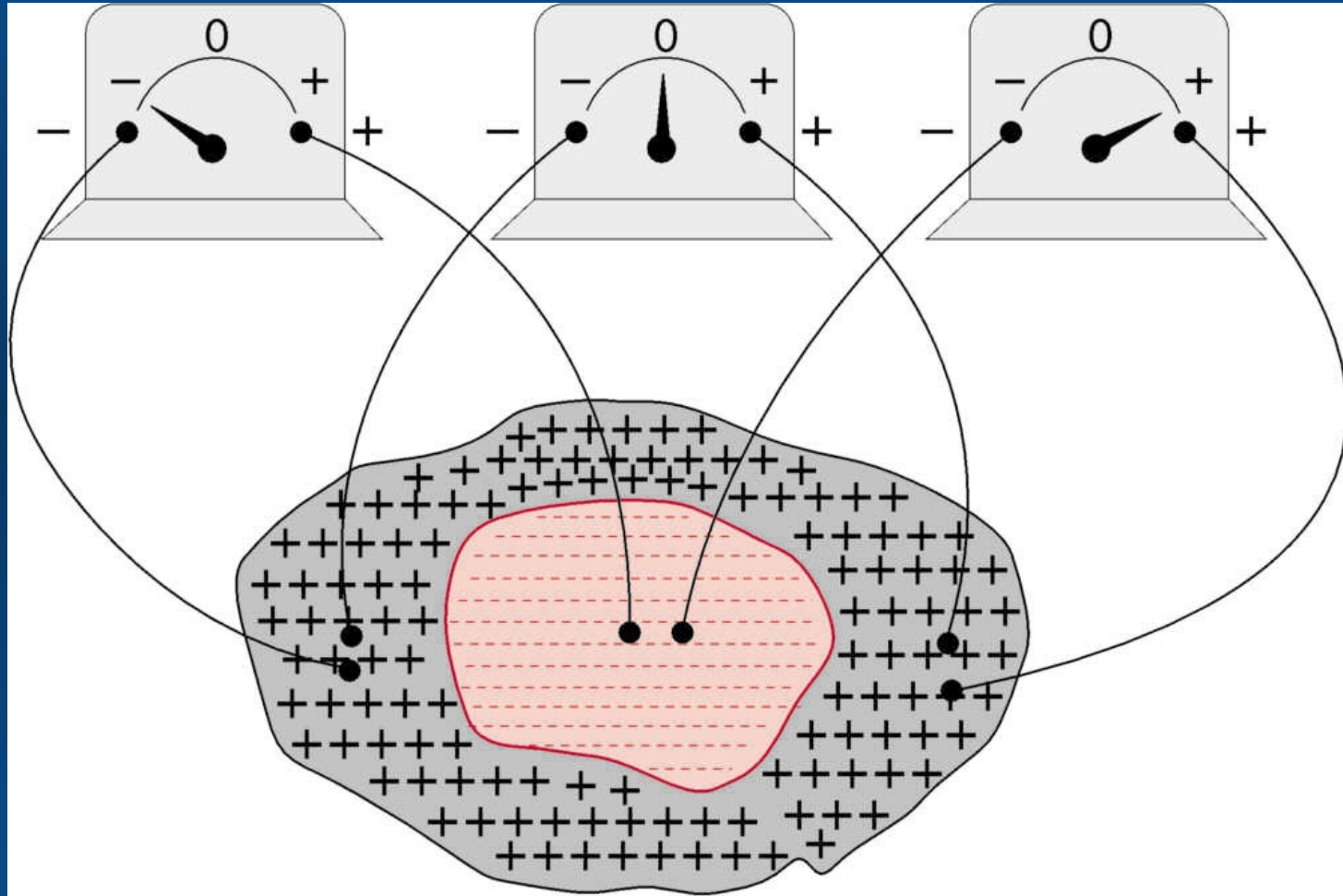
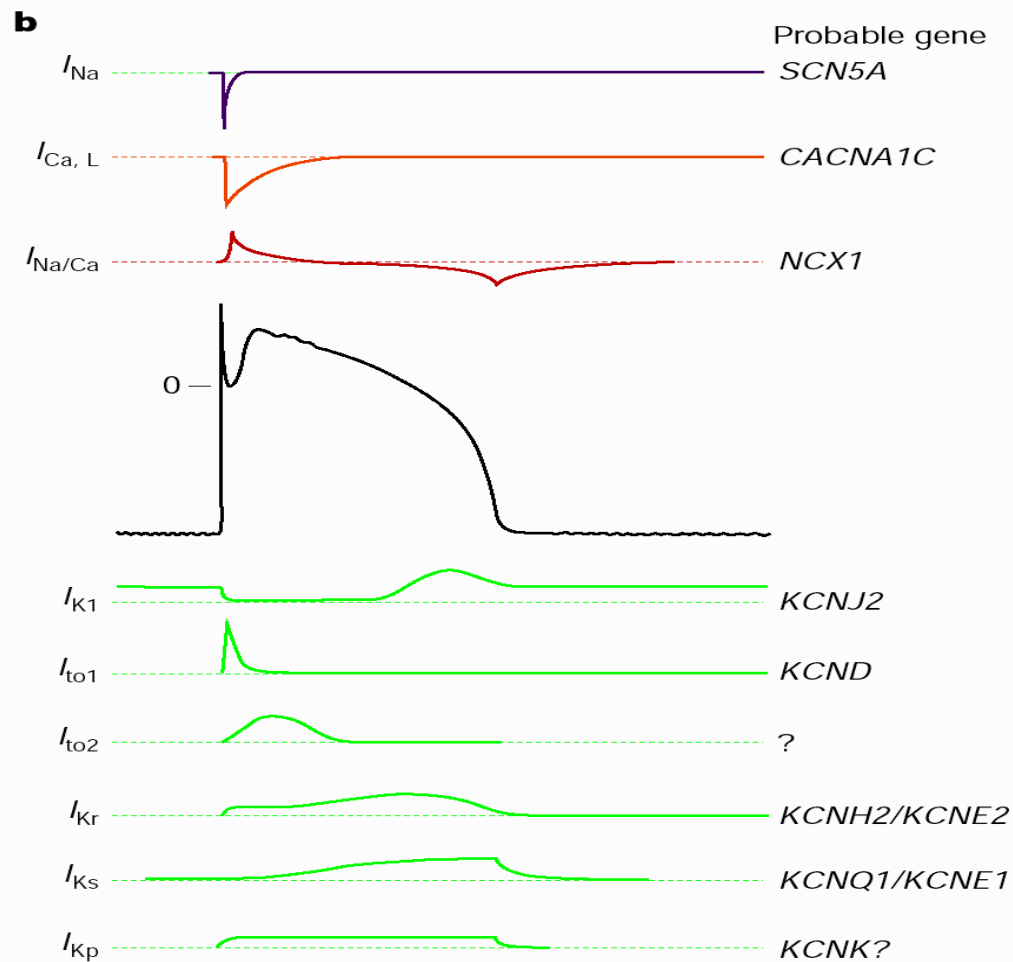
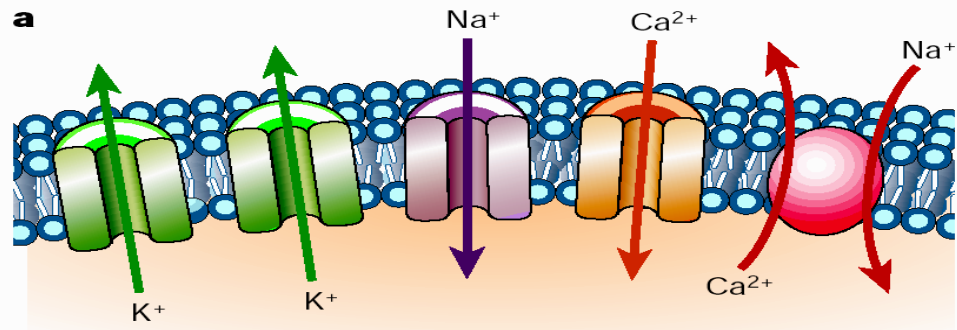


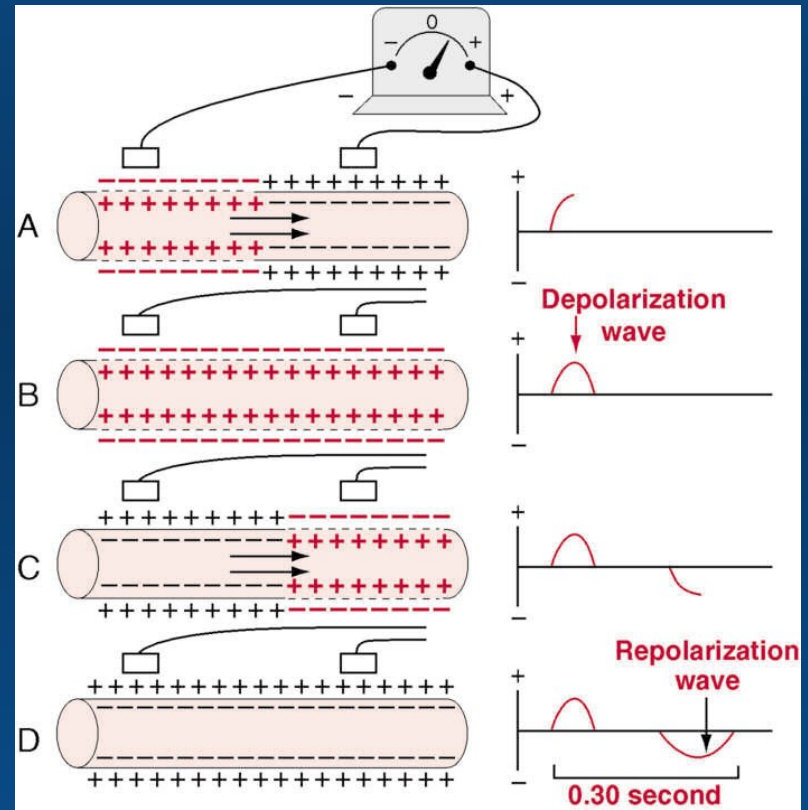
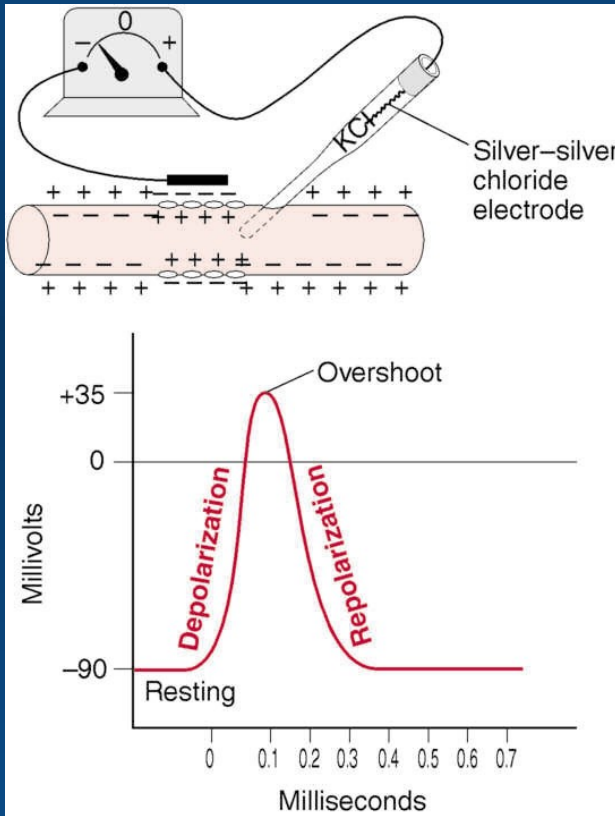
Figure 11-4.

Copyright 2000, WB Saunders Company, All Rights Reserved





# Recording depolarization and repolarization waves



**Zero voltage - Isoelectric point**  
**Resting stage - Polarized**





# Flow of current in the chest around partially depolarized ventricles.

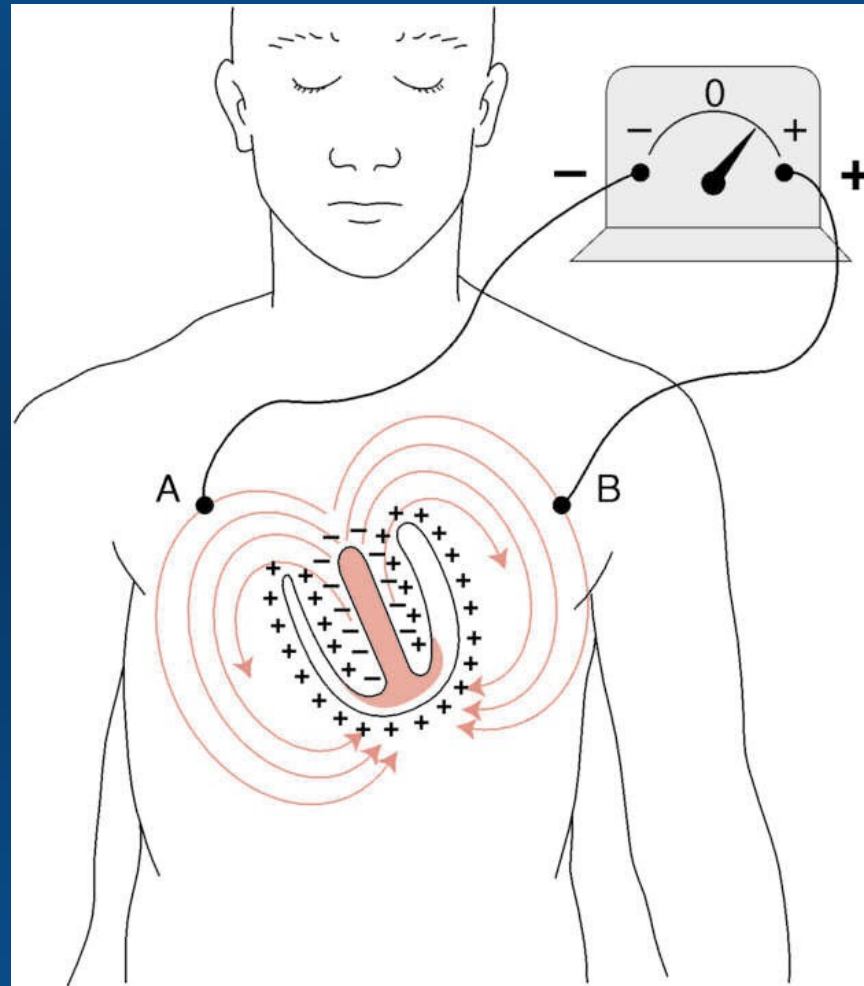
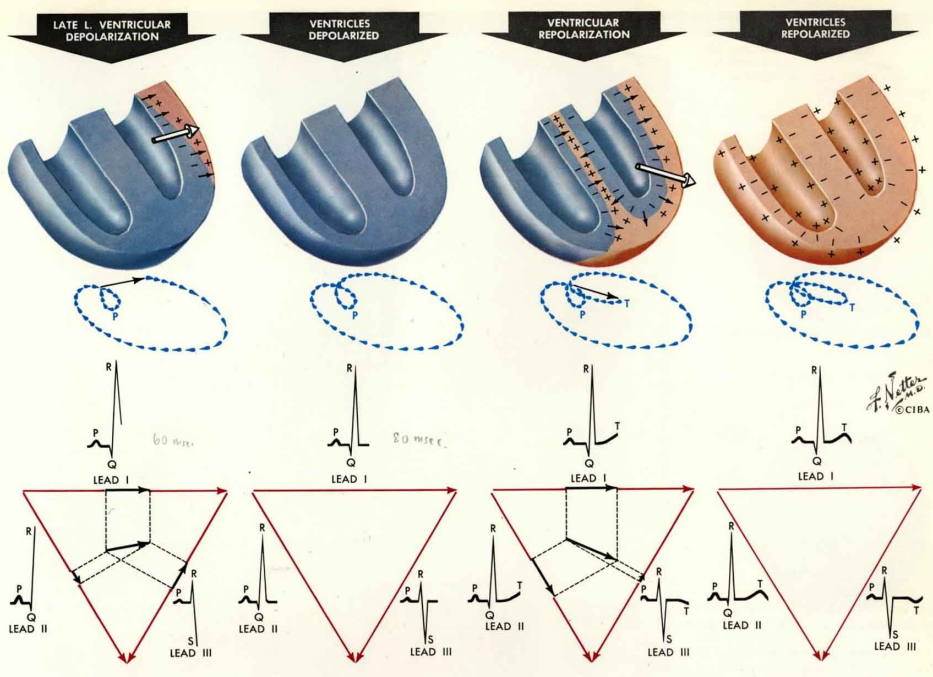
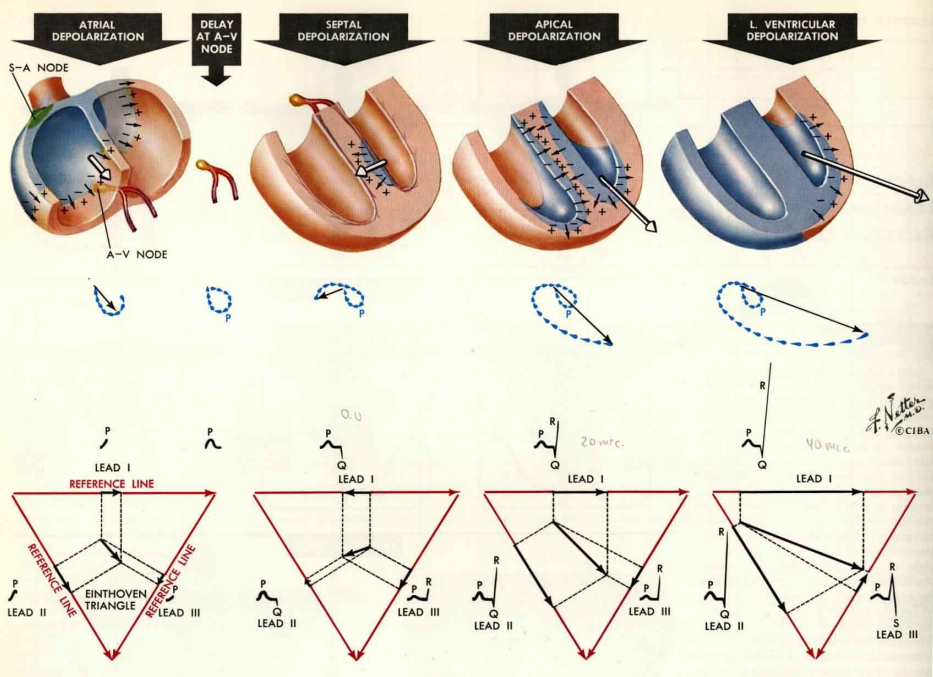
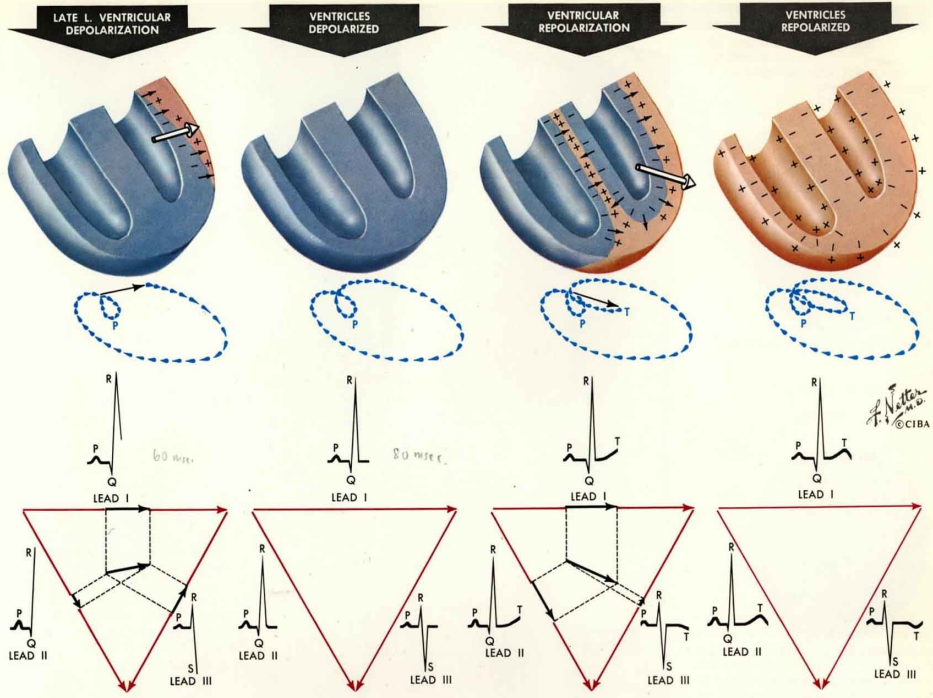
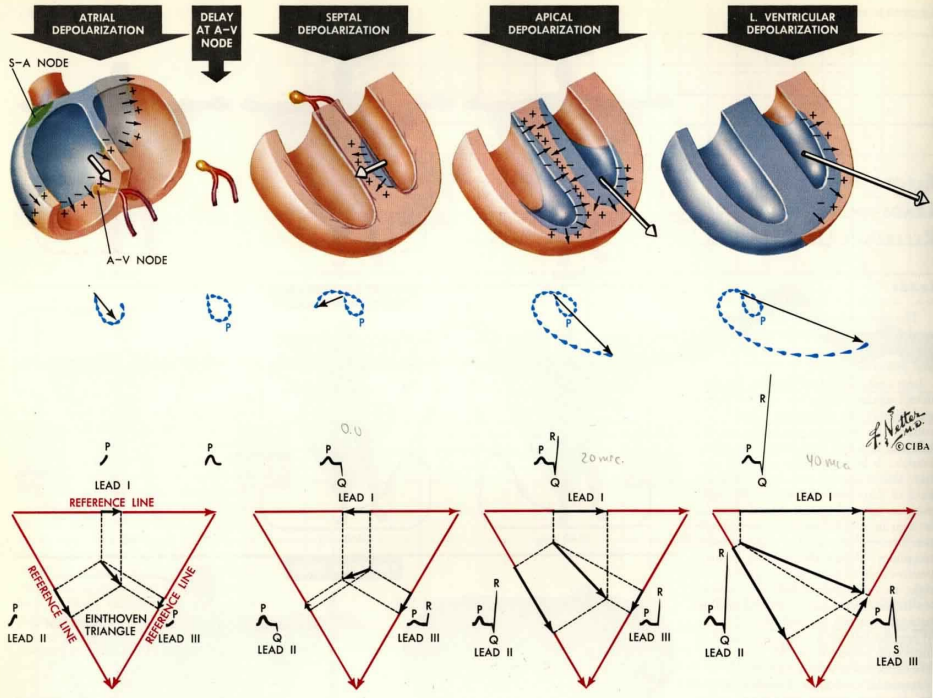
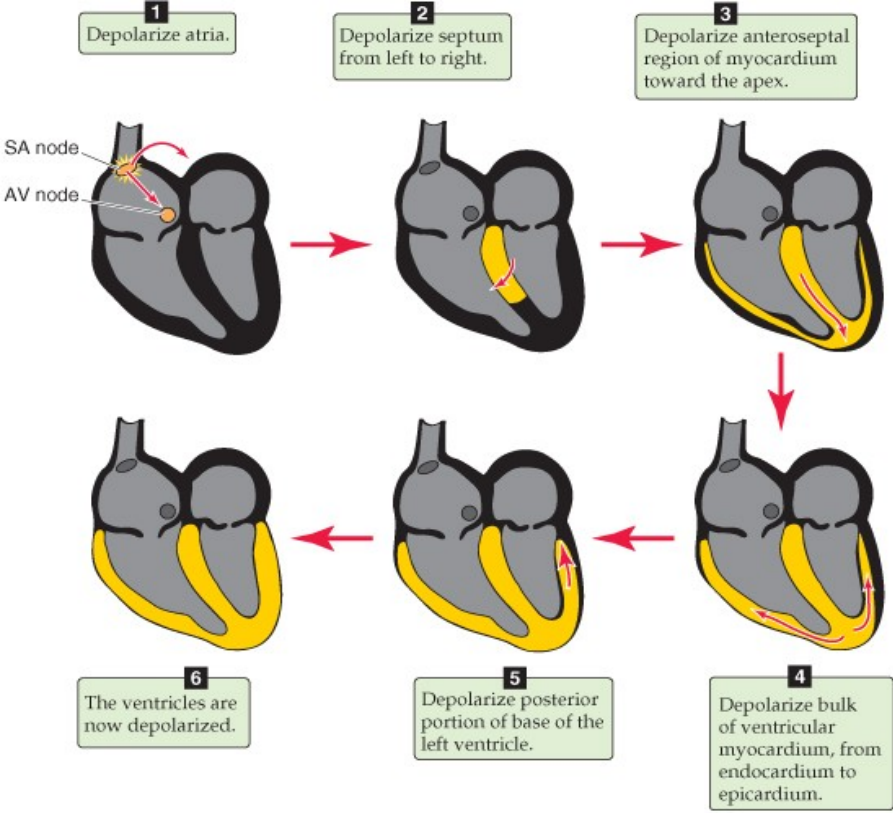


Figure 11-5.

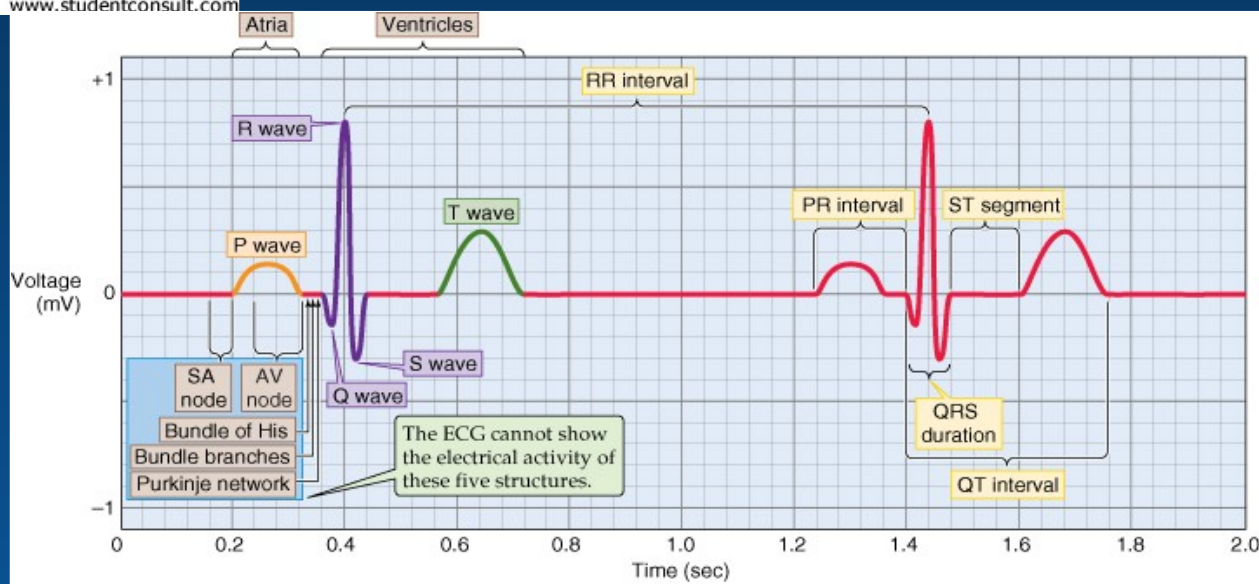
Copyright 2000, WB Saunders Company, All Rights Reserved





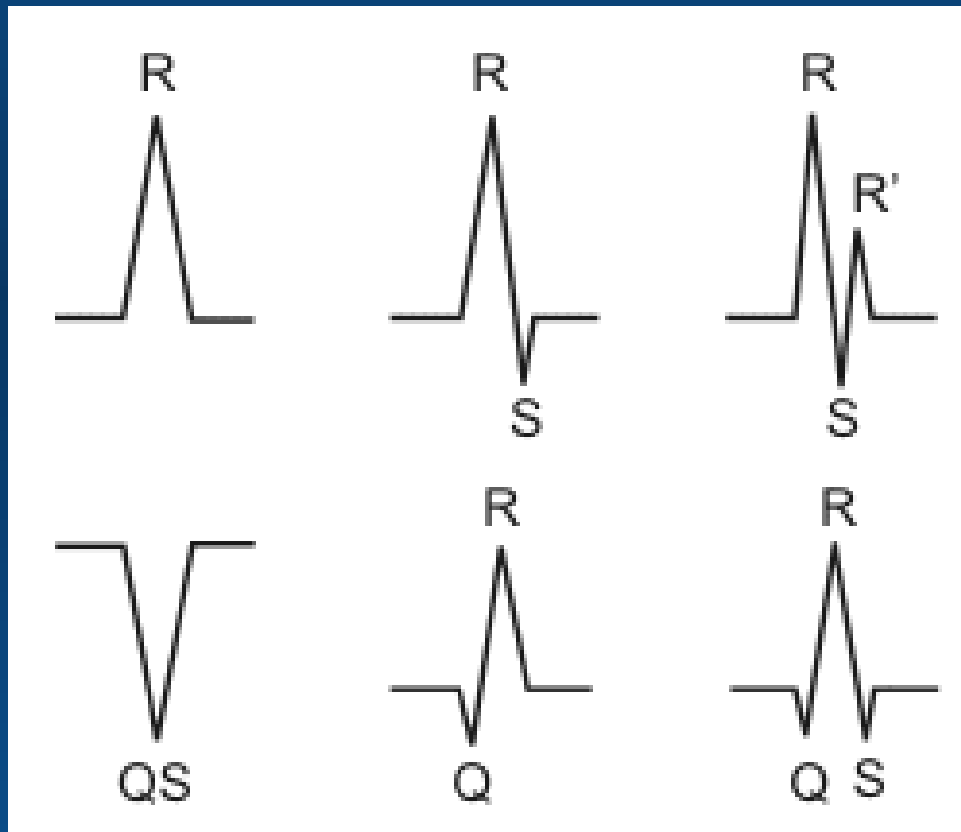


© Elsevier Ltd. Boron & Boulpaep: Medical Physiology, Updated Edition www.studentconsult.com



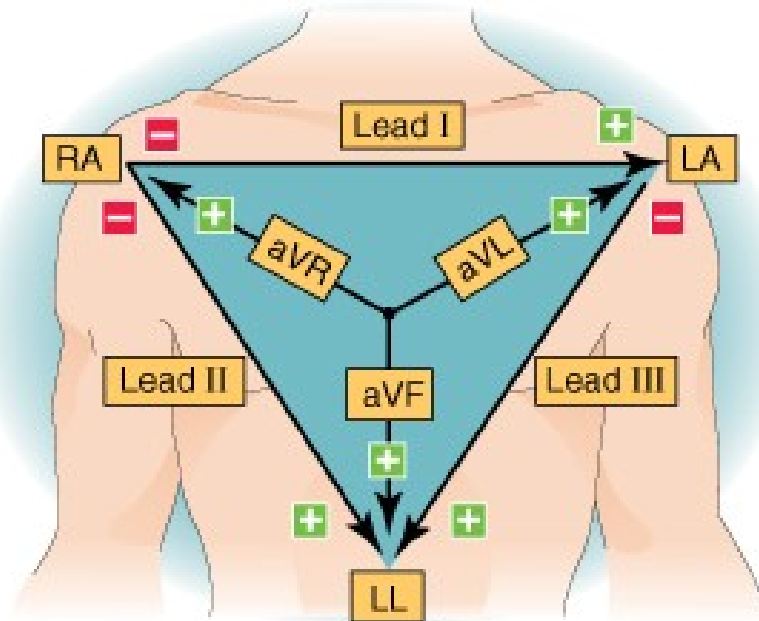
© Elsevier Ltd. Boron & Boulpaep: Medical Physiology, Updated Edition www.studentconsult.com

# Βασική Ονοματολογία

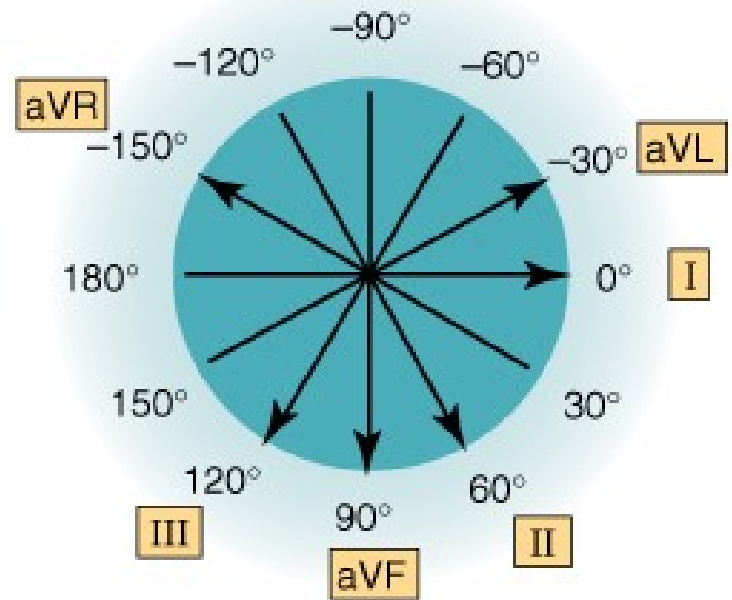


# Vector Analysis, cont'd

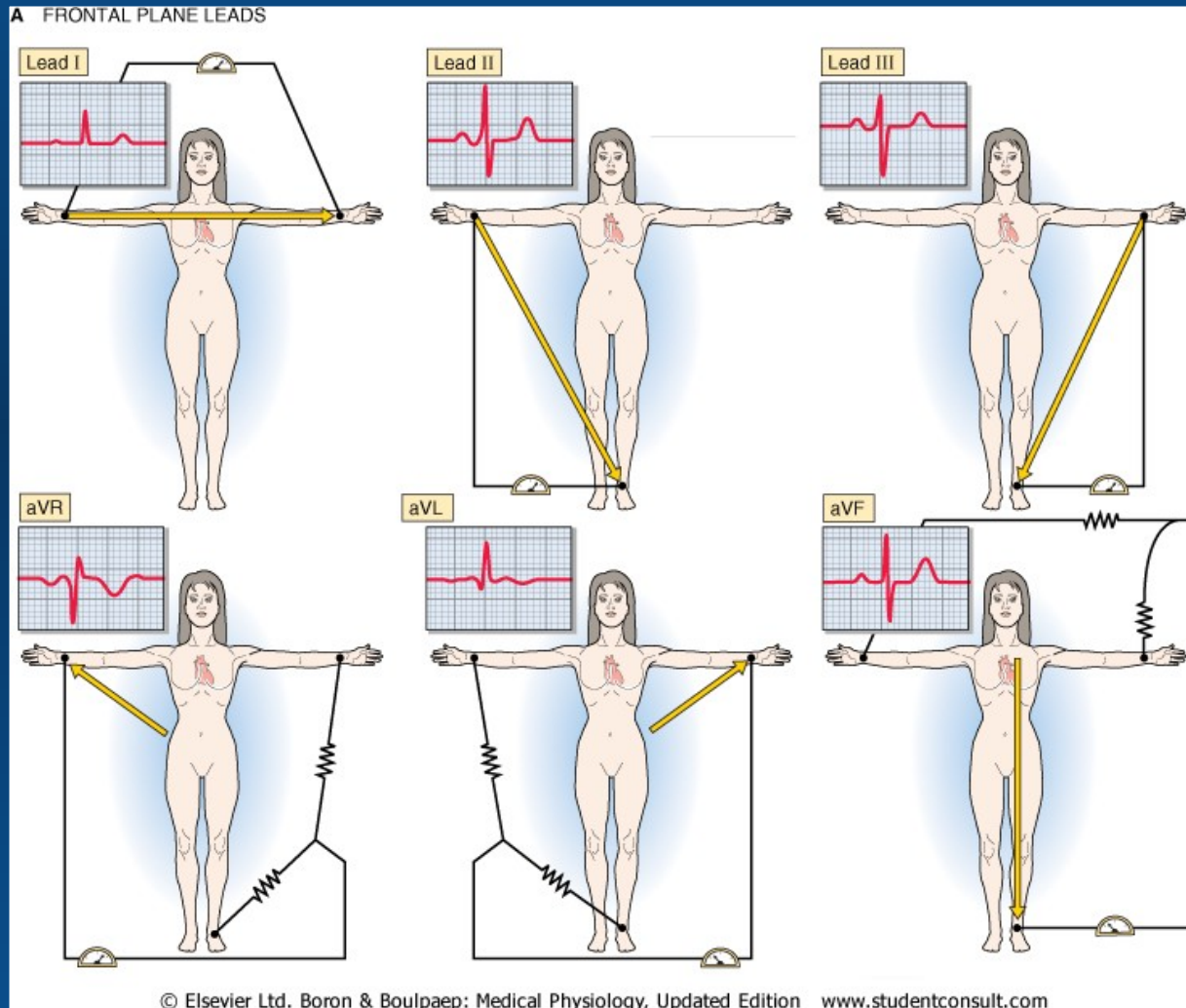
**A** EINTHOVEN'S TRIANGLE



**B** CIRCLE OF AXES

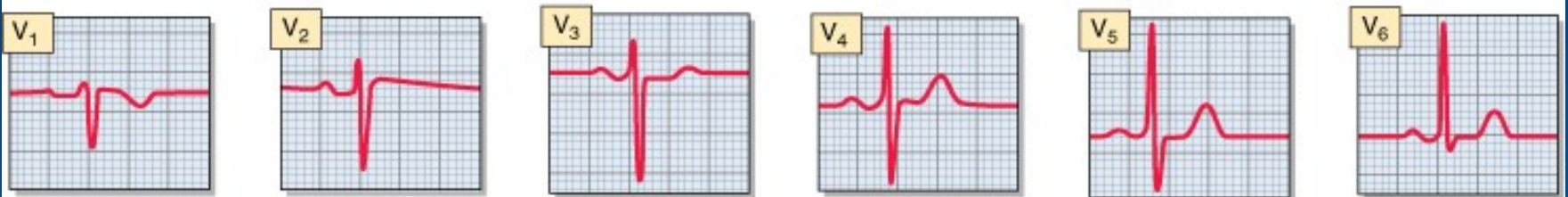
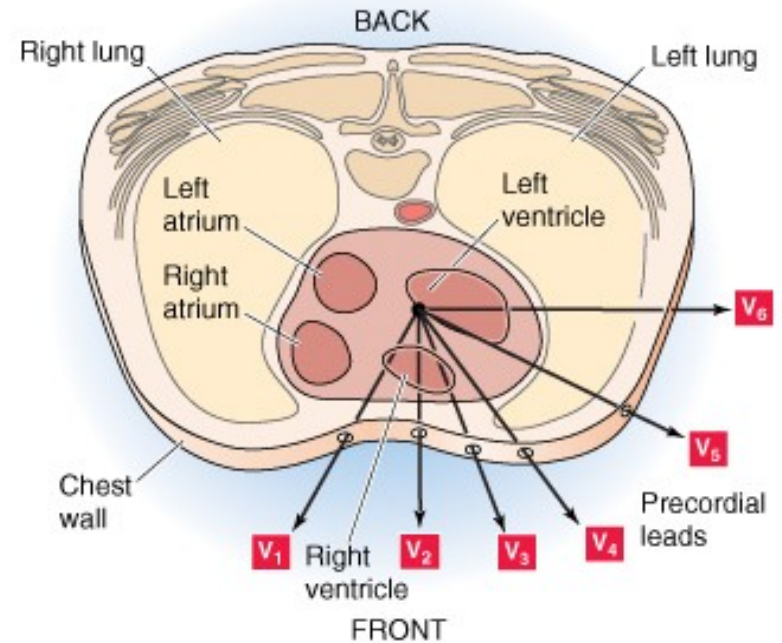
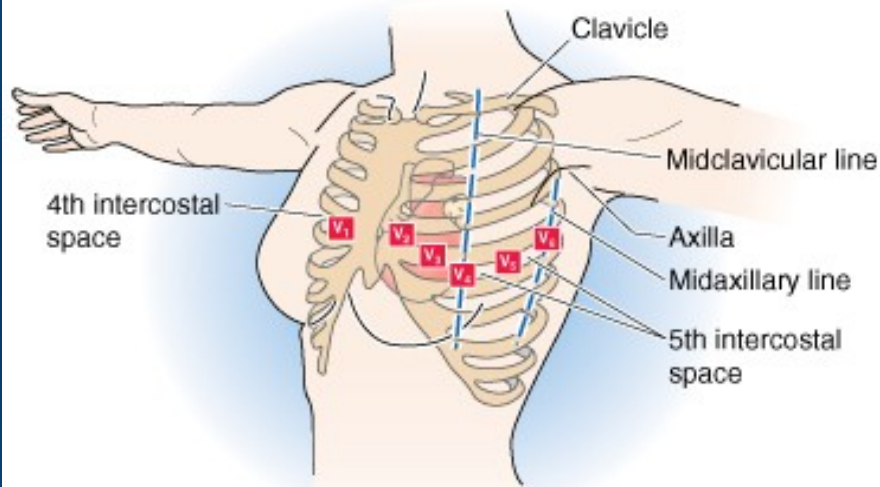


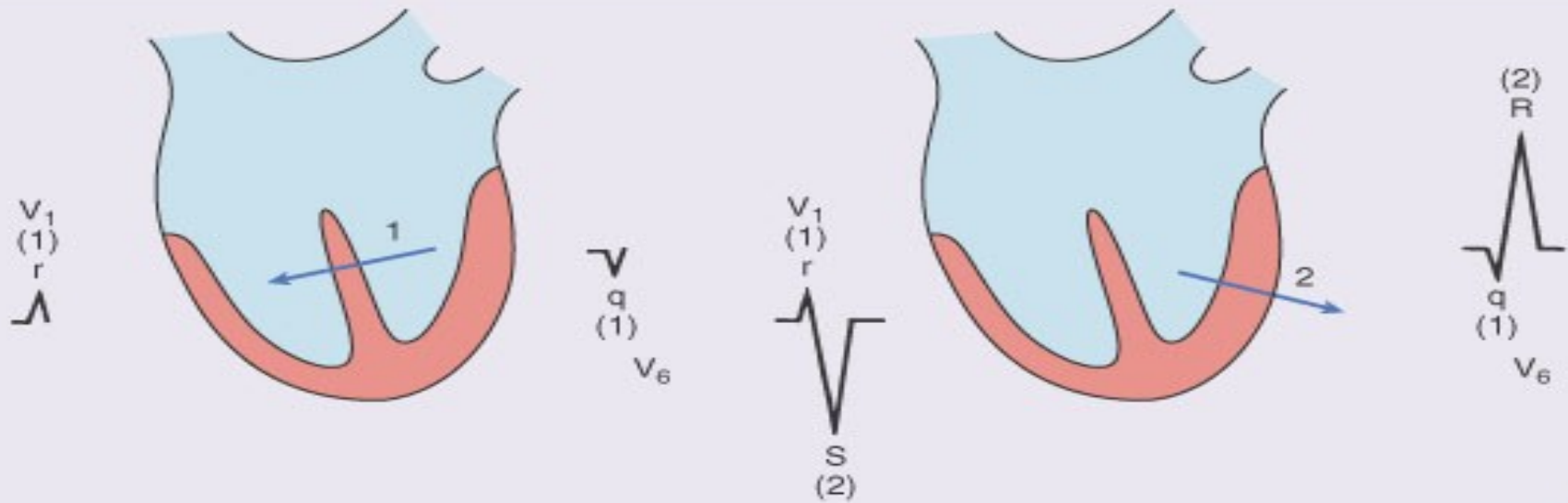
# Summary of Limb Leads



# The Precordial (Chest) Leads

## B TRANSVERSE PLANE—PRECORDIAL LEADS





**FIGURE 12–14** Schematic representation of ventricular depolarization as two sequential vectors representing septal (left) and left ventricular free wall (right) activation. QRS waveforms generated by each stage of activation in leads V<sub>1</sub> and V<sub>6</sub> are shown.

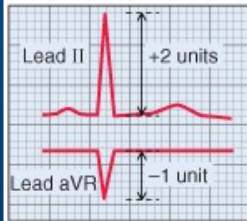
© Copyright 2008 by Saunders, an imprint of Elsevier Inc.



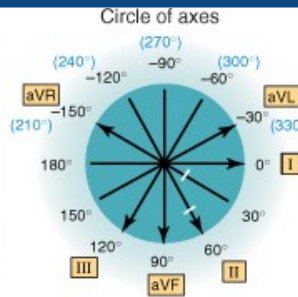


# Vector Algebraic Analysis

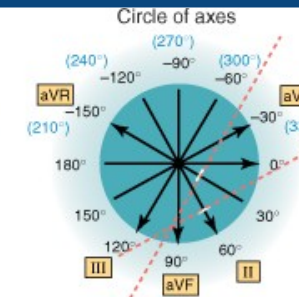
## A GEOMETRIC METHOD



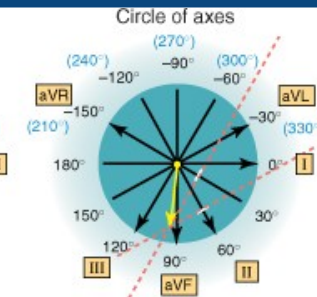
**1**  
Measure magnitude of QRS.



**2**  
Mark on circle of axes, +2 units at 60° (lead II) and 1 unit at 30° (negative direction on aVR).



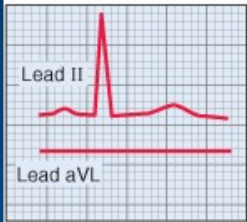
**3**  
Draw two perpendiculars.



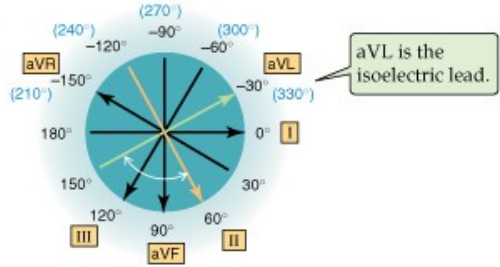
**4**  
Connect center of circle with intersection of two perpendiculars.

**5**  
Estimate axis of yellow arrow (about 95°).

## B INSPECTION METHOD

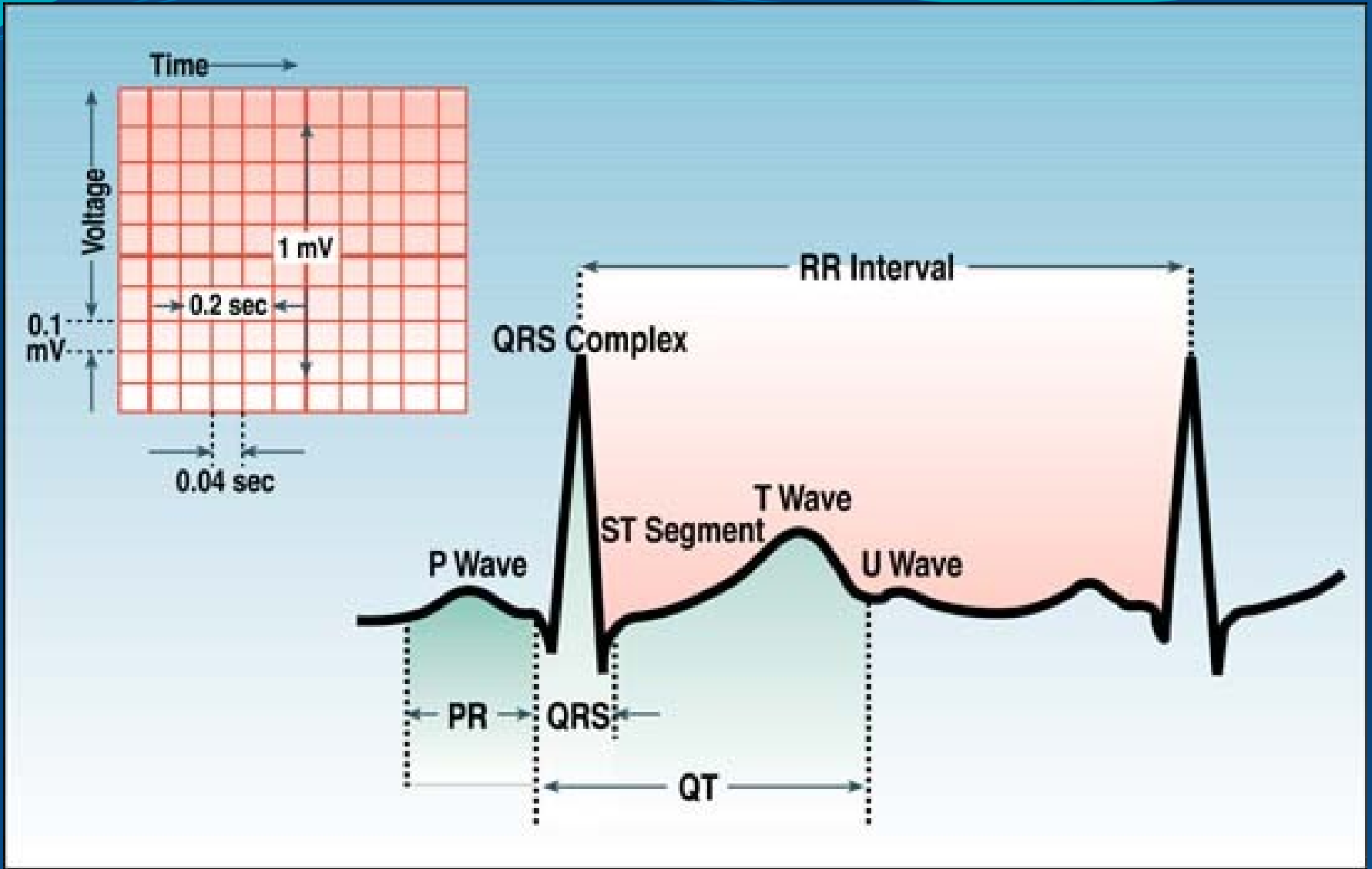


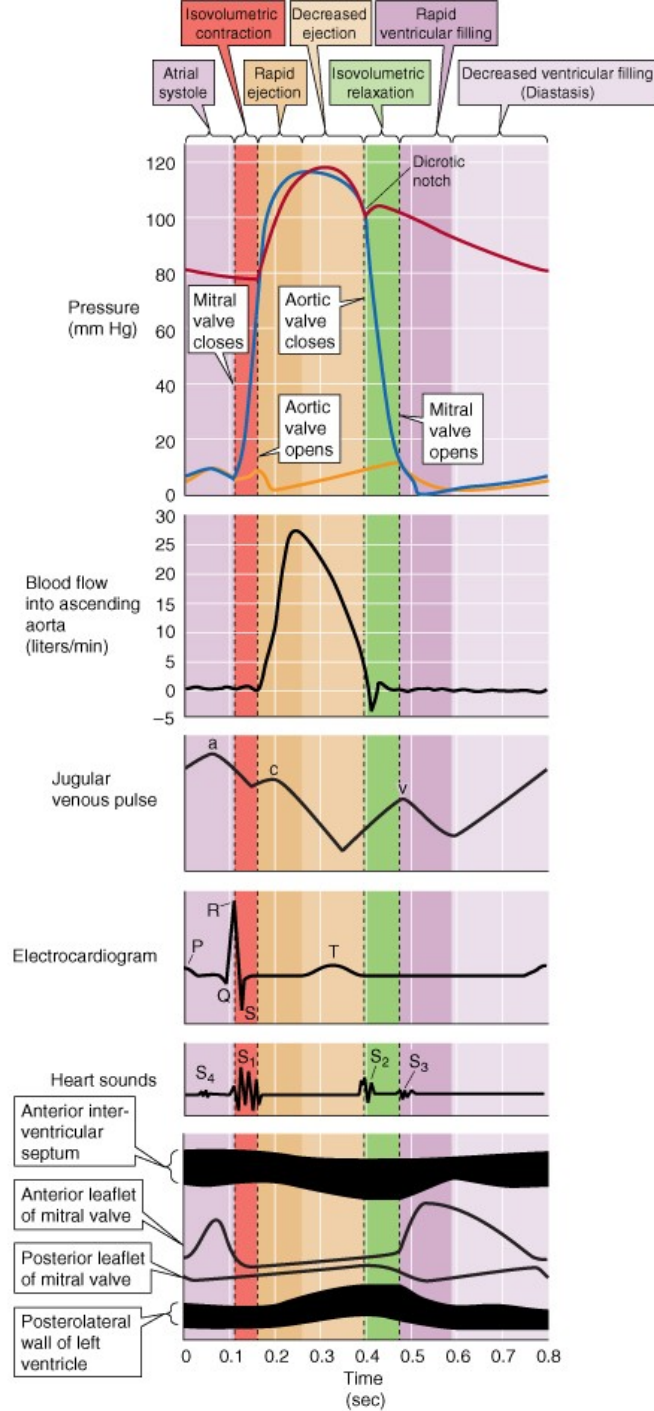
**1**  
Identify lead where QRS is isoelectric, in this example, aVL.



**2**  
Identify axis perpendicular to isoelectric lead. In this example, lead II (+60° or -120°) is perpendicular to aVL. If QRS on lead II is positive, axis is +60°. If negative, axis is -120°. Because lead II shows a positive deflection, +60° must be correct.







# Μέθοδος προσέγγισης

- Μετρήσεις
- Ανάλυση ρυθμού
- Ανάλυση αγωγής
- Περιγραφή κυματομορφής
- Γνωμάτευση
- Σύγκριση με προηγούμενα ΗΚΓ

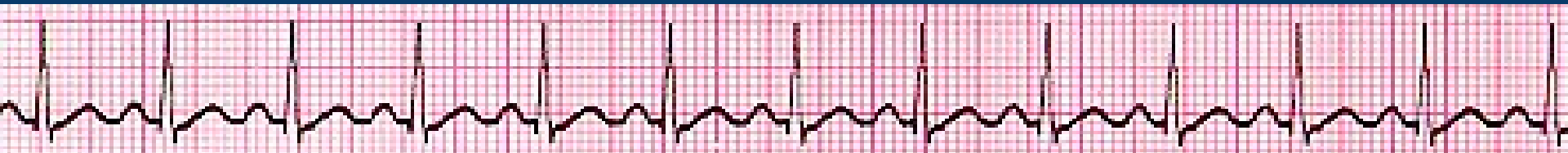


# Μετρήσεις

- Συχνότητα (Κολπική & Κοιλιακή αν διαφέρουν)
- PR διάστημα (Αρχή του P με αρχή QRS)
- Εύρος QRS (του πιο αντιπροσωπευτικού)
- Μέγεθος QT (αρχή QRS με τέλος του T)
- Άξονας του QRS

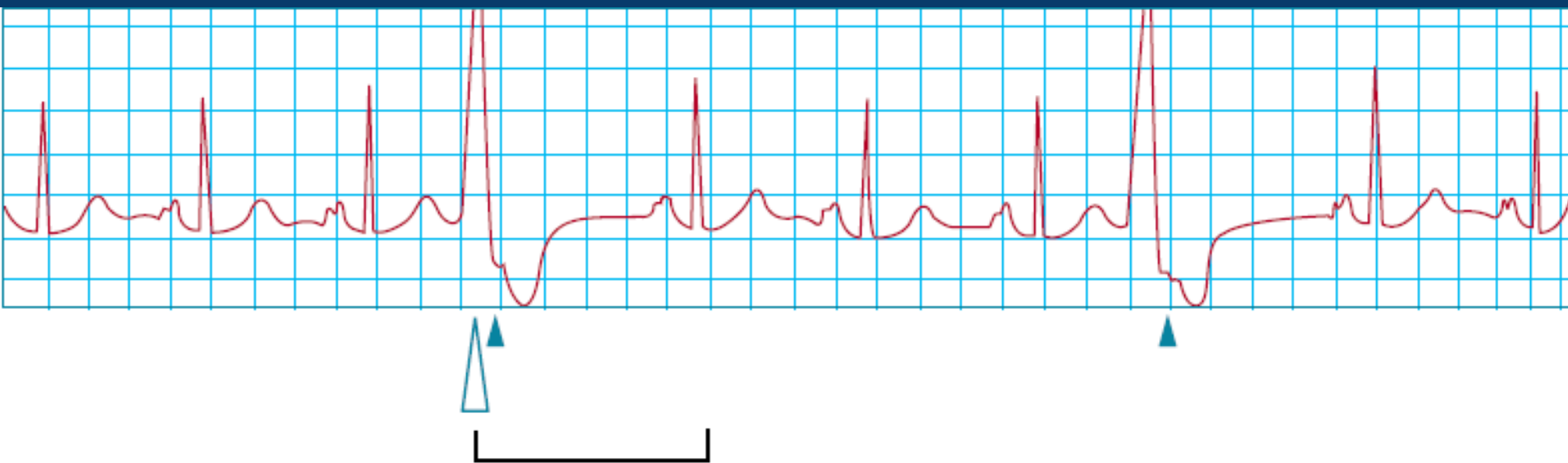
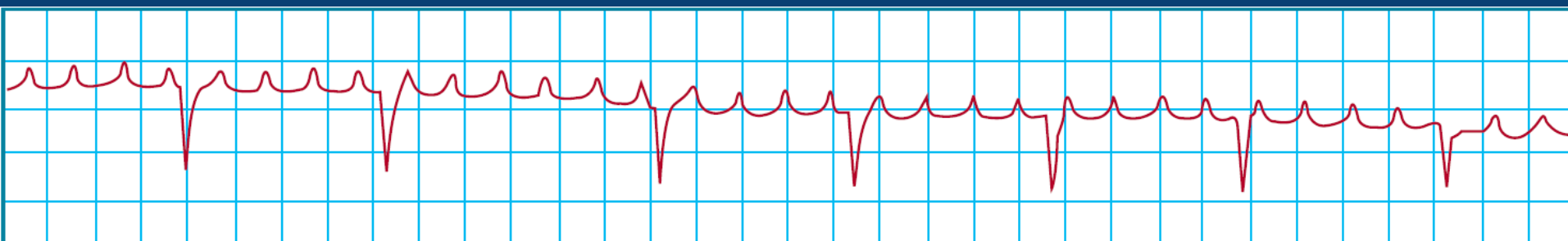
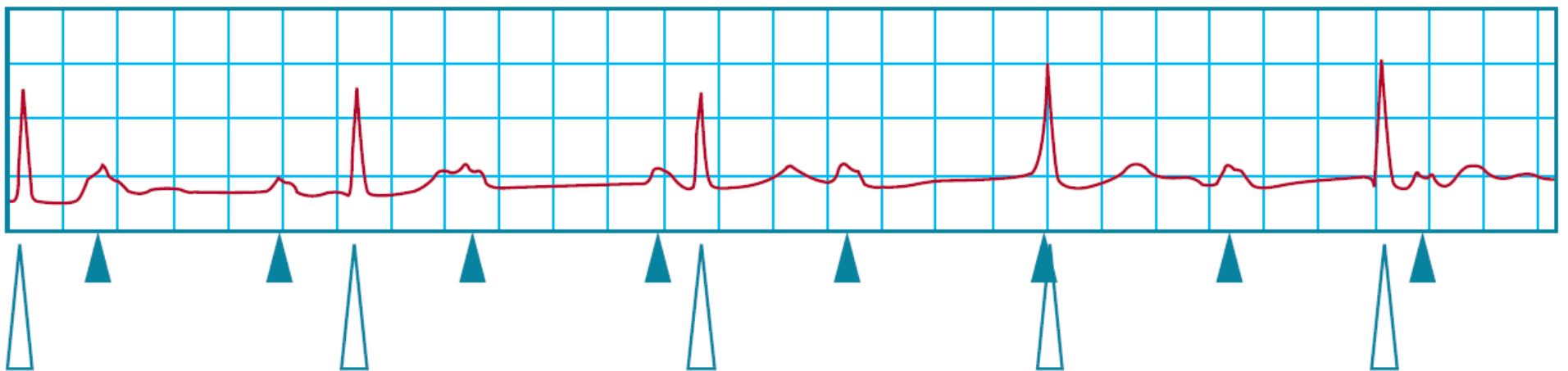


# Συχνότητα (Κολπική & Κοιλιακή αν διαφέρουν)



300 / μεγάλα τετράγωνα  
300, 150, 100, 75, 60, 50...  
1500 / μικρά τετράγωνα





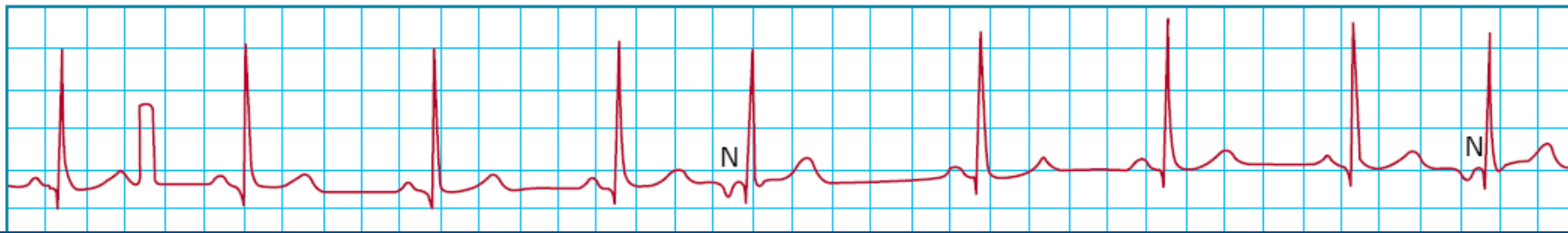
# PR διάστημα

- Φυσιολογικό = 120 – 200 msec
- Βραχύ < 120 msec ή 0,12 sec
  - Προδιέγερση
  - Κομβικός ρυθμός (ανεστραμμένα στις II III aVf)
  - Έκτοπος κοιλιακός ρυθμός
  - Φυσιολογική παραλλαγή
- Μακρύ > 200 msec
  - 1ου Βαθμού κ-κ αποκλεισμός
  - 2ου Βαθμού κ-κ αποκλεισμός
  - Κολποκοιλιακός διαχωρισμός





II



BOSSHART MICHAEL

ID: 000004258

06-SEP-97 17:40

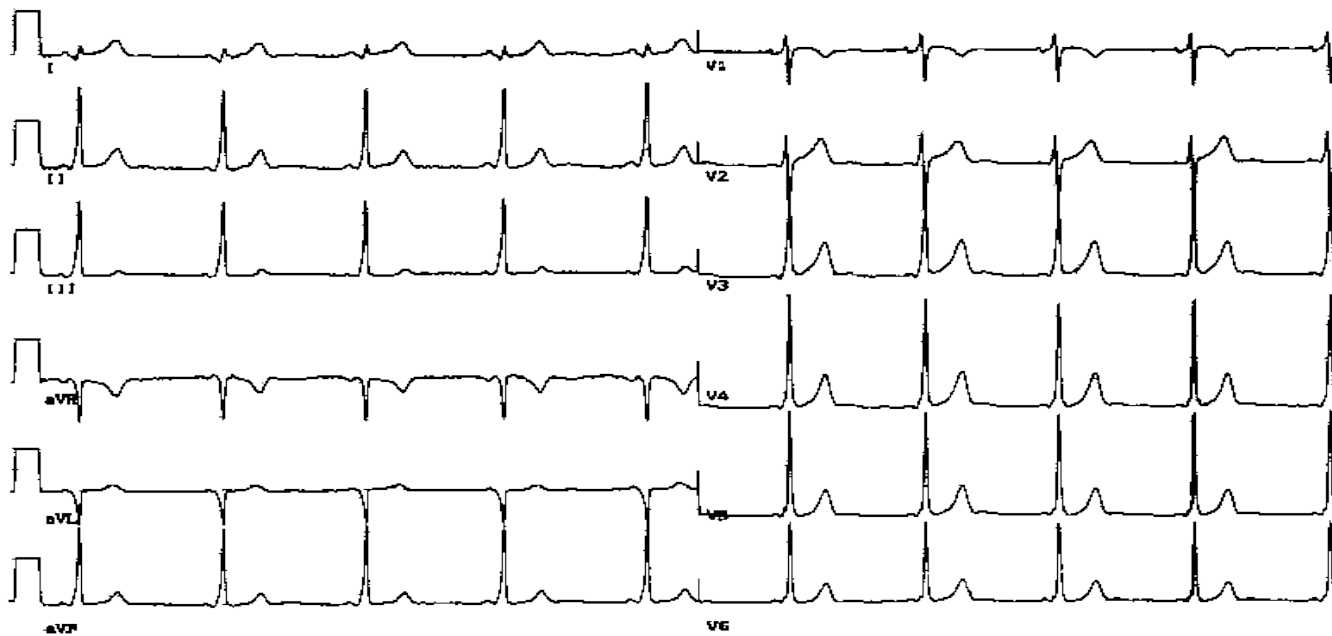
25mm/s  
 10mm/mV  
 40Hz  
 Papi 3060B  
 125L/m v78

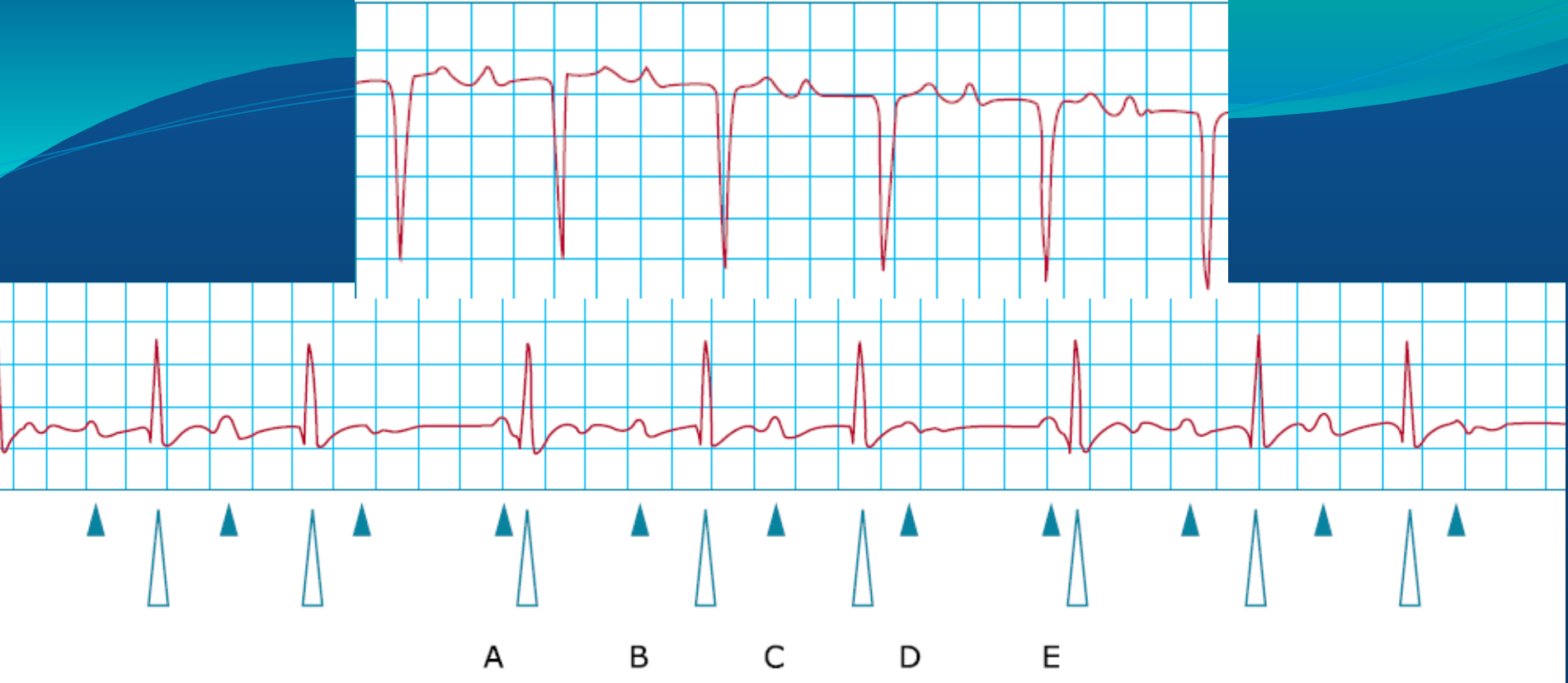
Med: Unbek.  
 25J. 175cm 72kg  
 Gesch: M  
 Abt: - 0 Zimmer 2  
 Frequenz 96 S/a  
 PQ-Zeit 104 ms  
 QRS-Dauer 112 ms  
 QT/QTc 432/410 ms  
 PRT-Achse 28 67 43

SINUSBRADYKARDIE  
 WOLFF-PARKINSON-WHITE (WPW-SYNDROM)  
 ABNORMALES EKG

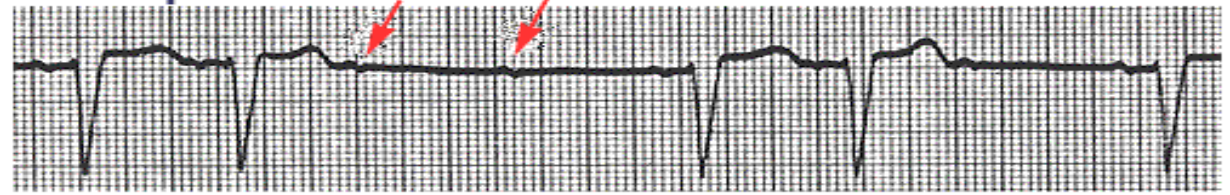
Behandelnder:

Ungespr. 8/9

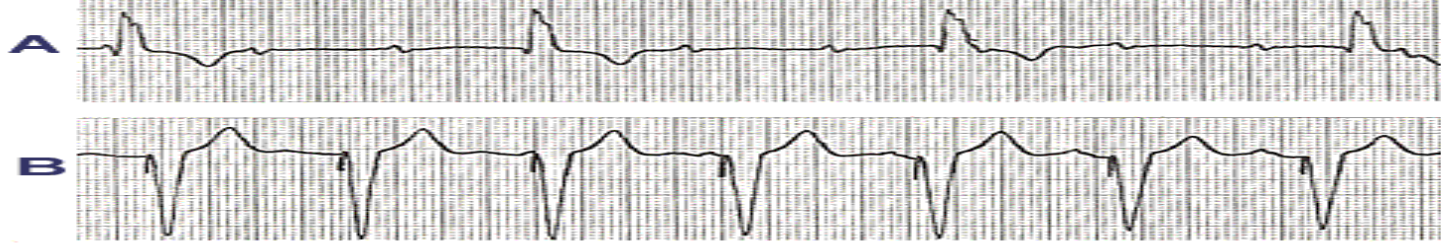




Lead  $V_1$



Lead  $V_1$

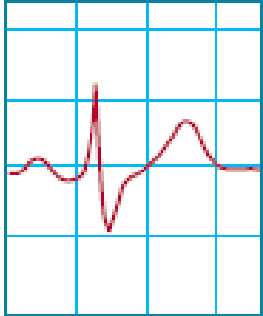


# Εύρος QRS

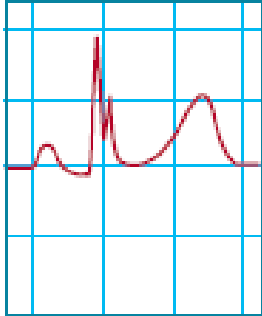
- Φυσιολογικό: 60 – 100 msec ή 0.06 - 0.10s
- Διαφορική διάγνωση QRS >0.10s:
  - QRS 0.10 - 0.12s
    - Ατελές RBBB ή LBBB
    - Μη ειδική διαταραχή ενδοκοιλιακής αγωγής (IVCD)
    - Κάποιες περιπτώσεις LAH ή LPH
  - QRS  $\frac{24}{12}$  0.12s
    - RBBB ή LBBB
    - Μη ειδική διαταραχή ενδοκοιλιακής αγωγής (IVCD)
    - Έκτοποι ρυθμοί από τις κοιλίες (πχ κοιλιακή ταχυκαρδία, επιταχυνόμενος ιδιοκοιλιακός ρυθμός, τεχνητός βηματοδότης)



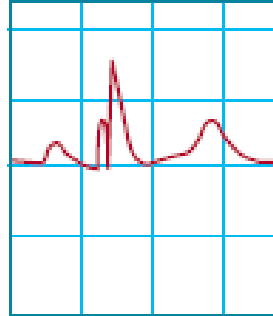
I



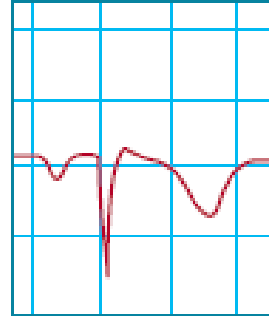
II



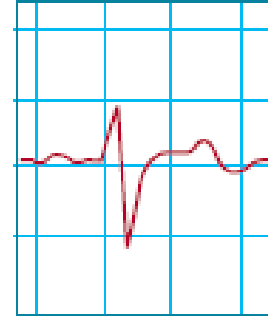
III



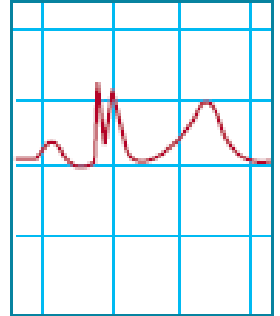
aVR



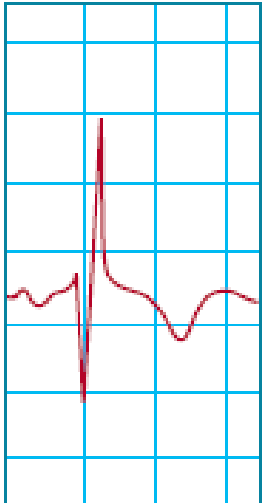
aVL



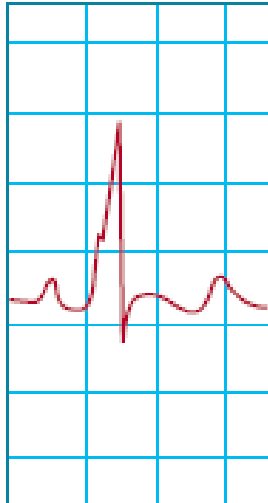
aVF



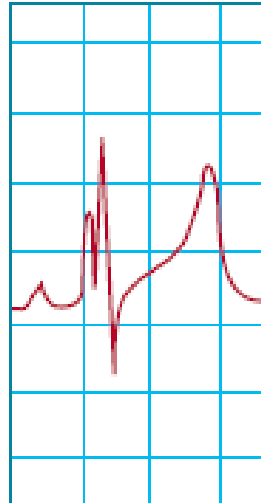
V1



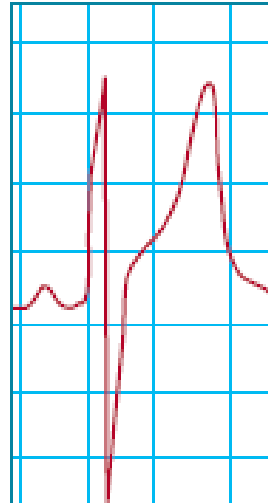
V2



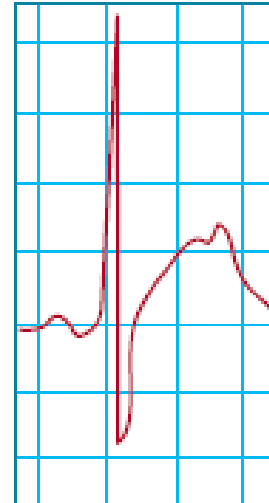
V3



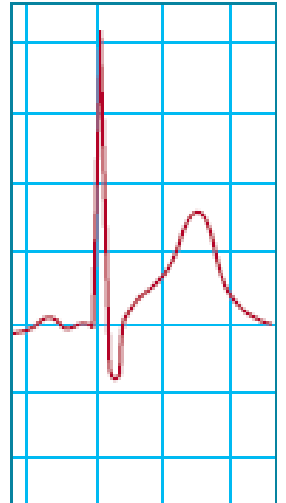
V4



V5



V6



# Μέγεθος QT (αρχή QRS με τέλος του T)

- Πάντα ανάγεται στη συχνότητα ως διορθωμένο

$$QTc = \frac{QT}{\sqrt{RR(sec)}}$$

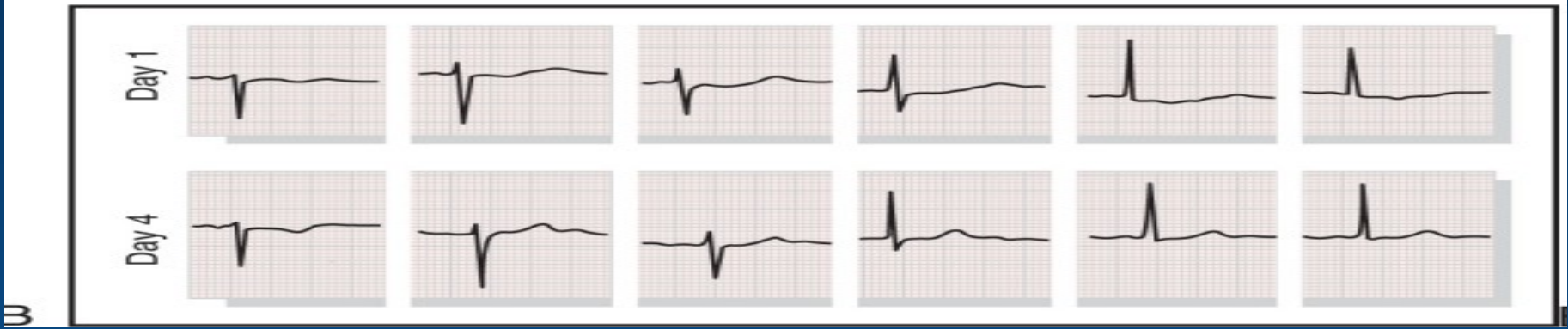
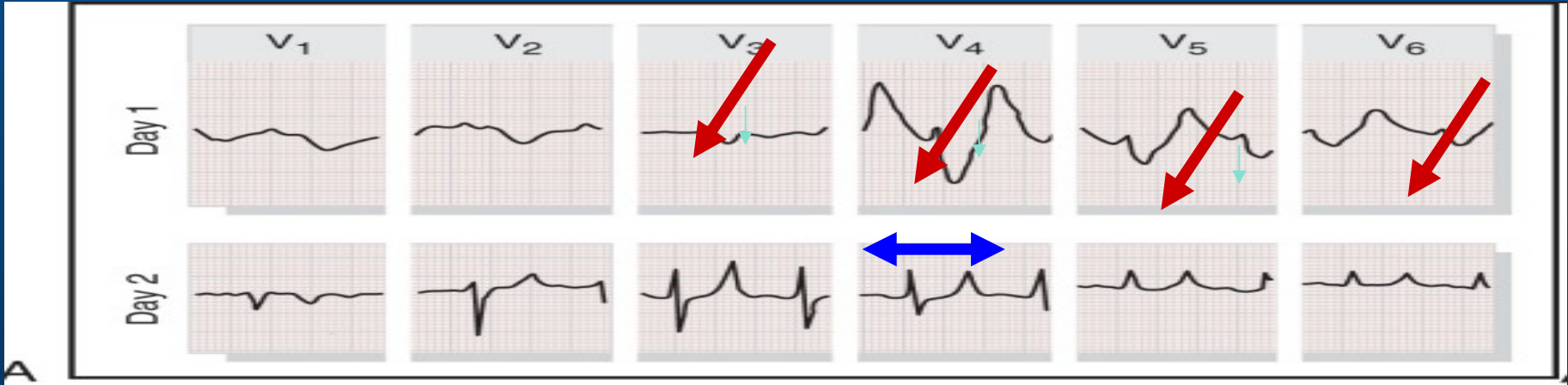
QT ≤ 440 msec



# QTc

- ΠΡΟΣΟΧΗ σε παράταση (Torsades de Pointes)
  - Φάρμακα (Αντιαρρυθμικά, αντιβιοτικά, Ψυχοφάρμακα)
  - Ηλεκτρολύτες ( $\downarrow$  K<sup>+</sup>,  $\downarrow$  Ca<sup>++</sup>,  $\downarrow$  Mg<sup>++</sup>)
  - Παθήσεις ΚΝΣ (Υπαραχνοειδής, ΑΕΕ, Τραύμα)
  - LQTS
  - Στεφανιαίοι
  - Μυοκαρδιοπάθειες
- Βραχύ σε SQTS (<0,32 sec)



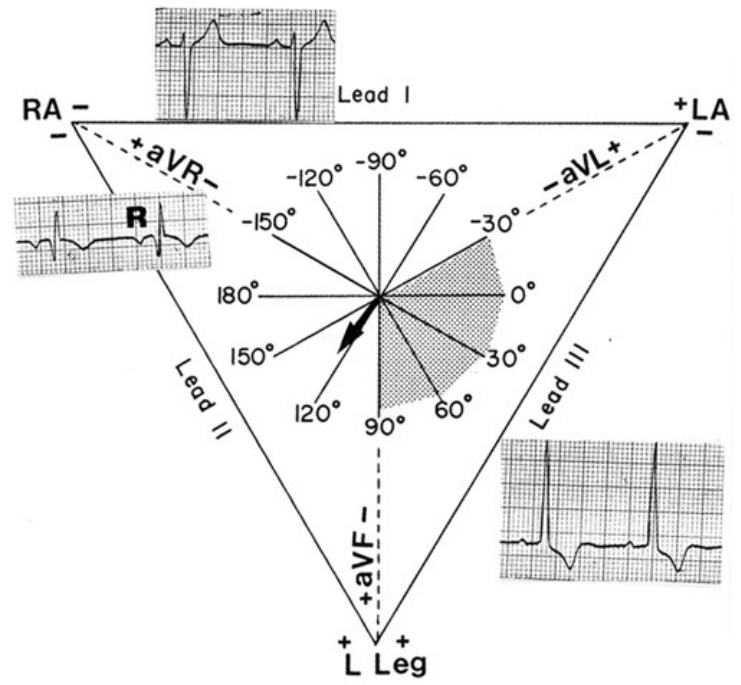
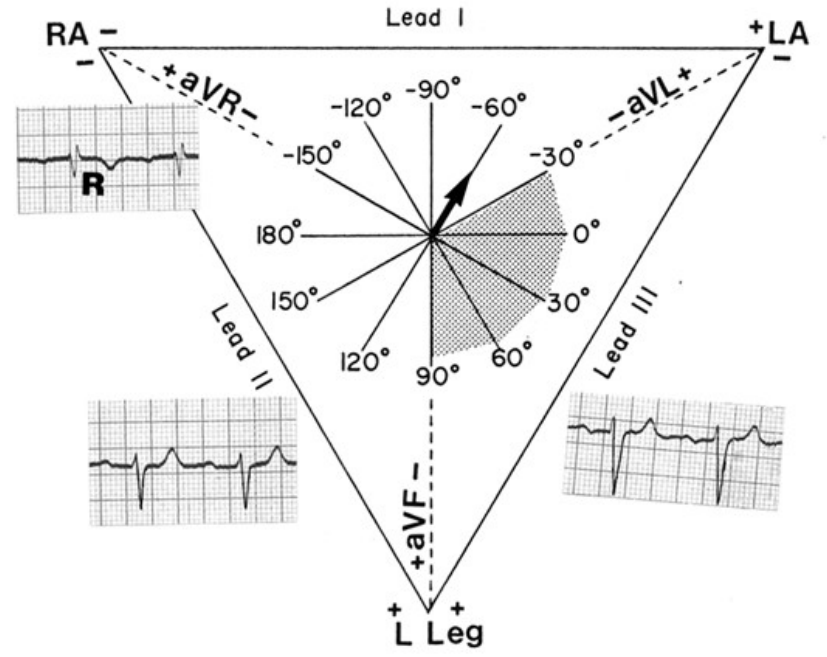
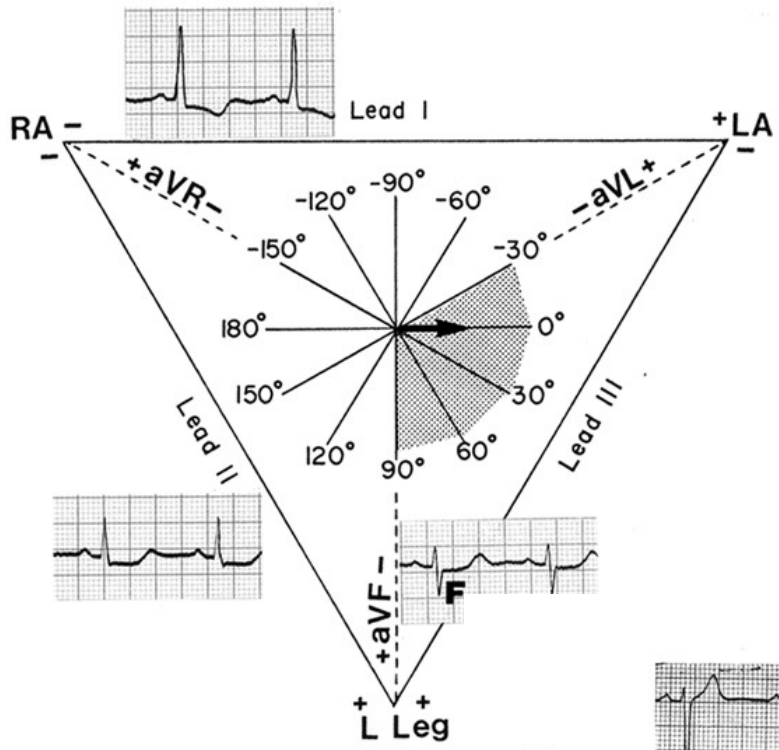


# Άξονας QRS

- Φυσιολογικός =  $-30^{\circ}$  -  $+90^{\circ}$
- LAD:  $< -30^{\circ}$ 
  - LAH
  - LBBB
  - LVH
  - Κατώτερο EM
  - ASD 1um
  - WPW
- RAD:  $> +90^{\circ}$ 
  - LPH
  - RBBB
  - RVH
  - WPW
  - Πλάγιο EM
  - Παιδιά νέοι
- Απροσδιόριστος
  - Λάθος απαγωγές
  - Δεξιοκαρδία
  - Σίμπλοκες Συννευείς







# Μέθοδος προσέγγισης

- Μετρήσεις
- Ανάλυση ρυθμού
- Ανάλυση αγωγής
- Περιγραφή κυματομορφής
- Γνωμάτευση
- Σύγκριση με προηγούμενα ΗΚΓ



# Γένεση ερεθίσματος

- Σημείο γένεσης
  - Φλεβόκομβος
  - Κόλποι
  - AV κόμβος
  - Κοιλίες
- Συχνότητα
  - Αναμενόμενη
  - Ταχύτερη Αναμενόμενης
  - Βραδύτερη Αναμενόμενης
- Ρυθμικότητα κοιλιακής ή κολπικής ανταπόκρισης
  - Κανονική
  - Τακτικά ακανόνιστη



# Αγωγή ερεθίσματος

- Ορθόδρομη ή παλίνδρομη
- Καθυστερήσεις ή αποκλεισμοί
  - Φλεβοκομβοκολπικός αποκλεισμός
  - Ενδοκοιλιακός αποκλεισμός
  - Κ-κ αποκλεισμός
  - Ενδοκοιλιακός αποκλεισμός

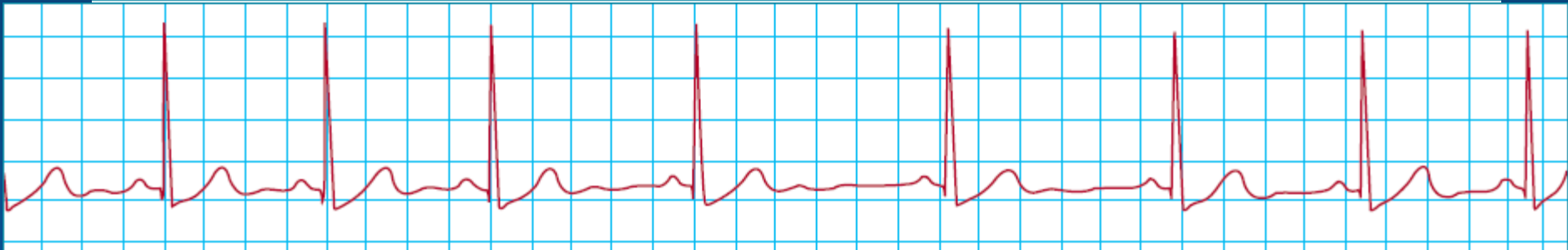
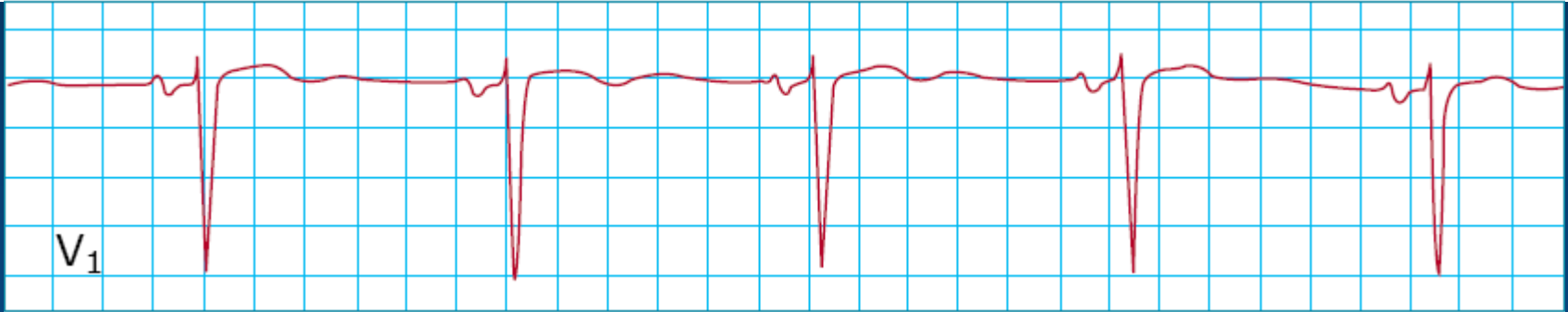
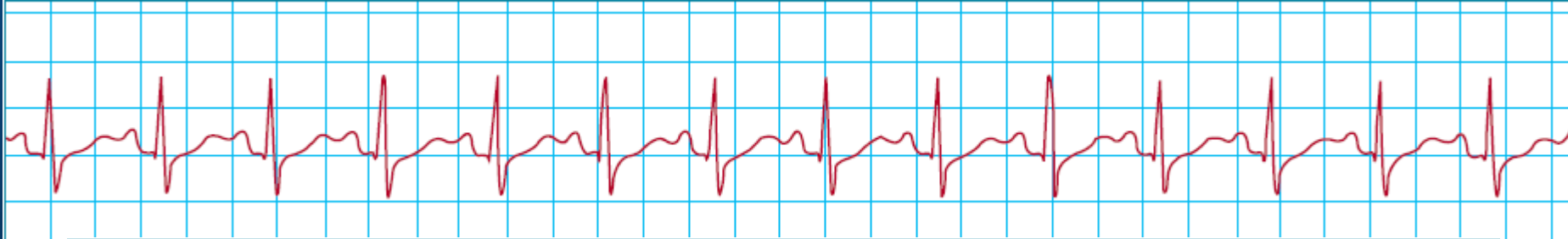
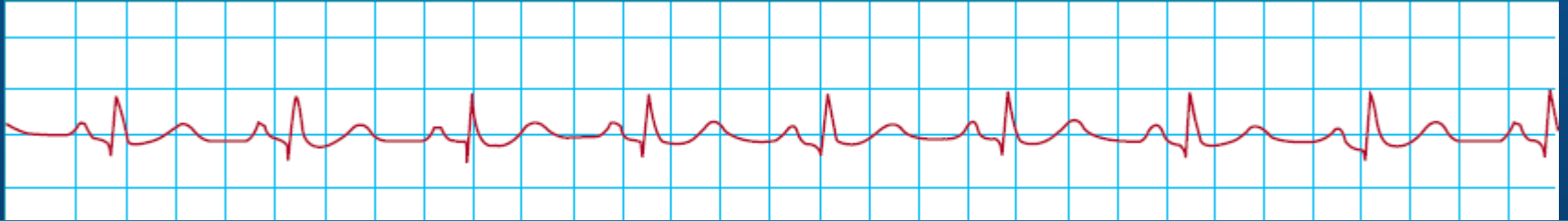


# Κόλποι

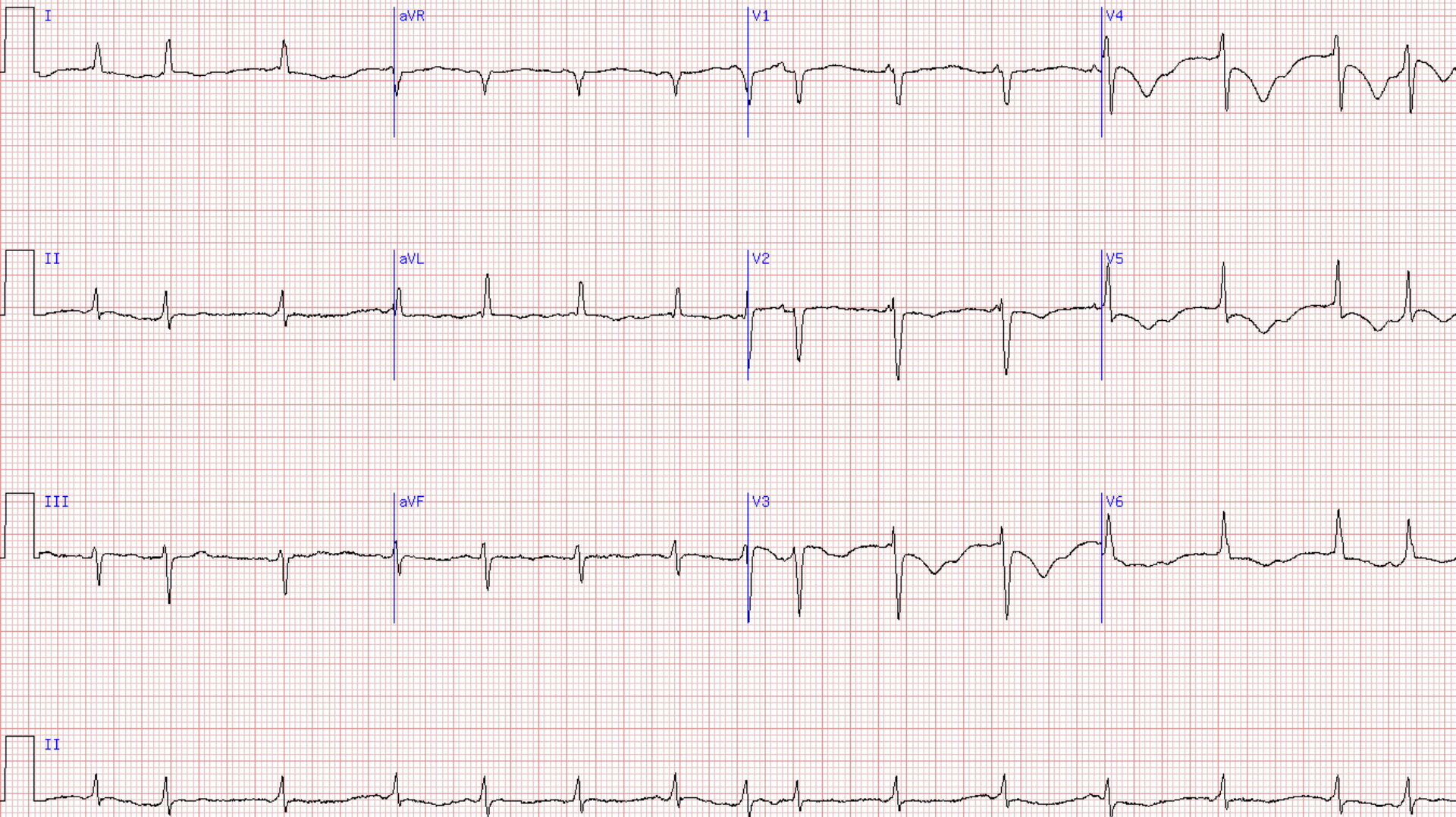
- Φλεβόκομβος
- Πρώιμες κολπικές
- Πρώιμες κομβικές
- Af & AF
- Έκτοπες κολπικές ταχυκαρδίες – ρυθμοί
- Πολυεστιακή AT
- Παροξυσμική ΥΚ ταχυκαρδία
- Κομβικοί ρυθμοί και ταχυκαρδίες



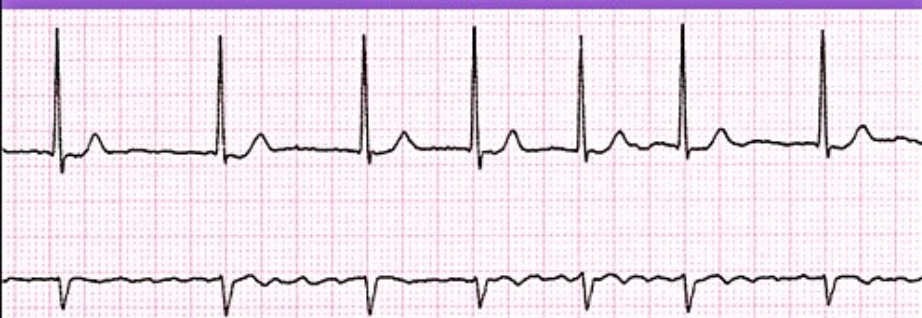
# Φλεβόκομβος



# Πλανώμενος

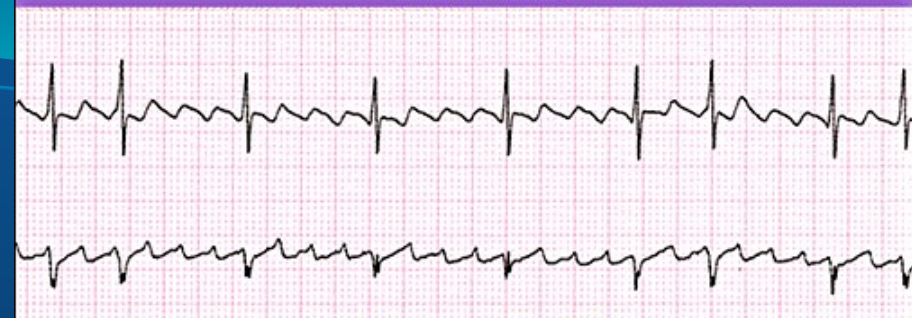


### Atrial Fibrillation

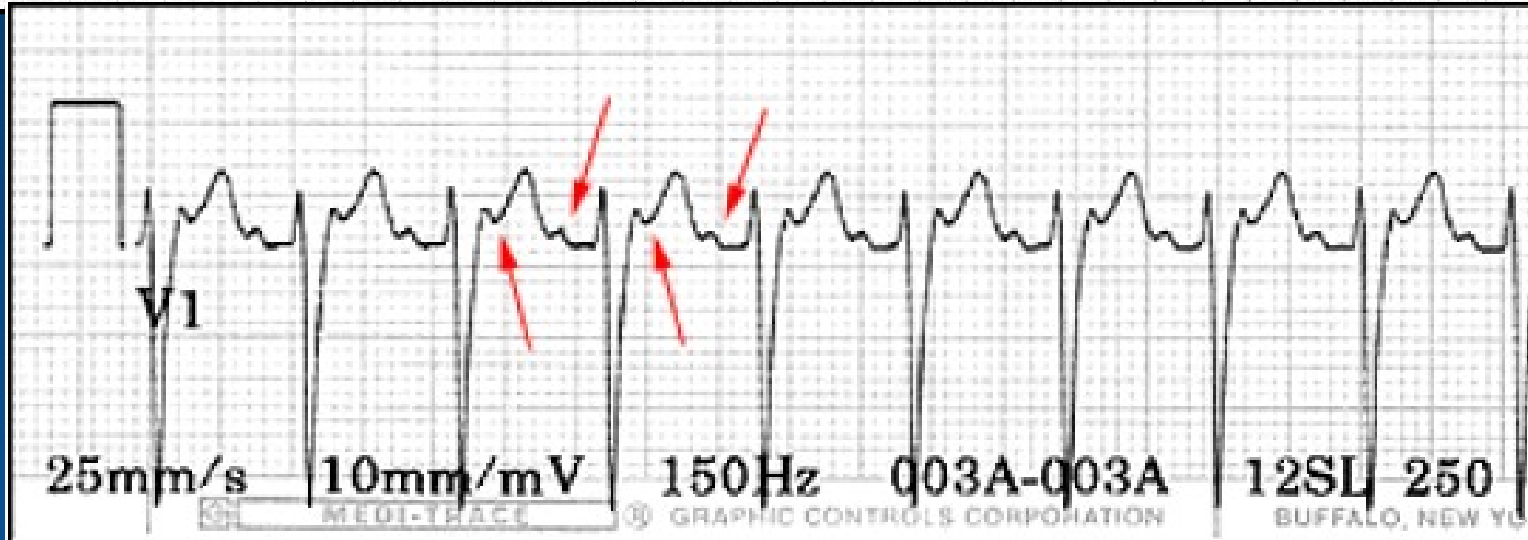


Heart Rate	Rhythm	P Wave	PR interval (in seconds)	QRS (in seconds)
A: 350-650 bpm V: Slow to rapid	Irregular	Fibrillatory (fine to coarse)	N/A	<.12

### Atrial Flutter

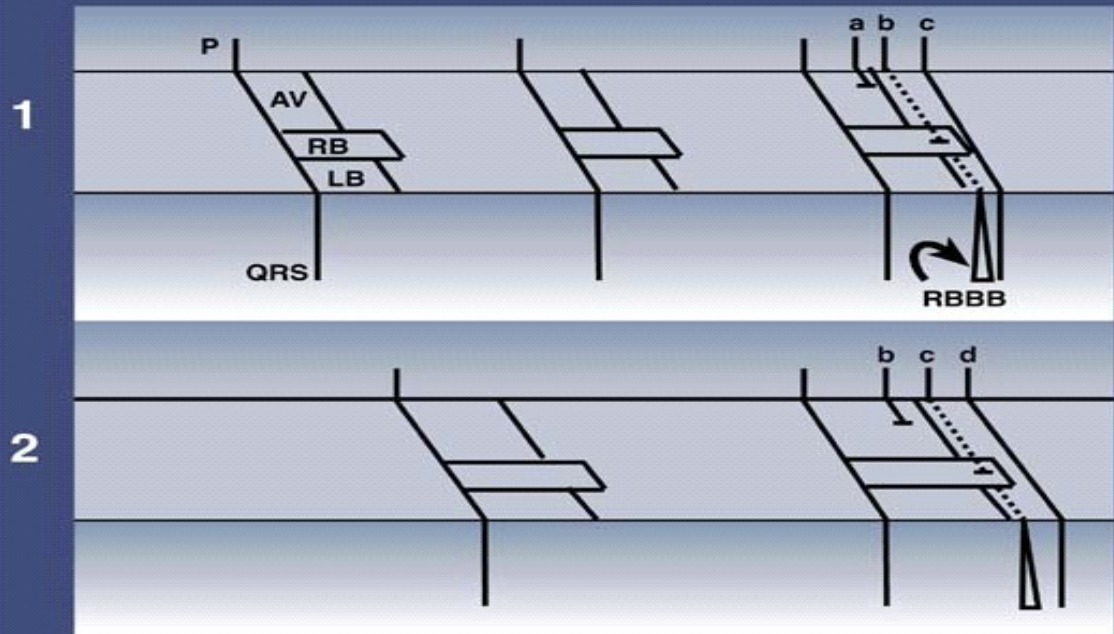


Heart Rate	Rhythm	P Wave	PR interval (in seconds)	QRS (in seconds)
A: 220-430 bpm V: <300 bpm	Regular or variable	Sawtoothed appearance	N/A	<.12

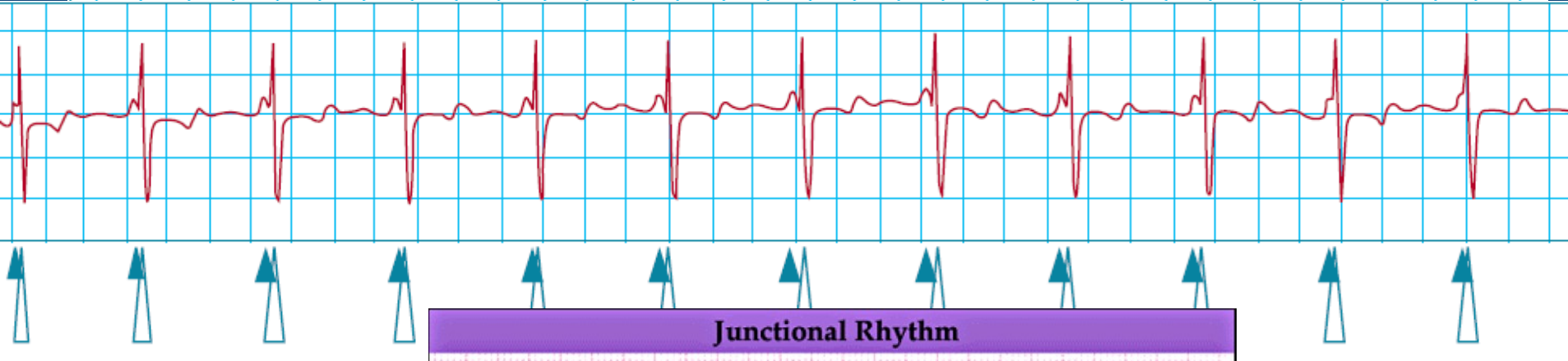
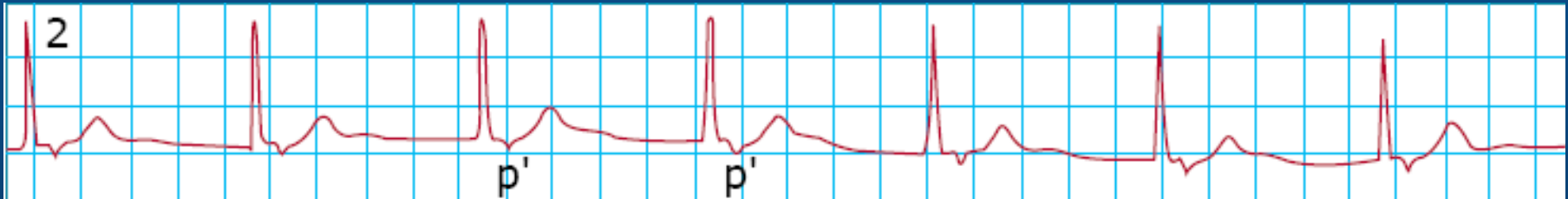




# The Three Fates of PACS



# ΑΝ Κόμβος



## Junctional Rhythm



Heart Rate	Rhythm	P Wave	PR interval (in seconds)	QRS (in seconds)
40-60 bpm	Regular	Inverted, absent or after QRS	<.12	<.12

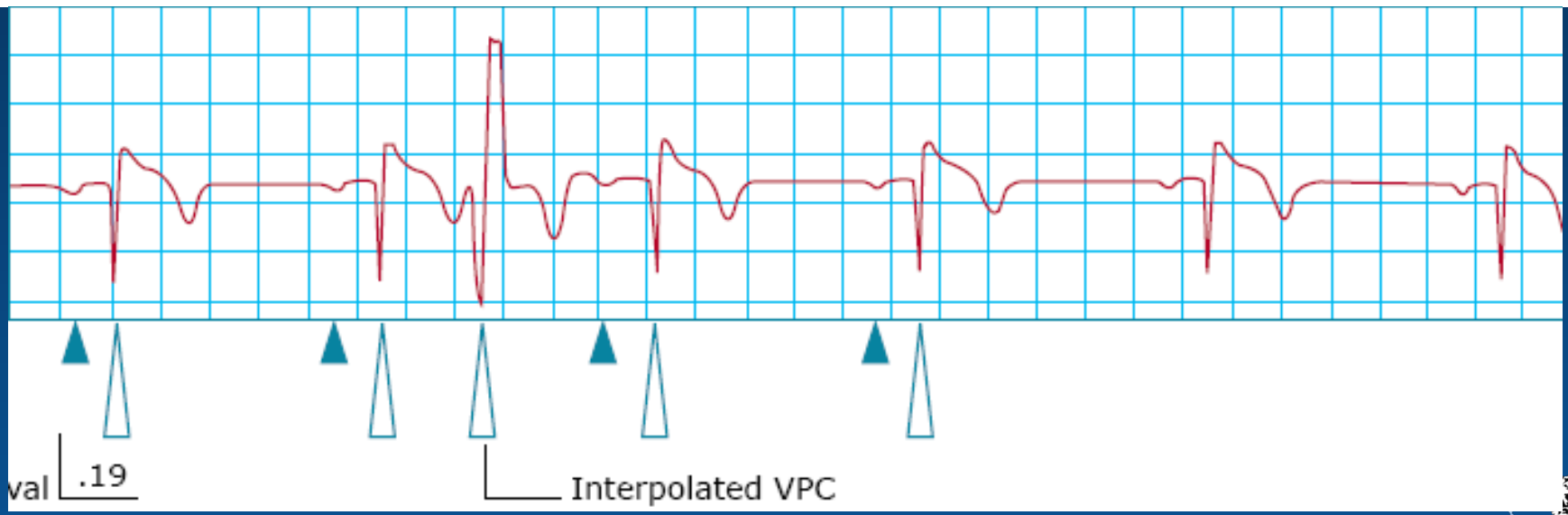


# Κοιλιακές συστολές

- PVCs
- Αλλόδρομες ή κοιλιακές ?
- VT
- ΔΔ VT – SVT
- Επιταχυνόμενοι κοιλιακοί ρυθμοί
- Ιδιοκοιλιακός ρυθμός
- Παρασυστολία



# Κοιλίες



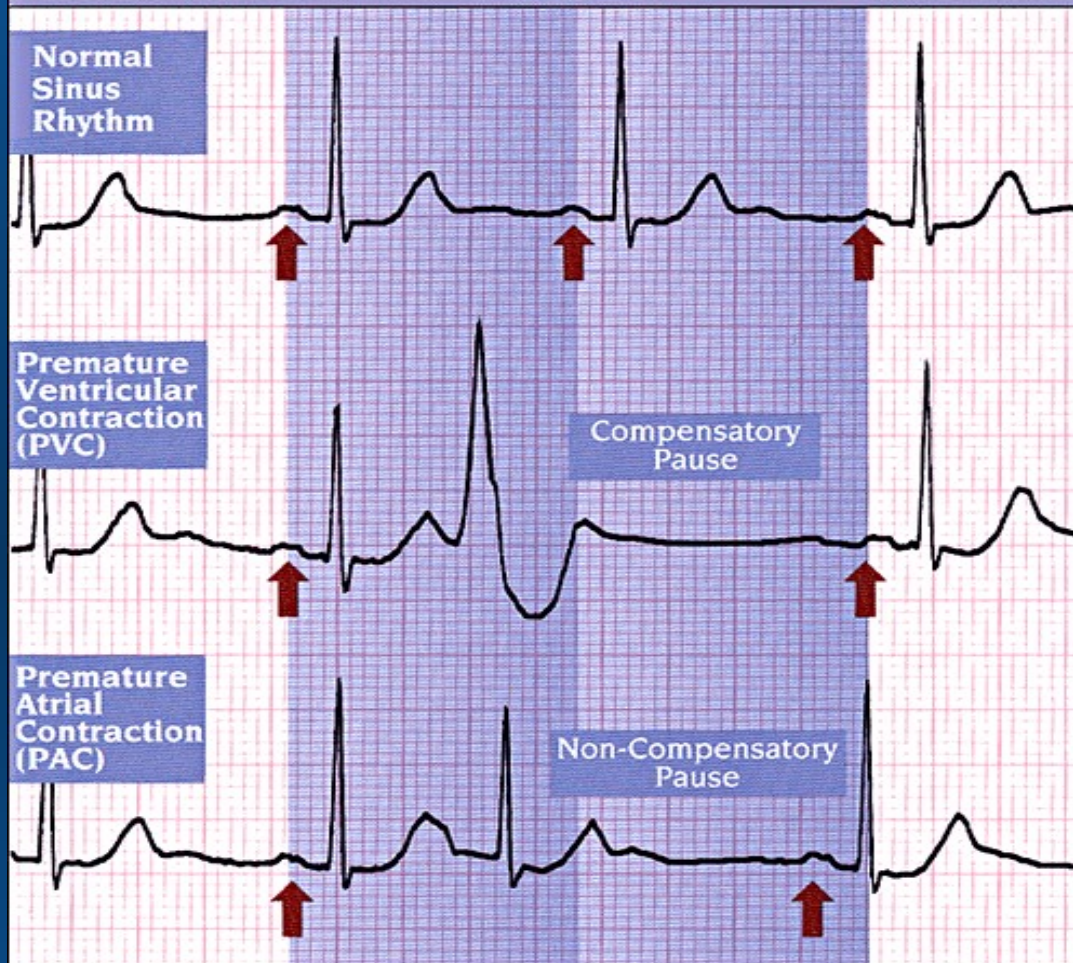
## Multifocal PVC's: more than one shape



## Triplet PVC's: occur in groups of three



## Compensatory vs Noncompensatory Pauses

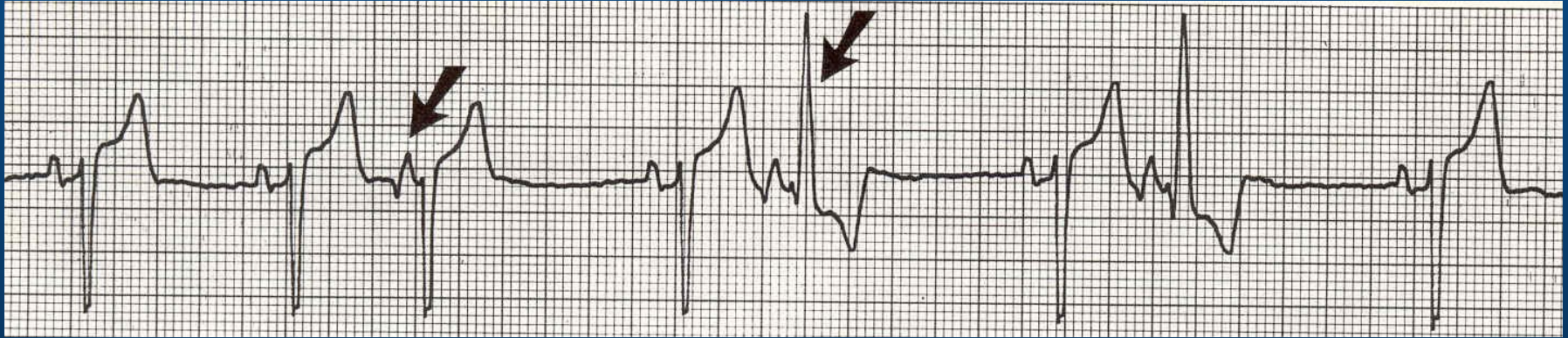


To measure a full compensatory pause

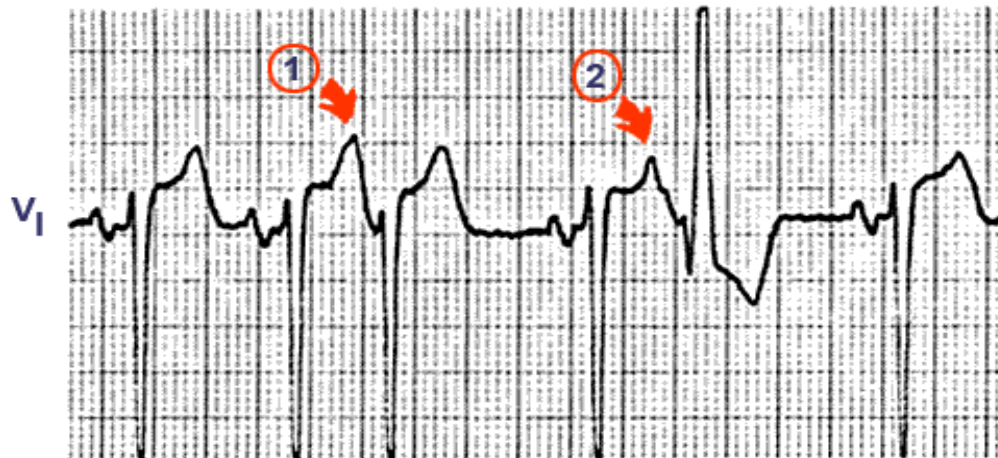
1. Mark off 3 normal cycles
2. Place the first mark on the P wave of the normal cycle preceding the premature complex.
3. The third mark should fall exactly on the P wave following the premature complex to be called a compensatory pause.



# Προέλευση Εκτάκτων



## Not all sore thumbs are PVC's



PAC (1) with normal IV conduction

PAC (2) with RBBB aberration (note: longer preceding cycle prior to aberrancy)



# Αλλοδρομία (Aberrancy)

- Από φυσιολογική οδό
  - Εξαρτώμενη από το μήκος του προηγούμενου κύκλου (Long-Short ή Ashman)
  - Εξαρτώμενη από τη συχνότητα
- Από παραπληρωματικές οδούς

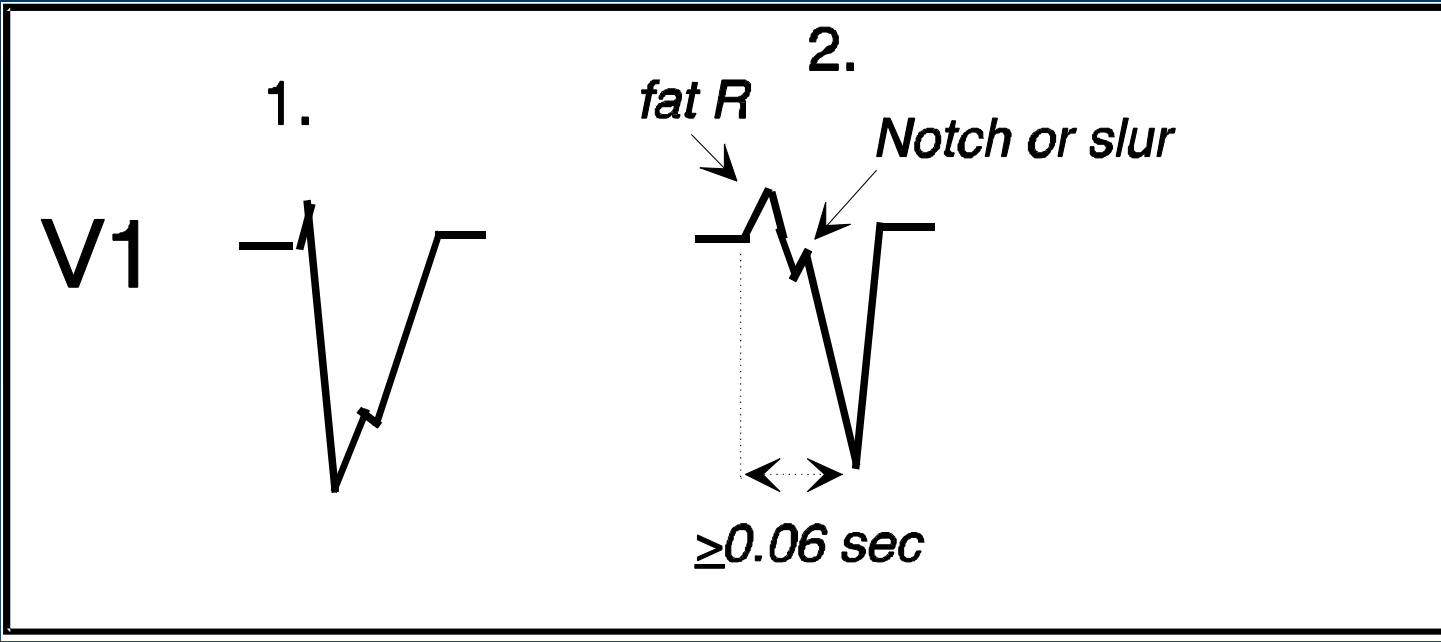
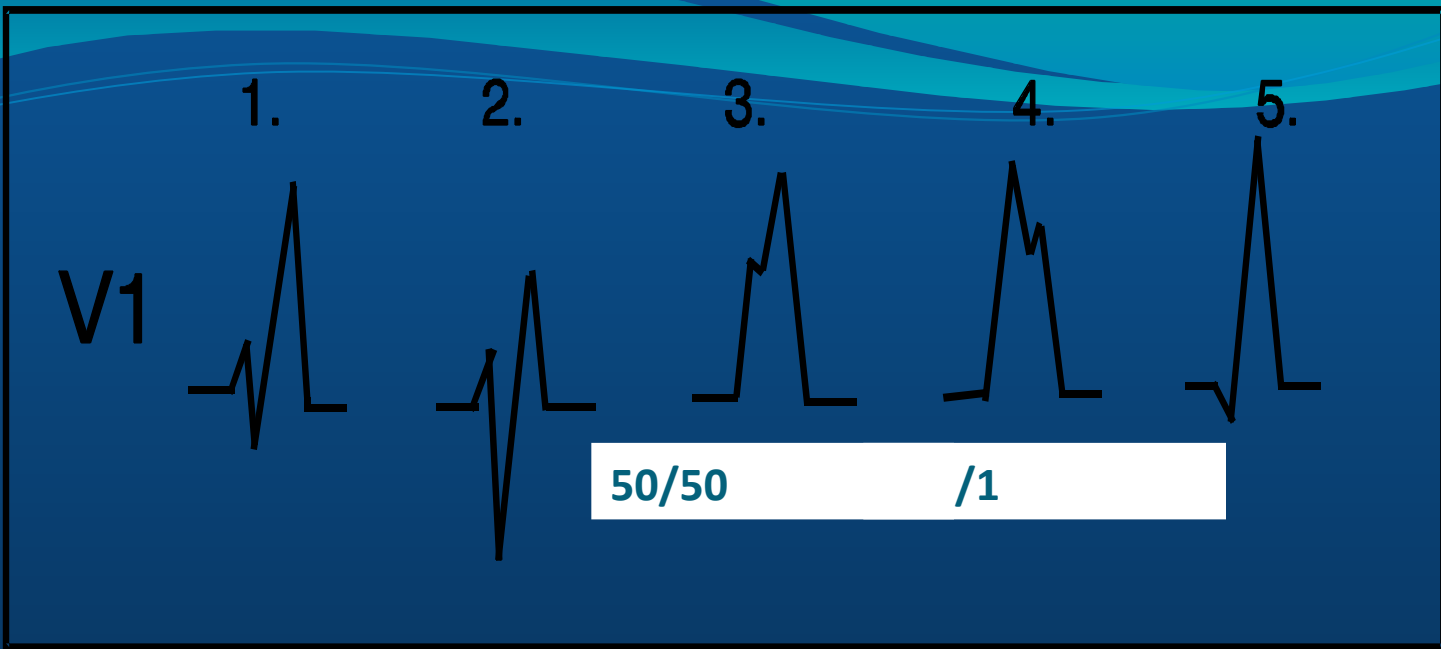


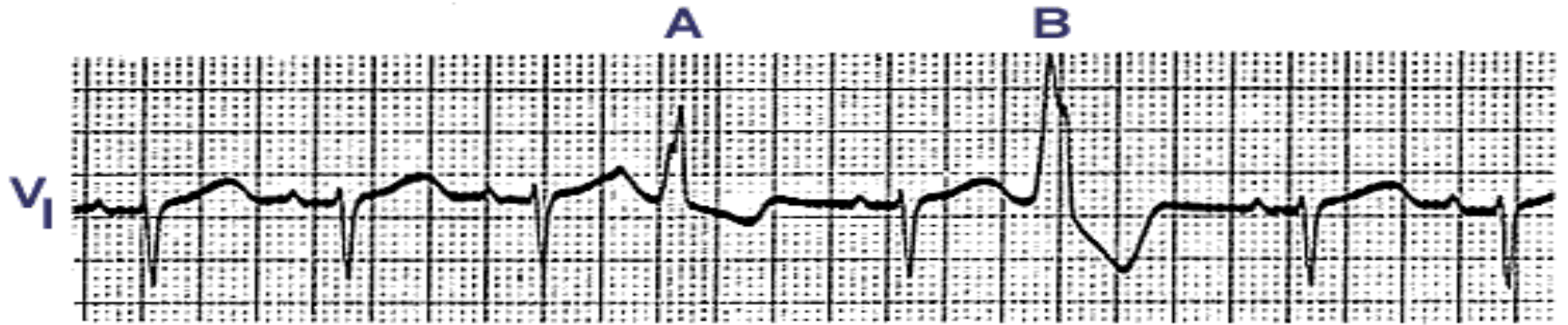


# Στοιχεία υπέρ αλλοδρομίας όταν μορφολογία RBBB

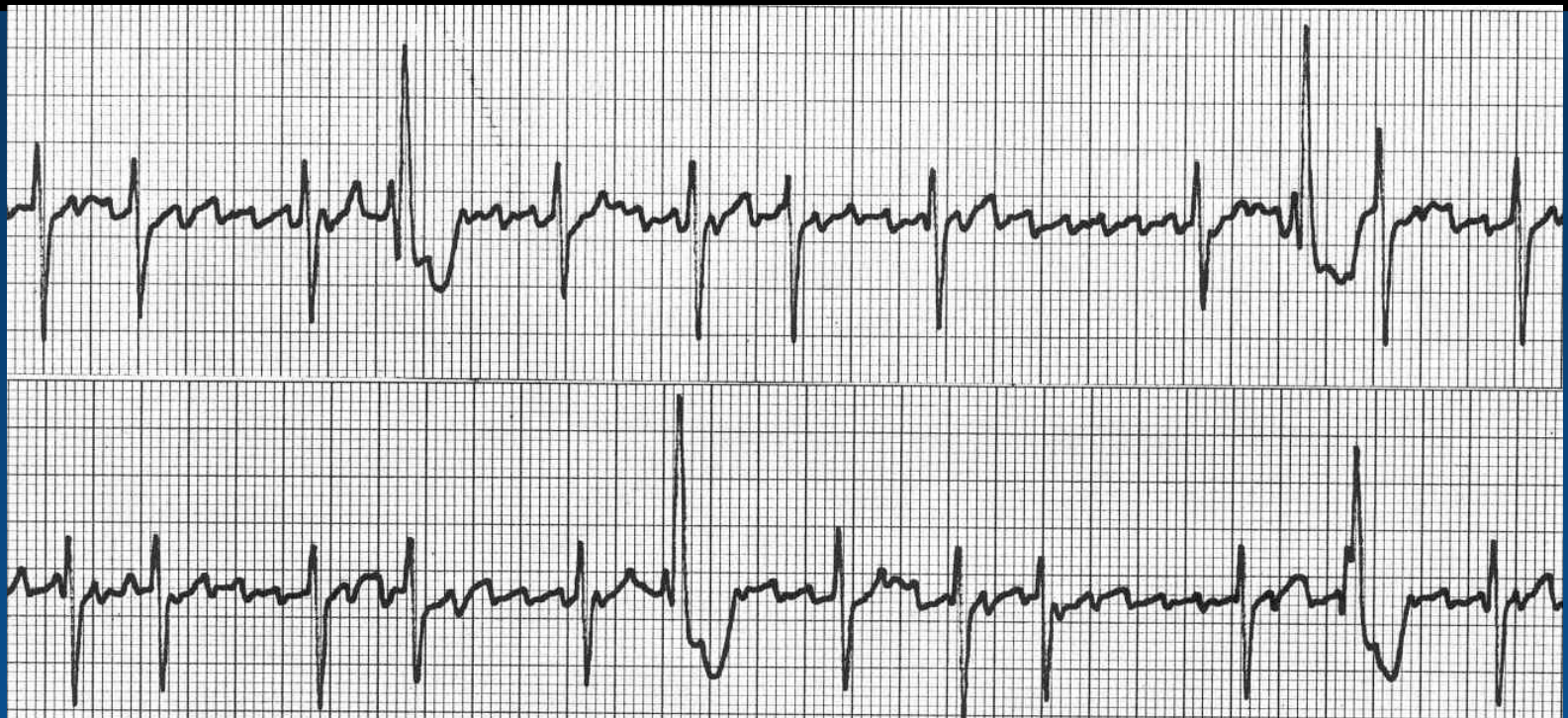
- Προηγείται κοιλιακή δραστηριότητα (πρώιμο P)
- rSR' ή rsR' στη V1
- qRs στη V6
- Ίδιο αρχικό r κύμα όπως στο κανονικό QRS (στη V1)



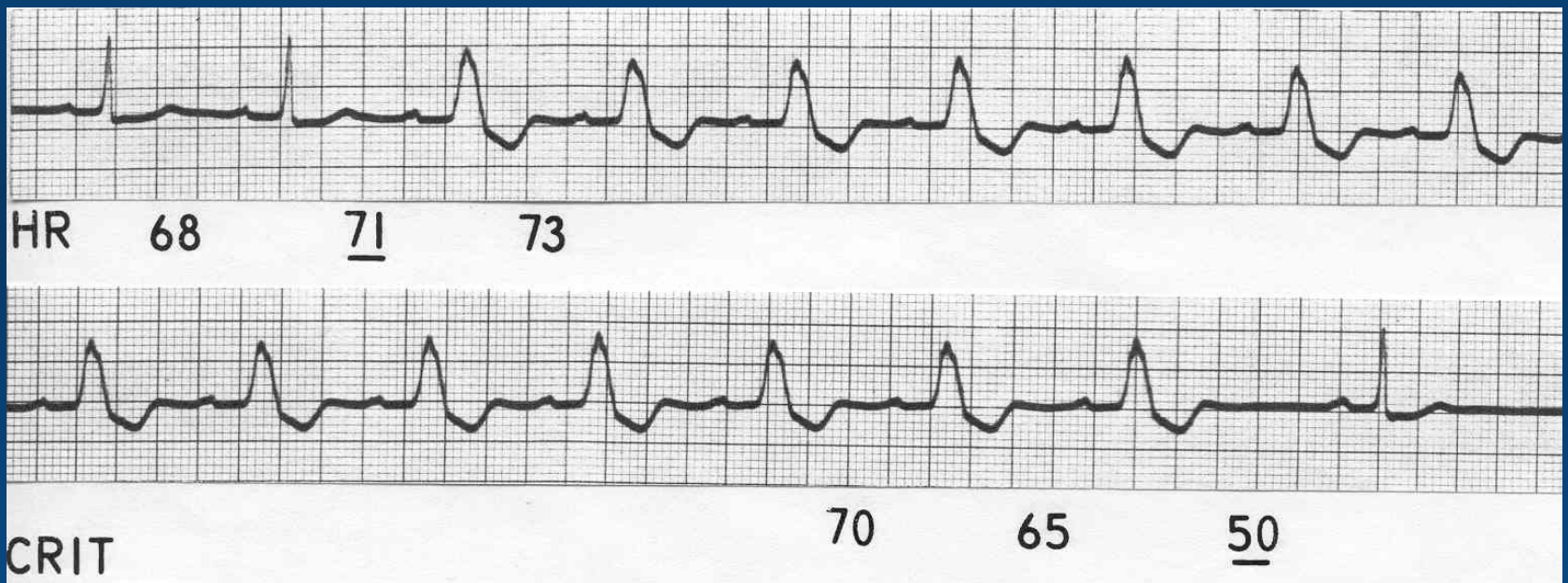




**Can you differentiate sore thumbs 'A' and 'B'?**



# Συχνοεξάρτηση



# Κοιλιακές Ταχυκαρδίες

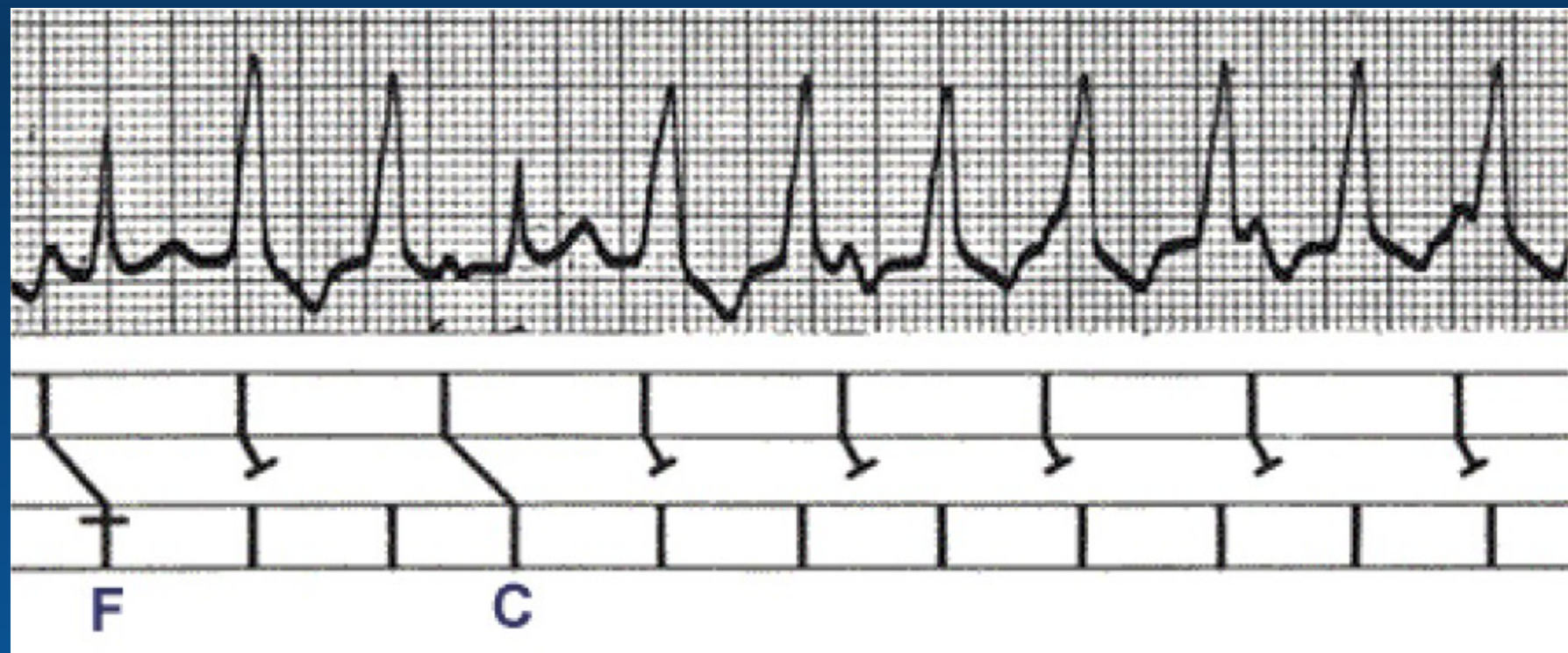
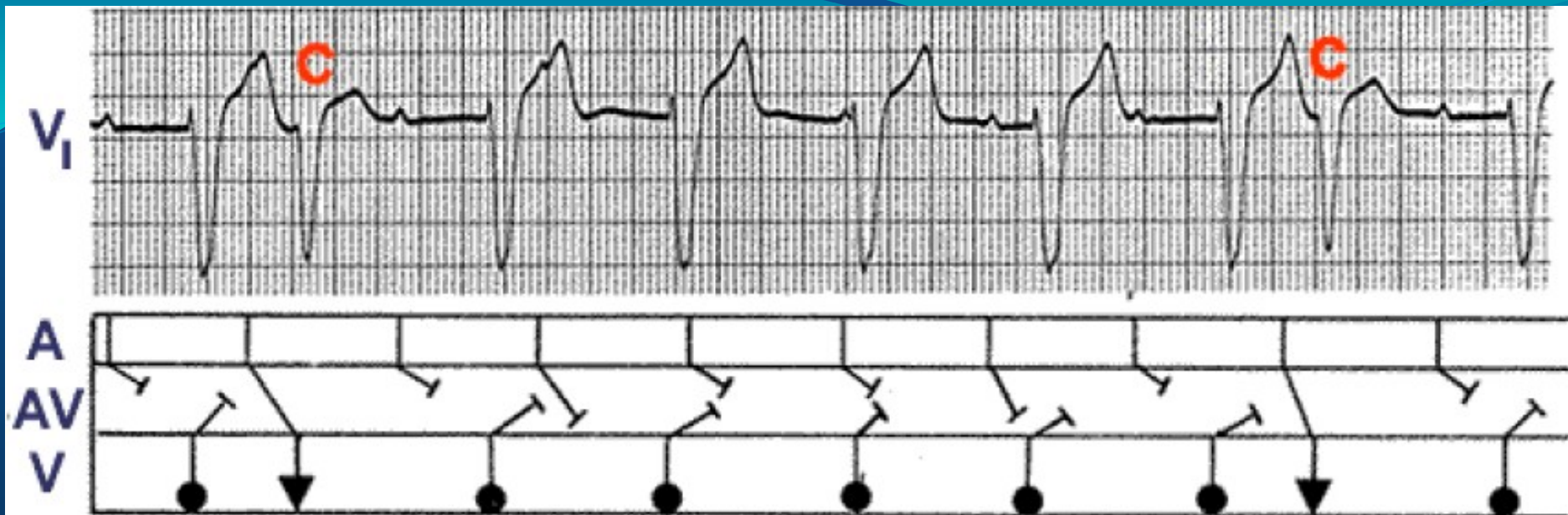
## ΔΔ ταχυκαρδίας με ευρέα QRS

- Ρυθμικότητα
- κ-κ διαχωρισμός
- Συστολές εκ συλλήψεως ή εκ συγχωνεύσεως
- Μορφολογία
  - Όσα αναφέρθηκαν στην αλλοδρομία
  - Περίεργος άξονας
  - Ομοιότητα με προηγούμενες PVCs
  - Παρόμοιες όλες από V1 έως V6 (Concordance)
  - Αρνητική V6
  - Αλγόριθμος Brugada
- ΕΠΙ ΑΜΦΙΒΟΛΙΑΣ ΚΑΙ ΑΙΜΔ/ΚΗΣ ΑΣΤΑΘΕΙΑΣ ΝΑ ΘΕΩΡΟΥΝΤΑΙ ΚΟΙΛΙΑΚΕΣ

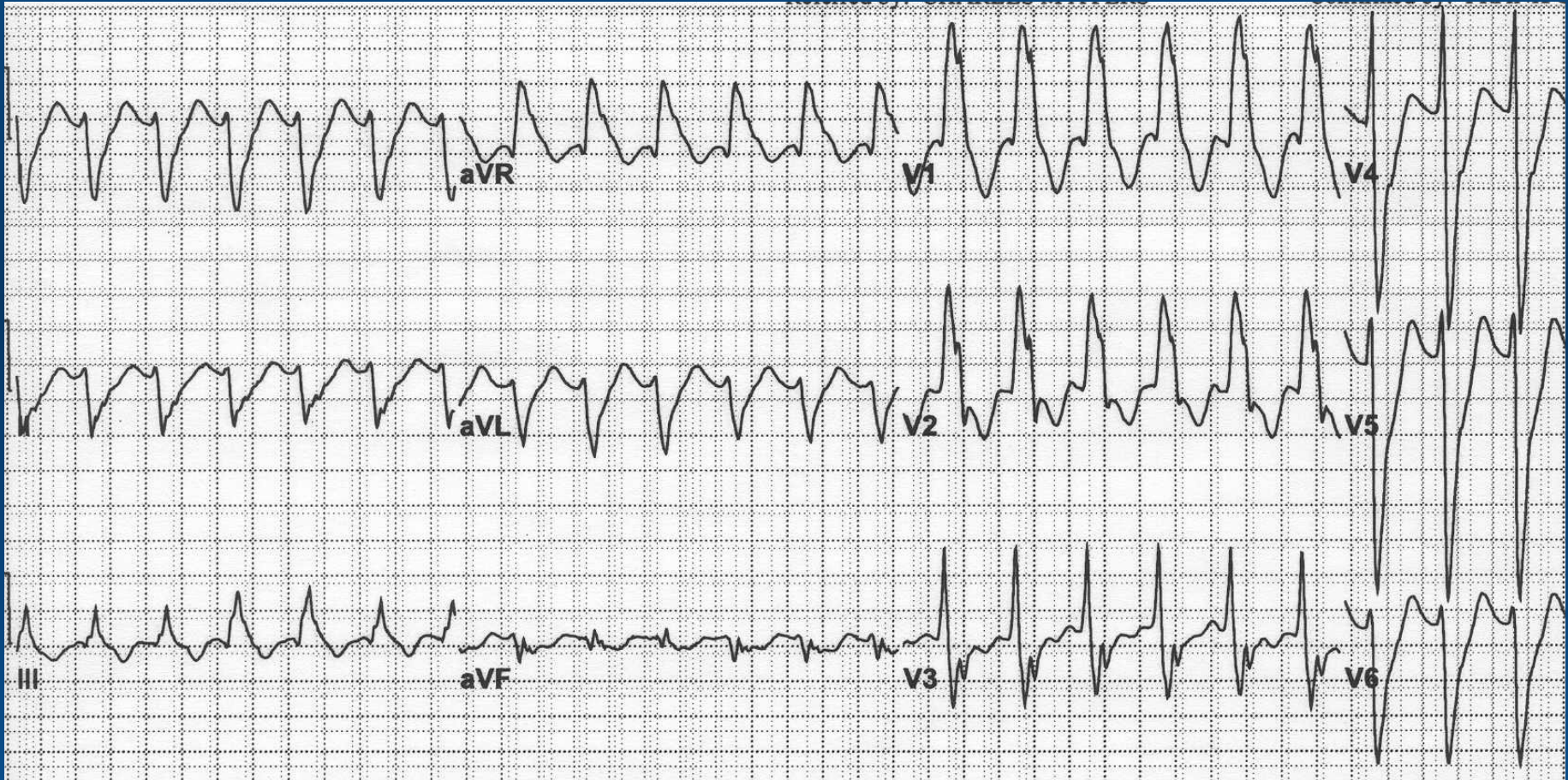


# Ρυθμικότητα



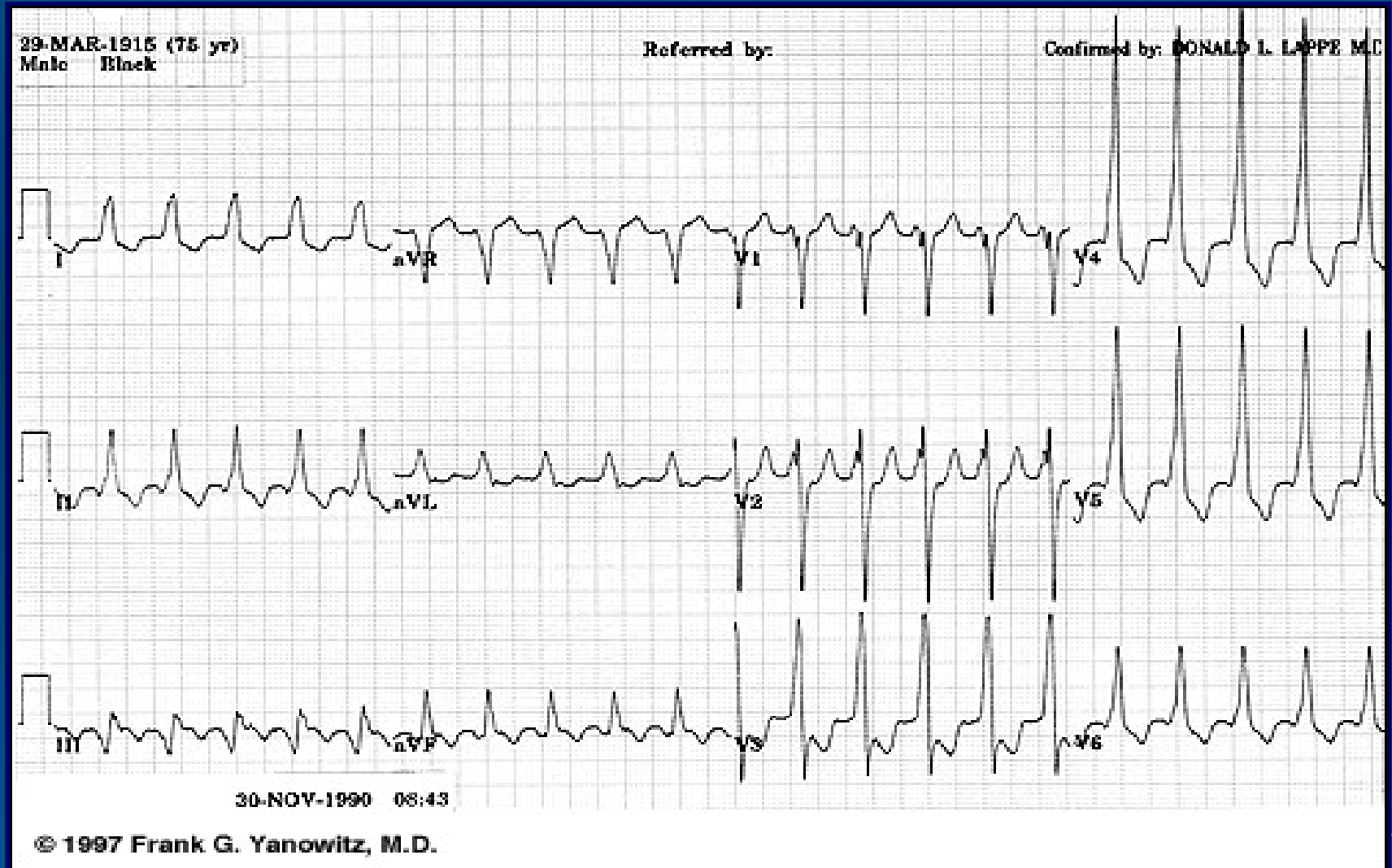


# Κοιλιακές Ταχυκαρδίες

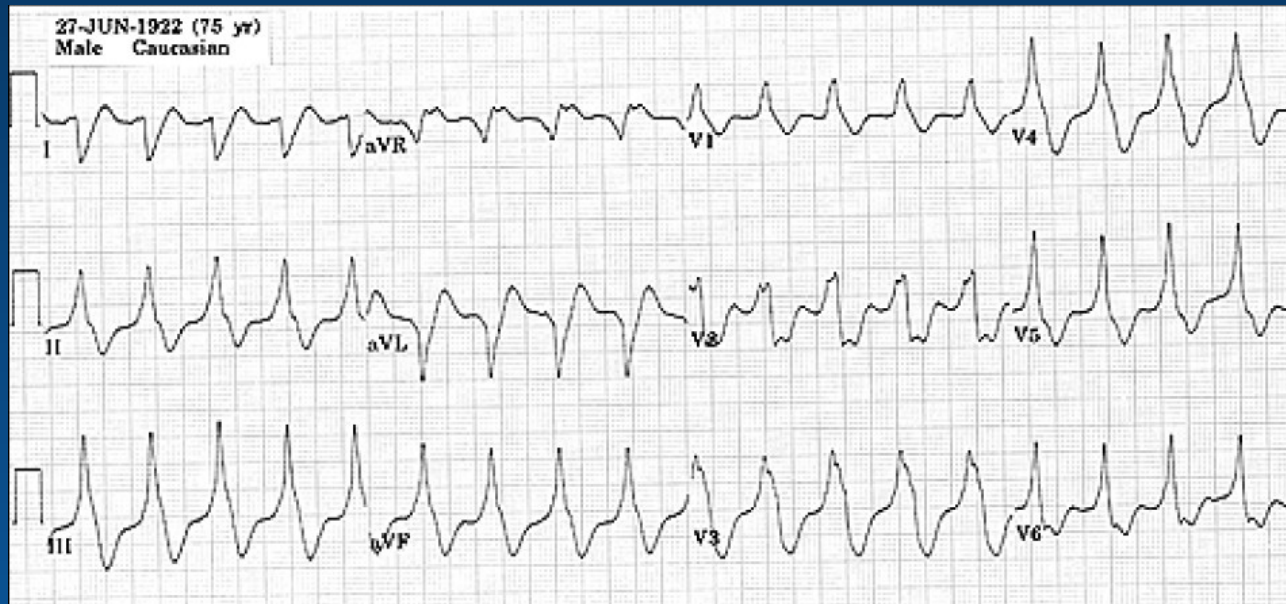
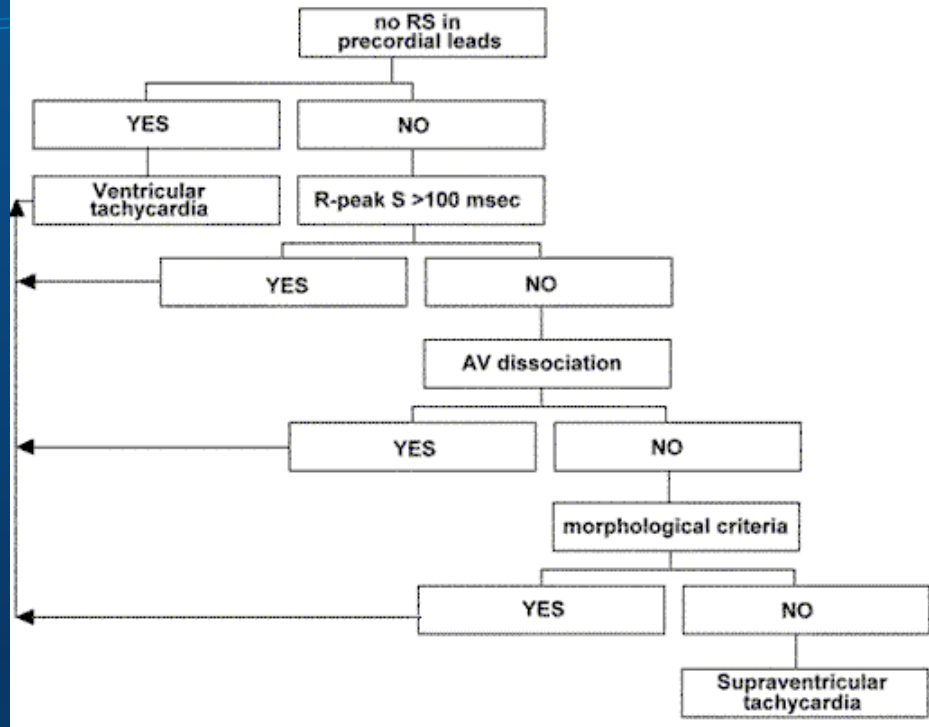




# Κοιλιακές Ταχυκαρδίες



## Regular wide-QRS tachycardia



# Μέθοδος προσέγγισης

- Μετρήσεις
- Ανάλυση ρυθμού
- Ανάλυση αγωγής
- Περιγραφή κυματομορφής
- Γνωμάτευση
- Σύγκριση με προηγούμενα ΗΚΓ



# Διαταραχές Αγωγής



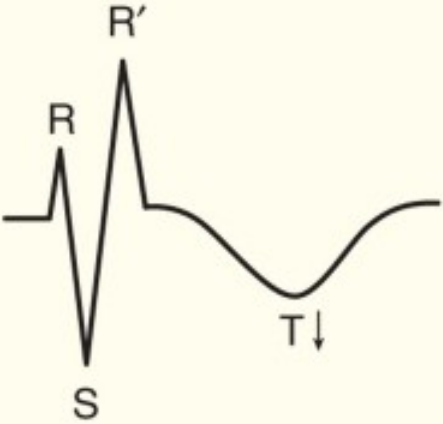
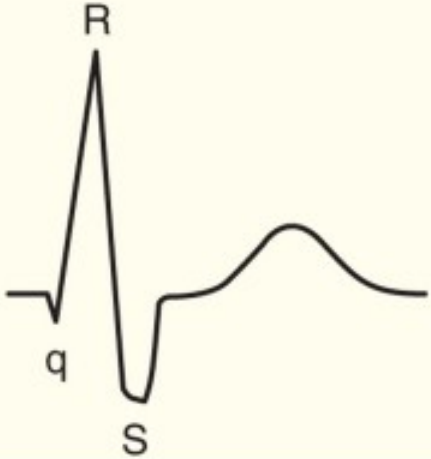

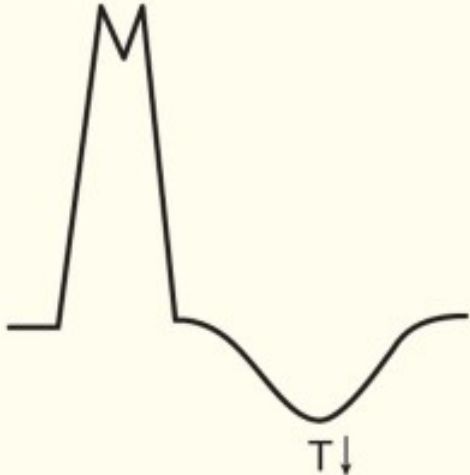
- Φκ – κ διαταραχές αγωγής
- κ - κ διαταραχές αγωγής
  - 1ου βαθμού
  - 2ου βαθμού
    - Mobitz I
    - Mobitz II
- Πλήρης κ – κ αποκλεισμός
- κ – κ διαχωρισμός



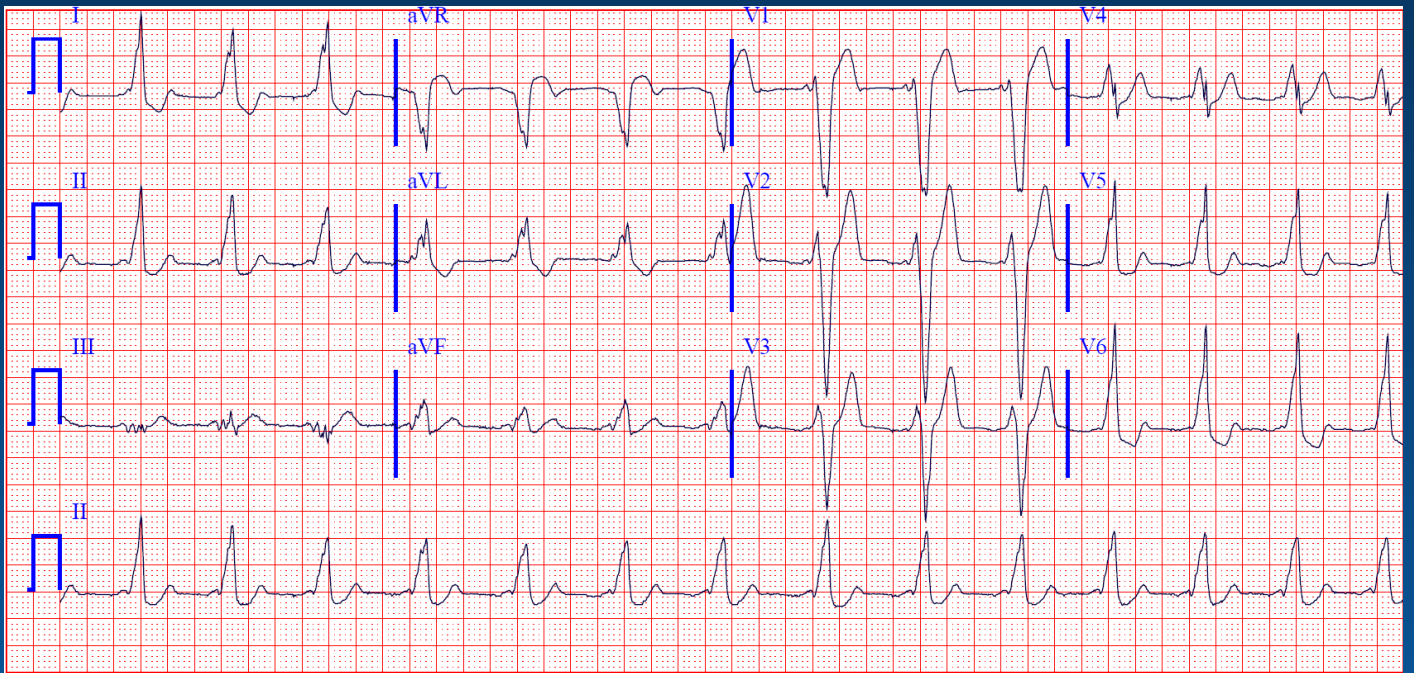
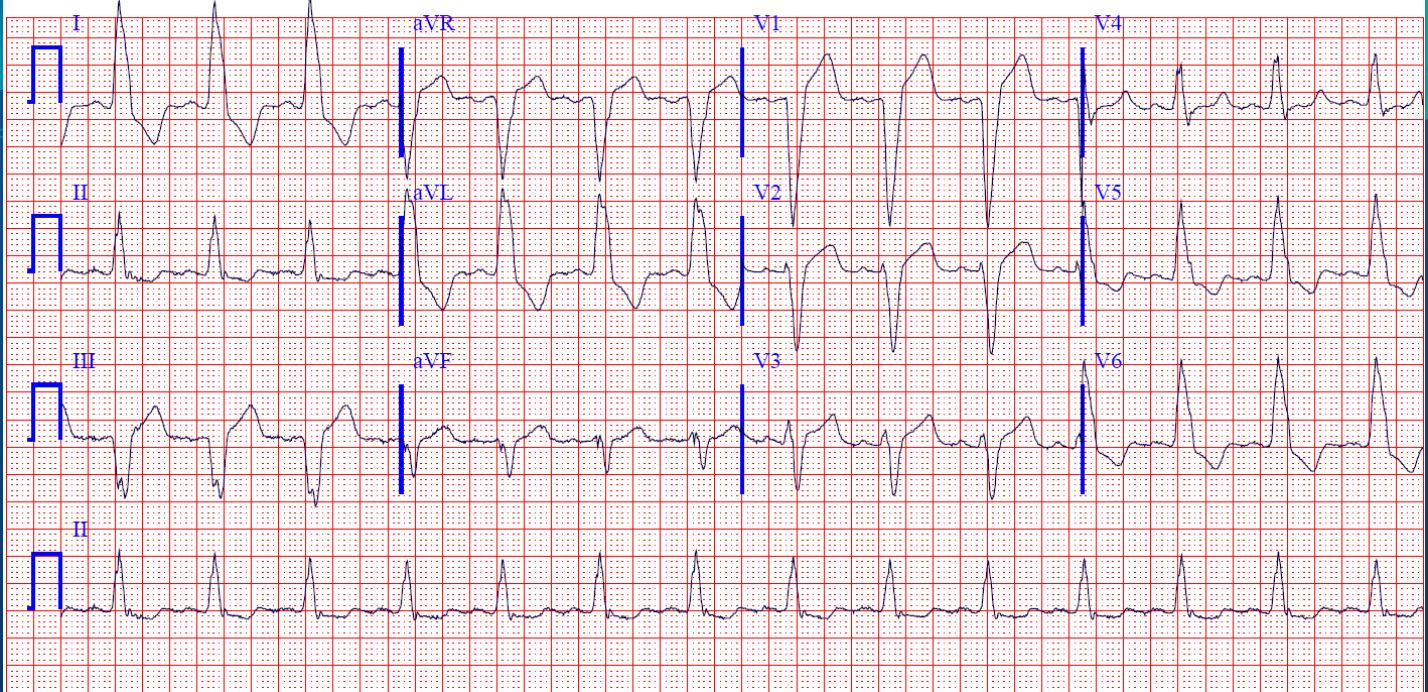
# Ενδοκοιλιακή αγωγή

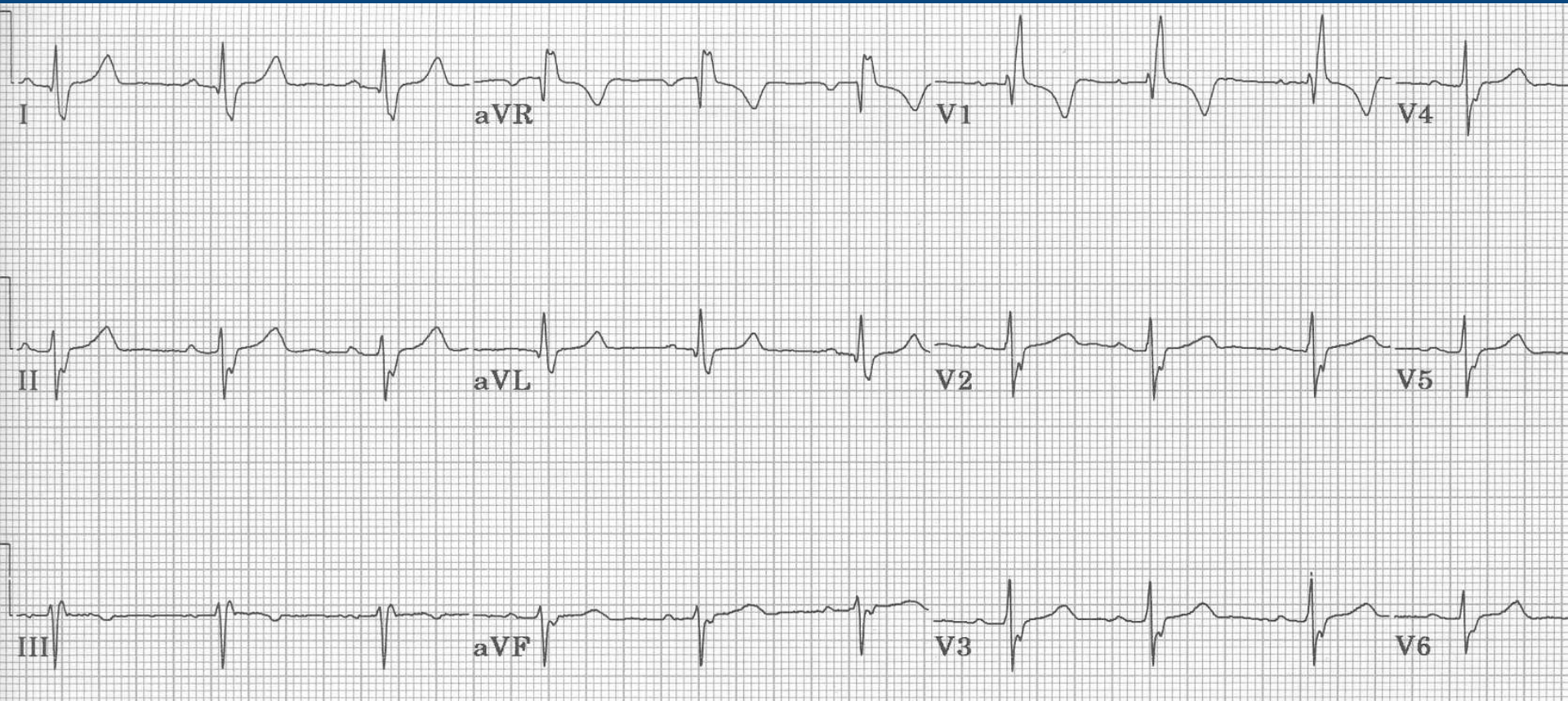
- RBBB
- LBBB
- LAH
- LPH
- Διδεσμικοί αποκλεισμοί
- Μη ειδικού τύπου
- Προδιέγερση



	$V_1$	$V_6$
Normal		
RBBB		
LBBB		

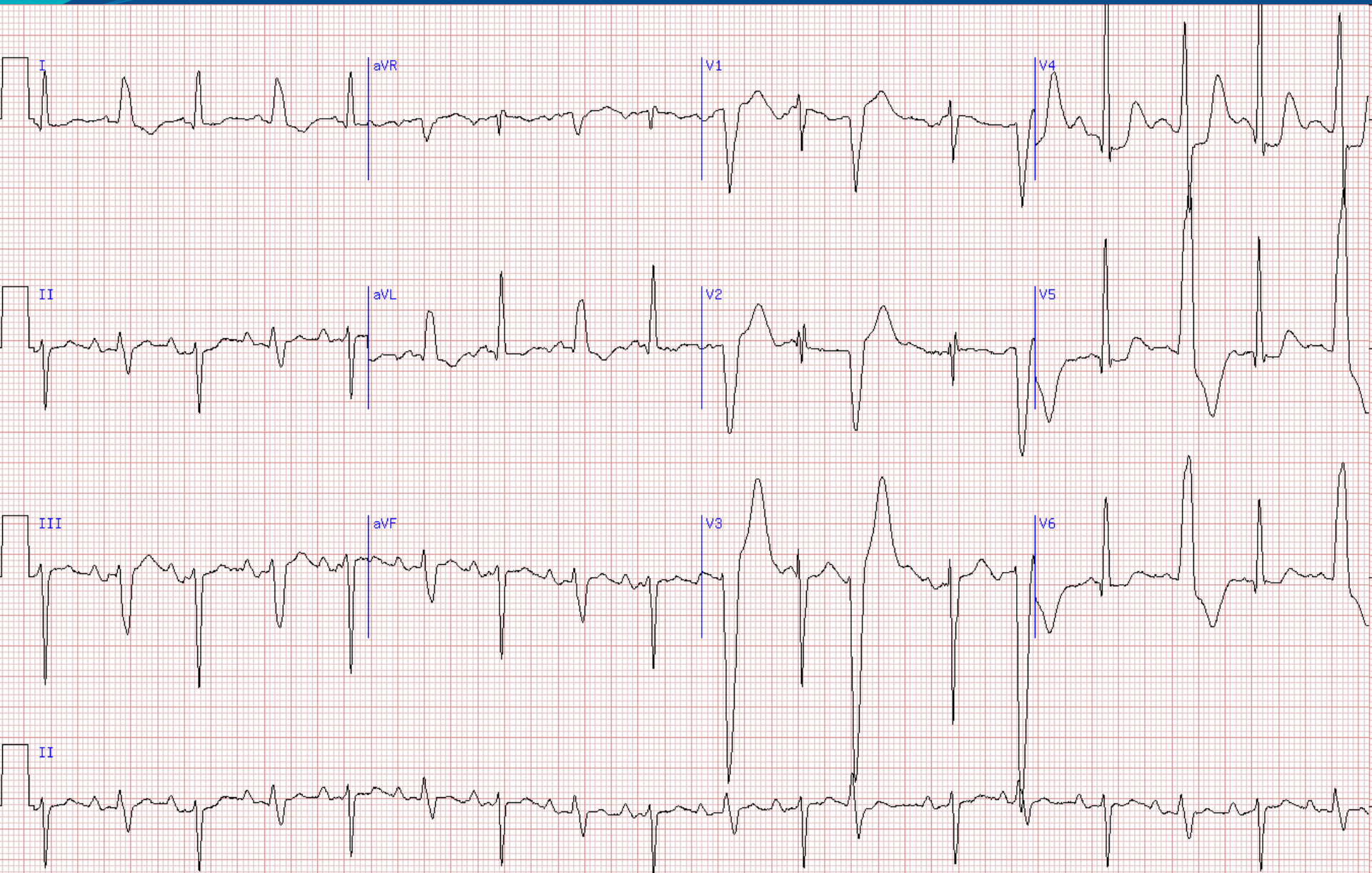








# Στο όριο του αρ. σκέλους



# Μέθοδος προσέγγισης

- Μετρήσεις
- Ανάλυση ρυθμού
- Ανάλυση αγωγής
- Περιγραφή κυματομορφής
- Γνωμάτευση
- Σύγκριση με προηγούμενα ΗΚΓ

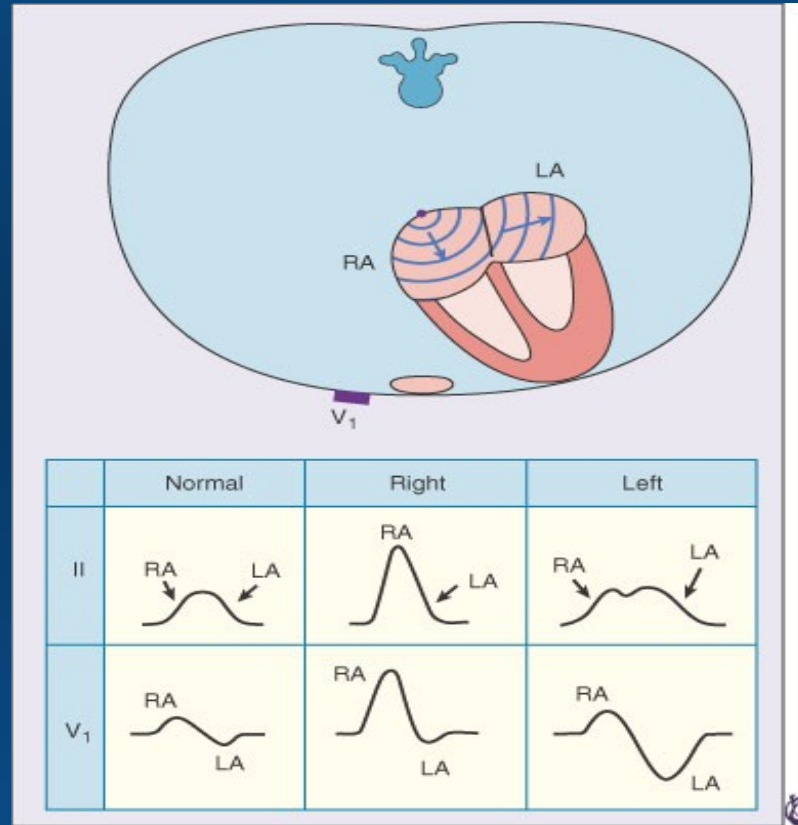


# Περιγραφή κυματομορφής

- P
- QRS
- ST
- T
- U



# Δεξιά & αριστερή κοιλιακή ανωμαλία

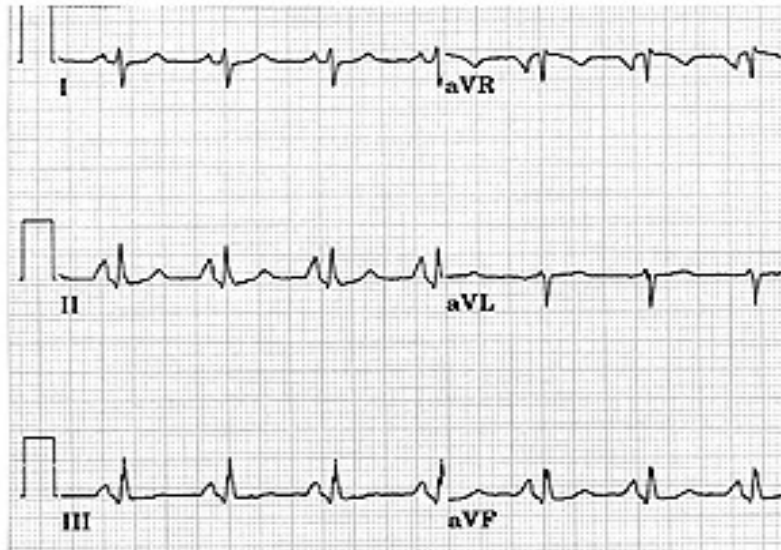


**FIGURE 12-17** Schematic representation of atrial depolarization (**diagram**) and P wave patterns associated with normal atrial activation (**left panel**) and with right (**middle panel**) and left (**right panel**) atrial abnormalities. LA = left atrium; RA = right atrium.

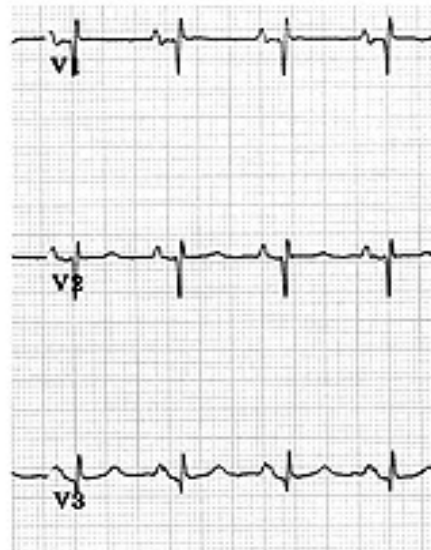
(Modified from Park MK, Guntheroth WG: *How to Read Pediatric ECGs*. 3rd ed. St. Louis, Mosby-Year Book, 1993, p 51.)



# Δεξιά & αριστερή κοιλική ανωμαλία



© 1997 Frank G. Yanowitz, M.D.



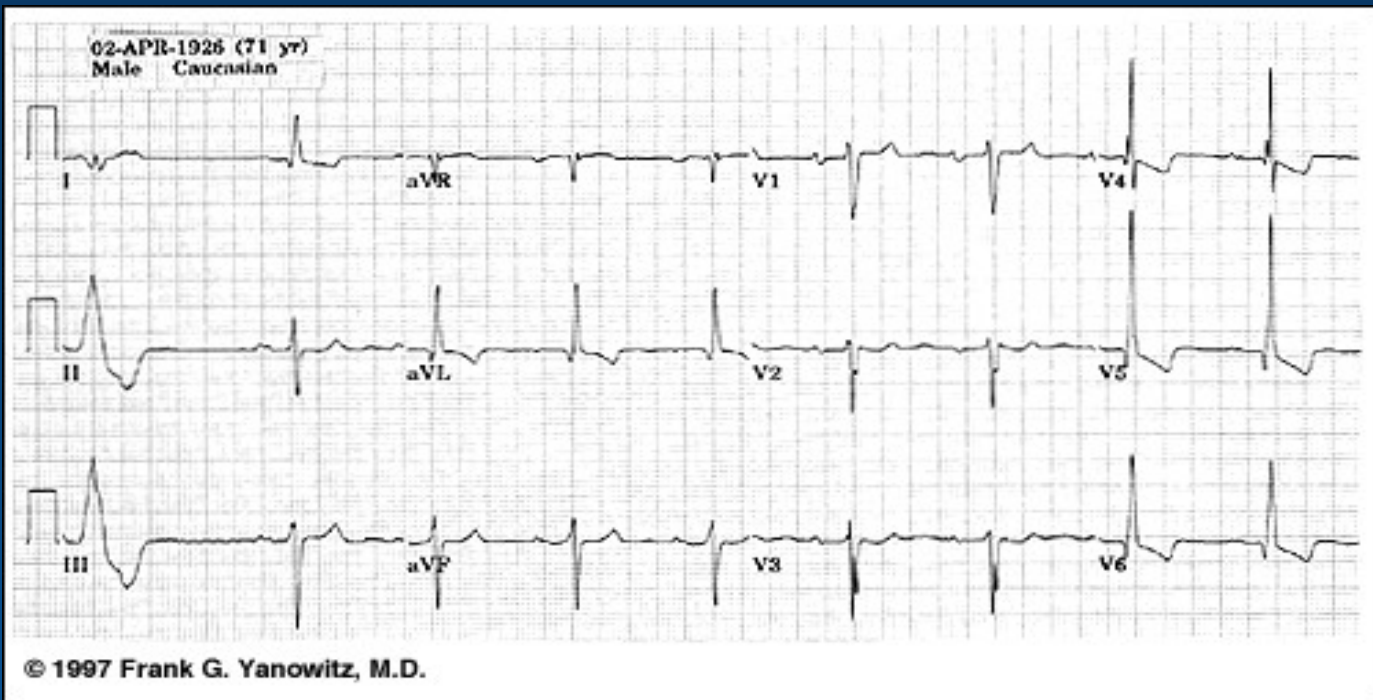
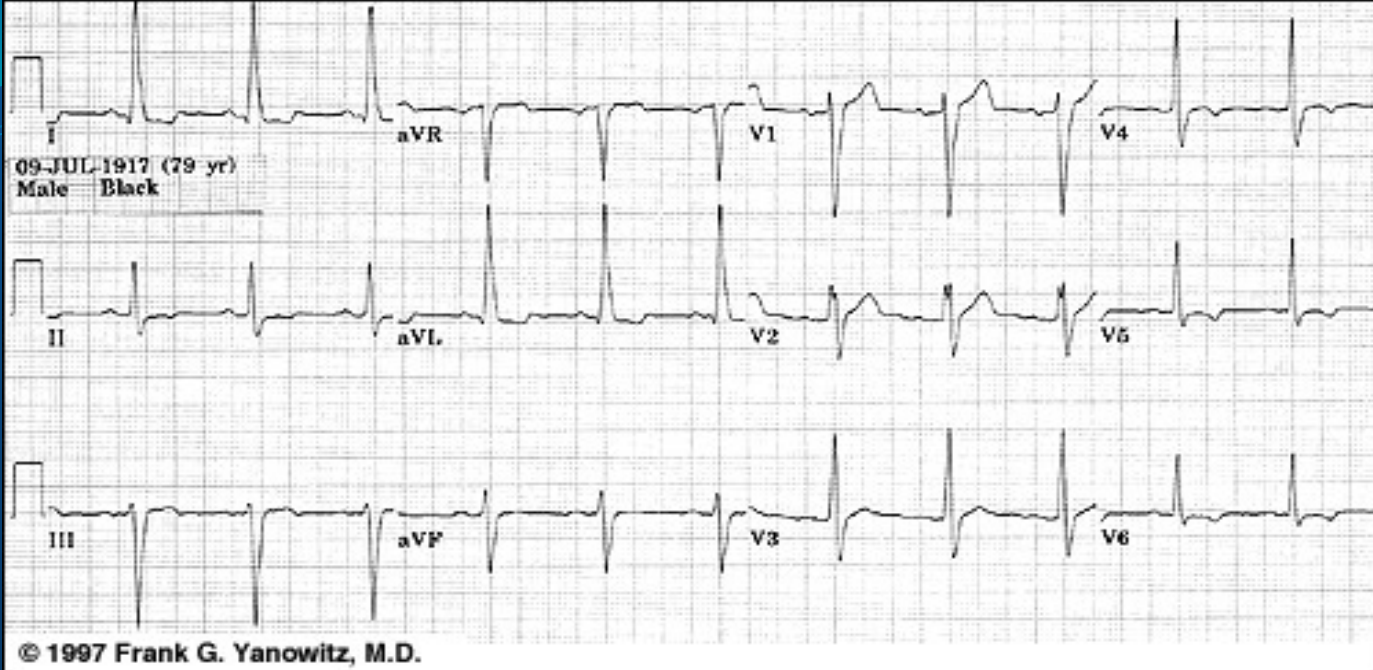
Lead II

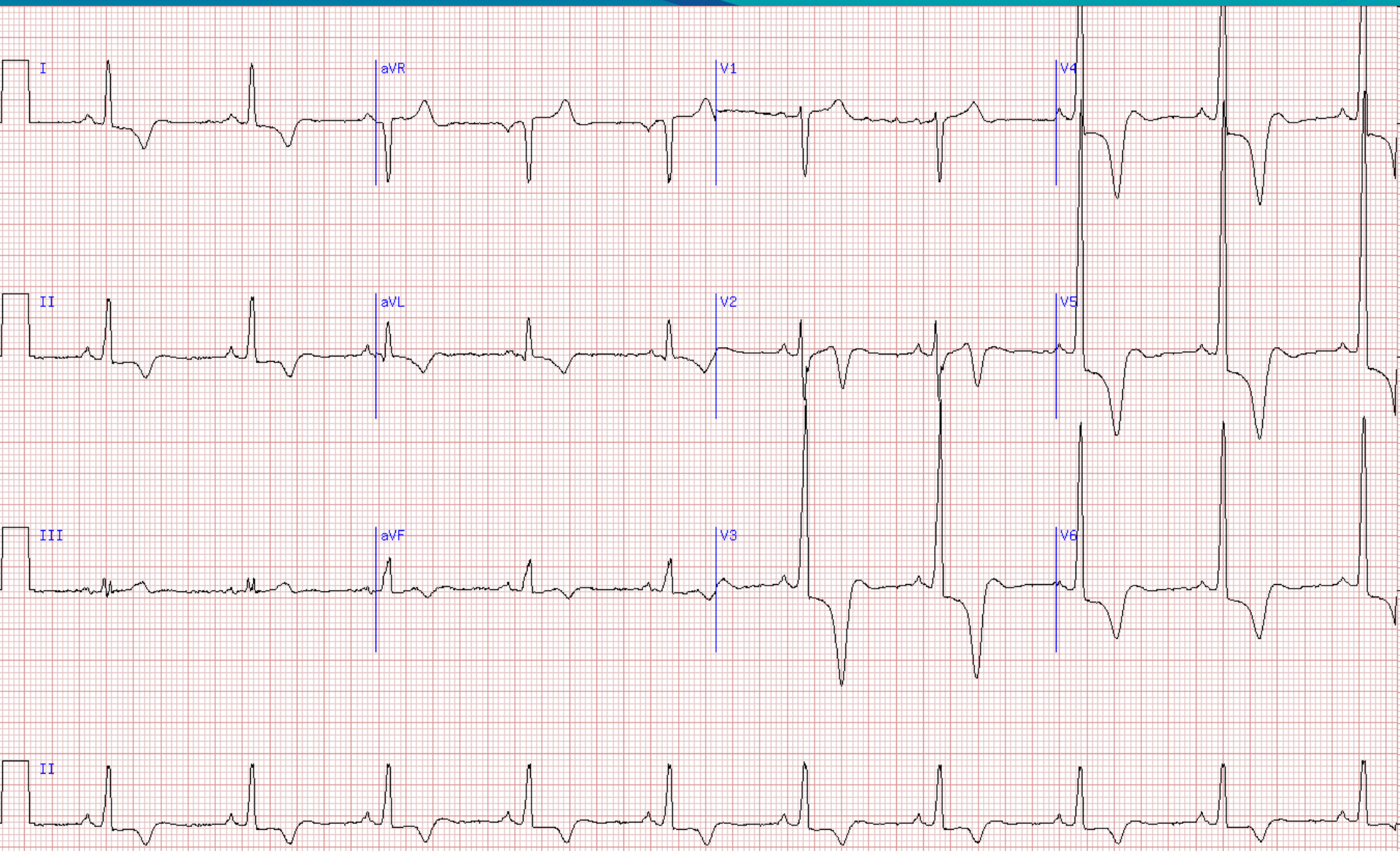


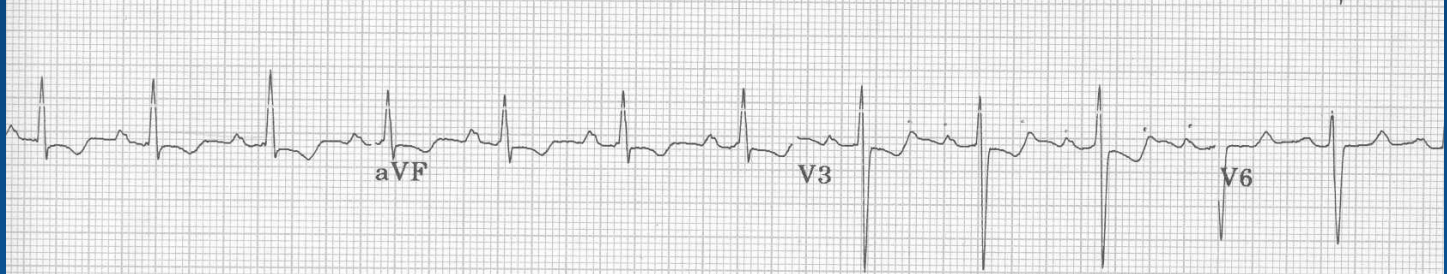
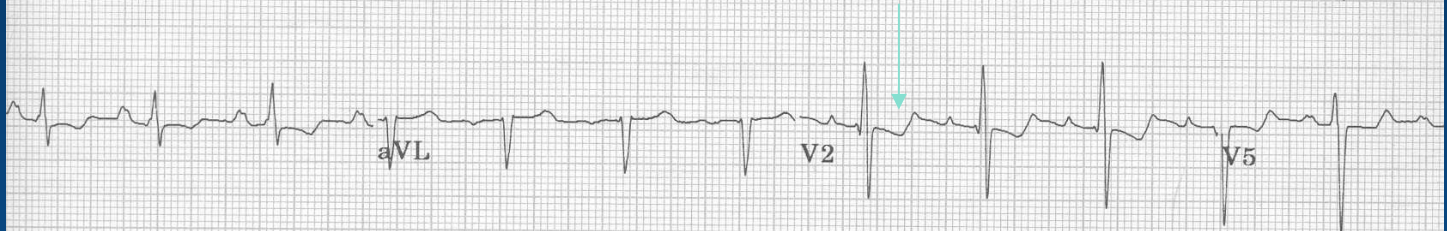
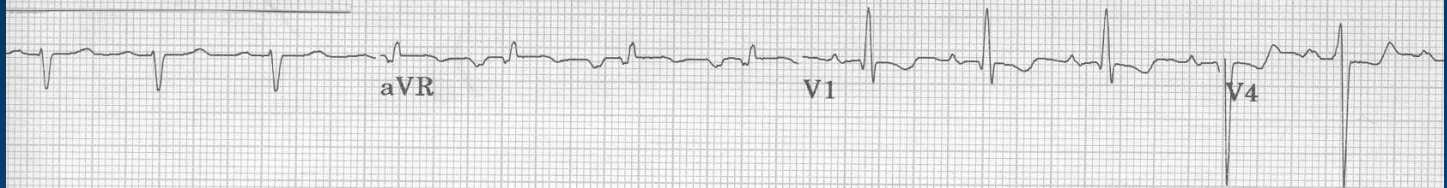
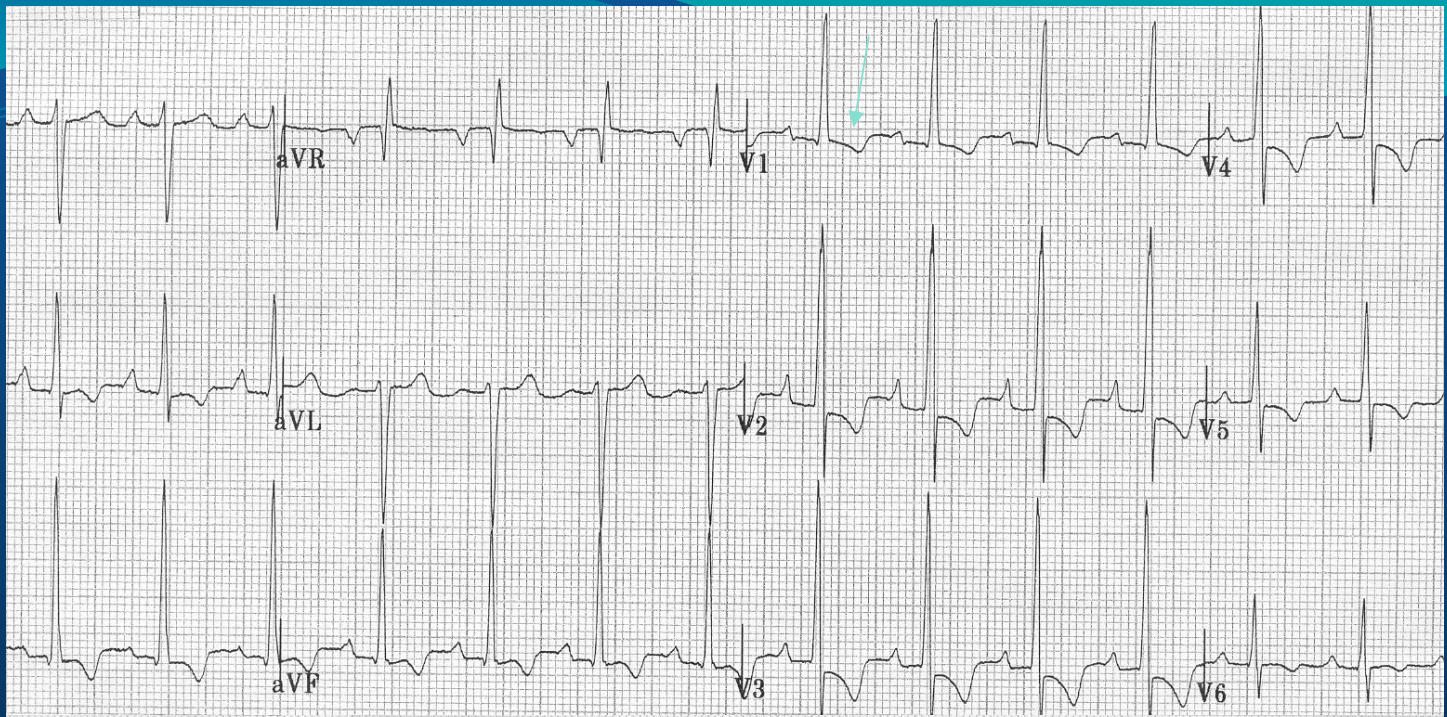
Lead V<sub>1</sub>



© 1997 Frank G. Yanowitz, M.D.

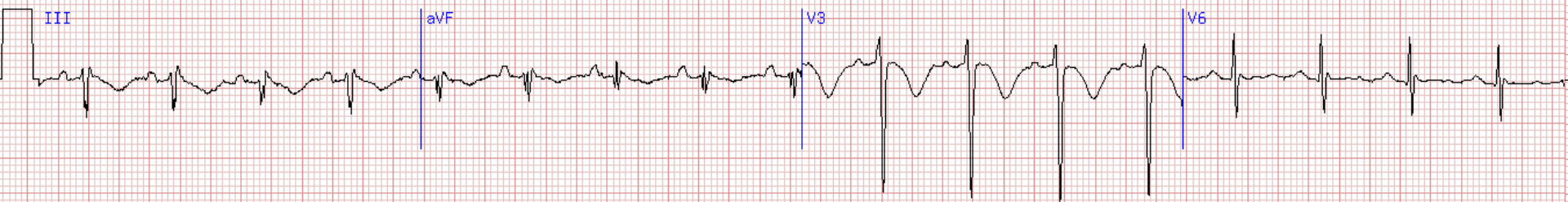
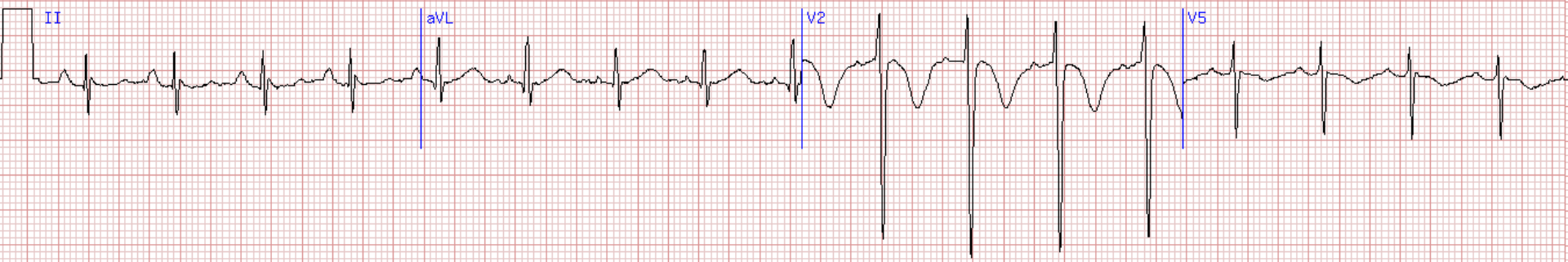
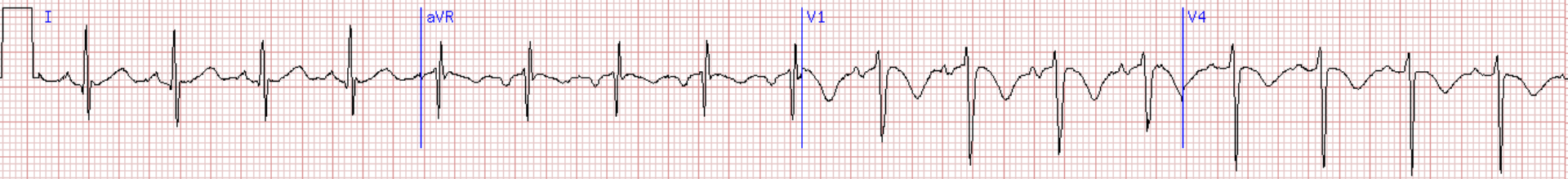




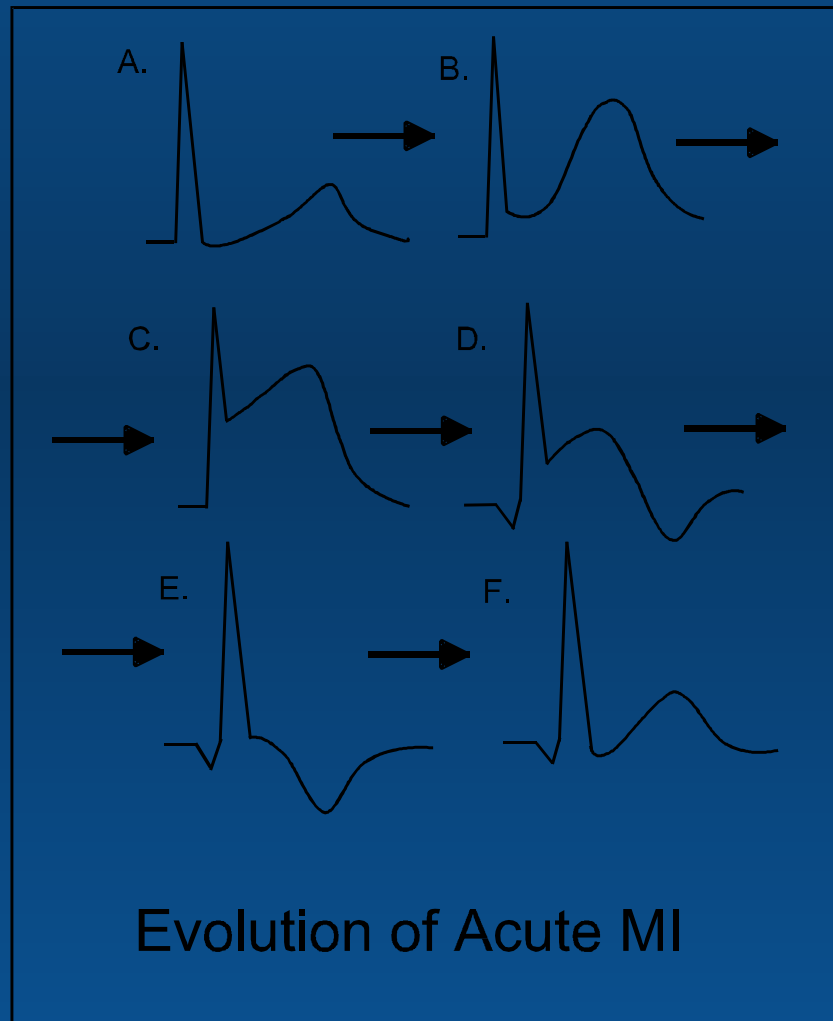




# Απροετοίμαστη Δεξιά



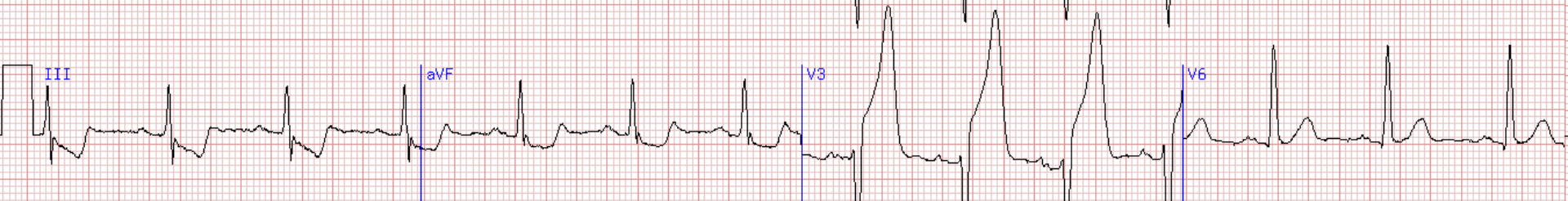
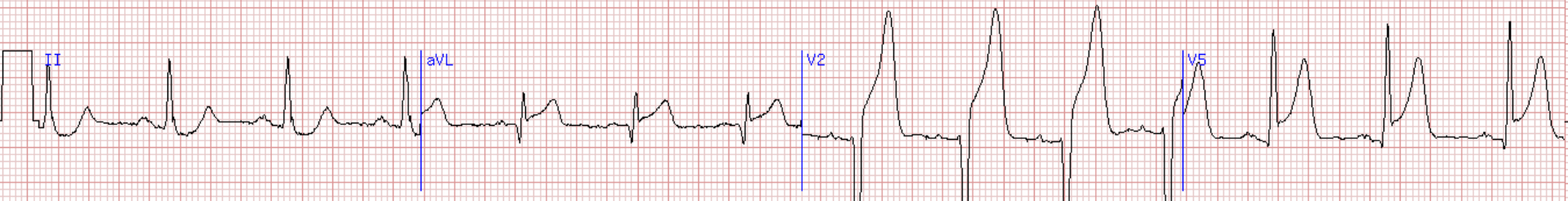
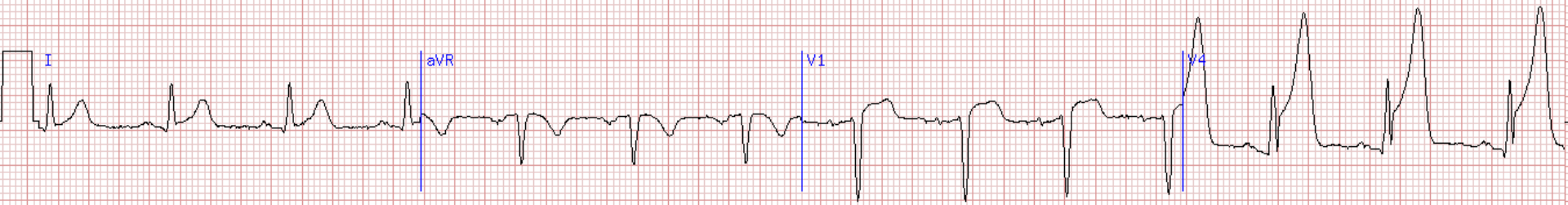
# OEM



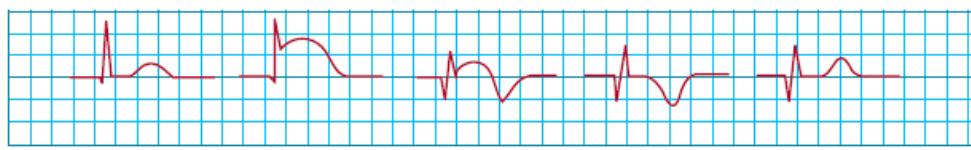
# Κατανομή

I Lateral	aVR None	V <sub>1</sub> Septal	V <sub>4</sub> Anterior
II Inferior	aVL Lateral	V <sub>2</sub> Septal	V <sub>5</sub> Lateral
III Inferior	aVF Inferior	V <sub>3</sub> Anterior	V <sub>6</sub> Lateral

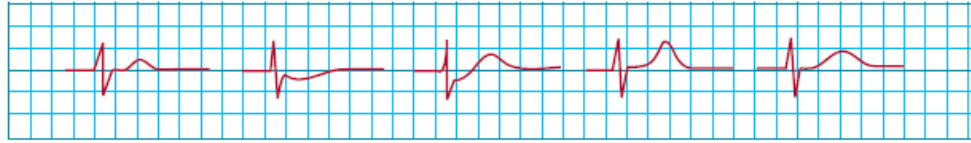




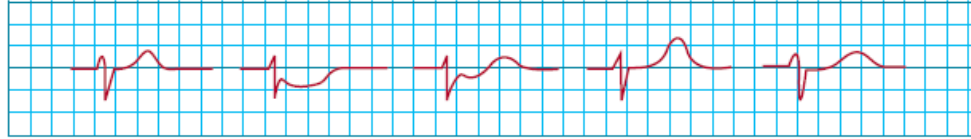
I



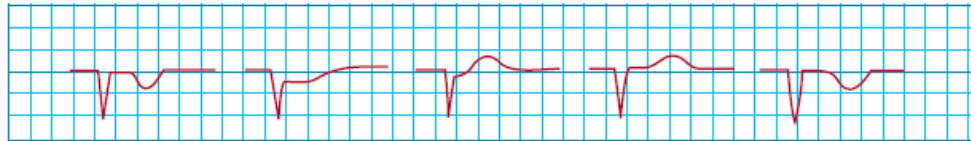
II



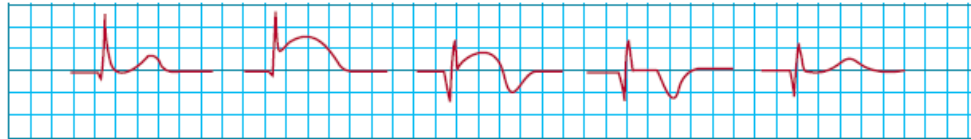
III



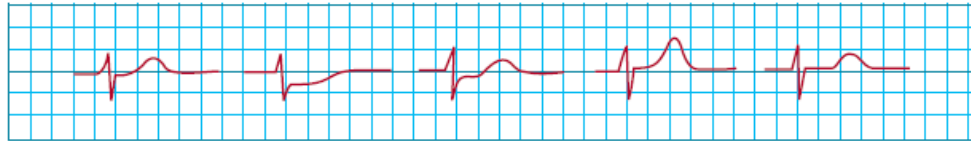
aVR



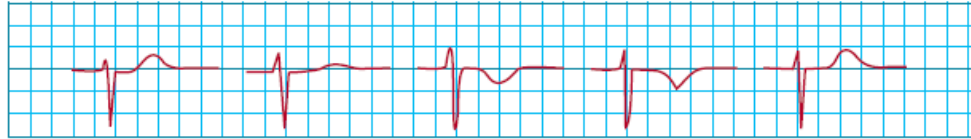
aVL



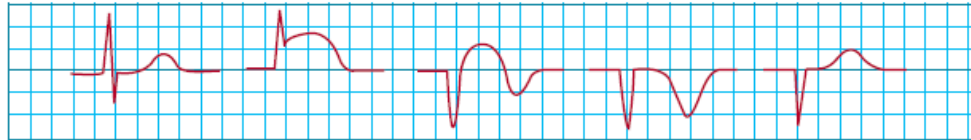
aVF



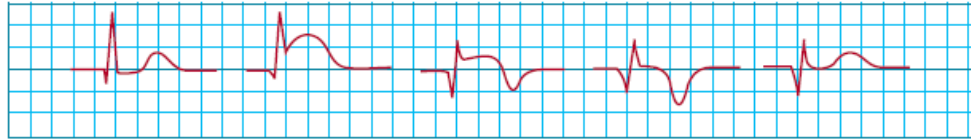
V<sub>1-2</sub>



V<sub>3-4</sub>



V<sub>5-6</sub>



A

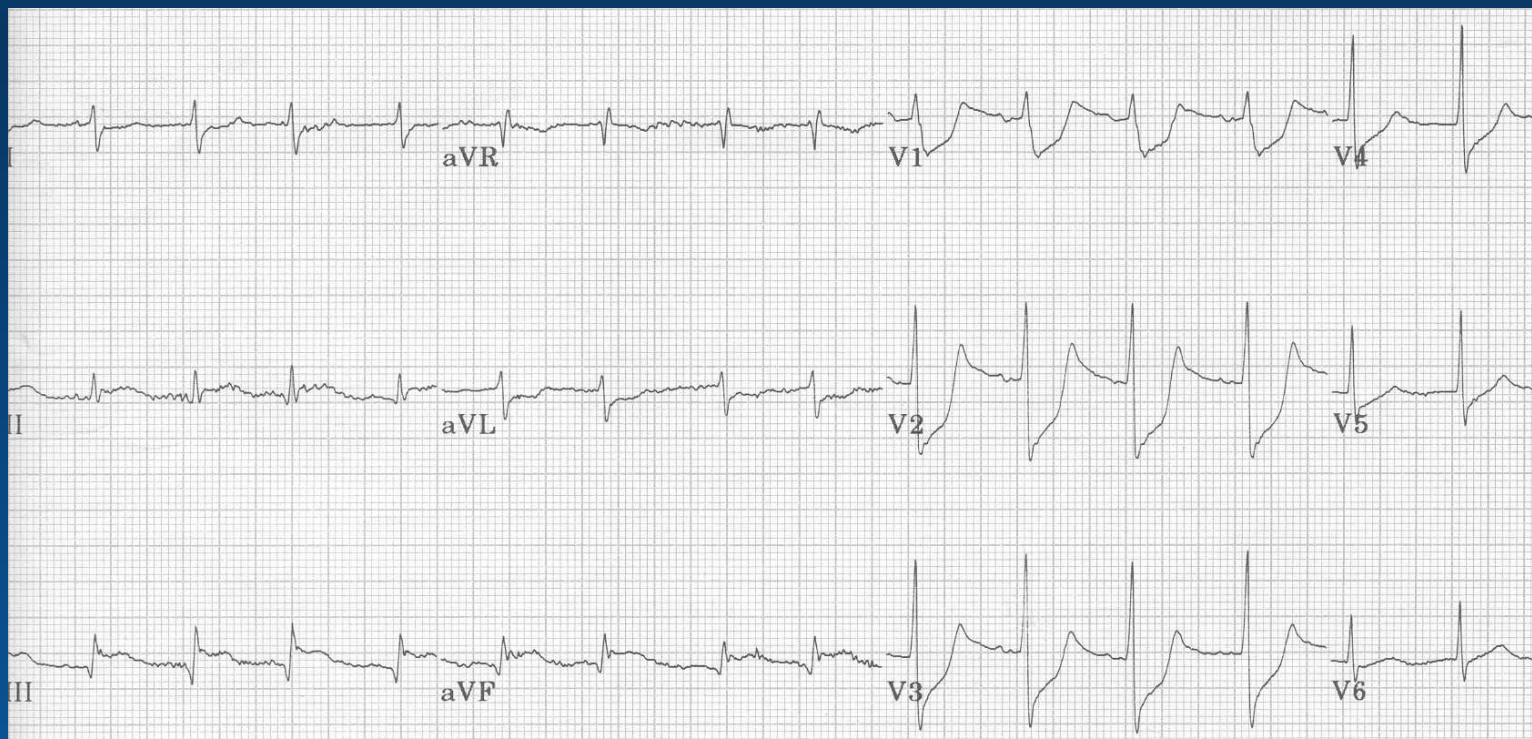
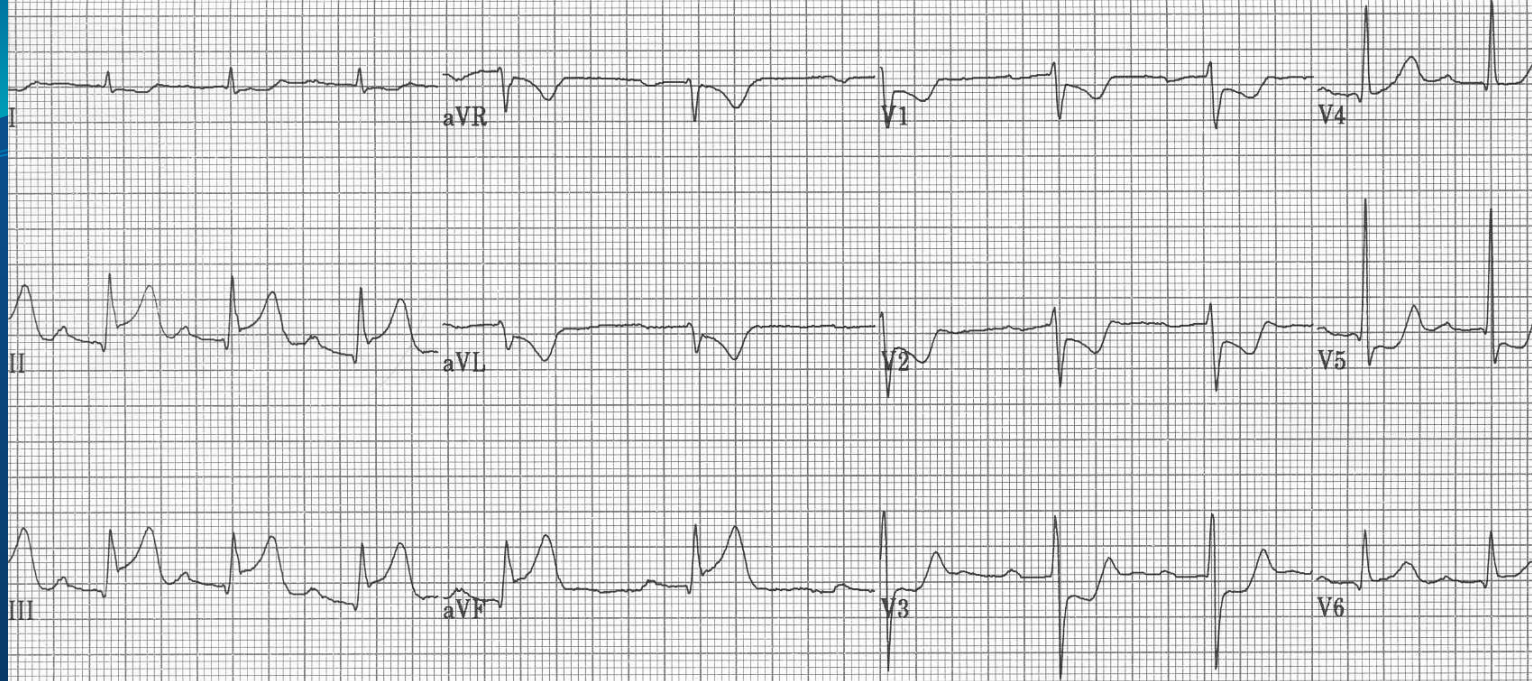
B

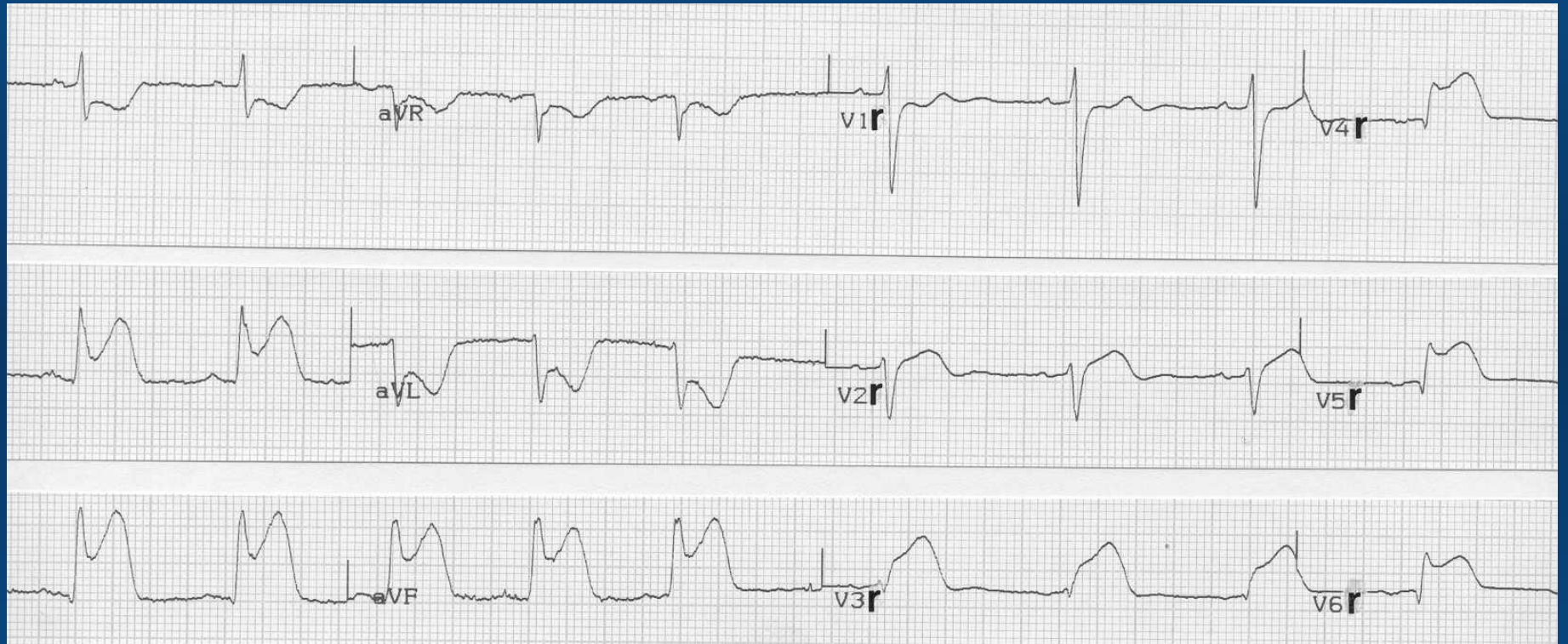
C

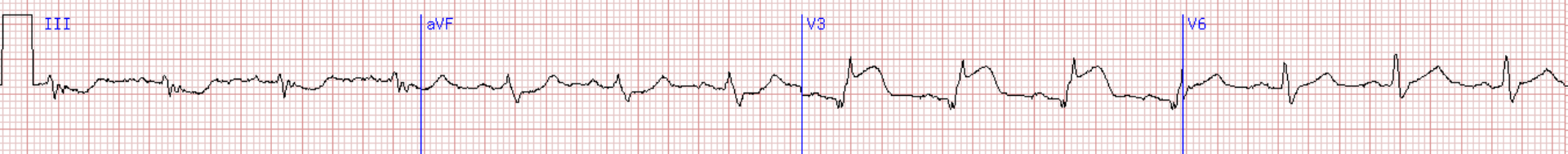
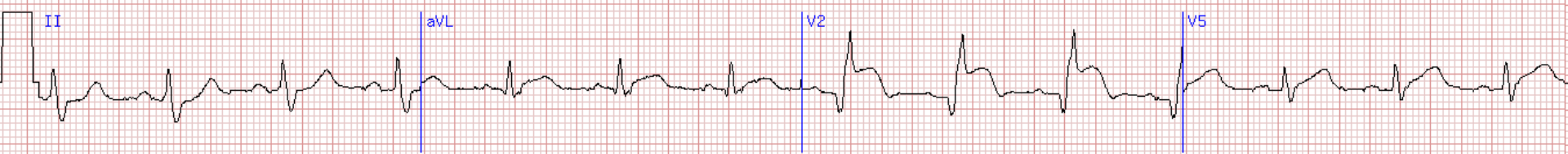
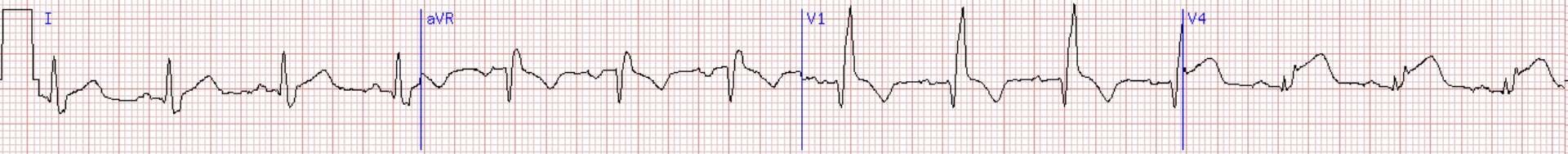
D

E



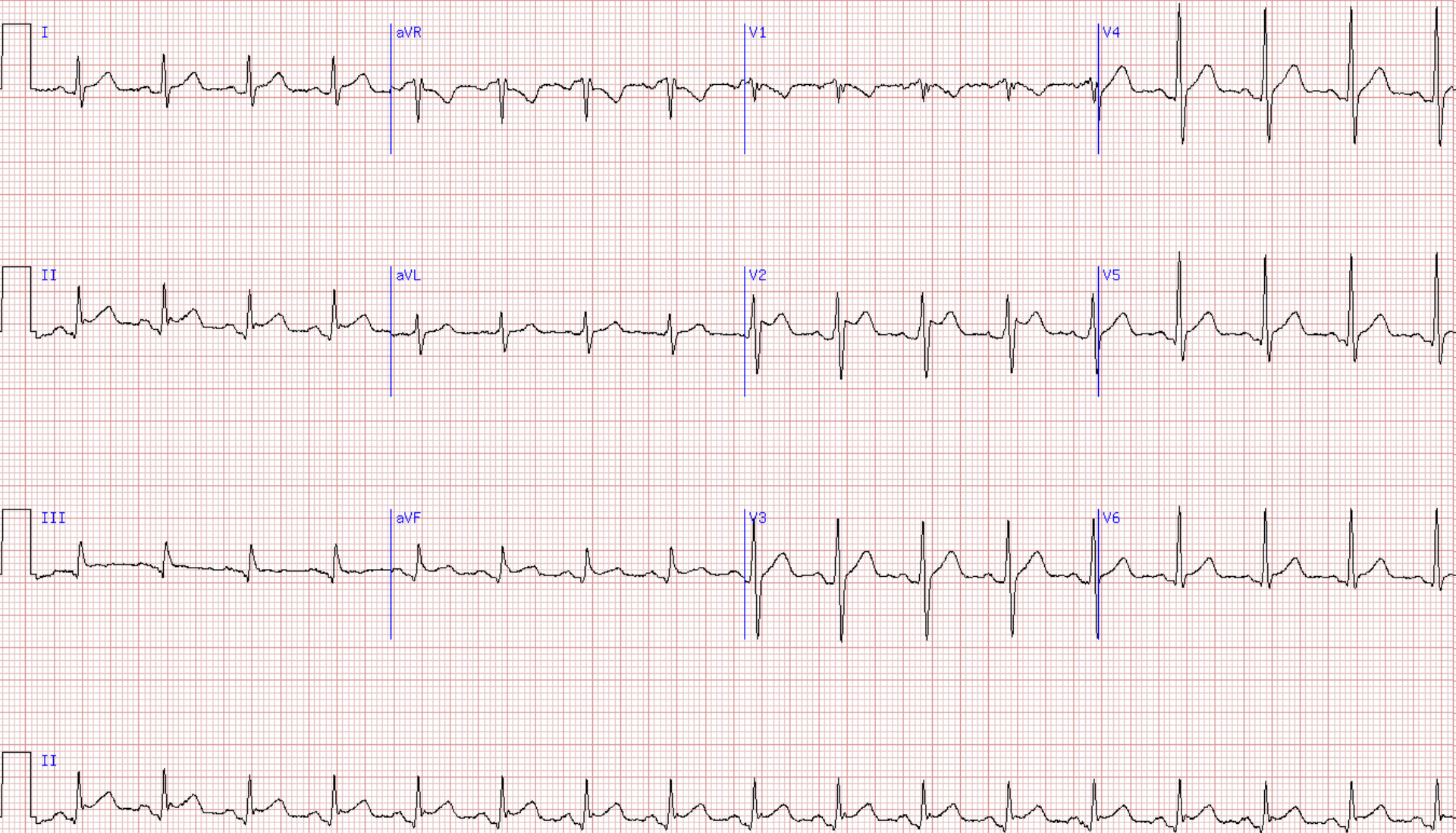


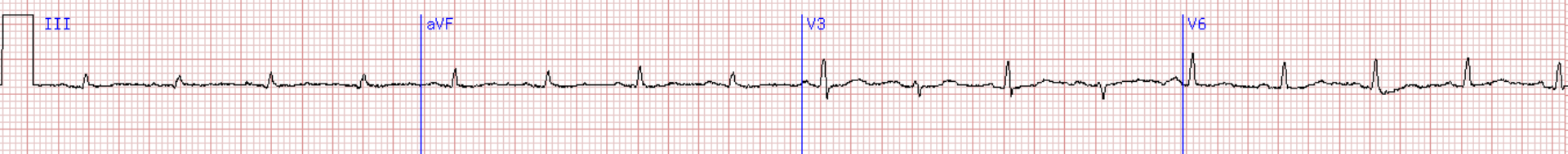
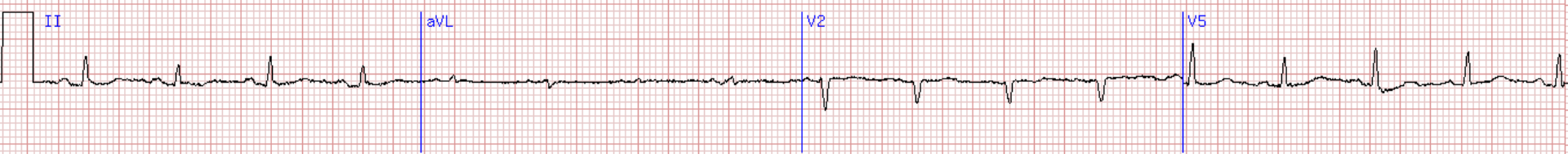




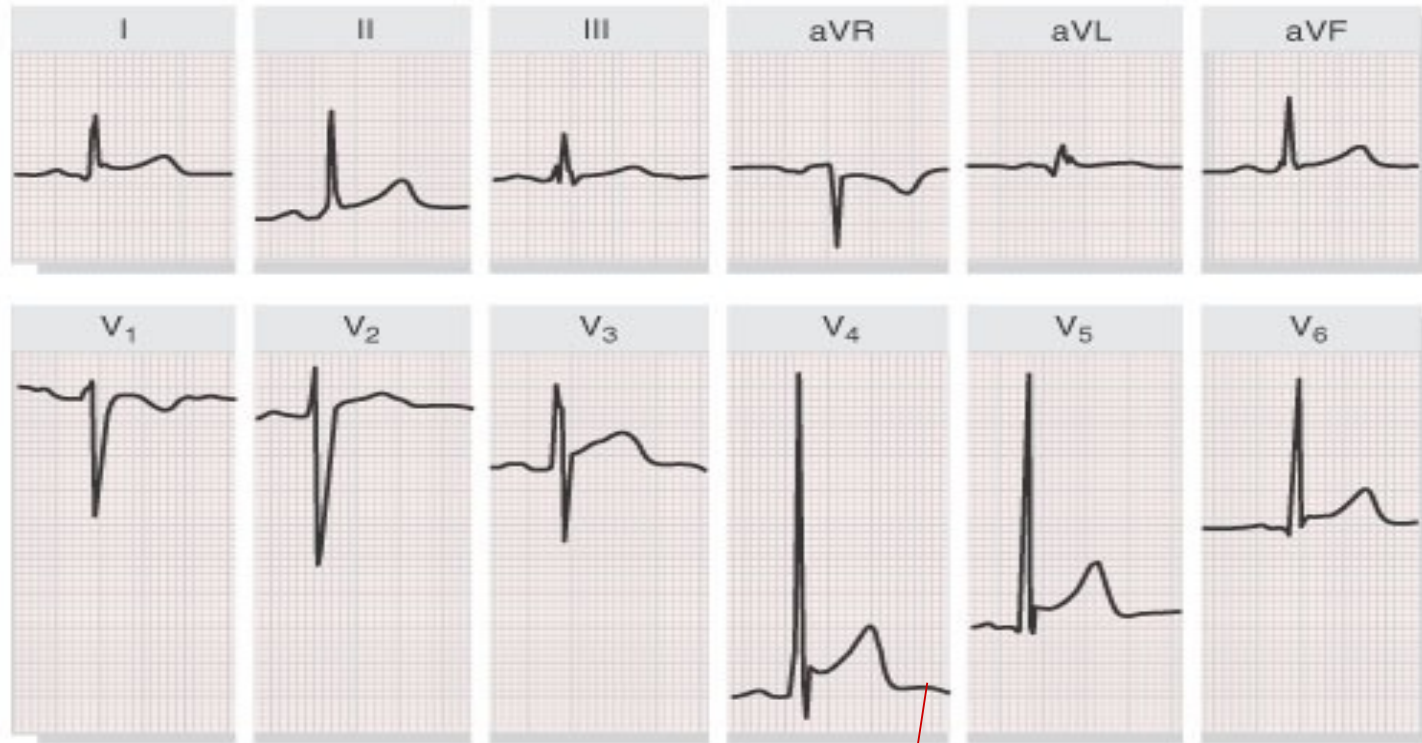


# Δεν είναι πάντα έμφραγμα





# Μα, δεν πονάει ...



**FIGURE 12-16** Normal variant pattern with functional ST elevations ("early repolarization" variant). These benign ST segment elevations are usually most marked in the midprecordial leads (here,  $V_4$ ). Note the absence of reciprocal ST depression (except in lead aVR), as well as the absence of PR segment deviation, which may be helpful in the differential diagnosis of ischemia and pericarditis, respectively. Note also that lead II has a baseline recording shift.

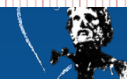
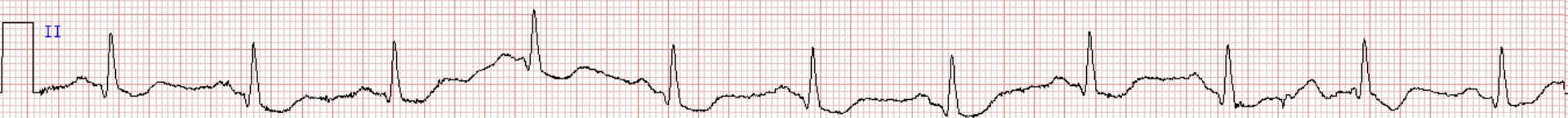
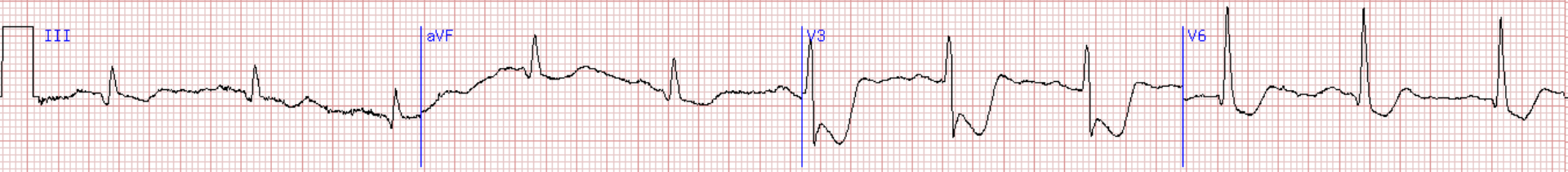
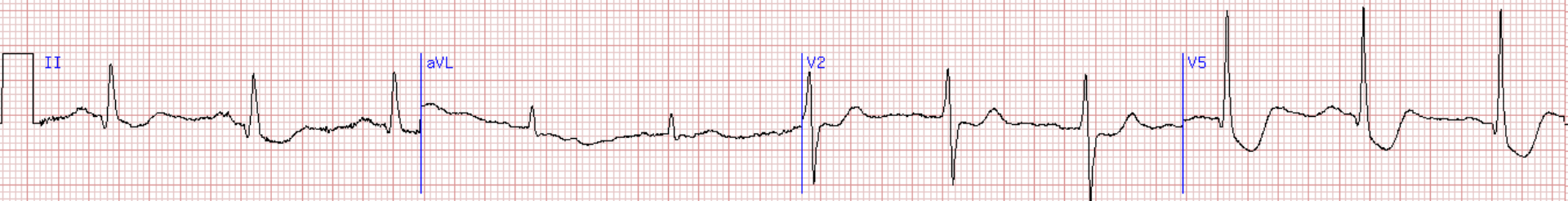
(From Goldberger AL: *Myocardial Infarction: Electrocardiographic Differential Diagnosis*. 4th ed. St. Louis, Mosby-Year Book, 1991, p 201.)

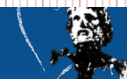
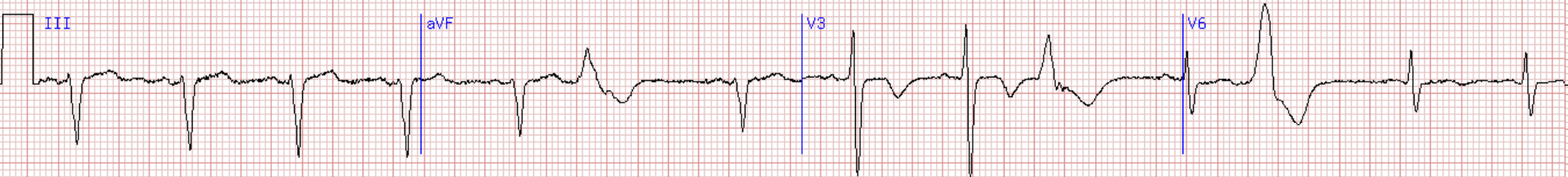
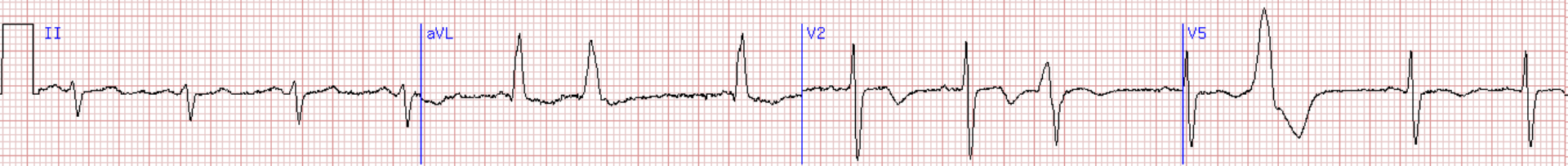
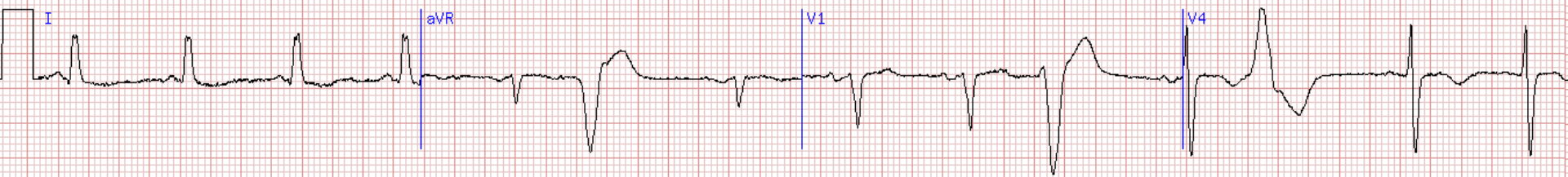


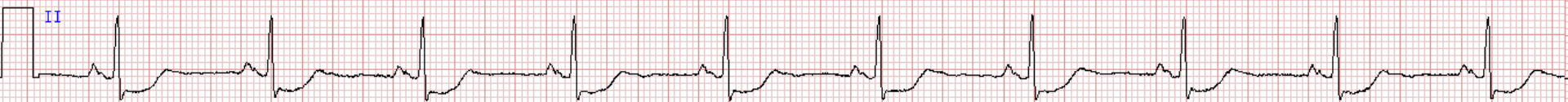
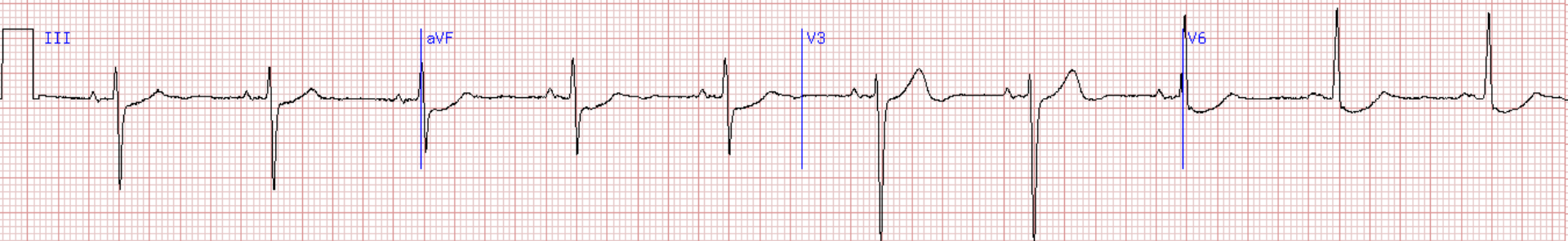
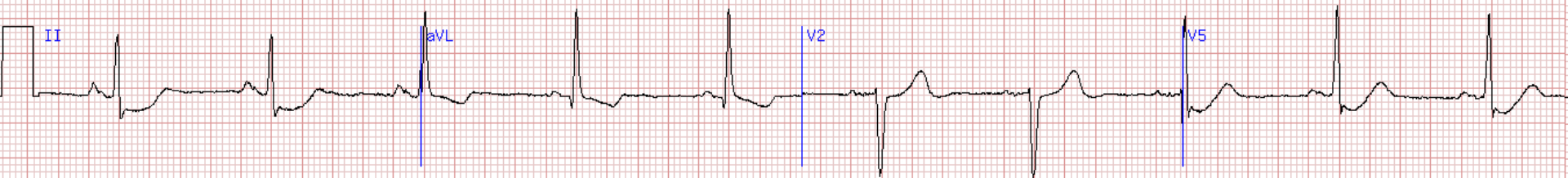
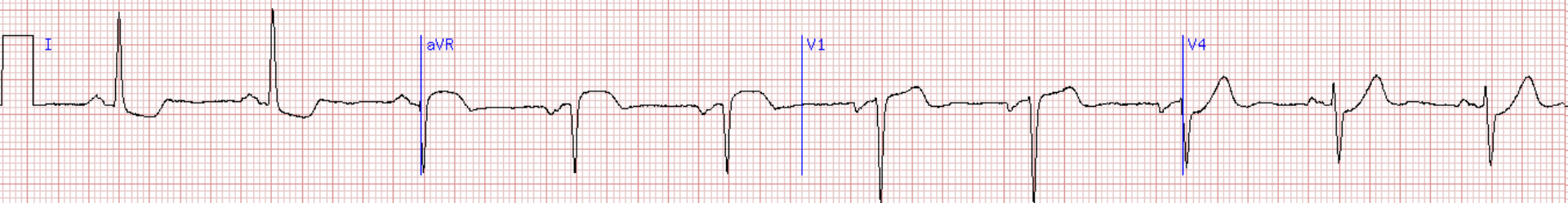
# Αίτια κατάσπασης ST

- Φυσιολογική παραλλαγή ή τέχνημα:
  - Ψευδο-ST-κατάσπαση
  - Φυσιολογική κατάσπαση του J-junctional με φλεβοκομβική ταχυκαρδία
  - Υπεραερισμός (stress)
- Υπενδοκάρδια ισχαιμία - NSTEMI
- Κάτοπτρο STEMI
- Αληθώς οπίσθιο EM (κατάσπαση ST V1-3)
- “Strain” στην RVH (Δεξιές προκάρδιες) και LVH (αριστερές προκάρδιες)
- Φάρμακα (π.χ. digoxin)









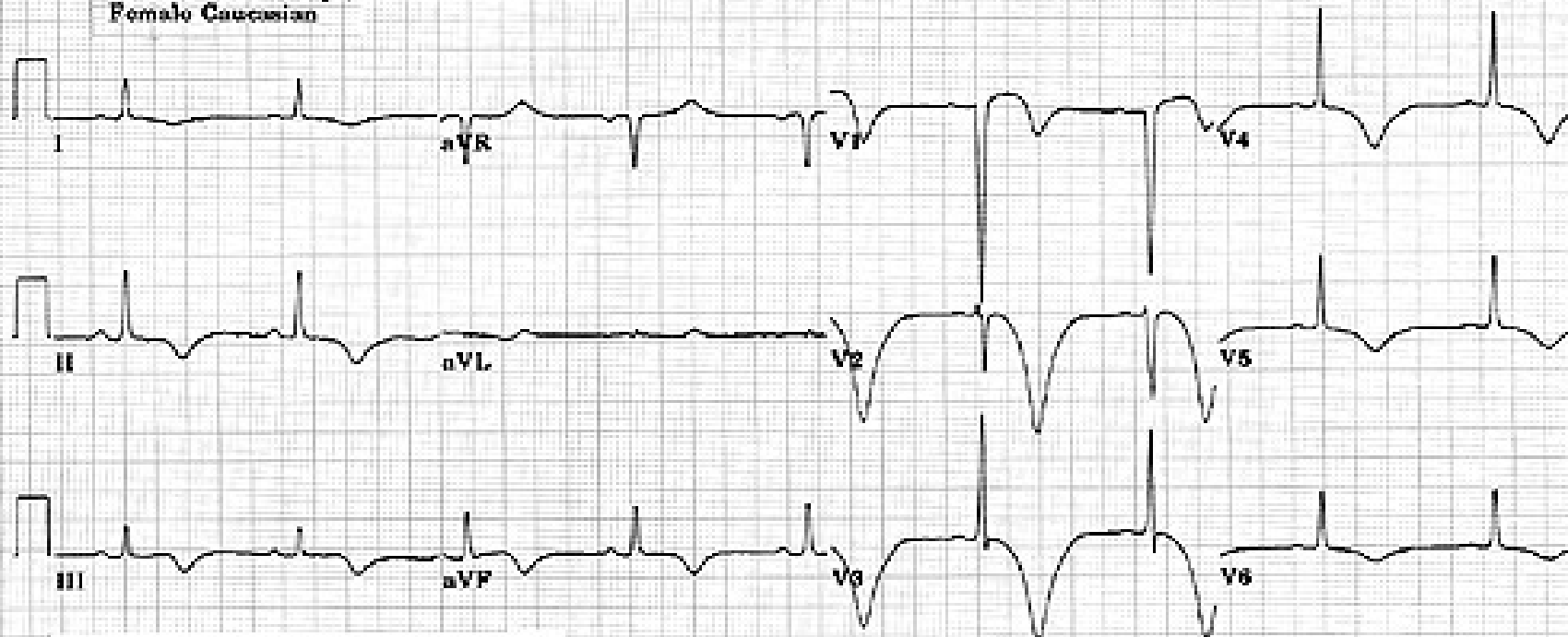
# Αίτια ανεστραμμένων T

- Ισχαιμία
- Υποξεία περικαρδίτις
- Μυοκαρδίτις
- Διάσειση μυοκαρδίου (τραύμα)
- Νόσοι του ΚΝΣ ( συχνά Υπαραχνοειδής)
- Νόσος Yamaguchi
- Πρόπτωση μιτροειδούς (ιδίως II, III, aVf)
- Δακτυλίτιδα
- Strain
- Ηλεκτρολύτες





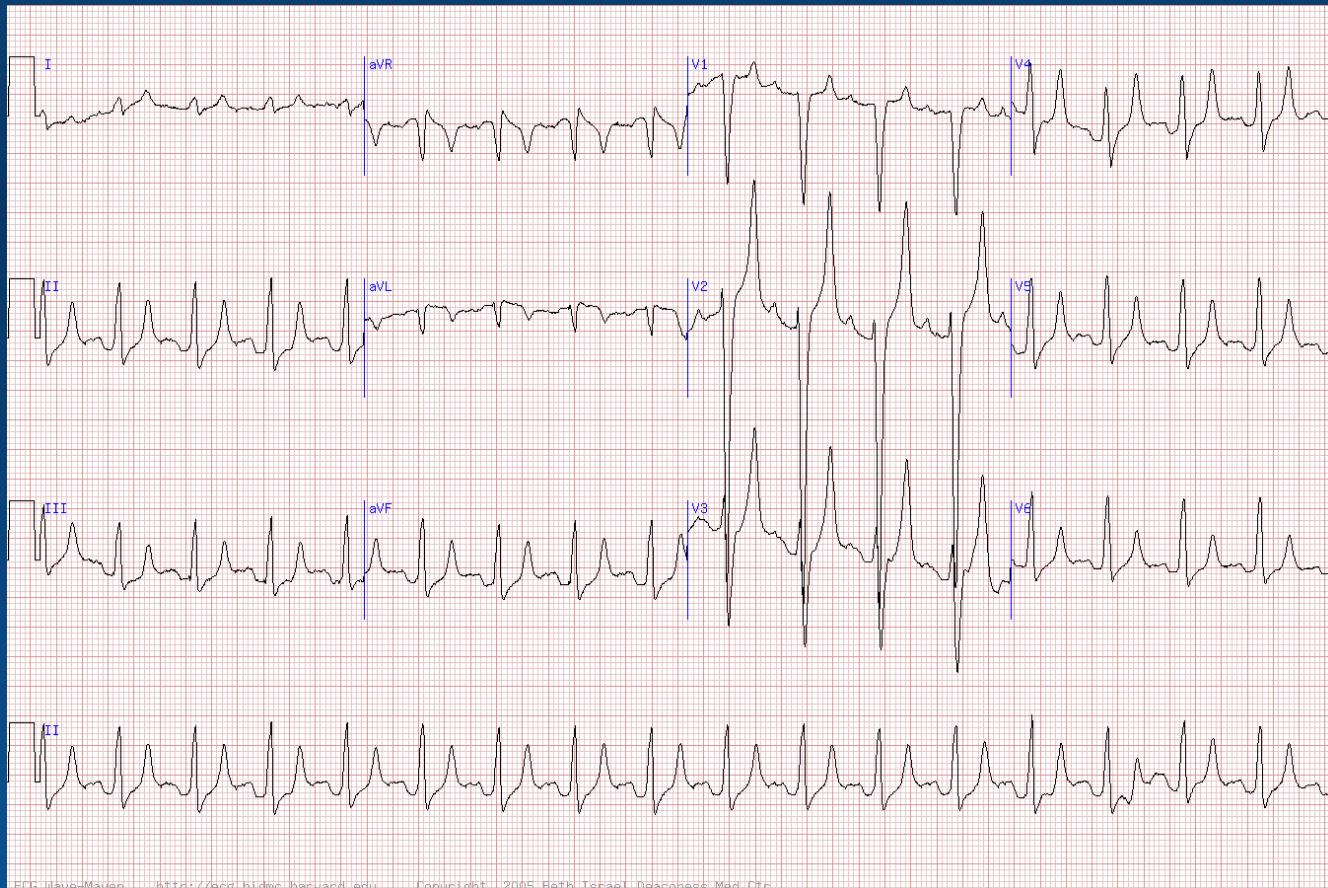
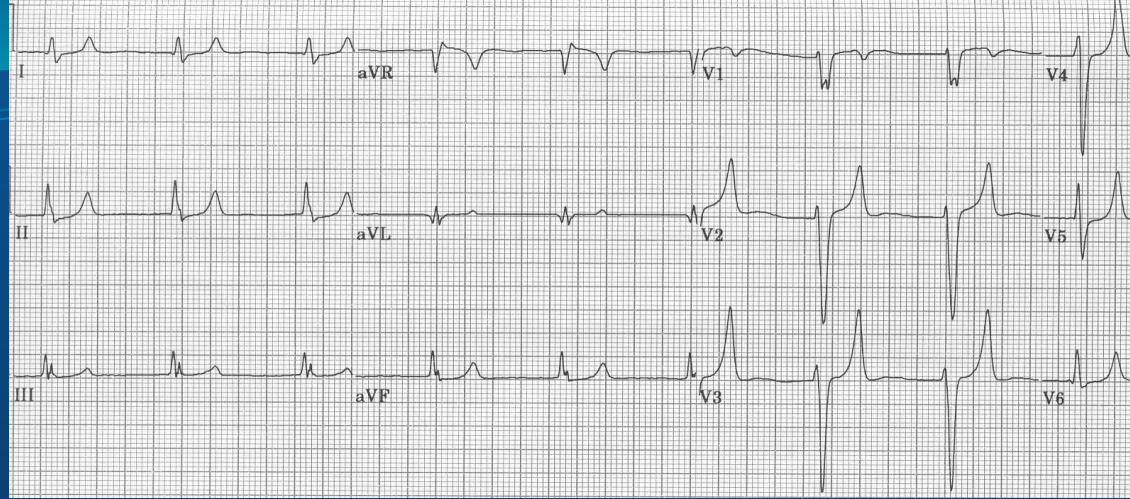
20-DEC-1920 (71 yr)  
Female Caucasian

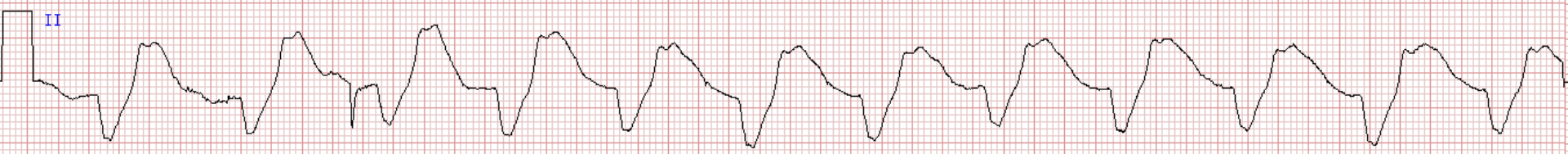
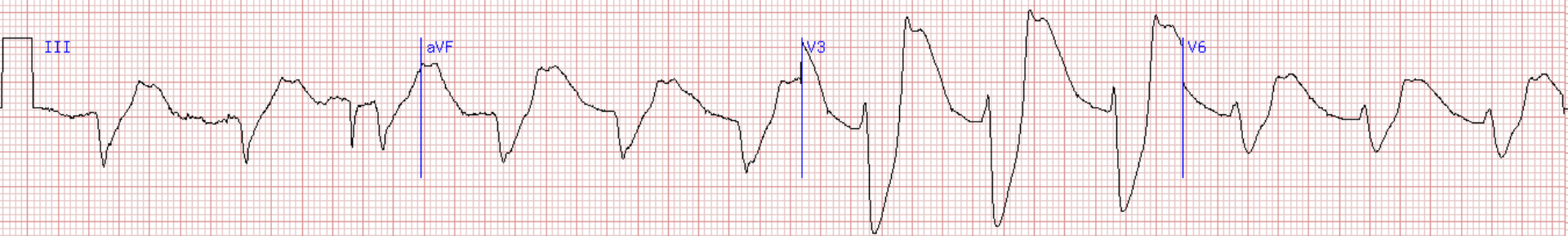
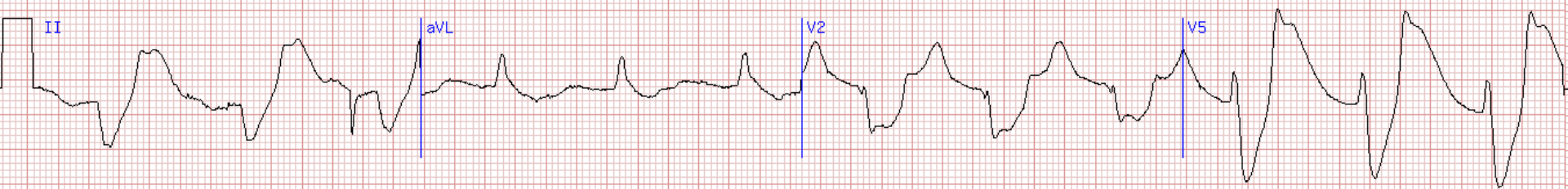
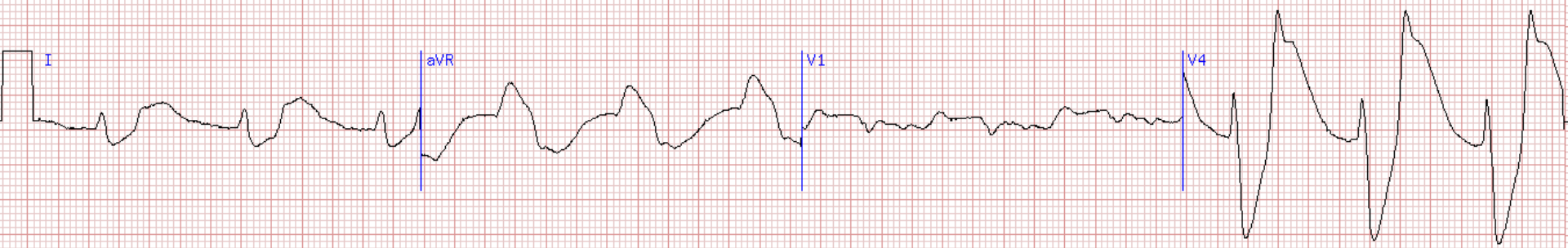


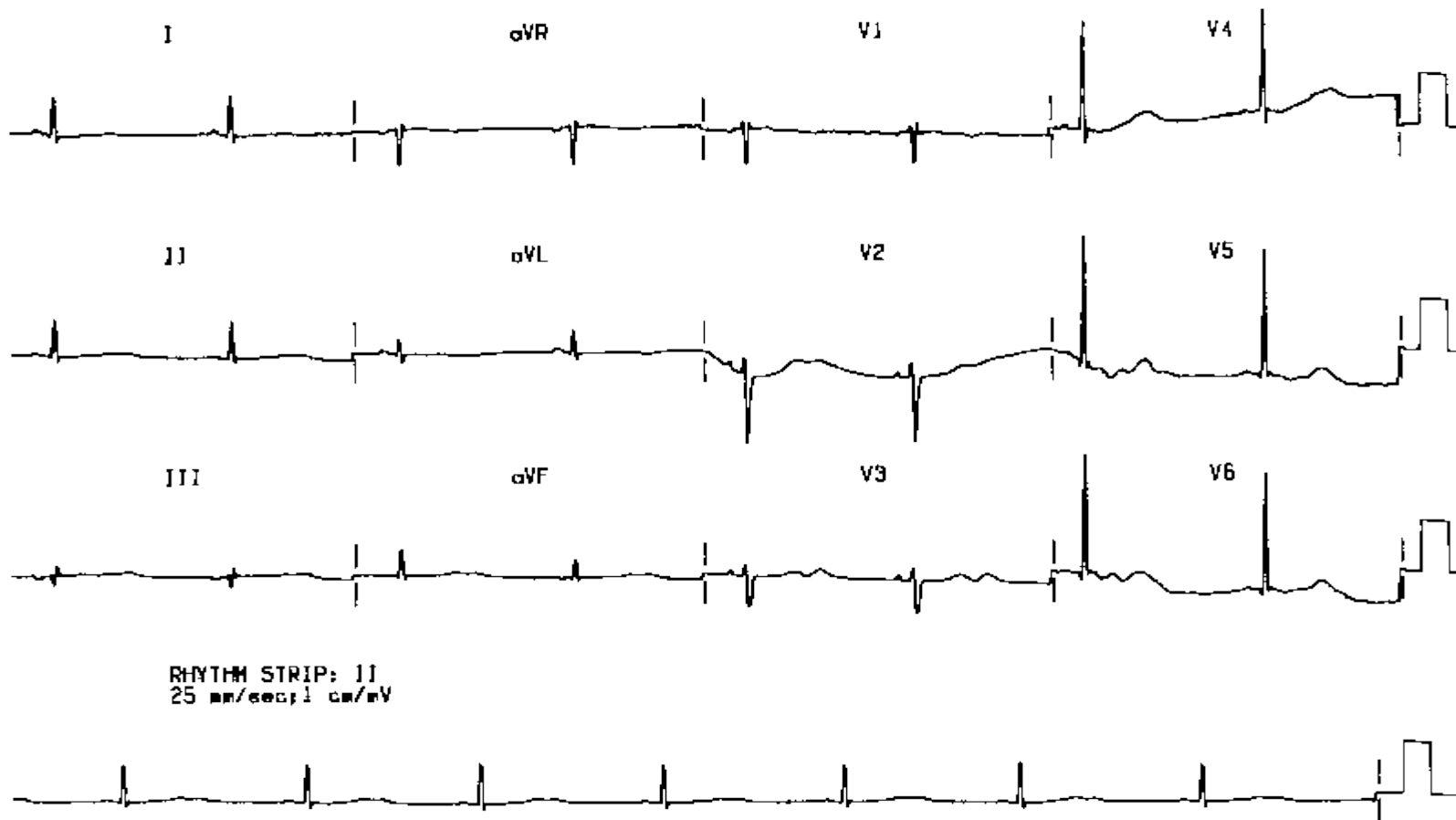
ID: 528607577 09-MAY-1992 07:00

© 1997 Frank G. Yanowitz, M.D.





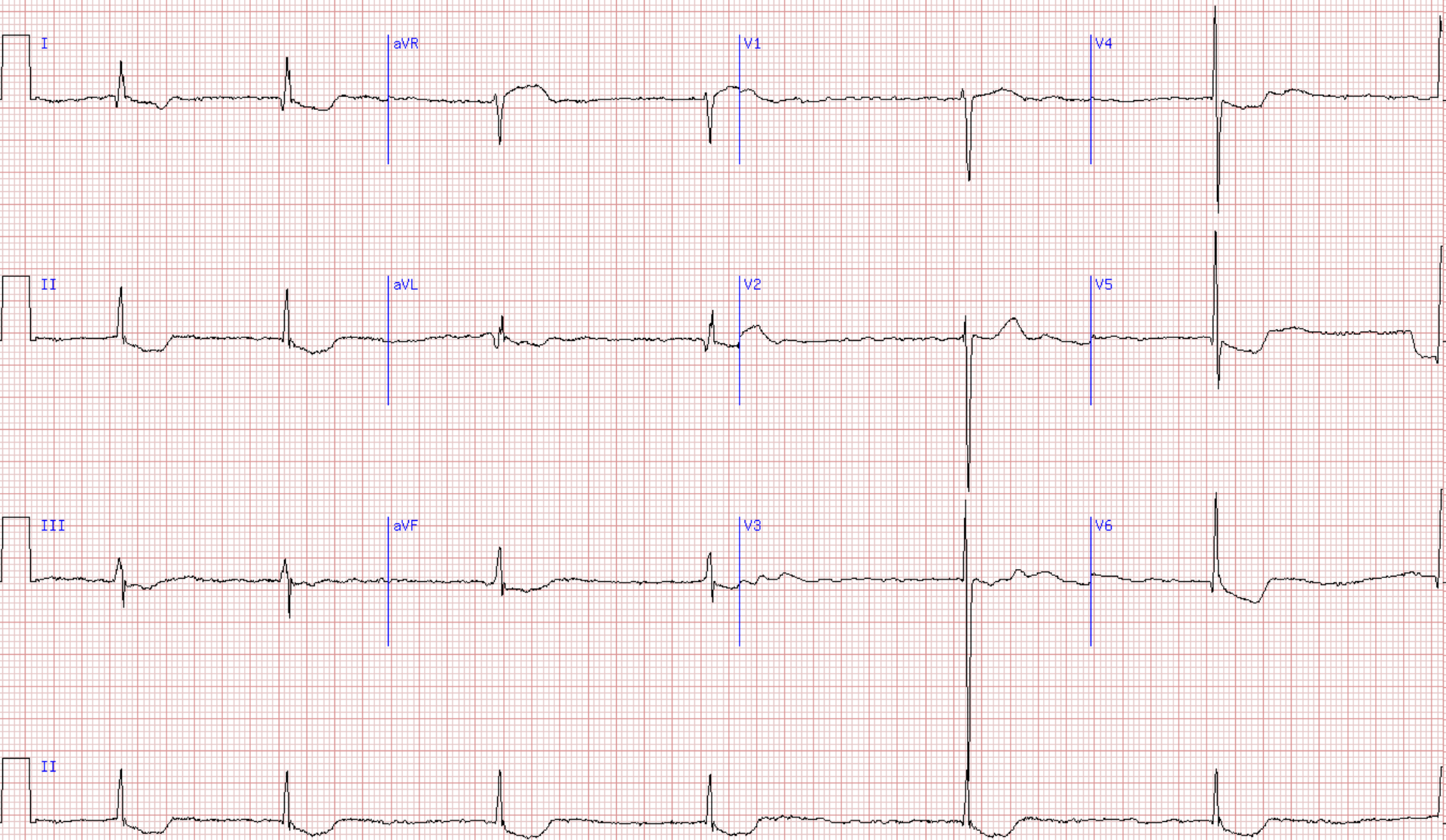


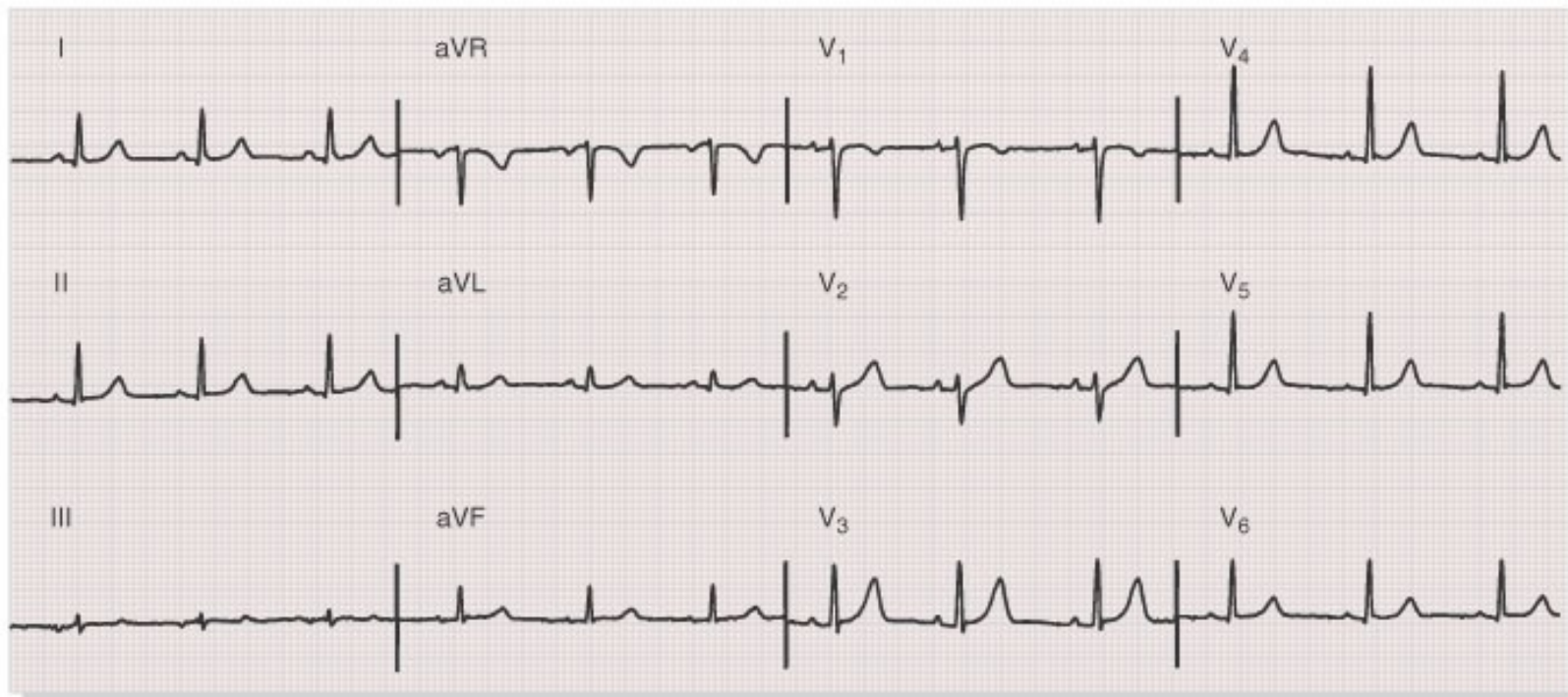


RHYTHM STRIP: 11  
25 mm/sec; 1 cm/mV



# Λακτυλίτιδα





**FIGURE 12–12** Normal electrocardiogram recorded from a 48-year-old woman. The vertical lines of the grid represent time, with lines spaced at 40-millisecond intervals. Horizontal lines represent voltage amplitude, with lines spaced at 0.1-mV intervals. Every fifth line in each direction is typically darkened. The heart rate is approximately 72 beats/min, the PR interval and QRS durations measure 140 and 84 milliseconds, respectively, the  $QT_c$  measures 400, and the mean QRS axis is approximately +35 degrees.