ECG Recognition of Myocardial Ischemia & Infarction

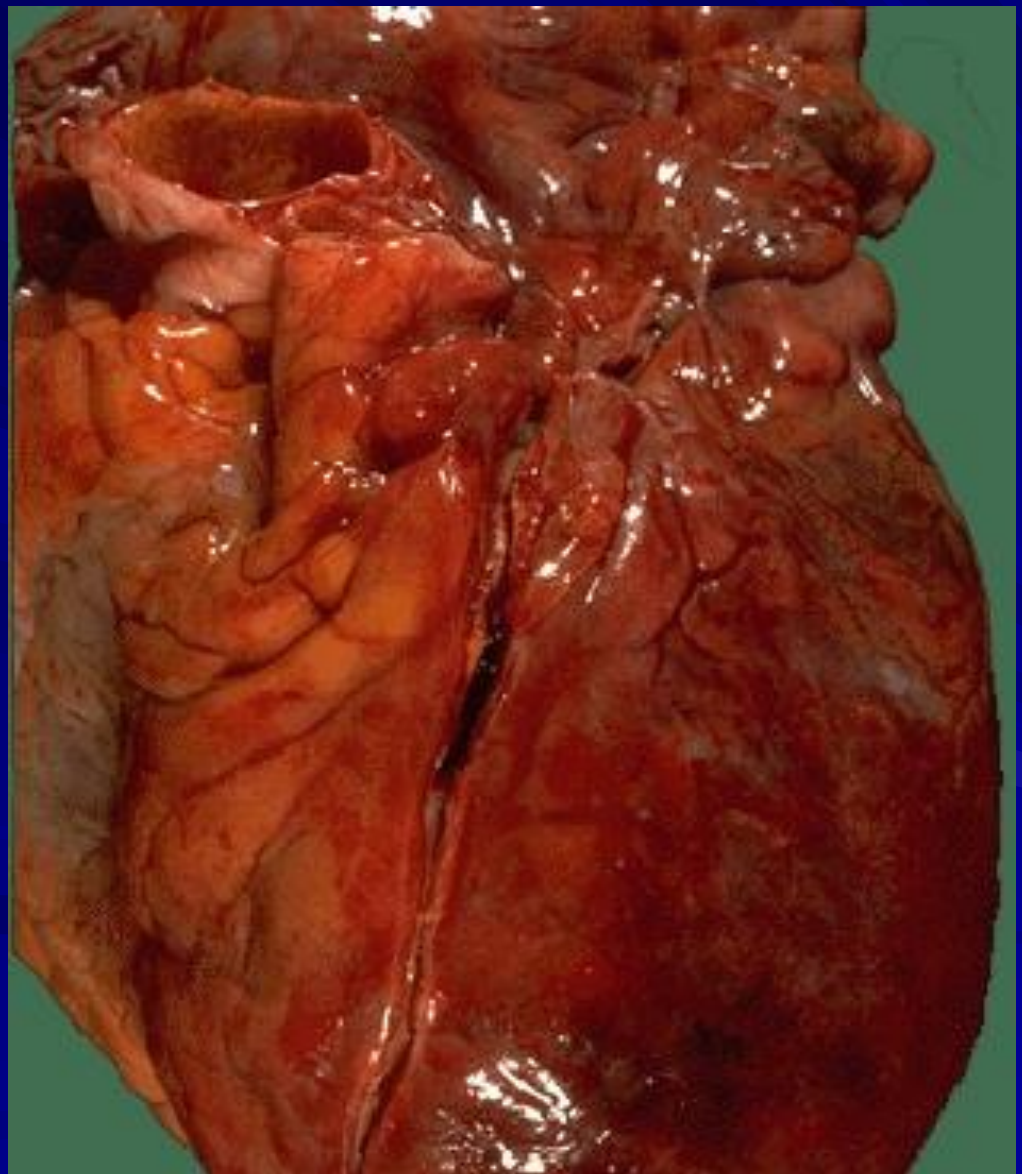
J. Lee Garvey, MD

Department of Emergency Medicine
Carolinas Medical Center

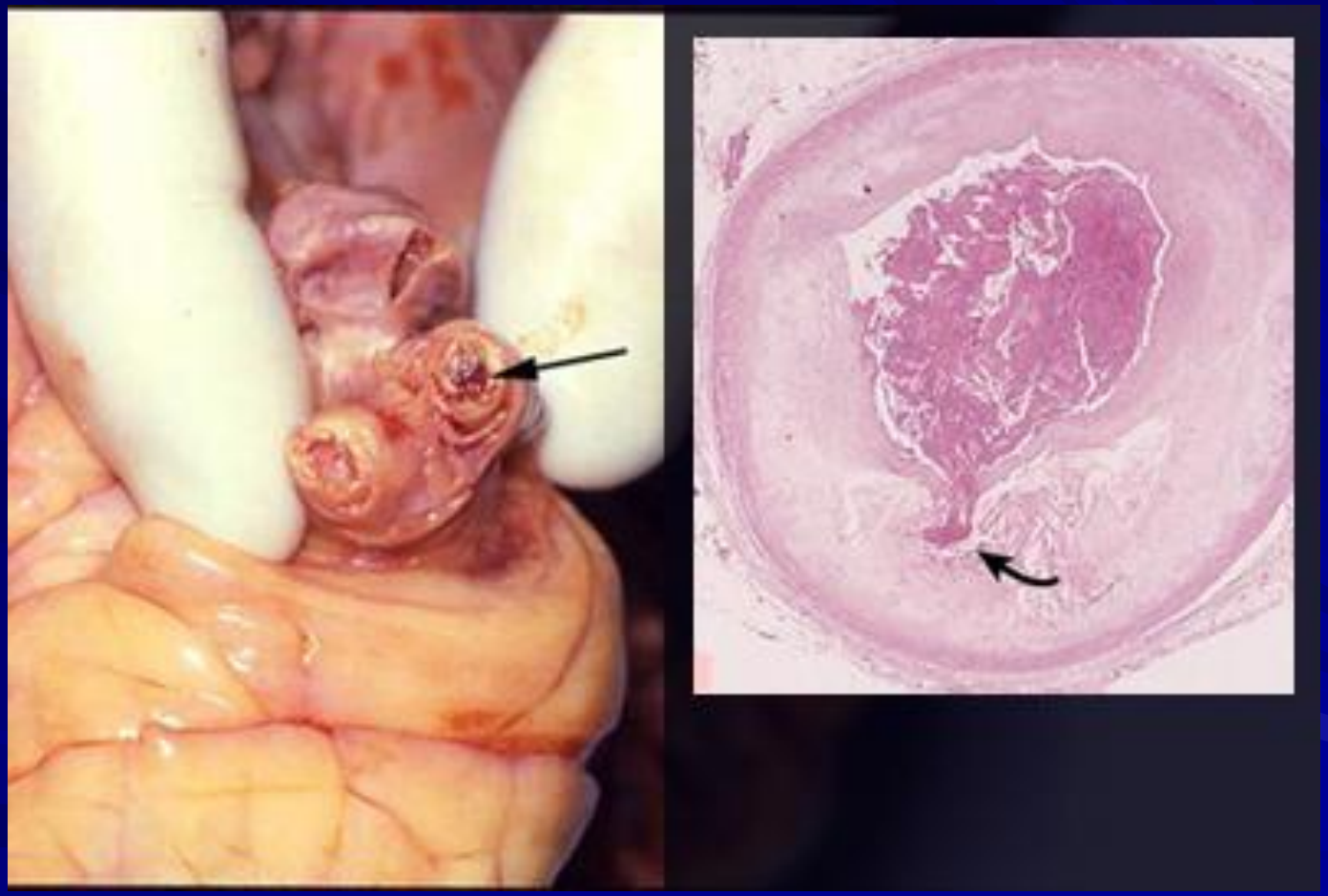
Objectives

- To detect myocardial ischemia & infarction on an electrocardiogram
- To define the areas of the heart to which the twelve standard ECG leads correspond
- To correlate coronary anatomy with areas of ischemia & infarction

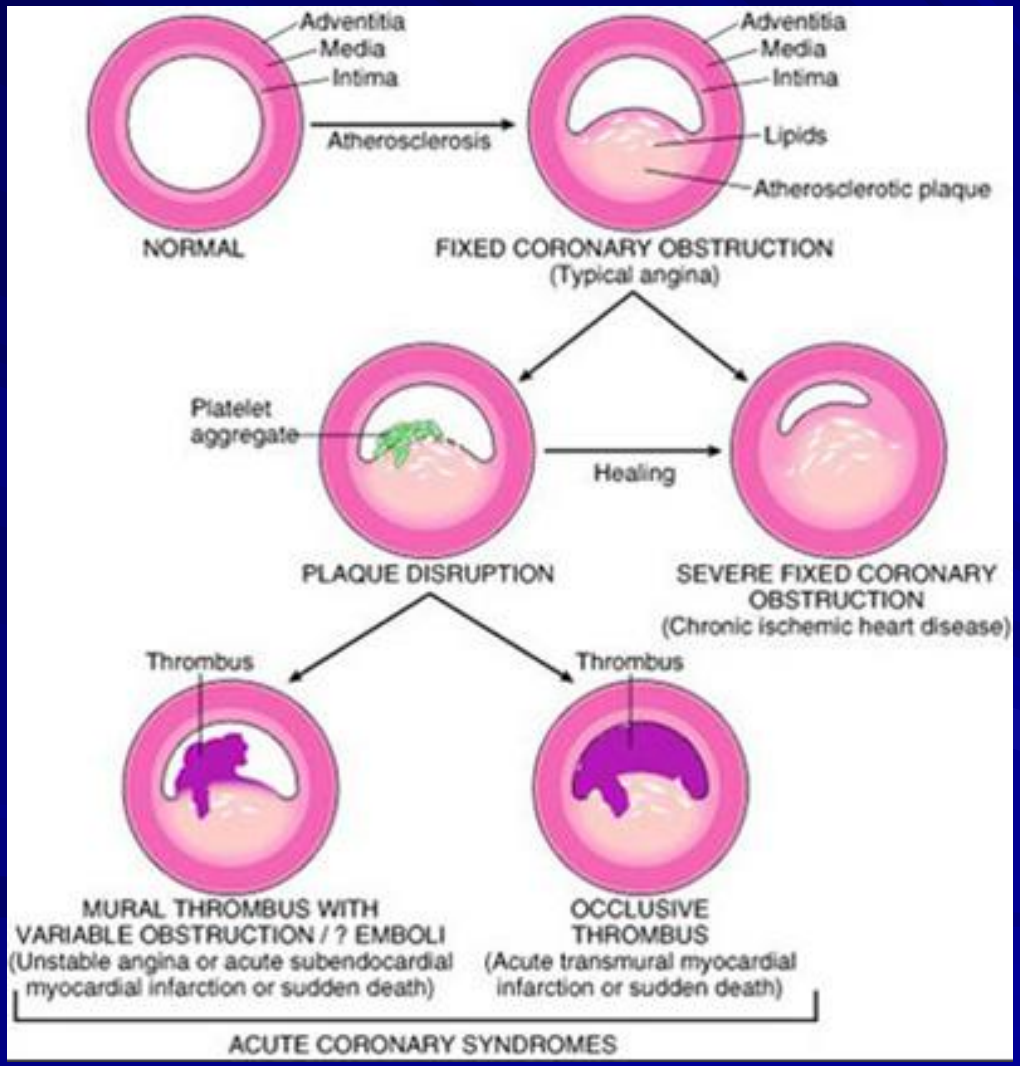
Acute Myocardial Injury



Acute Myocardial Injury

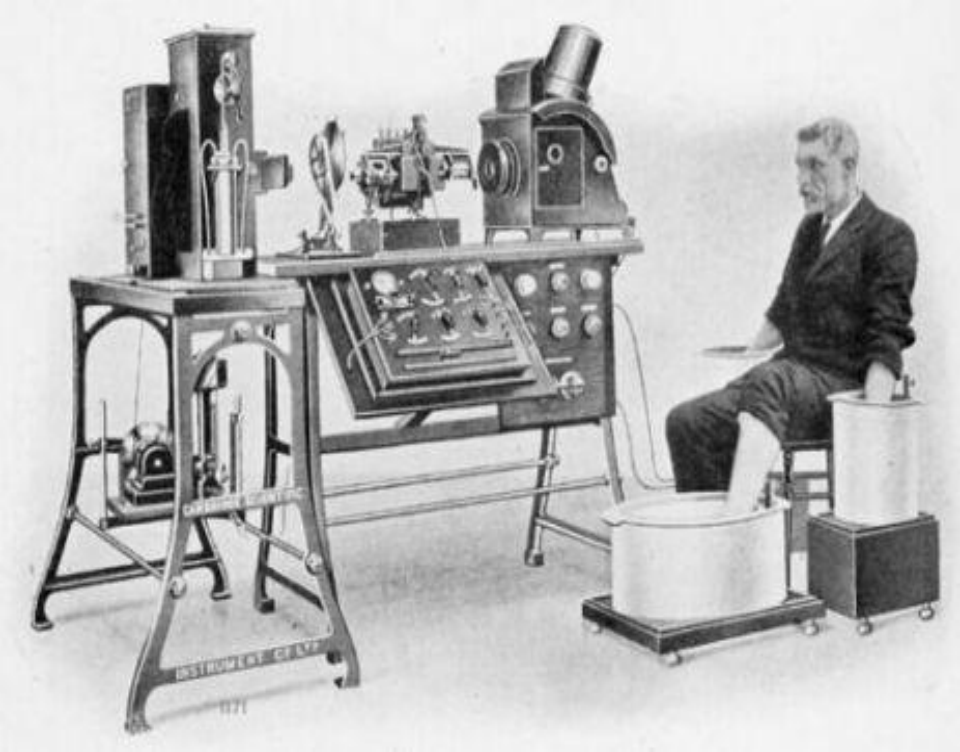


Acute Myocardial Injury



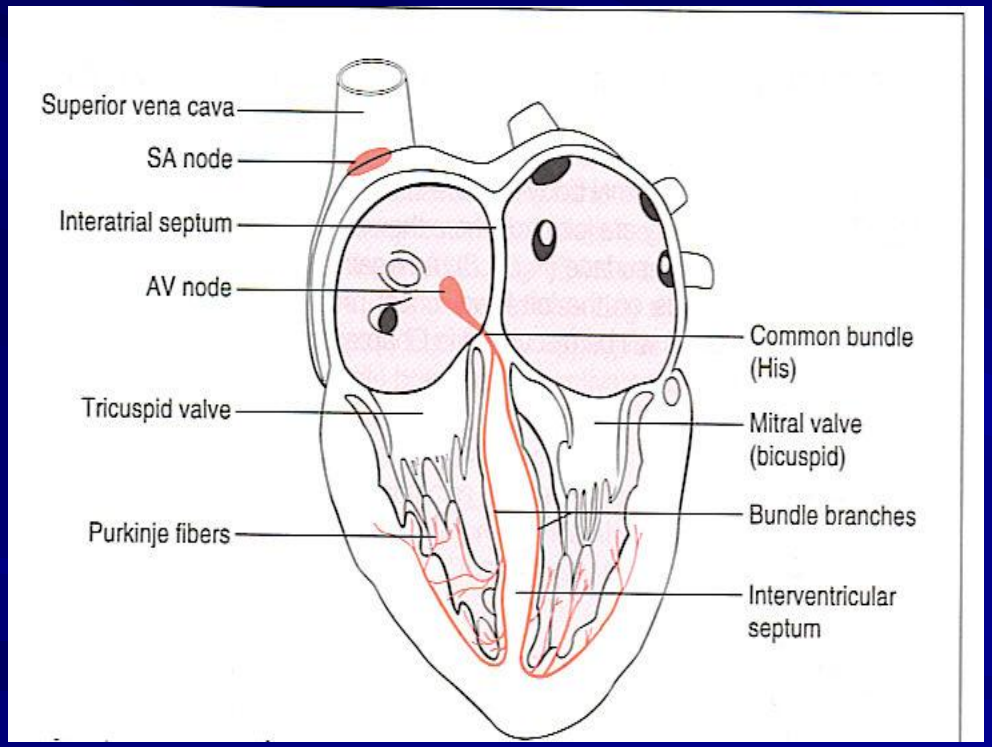
EKG Basics

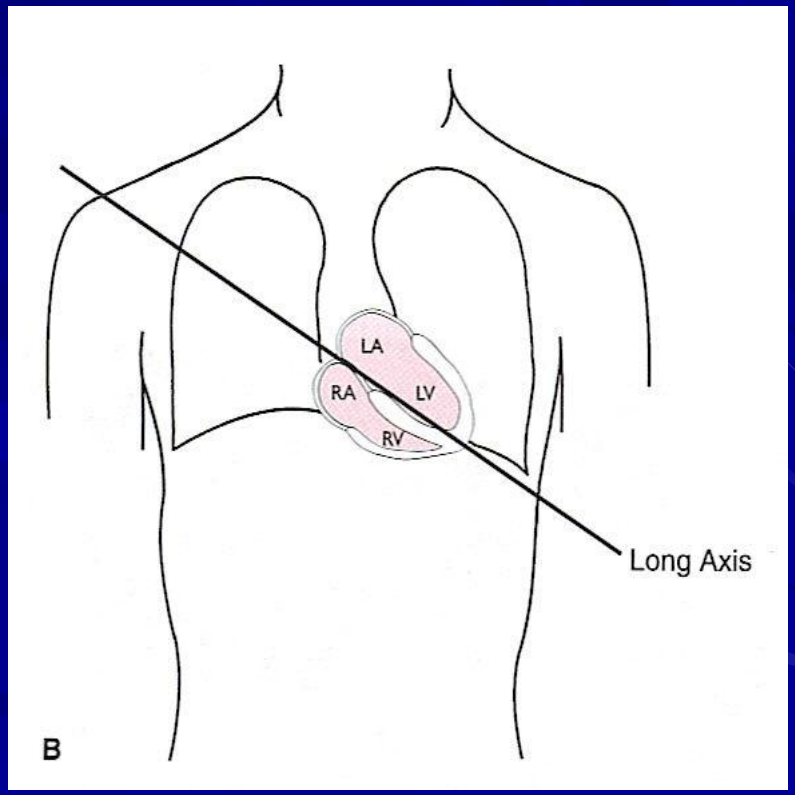
- The electrocardiogram (ECG): the *electrical activity* of the heart recorded at the body surface



ECG Basics

- Anatomy of the heart: positioning in chest

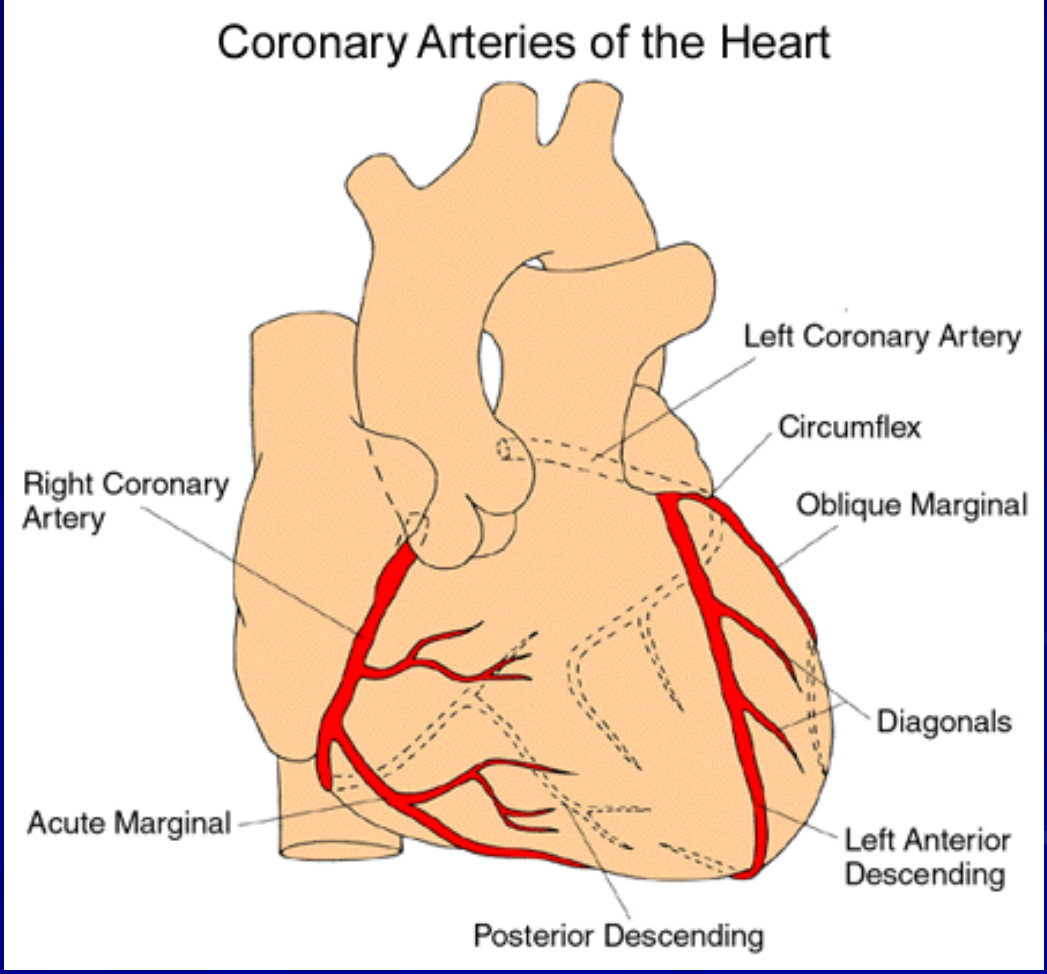




Coronary Anatomy

Coronary Anatomy

- There are *two* coronary arteries which supply the heart with blood



Coronary Anatomy
LCA

Figure 4: Schematic diagram of the left coronary artery viewed from a right anterior oblique orientation.

Figure 5: Schematic diagram of the left coronary artery viewed from a left anterior oblique orientation.

Coronary Anatomy

- The *LEFT* coronary artery has 2 major branches:
  - Left Anterior Descending (LAD)- supplies *Anterior wall* of the ventricles & septum
  - Circumflex branch- supplies *Lateral wall* of the left ventricle & atrium

Coronary Anatomy
RCA

Figure 6: Schematic diagram of the right coronary artery viewed from a right anterior oblique orientation.

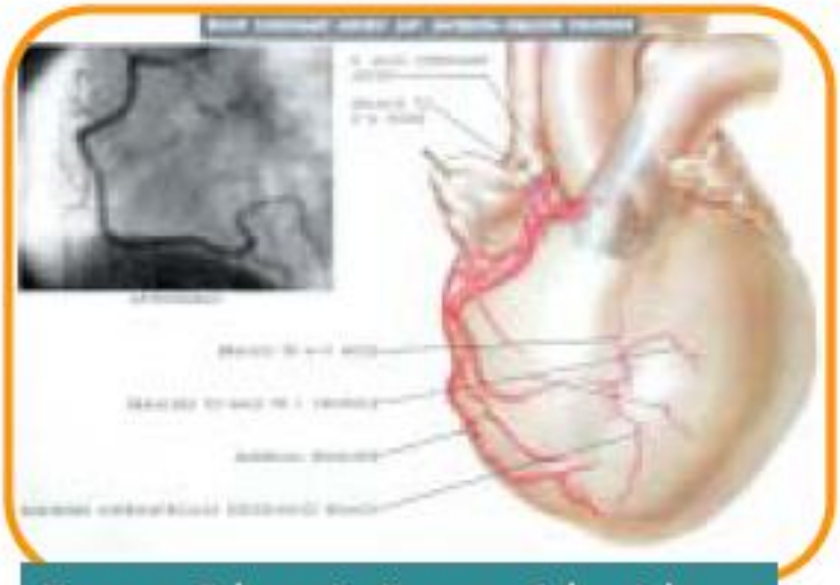


Figure 7: Schematic diagram of the right coronary artery viewed from a left anterior oblique orientation.

Coronary Anatomy
RIGHT coronary artery (RCA)

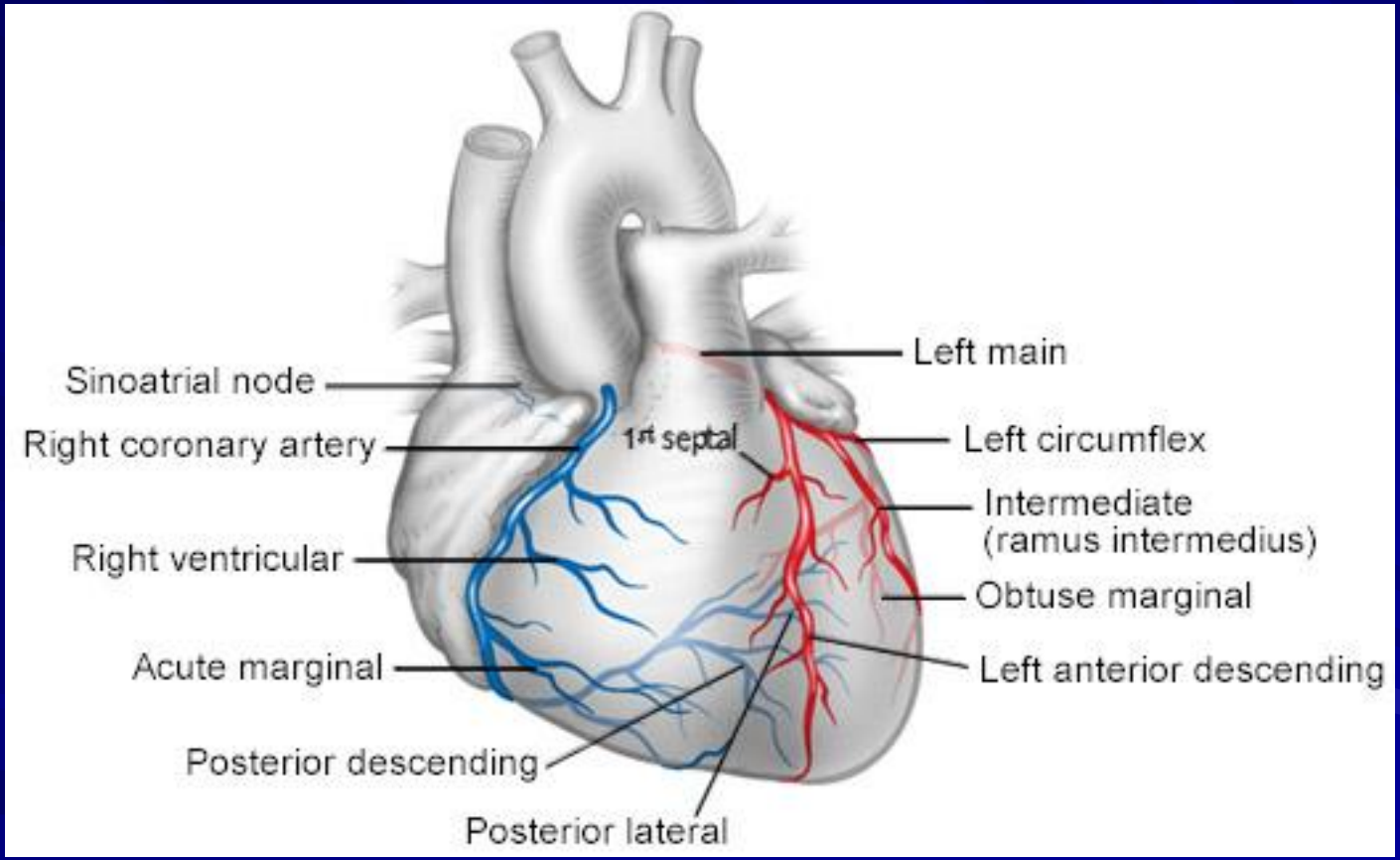
- The RCA supplies:

  Right atrium

  SA & AV nodes

  Posterior regions of ventricles

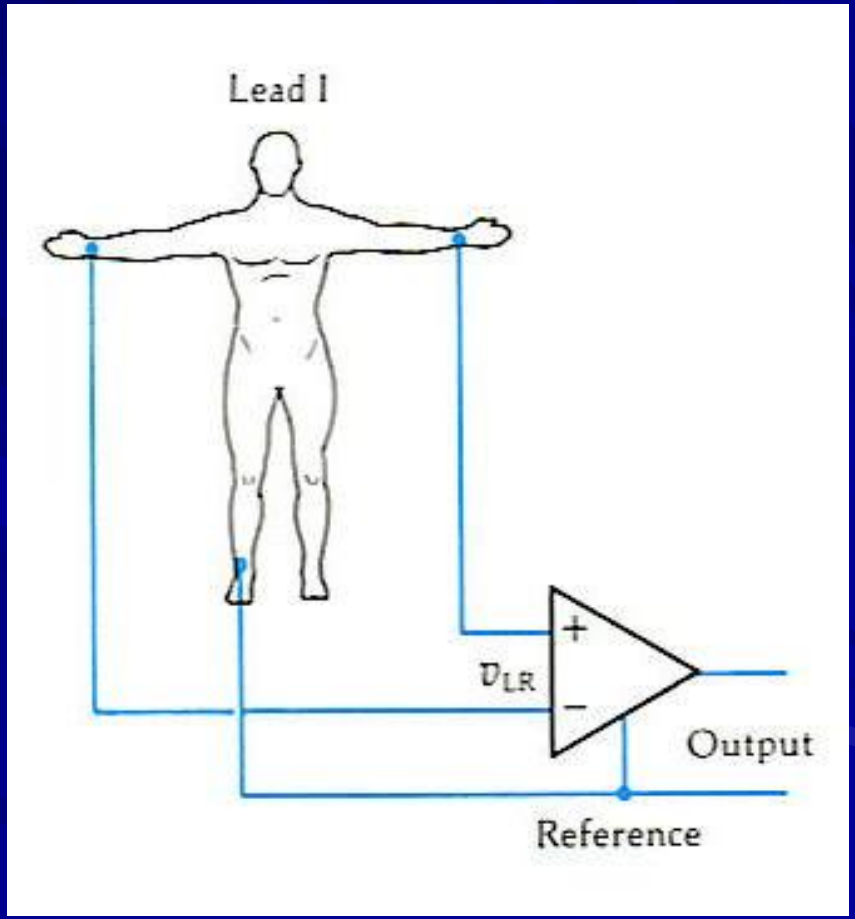
Coronary Anatomy
RCA



EKG Basics

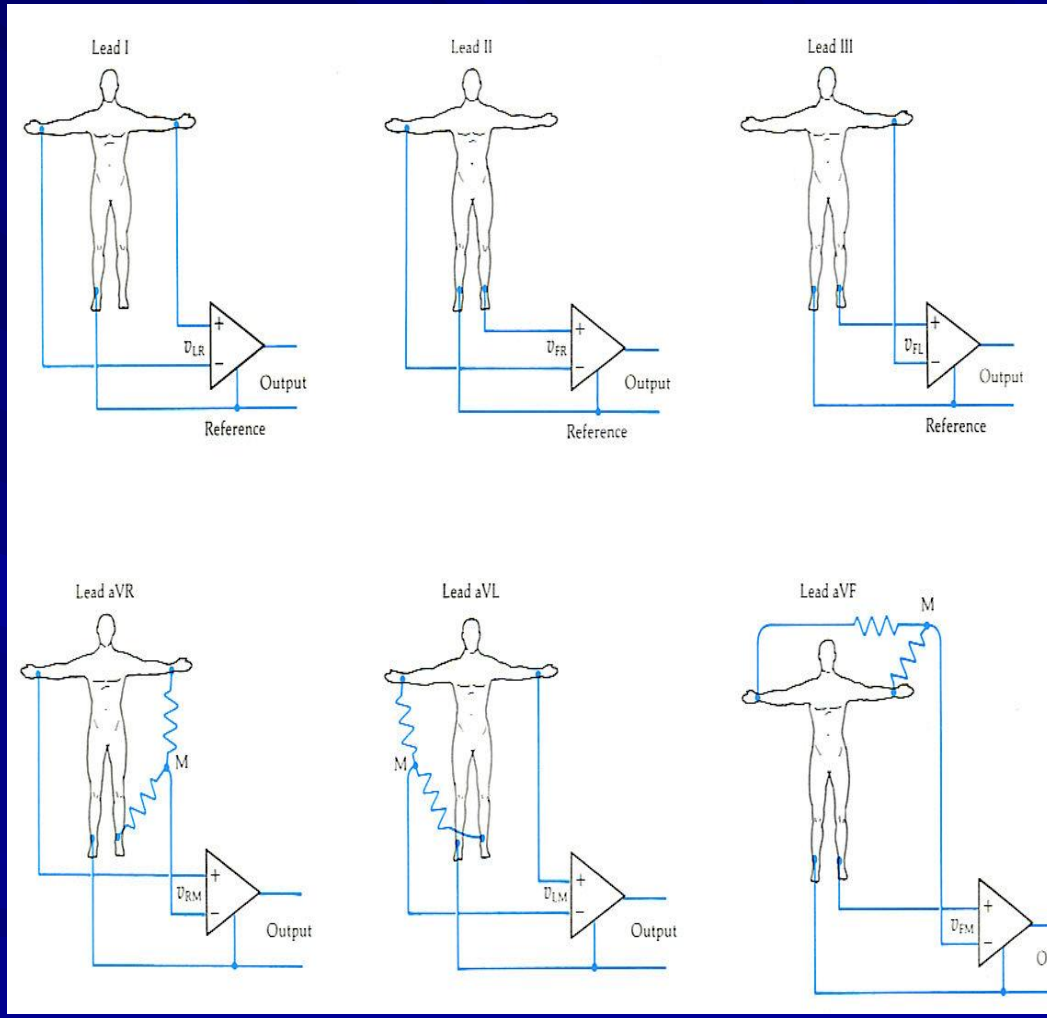
EKG Basics

- The EKG – essentially a voltmeter.
- Measures voltage - electrical potential - between two points.
- Records this voltage over time.



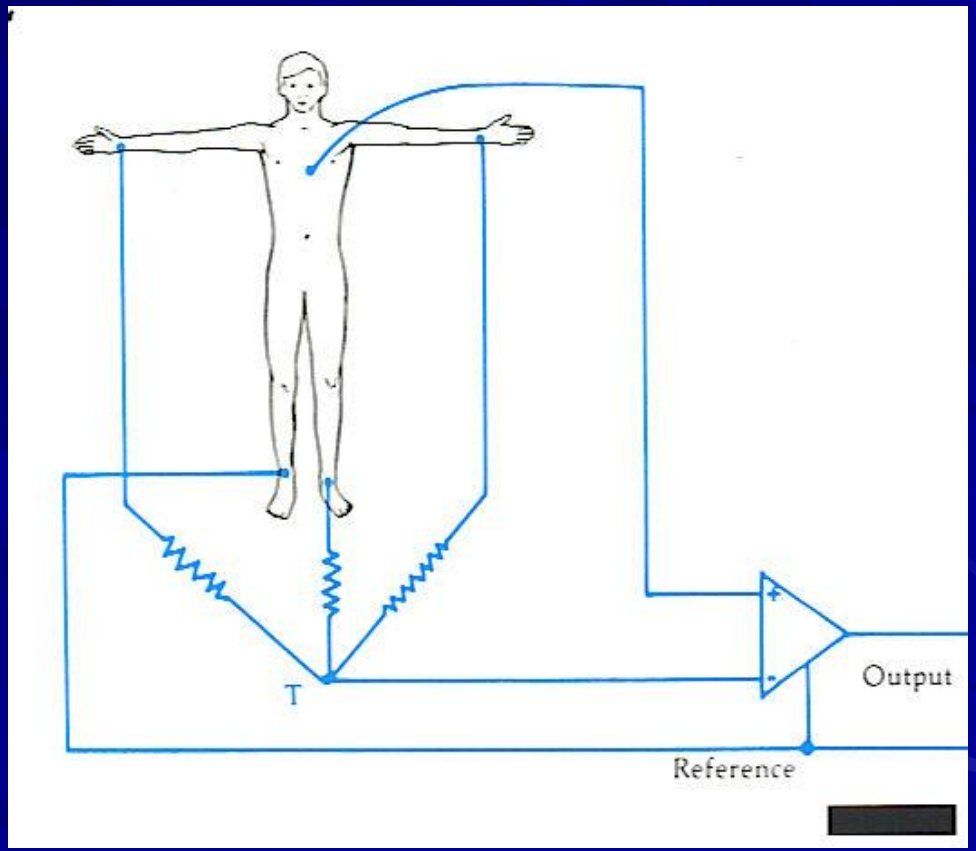
EKG Basics

- The EKG – 12 voltmeters.
- Upward deflections move towards the (+) electrode.
- Downward deflections move toward the (-) electrode.



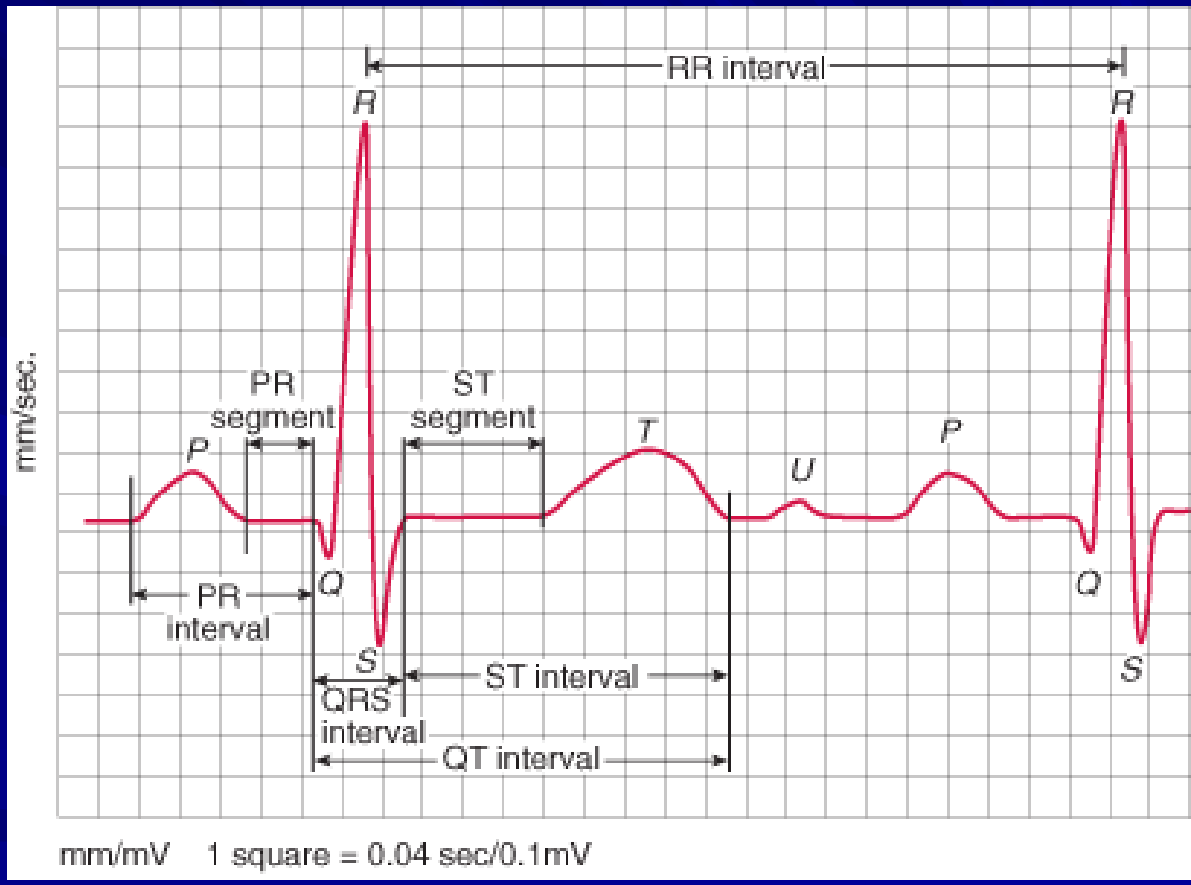
EKG Basics

- Chest Leads
- Exploring leads (V1 – V6) are (+)
- Reference lead (-) is Wilson's Central Terminus



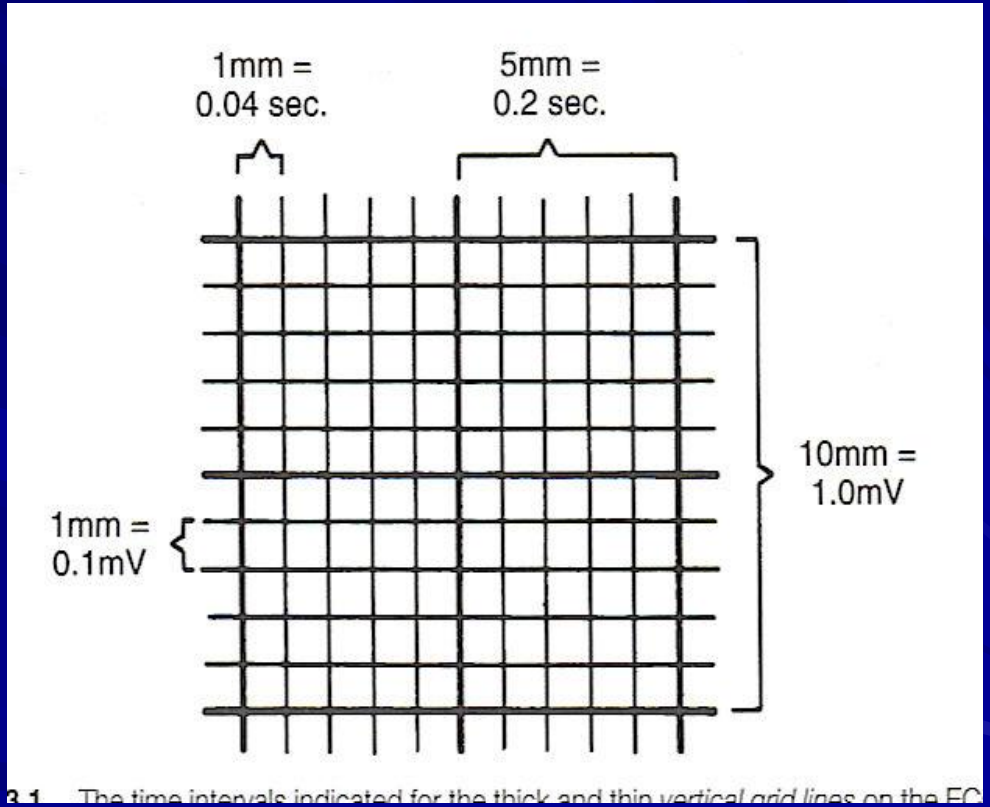
EKG Basics

- The EKG: electrical activity of atria and ventricles
- Depolarization and repolarization



EKG Basics

- The EKG: Standardized grid
  - small box
    - 40 mSec
    - 100 uV
  - Large box
    - 200 mSec
    - 500 uV



EKG - Leads and Electrode Positioning

The standard EKG is composed of *12 Leads*

Six *limb* leads: I, II, III, aVR, aVL, aVF

Six *chest* leads: V1, V2, V3, V4, V5, V6

EKG - Leads and Electrode Positioning

For a *STANDARD RESTING 12 LEAD*
Extremity leads placed:

- Beyond the tip of the clavicles (arm leads)
- Beyond the inguinal ligament (leg leads)

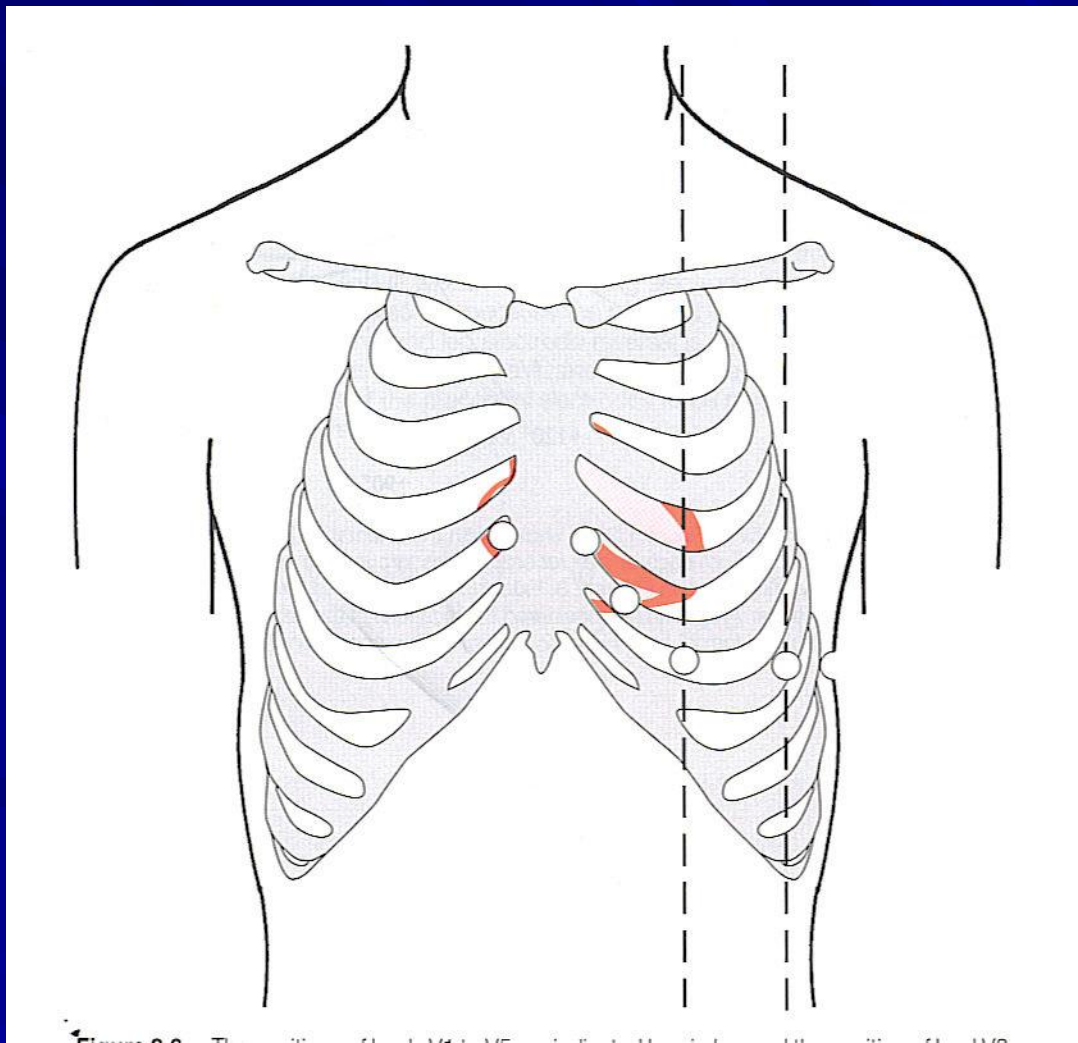
Monitoring lead placement – more centrally on torso (Mason- Likar lead positions)

EKG - Leads and Electrode Positioning

Chest Leads: V1 – V6

Palpate chest to locate landmarks

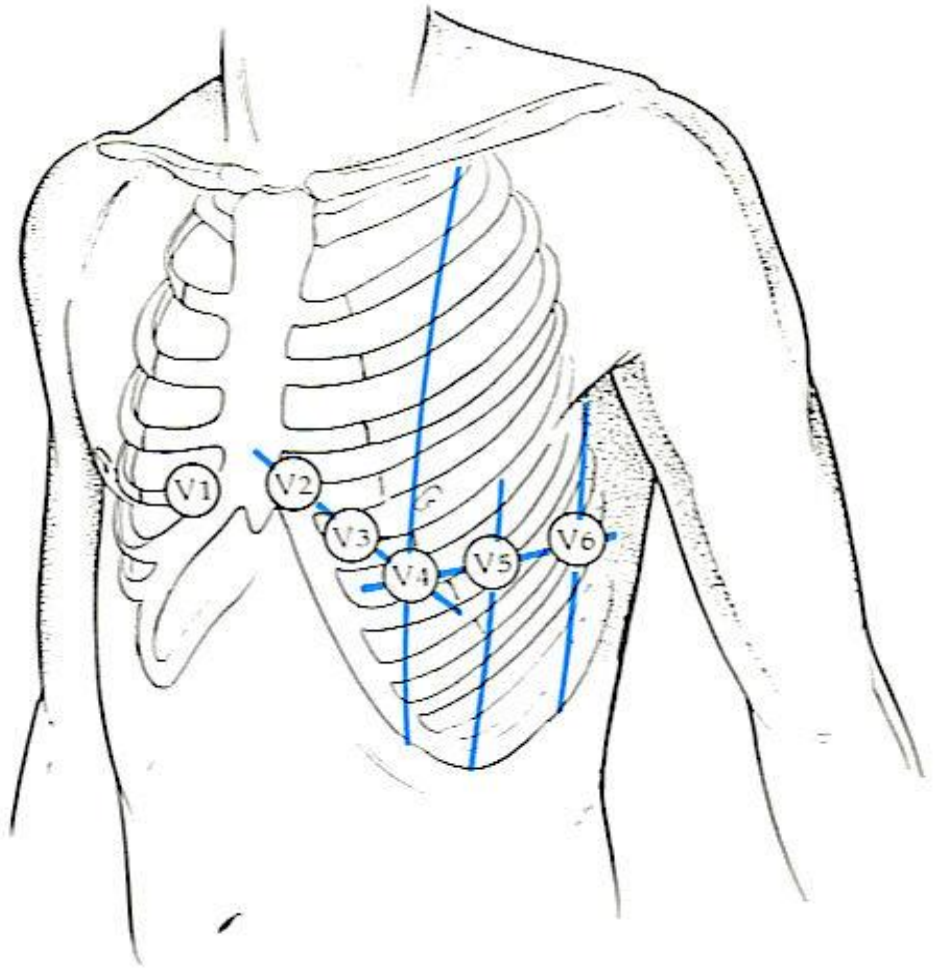
Small lead position changes can lead to changes in interpretation.



EKG - Leads and Electrode Positioning

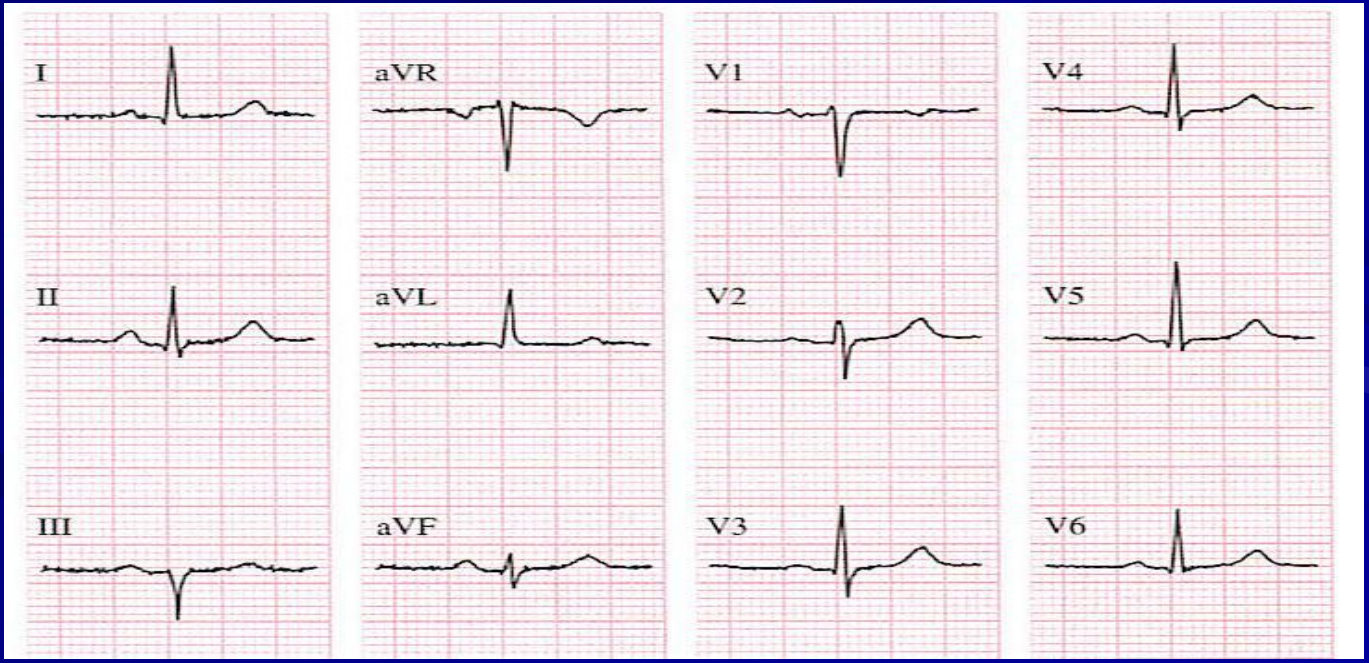
Chest Leads: V1 – V6

V1 – 4th IC space, R of sternum
V2 – 4th IC space, L of sternum
V3 – between V2 and V4
V4 – 5th IC space, Mid clav line
V5- Lat to V4, Anterior Ax line
V6 – Lat to V4 and V5, Mid Ax



EKG Basics

- On a standard EKG mounting, the six chest leads and six limb leads are typically arrayed in columns:

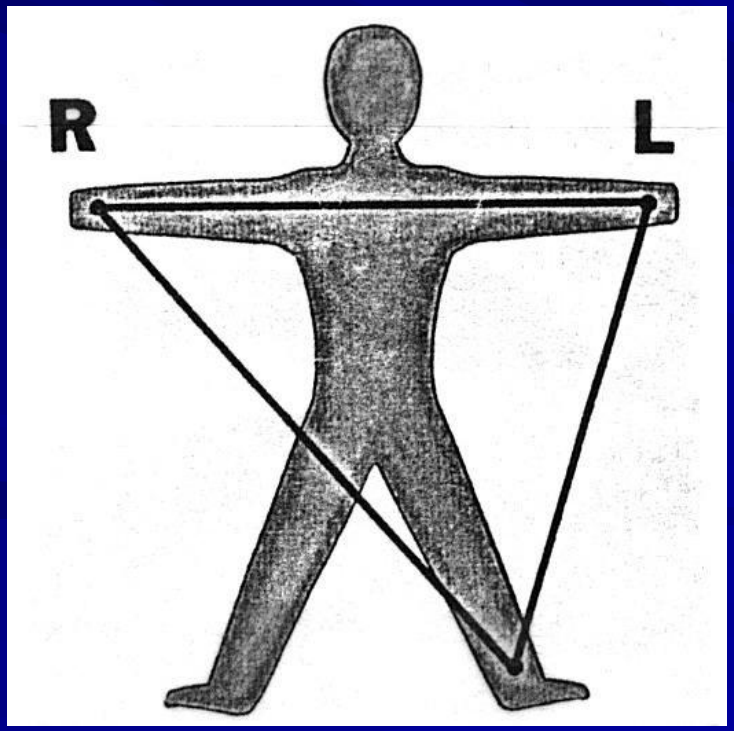


Localization of MI

Area of Infarction	Leads Involved
Anterior wall	V1, V2, V3, V4
*Anteroseptal	V1, V2
Lateral wall	I, AVL, V5, V6
Inferior wall	II, III, AVF
Right ventricle	V4 R
Posterior wall	V7, V8, V9 + Tall R & ST ↓ V1, V2

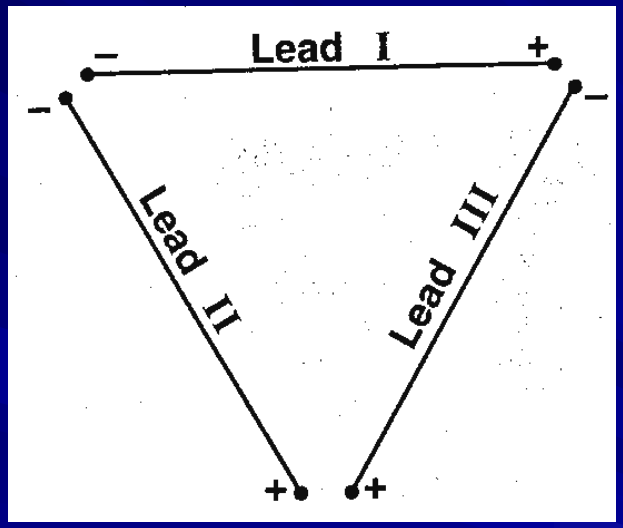
Limb Leads

- To obtain the 6 limb leads, electrodes are placed on the right arm, the left arm & the left leg forming a triangle



Bipolar Limb Leads

- Leads I, II, III are formed by a *pair* of electrodes



- Each records from a different perspective: going *away from* the (-), and lead *toward* (+) lead

Bipolar Limb Leads

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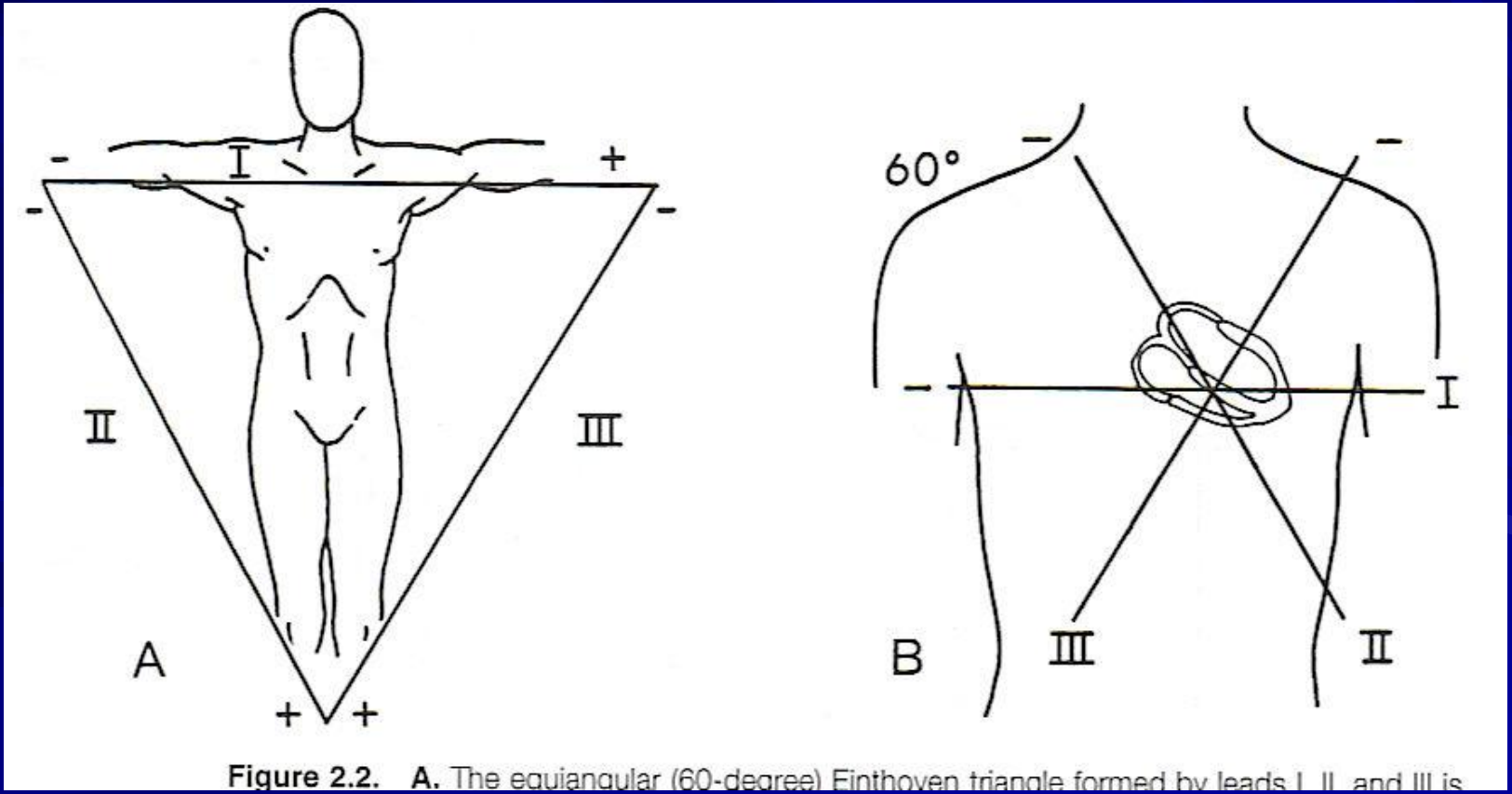


Figure 2.2. **A.** The equiangular (60-degree) Einthoven triangle formed by leads I, II, and III is

Bipolar Limb Leads

- Leads I, II, III are formed by a *pair* of electrodes

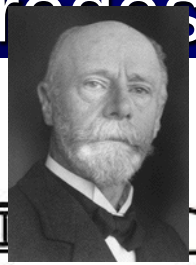
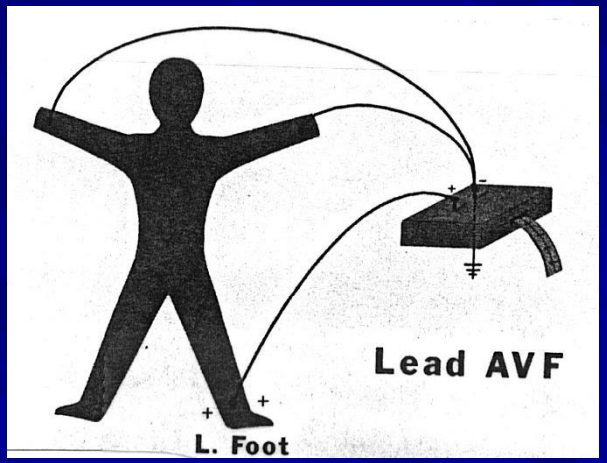


Figure 2.2. **A.** The equiangular (60-degree) Einthoven triangle formed by leads I, II, and III is

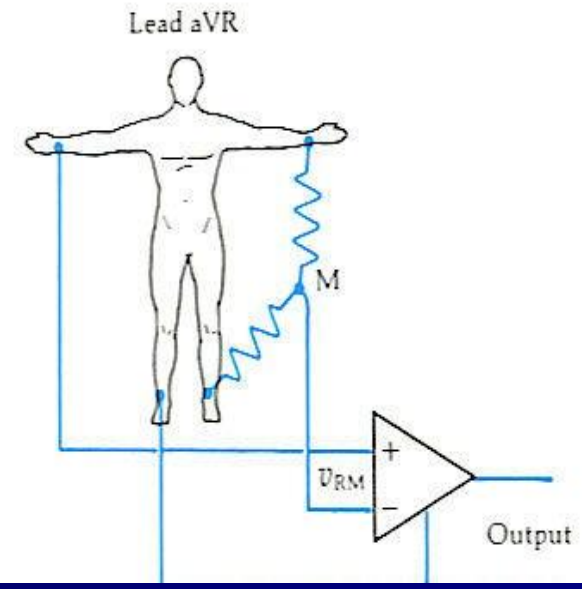
“Augmented” limb leads

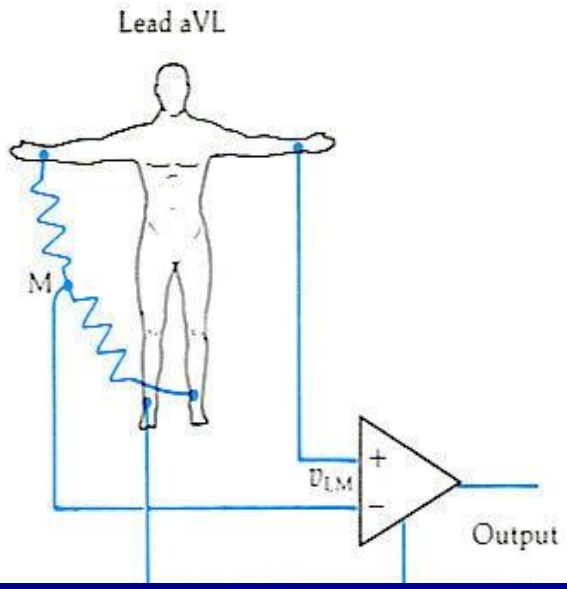
- Are *unipolar* limb leads, stressing the importance of the (+) electrode

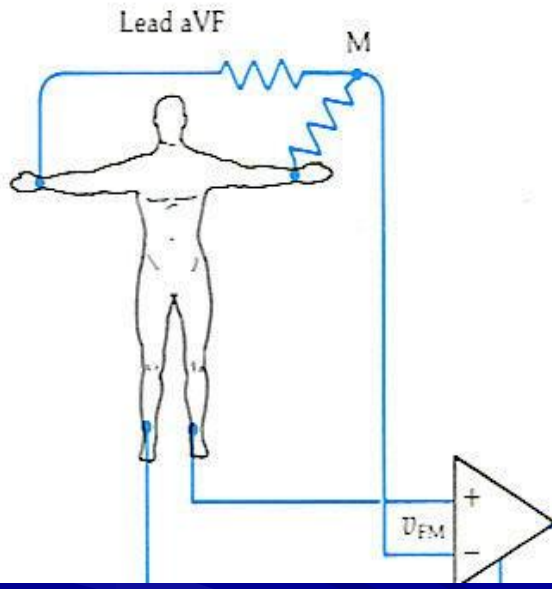


- AV**R**- *Right* arm positive
- AV**L**- *Left* arm positive
- AV**F**- *Foot* (left) positive

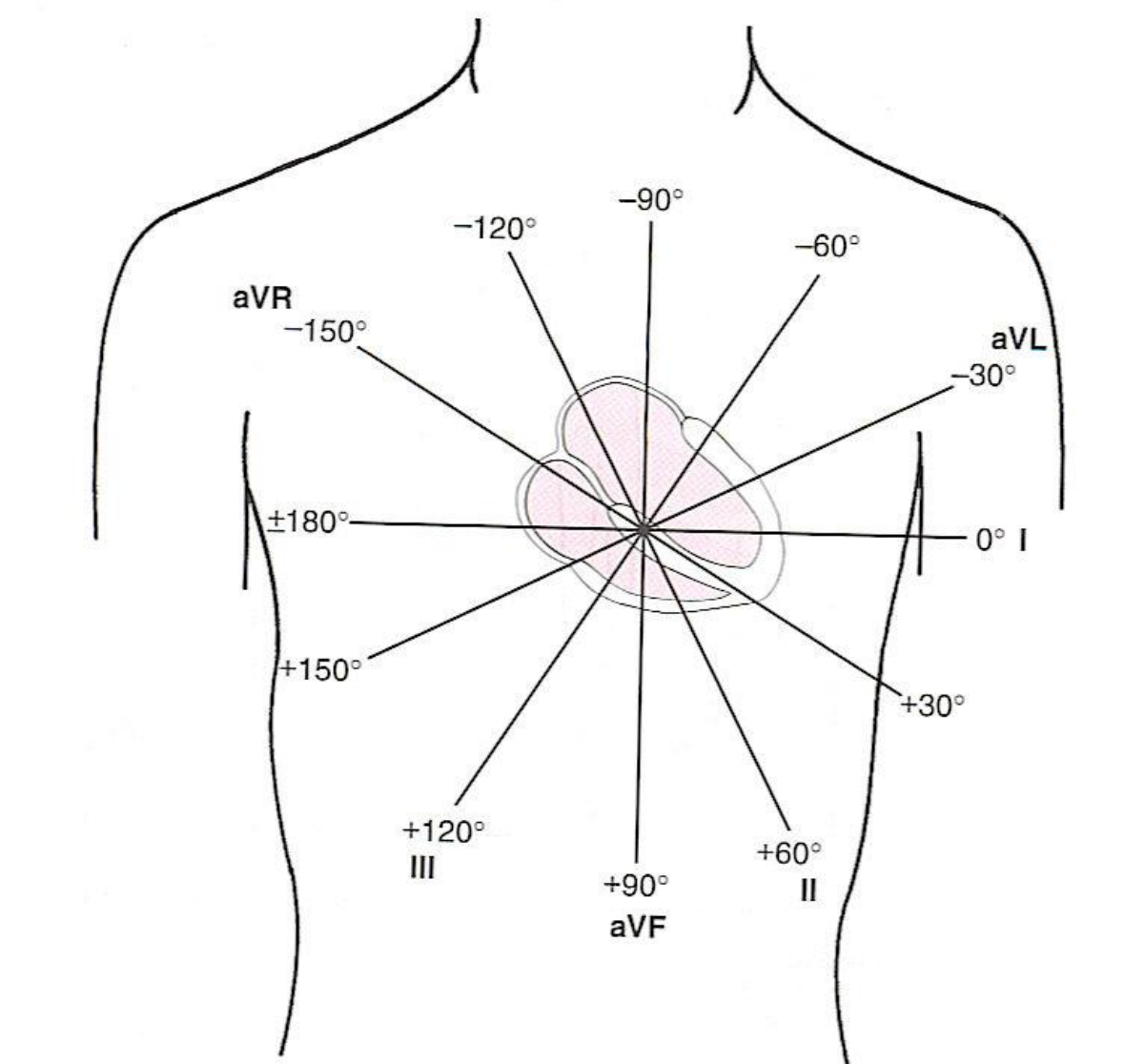
“Augmented Limb leads”



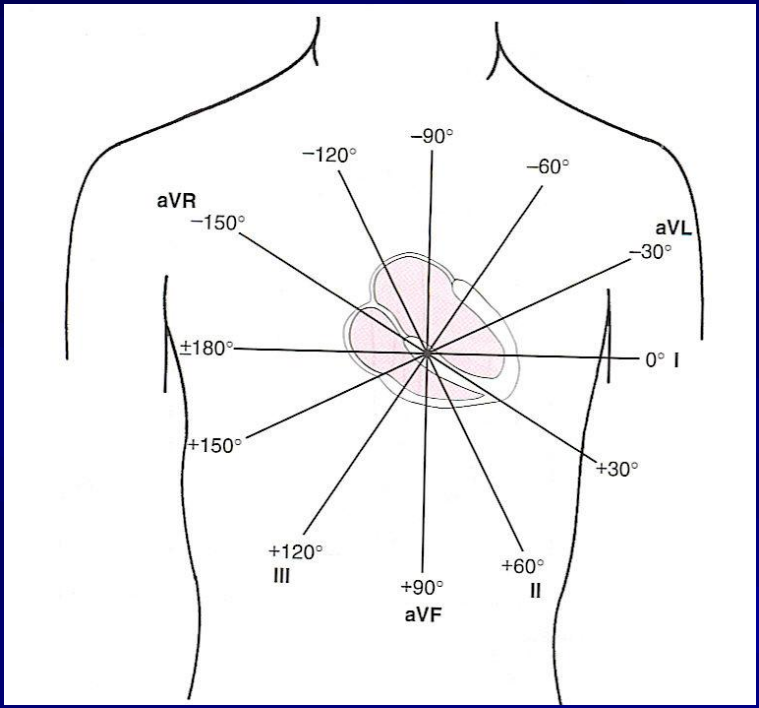




Frontal Plane leads



Limb Leads



- Leads I and AVL view the: *high lateral wall* of the heart
- Leads II, III & AVF view the: *inferior wall* of the heart

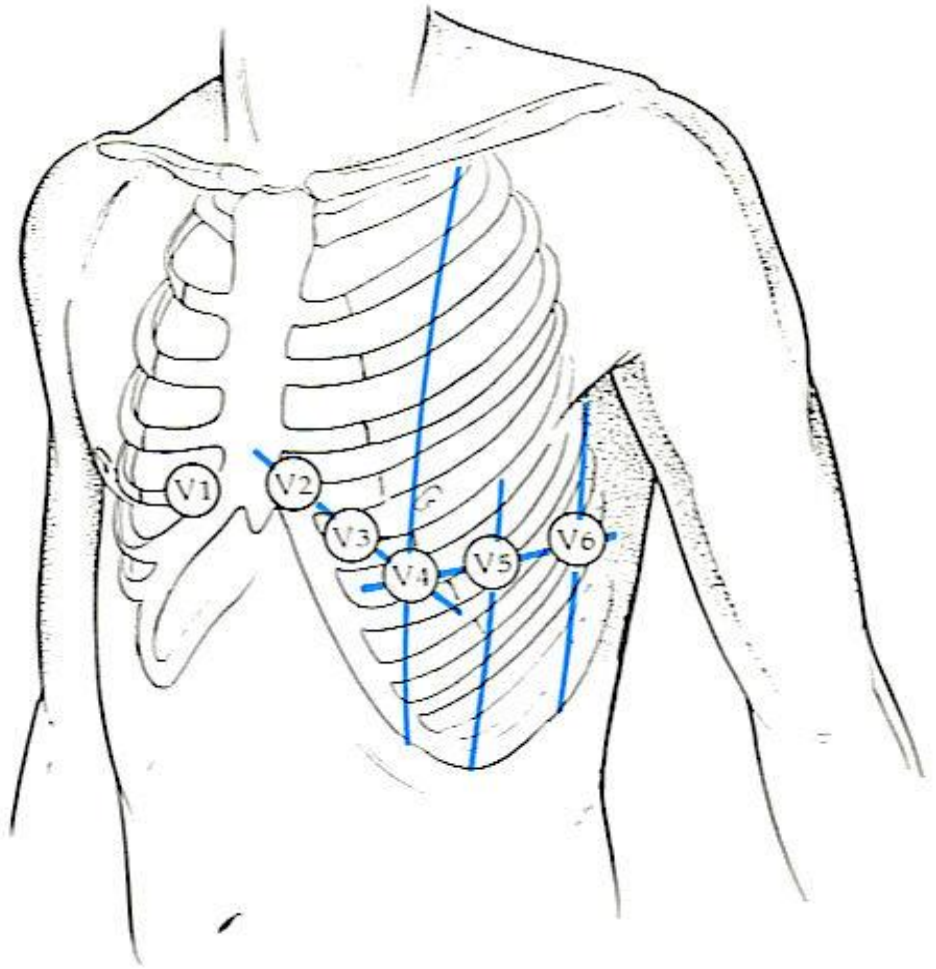
Limb Leads

- Lead AVR looks “away” from the heart
- Therefore the “P”, “QRS” & “T waves” should be *inverted*
- If they are *upright* in AVR, then the electrodes are likely misplaced.

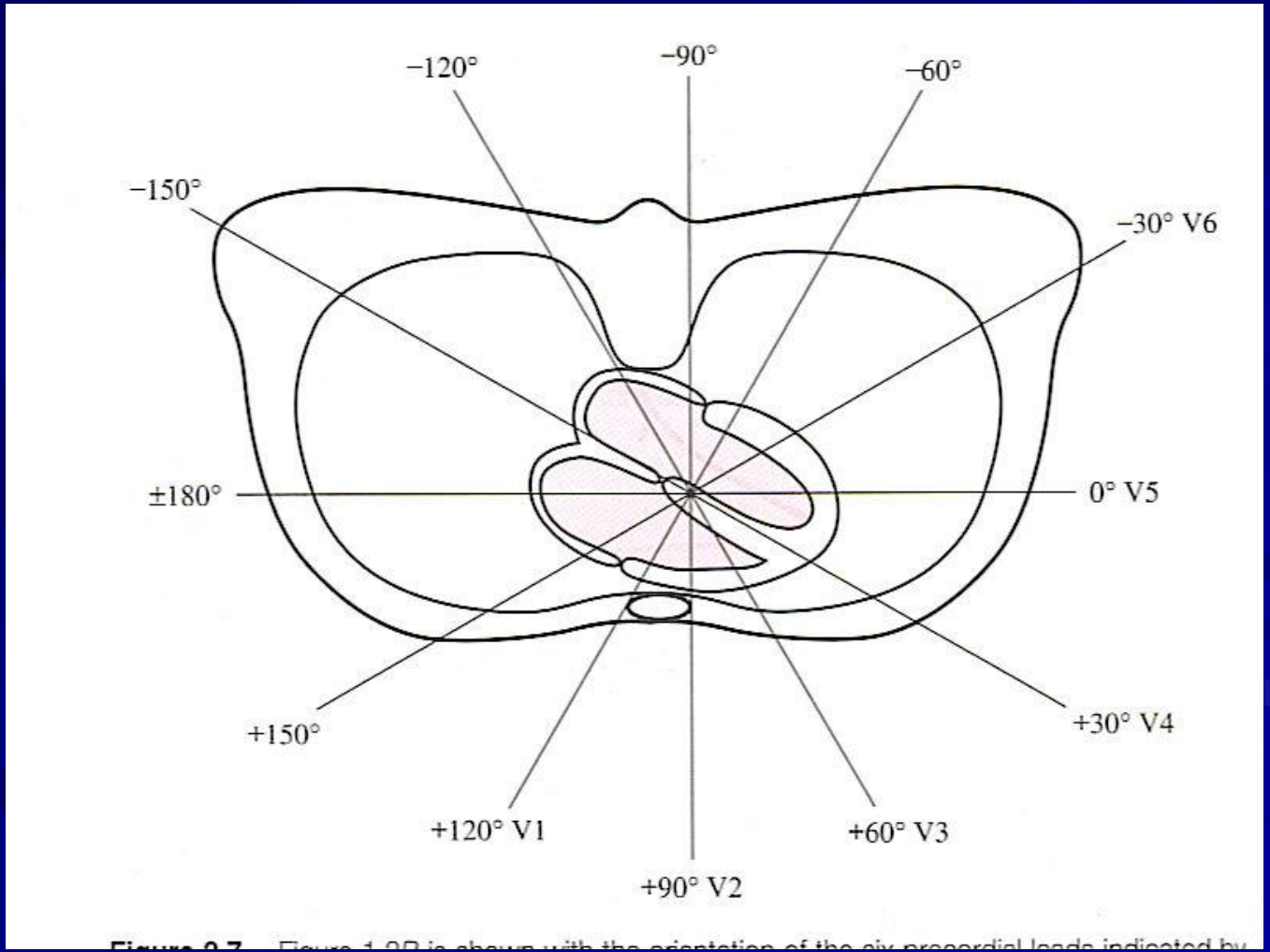
ECG - Chest Leads

Chest Leads: V1 – V6

Each lead gives a different perspective of the heart… sees the electrical activity from a slightly different view.

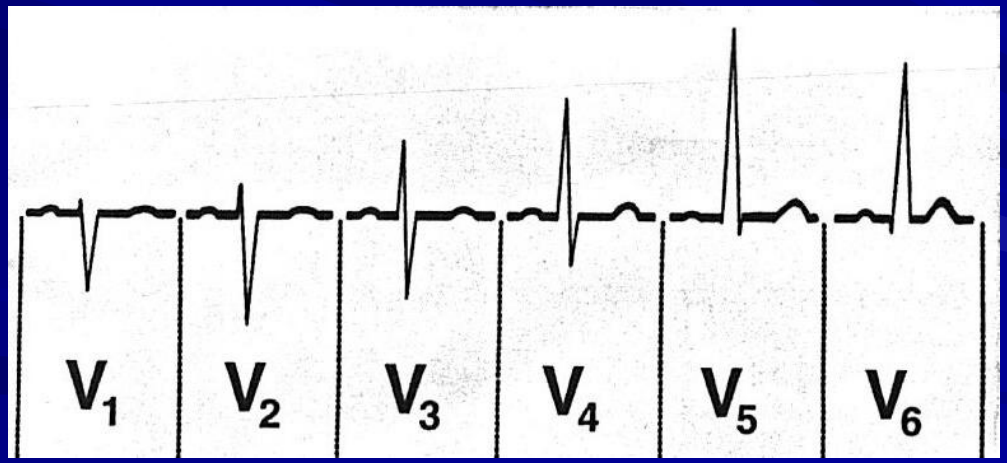


Chest leads



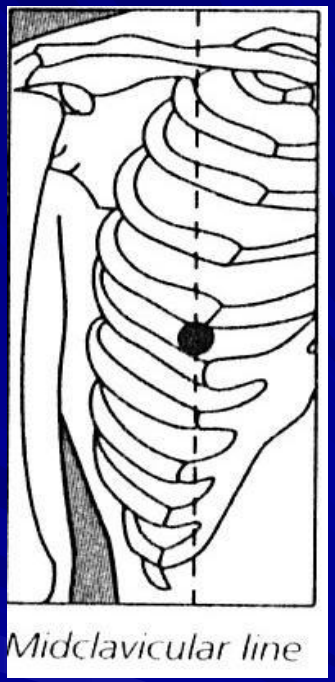
Chest Leads

- The ECG tracing from V1-V6 shows gradual changes in all the waves as the position of each lead changes



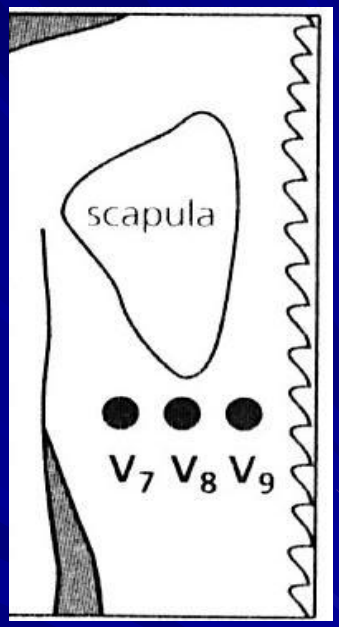
Right sided chest lead: V4 R

- Looks at *right ventricle*
- 5th ICS, Rt. midclavicular line



Left posterior leads: V7, V8, V9

- Look at the *posterior wall*



- V7- 5th ICS, post axillary line
- V8- 5th ICS, midscapular line
- V9- 5th ICS, 2cm left of vert column

Myocardial Ischemia & Infarction

ECG: Ischemia / Injury

- Identify the most SEVERE abnormality – this is the ‘name’ injury:
  eg: Anterior STEMI

- Look for ‘RECIPROCAL’ findings – typically ST depression or T wave inversion in the setting of ST elevation.

Myocardial Infarction
Problems with diagnosis

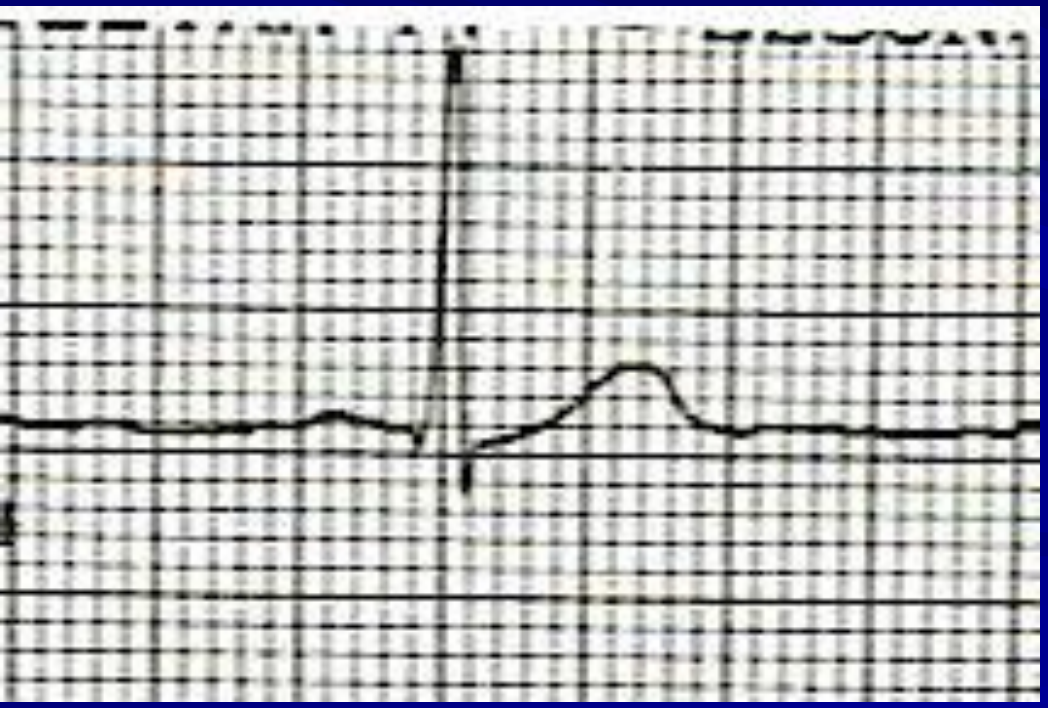
- History: symptoms & signs often vague
- Enzyme markers: take time to detect
- EKG: *non*-diagnostic in up to 60%

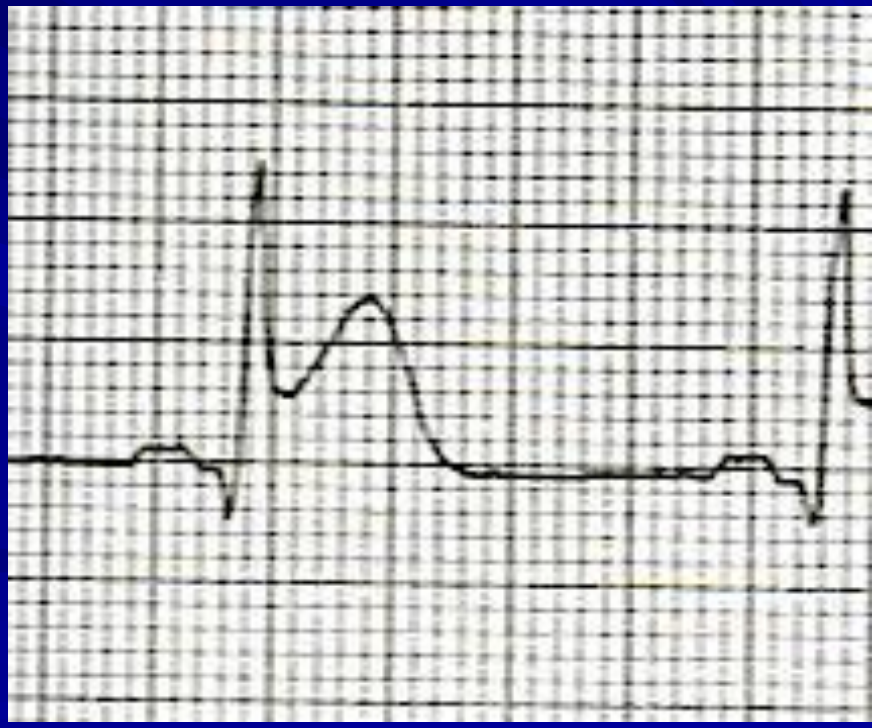
- 0.4 - 3% of patients are sent home with MI & up to 25% of these die!

Myocardial Infarction

Acute Injury Phase

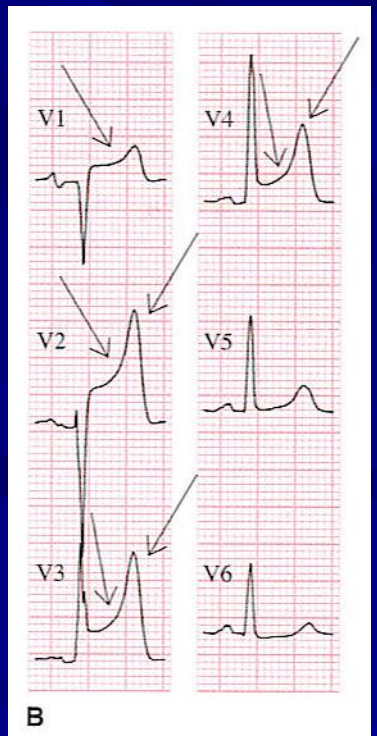
- Isoelectric point: somewhere in T-P interval
- Measure ST elevation : J point + 60 mSec

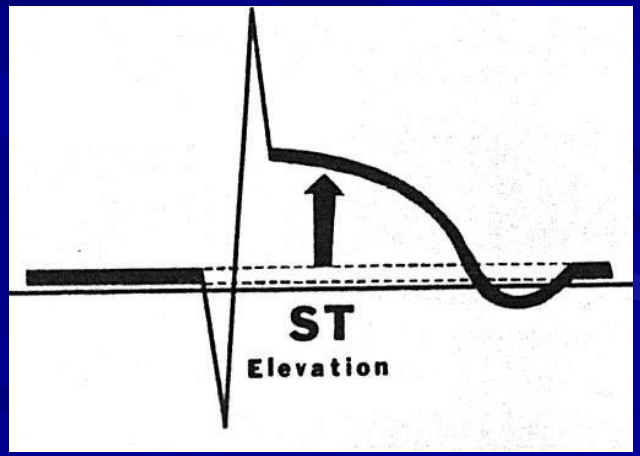




Myocardial Infarction
Acute Injury Phase

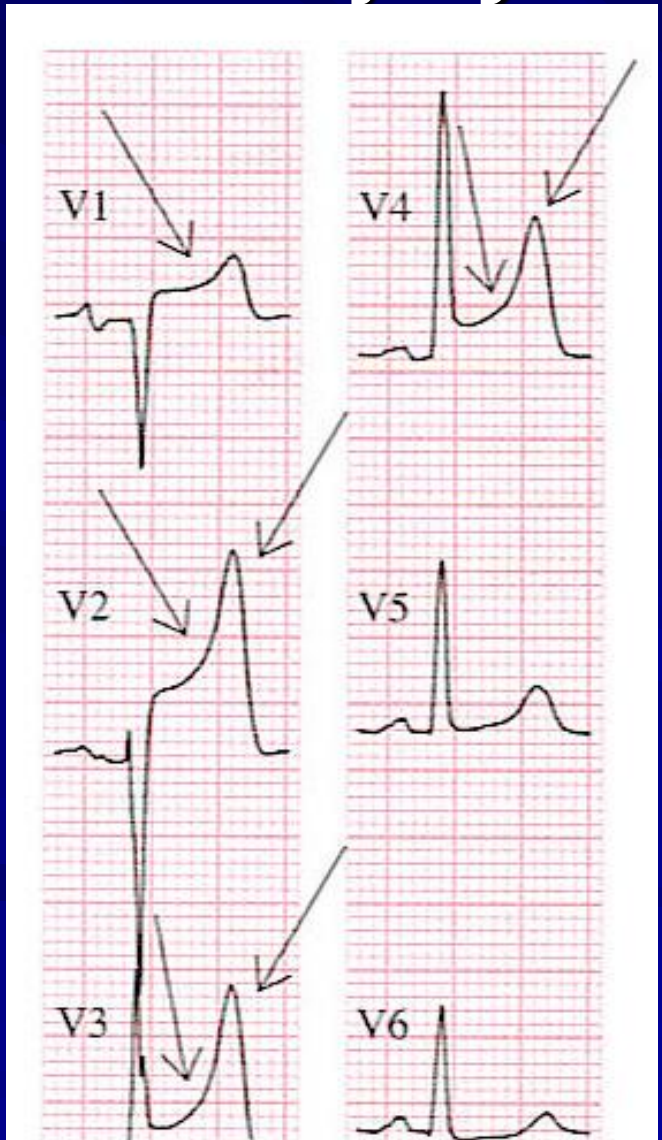
- Initially see tall *peaked* T waves and ST segment elevation



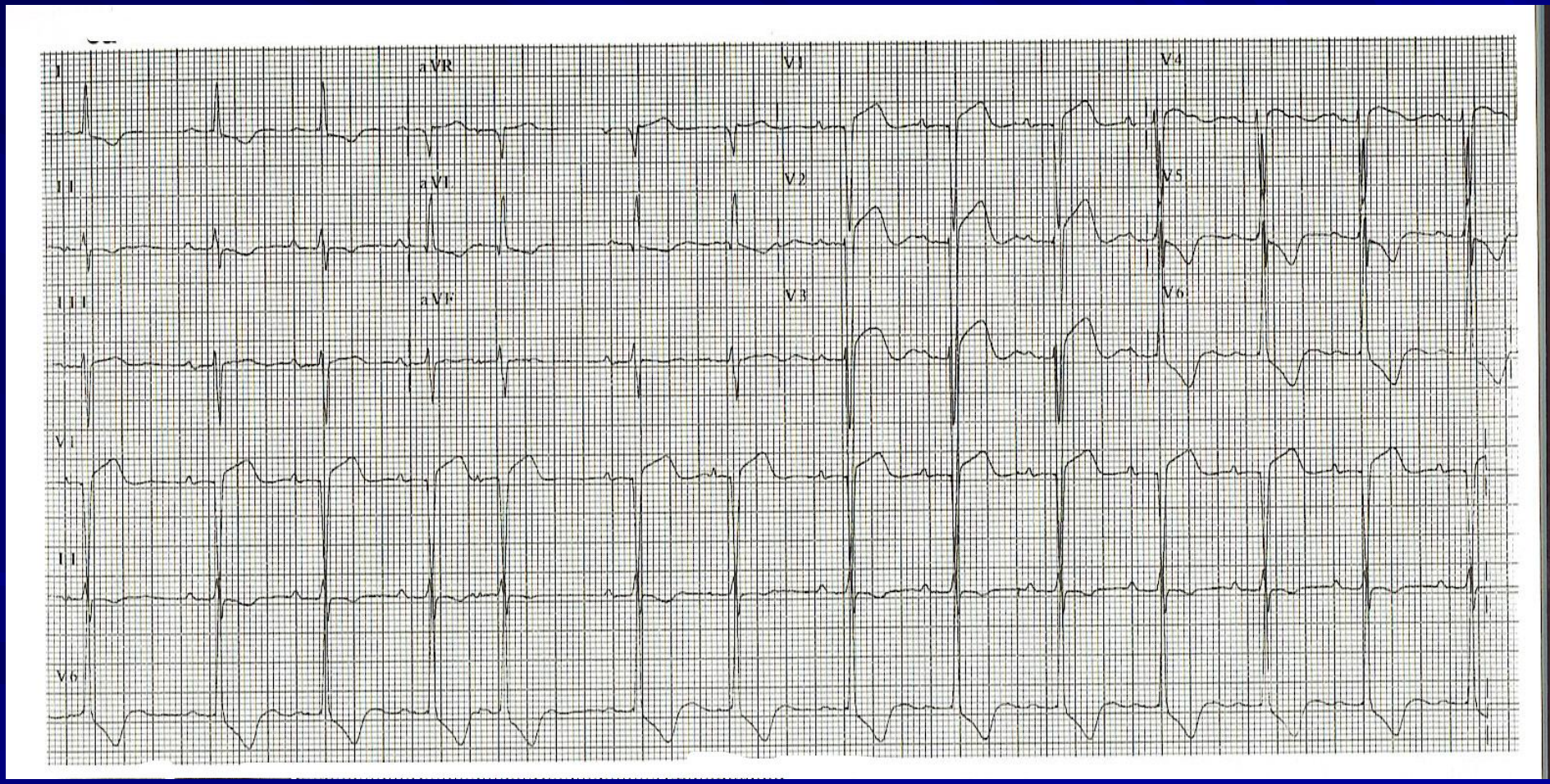


Myocardial Infarction

Acute Injury Phase

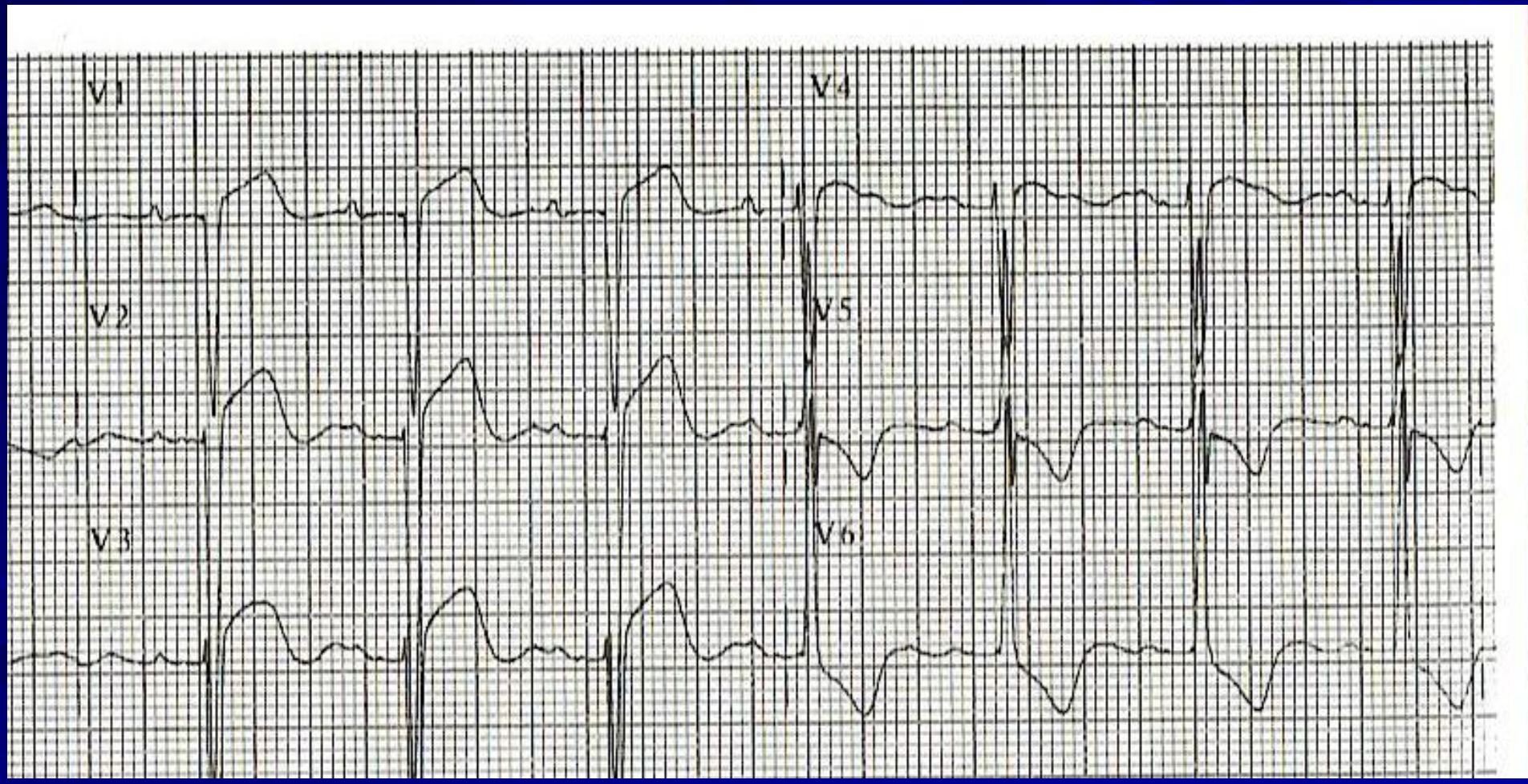


Myocardial Infarction
Acute Injury Phase



Myocardial Infarction

Acute Injury Phase

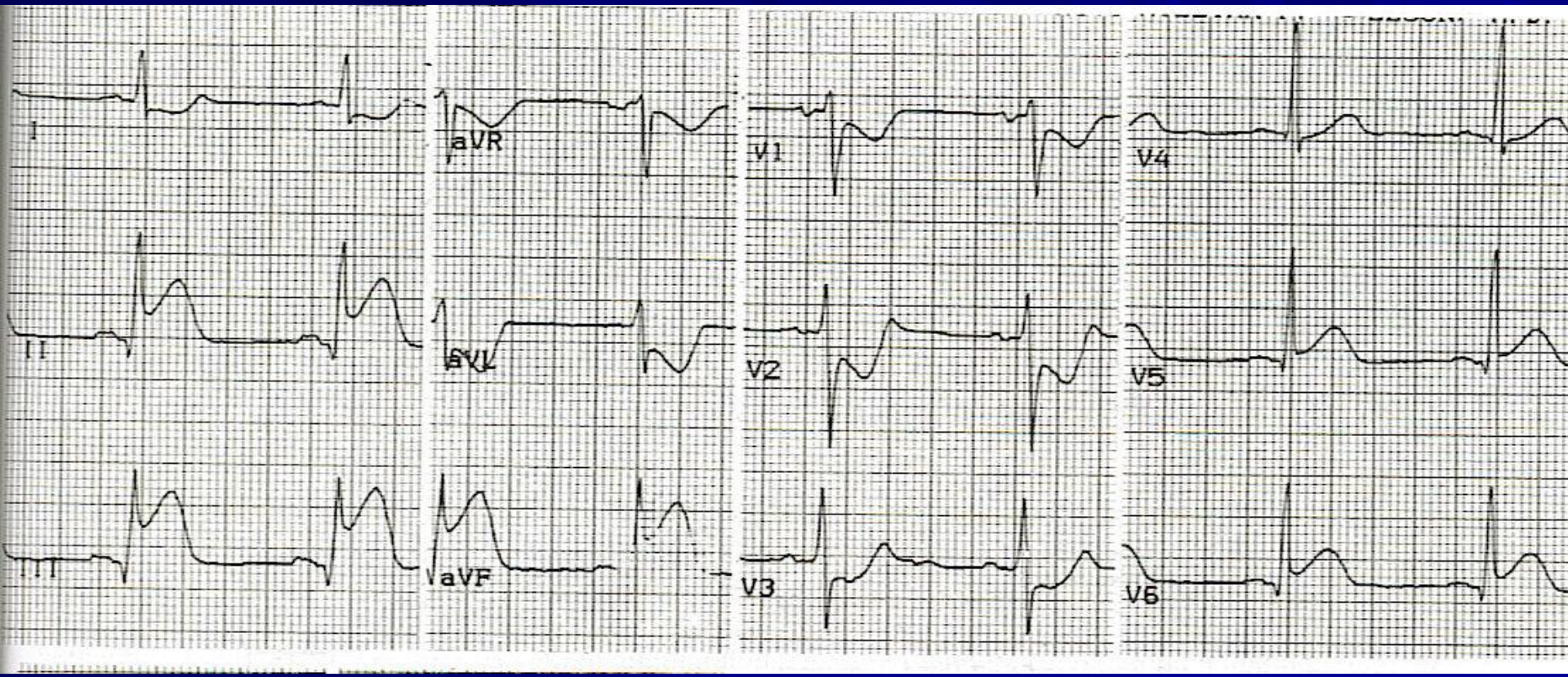


Localization of MI

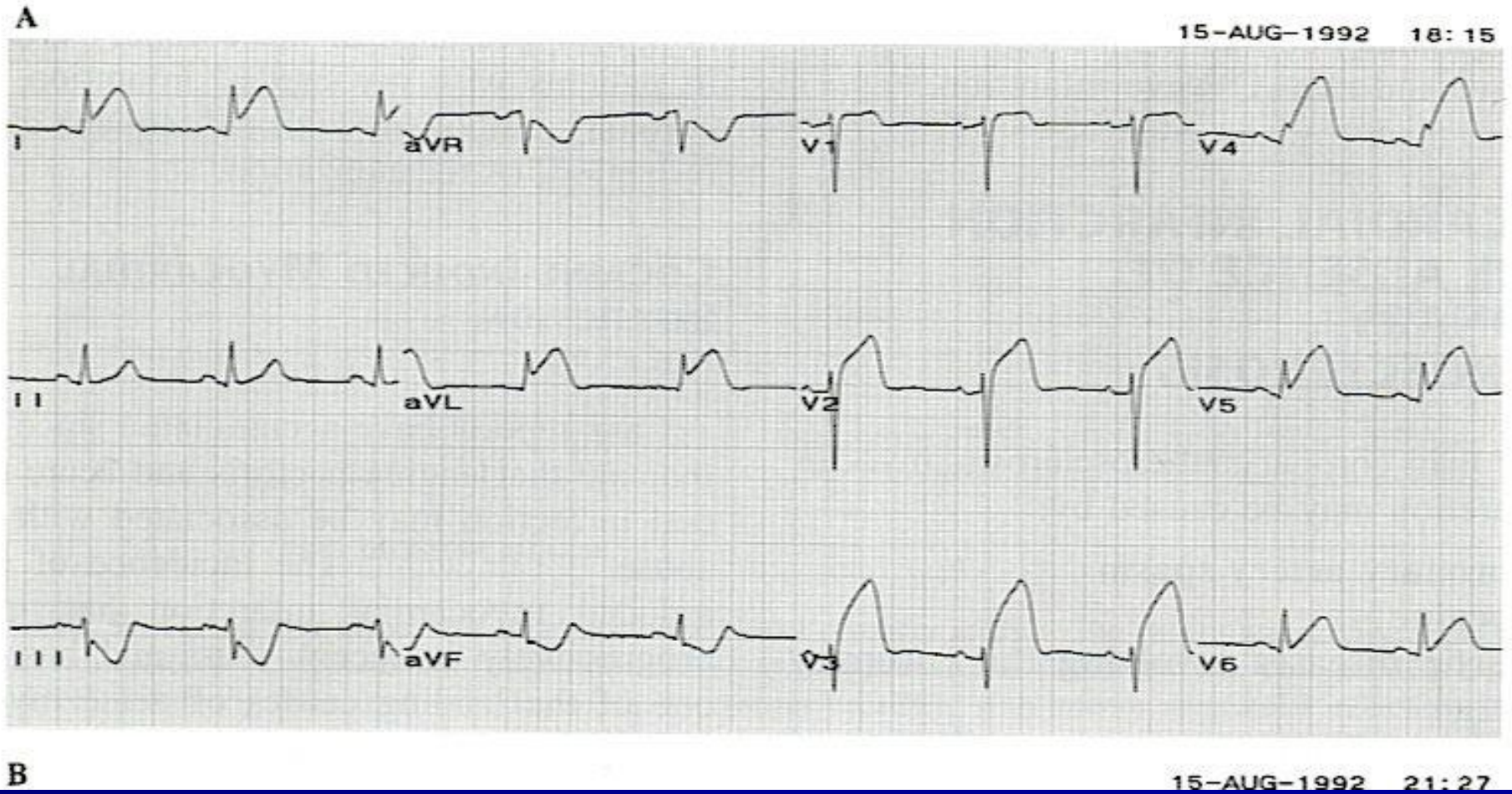
Area of Infarction	Leads Involved
Anterior wall	V1, V2, V3, V4
*Anteroseptal	V1, V2
Lateral wall	I, AVL, V5, V6
Inferior wall	II, III, AVF
Right ventricle	V4 R
Posterior wall	V7, V8, V9 + Tall R & ST ↓ V1, V2

Myocardial Infarction

Acute Injury Phase

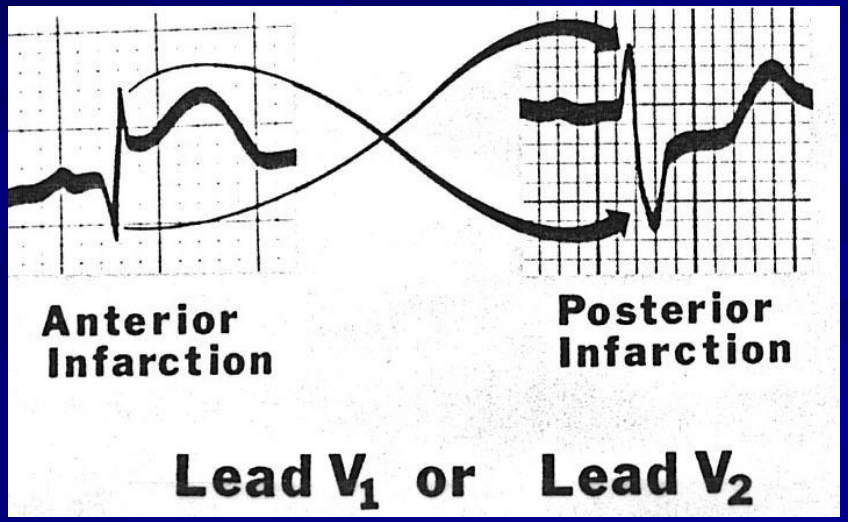


Myocardial Infarction
Acute Injury Phase



Posterior wall infarction

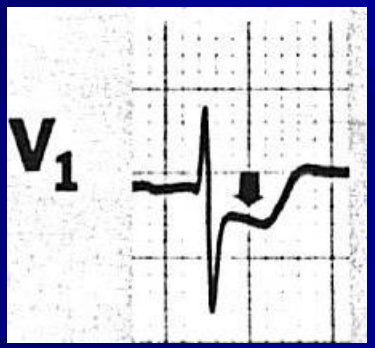
- *If* an Anterior wall MI is manifested by Q waves & ST segment elevation

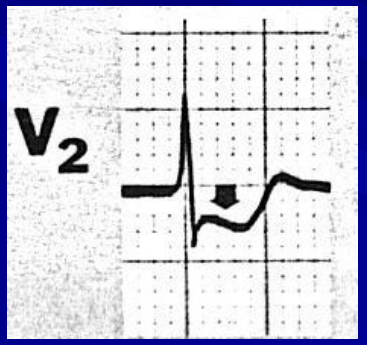


- *Then* a Posterior wall MI will appear just the opposite (R waves & ST depression)

Posterior wall infarction

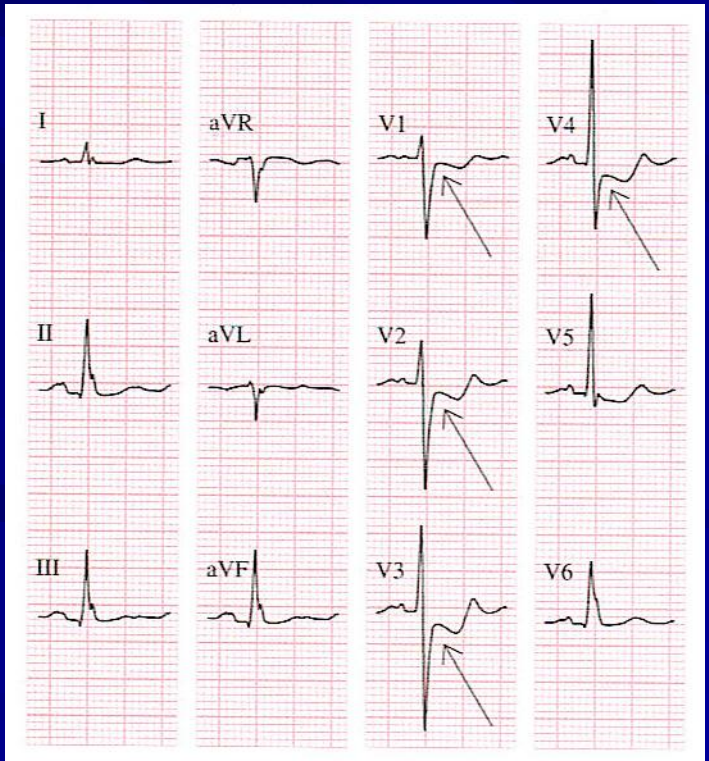
- In acute posterior infarctions, there is a *large R* wave with ST *depression* in: V1, V2 and / or V3





Myocardial Infarction
Posterior wall MI

- Note that the electrical activity of the anterior and posterior wall of the LV is in *opposite* directions



ST Segment Elevation

- Not as easy as it sounds
  - Inconsistent interpretation
    - Interobserver and intraobserver
      - Up to 14% inconsistently classified
  - Many reasons for STE
    - 29% of prehospital ECGs in CP pts have at least 100 uV of STE on 2 contiguous limb leads or 200 uV of STE on 2 contiguous precordial leads
    - But only 49% and 15% (limb/ precord) have AMI
    - Majority have LVH, LBBB, BER, or ventricular aneurysm

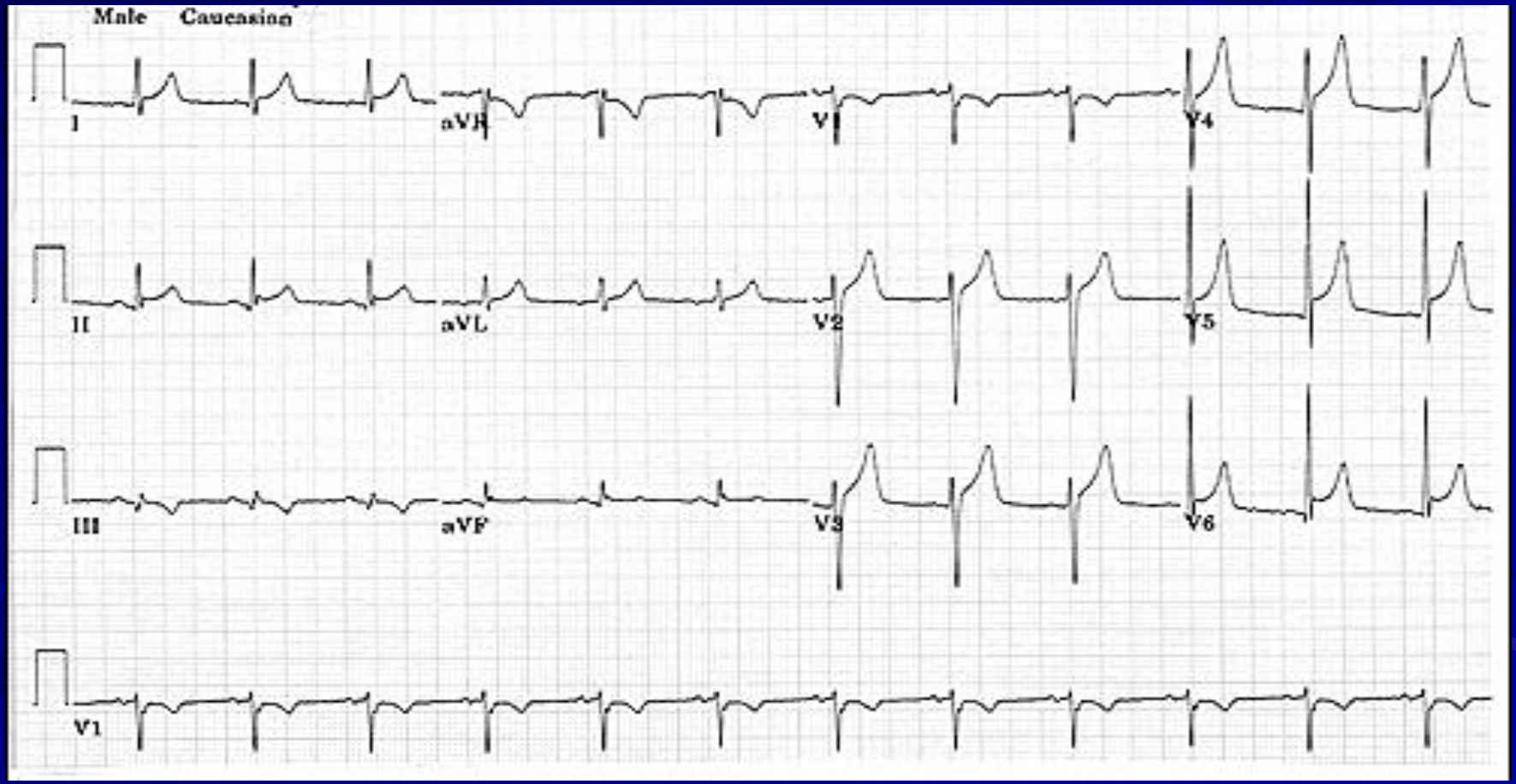
ST Segment Elevation

- How often are we right/ wrong in initiating reperfusion therapy?
  - 11% of lytic patients did not have AMI
  - 9 of 83 lytic treated pts – exposed to risk of Rx
- If STE is minor, it is more difficult to definitively call, and leads to delay in Rx
  - D2Drug < 30 min: ST Segment Sum 21.5 mm
  - D2Drug > 30 min: ST Segment Sum 11.5

The ST Segment

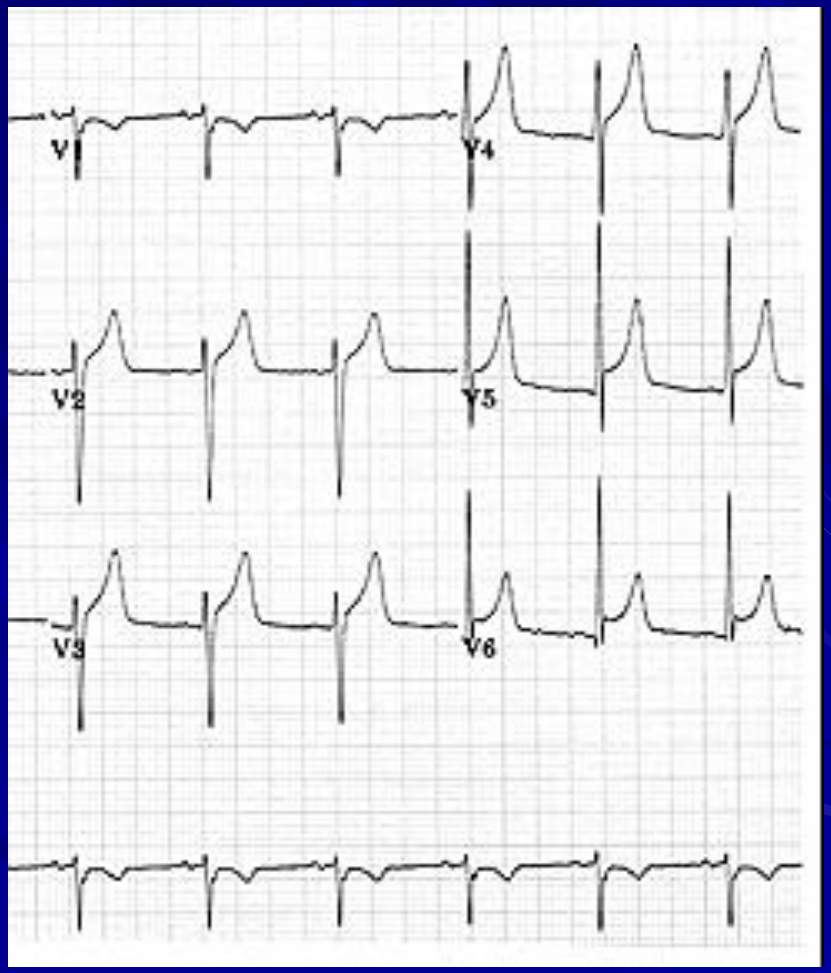
- Myocardial Infarction/ Ischemia
- Ventricular aneurysm
- LVH
- LBBB
- Early repolarization/ normal variant
- Acute pericarditis
- Hyperkalemia
- Hypothermia
- Hypercalcemia
- Post cardioversion

Early Repolarization



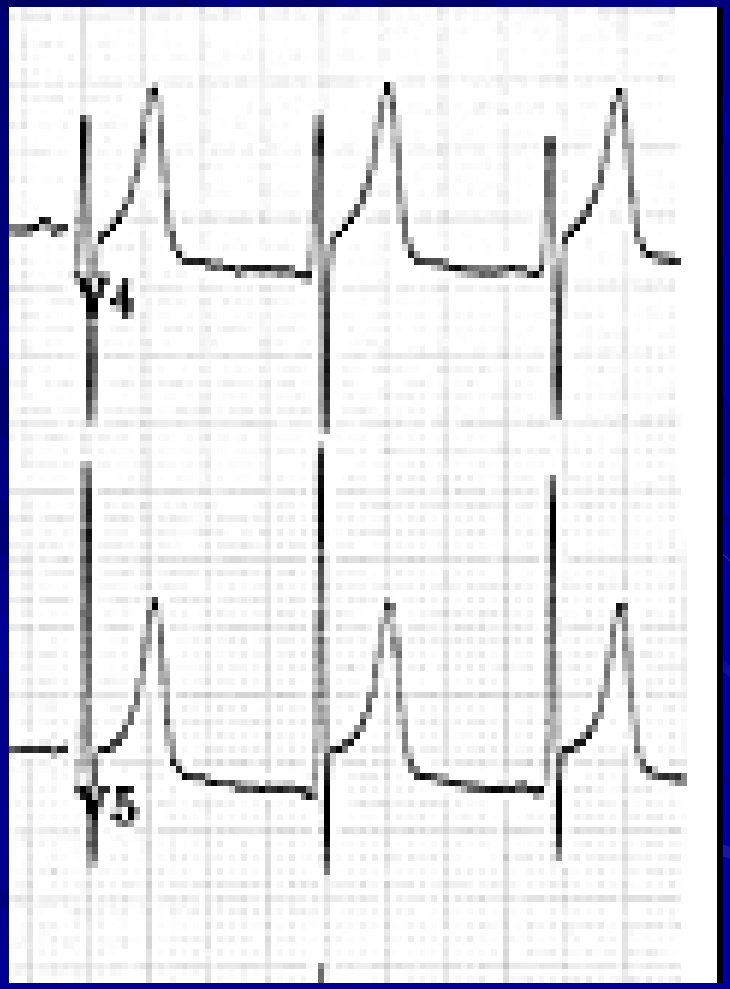
Early Repolarization

- Early Repolarization
  - Usually mid-precordial leads
  - Elevated J point (up to ~300 uV)
  - ST usually concave
  - Notching in downstroke of QRS
  - Large symmetric T waves
  - Relatively fixed pattern



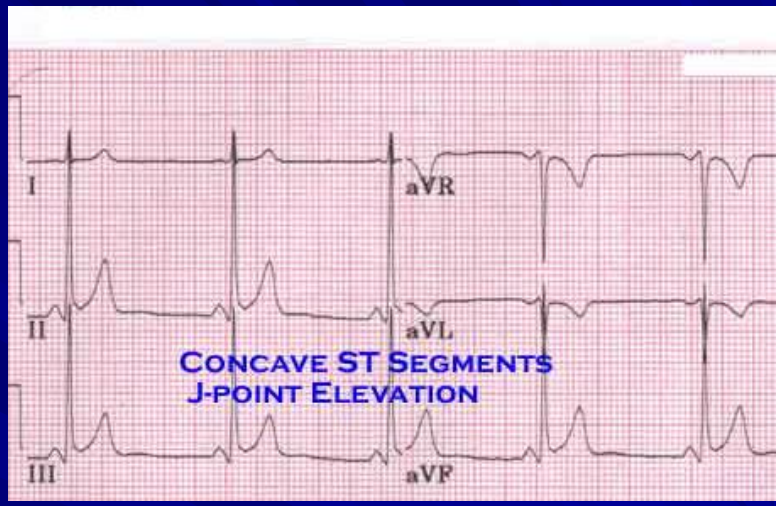
Early Repolarization

- Early Repolarization
  - 1% of general population
  - 13% of Chest Pain pts
  - 23-48% of Cocaine CP pts
  - All ages, races
  - Mean age 39 yr (16-80)
  - Rare in those > 70 (3%)

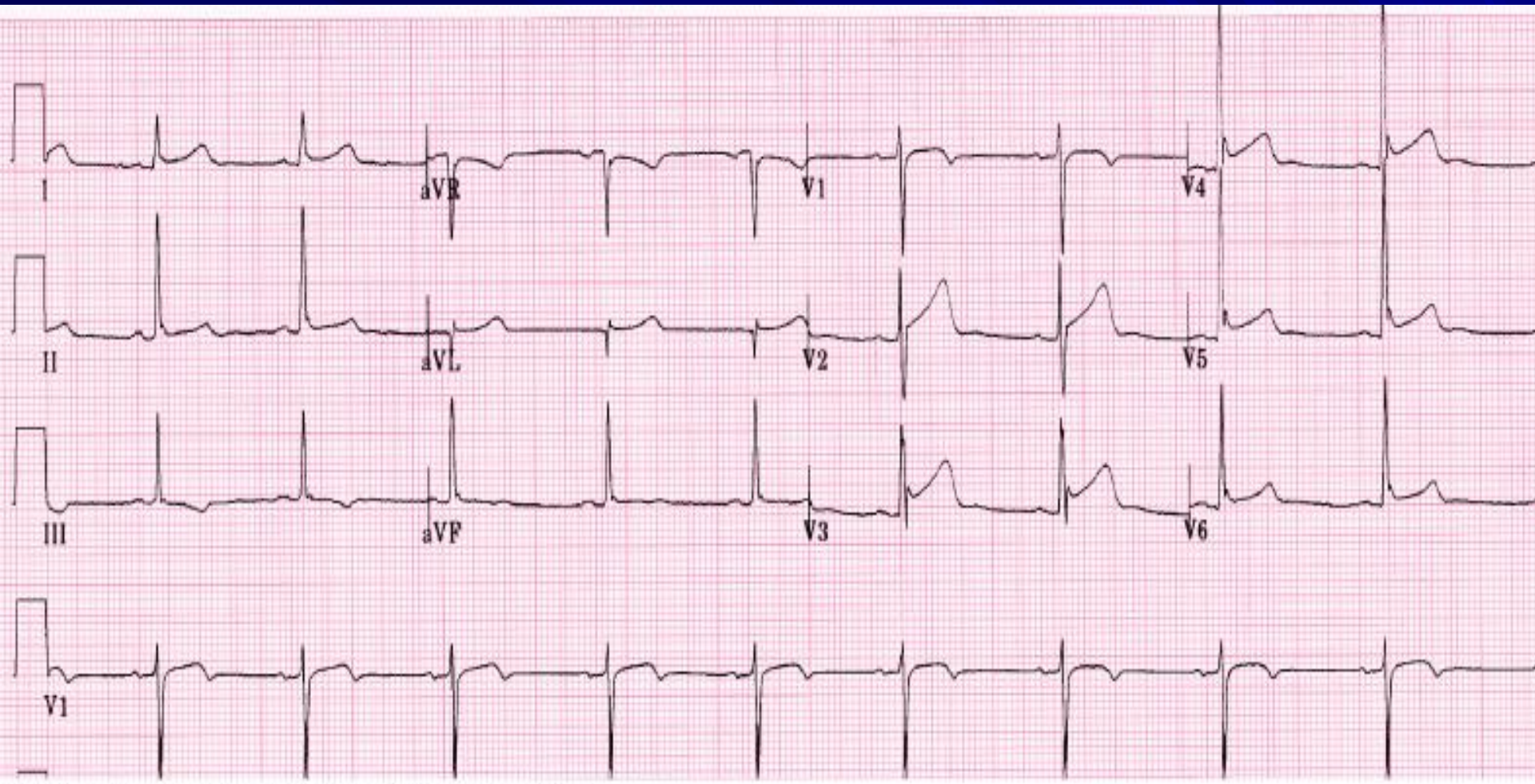


Early Repolarization

- Early Repolarization
  - Limb leads involved ~ 45% of cases
  - “Isolated” BER in limb leads is VERY RARE
    - Think of other causes for STE

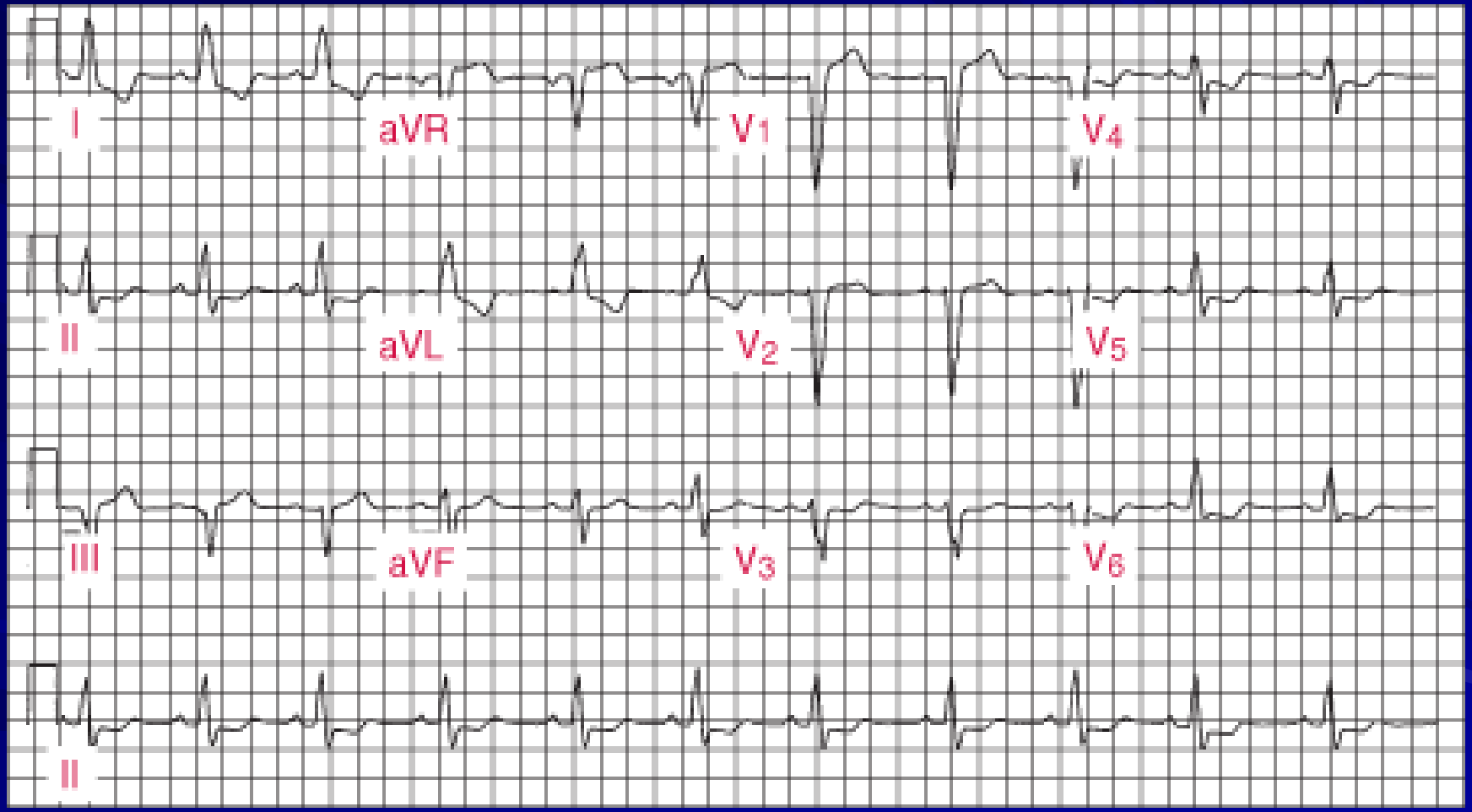


Early Repolarization

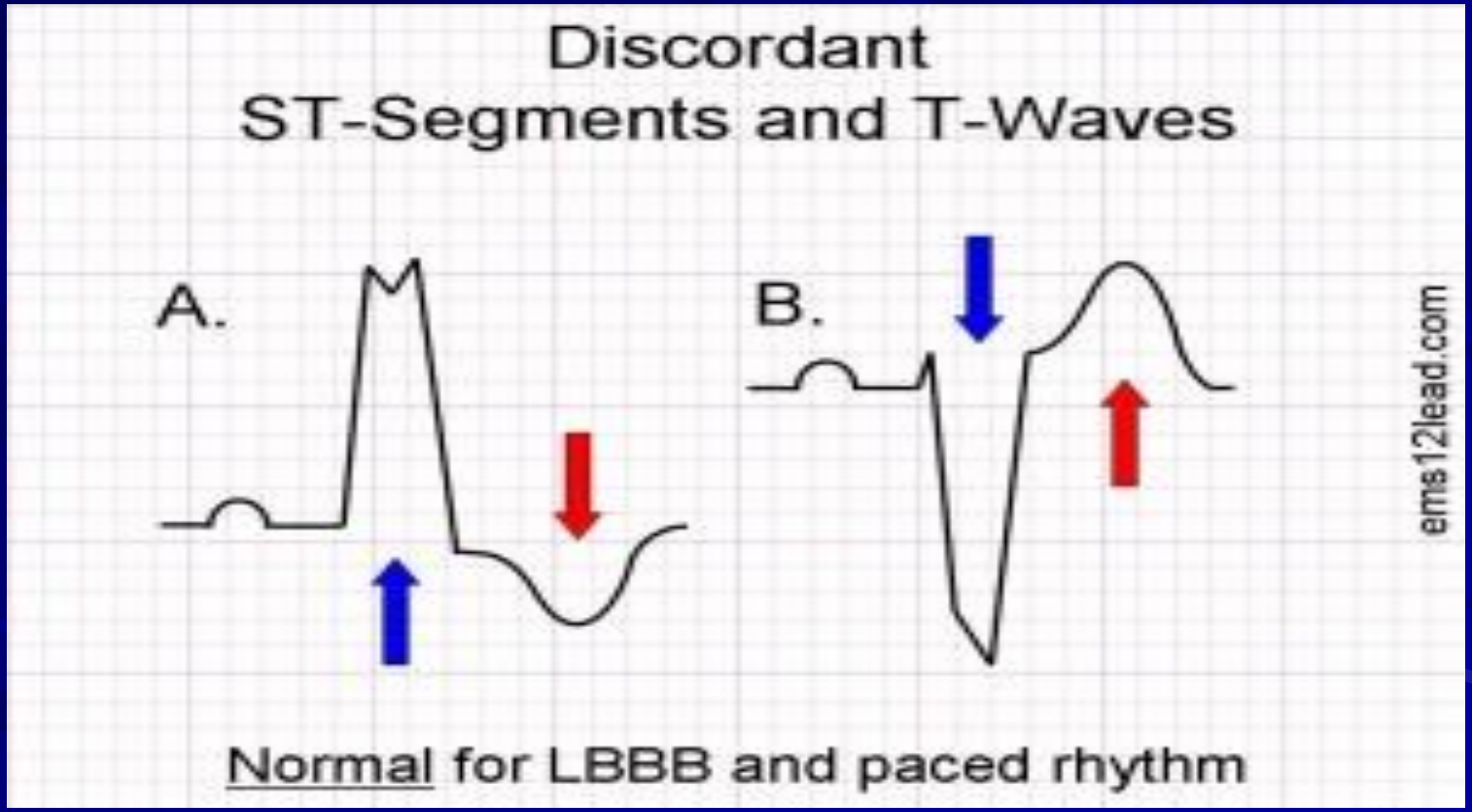


Source: Knoop KJ, Stack LB, Storrow AB, Thurman RJ: *The Atlas of Emergency Medicine, 3rd Edition:* http://www.accessmedicine.com

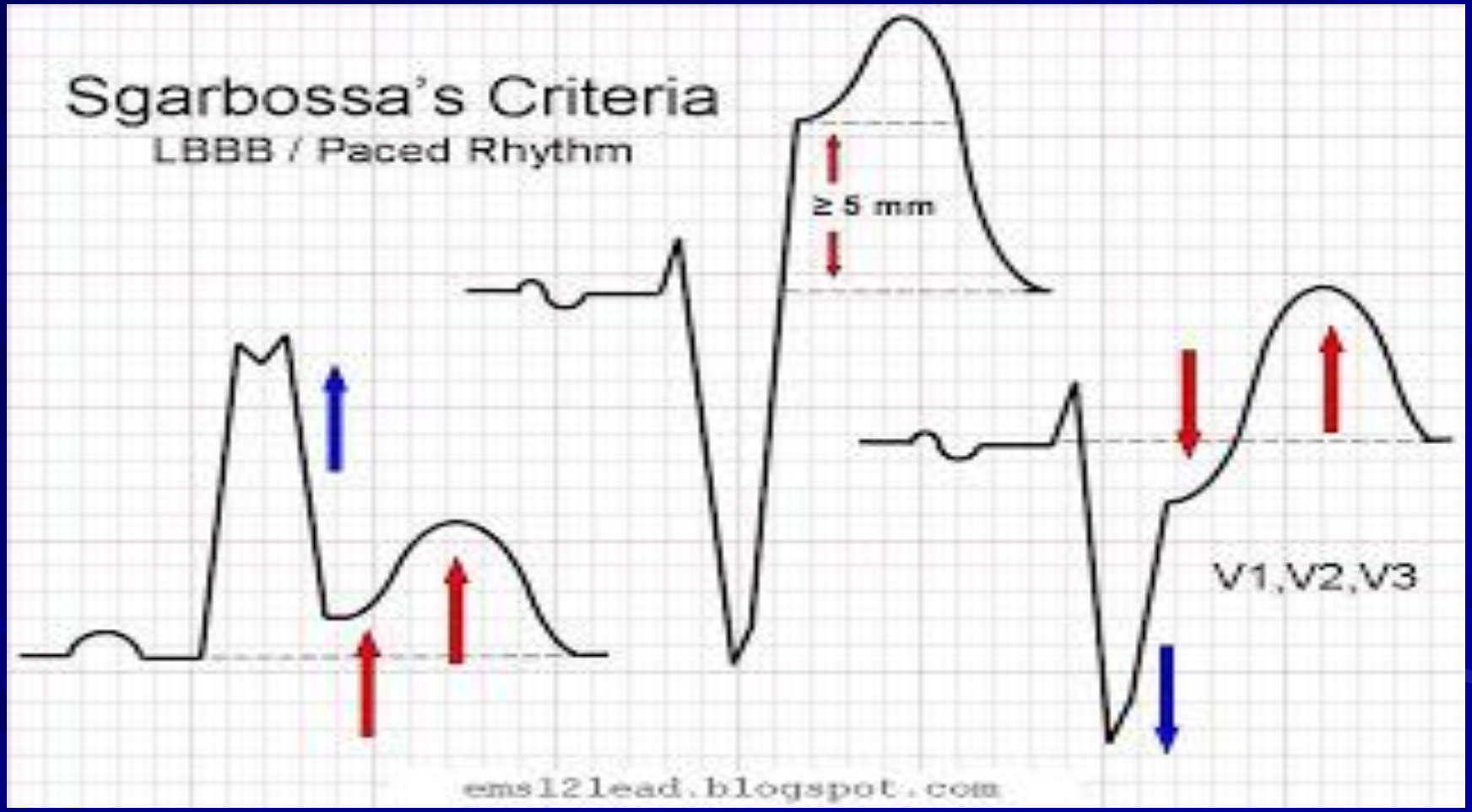
LBBB



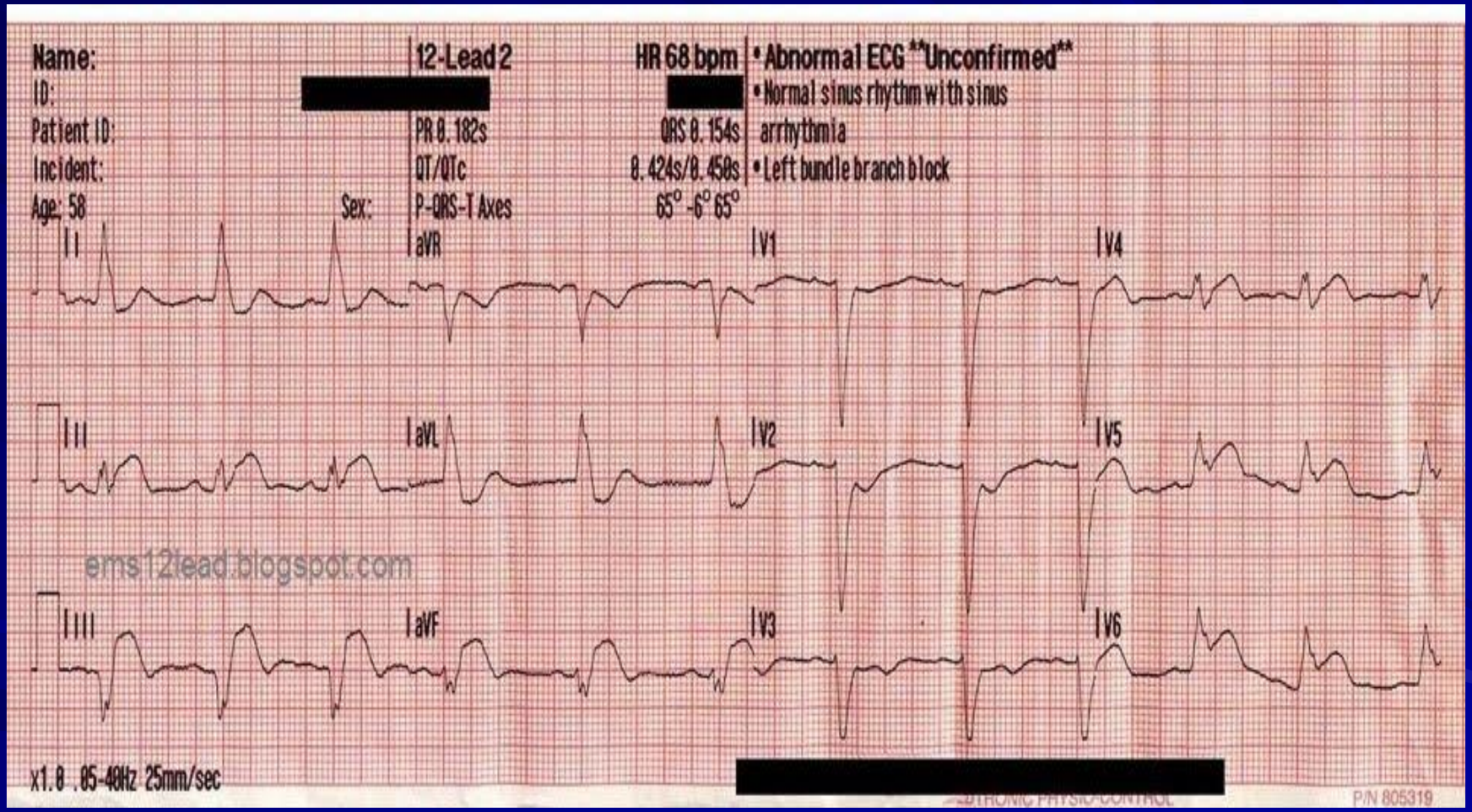
LBBB


Discordant
ST-Segments and T-Waves
A.
B.
ems12lead.com
Normal for LBBB and paced rhythm

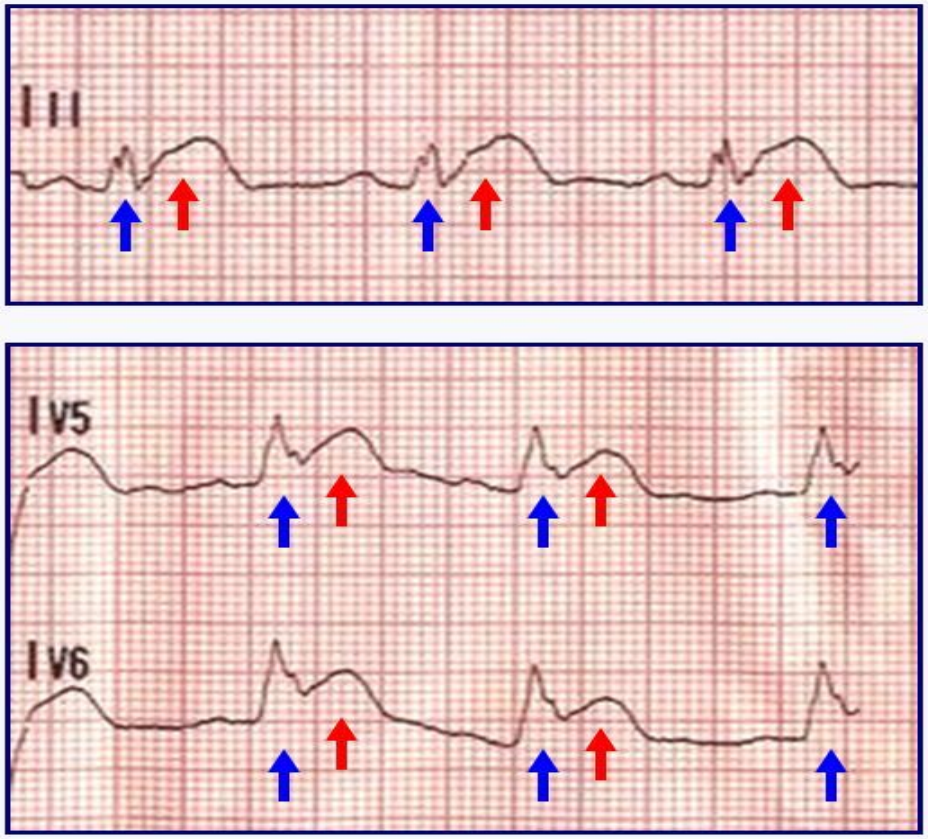
LBBB + Injury


Sgarbossa's Criteria
LBBB / Paced Rhythm
≥ 5 mm
V1,V2,V3
ems12lead.blogspot.com

LBBB + Injury


Name:
ID:
Patient ID:
Incident:
Age: 58
Sex:
12-Lead 2
PR 0.182s
QT/QTc
P-QRS-T Axes
HR 68 bpm
QRS 0.154s
0.424s/0.458s
65° -6° 65°
• Abnormal ECG **Unconfirmed**
• Normal sinus rhythm with sinus arrhythmia
• Left bundle branch block
I
II
III
aVR
aVL
aVF
V1
V2
V3
V4
V5
V6
ems12lead.blogspot.com
x1.0 .05-40Hz 25mm/sec
P/N 805319

LBBB + Injury

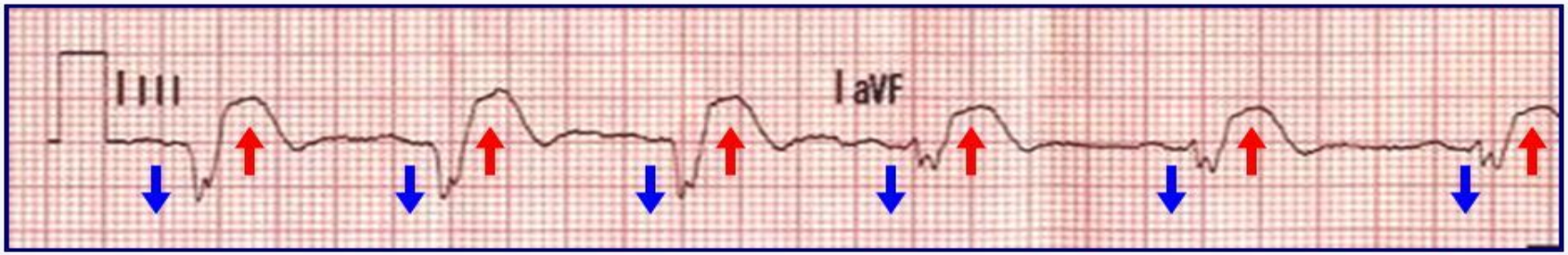


Concordant ST-elevation > 1 mm in leads II, V5 and V6

ems12lead.blogspot.com

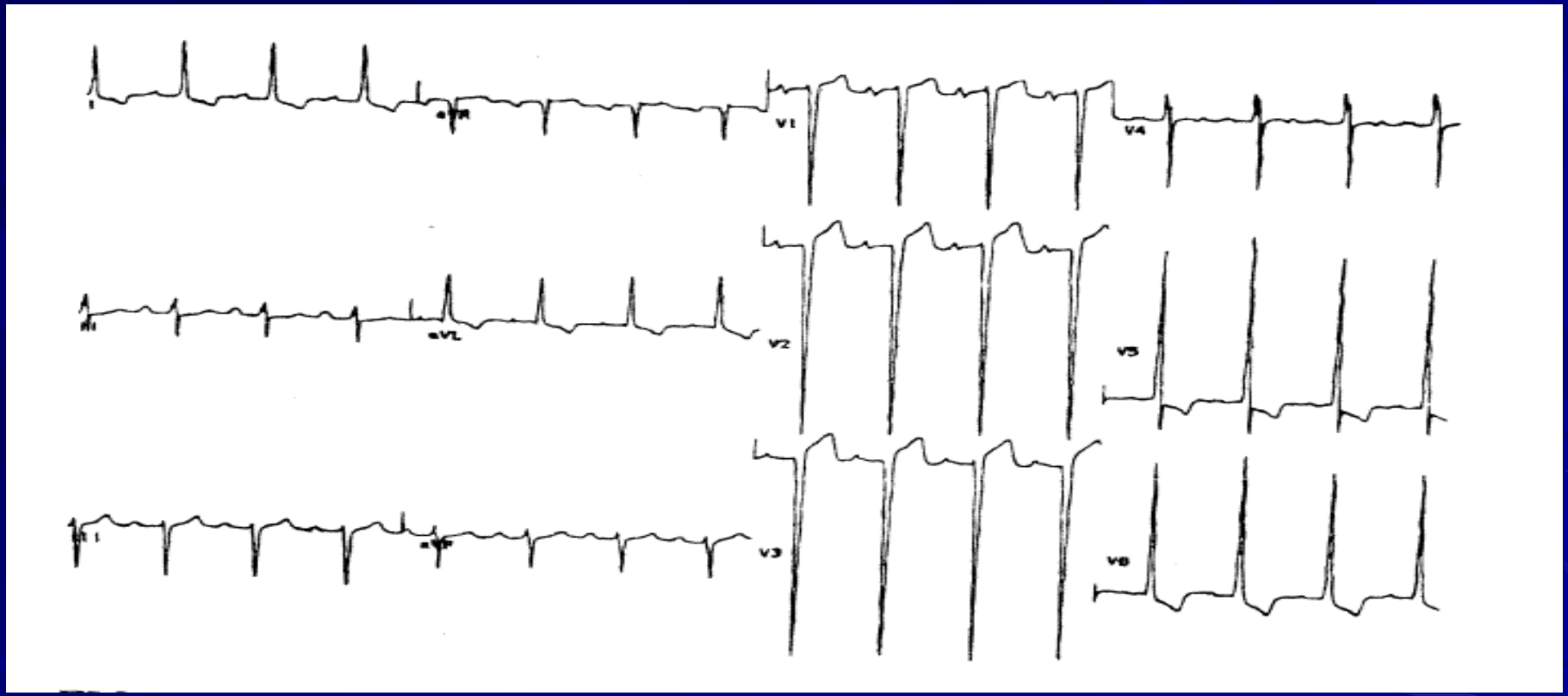
LBBB + Injury

Discordant ST-elevation > 0.2 the depth of the S-wave in leads III and aVF



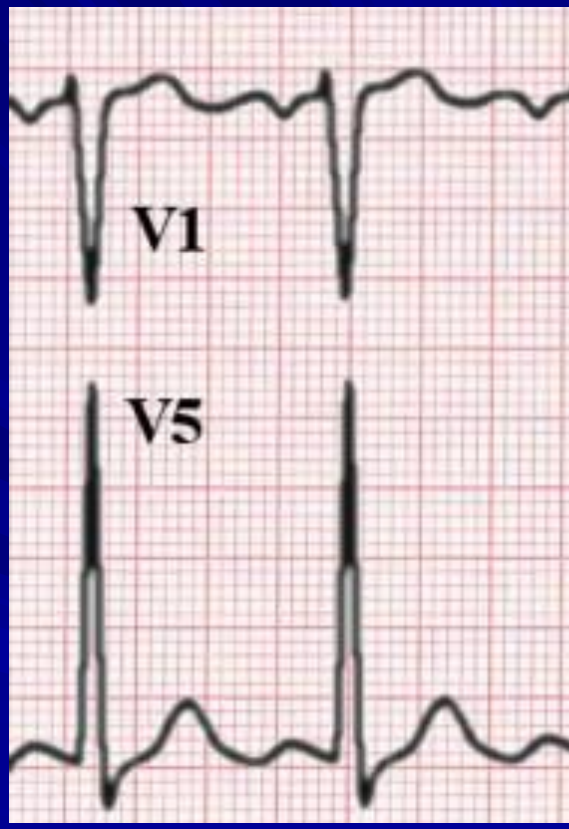
ems12lead.blogspot.com

LVH



The ST Segment

- Left Ventricular Hypertrophy
  - A number of different ECG criteria proposed
  - Vary in sensitivity and specificity
  - Easiest: Sokolow – Lyon
    - R_{aVL} > 1.1 mV or
    - S_{V1} + (R_{V5} or R_{V6}) > 3.5 mV
    - Sensitivity 10 – 35%; Specificity 85%
  - Repolarization abnormalities increase the assoc with anatomic LVH

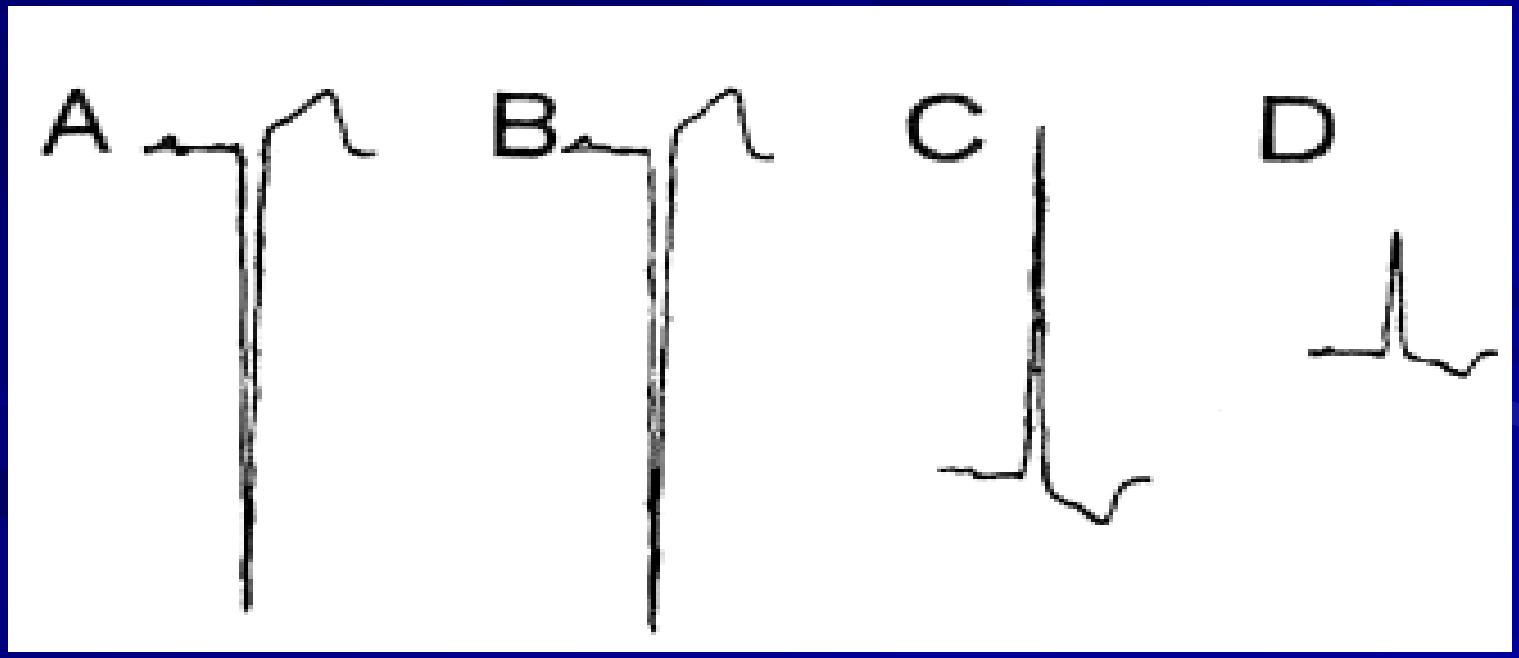


Standard LVH

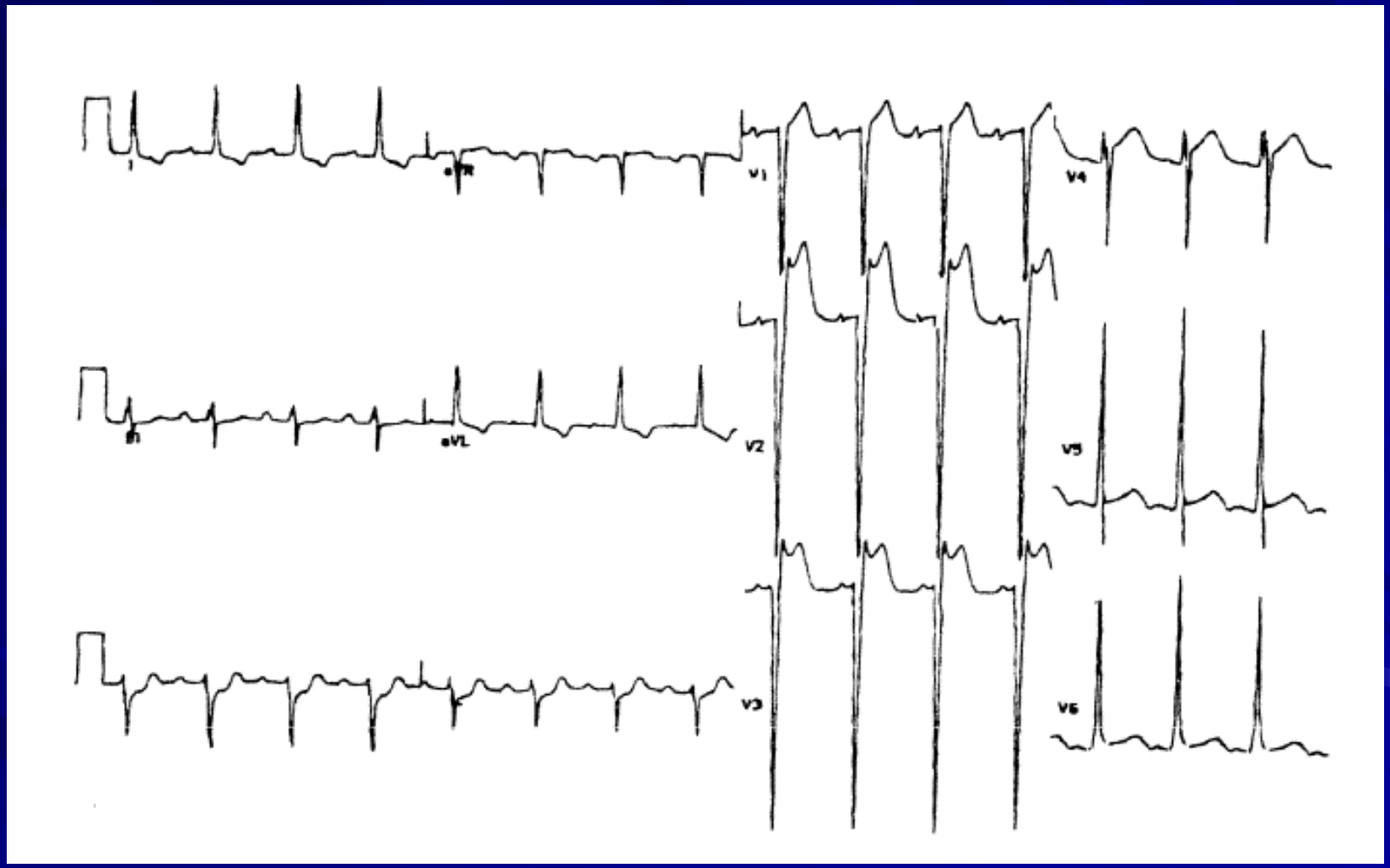
Expected findings in LVH:

* STE discordant with QRS – panels A and B

* STD and T inversion discordant with QRS – panels C and D



LVH with STE - AMI



Practice EKG’s

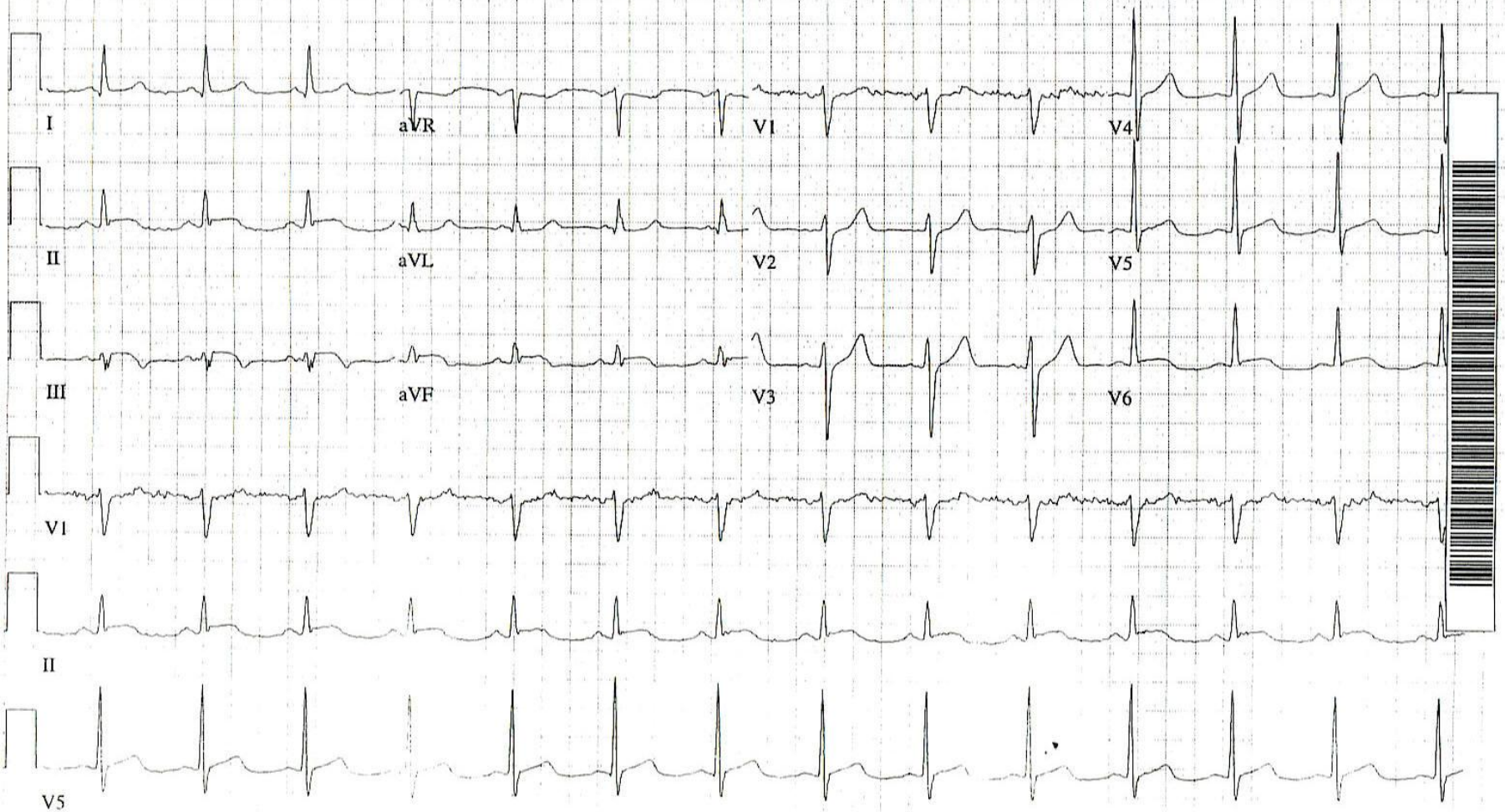
55 yr

Loc:0

Vent. rate	83	BPM
PR interval	133	ms
QRS duration	104	ms
QT/QTc	371/436	ms
P–R–T axes	52 25	20

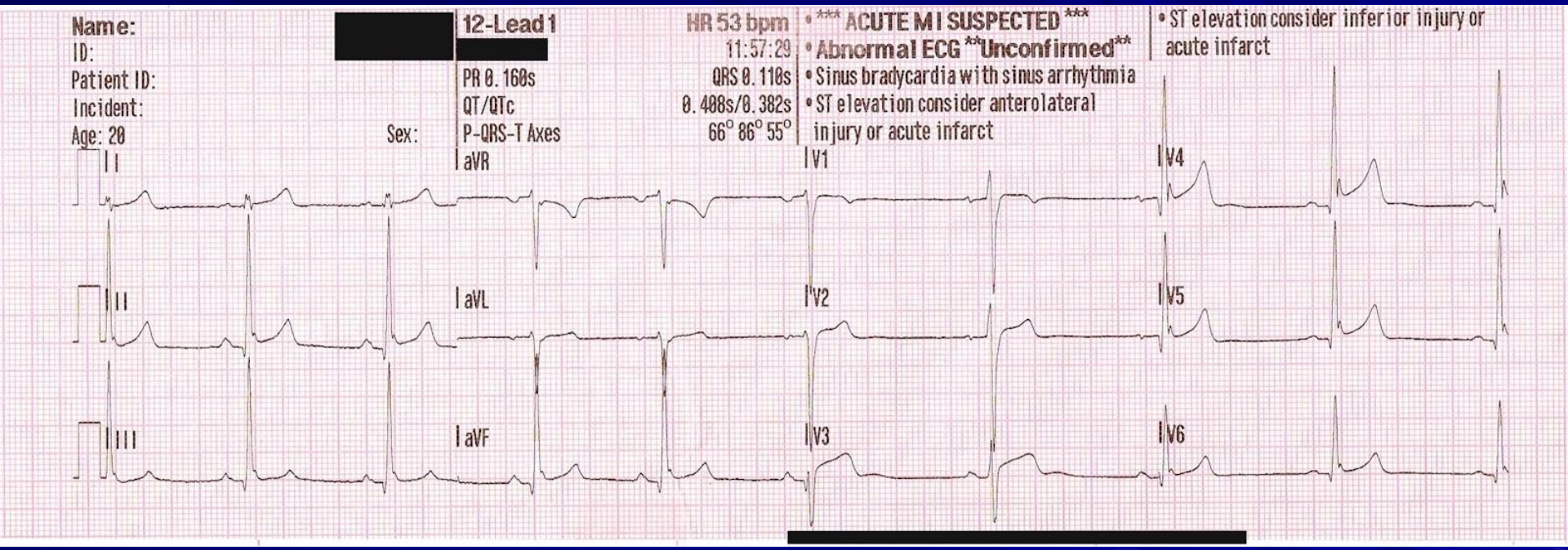
Referred by:

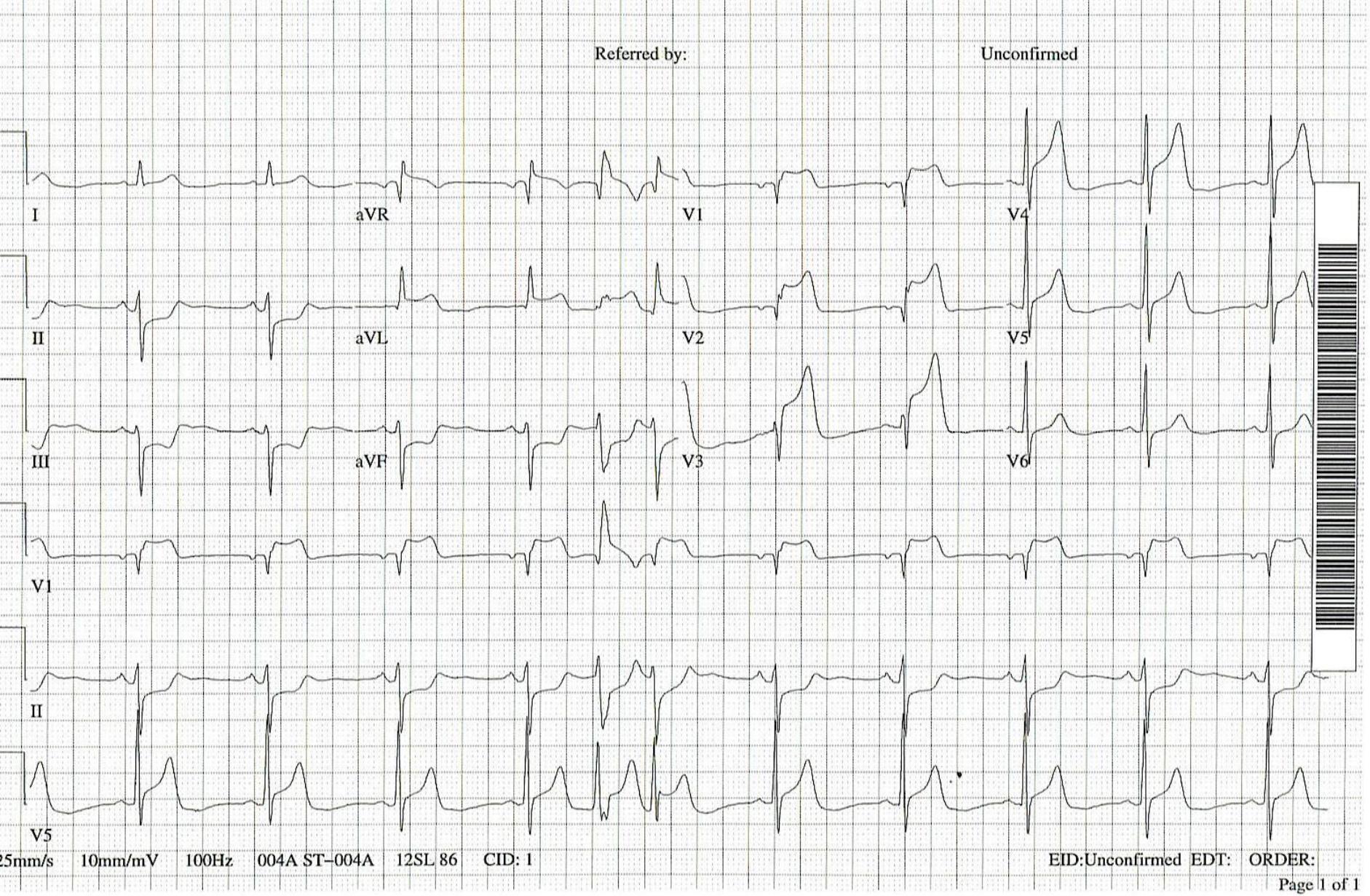
Unconfirmed



25mm/s 10mm/mV 100Hz 004A–004A 12SL 86 CID: 1

EID:Unconfirmed EDT: ORDER:


Name:
[redacted]
12-Lead 1
HR 53 bpm
*** ACUTE MI SUSPECTED ***
ST elevation consider inferior injury or acute infarct
ID:
11:57:29
Abnormal ECG **Unconfirmed**
Patient ID:
PR 0.160s
QRS 0.110s
Sinus bradycardia with sinus arrhythmia
Incident:
QT/QTc
0.408s/0.382s
ST elevation consider anterolateral injury or acute infarct
Age: 20
Sex:
P-QRS-T Axes
66° 86° 55°
I
aVR
V1
V4
II
aVL
V2
V5
III
aVF
V3
V6
[redacted]


Referred by:
Unconfirmed
I
aVR
V1
V4
II
aVL
V2
V5
III
aVF
V3
V6
V1
II
V5
25mm/s 10mm/mV 100Hz 004A ST-004A 12SL 86 CID: 1
EID:Unconfirmed EDT: ORDER:
Page 1 of 1

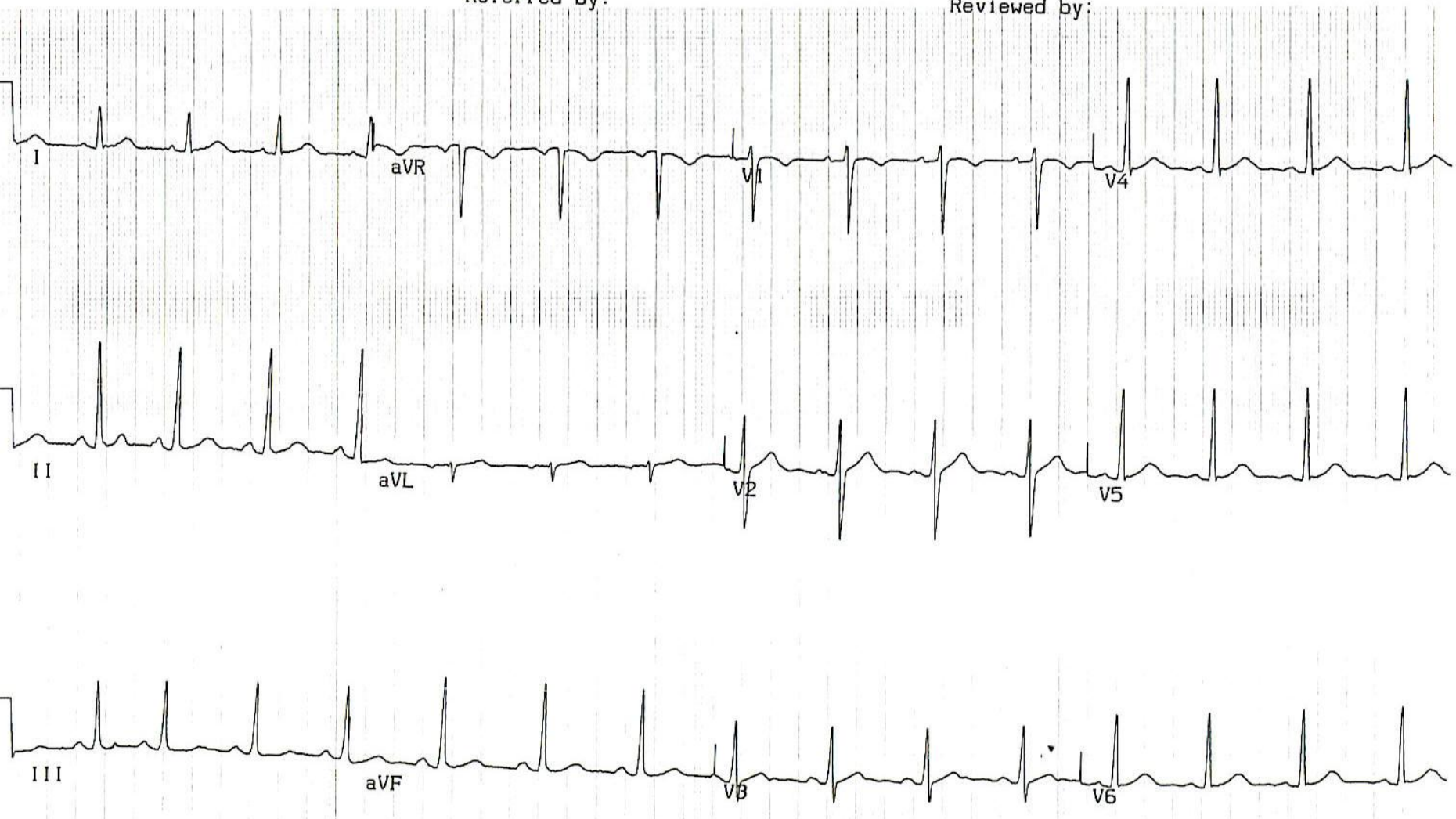
60Hz
Pgm 002A
.2SL v68

Age: Ht: Wt:
Sex: Race:
Loc: Room:
Option: BP:

Vent. rate	92 BPM
PR interval	140 ms
QRS duration	72 ms
QT/QTc	336/414 ms
P-R-T axes	68 69 41

Referred by:

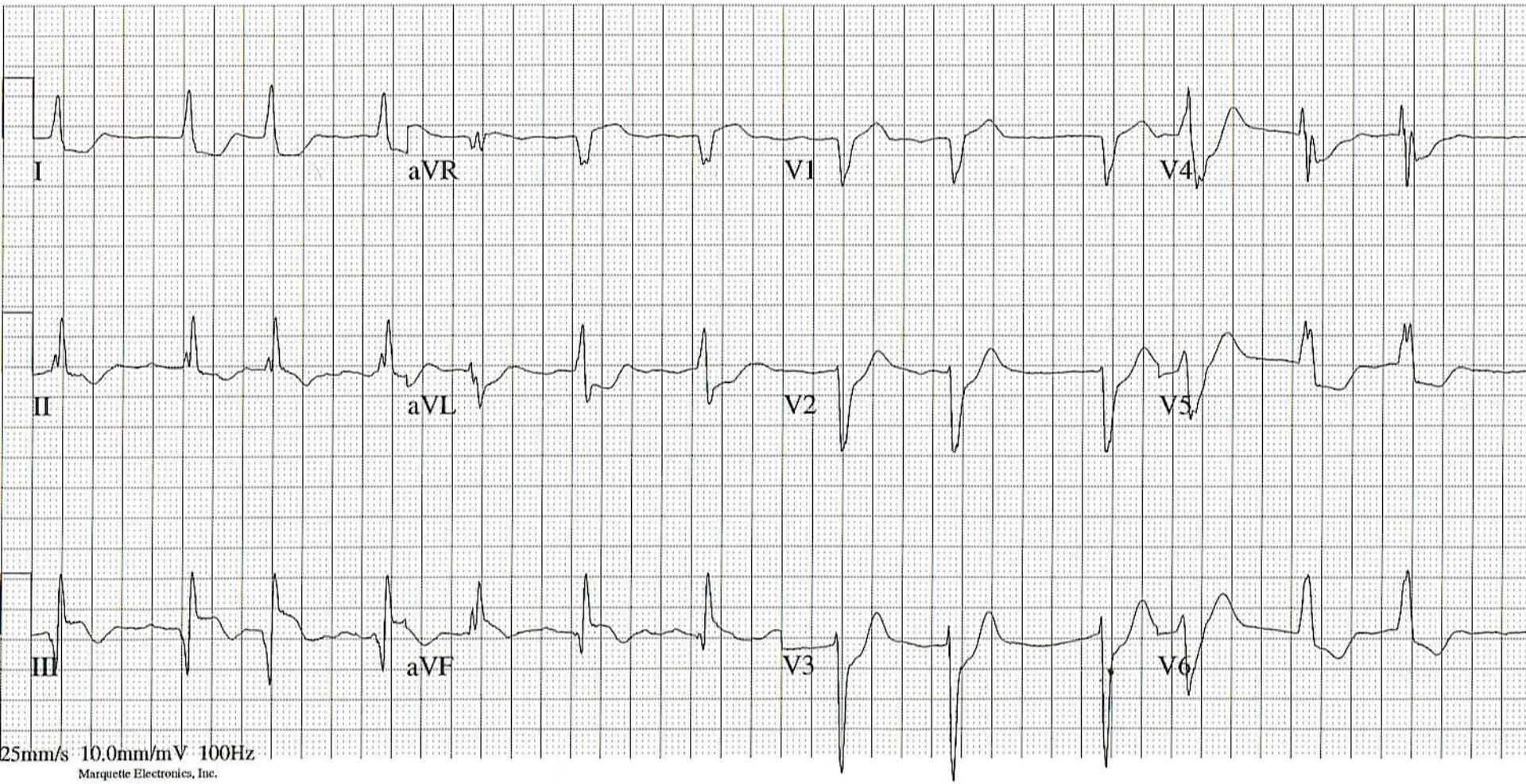
Reviewed by:

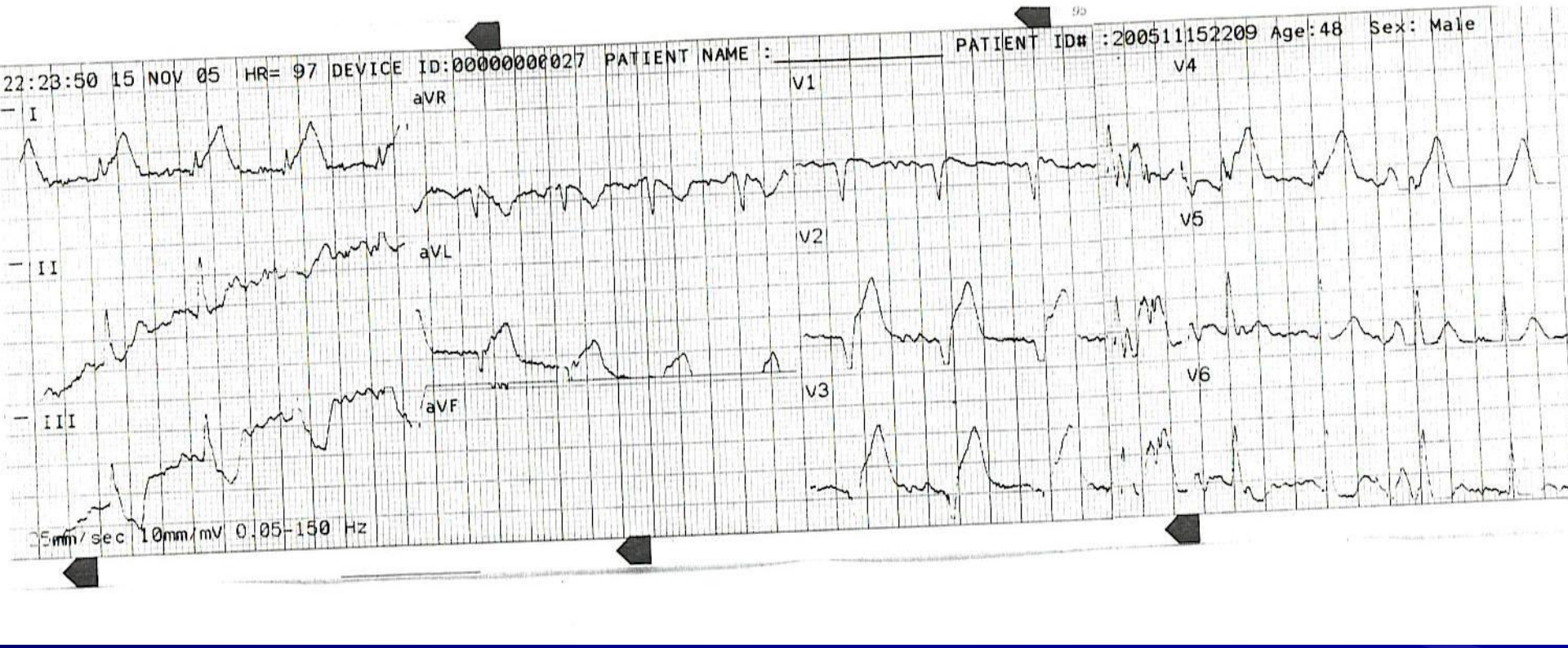


Loc:0

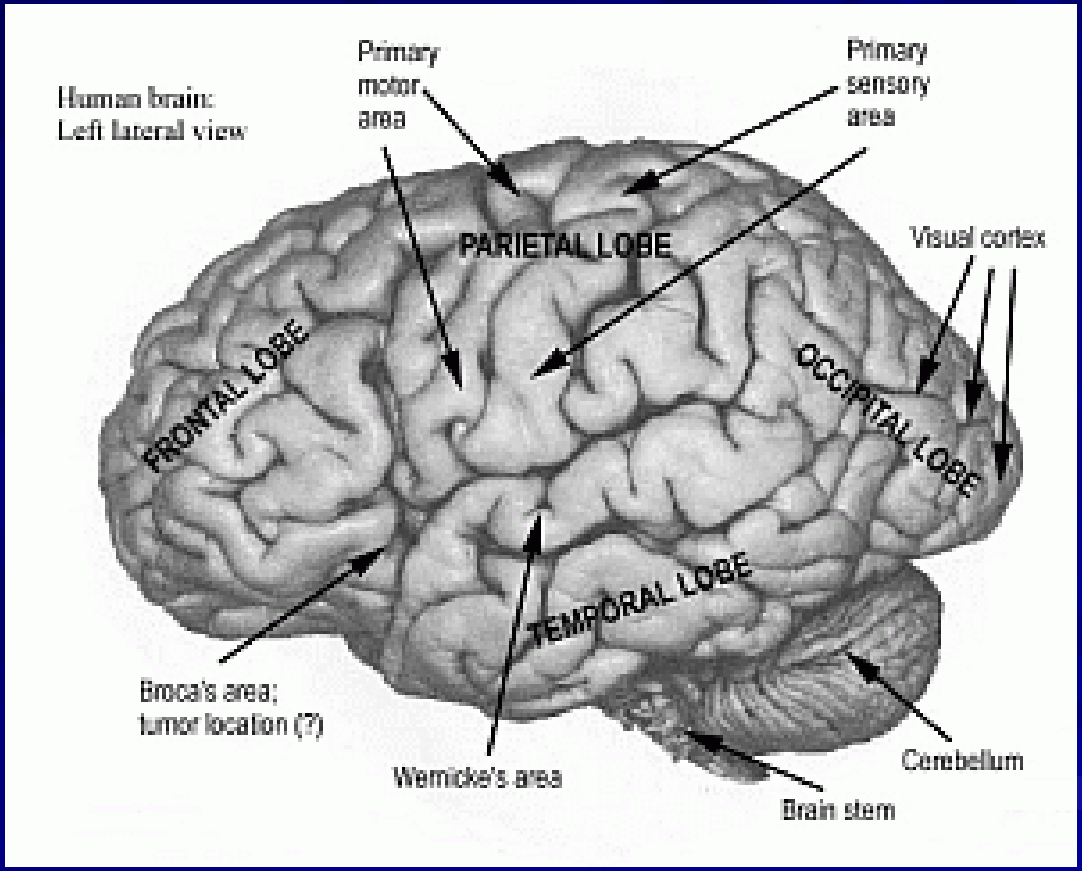
QT/QTc		400/458	ms
P–R–T axes	*	43	205

Unconfirmed




22:23:50 15 NOV 05 HR= 97 DEVICE ID:00000000027 PATIENT NAME :_____ PATIENT ID# :200511152209 Age:48 Sex: Male
I
II
III
aVR
aVL
aVF
V1
V2
V3
V4
V5
V6
25mm/sec 10mm/mV 0.05-150 Hz

Questions??



LGarvey@carolinas.org