

# Correlate the **Coronary Arteries**

Inferior – RCA – II, III, AVF

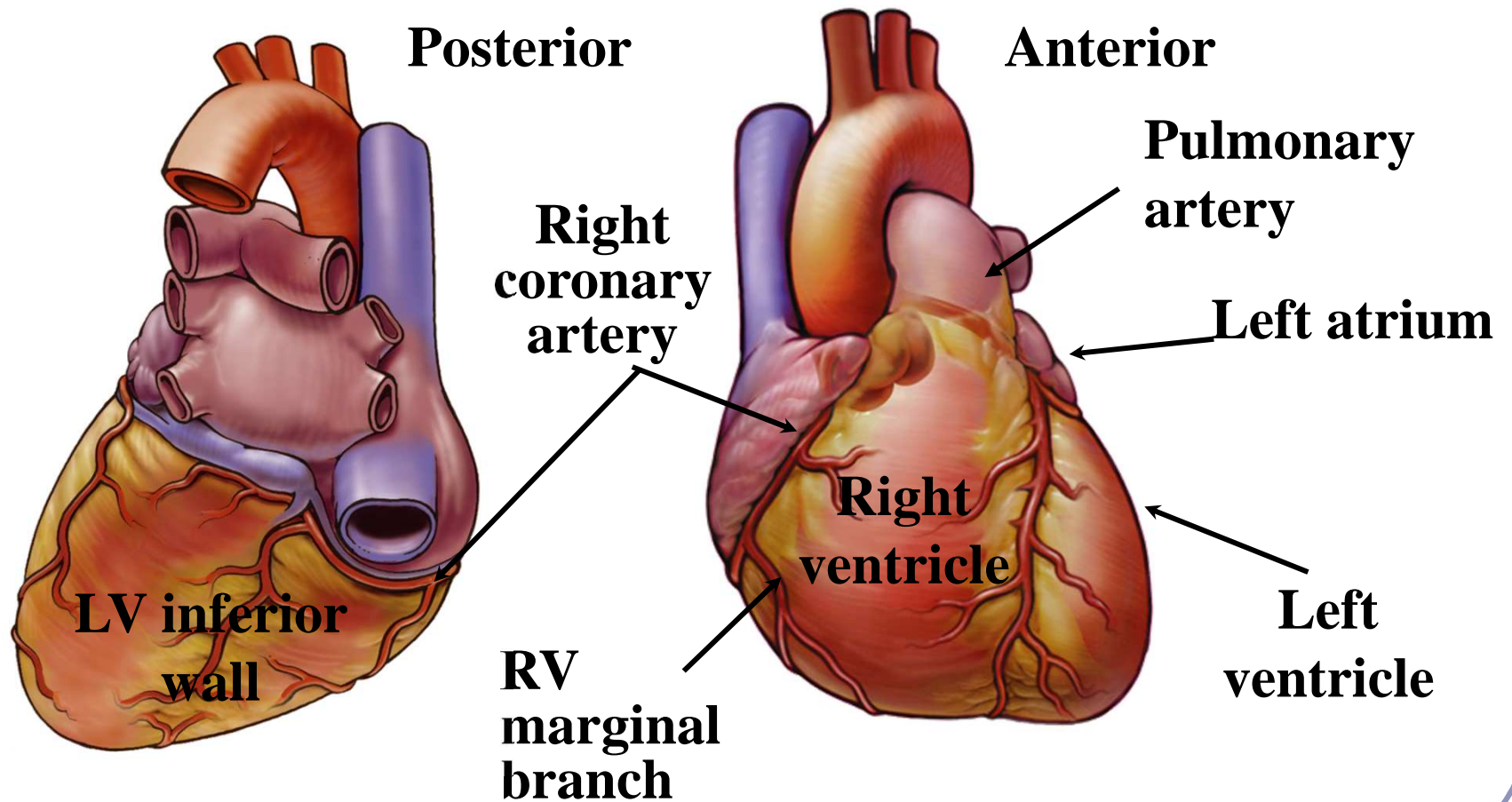
Septal – LAD – V1, V2

Anterior – LAD – V3, V4

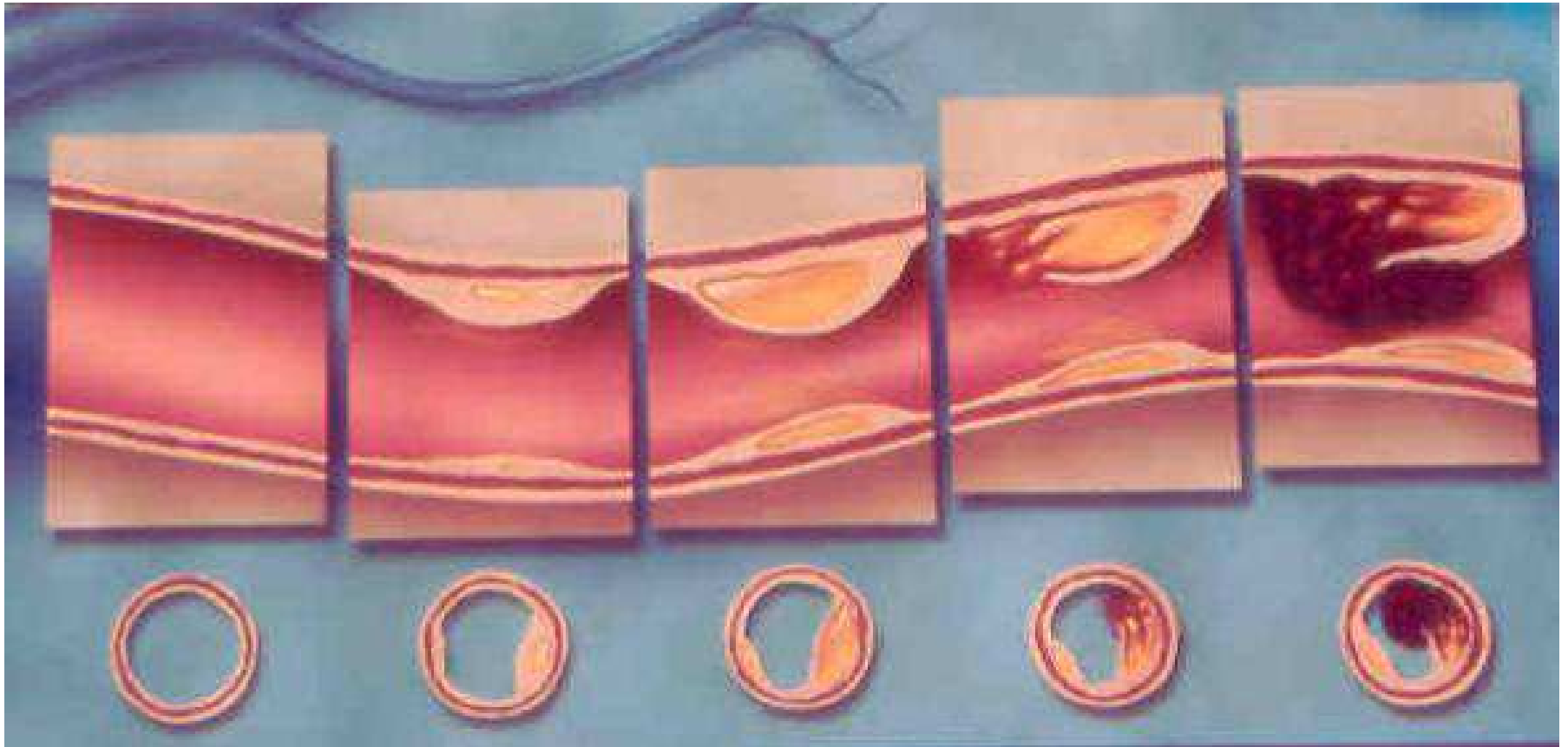
Lateral – Circumflex – I, AVL, V5, V6



# Cardiac Anatomy

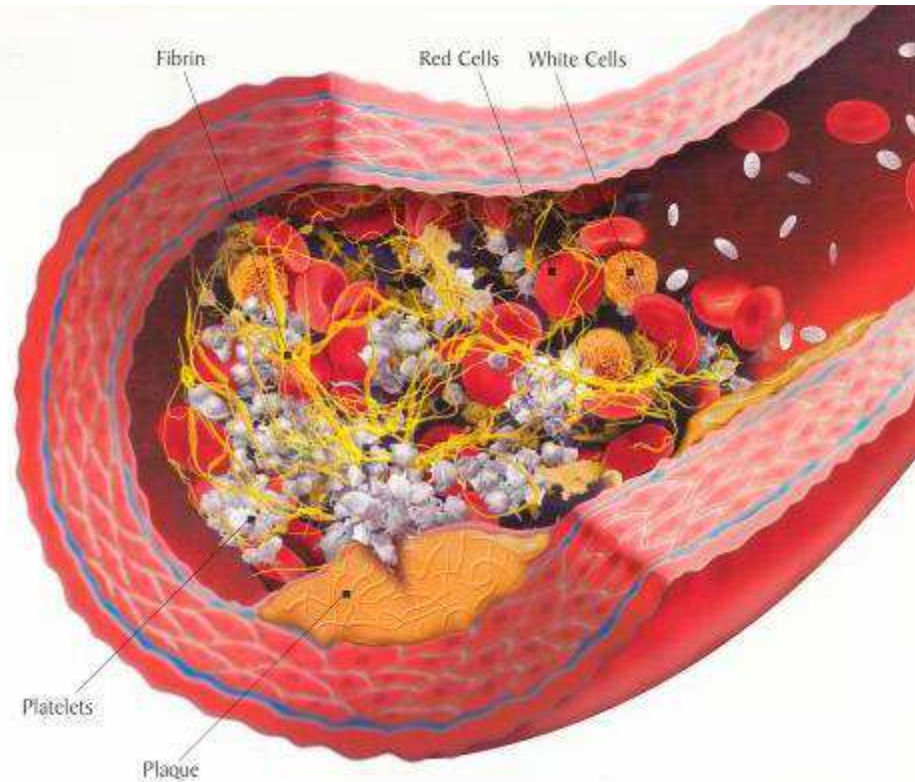


# Atherosclerosis



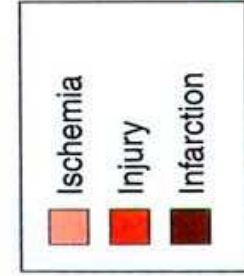
# Cascade effects of atherosclerotic plaque rupture

- Platelet aggregation
- Fibrin accumulation
- Thrombus formation
- Bleeding into the plaque
- Vasospasm

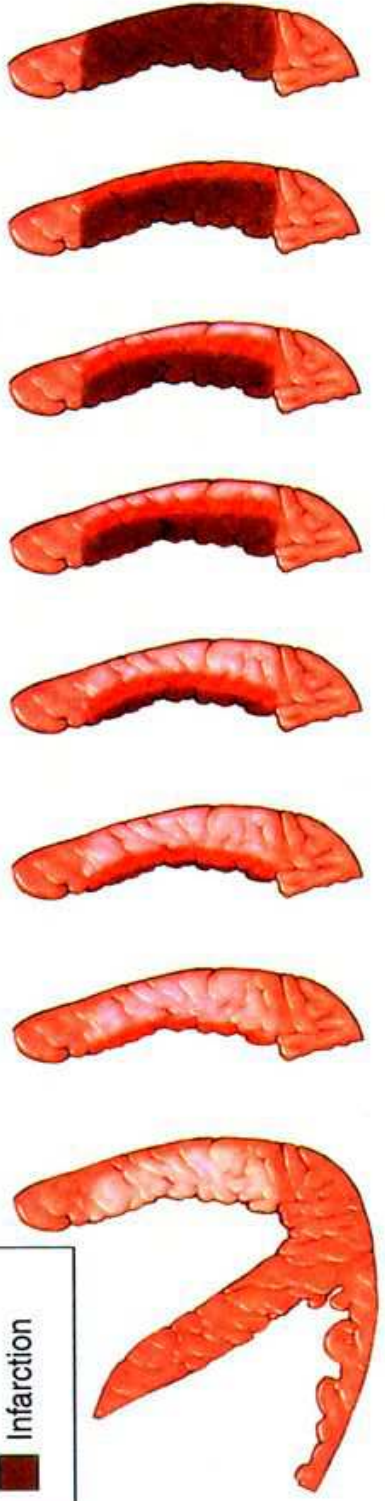


**ARTERY OCCULSION**

**A. Changes in Anatomy**



# Evolutional Changes of an Acute Myocardial Infarction

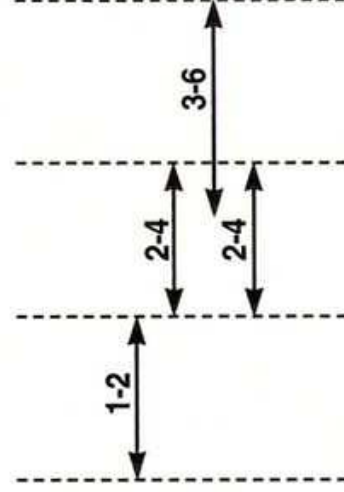


Time after onset    Onset    <20-40 min    0%    10%    30%    50%    70%    90%    100%

Extent of infarction

**B. When Serum Markers Are First Detectable (Hours)**

- Myoglobin
- Troponins
- CK-MB
- CK-MB isoforms





***Time Is Muscle***

**Muscle is Ejection Fraction**

**Ejection Fraction is  
Quality of Life**

# Target

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**Door to Balloon < 90 minutes**

(Class 1, Level A)

**or**

**Door to Needle < 30 minutes**

(Class 1, Level B)

ACC/AHA 2013 Guidelines for Management of STEMI

CRUSADING towards a GOAL



# Door to EKG

10 minutes or less

(Class 1: Level C)





## **EKG Changes with MI: Ischemia**

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**Ischemia < 20 Minutes**

**Lack of oxygen to the myocardial muscle**

- ♥ Peaked T Waves
- ♥ Inverted T Waves
- ♥ ST Segment Depression



**Ischemia = screaming for oxygen**

## **EKG Changes with MI: Injury**

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**Injury 20 - 40 minutes**

**When the period of ischemia is prolonged more than a few minutes, ischemic areas of the heart become damaged (injured)**

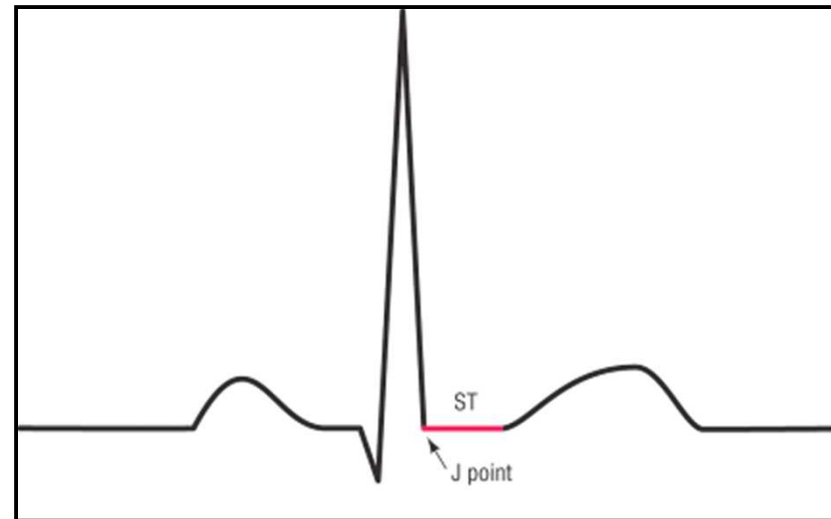
♥ **ST segment elevation**

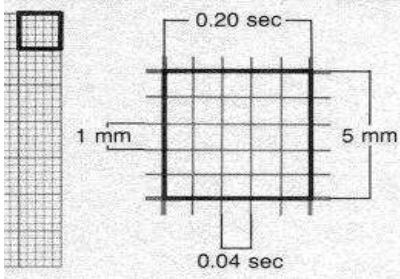


## The ST Segment

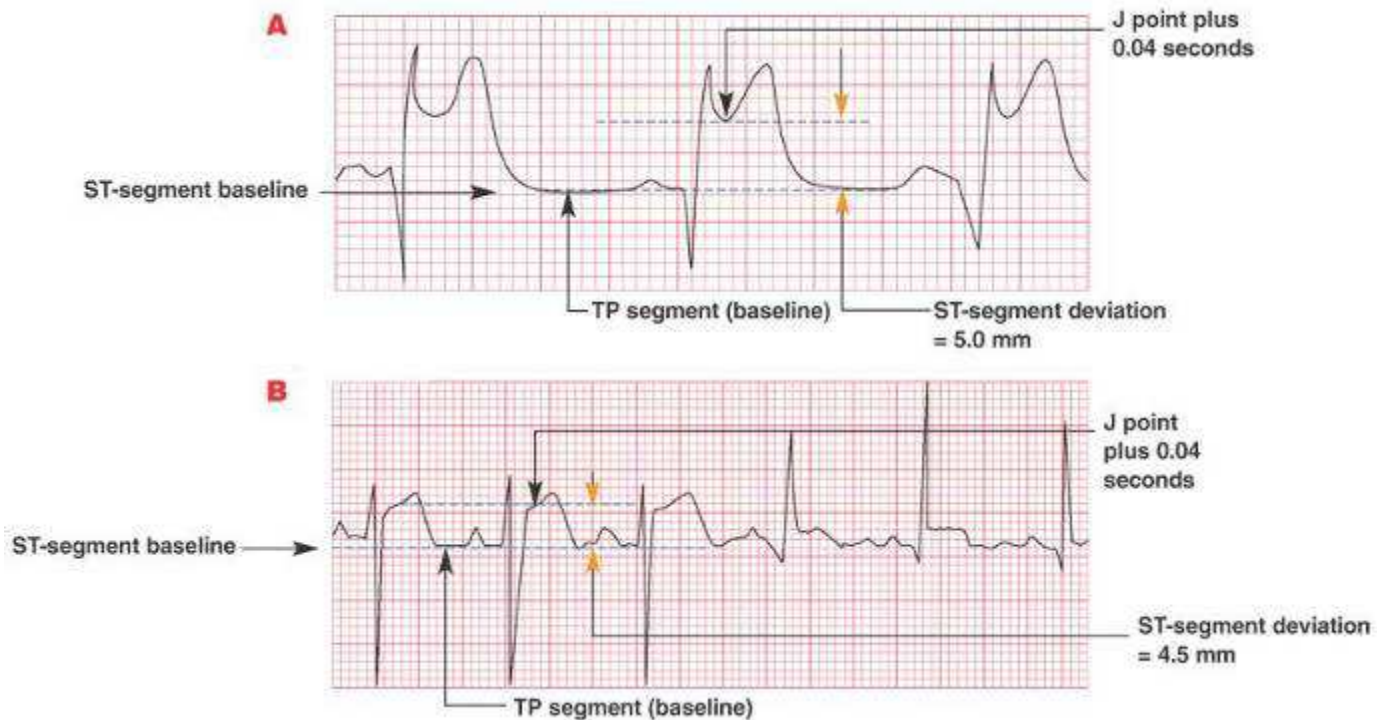
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- From the end of the QRS complex to the beginning of the T wave
- Should be at the baseline





# Measurement of ST-Segment Deviation



STEMI:  $\geq 1$  mm ST-segment elevation in 2 leads.\*

NSTEMI/UA:  $\geq 0.5$  mm ST-segment ischemic depression in 2 leads.\*

\*Anatomically (regionally) contiguous leads.

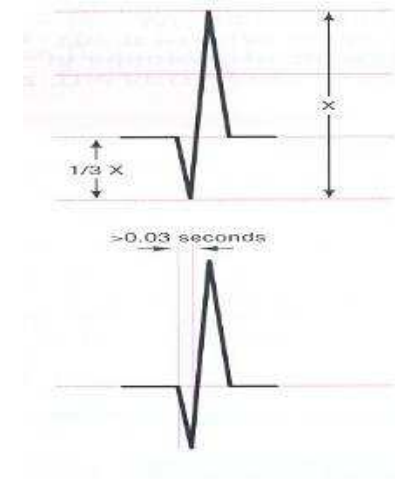
# EKG Changes with MI: **Infarction**

## Infarction > 1 - 2 hours

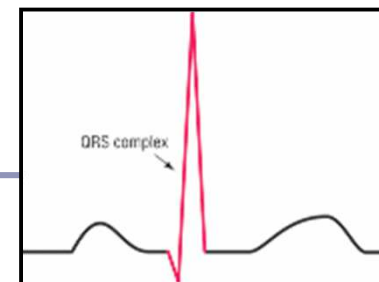
- ♥ Abnormal Q waves
  - > 1/3 the height of R wave in that lead
  - or
  - > 0.03 ms wide



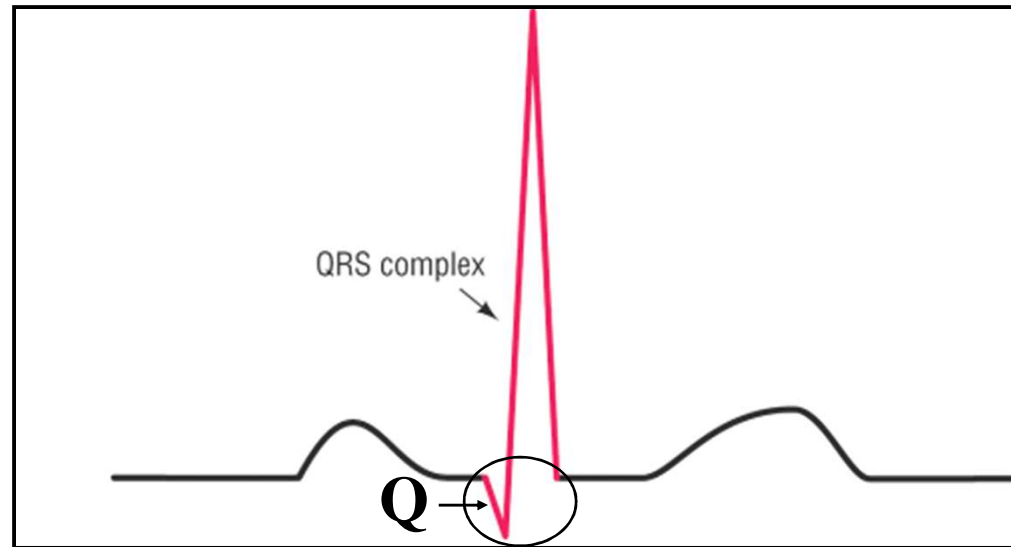
## Abnormal (significant Q waves)



## Normal Q wave 1st downward deflection of QRS

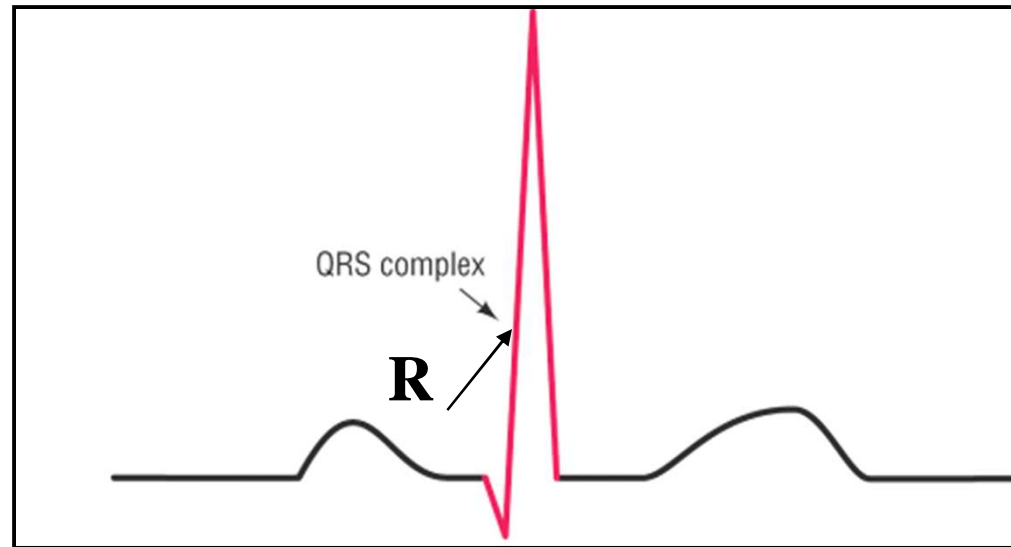


## Normal QRS complex – The Q wave



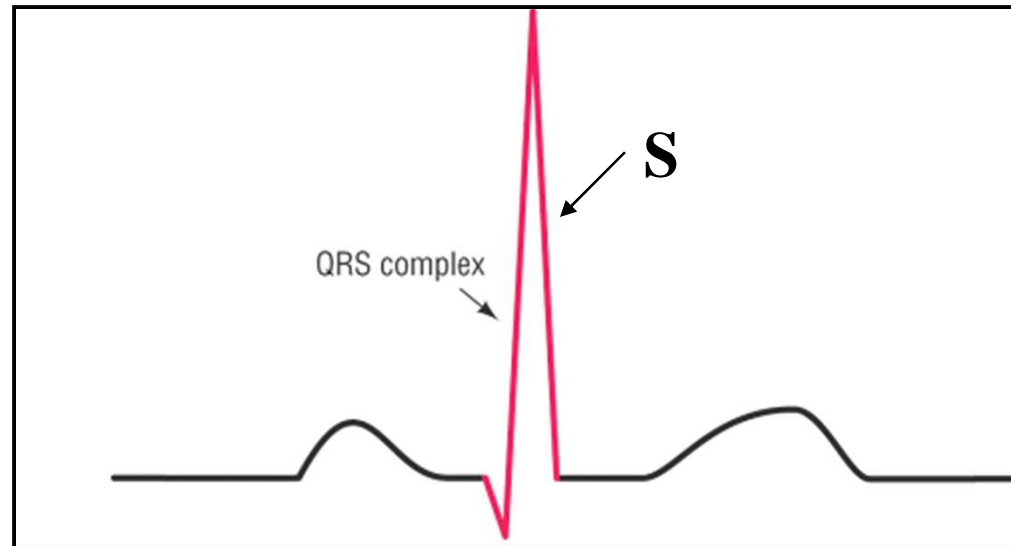
- Q wave is the first negative deflection after the p wave
- Always first may or may not be there.
- Comes first in the alphabet
- There are normal and abnormal Q waves

## Normal QRS complex – The R wave



- R wave is the first positive deflection after the p wave
- Always Rising above

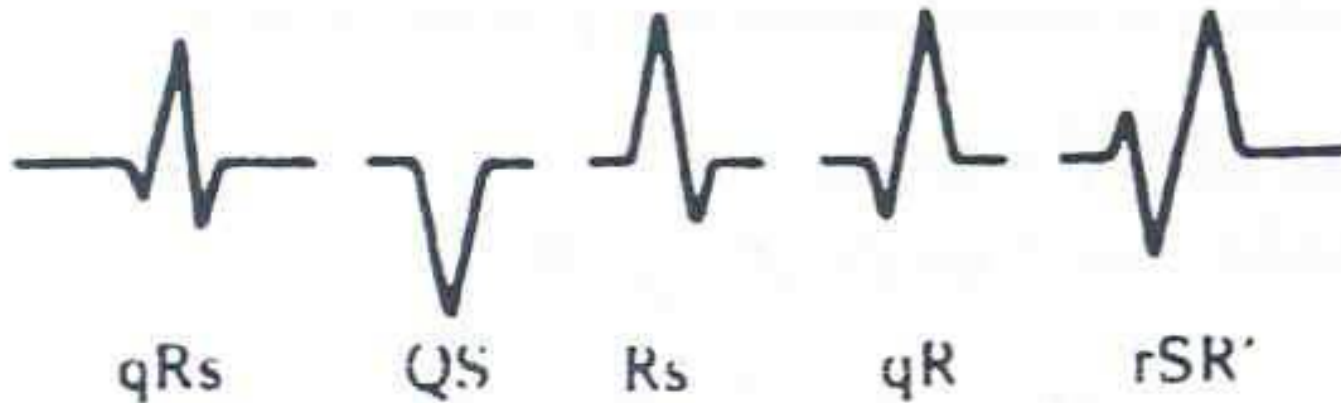
## Normal QRS complex – The S wave



- S wave is the second negative deflection after the R wave
- Slipping down
- Always after R wave like in the alphabet



## Review of Normal QRS complex



- Q wave is the first negative deflection after the p wave
- R wave is the first positive deflection after the p wave
- S wave is the second negative deflection after the R wave

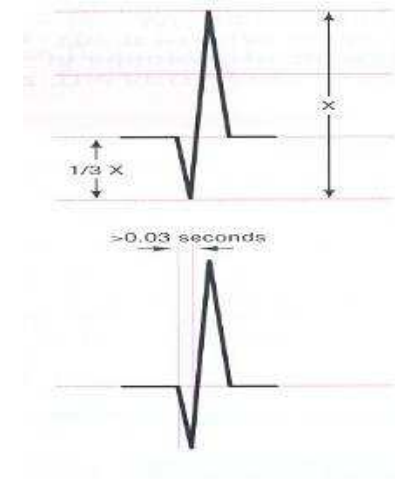
# EKG Changes with MI: **Infarction**

## Infarction > 1 - 2 hours

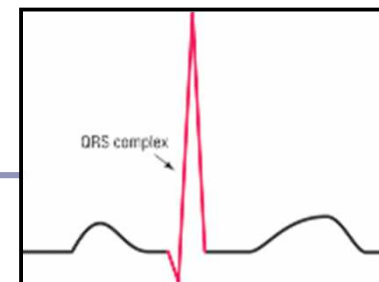
- ♥ Abnormal Q waves
  - > 1/3 the height of R wave in that lead
  - or
  - > 0.03 ms wide



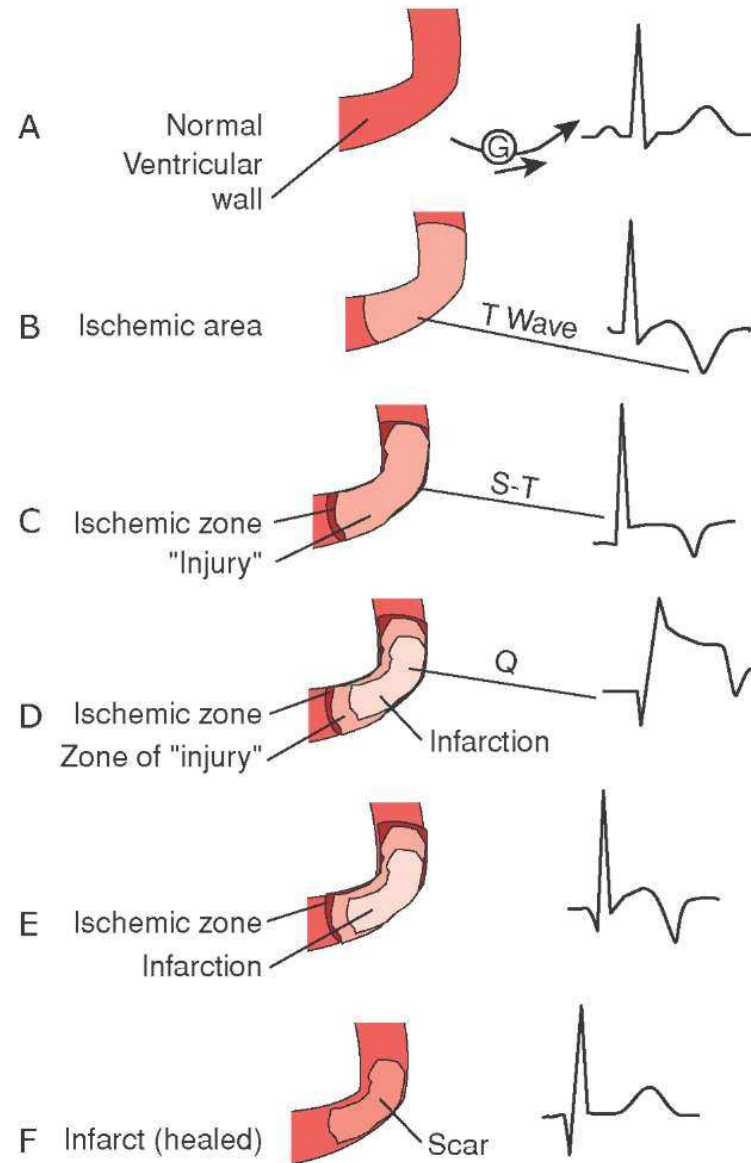
## Abnormal (significant Q waves)



## Normal Q wave 1st downward deflection of QRS

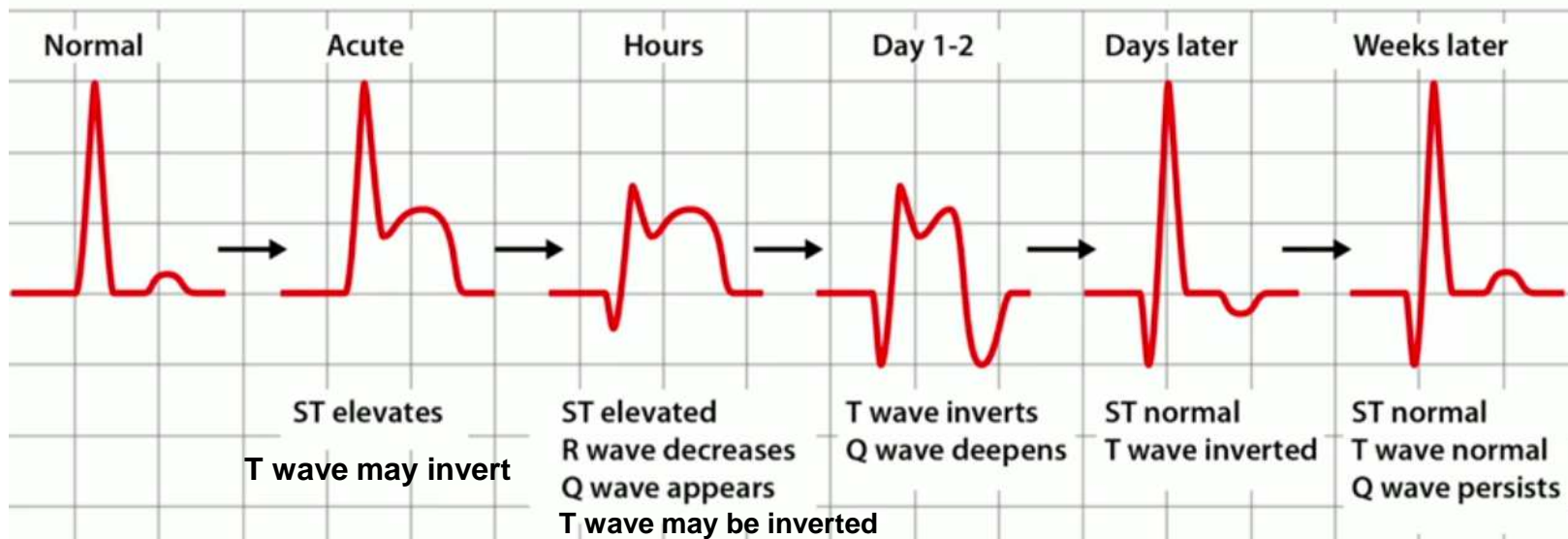


# Evolution of STEMI

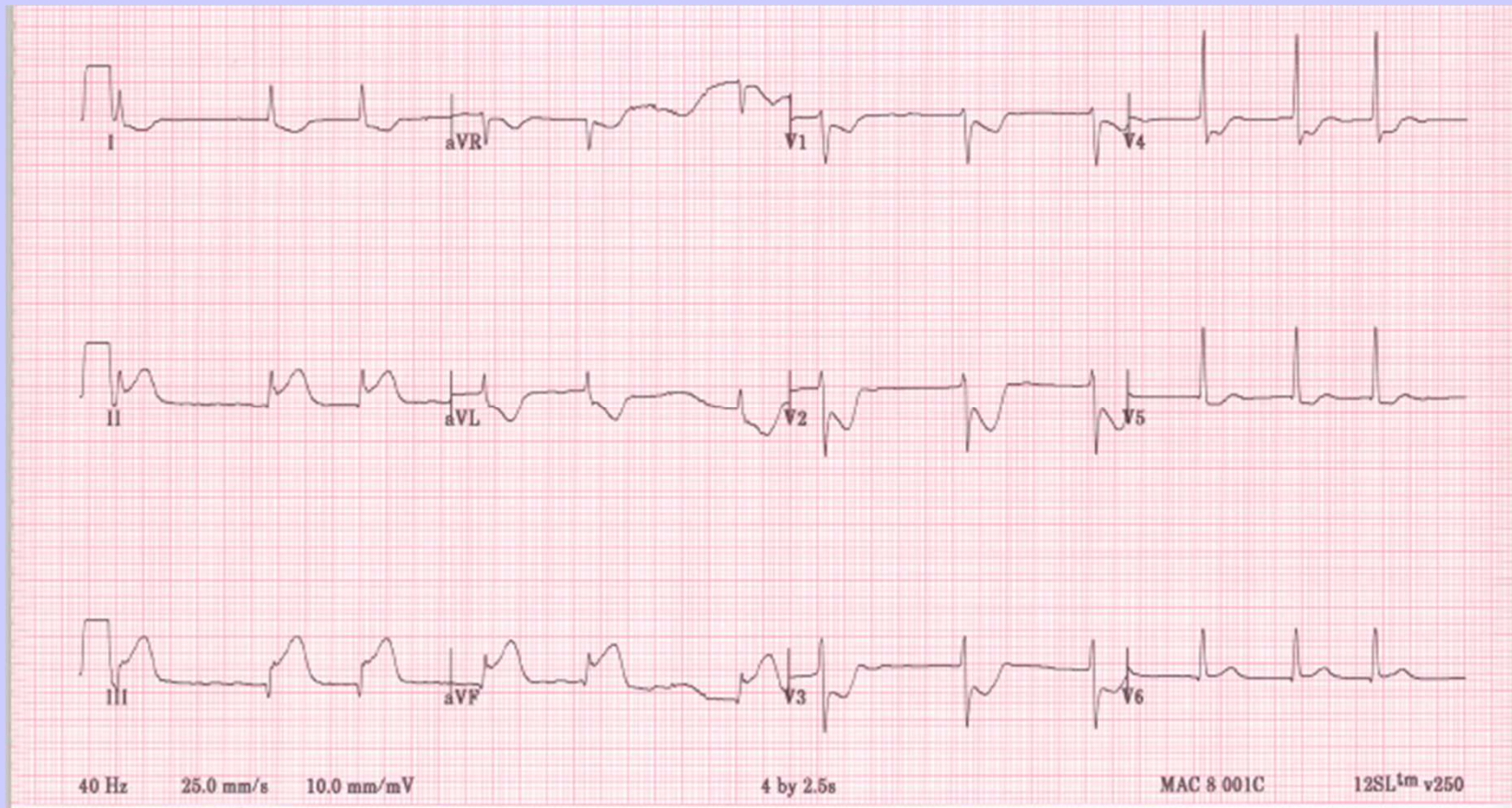


# STEMI EKG Timeframe

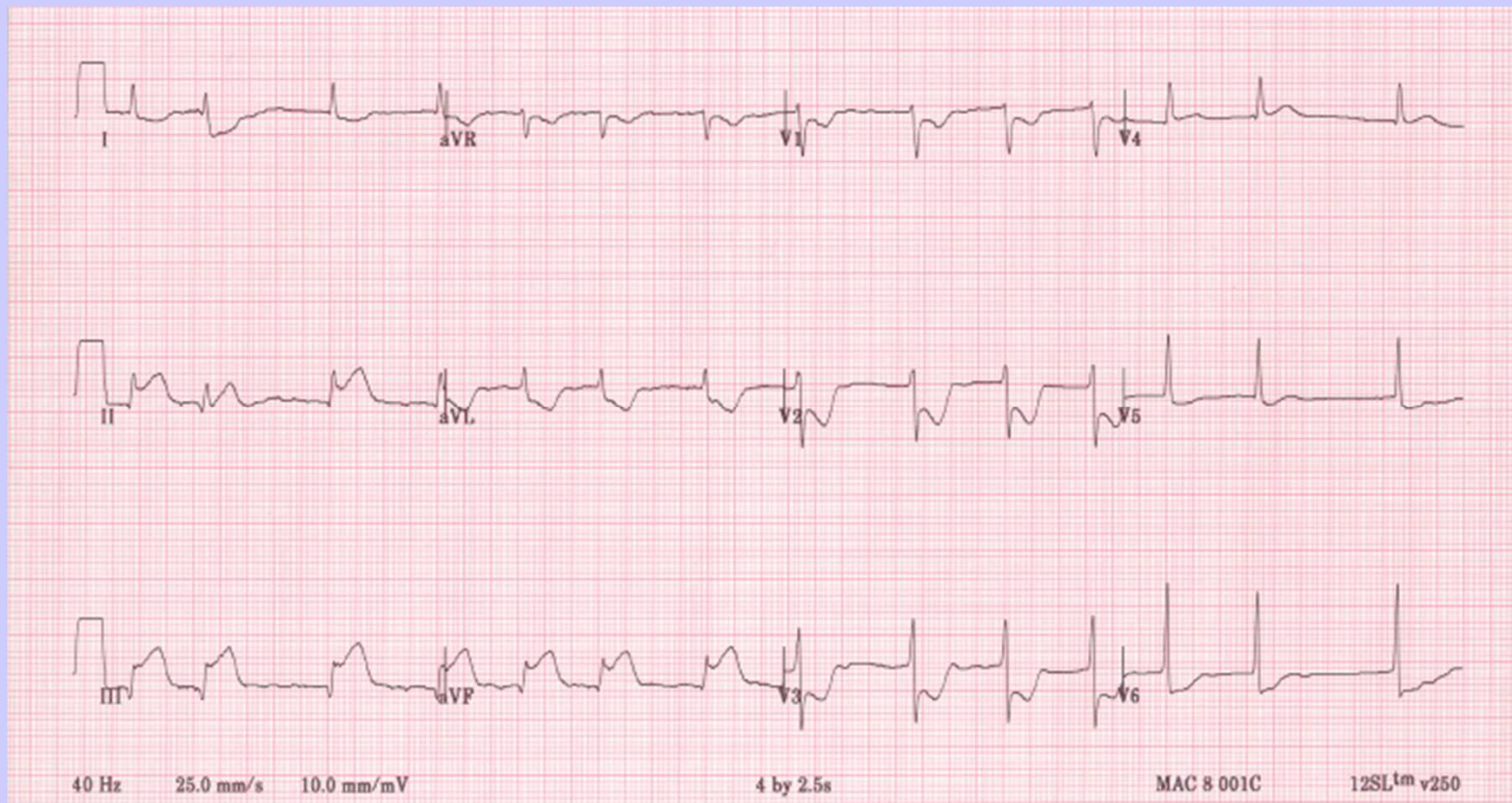
## Evolution of Myocardial Infarction



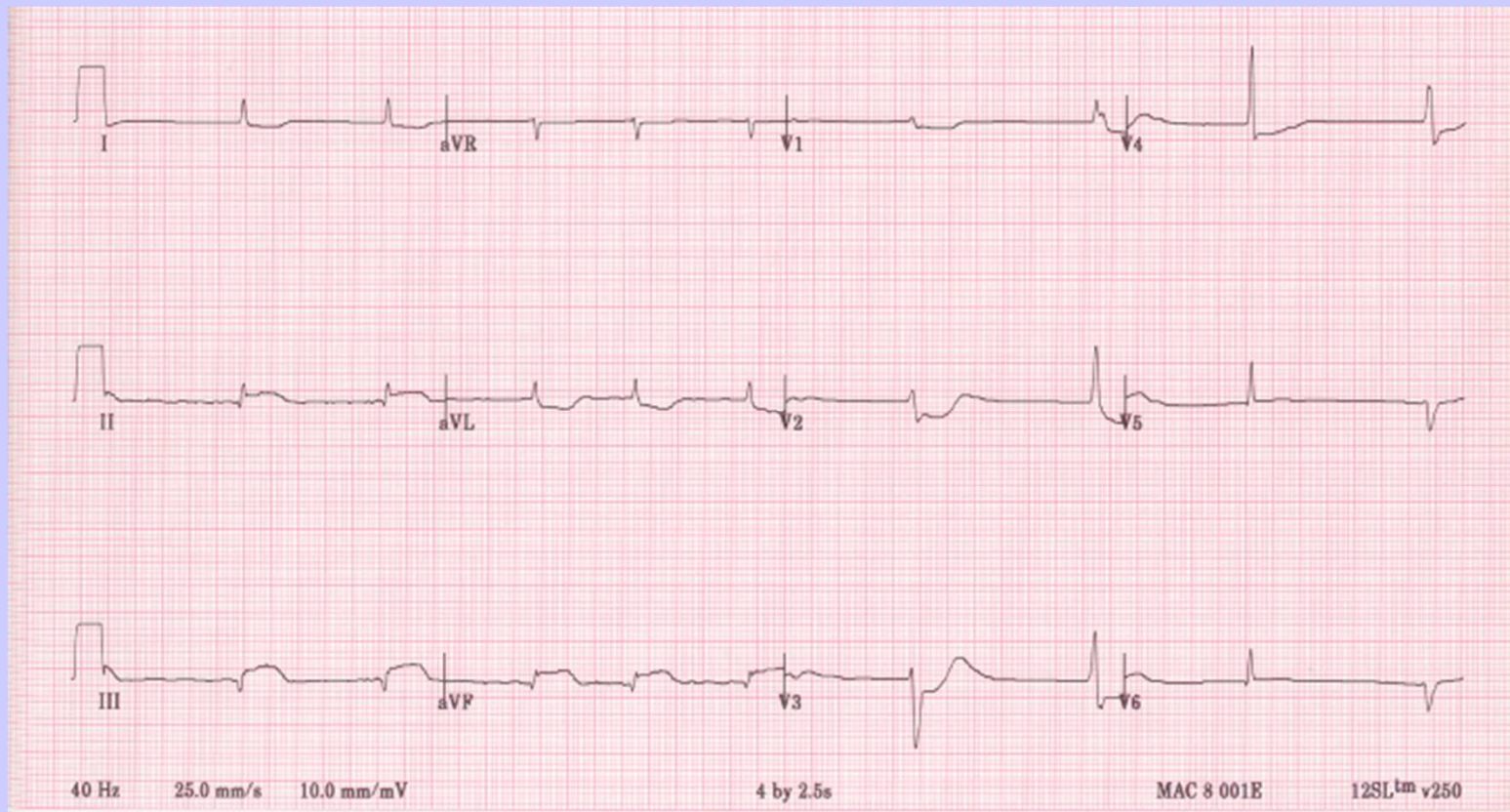
# Evolving AMI: EM #1 December 13 at 1701



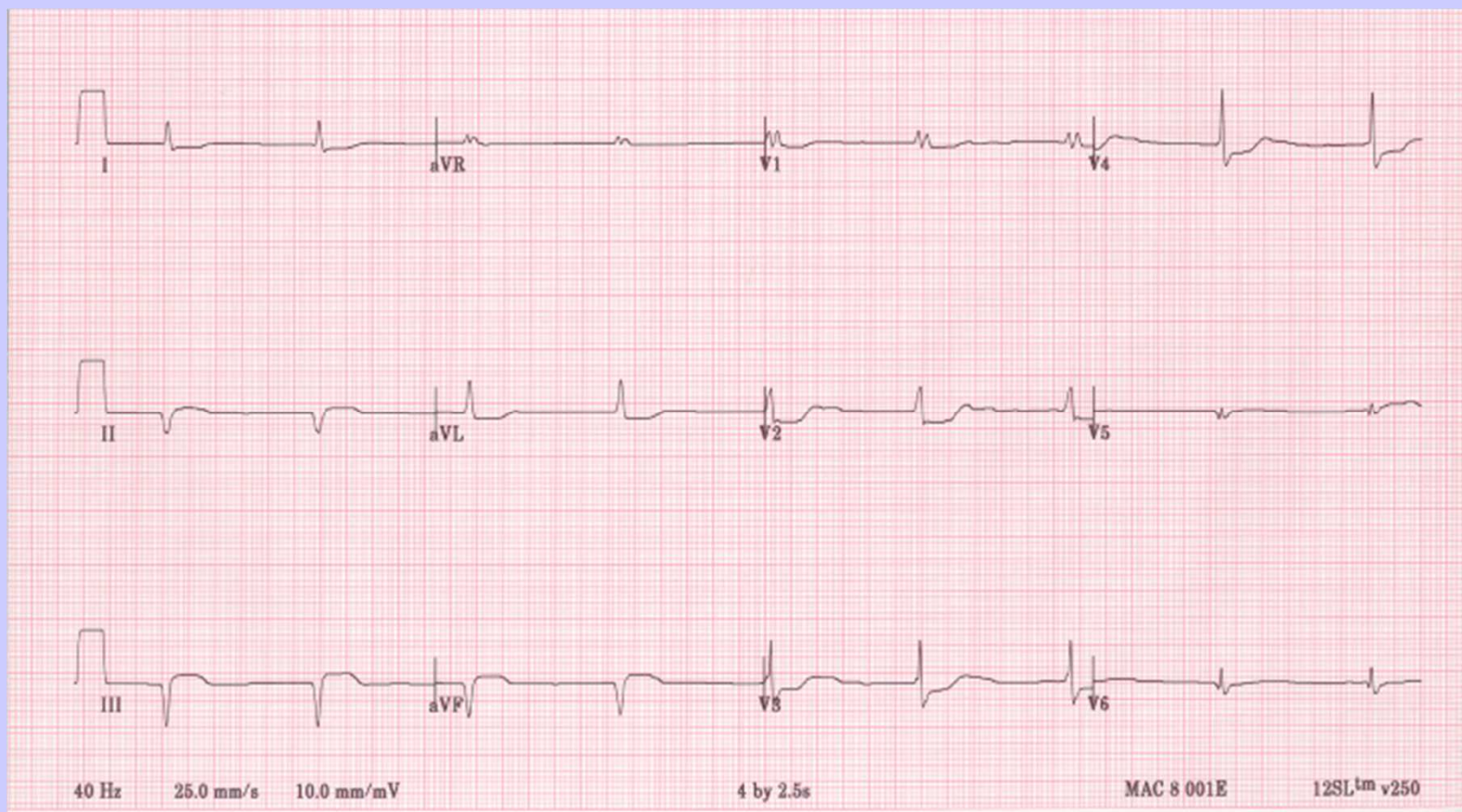
# EM # 2 December 13 at 1823



# EM #3 December 14 at 0630

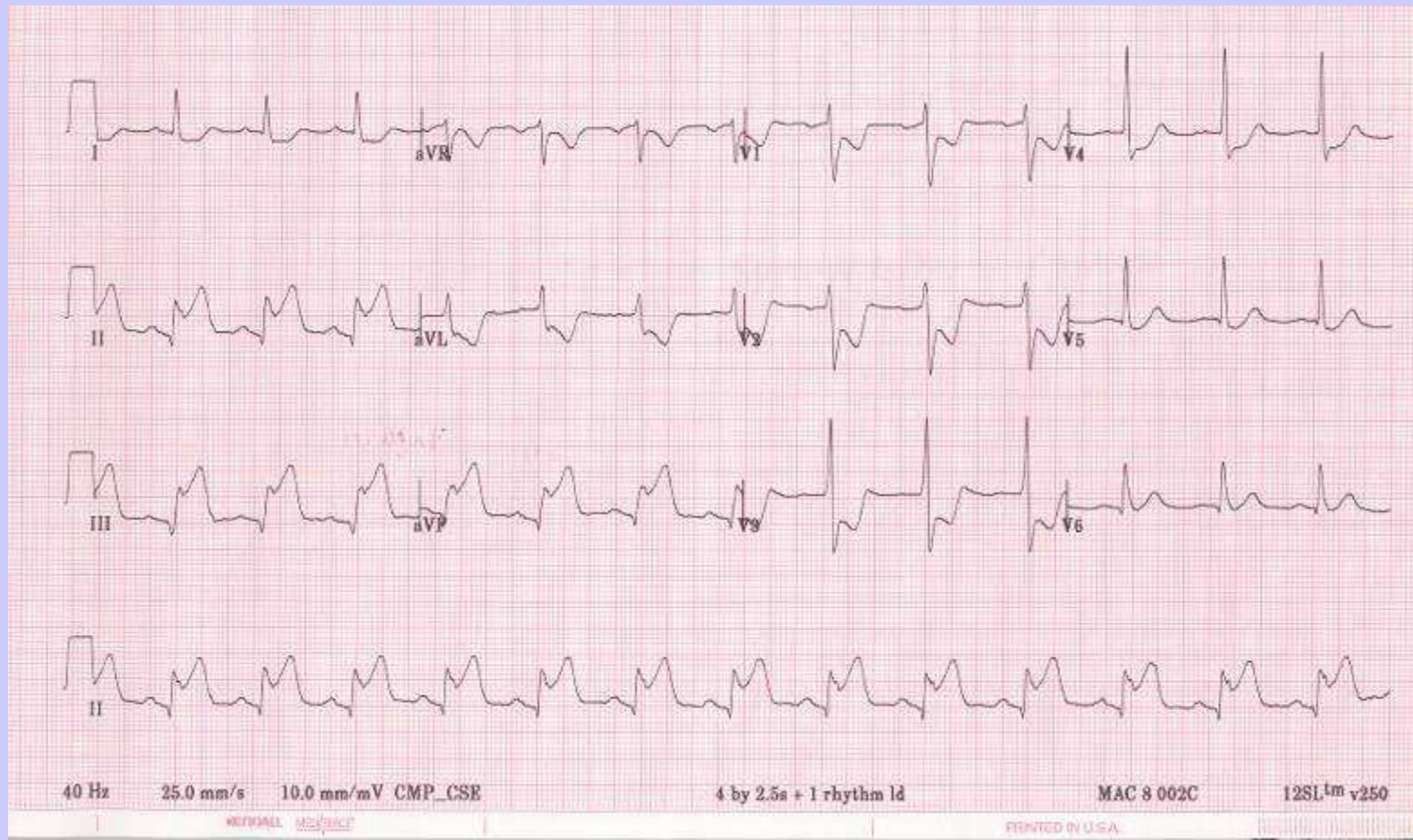


# EM # 4 December 15 0600

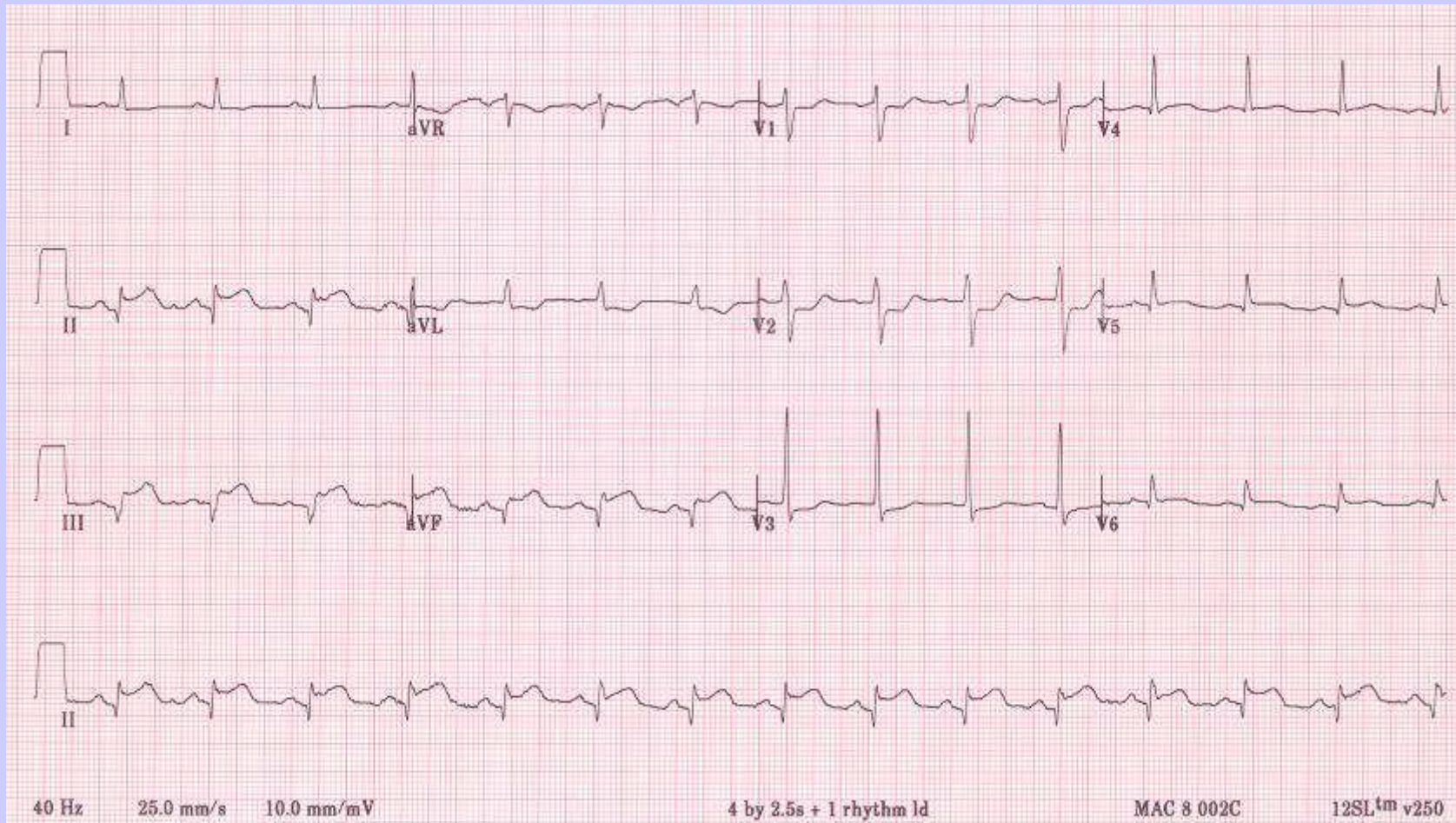




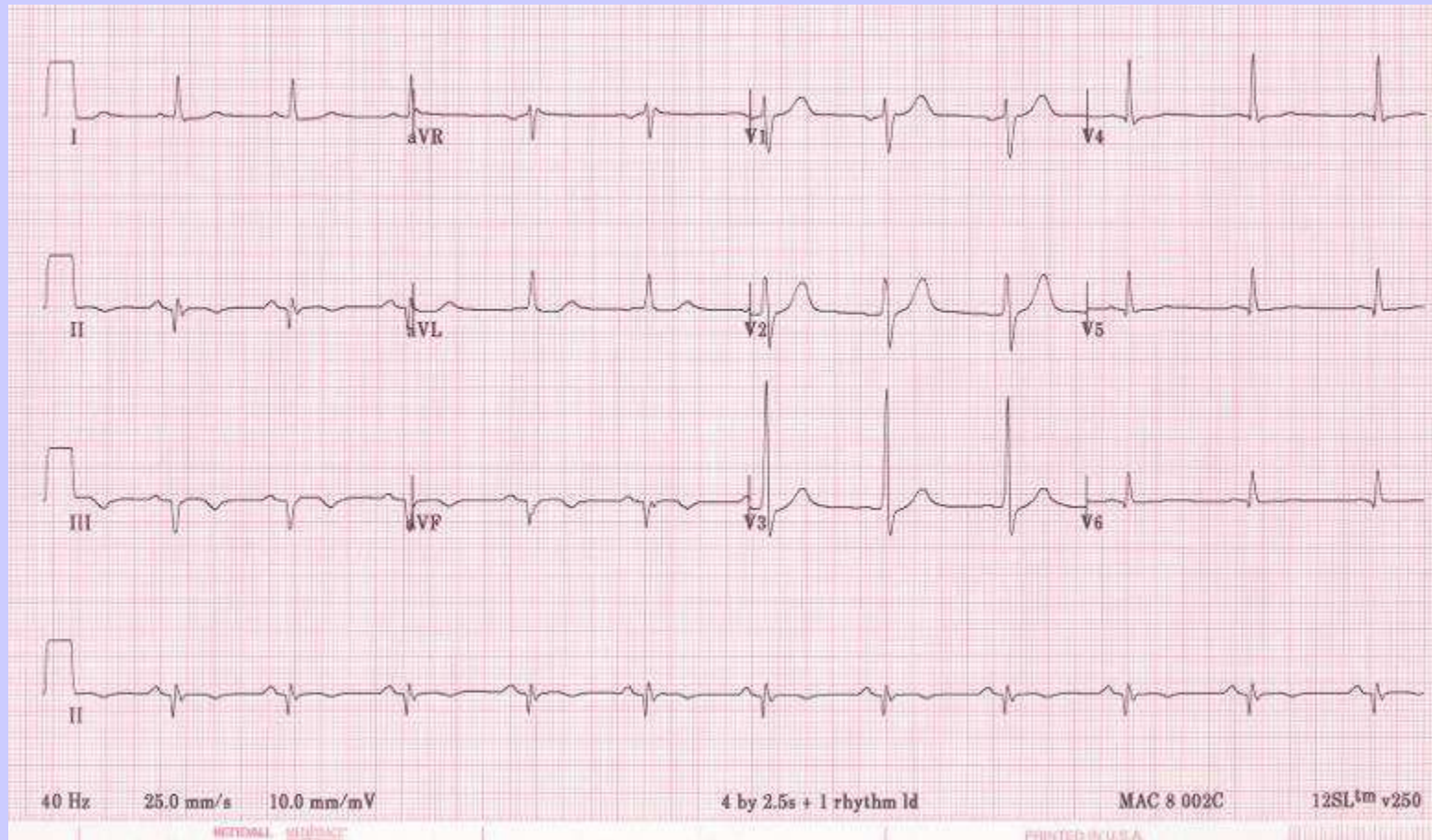
# CC: Admission EKG 1445



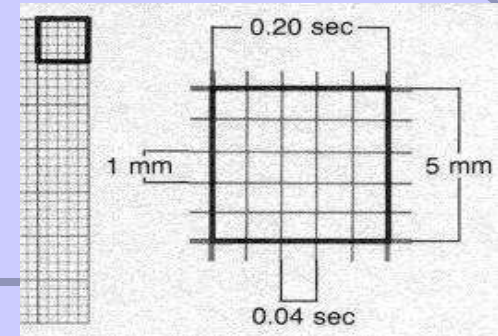
# CC: 3 hours later



# CC: 28 hours later



# Positive EKG

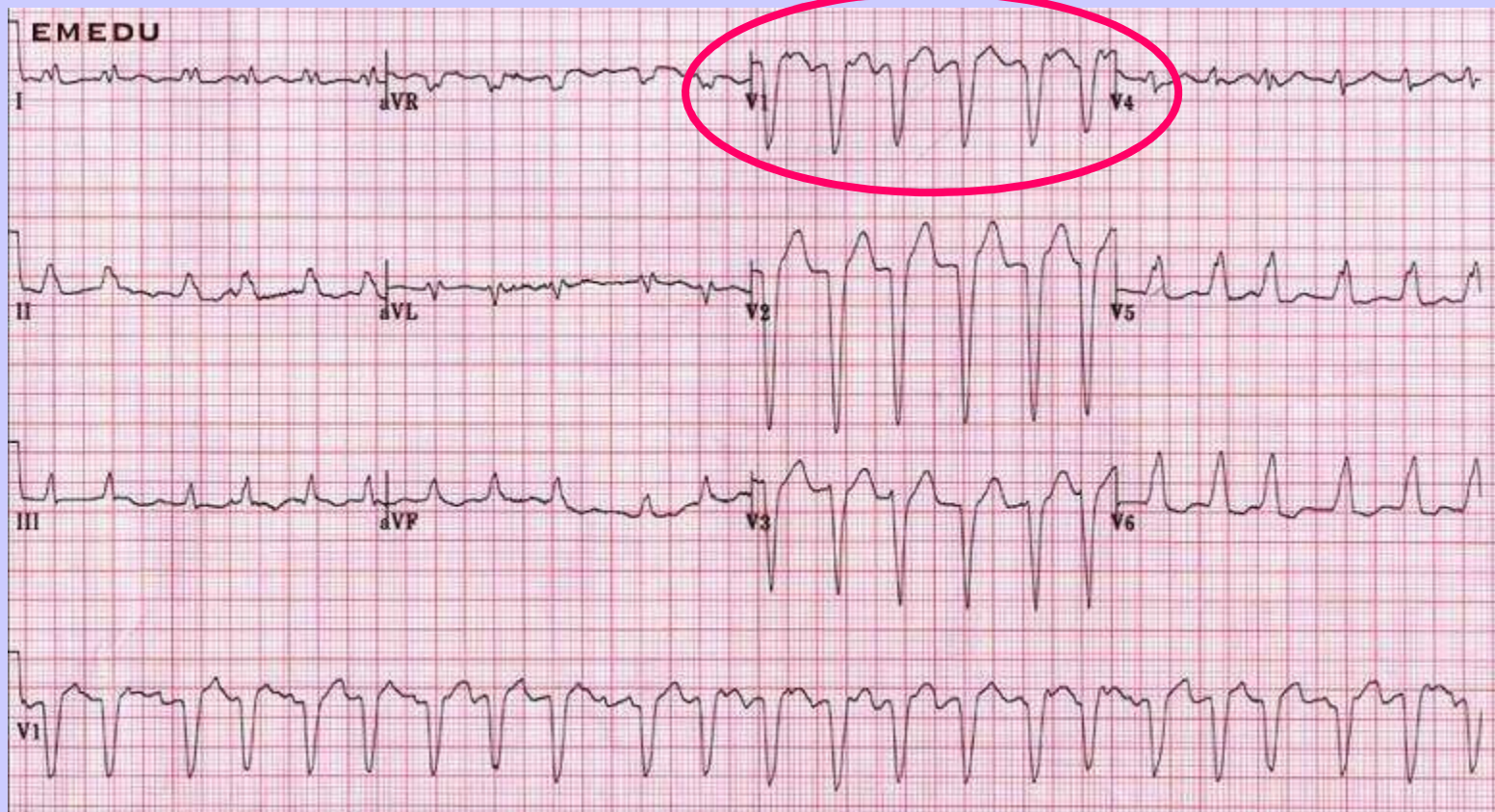


- ST elevation  $> 0.1\text{mV}$  (1 mm) in at least 2 contiguous precordial leads or at least 2 adjacent limb leads (STEMI) (Class 1, Level A)

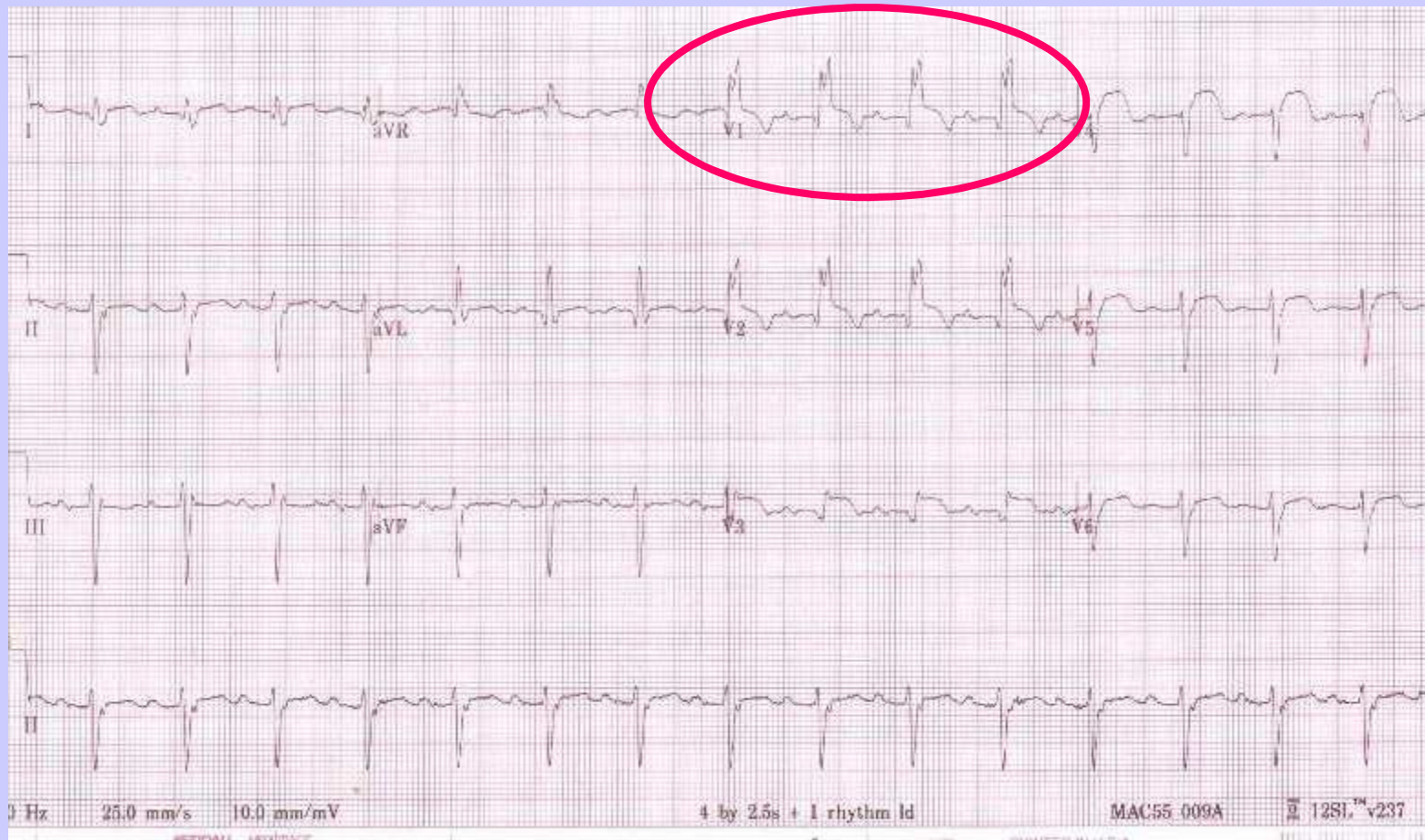
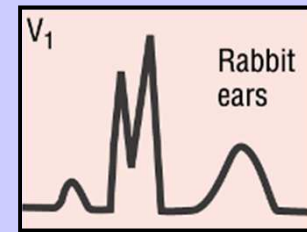
I lateral	aVR	V <sub>1</sub> septal	V <sub>4</sub> anterior
II inferior	aVL lateral	V <sub>2</sub> septal	V <sub>5</sub> lateral
III inferior	aVF inferior	V <sub>3</sub> anterior	V <sub>6</sub> lateral

- Transient ST Elevation  $> 0.5$  mm
- ST depression  $> 0.5$  mm (NSTEMI)
- T wave inversion  $> 0.2$  mV (2 mm)
- New LBBB (Class 1, Level A)

**LBBB = QRS > 0.12 sec**  
**Negative QRS in V1 (carrot)**



**RBBB = QRS > 0.12 sec**  
**Positive QRS in V1 (rabbit ears)**



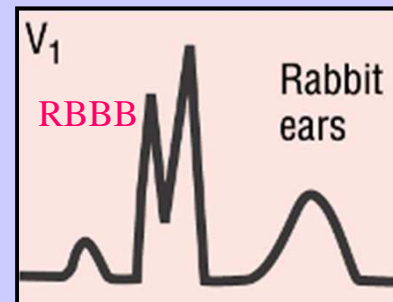
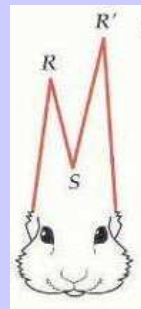
## **BBB = QRS > 0.12sec**

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- LBBB = QRS > 0.12 sec  
Negative QRS in V1  
(carrot)



- RBBB = QRS > 0.12 sec  
Positive QRS in V1  
(rabbit ears)



## LBBB with AMI

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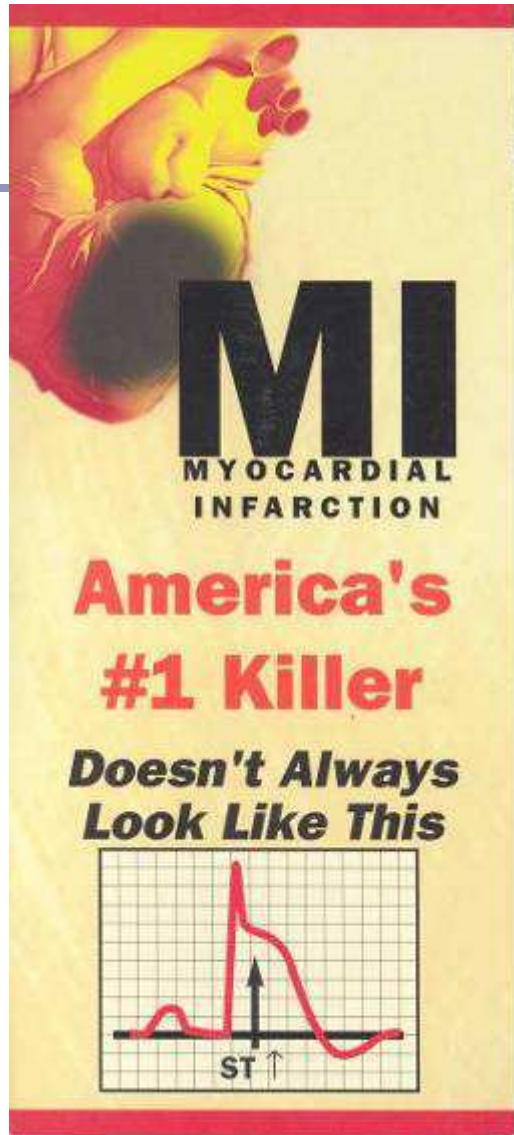
Sgarbossa, N Engl J Med 1996

- Q waves in at least two of leads I, AVL, V5, V6
- R wave regression from lead V1 – V4
- Late notching of S wave in at least two of leads V3 – V5
- Primary ST & T wave changes in two or more adjacent leads
- ST elevation of 8 mm or half the height of T wave

Fesmire Ann Emerg Med 1995

- ST elevation of  $\geq 1$  mm concordant with QRS
- ST depression  $\geq 1$  mm in leads V1, V2, or V3
- ST elevation  $> 5$  mm discordant with QRS
- QRS  $> 0.12$
- Q waves



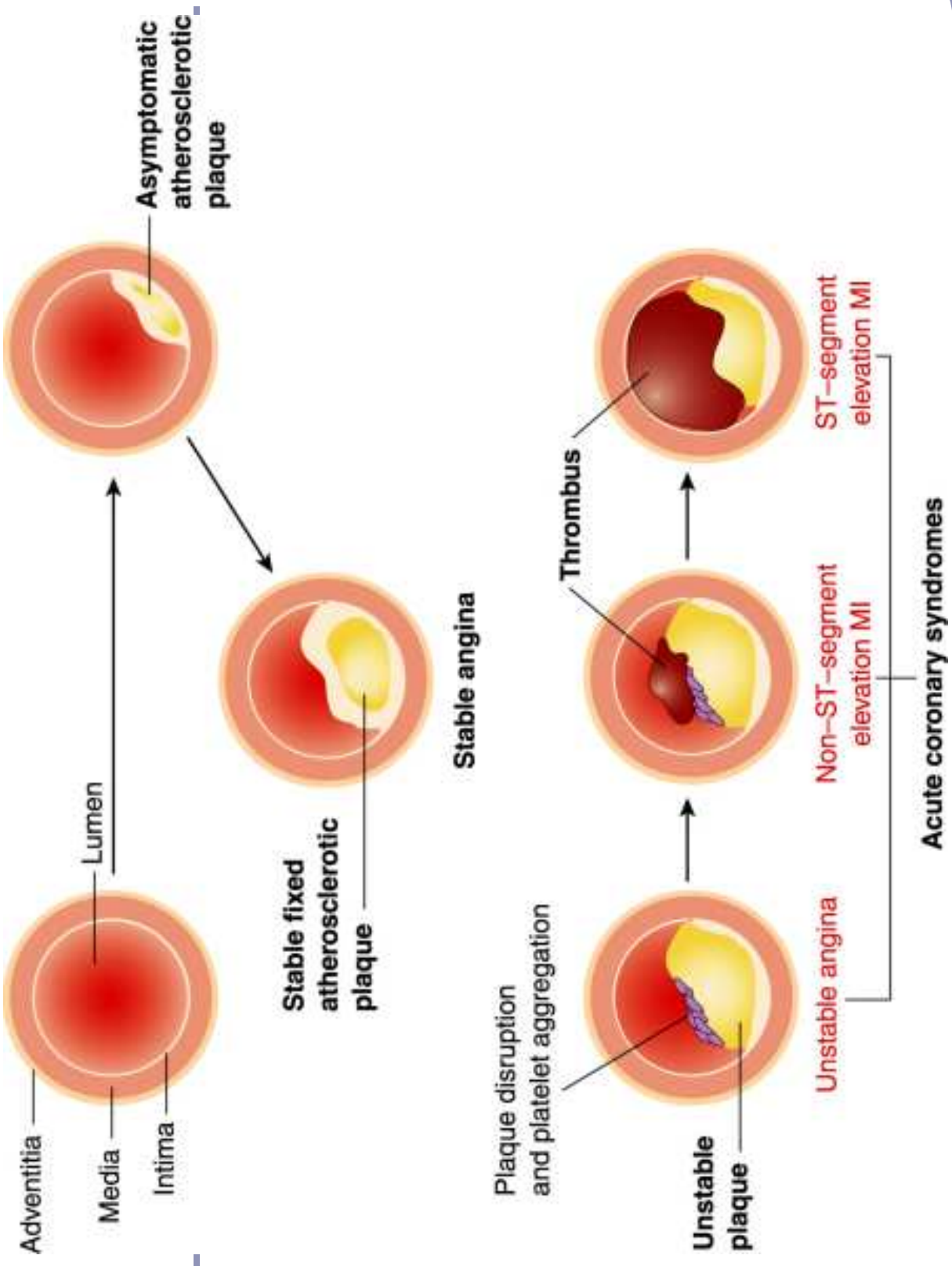


# NSTEMI

## Non ST Segment Elevation MI

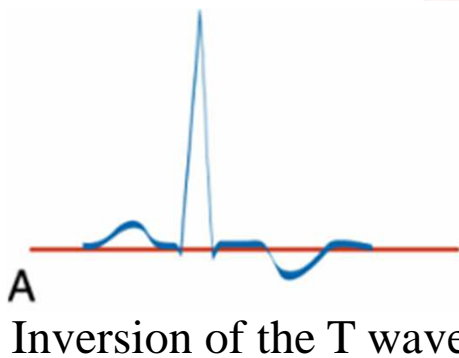
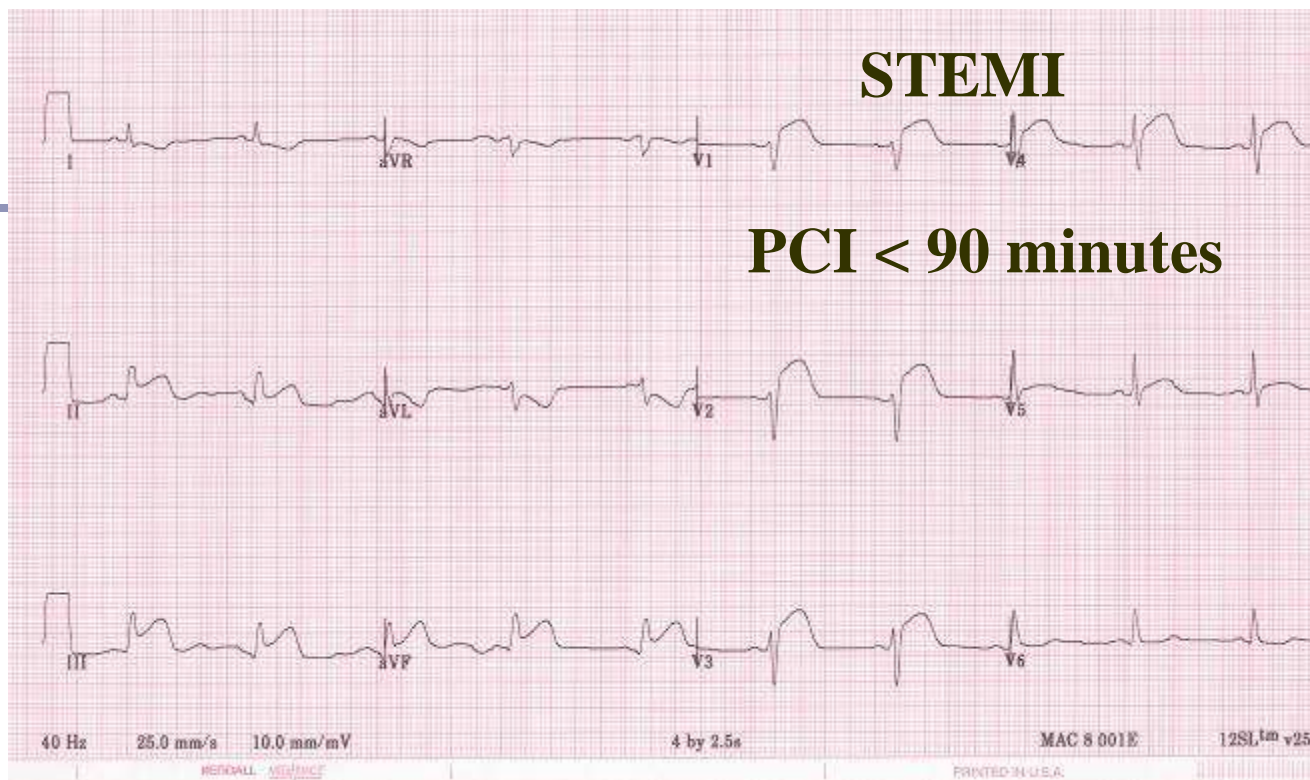
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- ♥ No ST segment Elevation
- ♥ ST segment depression



**Both elevated  
Troponins**

**NSTEMI**



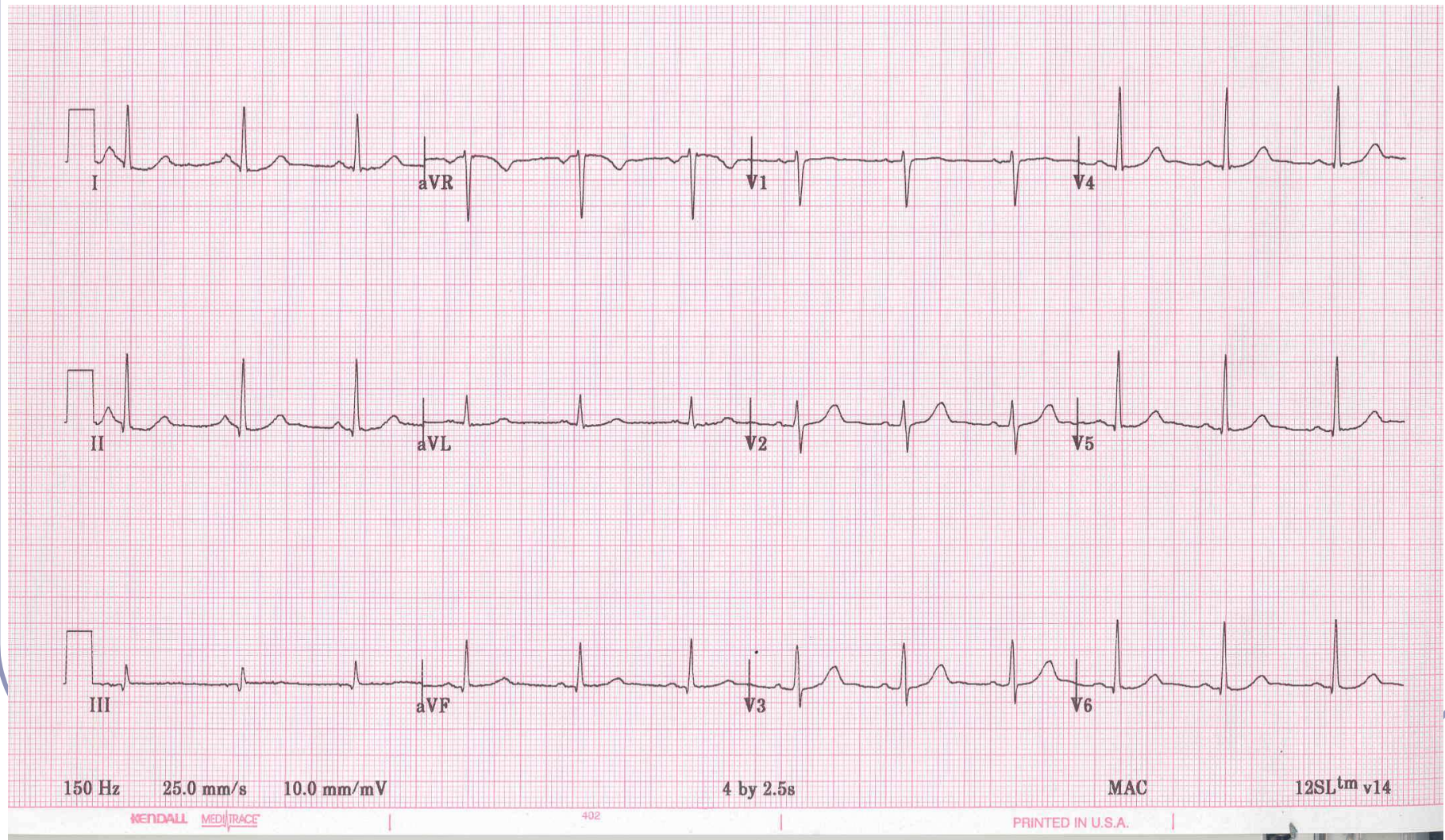
# **12 Lead EKG**

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## Understanding Lead Placement

# 12 Lead EKG 101

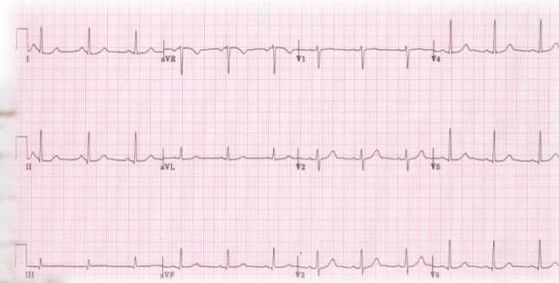
Learn the Normal so you can detect the abnormal



## To Learn 12 Lead EKG

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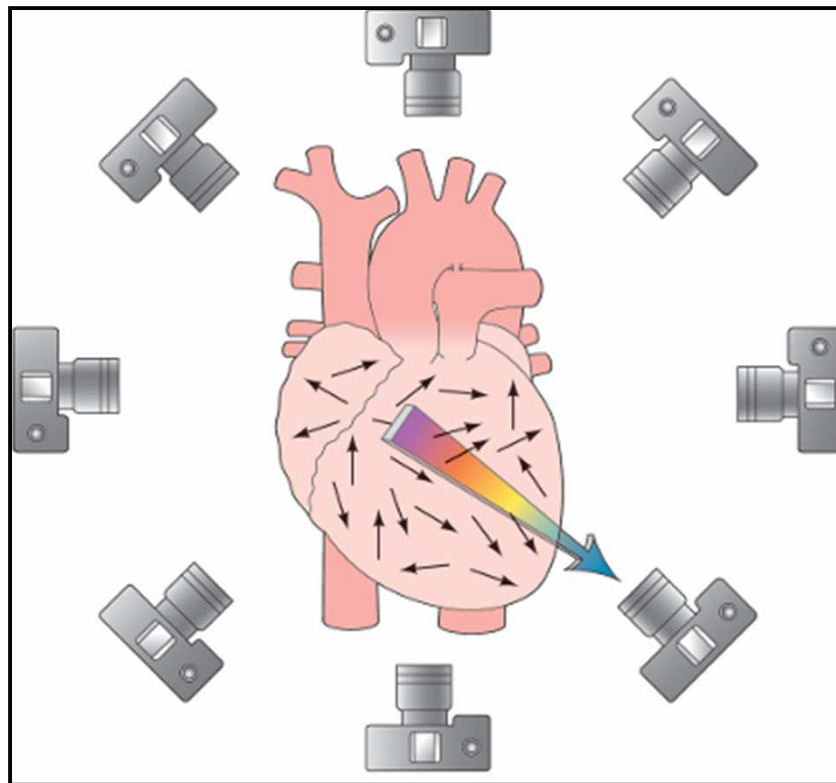
You **MUST** pick them up  
and **LOOK** at them!



# Leads Are Like Pictures

## Camera is on the positive lead

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# The 12 Leads

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## Bipolar Leads

Each lead has two poles:  
One positive & one negative

**I, II, III**

## Unipolar Leads

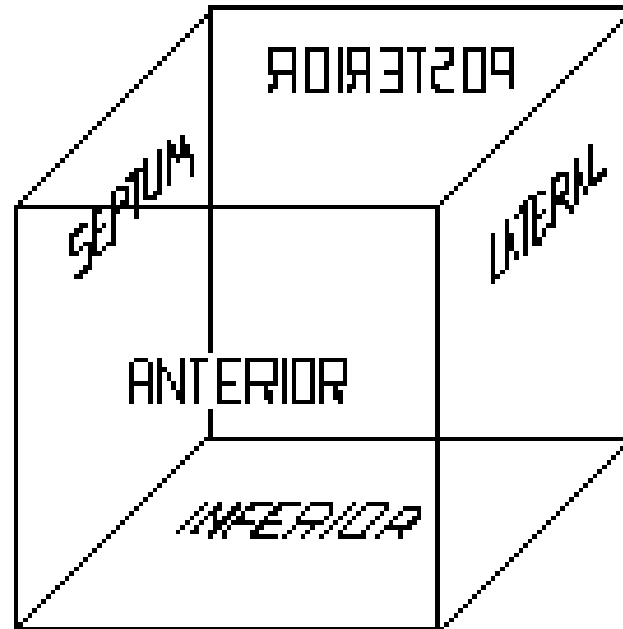
Only one lead is physically positive.  
Negative lead is not a specific site on the body

**AVR, AVL, AVF, V1-V6**



## Cube Concept of Left Ventricle

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Each face of the cube represents  
a different part of the left ventricle

# LIMB LEADS

## I, II, III

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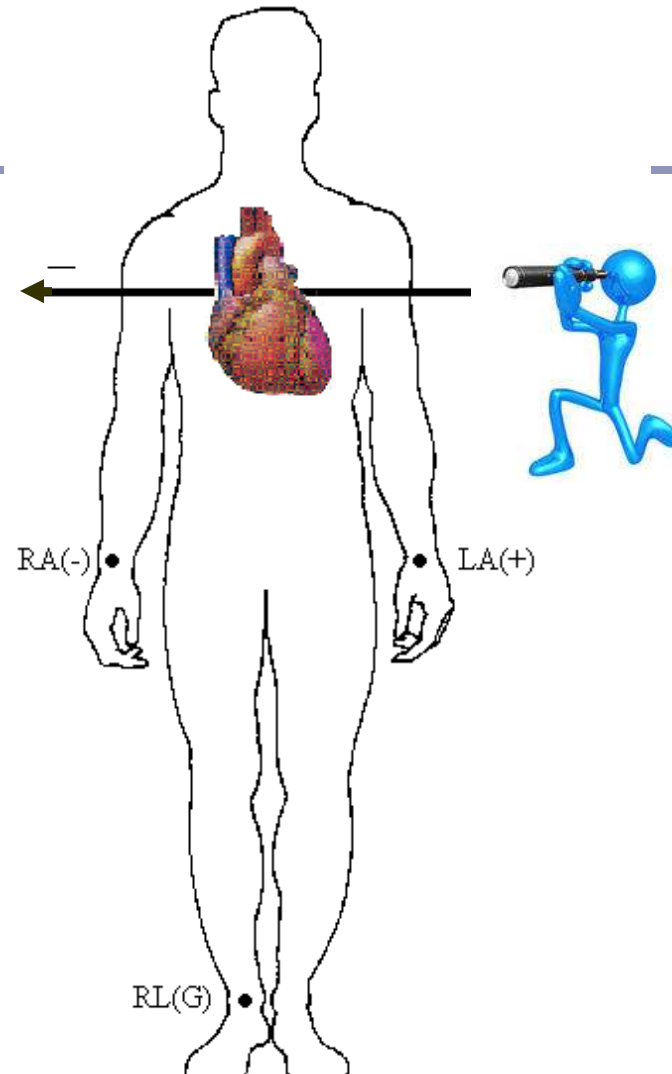
- Also referred to as extremity leads due to placement on the body
- Record electrical forces two points equidistant from the heart.
- Each lead has two poles: one positive & one negative
- Two leads to give the picture
- Current travels Negative to Positive to create the electrical complex
- 12 Lead EKG Reads or takes the picture from the **positive** electrode to the heart

## Lead I

Views the heart from  
left arm to right arm

Area: *Lateral*

Artery: *Circumflex*

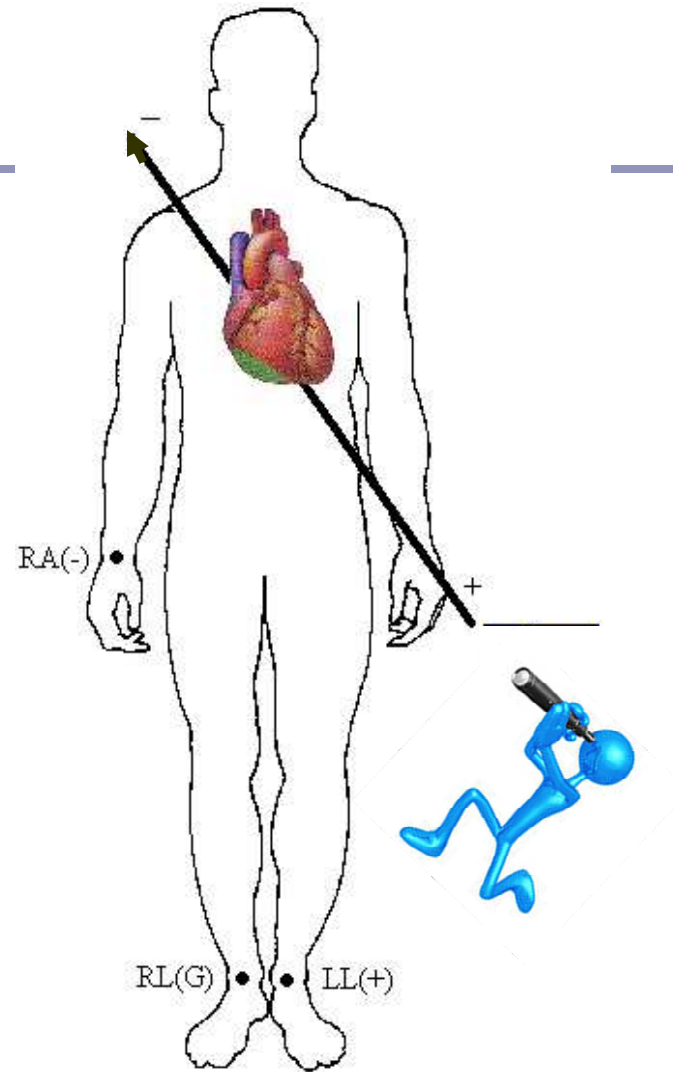


## Lead II

Views the heart from  
left leg to right arm

Area: *Inferior*

Artery: *RCA*

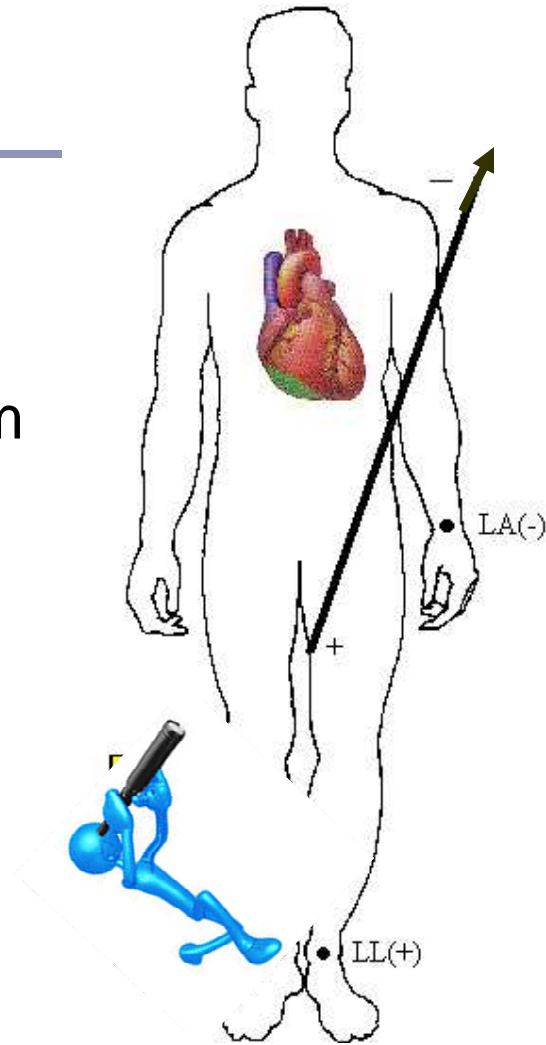


## Lead III

Views the heart from  
left leg to left arm

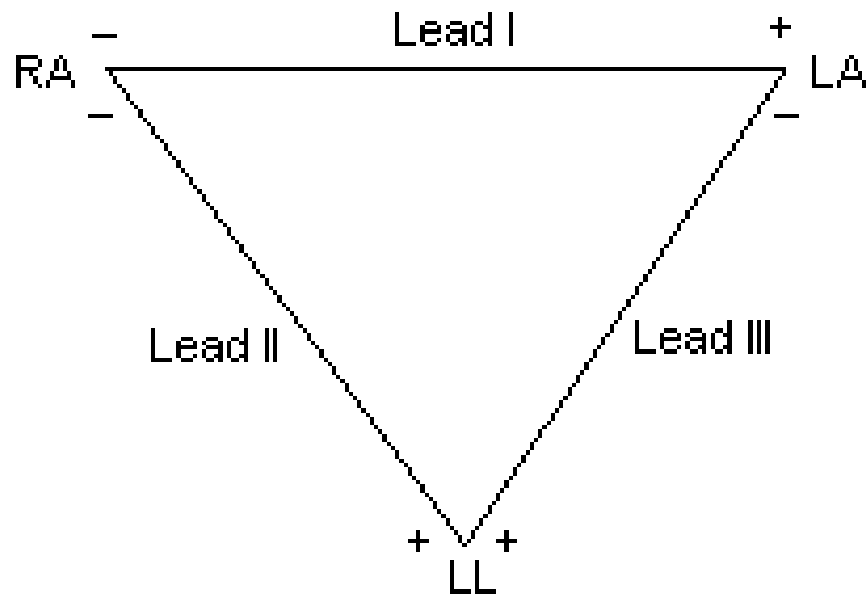
Area: *Inferior*

Artery: *RCA*



# Einthoven's Triangle

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**By connecting the electrodes of the limb leads, the Einthoven's Triangle is formed.**

## **Augmented Limb Leads**

### **AVR, AVL, AVF**

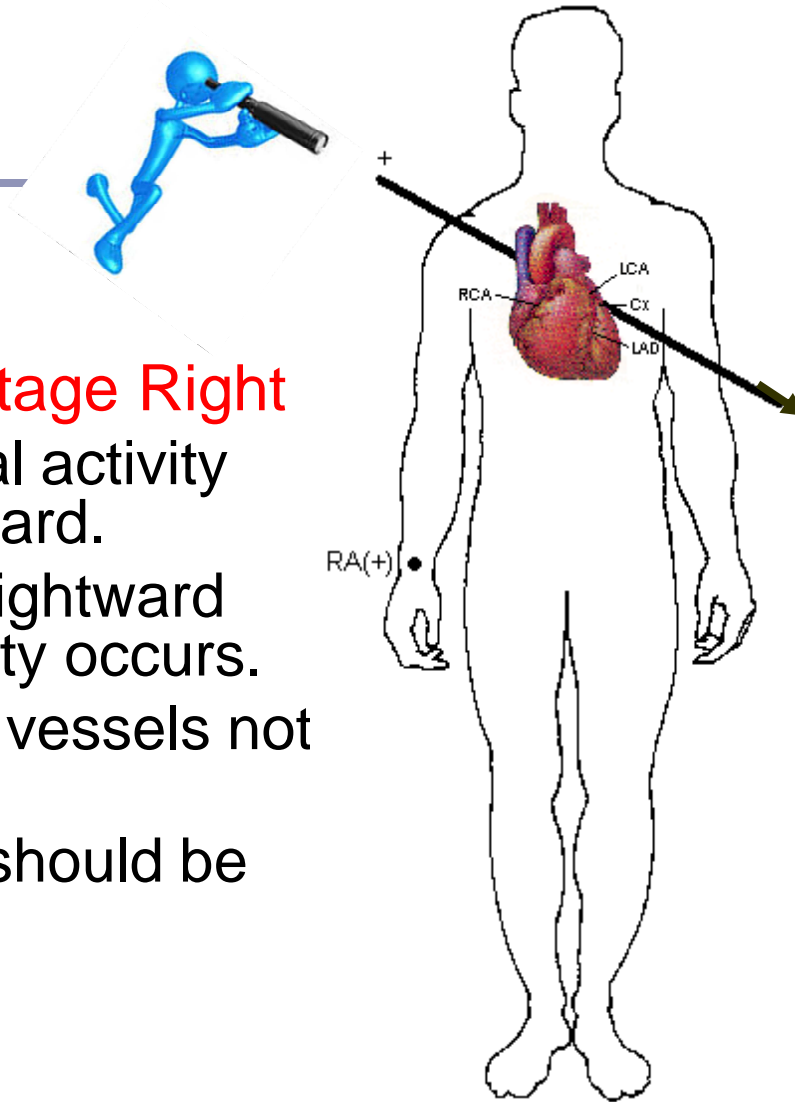
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- ♥ Records electrical activity between the center of the heart and an extremity
- ♥ Since these leads are low voltage they are artificially augmented
- ♥ Unipolar leads: Negative pole is the heart

## AVR

### Augmented Voltage Right

- Views electrical activity directed rightward.
- Very minimal rightward electrical activity occurs.
- Looks at great vessels not myocardium
- Configuration should be negative





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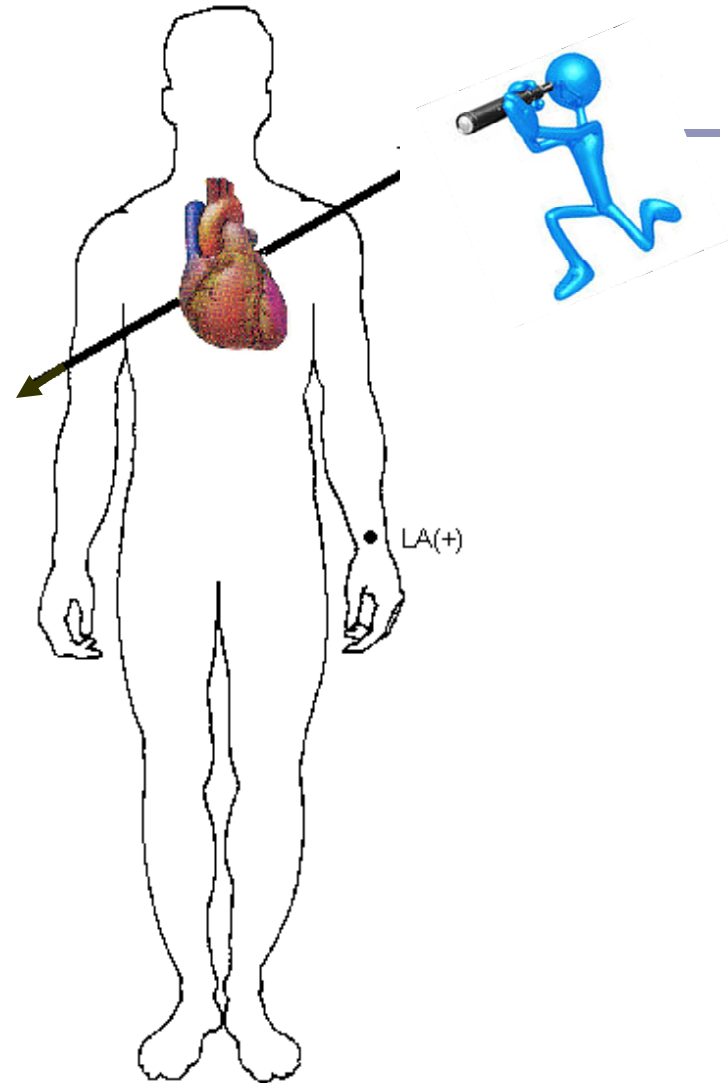
## AVL

### Augmented Voltage Left

Views the heart from the left arm to the mid-point between right arm & right leg

Area: *Lateral*

Artery: *Circumflex*



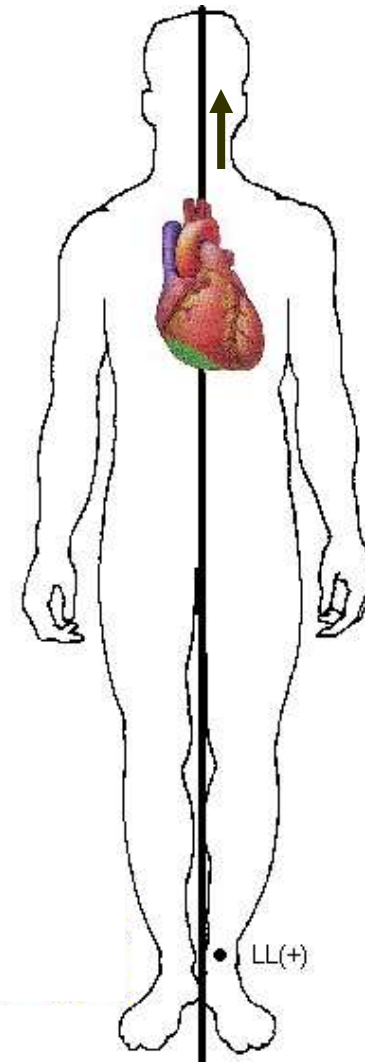
# AVF

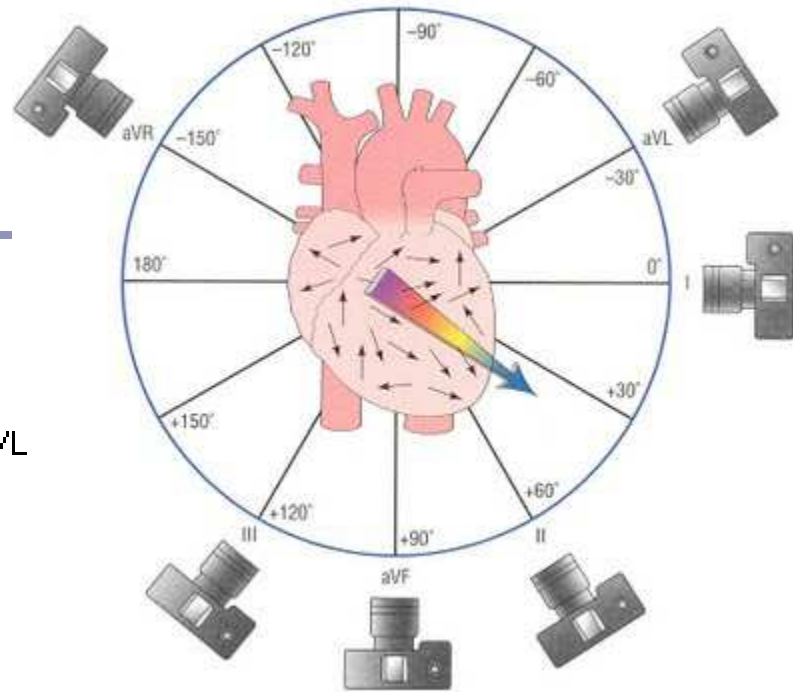
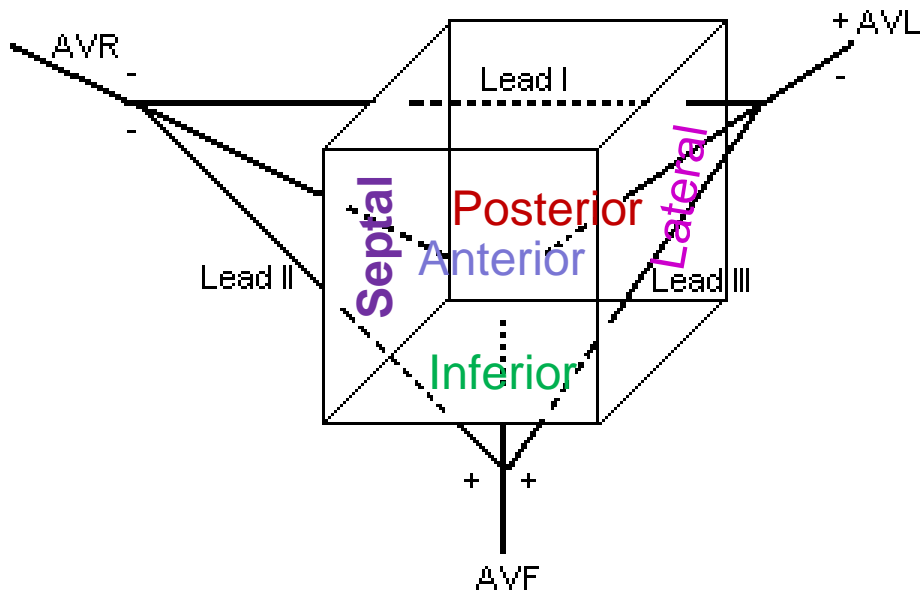
## Augmented Voltage Foot

Views the heart from the feet to the chin

Area: *Inferior*

Artery: *RCA*



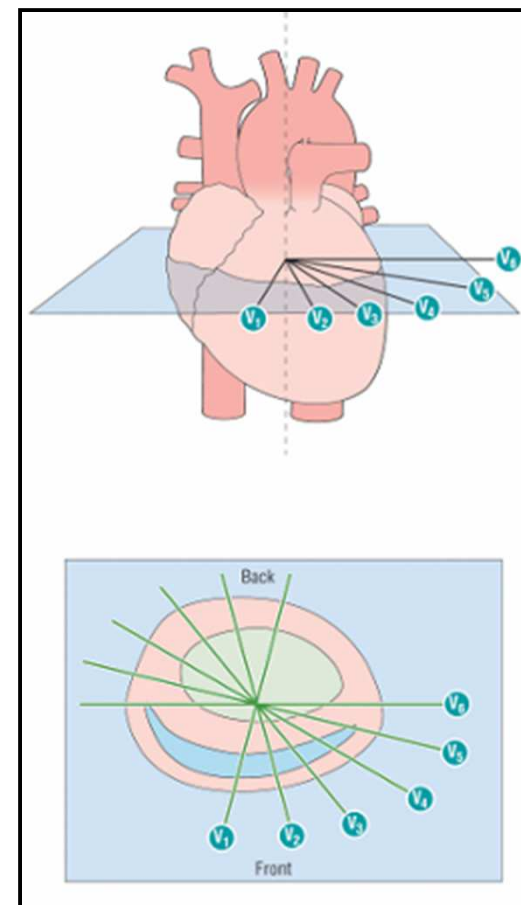


Correlation of the leads to the areas of left ventricle by superimposing Einthoven's Triangle over the cube.

# The Precordial System

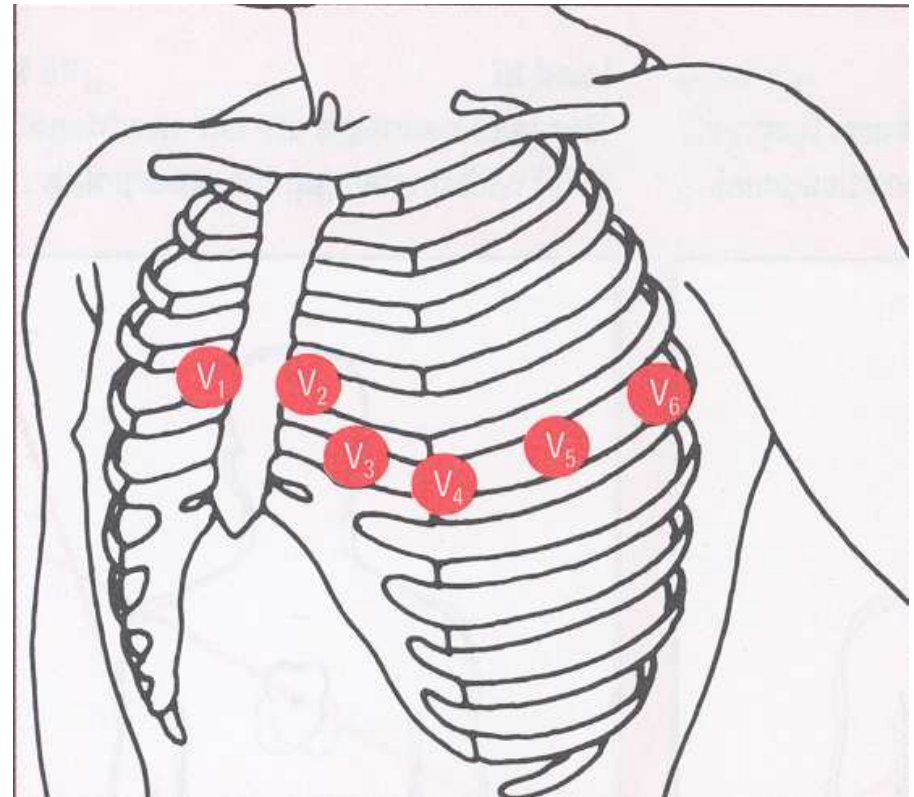
## Chest Leads V1 – V6

- ♥ Records electrical activity of the heart by placing electrodes on the anterior chest wall
- ♥ Heart is the negative pole
- ♥ Positive pole is where the electrode is placed
- ♥ Unipolar leads

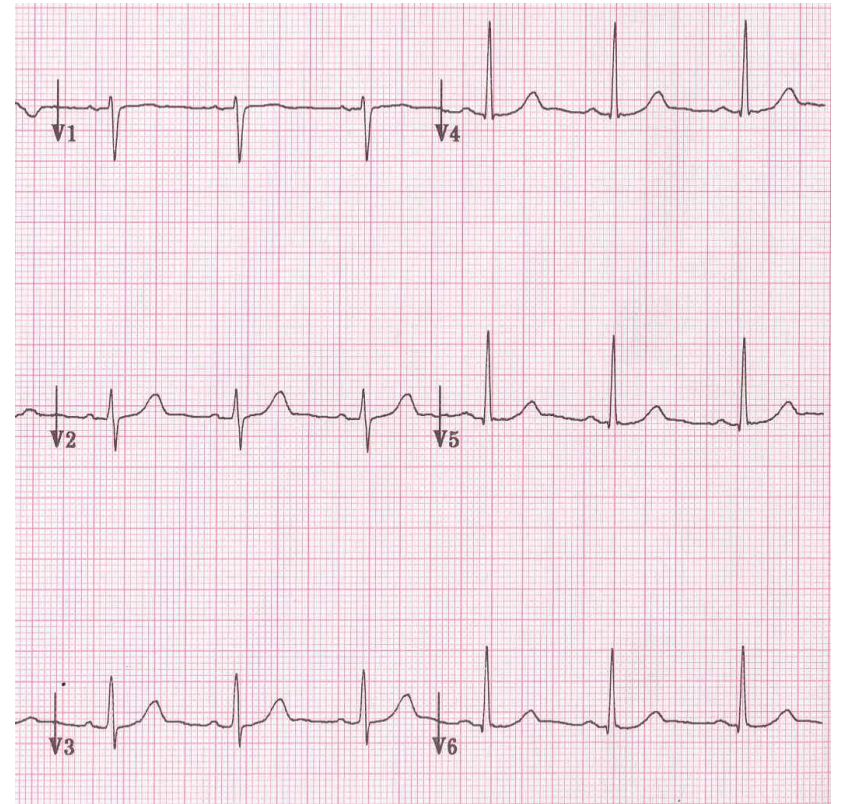
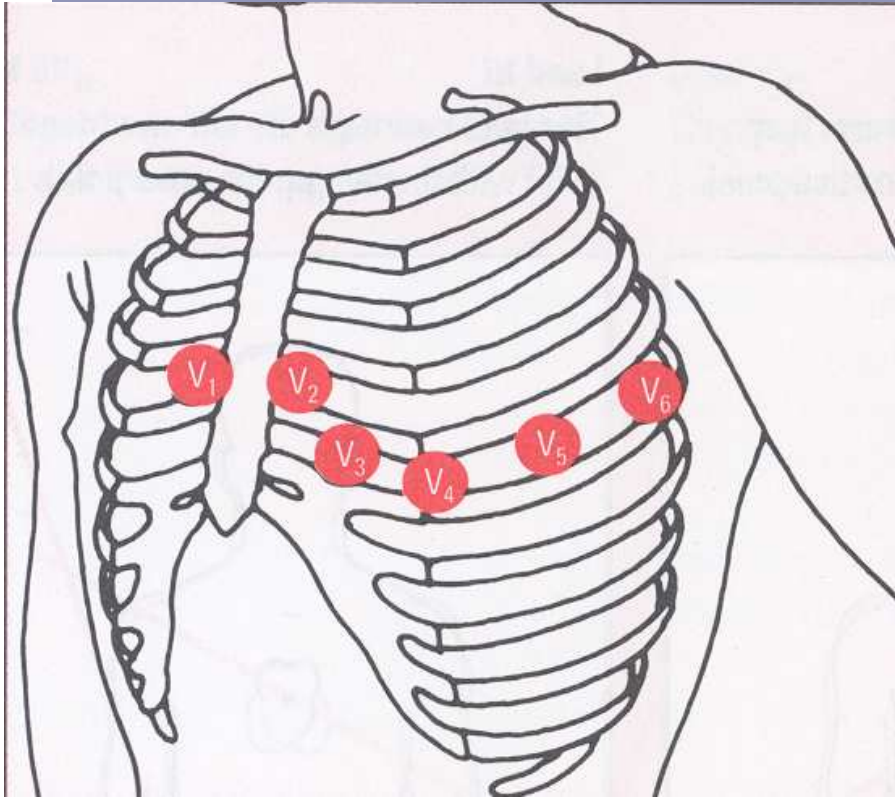


# Precordial Leads Placement

- **V1** 4th intercostal space (ICS) right sternal border (septum)
- **V2** 4th ICS, left sternal border (septum)
- **V3** Midway between V2 and V4 (anterior)
- **V4** 5th ICS, left midclavicular line (anterior)
- **V5** 5th ICS, left anterior axillary line (lateral)
- **V6** 5th ICS, left midaxillary line (lateral)

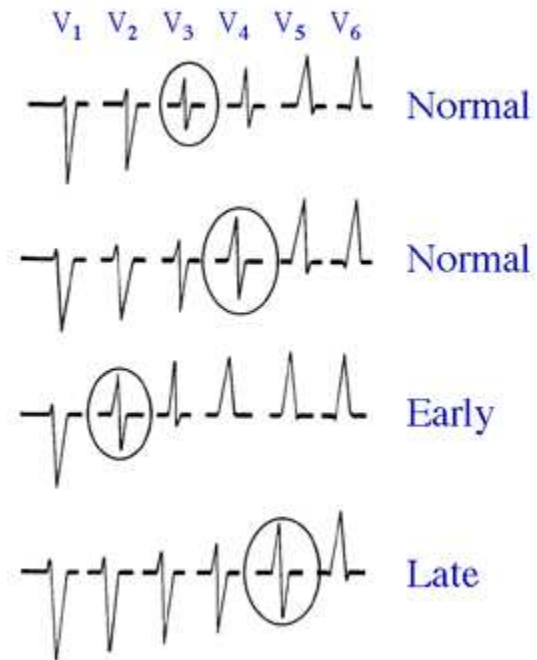
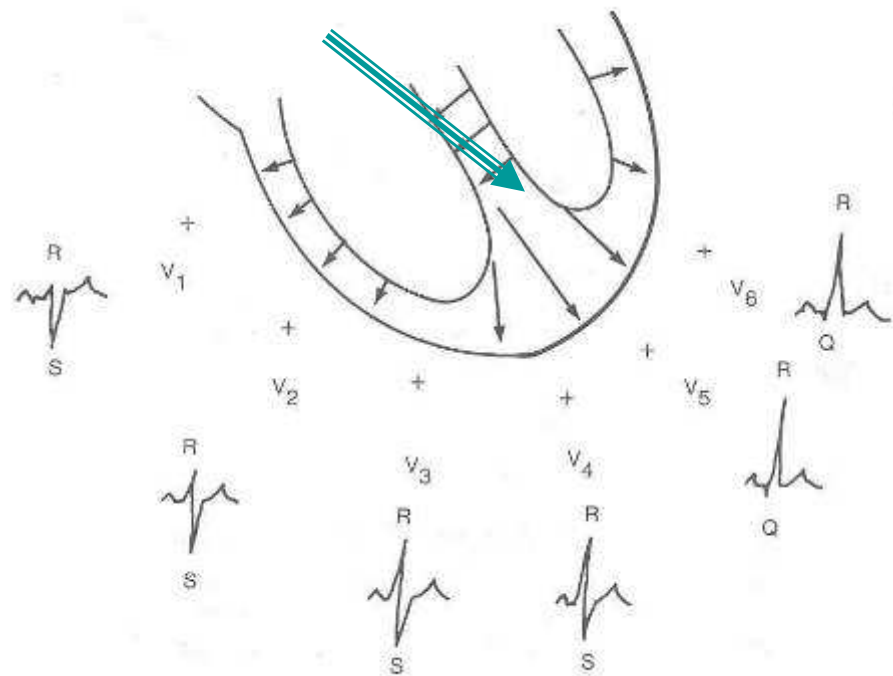


# Precordial Leads



# R Wave Transition

**R: Rises above baseline**

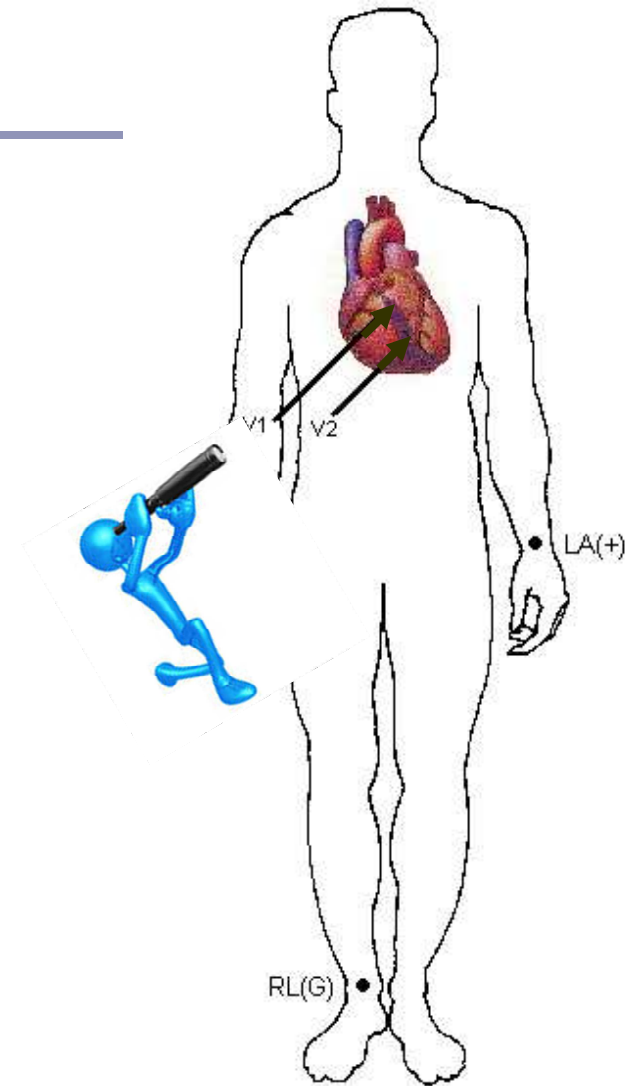


## V1 & V2

Views the septum  
of the heart

Area: *Septal*

Artery: *LAD*



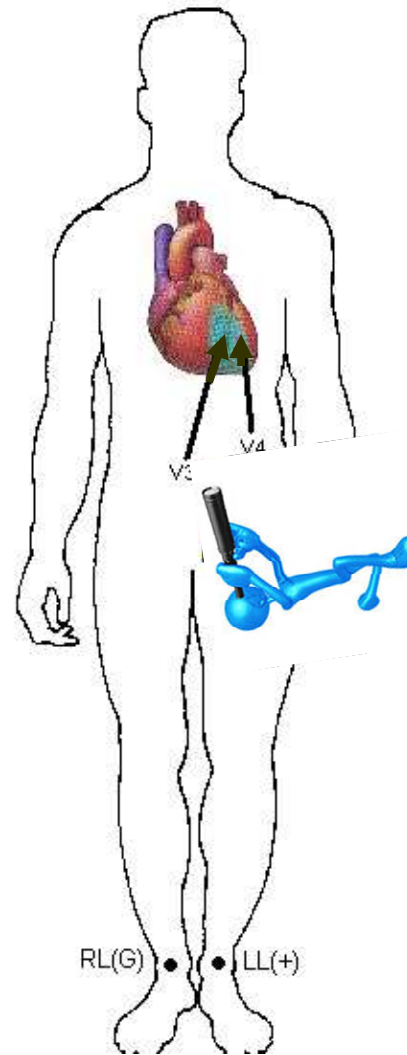


## V3 & V4

Views the anterior area  
of the left ventricle

Area: *Anterior*

Artery: *LAD*

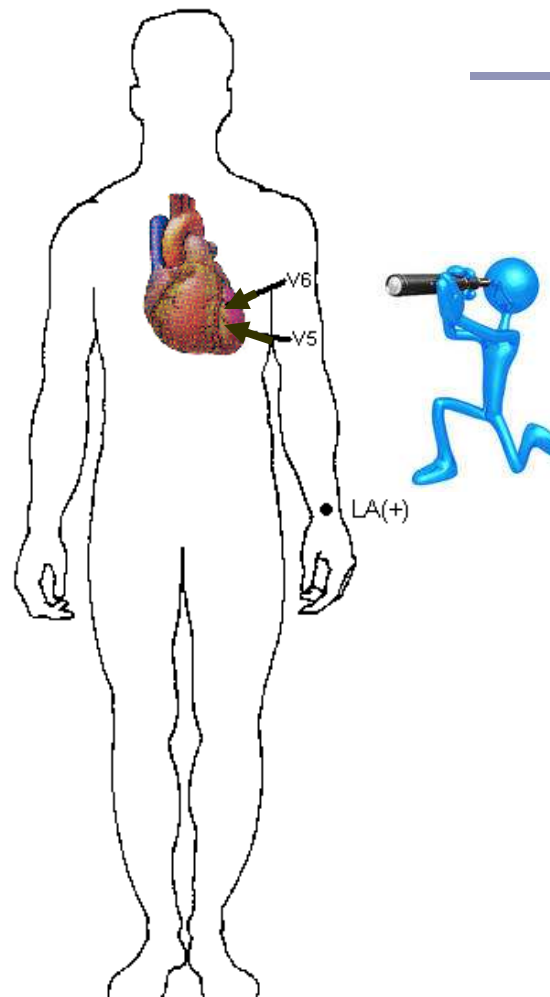


## V5 & V6

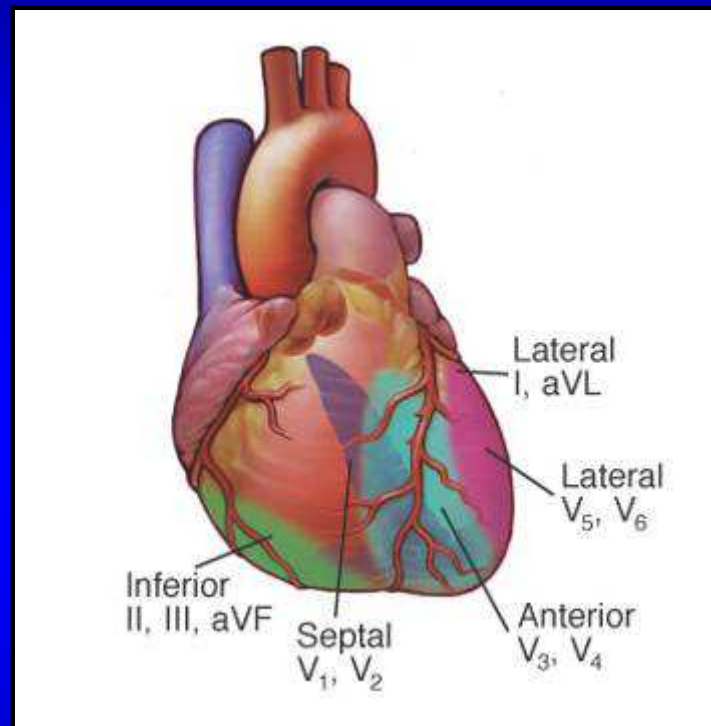
Views the lateral area  
of the left ventricle

Area: *Lateral*

Artery: *Circumflex*



# Cardiac Anatomy in Relation to Coronary Artery

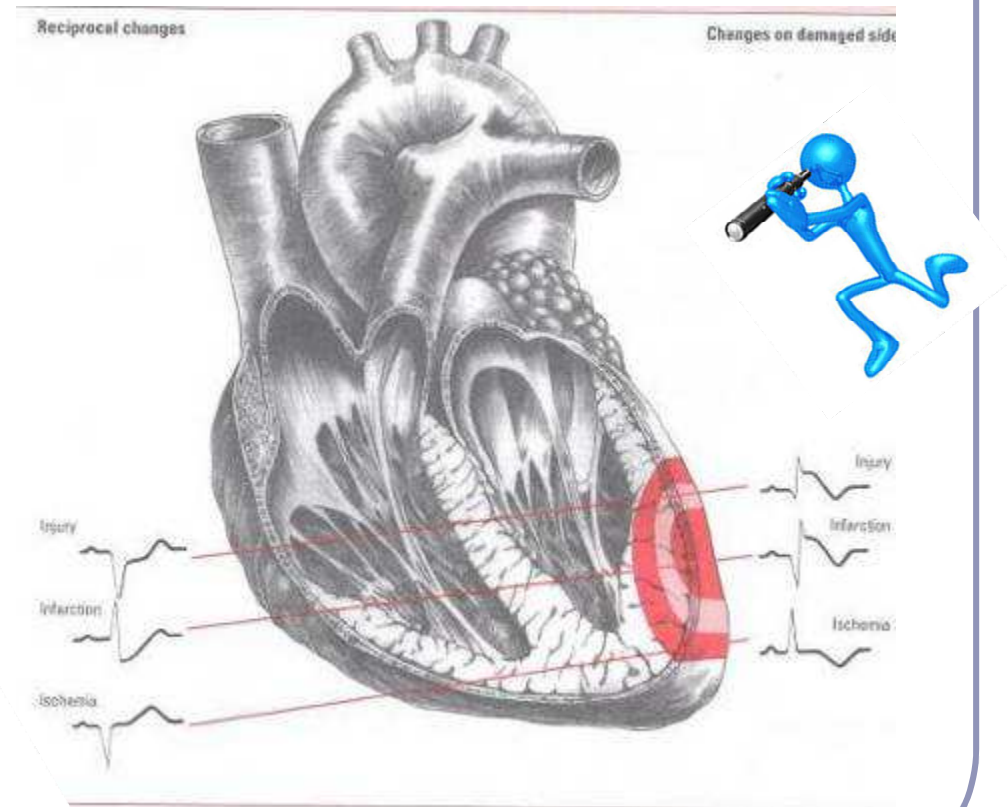


I lateral	aVR	V <sub>1</sub> septal	V <sub>4</sub> anterior
II inferior	aVL lateral	V <sub>2</sub> septal	V <sub>5</sub> lateral
III inferior	aVF inferior	V <sub>3</sub> anterior	V <sub>6</sub> lateral

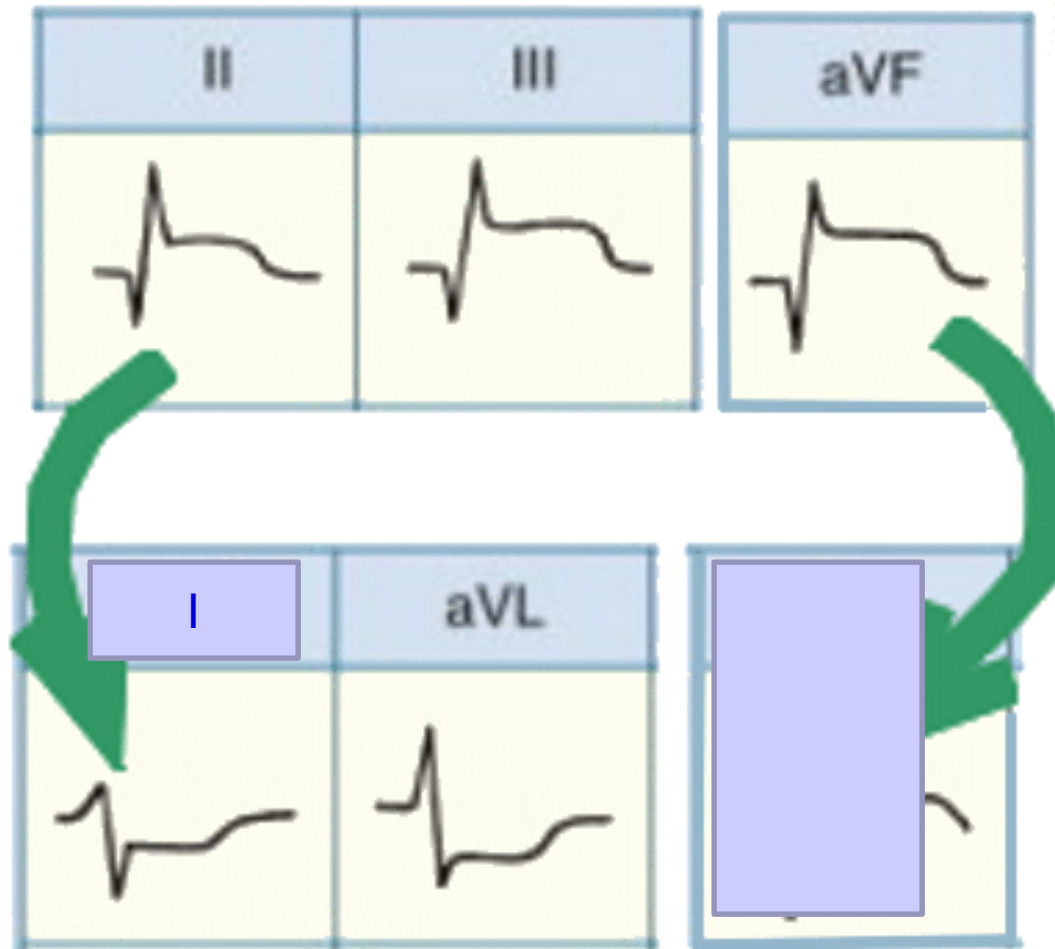
# Reciprocal Changes

**Reciprocal Leads that are opposite the damaged area will show opposite EKG Changes**

- Mirror Image
- Two different electrodes viewing AMI from opposite angles
- Example: Take photo of male from front and from back – still a male but different view



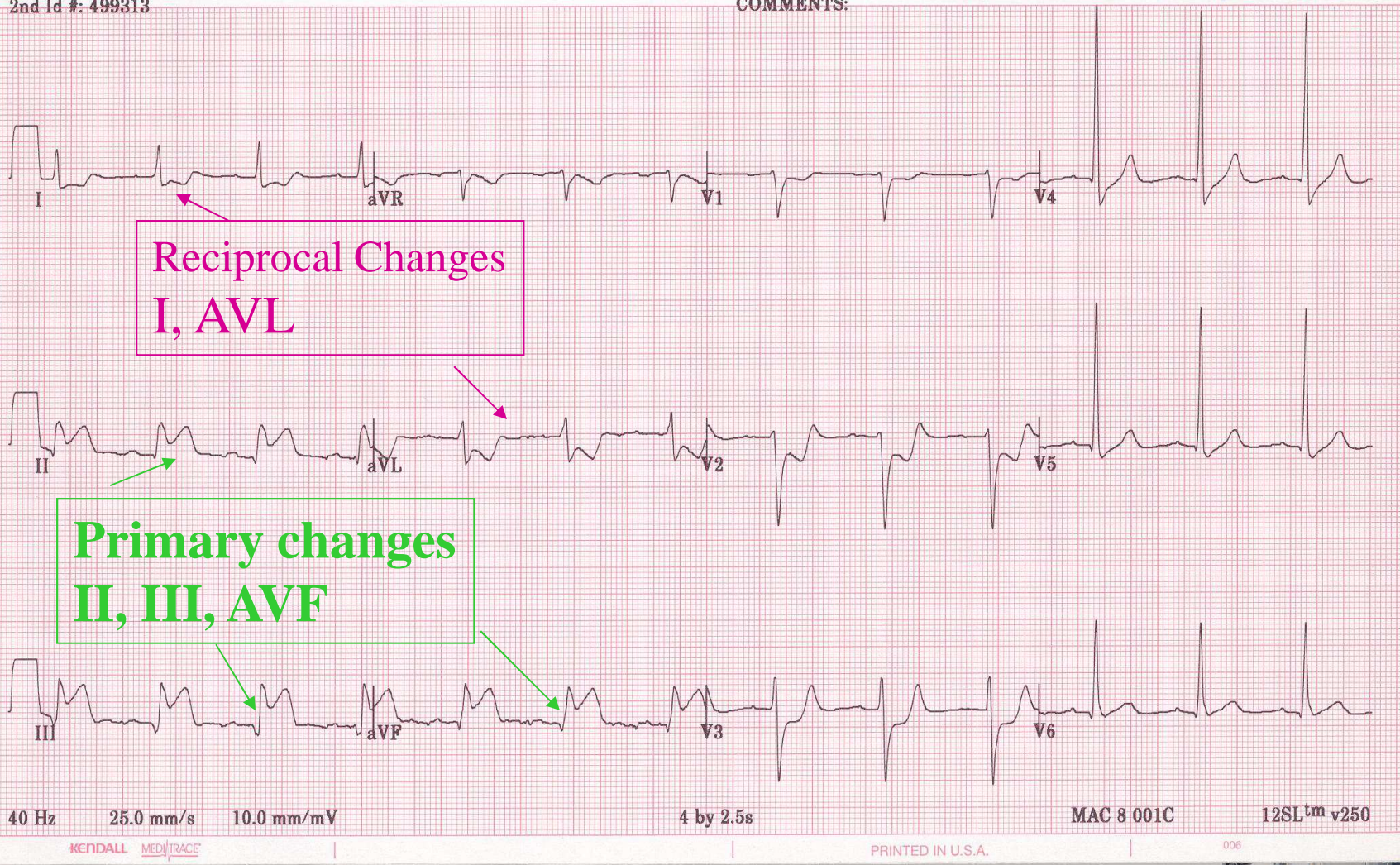
# Inferior STEMI



Reciprocal leads

2nd Id #: 499313

COMMENTS:



40 Hz 25.0 mm/s 10.0 mm/mV

4 by 2.5s

MAC 8 001C

12SL™ v250

KENDALL MEDITRACE

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006

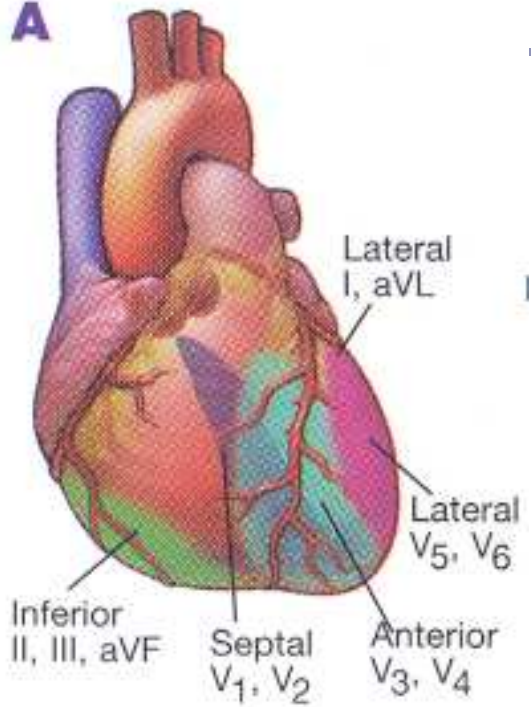
# Reciprocal Changes

## Secondary Changes

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- Ischemia , Injury , and infarction are primary changes
- Reciprocal changes are secondary changes
- Reciprocal Leads that are opposite the damaged area will show opposite EKG Changes
- Reciprocal changes = confirm primary changes

**A**



- Inferior ↔ Lateral
  - II, III, AVF ↔ I, AVL, V5, V6
- Anterior ↔ Posterior
  - V1 – V4

I lateral	aVR	V1 septal	V4 anterior
II inferior	aVL lateral	V2 septal	V5 lateral
III inferior	aVF inferior	V3 anterior	V6 lateral



# Reciprocal Changes

**Reciprocal Leads that are opposite the damaged area will show opposite EKG Changes**

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- If you see ST segment depression, look in opposite leads for primary changes
- If you see tall R waves in the V leads, question if this is an old posterior AMI and look for Q waves in the inferior leads

- 
- To learn you need to hear something

- 6 times

**SIX**

**6**

- 6 different ways

**VI**

**seis**

**|||| I**

**six**

# **Differential Diagnosis**

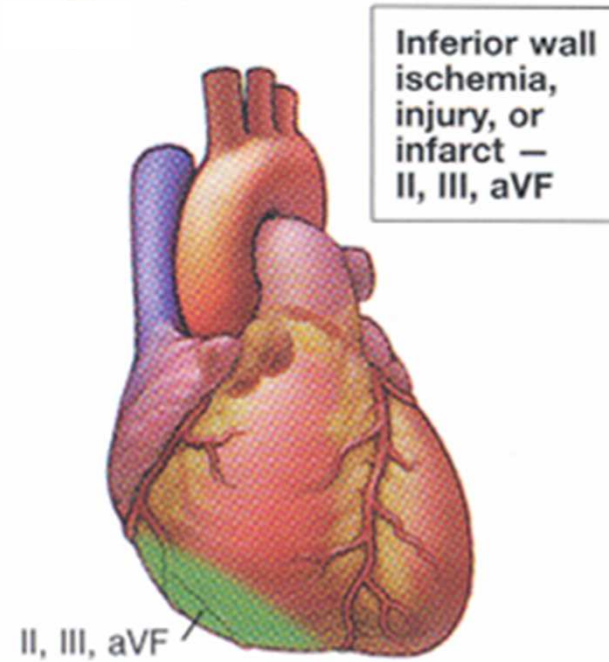
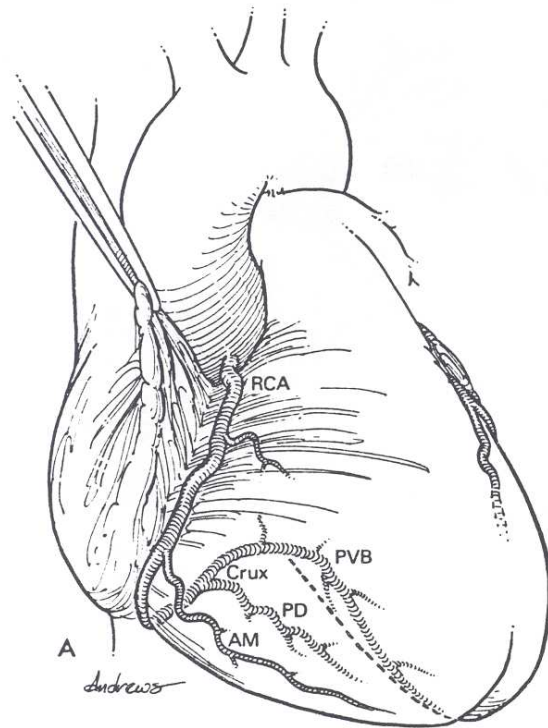
12 Lead EKG in Acute  
Coronary Syndrome

# Right Coronary Artery RCA

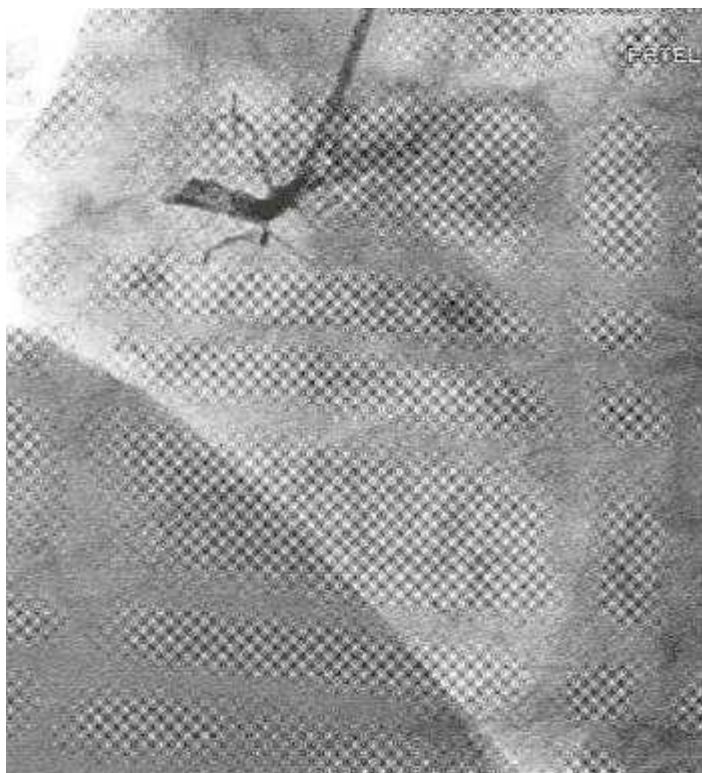
## Inferior Wall

### II, III, aVF

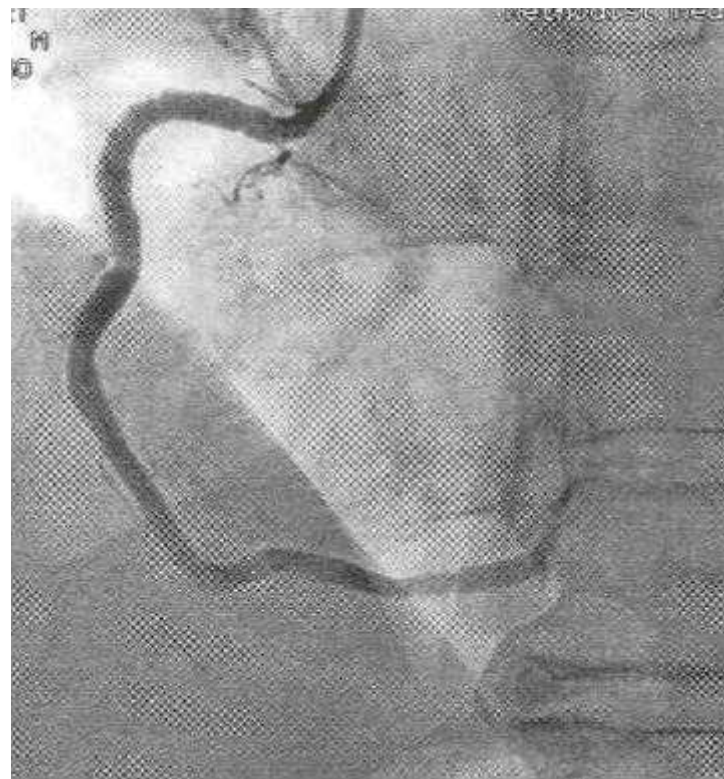
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Occluded RCA



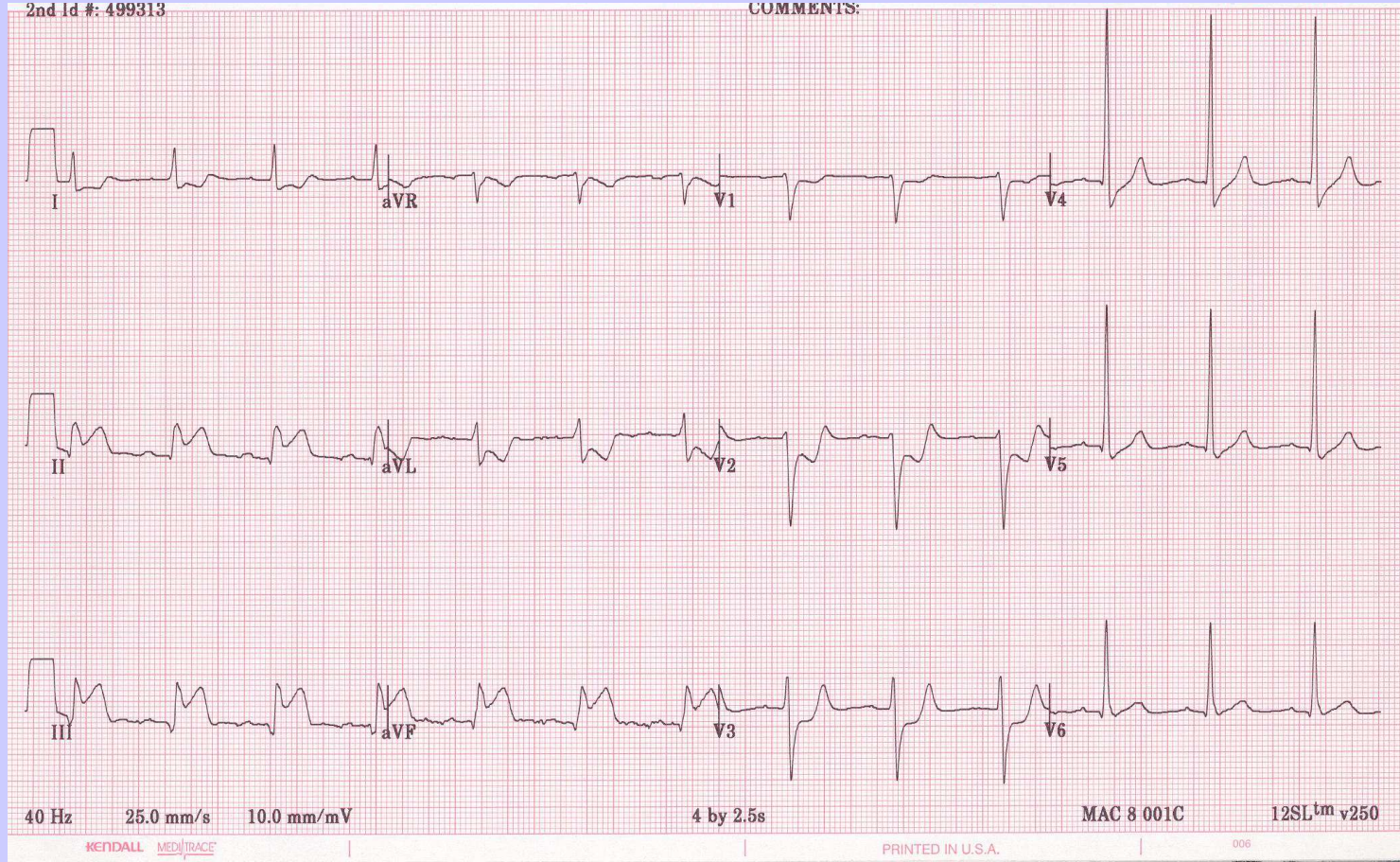
RCA post stent



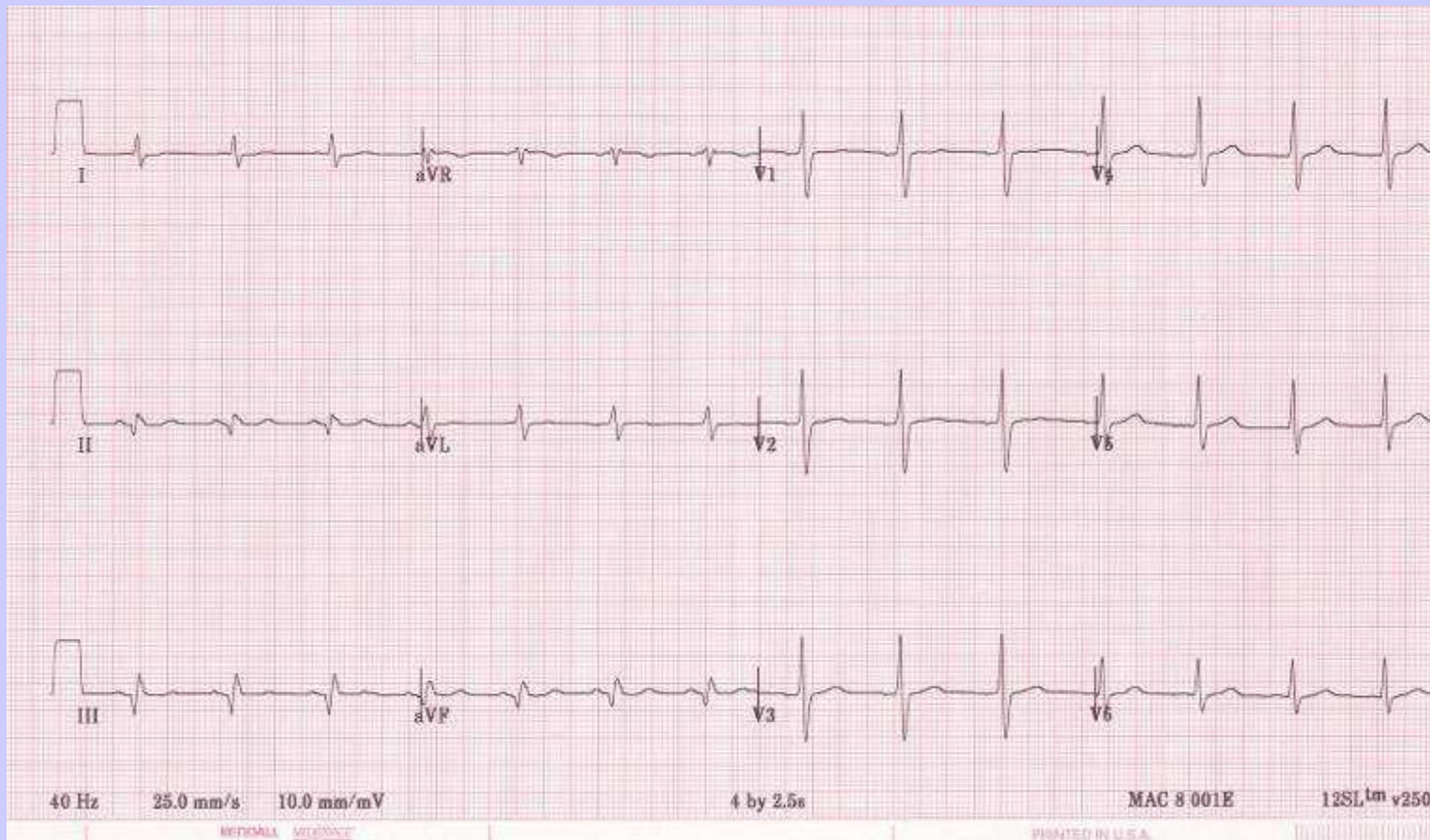
# Inferior Injury

2nd Id #: 499313

COMMENTS:



# Old Inferior Infarction



# Inferior AMI

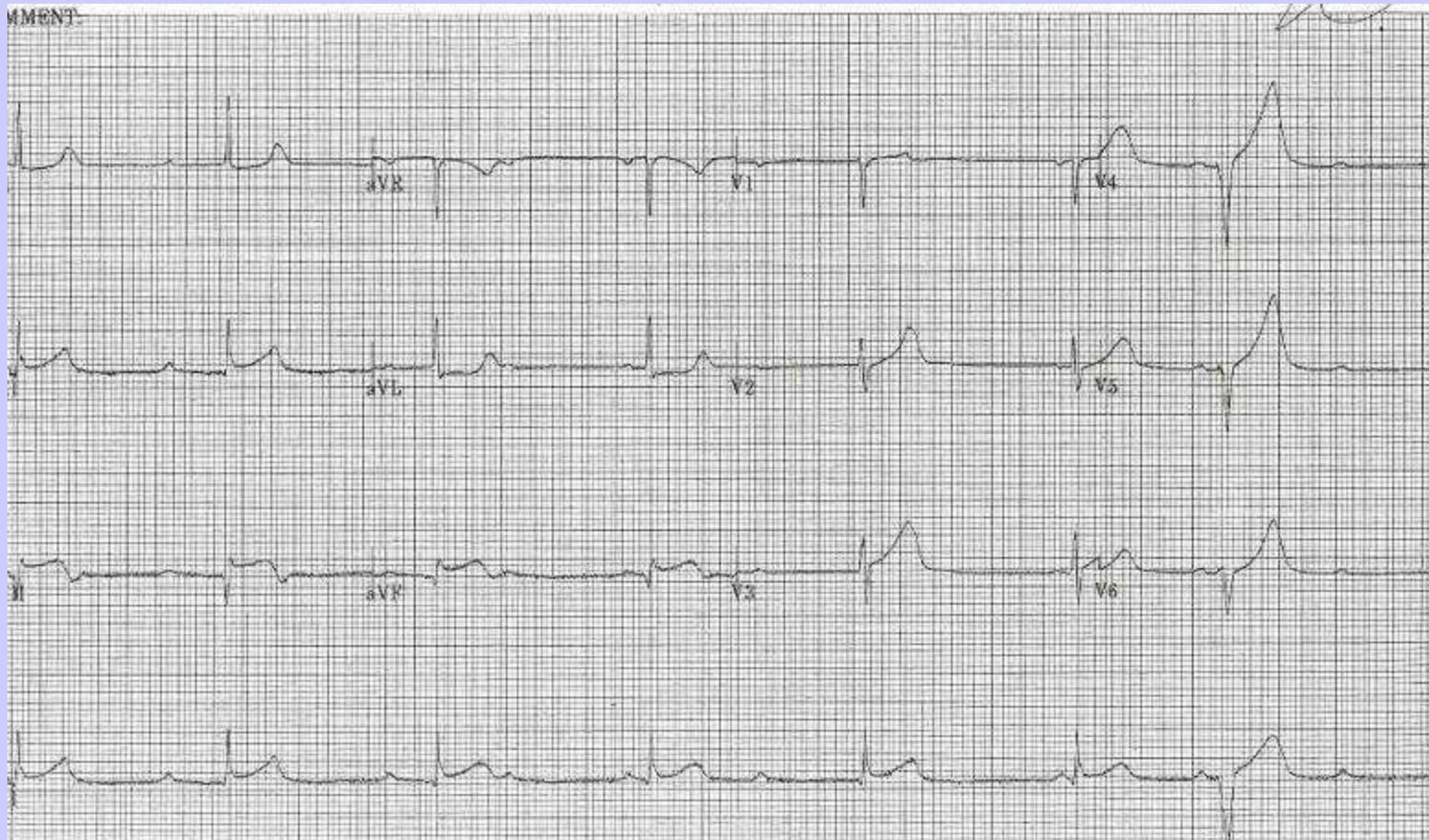
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- Involves right ventricle – may also get right ventricular infarct
- Need lots of fluids to increase preload since RV is involved
- Arrhythmias= Blocks
- RCA wraps around the back of the heart and changes to PDA. Typically have inferior –posterior AMI.
- Inferior- Posterior AMI:
  - ST Elevation: II, III, AVF and
  - ST depression V1, V2, V3



# Inferior AMI

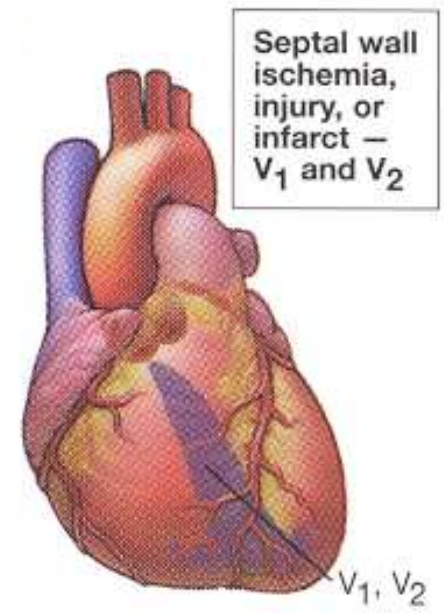
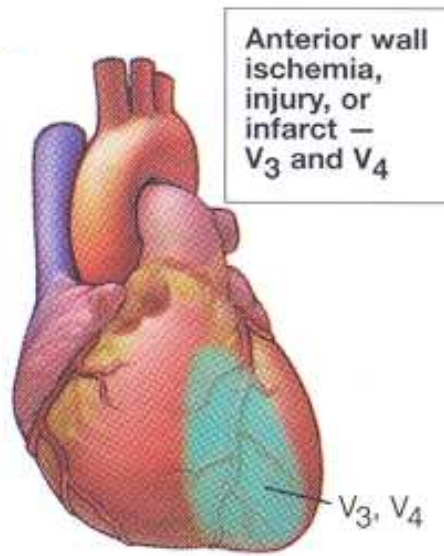
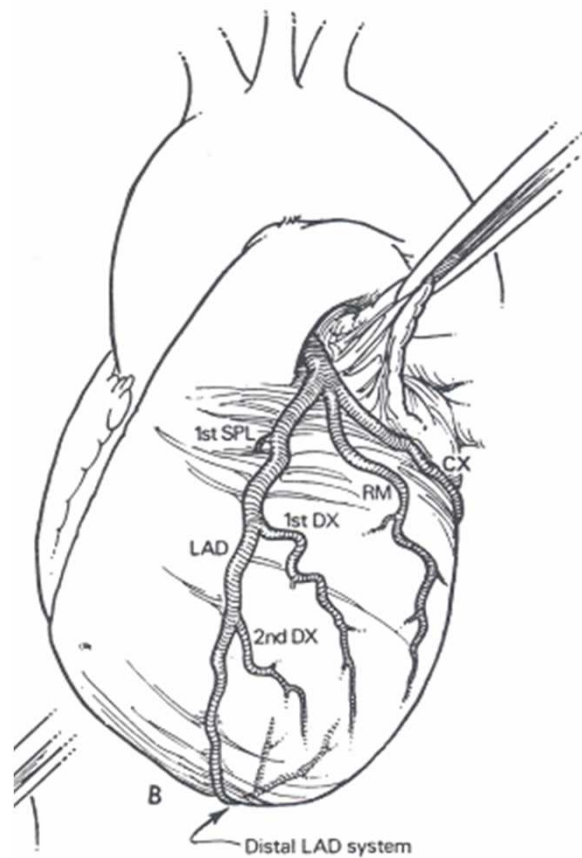
## What's the rhythm?



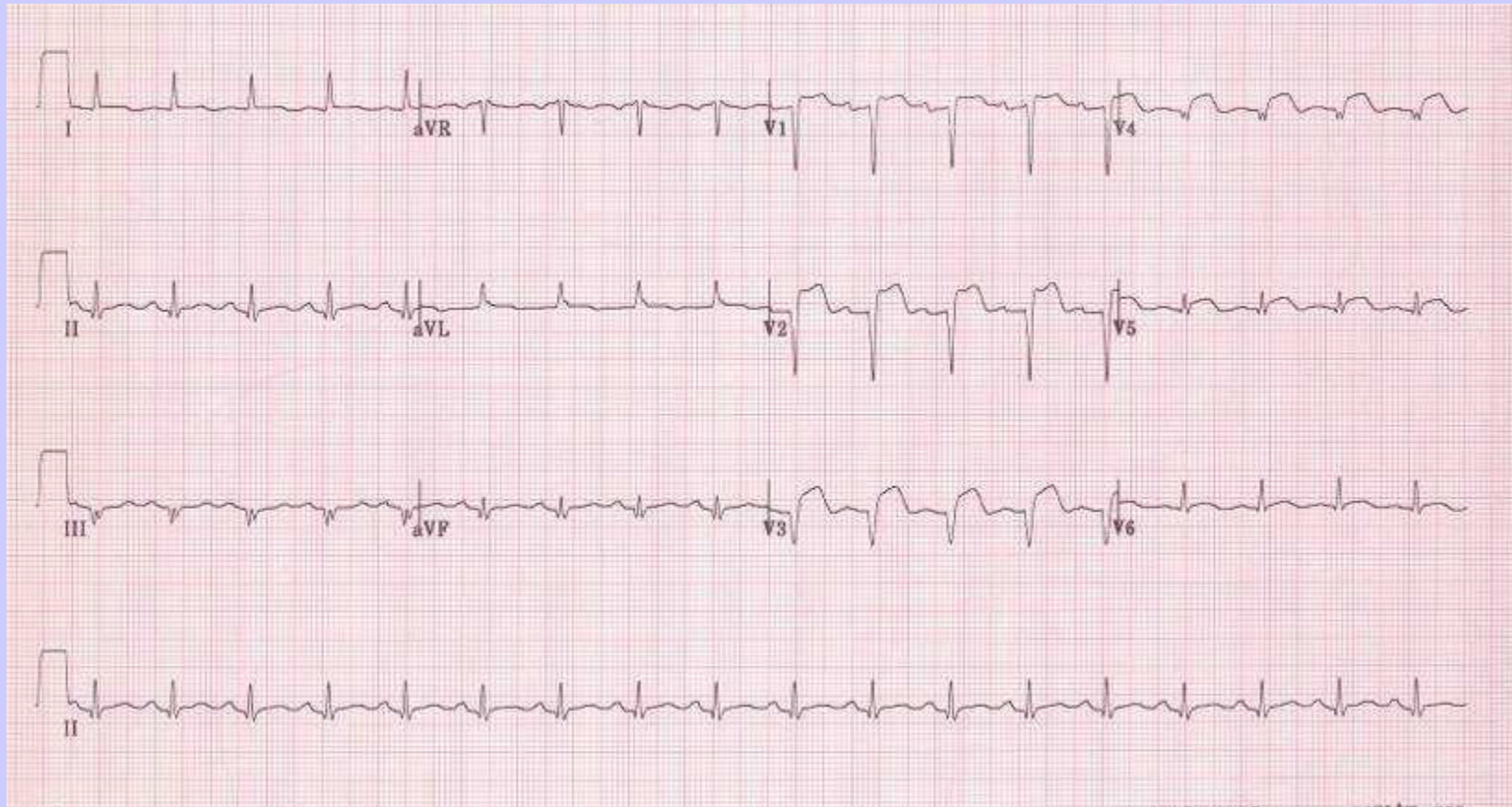
# Left Anterior Descending Artery LAD

## Anterior Wall V3 & V4

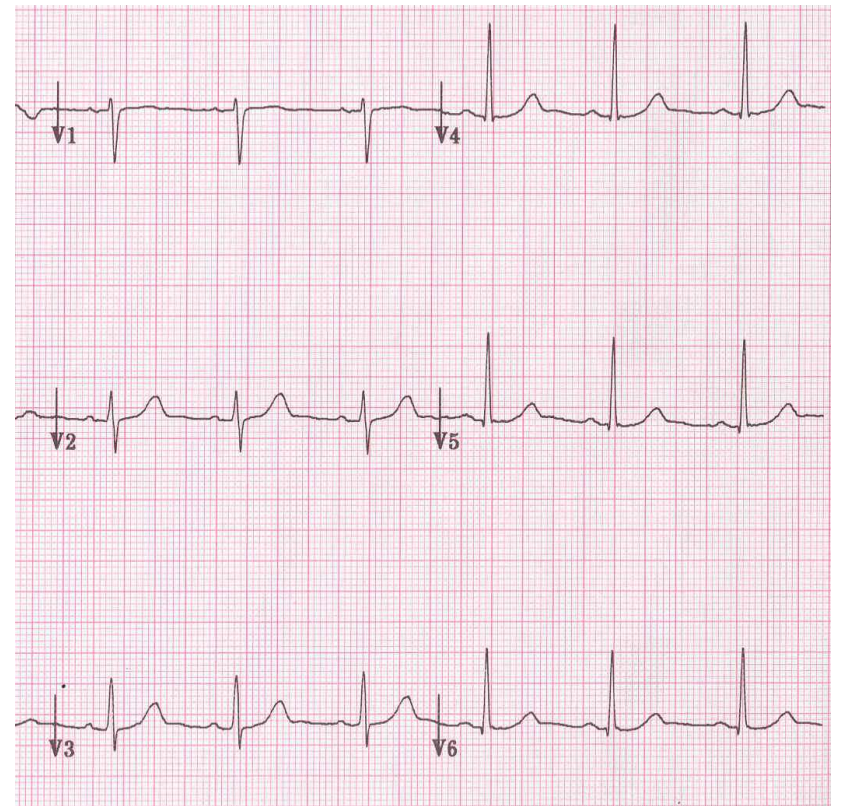
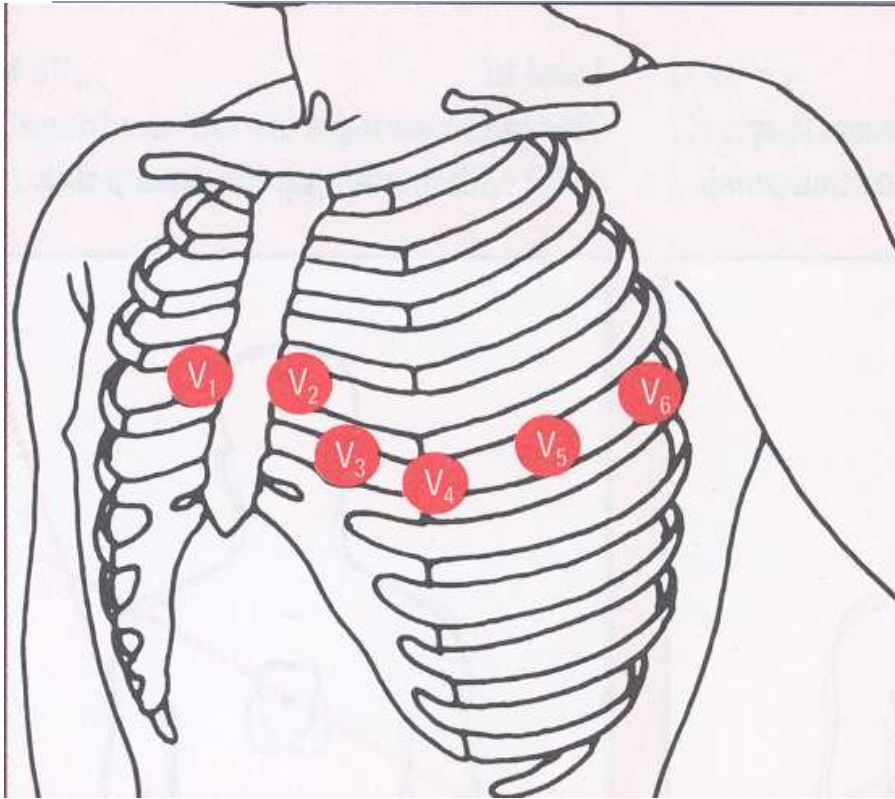
## Septal Wall V1 & V2



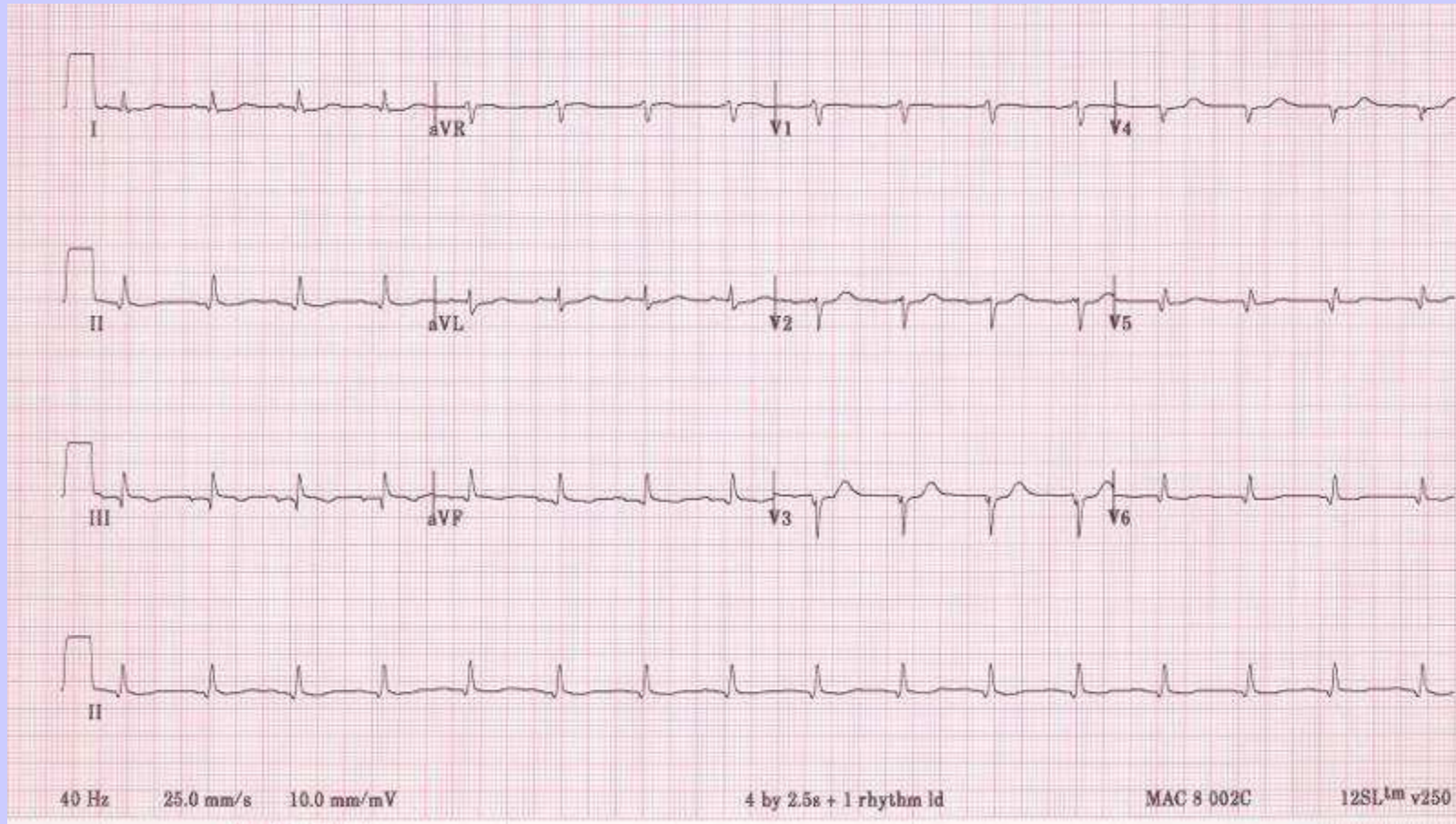
# Anterior-septal Injury



# Precordial Leads – Know normal

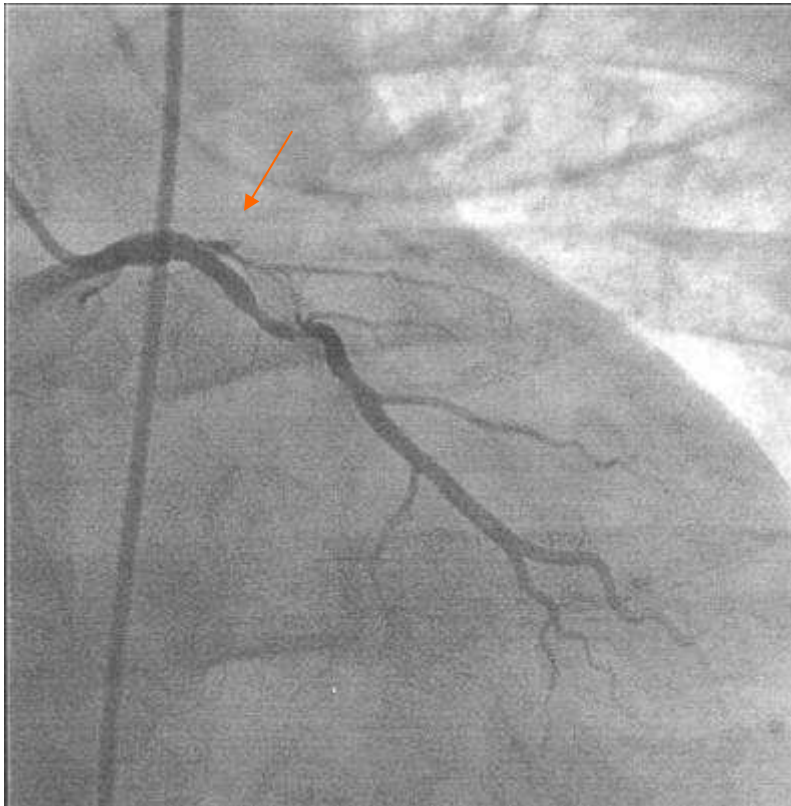


# Old Anterior Infarction

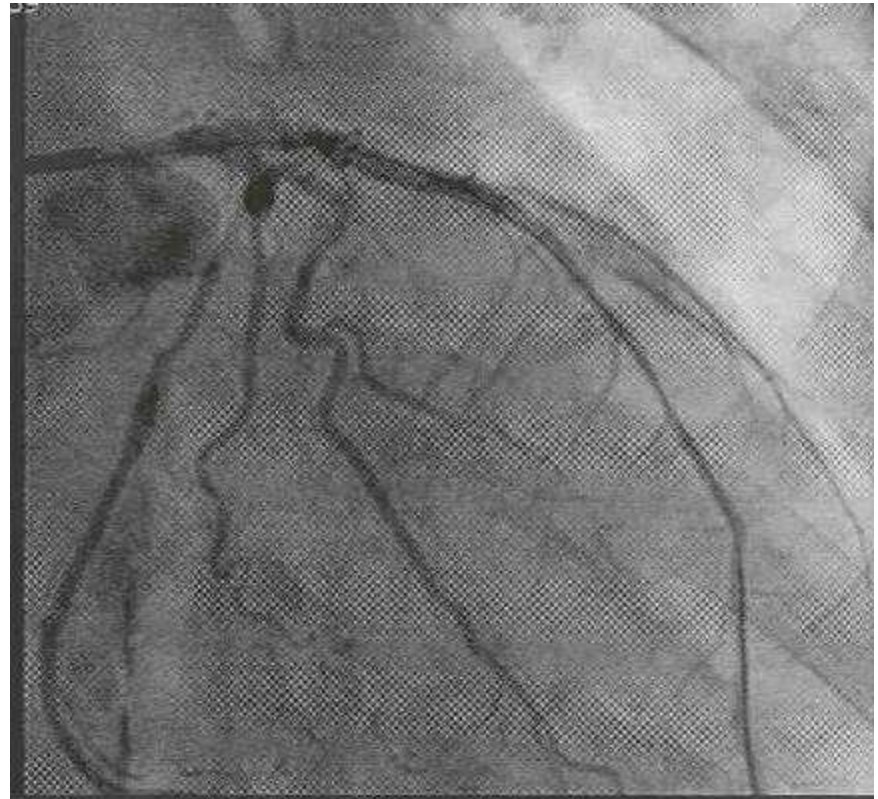


Occluded High LAD

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LAD post stent

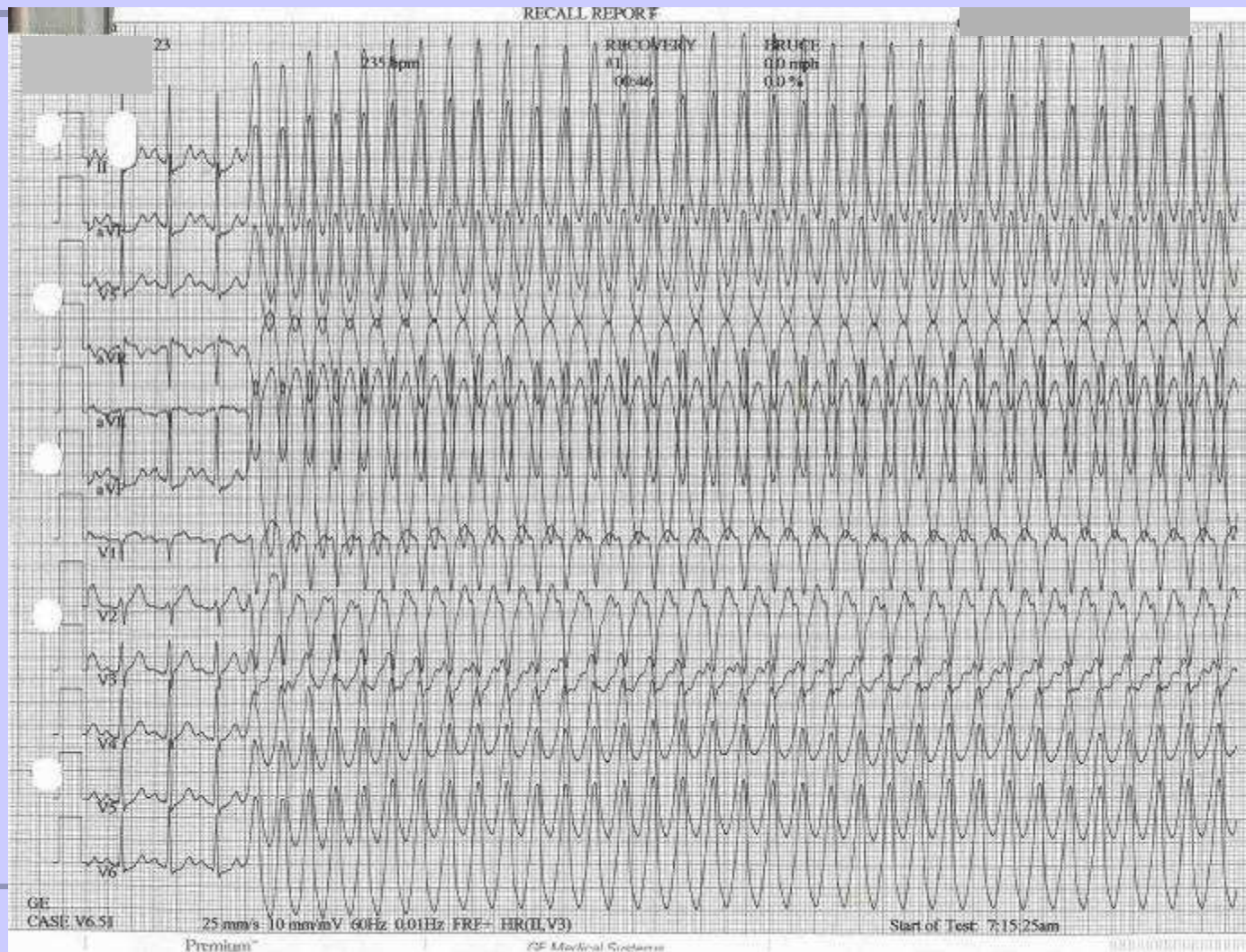


## **Anterior AMI**

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- Lose the most muscle mass
- Usually have the lowest EF
- Arrhythmias = VT or VF

# Stress Test – Angio found 3 occlusions in the LAD



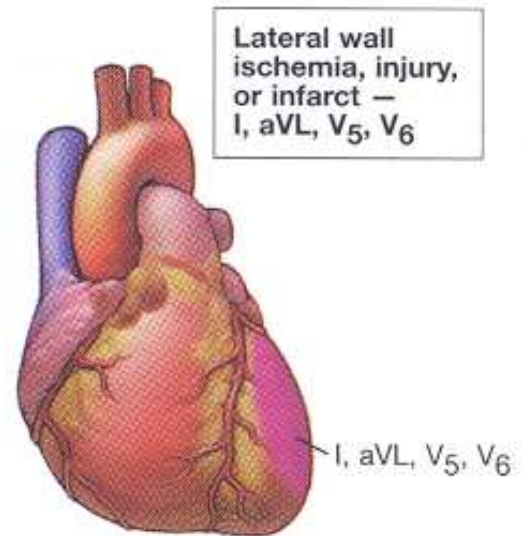
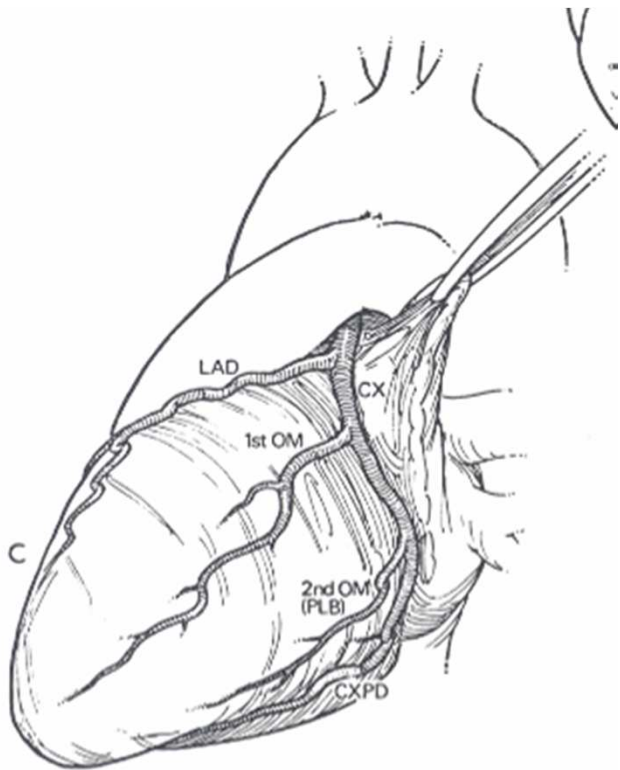


# Circumflex Artery Cx

## Lateral Wall

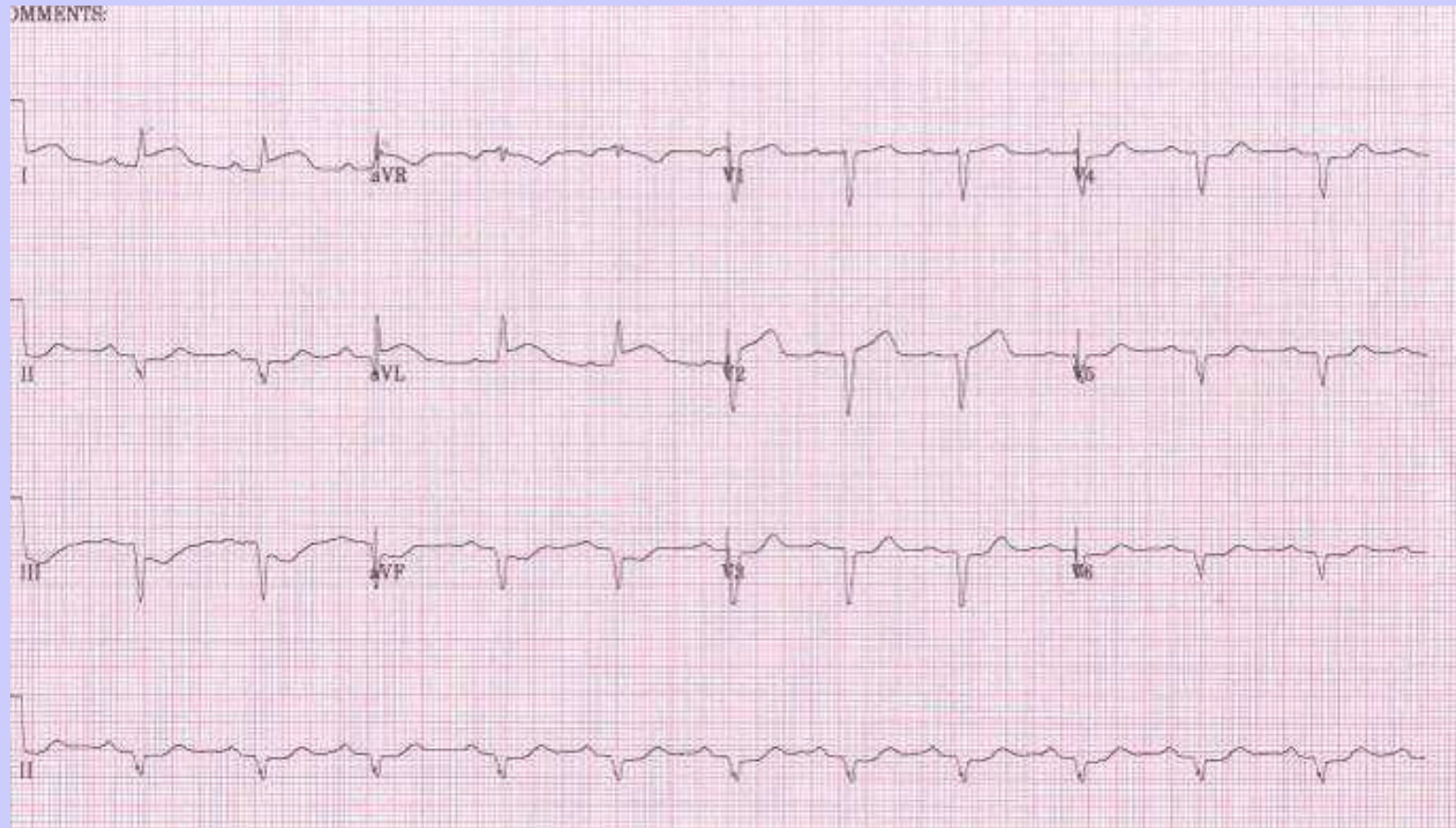
### I, AVL V5 & V6

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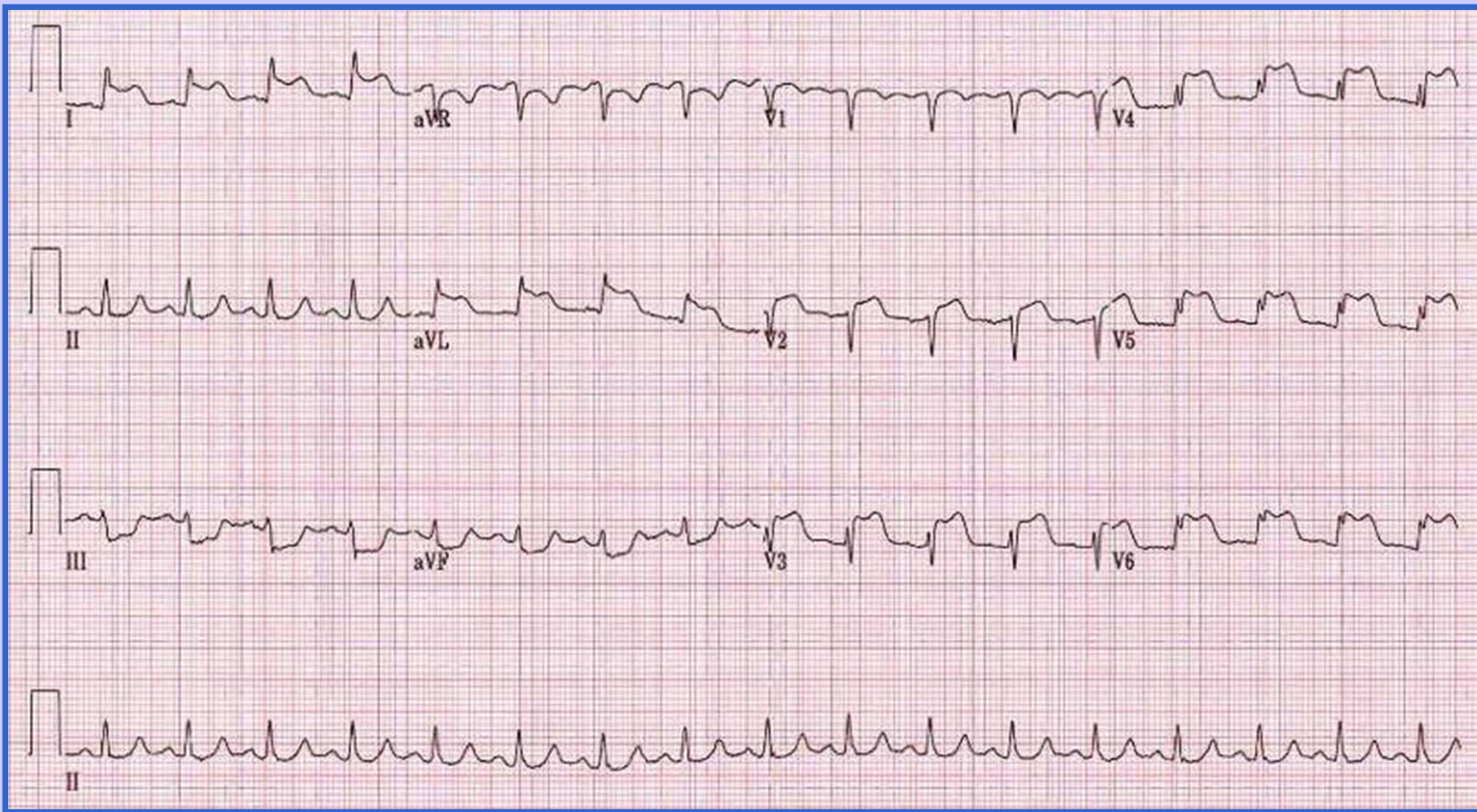


# High Lateral Injury

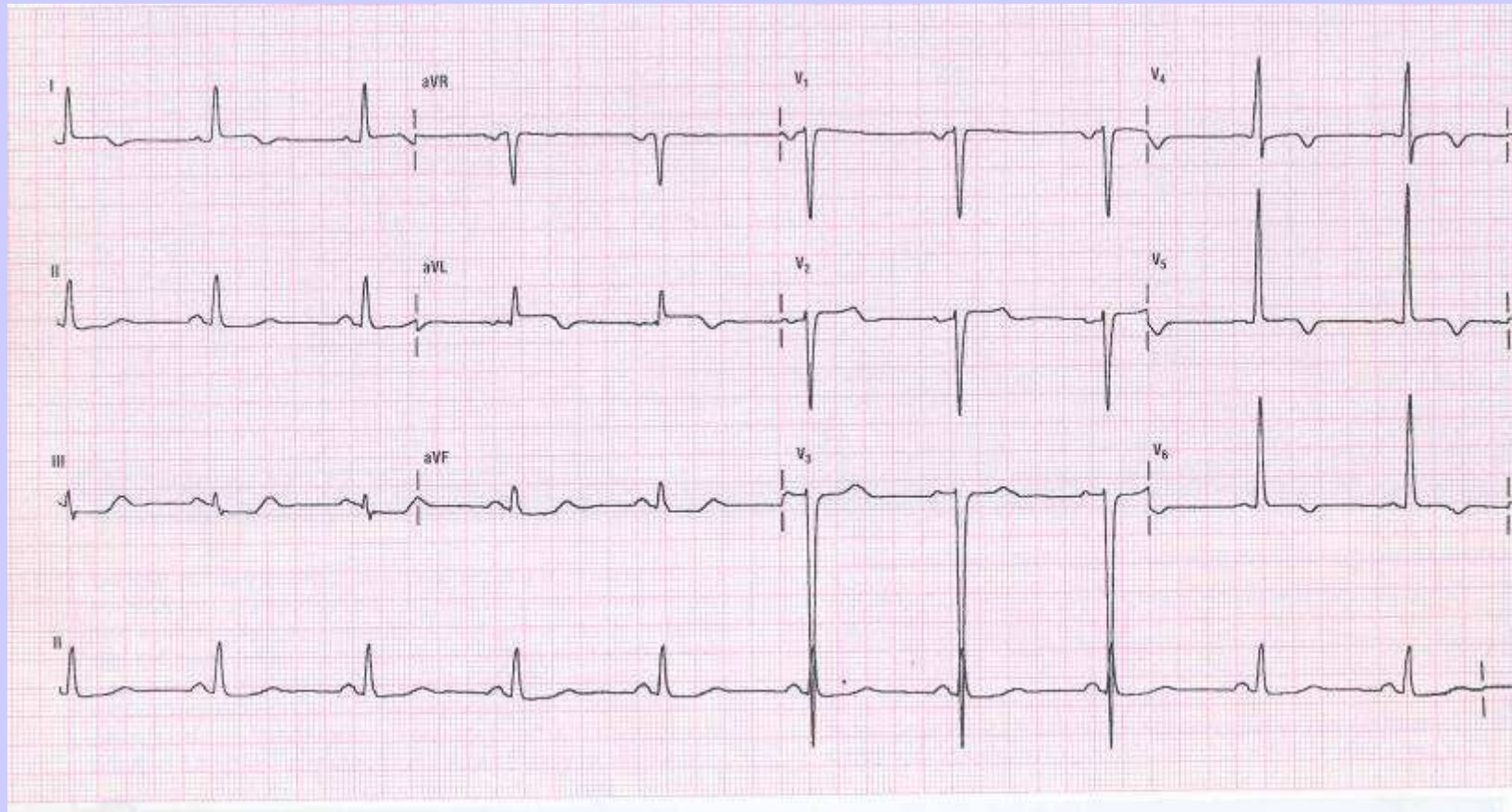
COMMENTS:



# Anterior Lateral Injury



# Lateral Ischemia

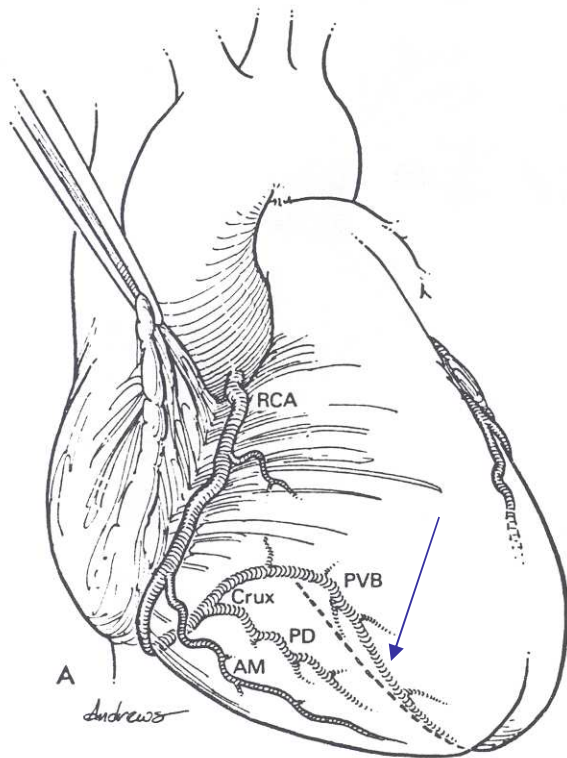


# Posterior Descending Artery PDA

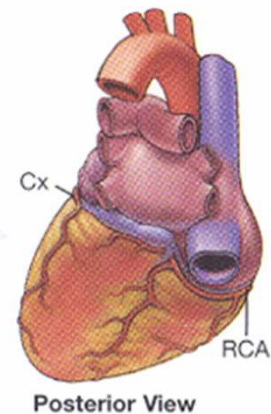
## Posterior Wall

## Reciprocal Changes

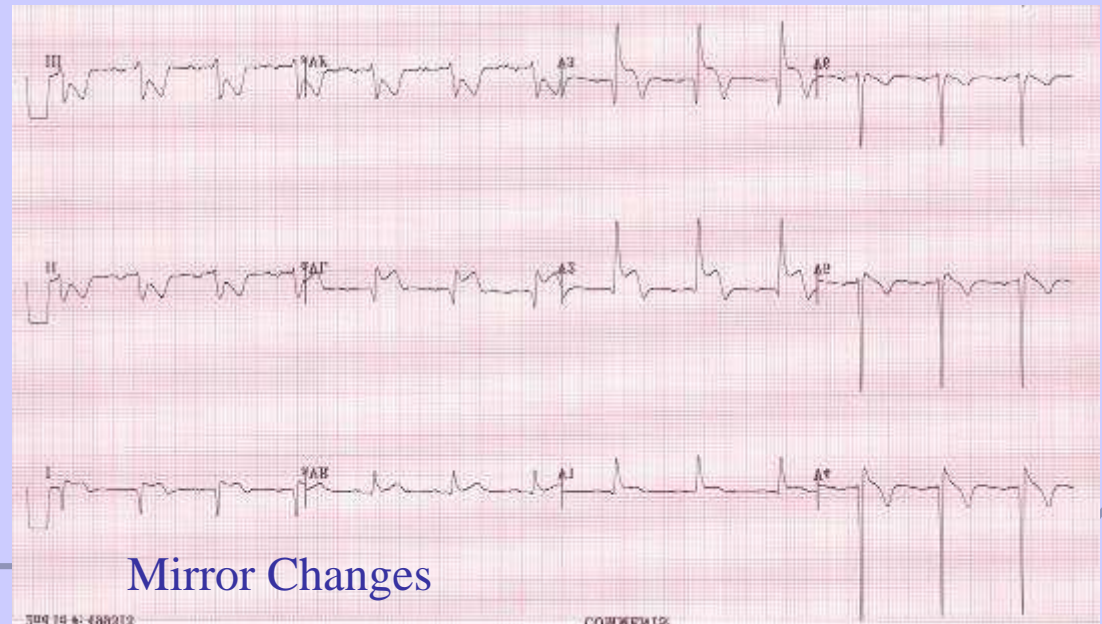
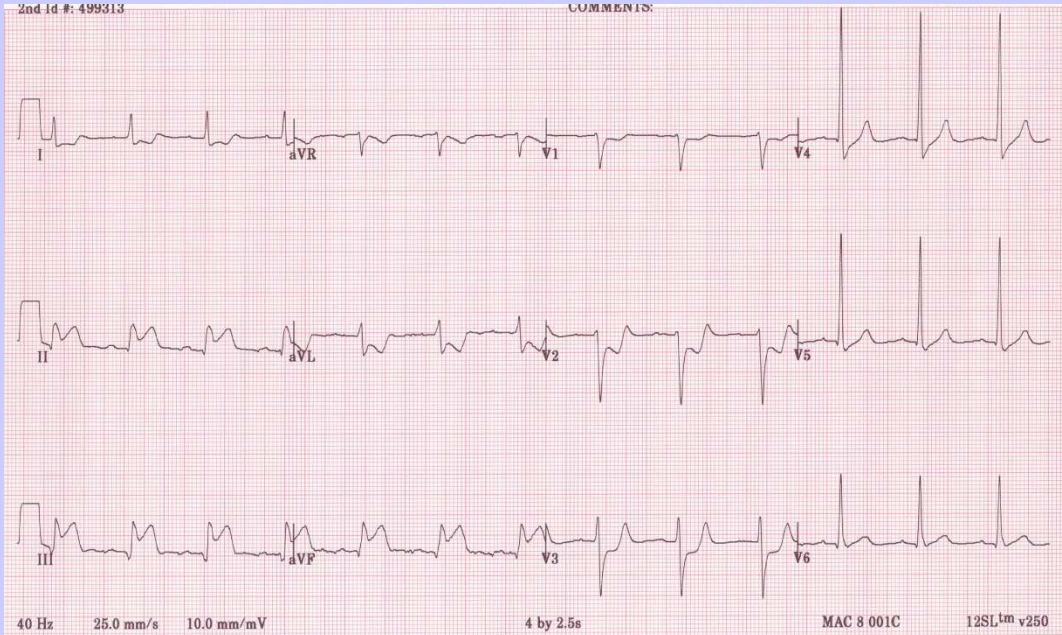
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- Usually see with Inferior AMI as RCA wraps around the back of the heart and changes to PDA
- Reciprocal Changes V1 , V2, V3  
(ST segment depression or Tall R Waves)
- 18 Lead EKG

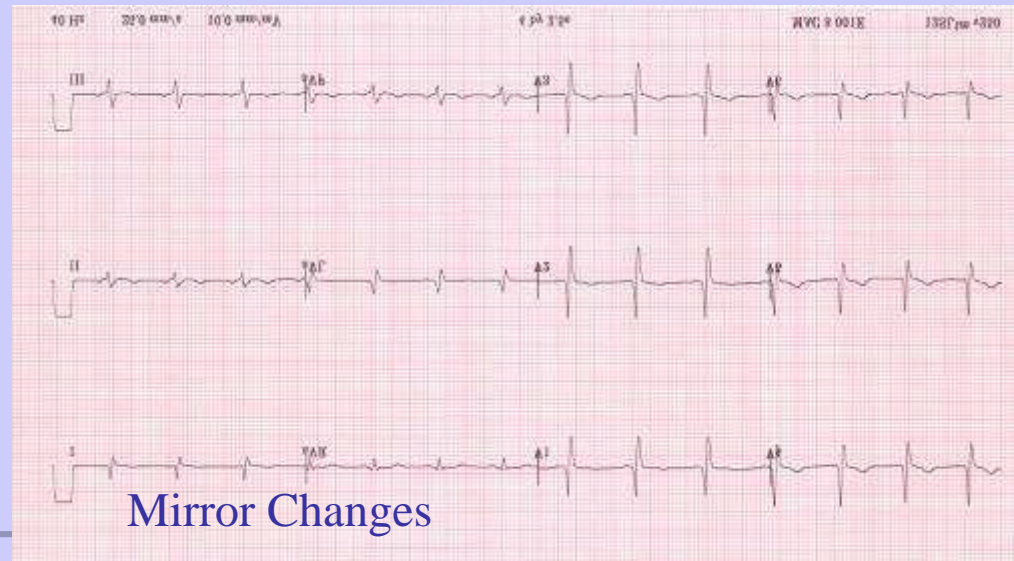
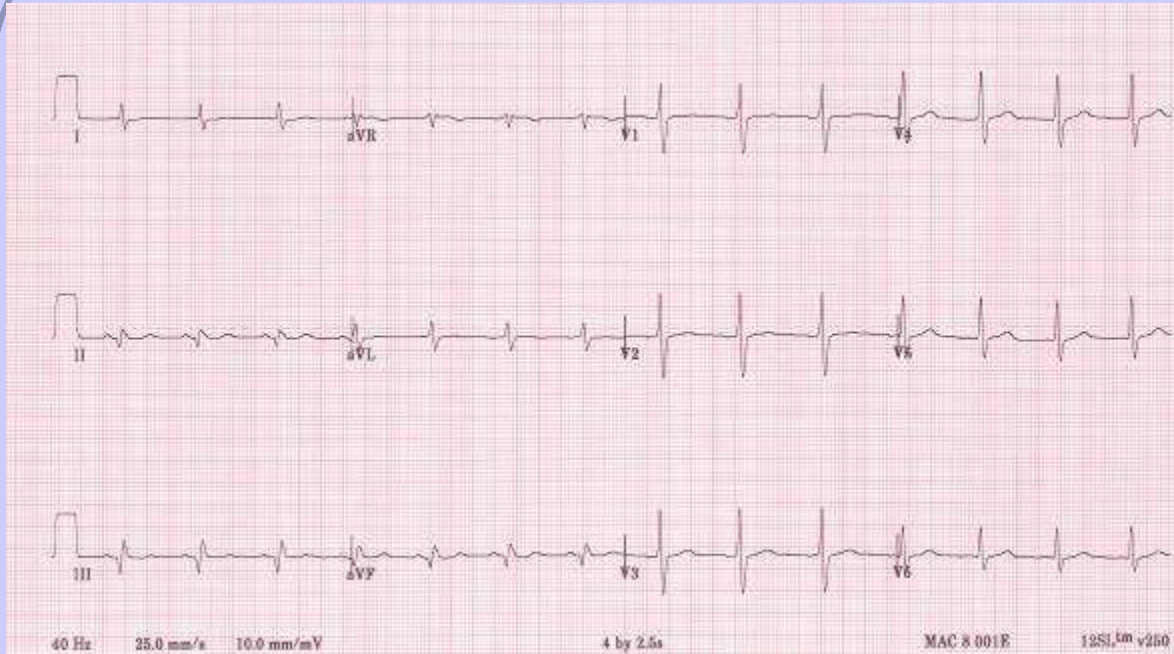


# Inferior & Posterior Injury



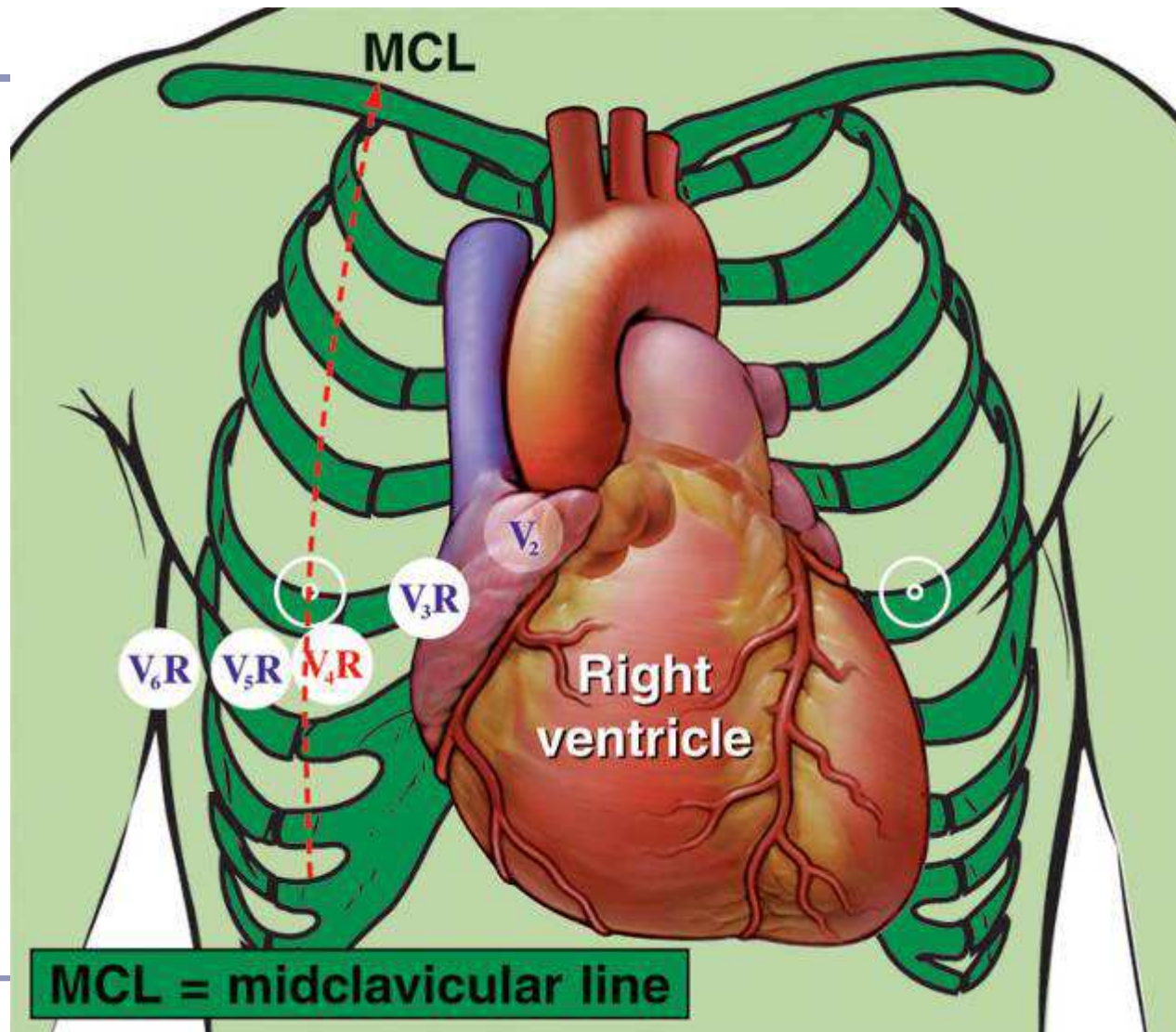
Mirror Changes

# Old Inferior-posterior Infarction



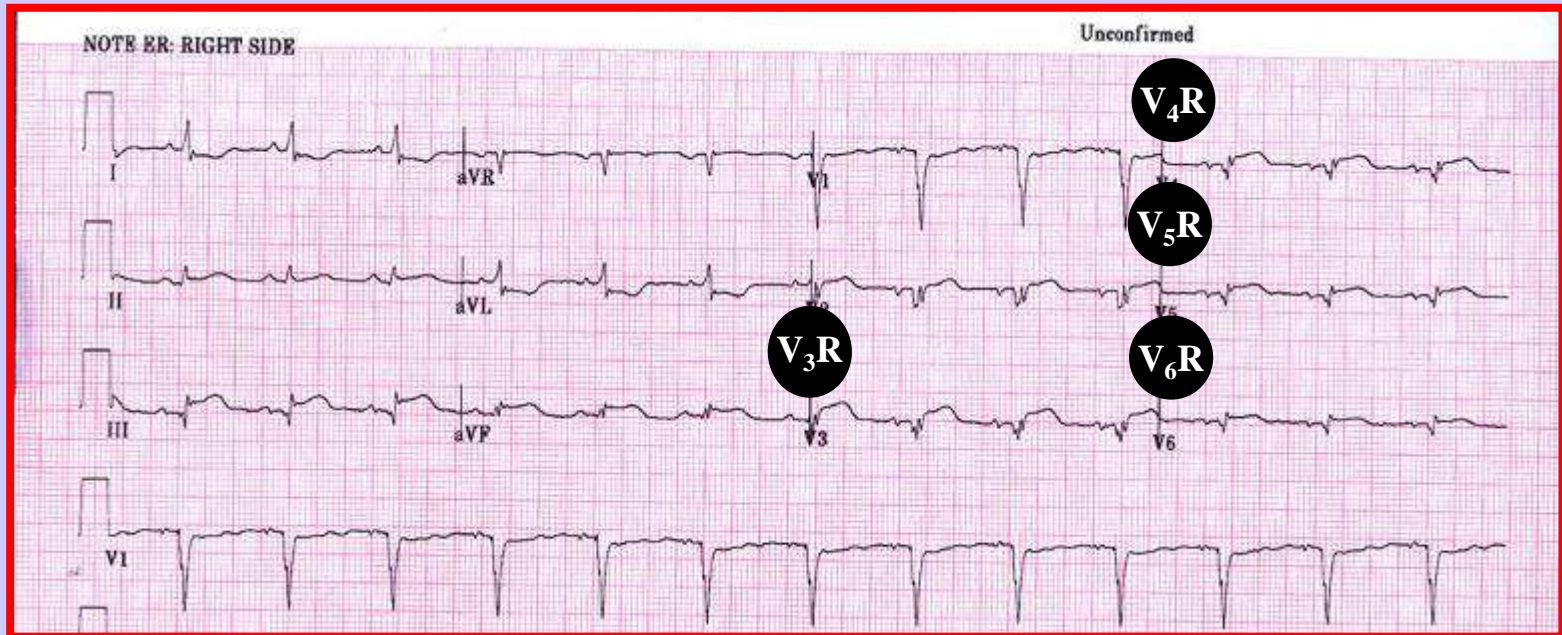
Mirror Changes

# Lead Placement: Right-Sided ECG



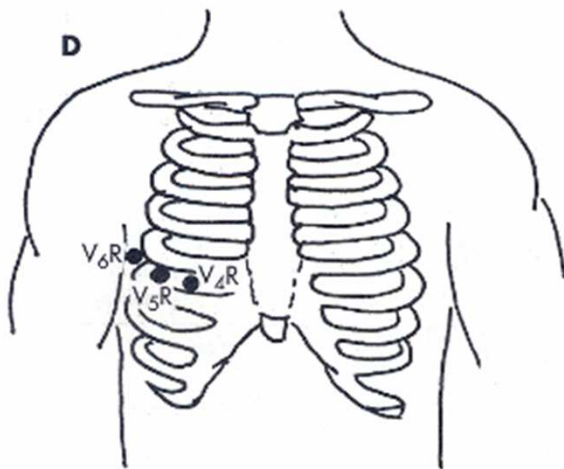


# Right-Sided 12-Lead ECG: Patient With Inferior ST-Segment Changes



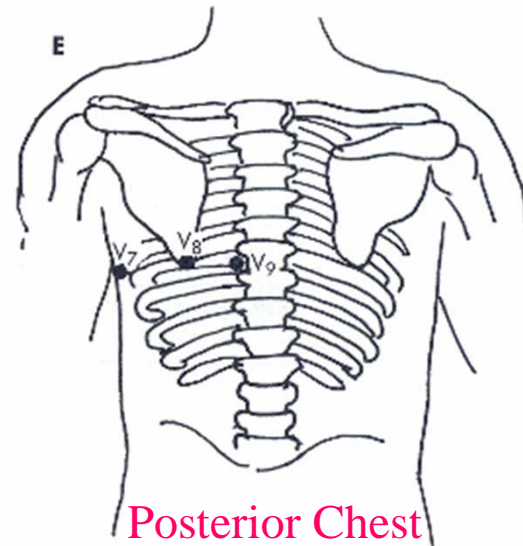
# 18 Lead EKG

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Anterior Chest

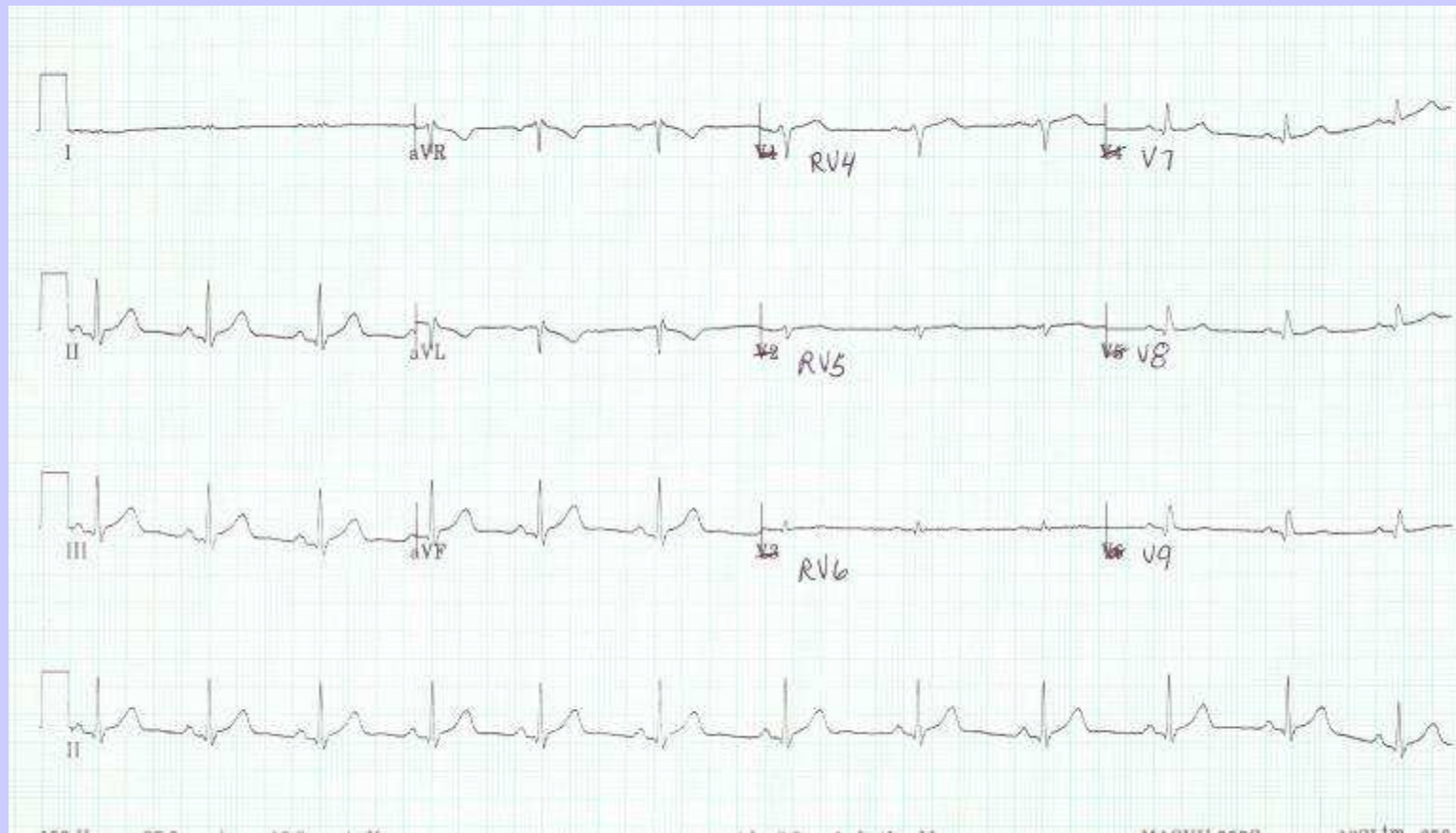
V4R = 5th ICS at RMCL  
V5R = 5th ICS at RAAL  
V6R = 5th ICS at RMAL



Posterior Chest

V7 = 5th ICS at Left Posterior axillary line  
V8 = Halfway between V7 & V9  
V9 = 5th ICS next to vertebral column

# Right Chest and Posterior EKG



**41 y/o c/o intermittent chest pain –  
last 1 -2 weeks. Persistent atypical  
chest pain today. EKG on  
admission**

HR 90

PR 207

QRSD 88

QT 368

QTc 451

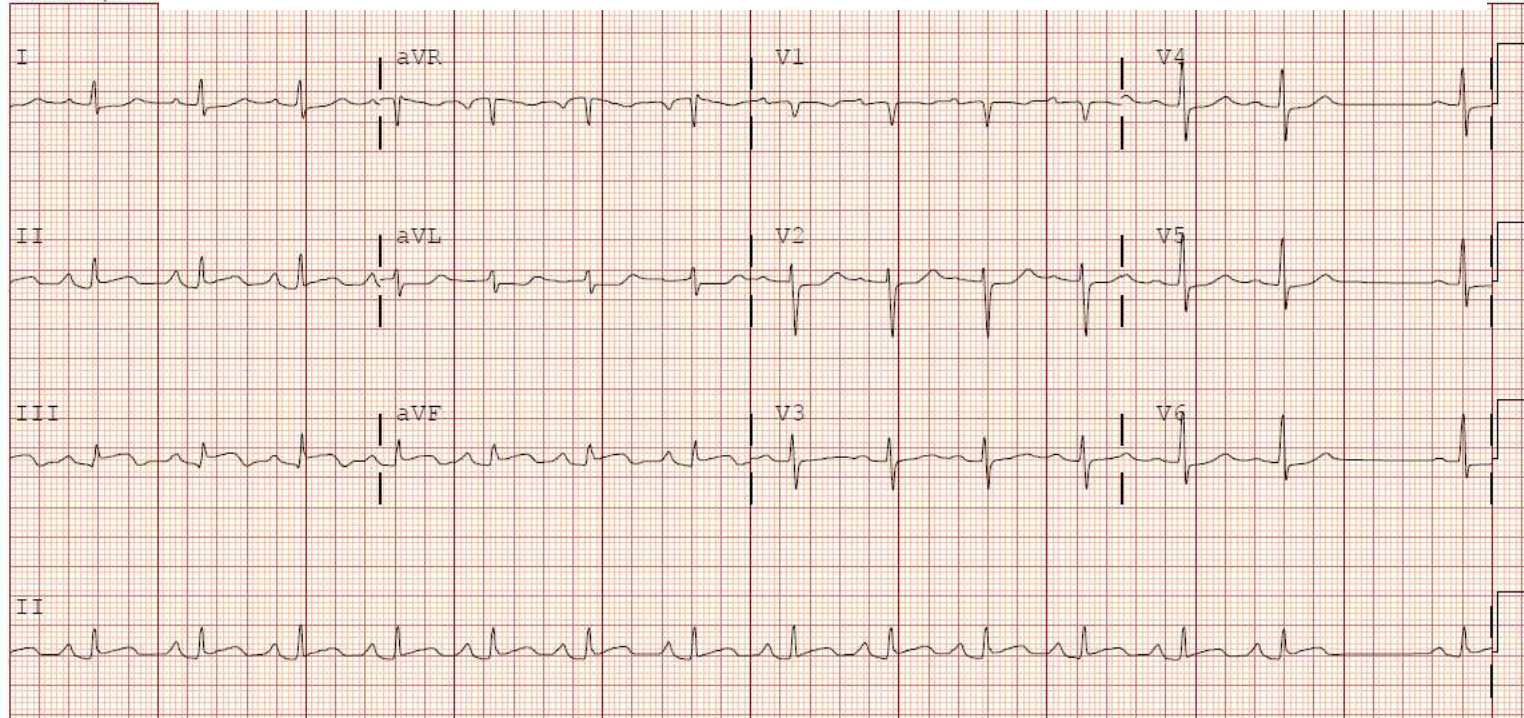
-- AXIS --

P 68

QRS 63

T 75

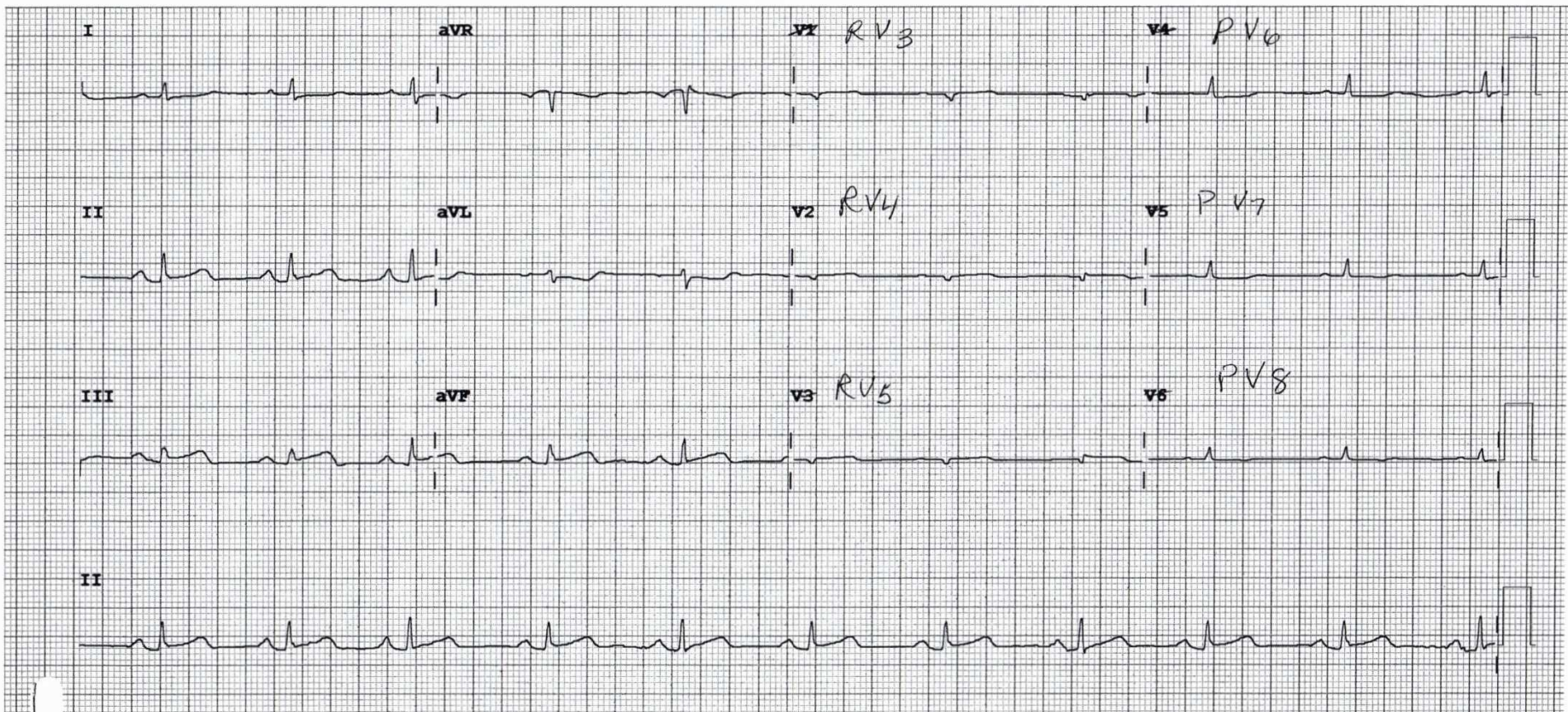
12 Lead; Sta



Rate 65  
PR 190  
QRSD 83  
QT 387  
QTc 403

--AXIS--  
P 70  
QRS 70  
T 82  
12 Lead; Stan

## Right Chest and Posterior EKG



Stent to RCA & PDA

# Pattern to Read EKG

## Be consistent

---

- Rate & Rhythm
- QRS Interval V1 – for RBBB or LBBB
- QT interval
- Normal Depolarization – If not, why not
- ST & T waves
- What lead is abnormal and what other lead goes with it
- Evaluate axis
- Evaluate for hypertrophy

# **Example & Analysis Time**

Peaked T waves  
T Wave inversion  
ST Depression  
ST Elevation  
Q waves  
Type of AMI  
Coronary Artery Involved

2nd Id #: 499313

COMMENTS:



40 Hz 25.0 mm/s 10.0 mm/mV

4 by 2.5s

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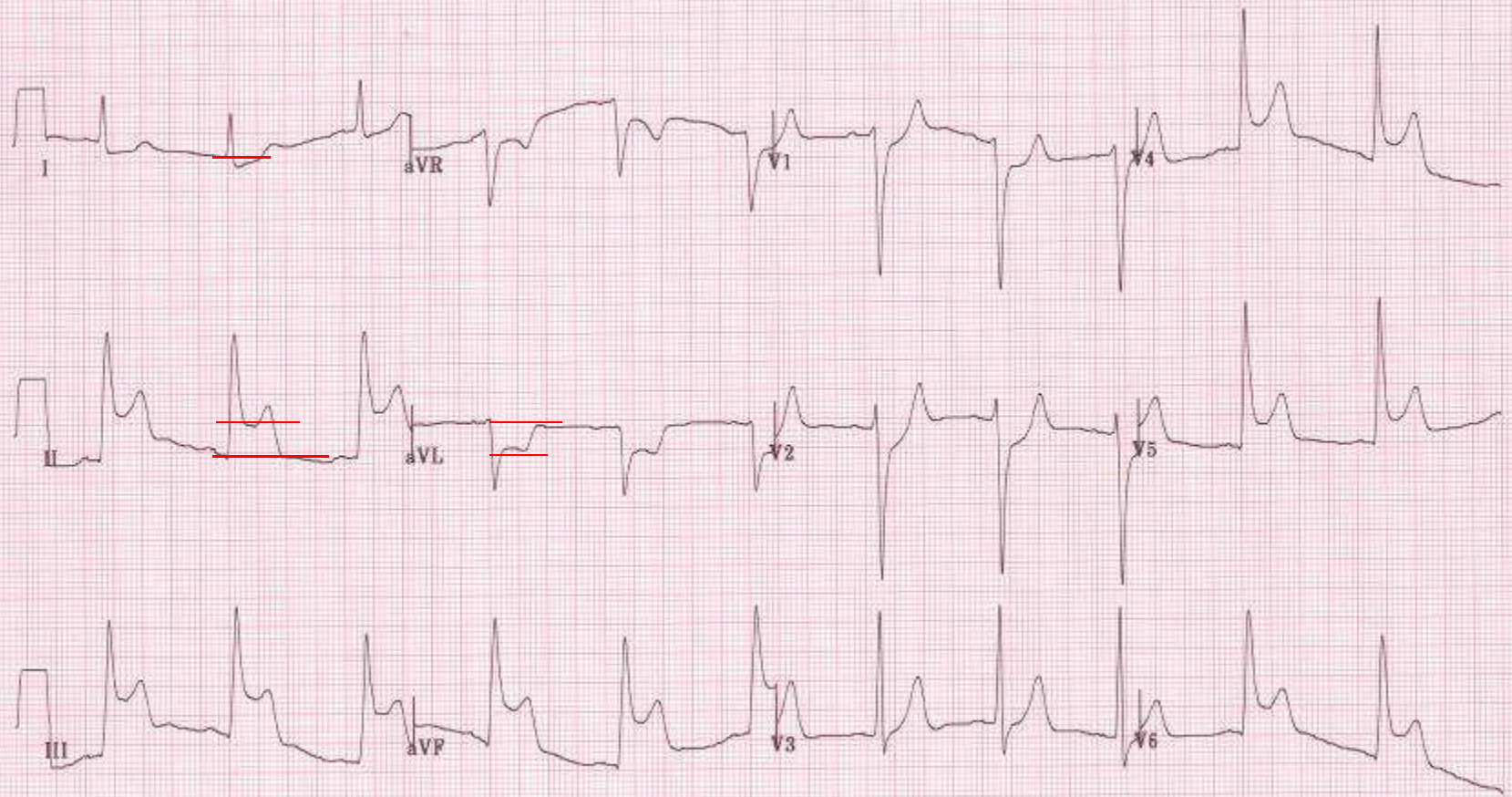
300

A



2nd Id #: 499313

COMMENTS:



40 Hz 25.0 mm/s 10.0 mm/mV

4 by 2.5s

MAC 8 001C

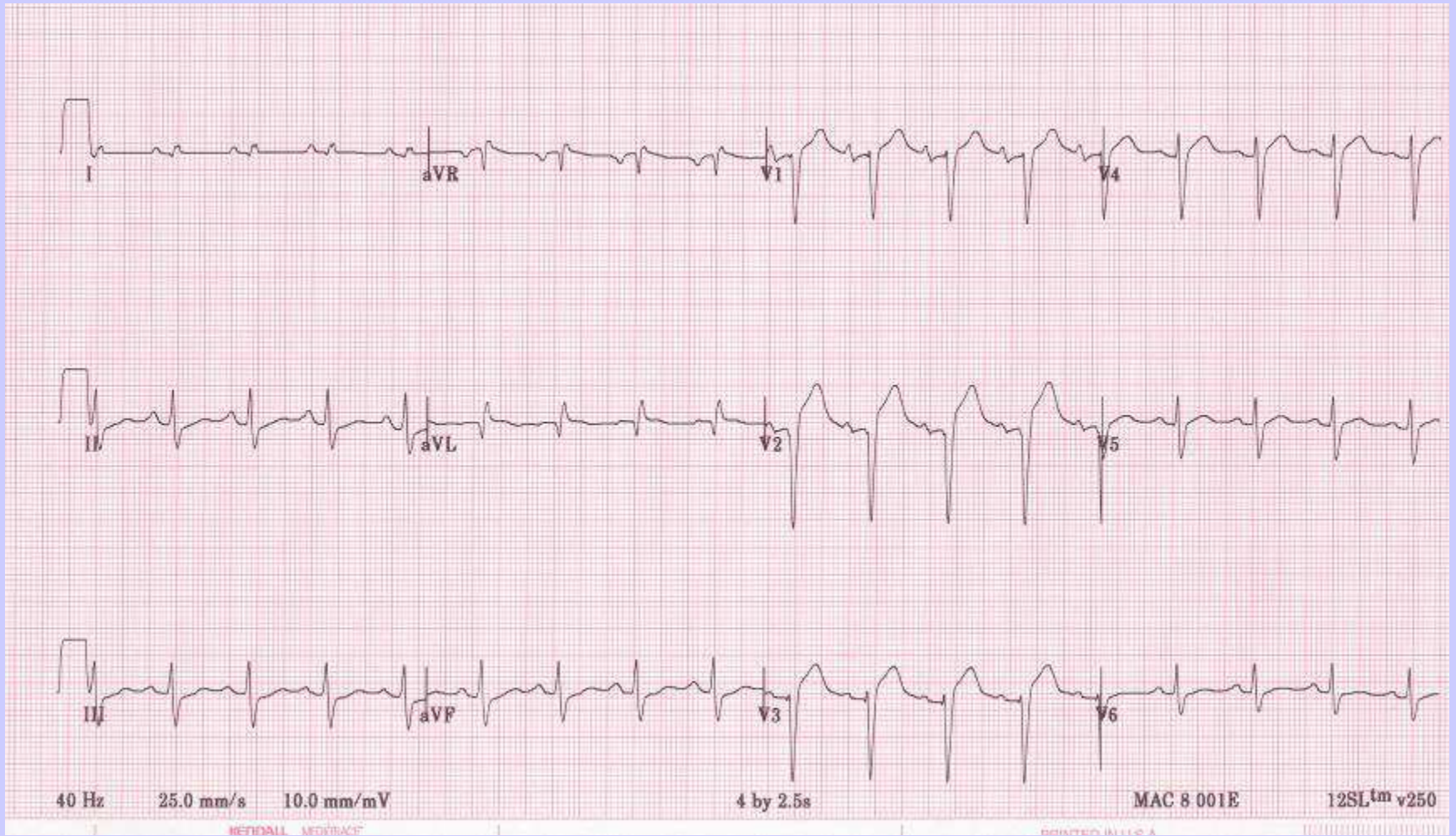
12SL™ v250

MEDALL MT-419AC7

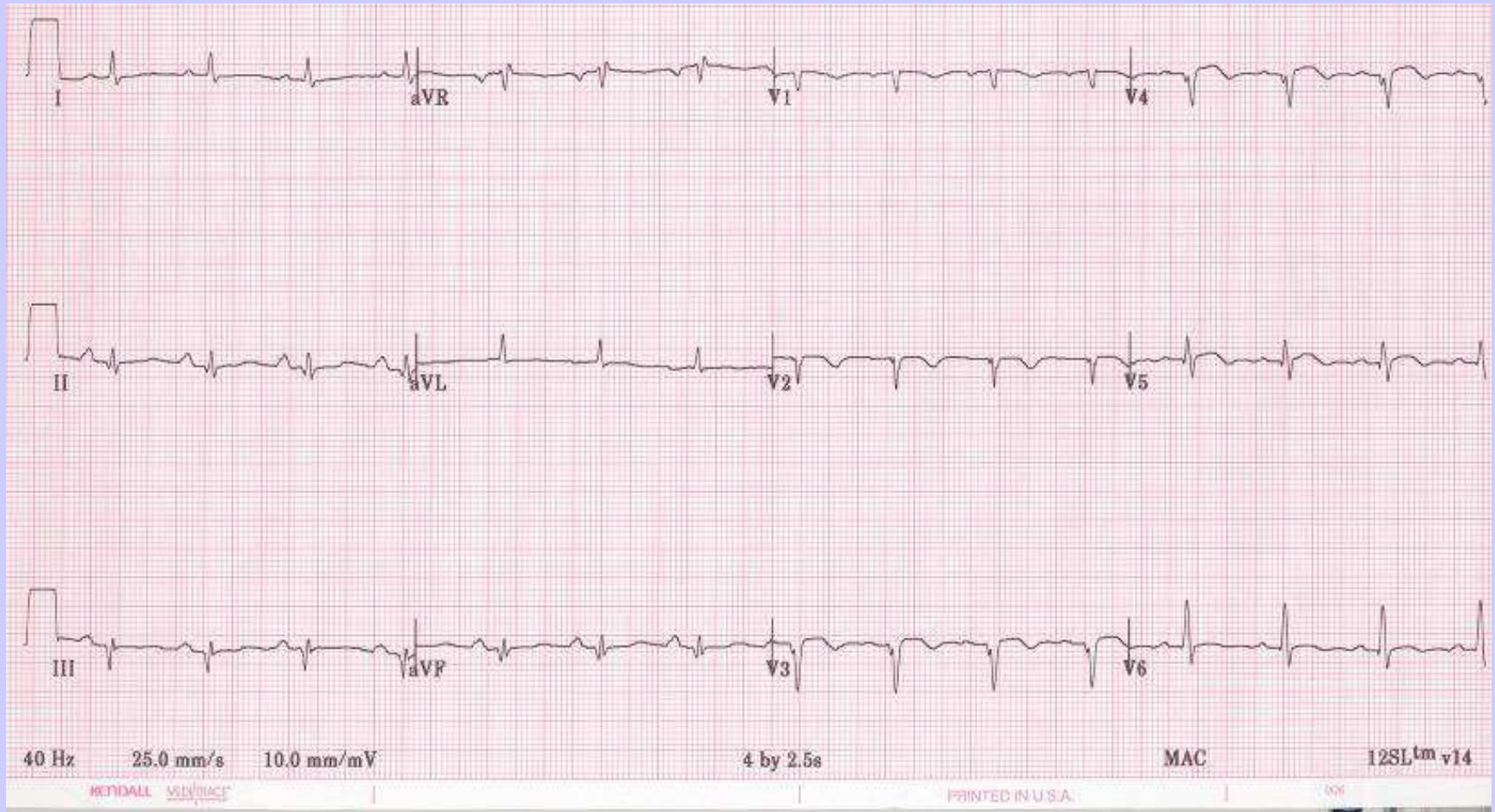
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300

A

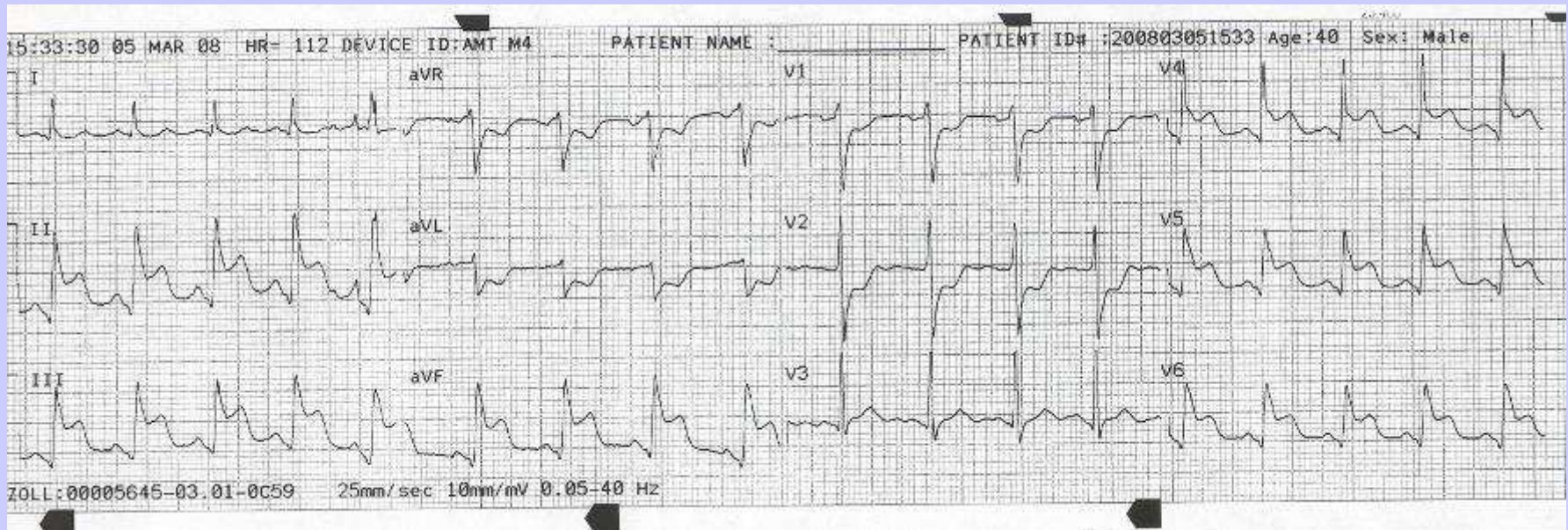


B



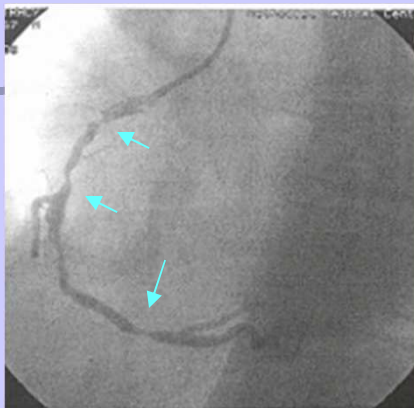
D

# 48 y/o male has crushing chest pain Calls 911

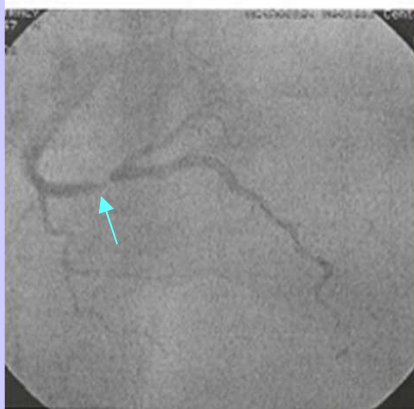


E

**Top: three stenosis in RCA & post 3 stents to RCA**



**Bottom: Stenosis in Cx & post stent**



## **Door to PCI time = 49 minutes**

---

- Initial CK = 72 IU/L, CK MB = 1.0 ng/ml  
Troponin = < 0.4 ng/ml
- 8 hours later CK MB = 2.8 ng/ml,  
Troponin = 0.58 ng/ml
- 12 hours later CK MB = 3.3 ng/ml,  
Troponin = 0.51 ng/ml

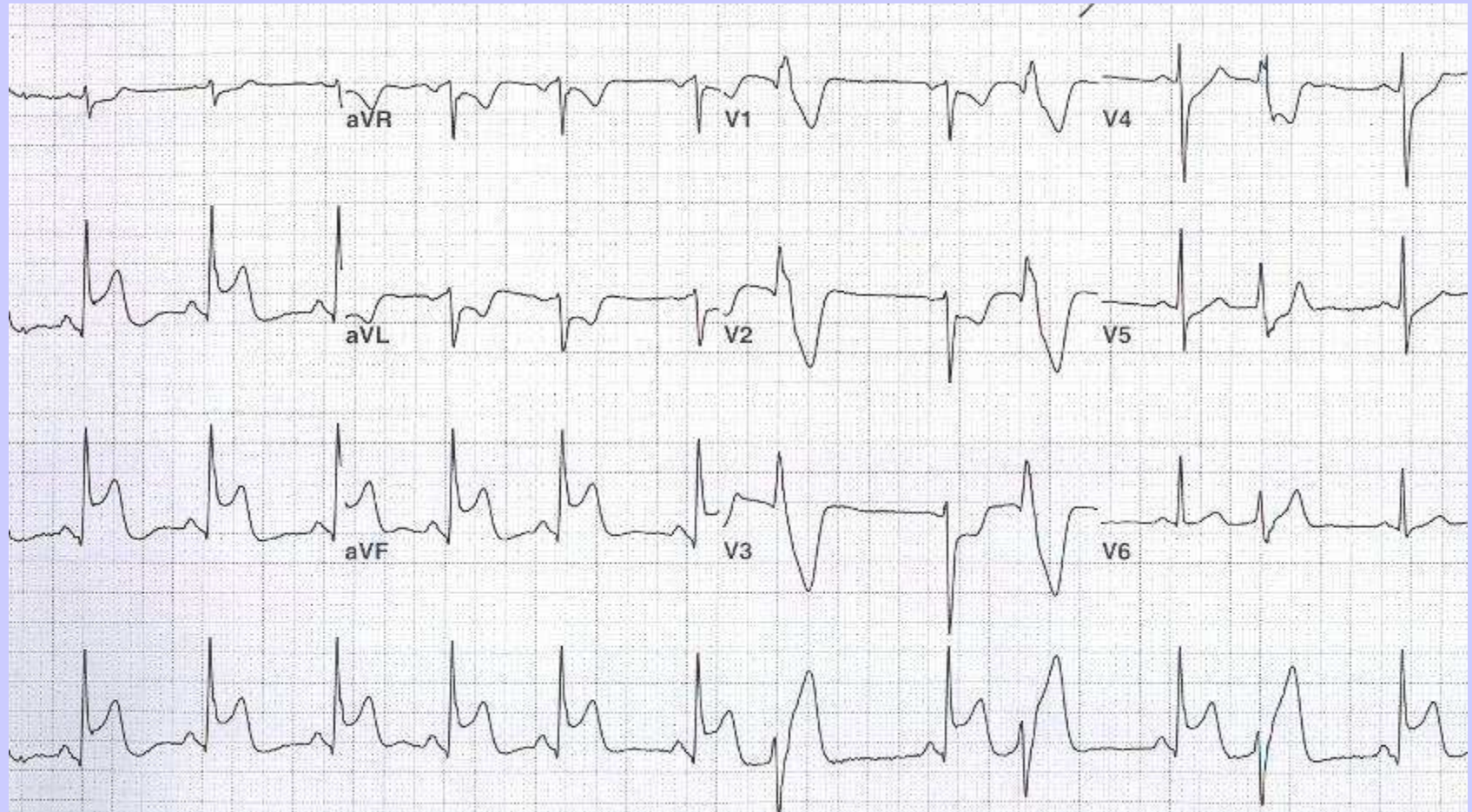
## **Case Study: 42 year old male comes to ED (wife drives him)**

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- Came to ED due to c/o substernal burning pain that radiates up chest to both arms.
- Becomes SOB with Chest pain
- Episodes last approx 10 minutes at a time.
- Episodes occur more when lying flat.
- Episodes have been occurring for last 4 months.
- Had a negative stress test & normal GI workup.
- Denies any drug use of cocaine or other medications
- Quit Smoking 4 months ago. No other past medical history
- Father had some cardiac problems when he was in his 50s or 60s --- history unclear.

- 
- Pain free on arrival to ED
  - Alert, Oriented
  - Skin Warm/dry
  - When laid down for EKG developed chest pain
  - BP 122/77, HR 87, RR 20 SpO2 99%
  - Chest pain 7/10
  - Weight: 70 kg





- **This 12 Lead was done when he was lying down and complaining of chest pain on Feb 24 at 1333.**
- **Patient is SOB & in severe pain at the time of the EKG.**
- **First time EKG done during chest pain**

**F**

- 
- Chest pain resolved when sat up
  - BP 118/56, HR 74, RR 20



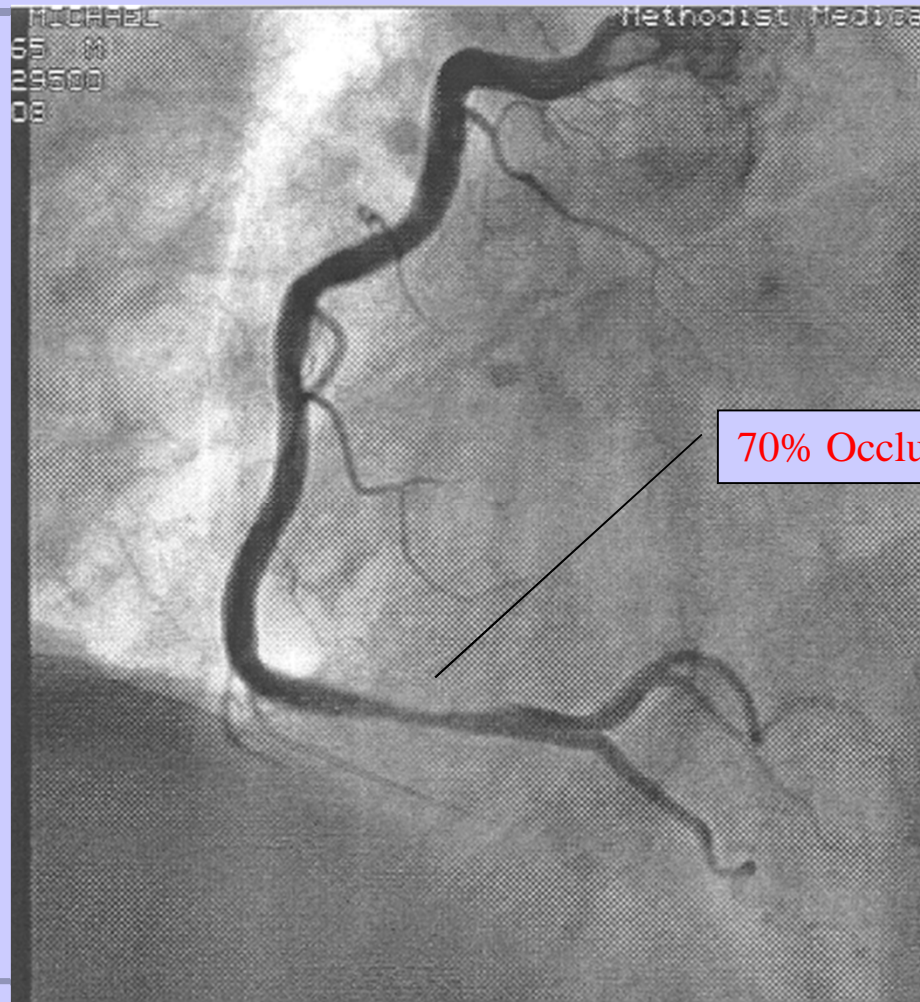
- **At 1339 on 2-24 (6 minutes later), the chest pain was gone. Pt was sitting up at the time. This is the 12 Lead EKG.**

- 
- **Serial troponin levels & lipid levels ordered**
  - **Troponin < 0.4 ng/ml**
  - **CK = 71**
  - **Total Cholesterol = 161**
  - **Triglycerides = 66**
  - **HDL = 35**
  - **LDL = 113**

- 
- Called cardiologist
  - 1st EKG STEMI that resolved after a few minutes.
  - Admit patient to CVICU. Started on ASA, plavix, heparin drip, nitroglycerin drip, and lopressor
  - Hold cardiac cath for now as pain free with normal EKG

# Cardiac Cath Feb 25

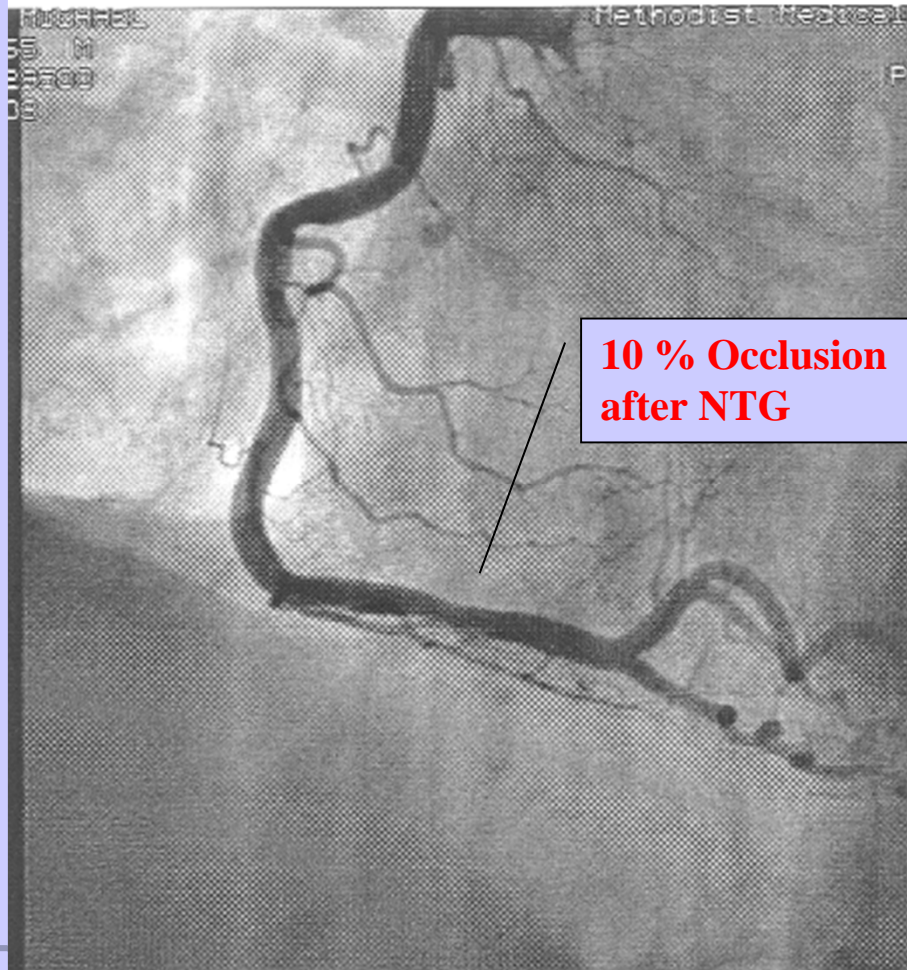
## Initial Injection of RCA



# Cardiac Cath Feb 25

## RCA after administration of Intracoronary Nitroglycerin

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# Management

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- **Diltiazem 180 mg**
- **Nitroglycerin 0.4 mg Transdermal patch. Apply at bedtime and remove at 10 am.**
- **Two days later, stated, “ I am finally sleeping at night!”**
- **Discharged with**
  - Diltiazem 180 mg daily**
  - Nitroglycerin 0.4 mg Transdermal patch at HS**