ECG Basics

Course Objectives

- To recognize the normal rhythm of the heart - “Normal Sinus Rhythm.”
- To recognize the 13 most common rhythm disturbances.
- To recognize an acute myocardial infarction on a 12-lead ECG.

Learning Modules

- ECG Basics
- How to Analyze a Rhythm
- Normal Sinus Rhythm
- Heart Arrhythmias
- Diagnosing a Myocardial Infarction
- Advanced 12-Lead Interpretation

Normal Impulse Conduction

Sinoatrial node

↓

AV node

↓

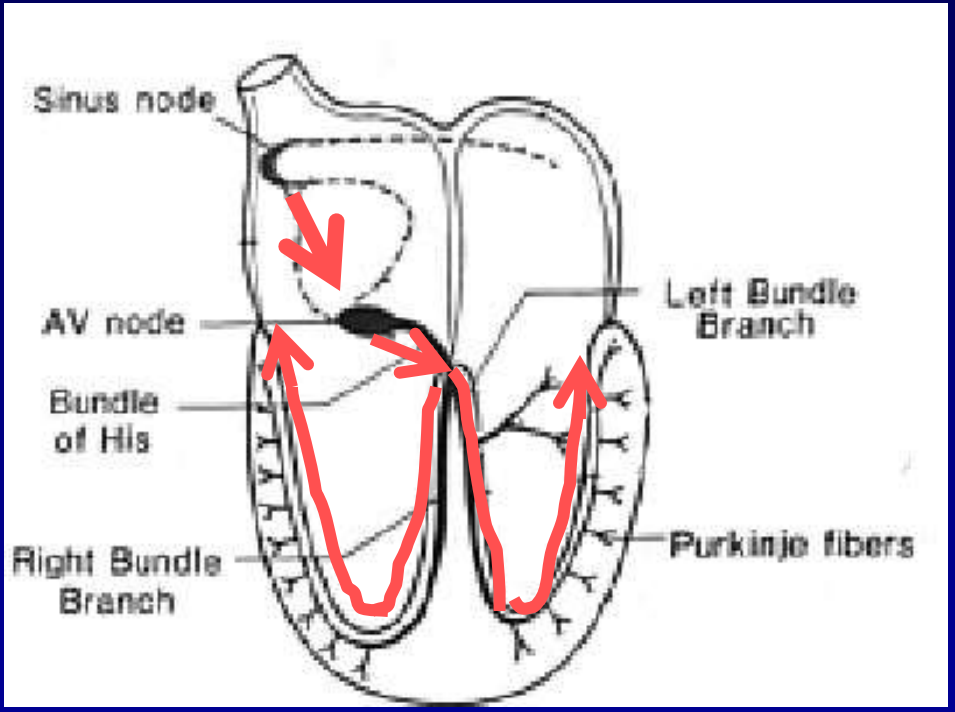
Bundle of His

↓

Bundle Branches

↓

Purkinje fibers



Impulse Conduction & the ECG

Sinoatrial node

↓

AV node

↓

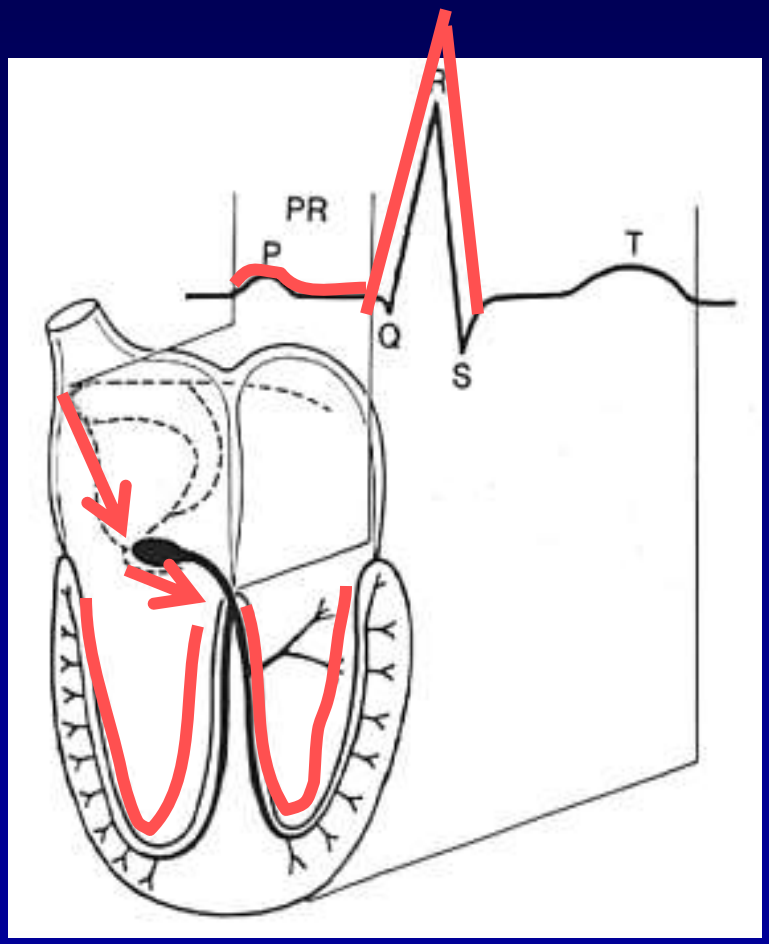
Bundle of His

↓

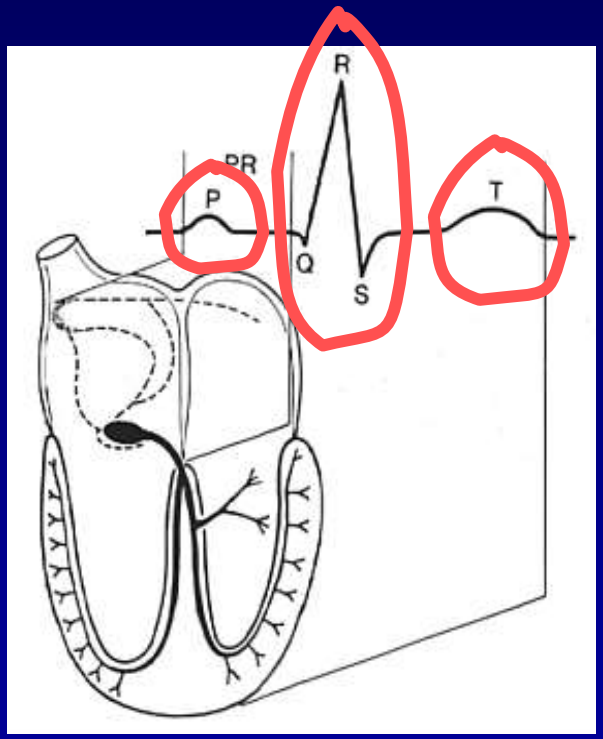
Bundle Branches

↓

Purkinje fibers



The “PQRST”



- P wave - Atrial depolarization
- QRS - Ventricular depolarization
- T wave - Ventricular repolarization

The PR Interval

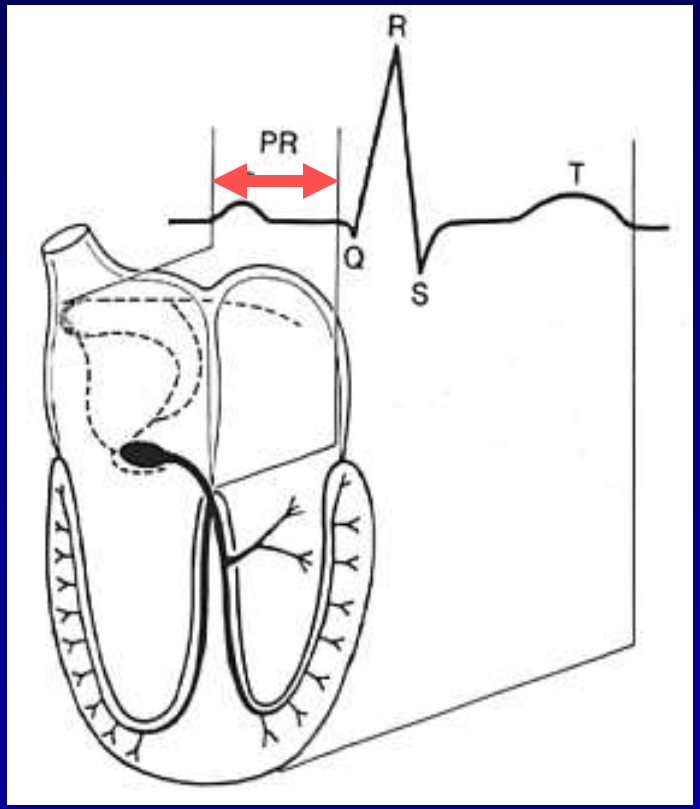
Atrial depolarization

+

delay in AV junction

(AV node/Bundle of His)

(delay allows time for the atria to contract before the ventricles contract)

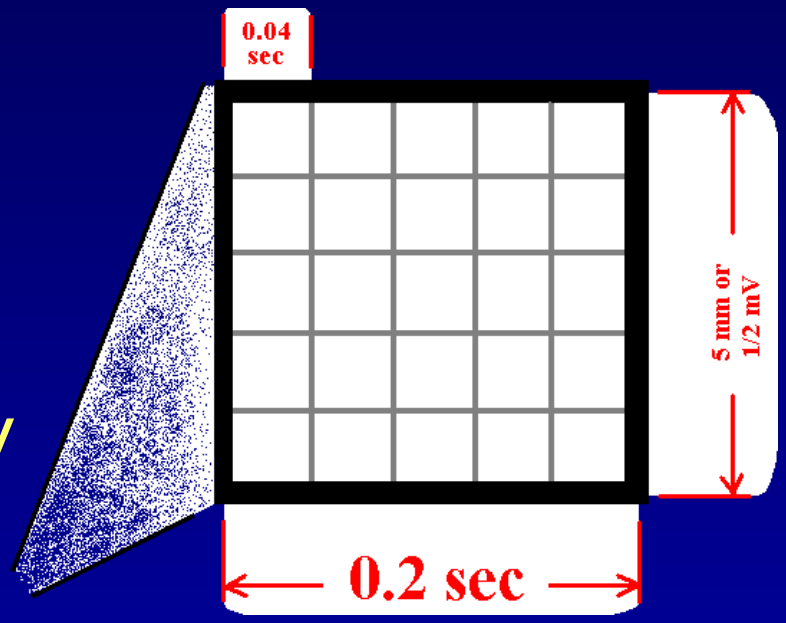


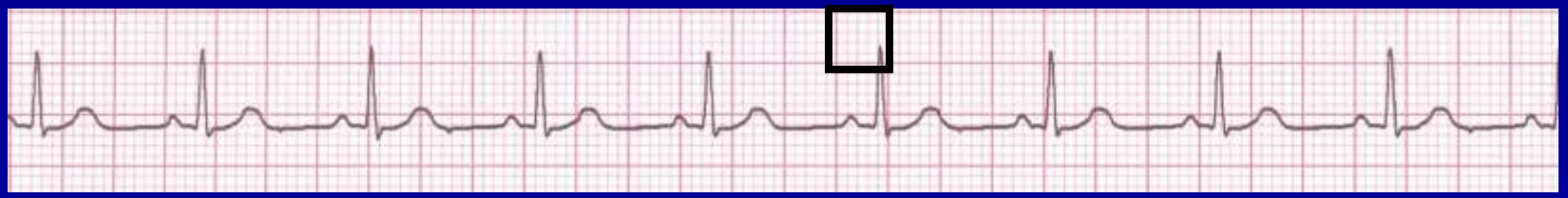
Pacemakers of the Heart

- SA Node - Dominant pacemaker with an intrinsic rate of 60 - 100 beats/minute.
- AV Node - Back-up pacemaker with an intrinsic rate of 40 - 60 beats/minute.
- Ventricular cells - Back-up pacemaker with an intrinsic rate of 20 - 45 bpm.

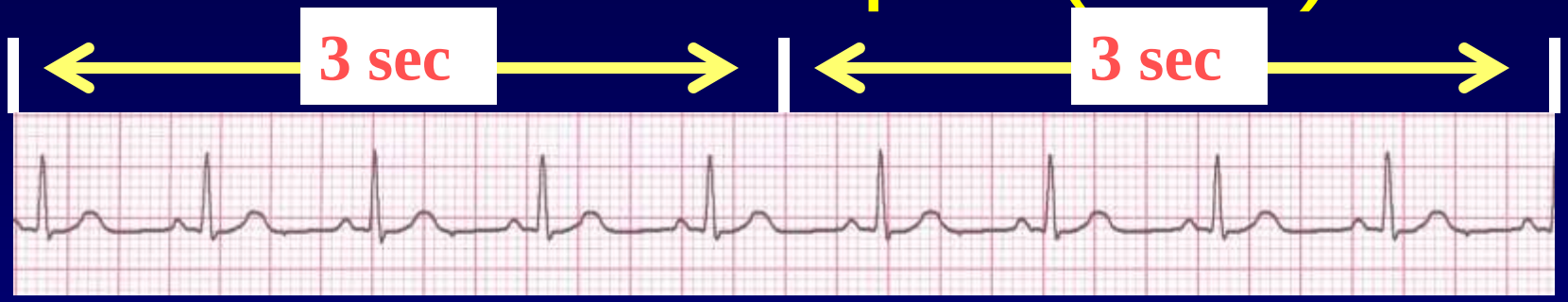
The ECG Paper

- Horizontally
  - One small box - 0.04 s
  - One large box - 0.20 s
- Vertically
  - One large box - 0.5 mV





The ECG Paper (cont)



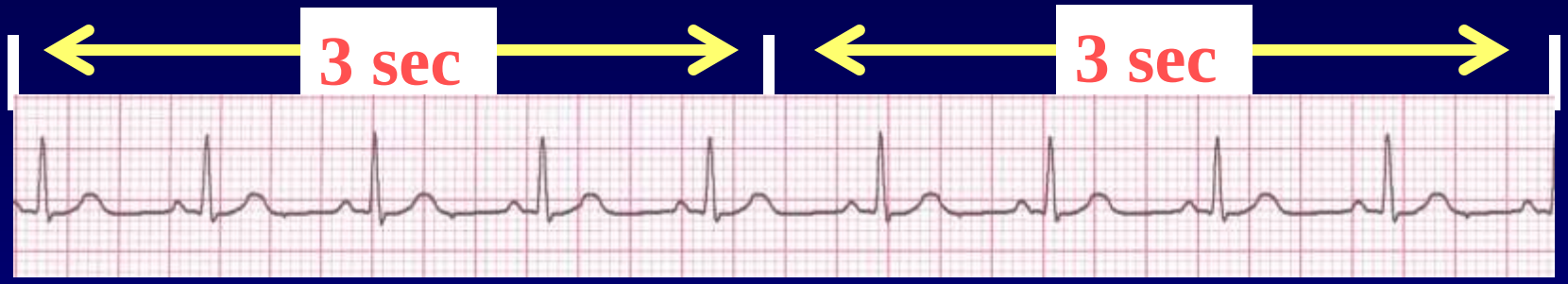
- Every 3 seconds (15 large boxes) is marked by a vertical line.
- This helps when calculating the heart rate.

NOTE: the following strips are not marked but all are 6 seconds long.

Rhythm Analysis

- Step 1: Calculate rate.
- Step 2: Determine regularity.
- Step 3: Assess the P waves.
- Step 4: Determine PR interval.
- Step 5: Determine QRS duration.

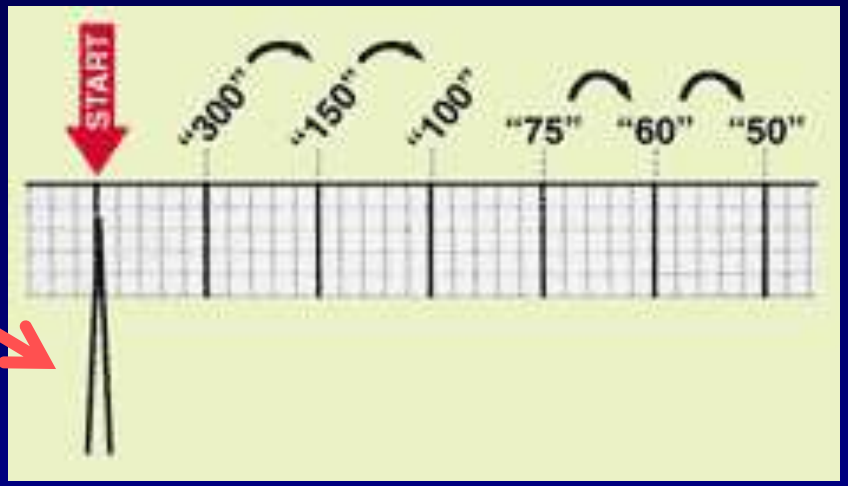
Step 1: Calculate Rate



- Option 1
  - Count the # of R waves in a 6 second rhythm strip, then multiply by 10.
  - Reminder: all rhythm strips in the Modules are 6 seconds in length.

Interpretation? *9 x 10 = 90 bpm*

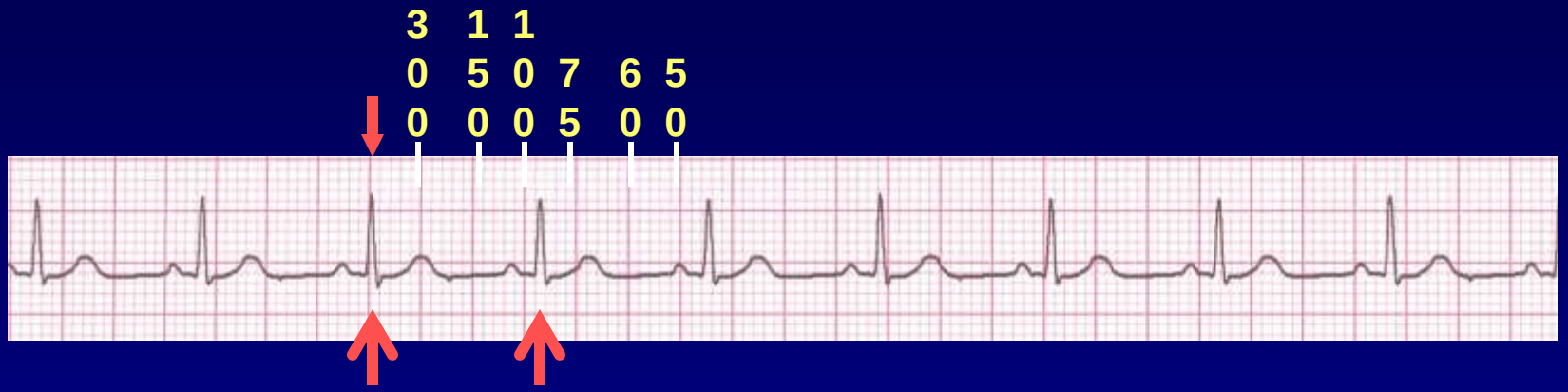
Step 1: Calculate Rate



R wave

- Option 2
  - Find a R wave that lands on a bold line.
  - Count the # of large boxes to the next R wave. If the second R wave is 1 large box away the rate is 300, 2 boxes - 150, 3 boxes - 100, 4 boxes - 75, etc. (cont)

Step 1: Calculate Rate

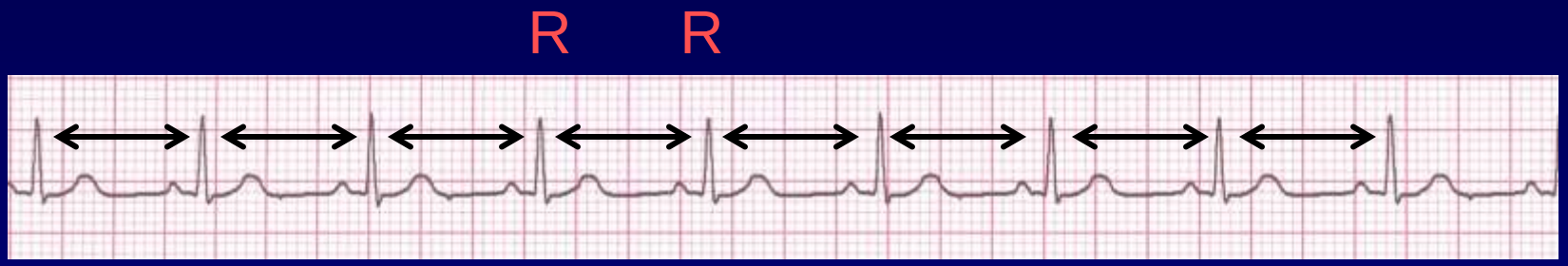


- Option 2 (cont)
  - Memorize the sequence:

    300 - 150 - 100 - 75 - 60 - 50

Interpretation? *Approx. 1 box less than 100 = 95 bpm*

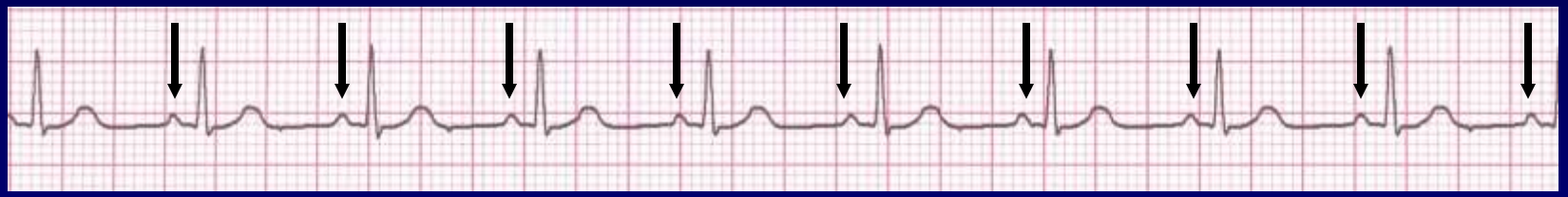
Step 2: Determine regularity



- Look at the R-R distances (using a caliper or markings on a pen or paper).
- Regular (are they equidistant apart)? Occasionally irregular? Regularly irregular? Irregularly irregular?

Interpretation? *Regular*

Step 3: Assess the P waves



- Are there P waves?
- Do the P waves all look alike?
- Do the P waves occur at a regular rate?
- Is there one P wave before each QRS?

Interpretation? *Normal P waves with 1 P wave for every QRS*

Step 4: Determine PR interval

- Normal: 0.12 - 0.20 seconds.
  (3 - 5 boxes)

Interpretation? *0.12 seconds*

Step 5: QRS duration

- Normal: 0.04 - 0.12 seconds.
  (1 - 3 boxes)

Interpretation? *0.08 seconds*

Rhythm Summary

- Rate 90-95 bpm
- Regularity regular
- P waves normal
- PR interval 0.12 s
- QRS duration 0.08 s

Interpretation? *Normal Sinus Rhythm*

ECG Rhythm Interpretation

Module III

Normal Sinus Rhythm

Normal Sinus Rhythm (NSR)

- Etiology: the electrical impulse is formed in the SA node and conducted normally.
- This is the normal rhythm of the heart; other rhythms that do not conduct via the typical pathway are called arrhythmias.

NSR Parameters

- Rate 60 - 100 bpm
- Regularity regular
- P waves normal
- PR interval 0.12 - 0.20 s
- QRS duration 0.04 - 0.12 s

Any deviation from above is sinus tachycardia, sinus bradycardia or an arrhythmia

Arrhythmia Formation

Arrhythmias can arise from problems in the:

- Sinus node
- Atrial cells
- AV junction
- Ventricular cells

SA Node Problems

The SA Node can:

- fire too slow — *Sinus Bradycardia*
- fire too fast — *Sinus Tachycardia*

Sinus Tachycardia may be an appropriate response to stress.

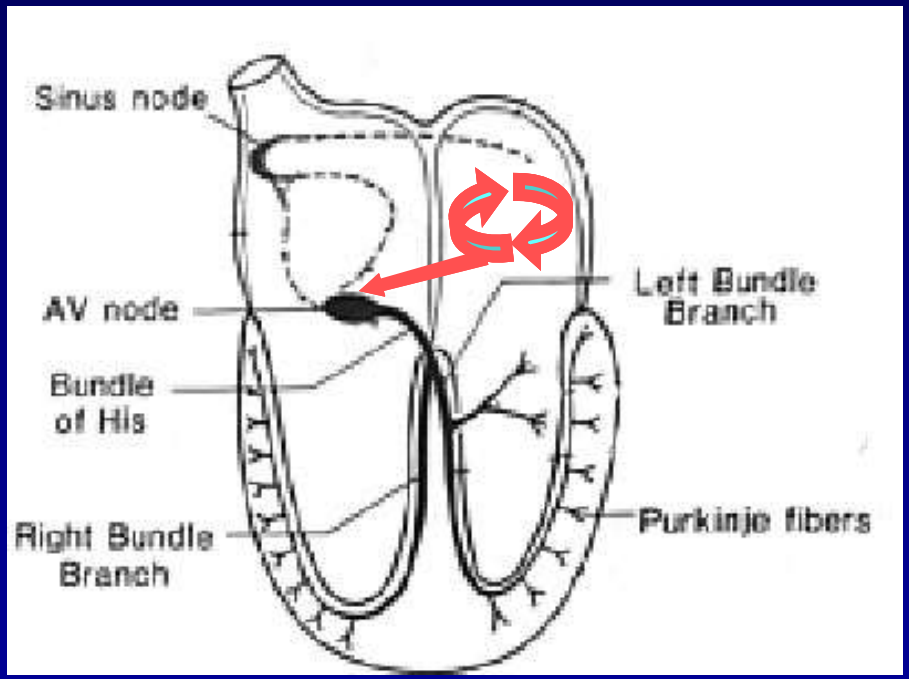
Atrial Cell Problems

Atrial cells can:

- fire occasionally from a focus — *Premature Atrial Contractions (PACs)*
- fire continuously due to a looping re-entrant circuit — *Atrial Flutter*

Teaching Moment

- A re-entrant pathway occurs when an impulse loops and results in self-perpetuating impulse formation.



Atrial Cell Problems

Atrial cells can also:

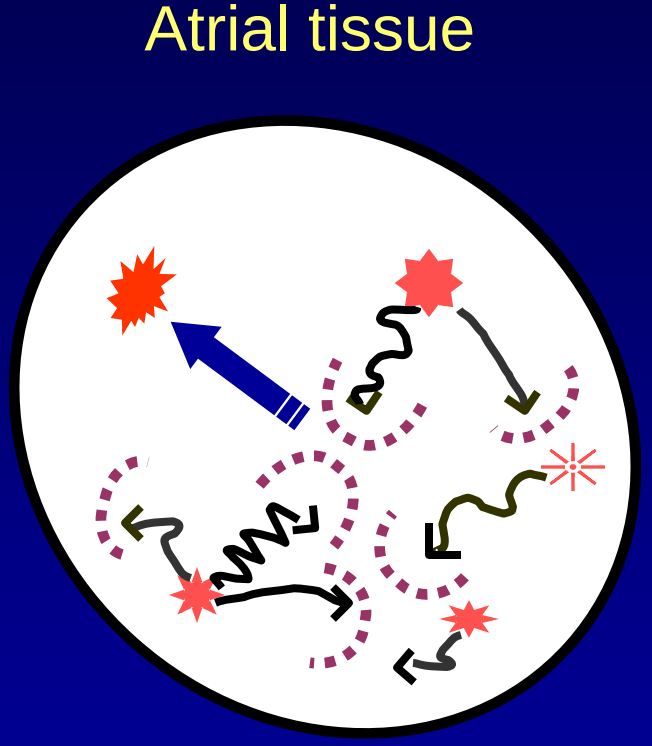
- fire continuously from multiple foci — *Atrial Fibrillation*

or

fire continuously due to multiple micro re-entrant “wavelets” — *Atrial Fibrillation*

Teaching Moment

Multiple micro re-entrant “wavelets” refers to wandering small areas of activation which generate fine chaotic impulses. Colliding wavelets can, in turn, generate new foci of activation.



AV Junctional Problems

The AV junction can:

- fire continuously due to a looping re-entrant circuit
- block impulses coming from the SA Node

Paroxysmal Supraventricular Tachycardia

AV Junctional Blocks

Ventricular Cell Problems

Ventricular cells can:

- fire occasionally from 1 or more foci — *Premature Ventricular Contractions (PVCs)*
- fire continuously from multiple foci — *Ventricular Fibrillation*
- fire continuously due to a looping re-entrant circuit — *Ventricular Tachycardia*

Arrhythmias

- Sinus Rhythms
- Premature Beats
- Supraventricular Arrhythmias
- Ventricular Arrhythmias
- AV Junctional Blocks

Sinus Rhythms

- *Sinus Bradycardia*
- *Sinus Tachycardia*

Rhythm #1

- Rate? 30 bpm
- Regularity? regular
- P waves? normal
- PR interval? 0.12 s
- QRS duration? 0.10 s

Interpretation? *Sinus Bradycardia*

Sinus Bradycardia

- Deviation from NSR
  - Rate < 60 bpm

Sinus Bradycardia

- Etiology: SA node is depolarizing slower than normal, impulse is conducted normally (i.e. normal PR and QRS interval).

Rhythm #2

- Rate? 130 bpm
- Regularity? regular
- P waves? normal
- PR interval? 0.16 s
- QRS duration? 0.08 s

Interpretation? *Sinus Tachycardia*

Sinus Tachycardia

- Deviation from NSR
  - Rate > 100 bpm

Sinus Tachycardia

- Etiology: SA node is depolarizing faster than normal, impulse is conducted normally.
- Remember: sinus tachycardia is a response to physical or psychological stress, not a primary arrhythmia.

Premature Beats

- *Premature Atrial Contractions (PACs)*
- *Premature Ventricular Contractions (PVCs)*

Rhythm #3

- Rate? 70 bpm
- Regularity? occasionally irreg.
- P waves? 2/7 different contour
- PR interval? 0.14 s (except 2/7)
- QRS duration? 0.08 s

Interpretation? *NSR with Premature Atrial Contractions*

Premature Atrial Contractions

- Deviation from NSR
  - These ectopic beats originate in the atria (but not in the SA node), therefore the contour of the P wave, the PR interval, and the timing are different than a normally generated pulse from the SA node.

Premature Atrial Contractions

- Etiology: Excitation of an atrial cell forms an impulse that is then conducted normally through the AV node and ventricles.

Teaching Moment

- When an impulse originates anywhere in the atria (SA node, atrial cells, AV node, Bundle of His) and then is conducted normally through the ventricles, the QRS will be narrow (0.04 - 0.12 s).

Rhythm #4

- Rate? 60 bpm
- Regularity? occasionally irreg.
- P waves? none for 7th QRS
- PR interval? 0.14 s
- QRS duration? 0.08 s (7th wide)

Interpretation? *Sinus Rhythm with 1 PVC*

PVCs

- Deviation from NSR
  - Ectopic beats originate in the ventricles resulting in wide and bizarre QRS complexes.
  - When there are more than 1 premature beats and look alike, they are called “uniform”. When they look different, they are called “multiform”.

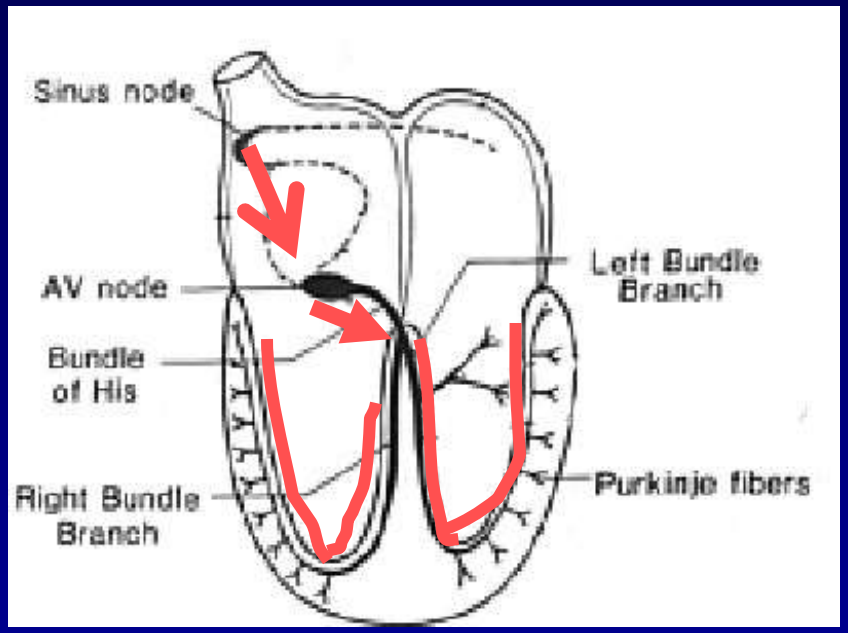
PVCs

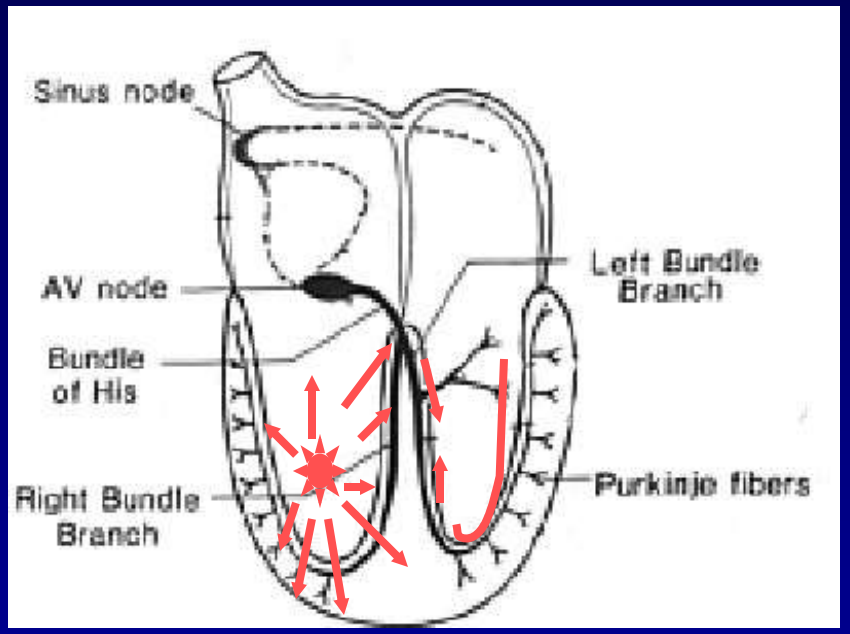
- Etiology: One or more ventricular cells are depolarizing and the impulses are abnormally conducting through the ventricles.

Teaching Moment

- When an impulse originates in a ventricle, conduction through the ventricles will be inefficient and the QRS will be wide and bizarre.

Ventricular Conduction





Normal

Signal moves rapidly through the ventricles

Abnormal

Signal moves slowly through the ventricles

Supraventricular Arrhythmias

- *Atrial Fibrillation*
- *Atrial Flutter*
- *Paroxysmal Supraventricular Tachycardia*

Rhythm #5

- Rate? 100 bpm
- Regularity? irregularly irregular
- P waves? none
- PR interval? none
- QRS duration? 0.06 s

Interpretation? *Atrial Fibrillation*

Atrial Fibrillation

- Deviation from NSR
  - No organized atrial depolarization, so no normal P waves (impulses are not originating from the sinus node).
  - Atrial activity is chaotic (resulting in an irregularly irregular rate).
  - Common, affects 2-4%, up to 5-10% if > 80 years old

Atrial Fibrillation

- Etiology: Recent theories suggest that it is due to multiple re-entrant wavelets conducted between the R & L atria. Either way, impulses are formed in a totally unpredictable fashion. The AV node allows some of the impulses to pass through at variable intervals (so rhythm is irregularly irregular).

Rhythm #6

- Rate? 70 bpm
- Regularity? regular
- P waves? flutter waves
- PR interval? none
- QRS duration? 0.06 s

Interpretation? *Atrial Flutter*

Atrial Flutter

- Deviation from NSR
  - No P waves. Instead flutter waves (note “sawtooth” pattern) are formed at a rate of 250 - 350 bpm.
  - Only some impulses conduct through the AV node (usually every other impulse).

Atrial Flutter

- Etiology: Reentrant pathway in the right atrium with every 2nd, 3rd or 4th impulse generating a QRS (others are blocked in the AV node as the node repolarizes).

Rhythm #7

- Rate? 74 → 148 bpm
- Regularity? Regular → regular
- P waves? Normal → none
- PR interval? 0.16 s → none
- QRS duration? 0.08 s

Interpretation? *Paroxysmal Supraventricular Tachycardia (PSVT)*

PSVT

- Deviation from NSR
  - The heart rate suddenly speeds up, often triggered by a PAC (not seen here) and the P waves are lost.

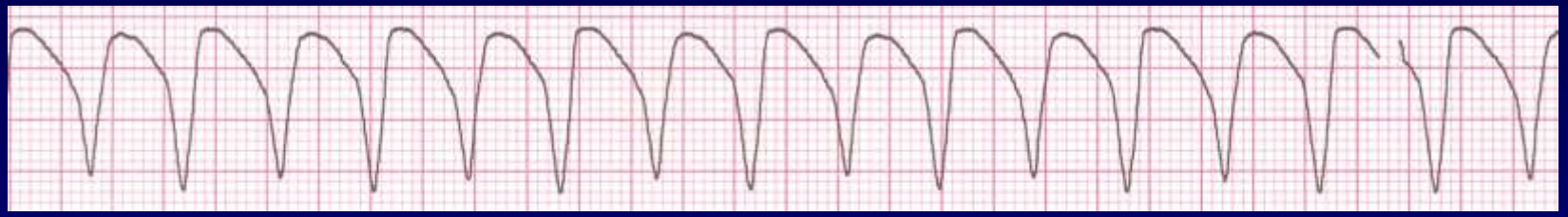
PSVT

- Etiology: There are several types of PSVT but all originate above the ventricles (therefore the QRS is narrow).
- Most common: abnormal conduction in the AV node (reentrant circuit looping in the AV node).

Ventricular Arrhythmias

- *Ventricular Tachycardia*
- *Ventricular Fibrillation*

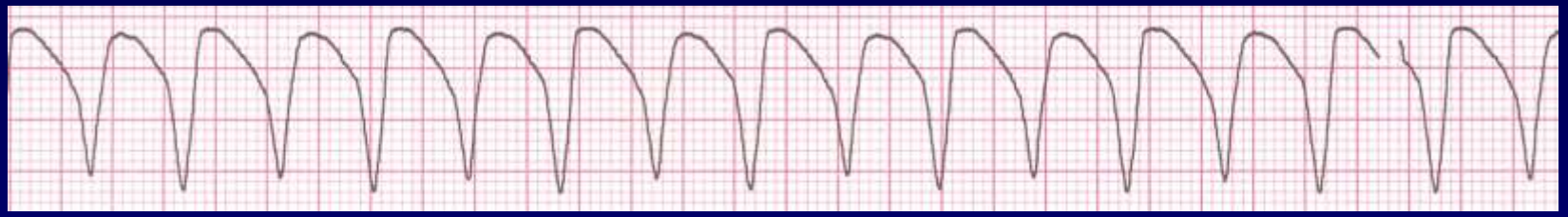
Rhythm #8



- Rate? 160 bpm
- Regularity? regular
- P waves? none
- PR interval? none
- QRS duration? wide (> 0.12 sec)

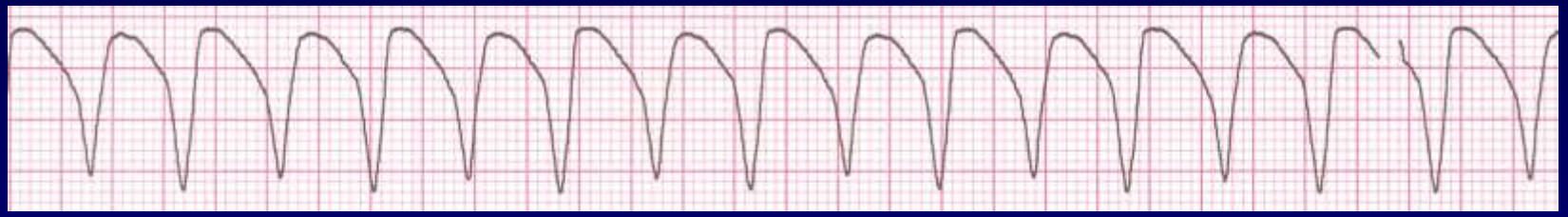
Interpretation? *Ventricular Tachycardia*

Ventricular Tachycardia



- Deviation from NSR
  - Impulse is originating in the ventricles (no P waves, wide QRS).

Ventricular Tachycardia



- Etiology: There is a re-entrant pathway looping in a ventricle (most common cause).

- Ventricular tachycardia can sometimes generate enough cardiac output to produce a pulse; at other times no pulse can be felt.

Rhythm #9

- Rate? none
- Regularity? irregularly irreg.
- P waves? none
- PR interval? none
- QRS duration? wide, if recognizable

Interpretation? *Ventricular Fibrillation*

Ventricular Fibrillation

- Deviation from NSR
  - Completely abnormal.

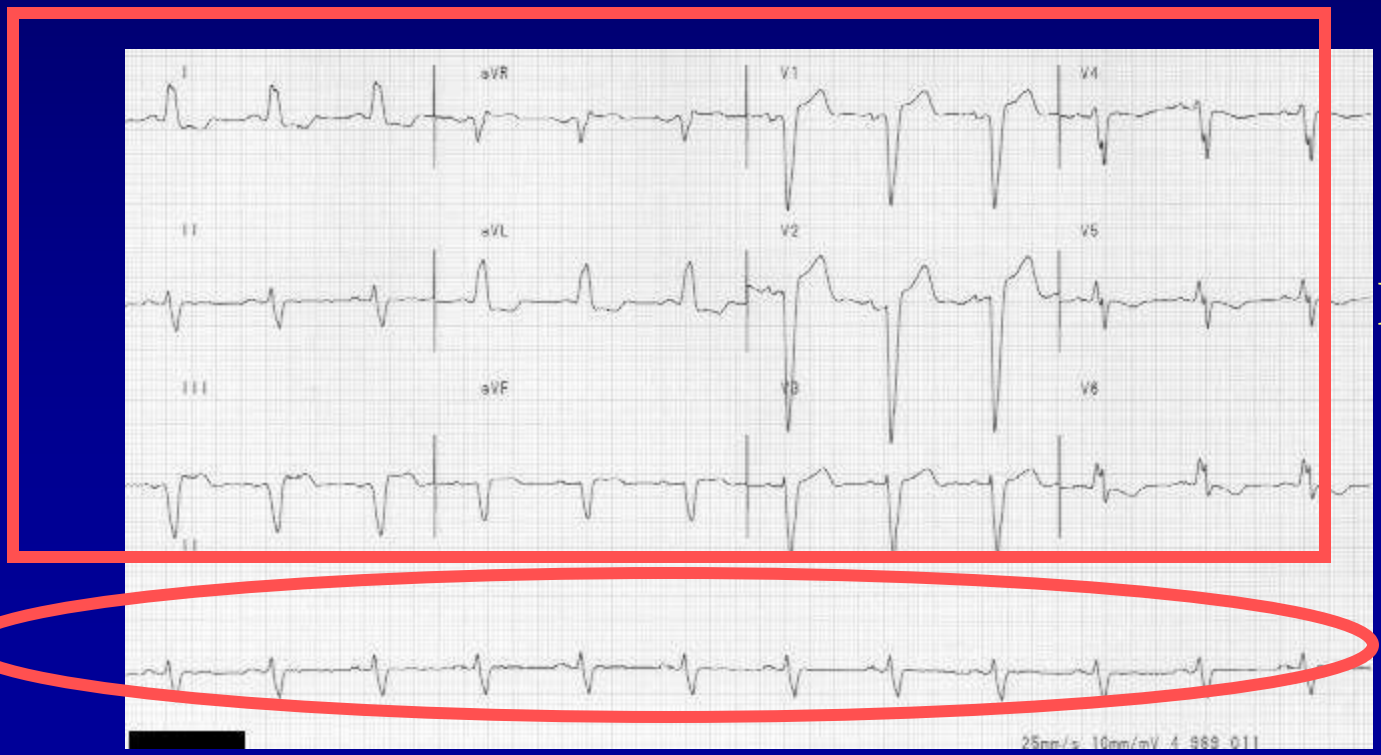
Ventricular Fibrillation

- Etiology: The ventricular cells are excitable and depolarizing randomly.

- Rapid drop in cardiac output and death occurs if not quickly reversed

Diagnosing a MI

To diagnose a myocardial infarction you need to go beyond looking at a rhythm strip and obtain a 12-Lead ECG.



12-Lead ECG

Rhythm Strip

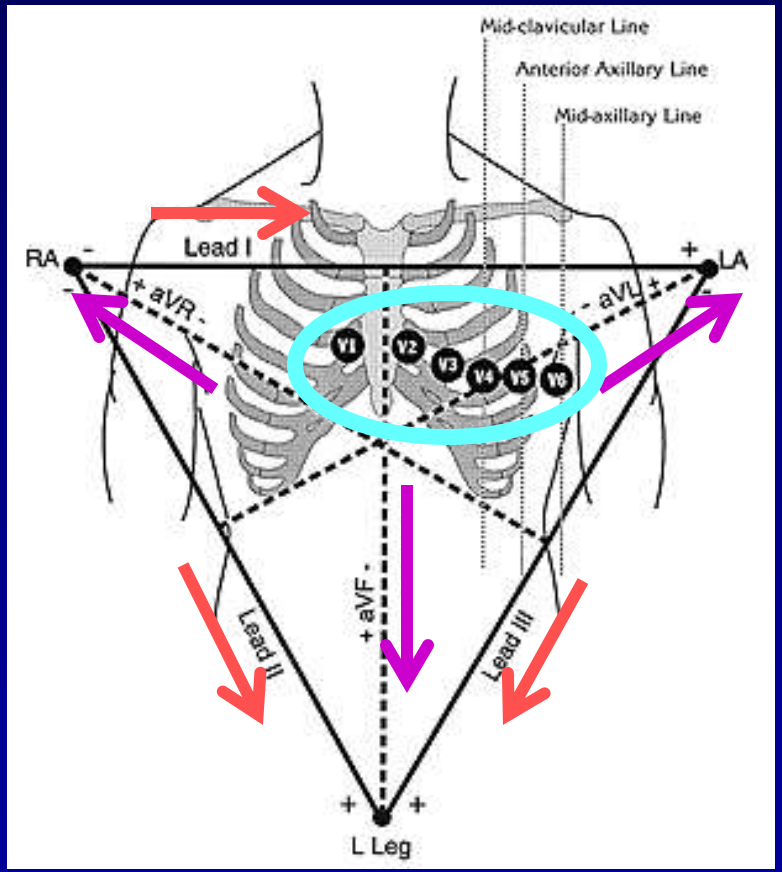
The 12-Lead ECG

- The 12-Lead ECG sees the heart from 12 different views.
- Therefore, the 12-Lead ECG helps you see what is happening in different portions of the heart.
- The rhythm strip is only 1 of these 12 views.

The 12-Leads

The 12-leads include:

- 3 Limb leads (I, II, III)
- 3 Augmented leads (aVR, aVL, aVF)
- 6 Precordial leads (V_1- V_6)

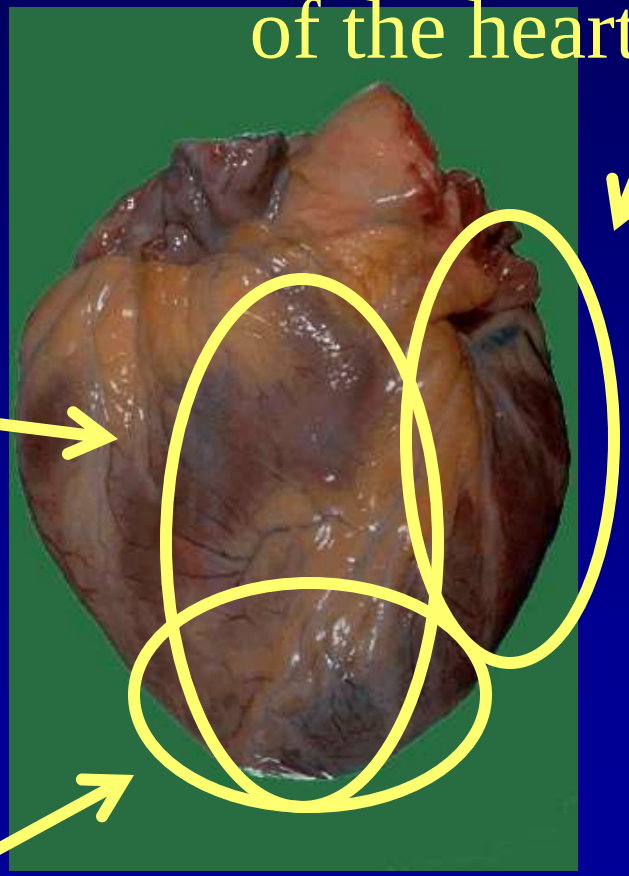


Views of the Heart

Some leads get a good view of the:

Anterior portion of the heart

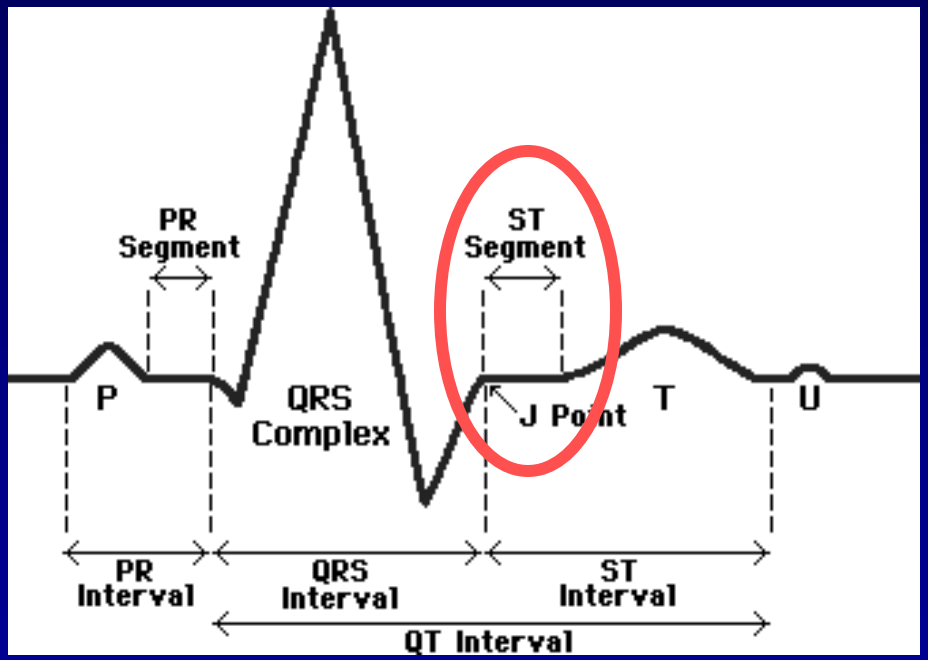
Lateral portion of the heart



Inferior portion of the heart

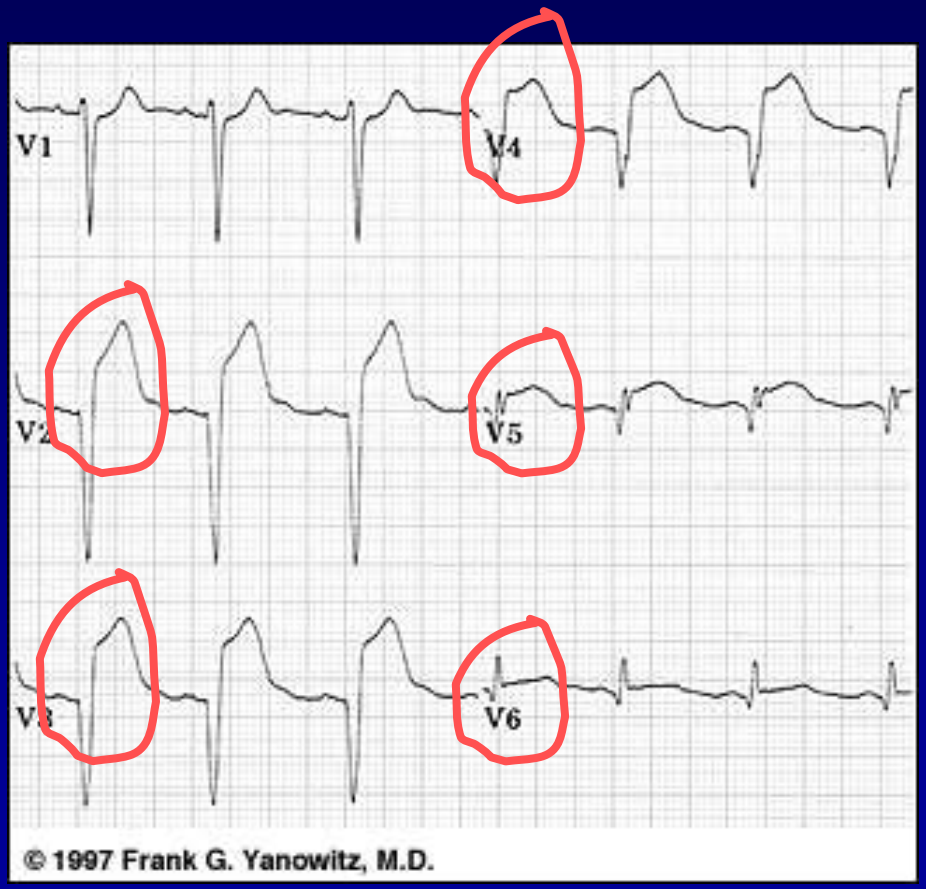
ST Elevation

One way to diagnose an acute MI is to look for elevation of the ST segment.



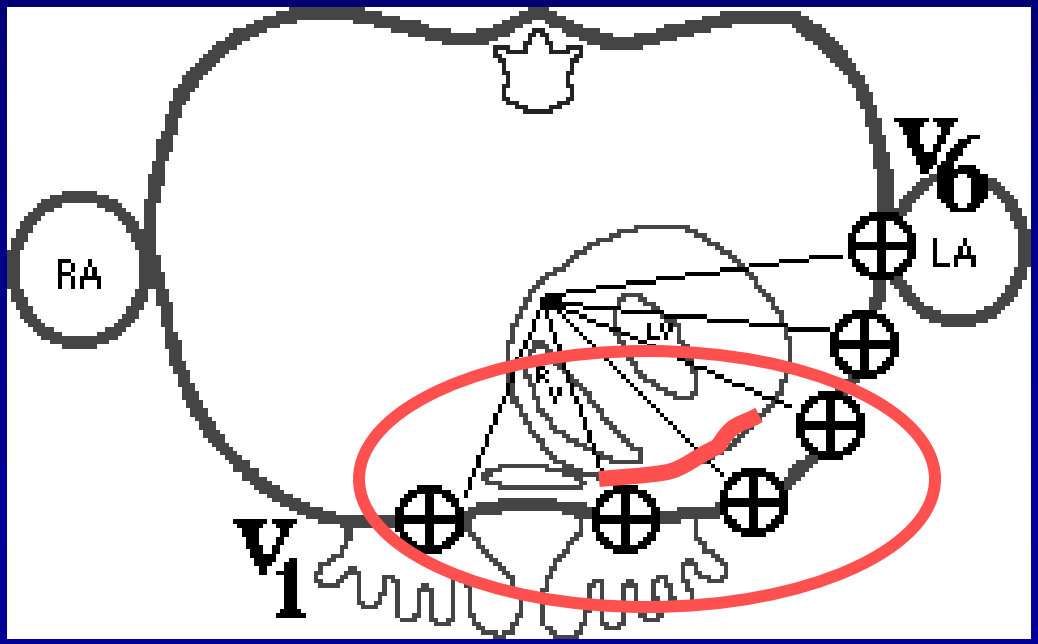
ST Elevation (cont)

Elevation of the ST segment (greater than 1 small box) in 2 leads is consistent with a myocardial infarction.



Anterior View of the Heart

The anterior portion of the heart is best viewed using leads V_1- V_4.

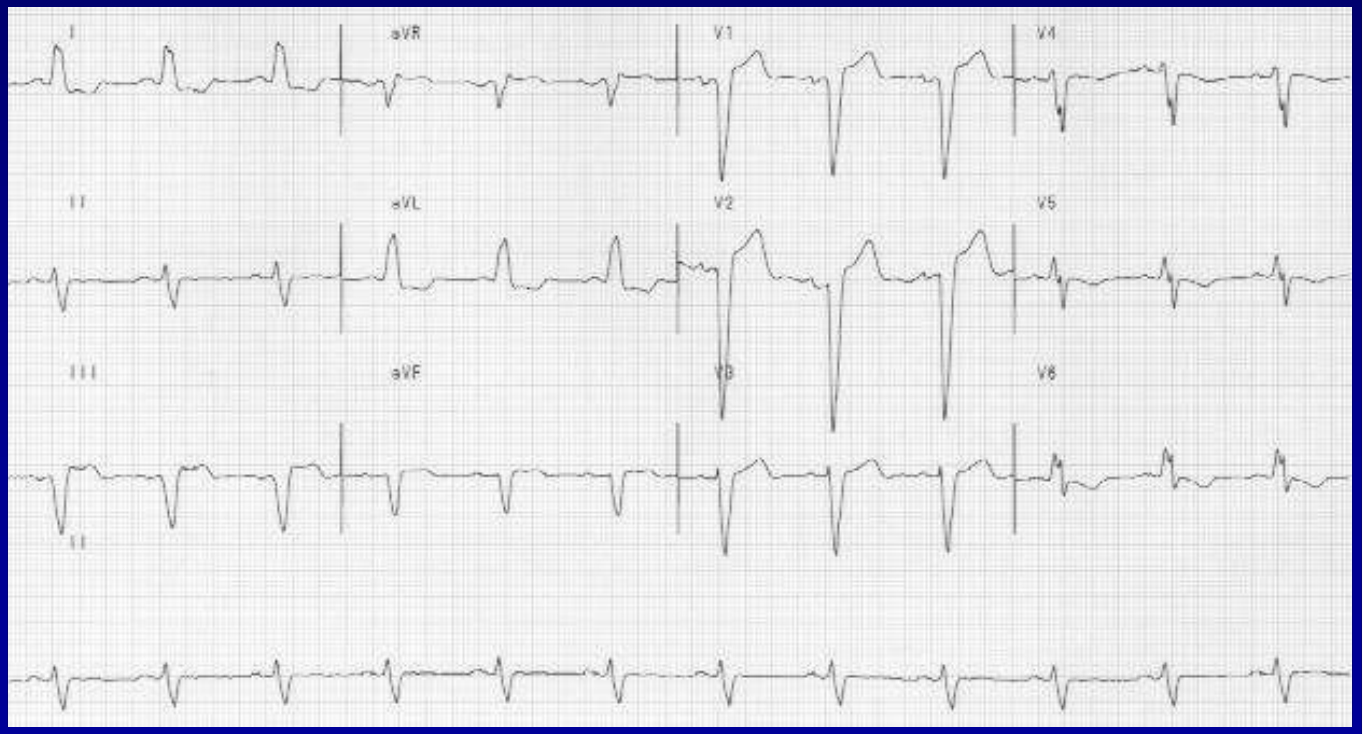


Anterior Myocardial Infarction

If you see changes in leads V_1 - V_4 that are consistent with a myocardial infarction, you can conclude that it is an anterior wall myocardial infarction.

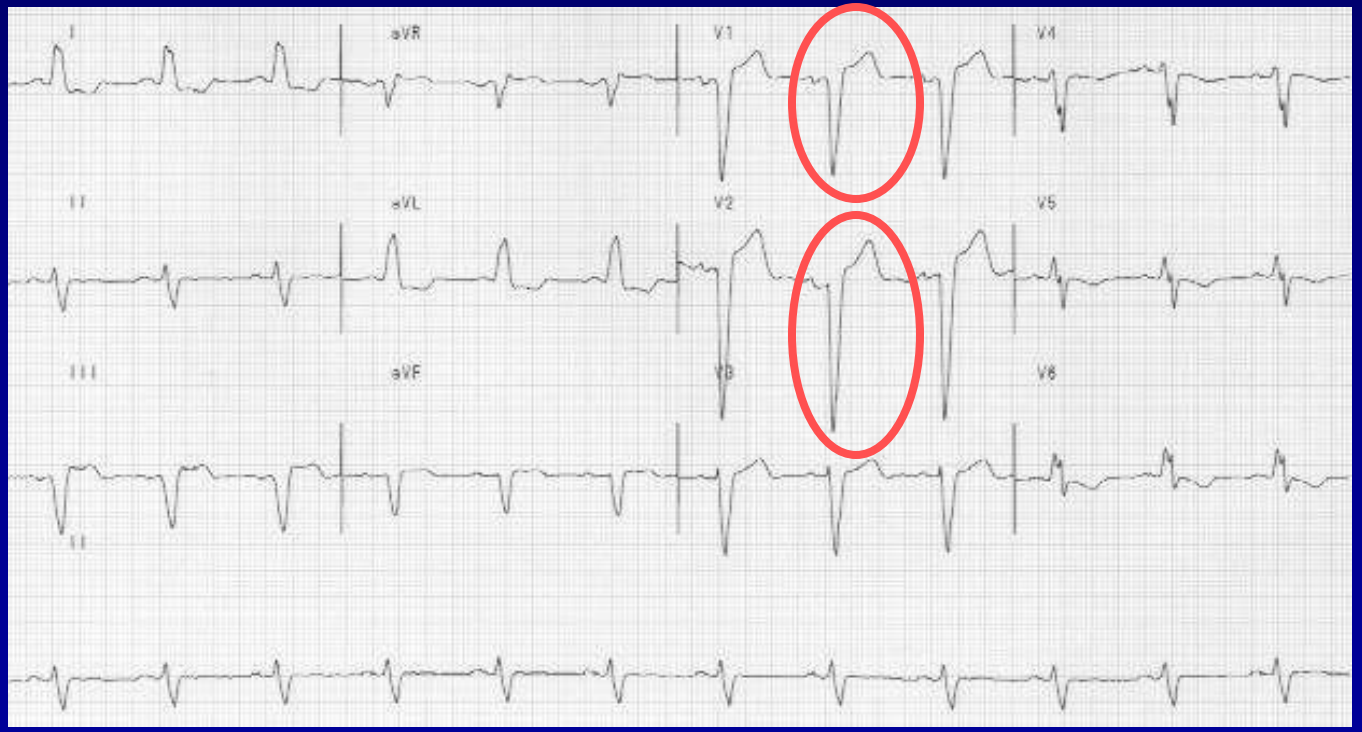
Putting it all Together

Do you think this person is having a myocardial infarction. If so, where?



Interpretation

Yes, this person is having an acute anterior wall myocardial infarction.

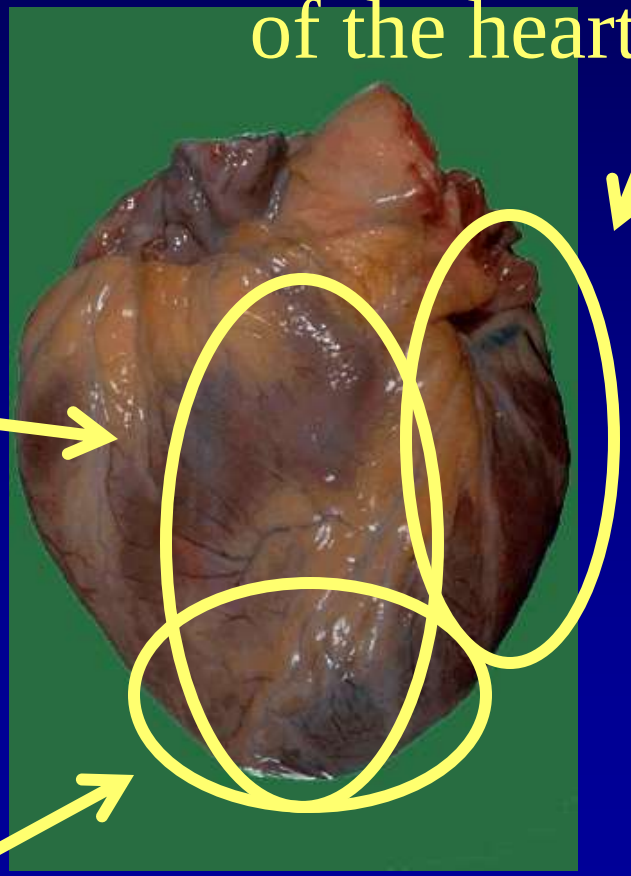


Other MI Locations

Now that you know where to look for an anterior wall myocardial infarction let's look at how you would determine if the MI involves the lateral wall or the inferior wall of the heart.

Other MI Locations

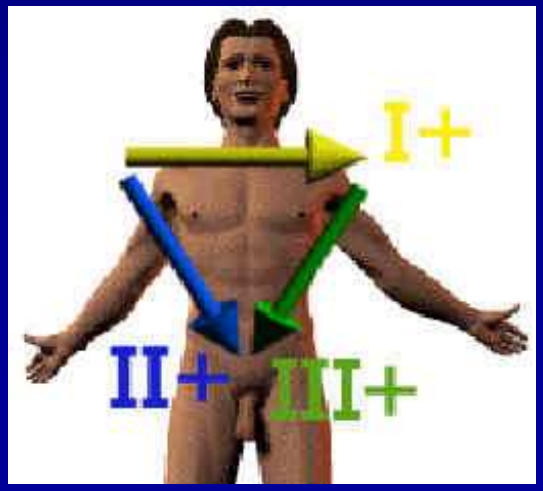
First, take a look again at this picture of the heart.



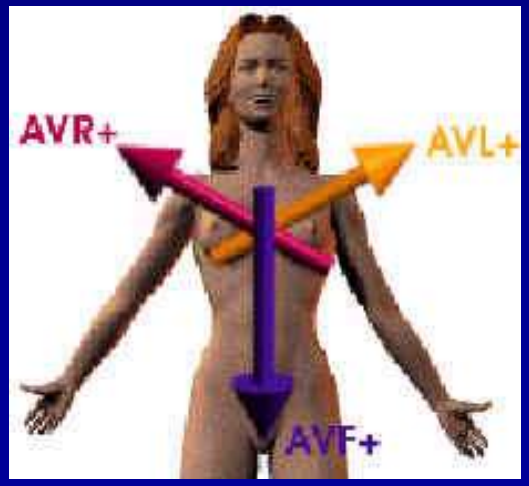
Other MI Locations

Second, remember that the 12-leads of the ECG look at different portions of the heart. The limb and augmented leads "see" electrical activity moving inferiorly (II, III and aVF), to the left (I, aVL) and to the right (aVR). Whereas, the precordial leads "see" electrical activity in the posterior to anterior direction.

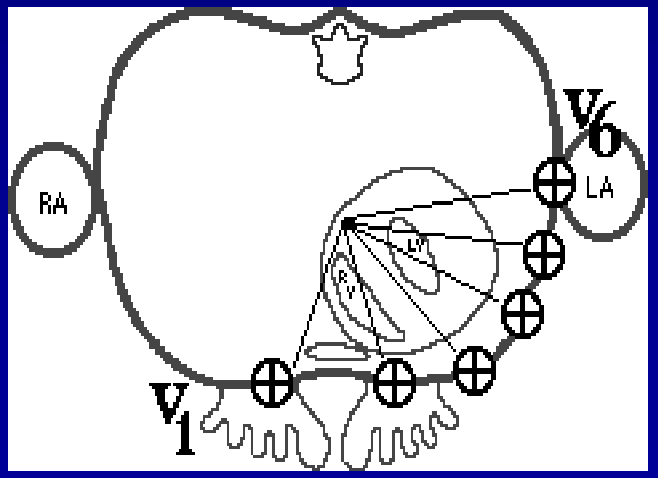
Limb Leads



Augmented Leads



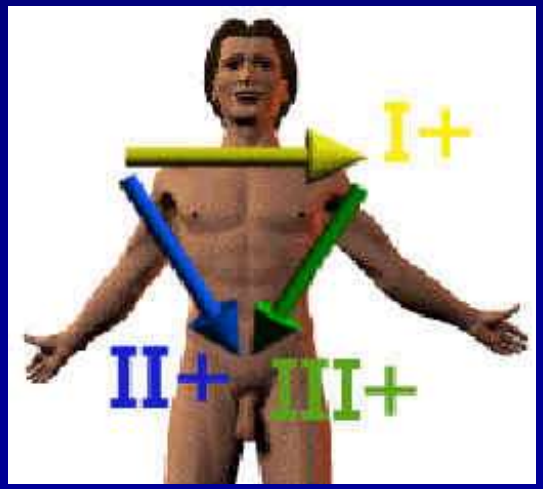
Precordial Leads



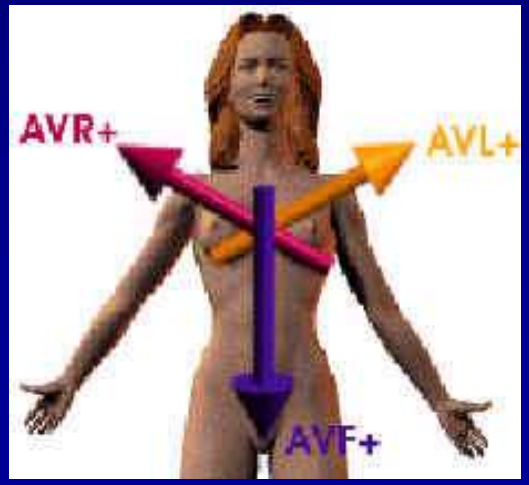
Other MI Locations

Now, using these 3 diagrams let's figure where to look for a lateral wall and inferior wall MI.

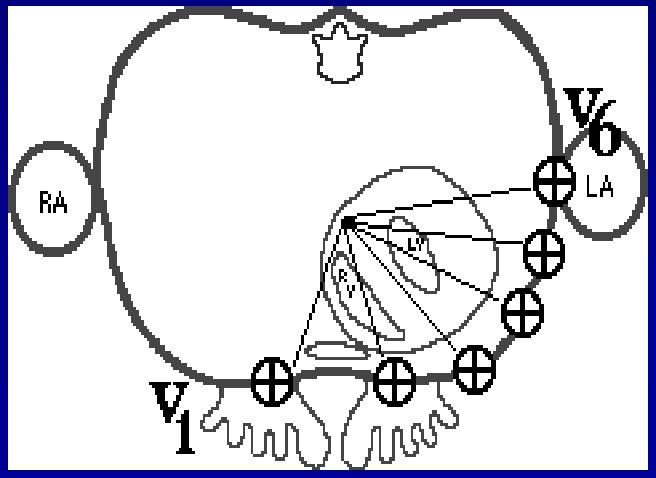
Limb Leads



Augmented Leads



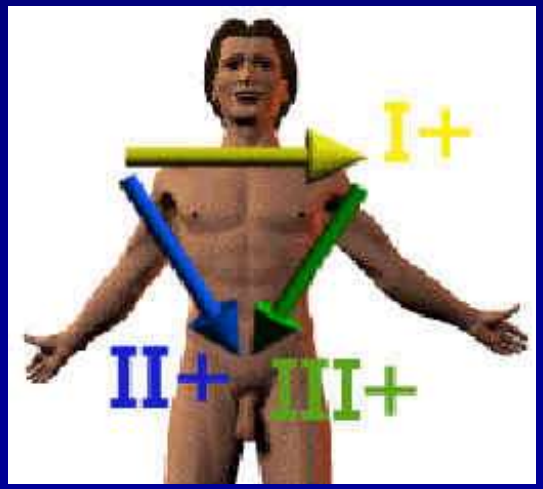
Precordial Leads



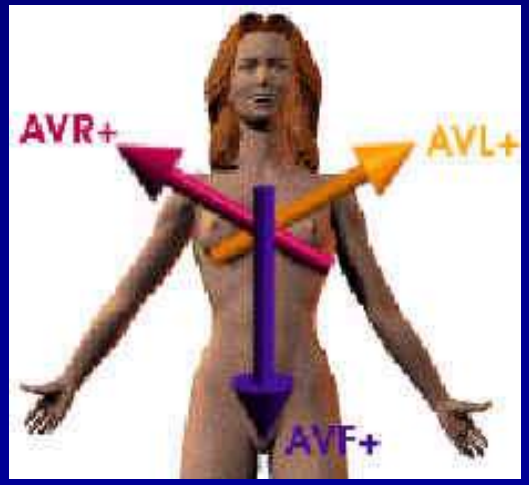
Anterior MI

Remember the anterior portion of the heart is best viewed using leads V_1- V_4.

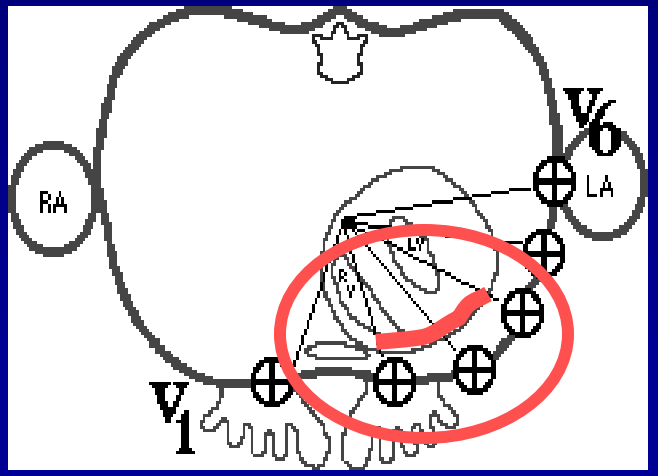
Limb Leads



Augmented Leads



Precordial Leads

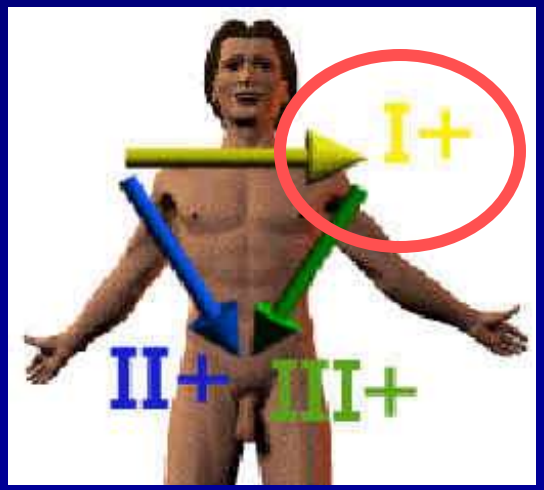


Lateral MI

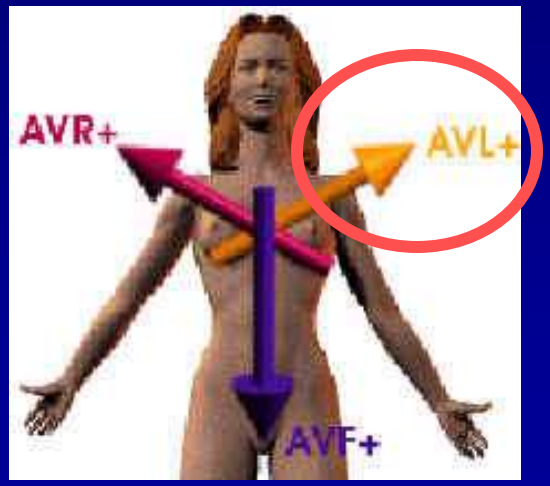
So what leads do you think the lateral portion of the heart is best viewed?

Leads I, aVL, and V_5- V_6

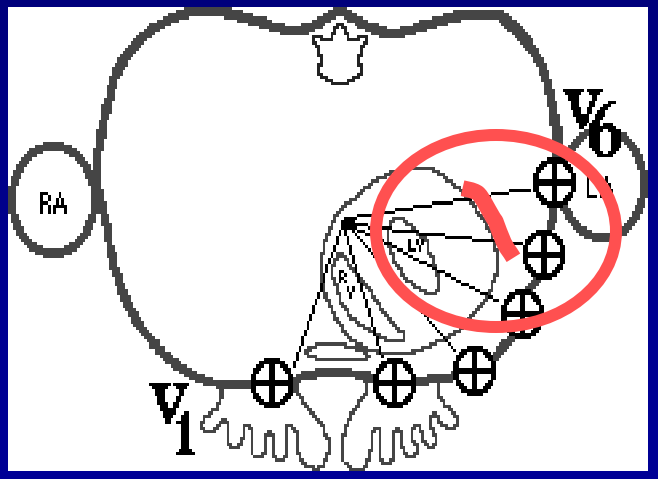
Limb Leads



Augmented Leads



Precordial Leads

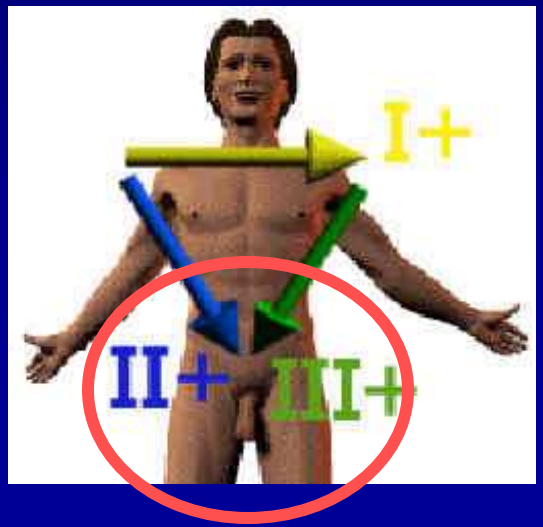


Inferior MI

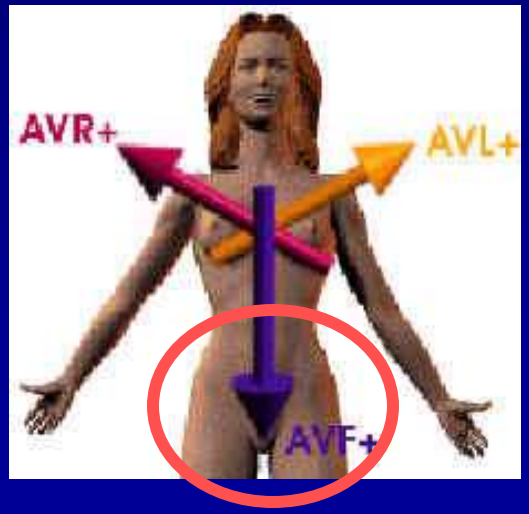
Now how about the inferior portion of the heart?

Leads II, III and aVF

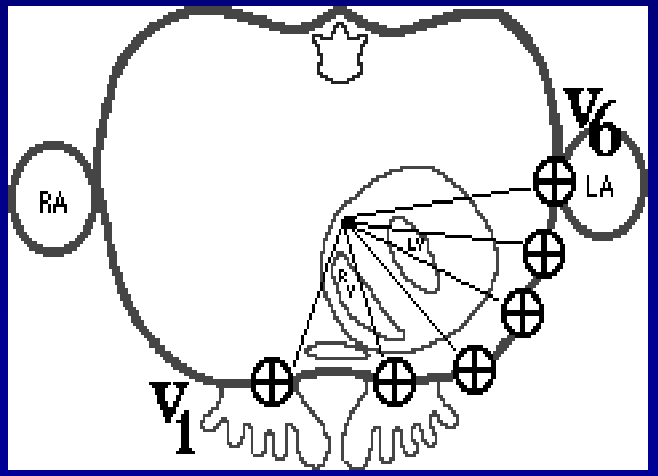
Limb Leads



Augmented Leads

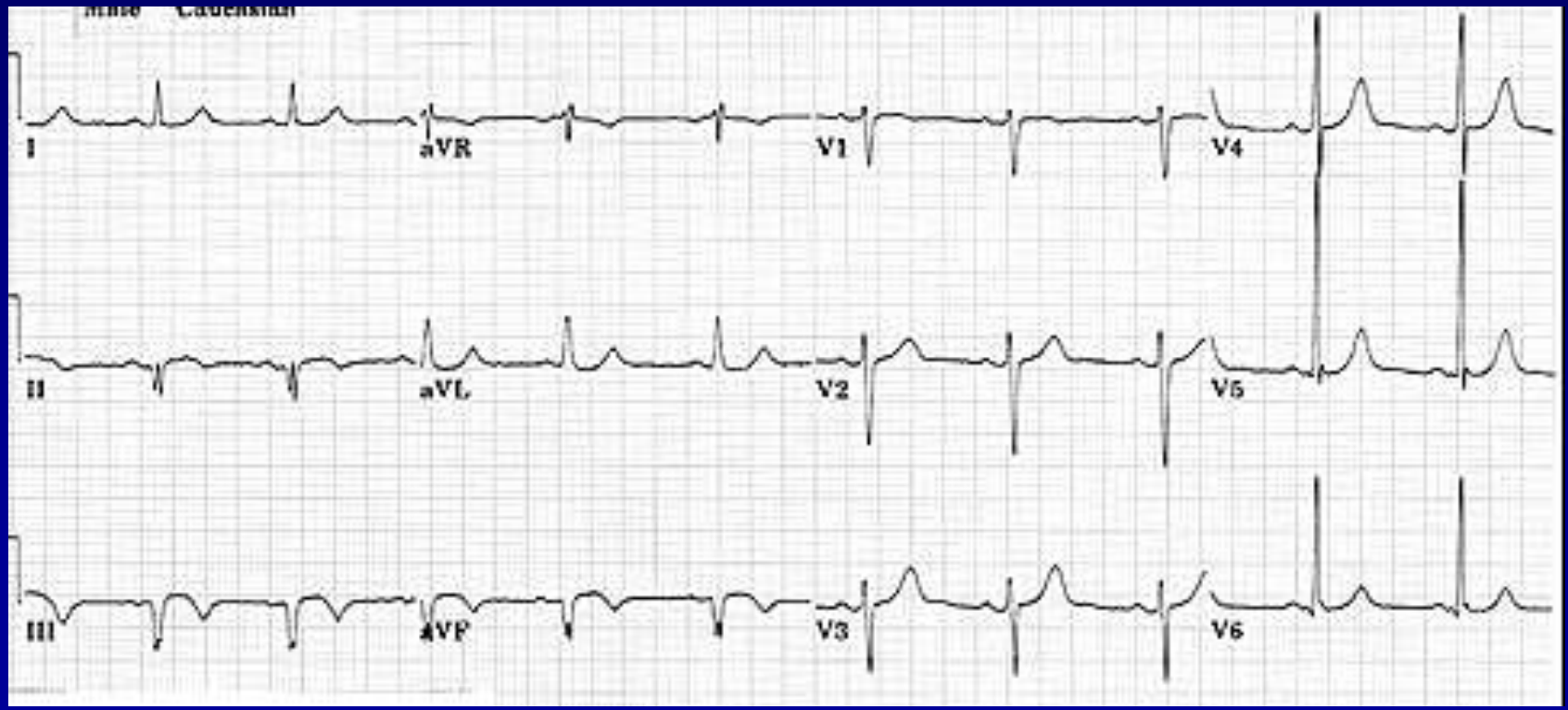


Precordial Leads



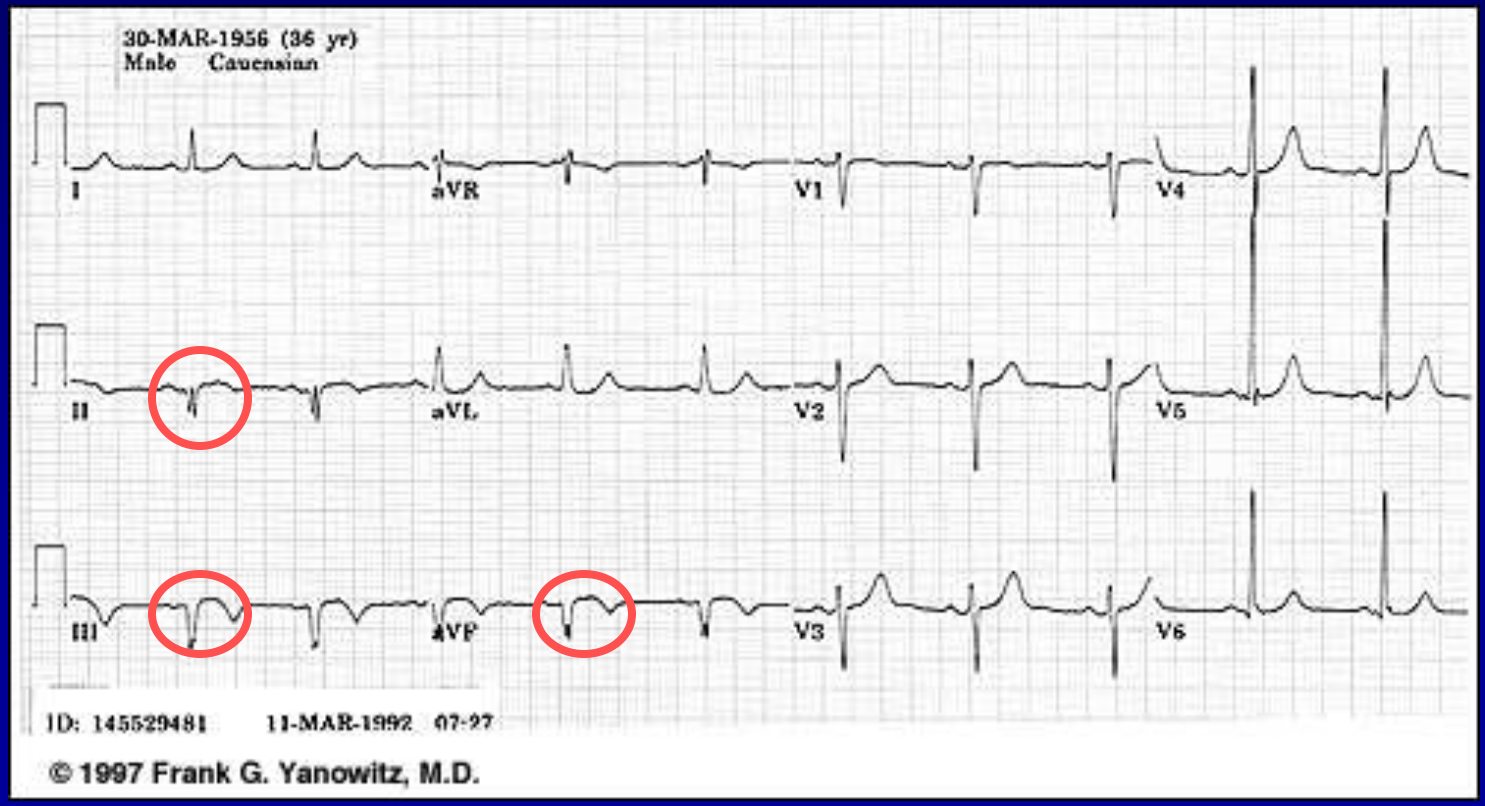
Putting it all Together

Now, where do you think this person is having a myocardial infarction?



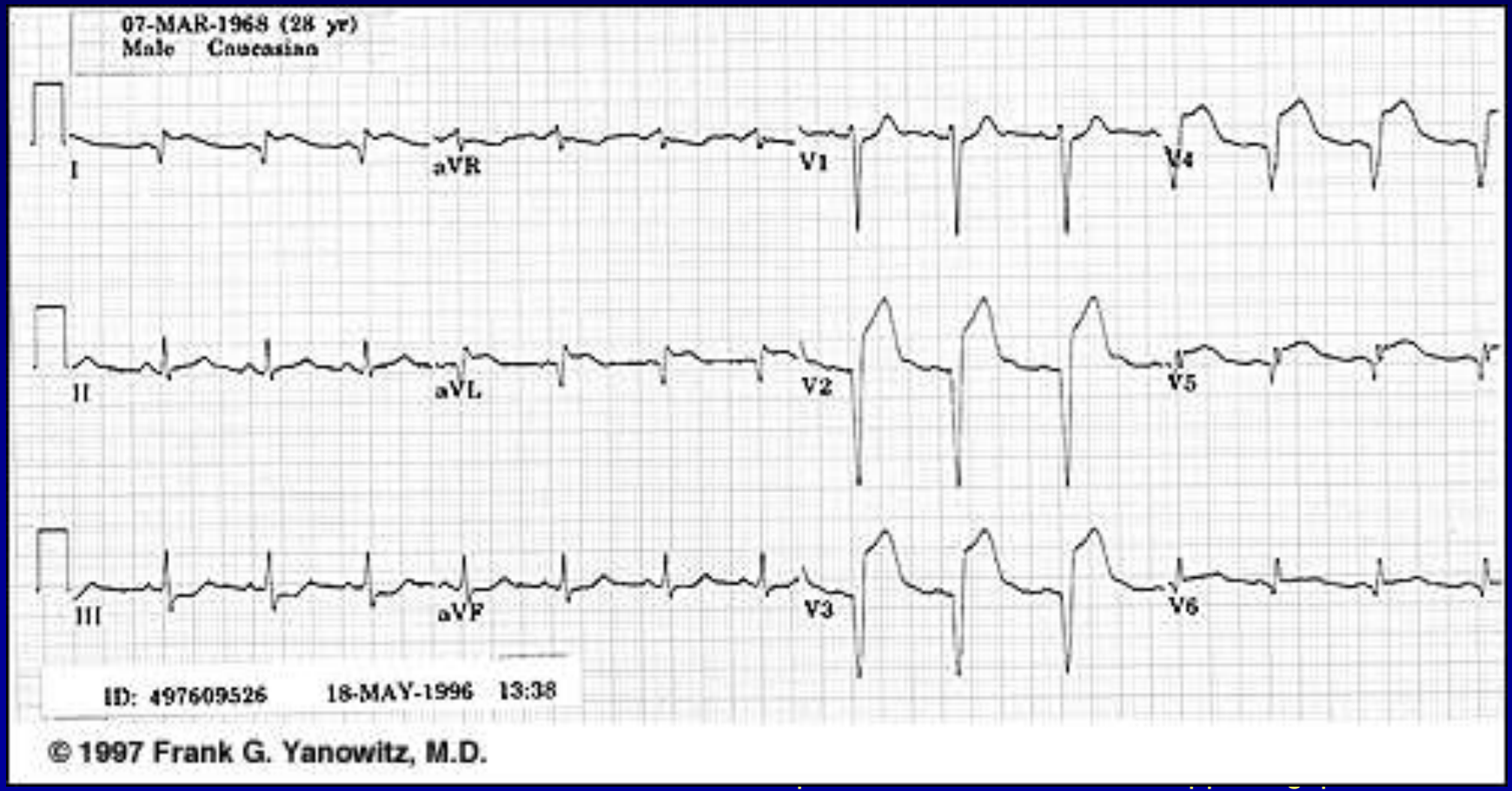
Inferior Wall MI

This is an inferior MI. Note the ST elevation in leads II, III and aVF.



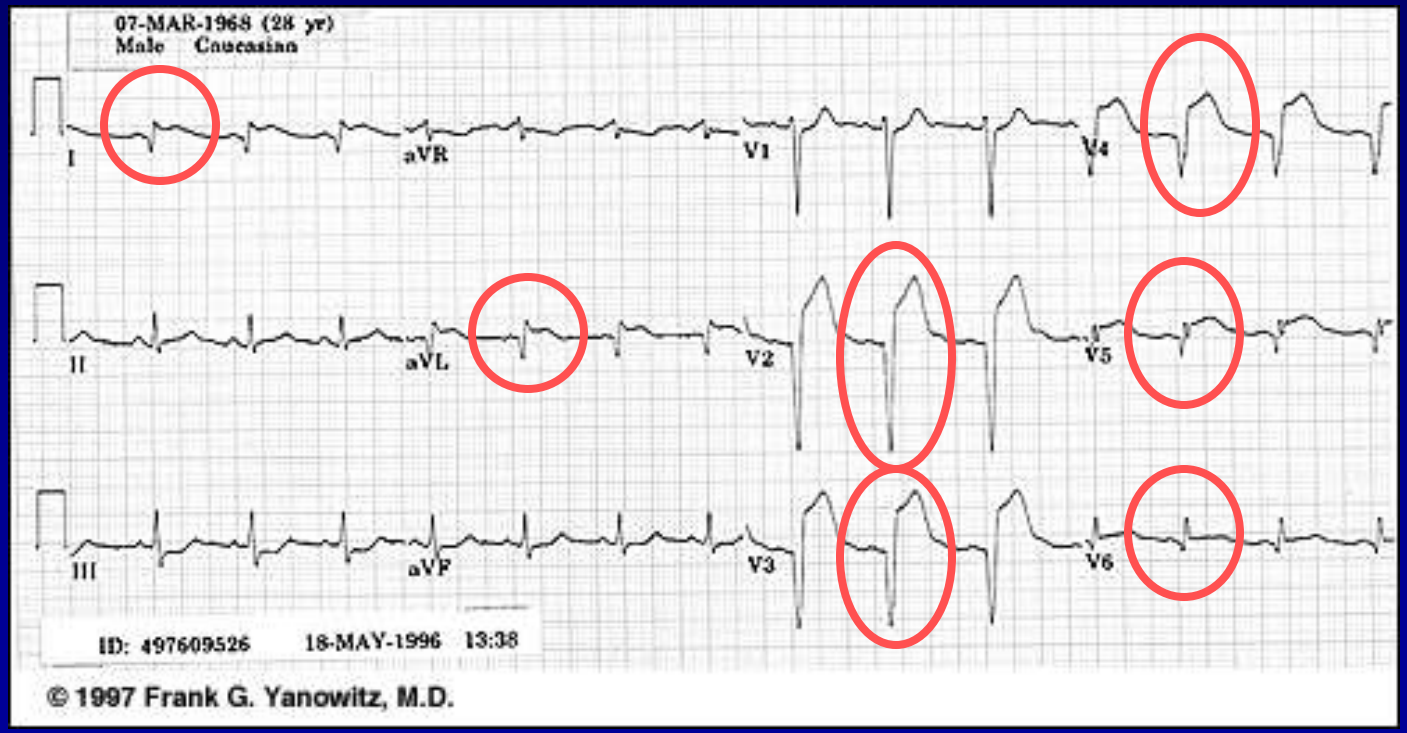
Putting it all Together

How about now?



Anterolateral MI

This person's MI involves both the anterior wall (V_2-V_4) and the lateral wall (V_5-V_6, I, and aVL)!



Thank you