

# ***STAT 12 Lead ECG Workshop: Basics & ACS***

## **Part 1: Basic Fundamentals**

**WAYNE W RUPPERT, CVT, CCCC, NREMT-P**

**Cardiovascular Coordinator  
Bayfront Health Seven Rivers  
Crystal River, Florida**

**Interventional Cardiovascular  
& Electrophysiology  
Technologist**

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Welcome !

# **WORKSHOP** Description

This is a **FOCUSED, CRASH COURSE** that **TEACHES YOU** to interpret 12 Lead ECGs to identify **INDICATORS** of Acute Coronary Syndrome (ACS).

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**TEACHES YOU** = *you will LEARN and NOT FORGET.*

- *You will do EXERCISES throughout course.*
- *There is a TEST.*

# OMG a *TEST*?!?!!!!

- YES !
- But you get THE ANSWERS . . . *in ADVANCE!*
- Everytime you see something that's important (*something that you should remember* in order to be a whiz at reading 12 Lead ECGs), it is written in bold, dark red font, and is **UNDERSCORED.**
- The NEXT SLIDE you see will **TEST YOUR RETENTION** of this material!

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\_\_\_\_\_ of this material!

# Source of Curriculum:

- Case Studies from Cardiac Catheterization and Electrophysiology Labs, 1996 – Present

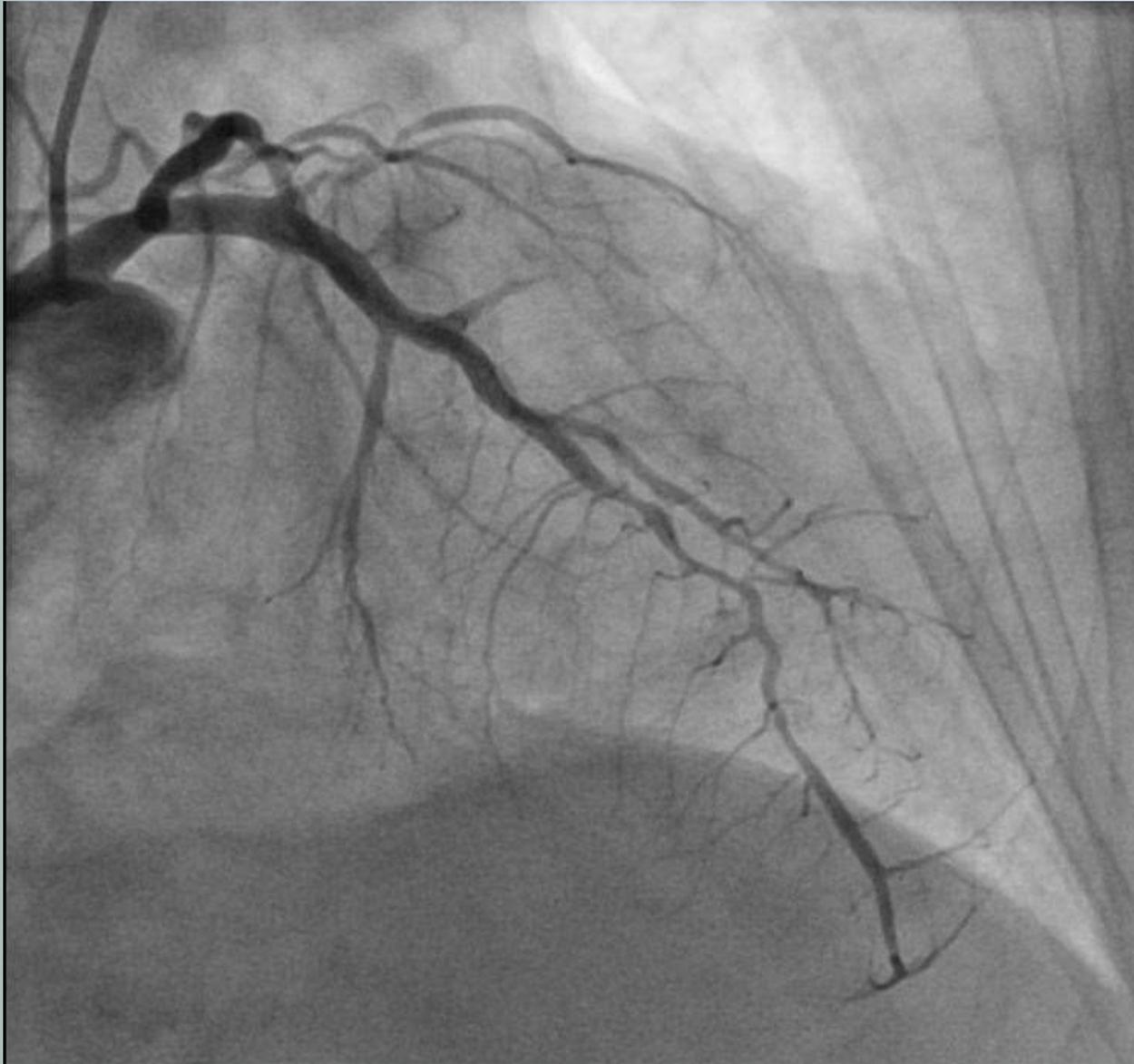
**Approximately 13,000 Cases between 1996 - Today**



**Wayne Ruppert and Dr. James Irwin, St Joseph's Hospital, Tampa, 7/29/2004**

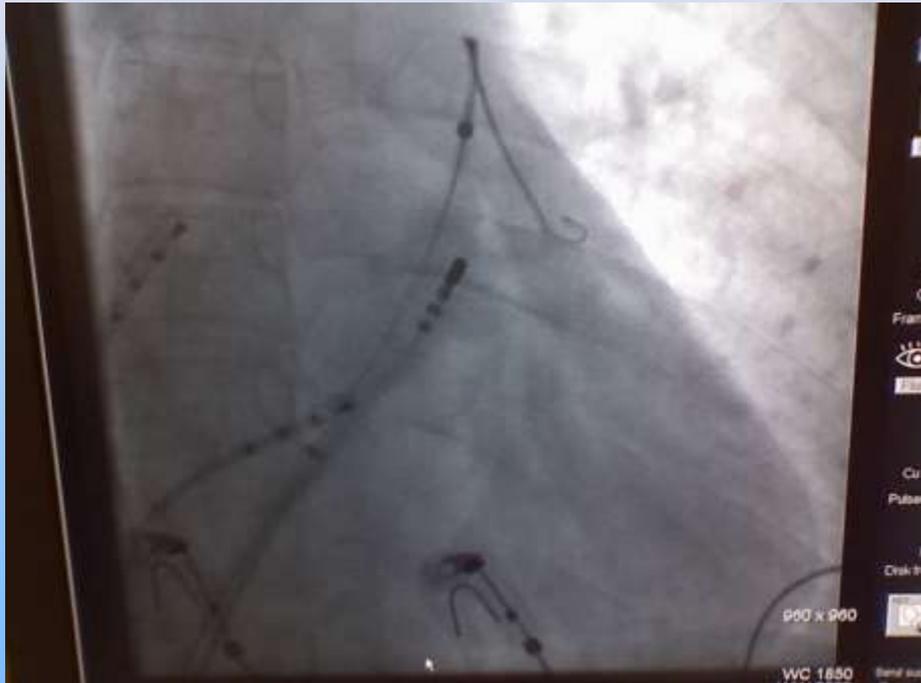
**7 . 29 06 : 55**

# Cardiac Cath Lab Advantage:



Allows us to  
CORRELATE  
ECG leads  
with  
SPECIFIC  
cardiac  
anatomic  
structures.

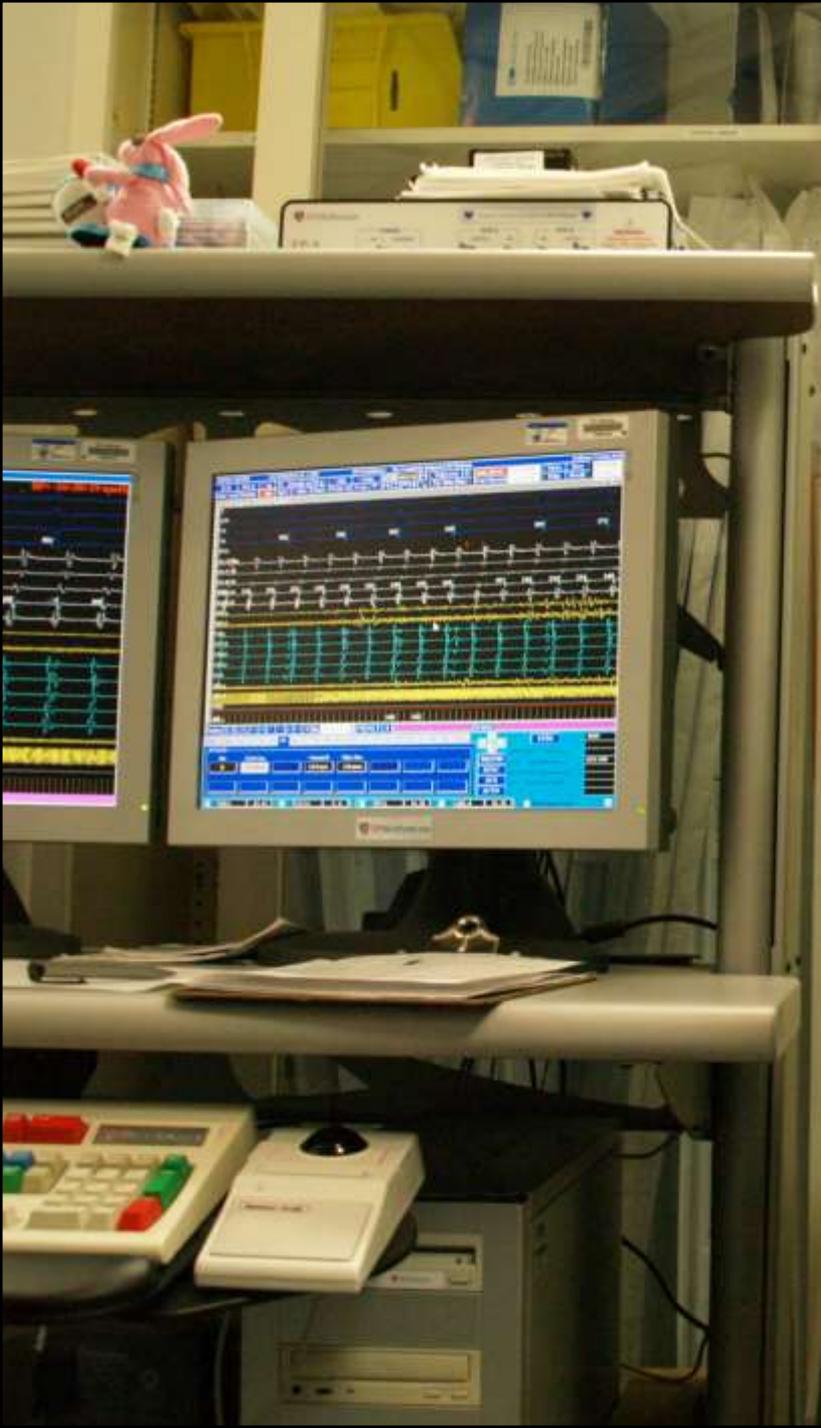
# Electrophysiology Lab



**EP Catheters within the heart used for obtaining the Electrogram (the “internal ECG”) Tracing and for Pace-mapping, an integral component of an EP study**



**Author Wayne Ruppert conducting Pace-mapping during EP study at the St Joseph’s Hospital Heart Institute, Pediatric Electrophysiology Program, Tampa, FL in 2004**



# Source of Curriculum:

- Case Studies from Cardiac Catheterization and Electrophysiology Labs, 1996 – Present
- Current Evidence-based Research
  - Journal of the American College of Cardiology (JACC)
  - American Heart Association (AHA) Circulation
  - ACC/AHA Guidelines
  - New England Journal of Medicine

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- Case Studies from Cardiac Catheterization and Electrophysiology Labs, 1996 – Present
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  - American Heart Association (AHA) Circulation
  - ACC/AHA Guidelines
  - New England Journal of Medicine
- Two peer reviewed, published textbooks

In the CARDIAC CATHETERIZATION LAB, we read our patients' 12 Lead ECGs and then evaluate their coronary arteries and ventricular function during angiography. Stated in plain English, we rapidly learn how to correlate 12 lead ECG findings with what's really going on inside our patients' hearts. Seeing ECGs from this perspective adds a new dimension to understanding the complex pathophysiologies of cardiovascular disease.

This book prepares you to:

- INTERPRET 12 Lead ECGs.
- ASSIMILATE DATA derived from the 12 Lead ECG into a comprehensive patient evaluation process designed to maximize diagnostic accuracy, while taking into consideration the 12 Lead ECGs inherent LACK OF SENSITIVITY and SPECIFICITY.
- IDENTIFY 13 PATTERNS associated with myocardial ischemia and infarction, including the most subtle ECG changes often missed by clinicians and the ECG machine's computerized interpretation software.
- CORRELATE each lead of the ECG with specific regions of the heart – and the CORONARY ARTERIAL DISTRIBUTION that commonly supplies it. In cases of STEM, this knowledge prepares you to ANTICIPATE the FAILURE OF CRITICAL CARDIAC STRUCTURES – often BEFORE THEY FAIL.

For those who need to master essential material quickly, this book has been written with an expedited learning<sup>®</sup> feature, designed to make learning as easy as 1 - 2 - 3:

1. READ the **YELLOW HIGHLIGHTED TEXT**
2. STUDY the GRAPHIC IMAGES, PICTURES and ECGs
3. CORRECTLY ANSWER the REVIEW QUESTIONS at the end of each section.

This is an invaluable resource for every medical professional who evaluates patients and reads their 12 lead ECGs:

- Fellows in Emergency, Cardiology, and Family Medicine
- Medical Residents
- Veteran Physicians wanting a good review in ACE patient evaluation
- Physician Assistants and Nurse Practitioners
- Emergency Department Nurses
- Coronary Care Unit and Cardiac Telemetry Nurses
- Walk-in Clinic Physicians and Nurses
- Paramedics

"I think this book will be a wonderful addition to the textbooks that are already available, with a fresh perspective"

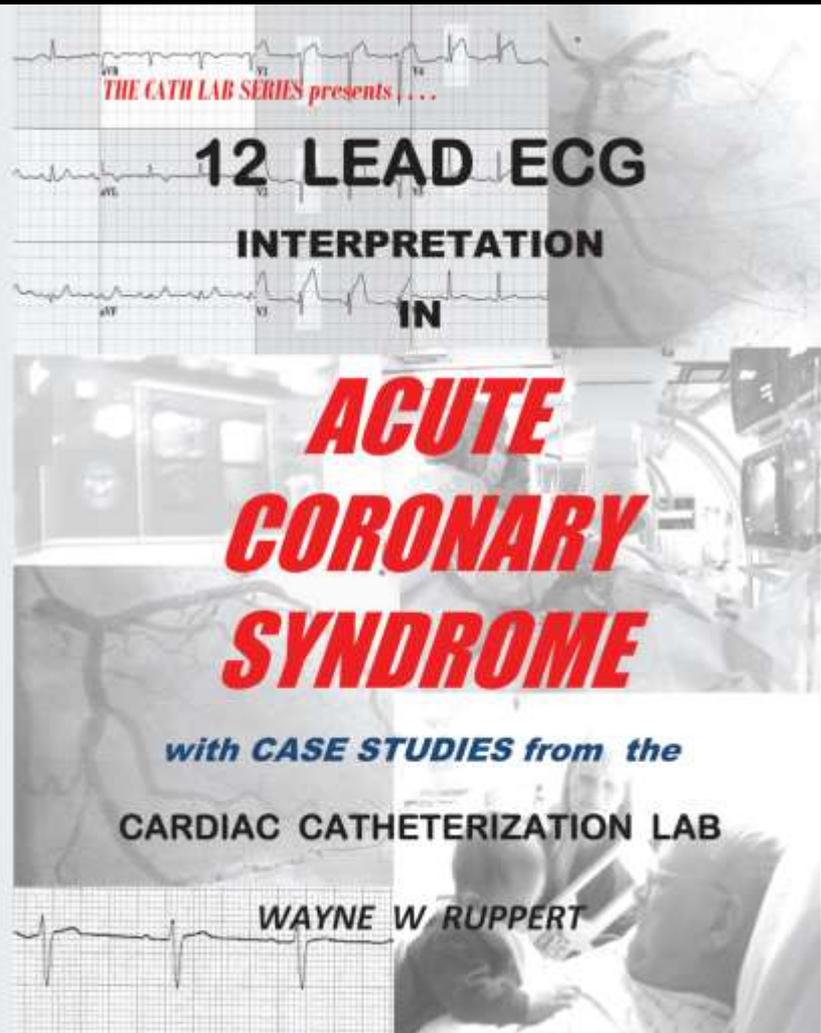
**Joseph F. Ornato, MD, FACP, FACC, FACEP**  
- Professor and Chairman, Department of Emergency Medicine  
Medical College of Virginia/Virginia Commonwealth University  
- Medical Director, Richmond Ambulance Authority,  
Richmond, Virginia

"This book integrates academic ECG principles with real-world clinical practice by incorporation of well chosen cath lab case studies into its curriculum. This combination lets readers see patients and their ECGs through the eyes of an experienced cath lab interventionalist, and provides a balanced approach to patient evaluation that compensates for the ECGs inherent lack of sensitivity and specificity. I highly recommend this book for all Emergency Medicine and Cardiology Fellows. For experienced clinicians, it's a superb review."

**Humberto Coto, MD, FACP, FACC**  
- Chief of Interventional Cardiology  
St. Joseph's Hospital  
Tampa, Florida



12 LEAD ECG INTERPRETATION IN ACUTE CORONARY SYNDROME with CASE STUDIES from the CATH LAB - WAYNE W RUPPERT



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[BarnesandNoble.com](http://BarnesandNoble.com)  
[Amazon.com](http://Amazon.com)

# “12 Lead ECG in ACS” Editorial

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Humberto Coto, MD, FACEP Past Chief of Cardiology, St. Joseph’s Hospital, Tampa, FL

Mike Taigman, EMS Industry Author, Conference Speaker, Journalist; Author, “Taigman’s Advanced Cardiology in Plain English”

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2010 - Current

# STEMI Assistant

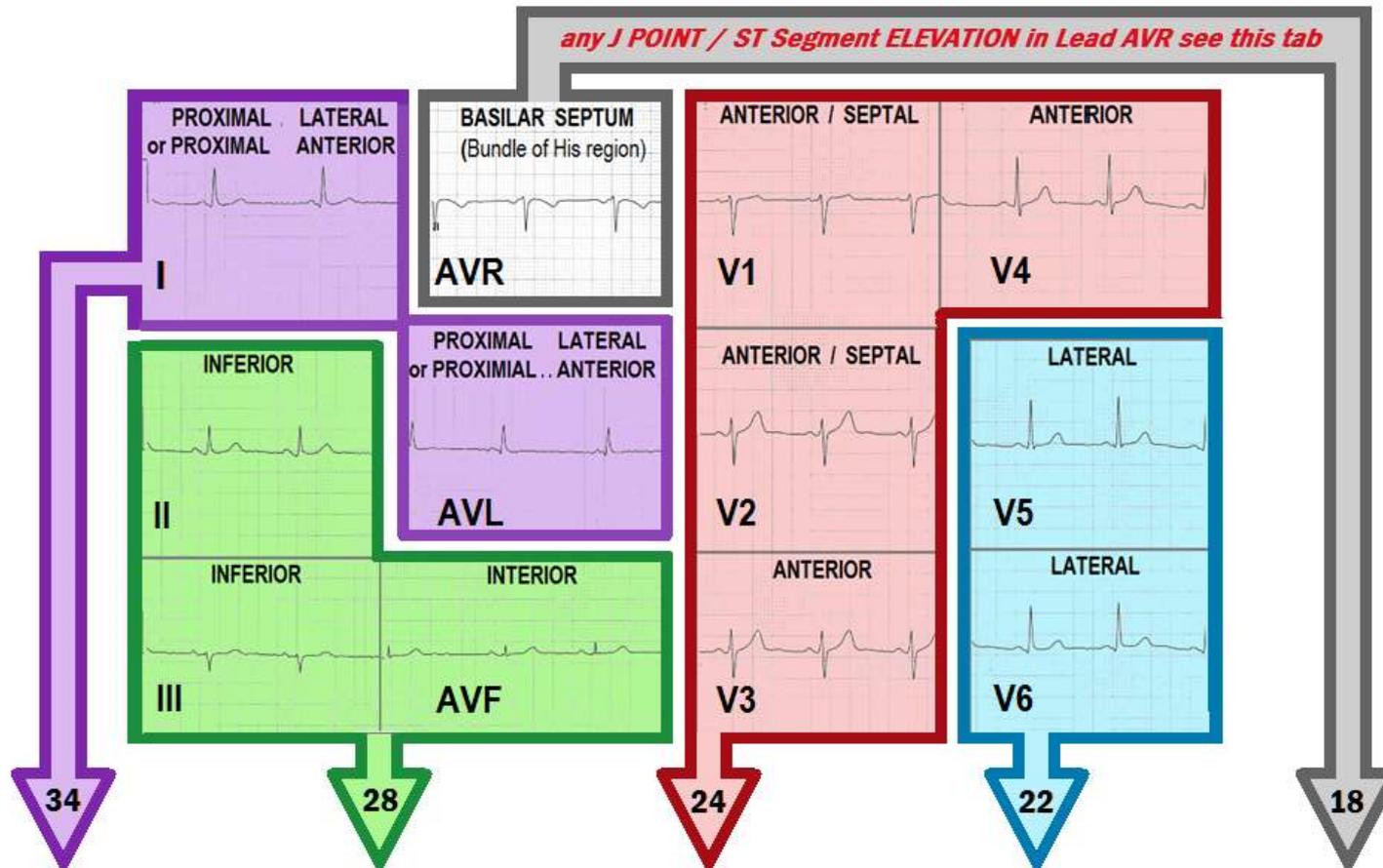
by Wayne Ruppert

UNIVERSAL ACS PATIENT MANAGEMENT ALGORITHM

--- See PAGE ONE ---

Select LEAD SET with HIGHEST ST ELEVATION and open to associated page . . .

CRASH CART EMERGENCY REFERENCE



Bayfront Health  
Dade City

# “STEMI Assistant” Editorial Board:

Barbra Backus, MD, PhD Inventor of “The HEART Score,” University Medical Center, Utrecht, Netherlands

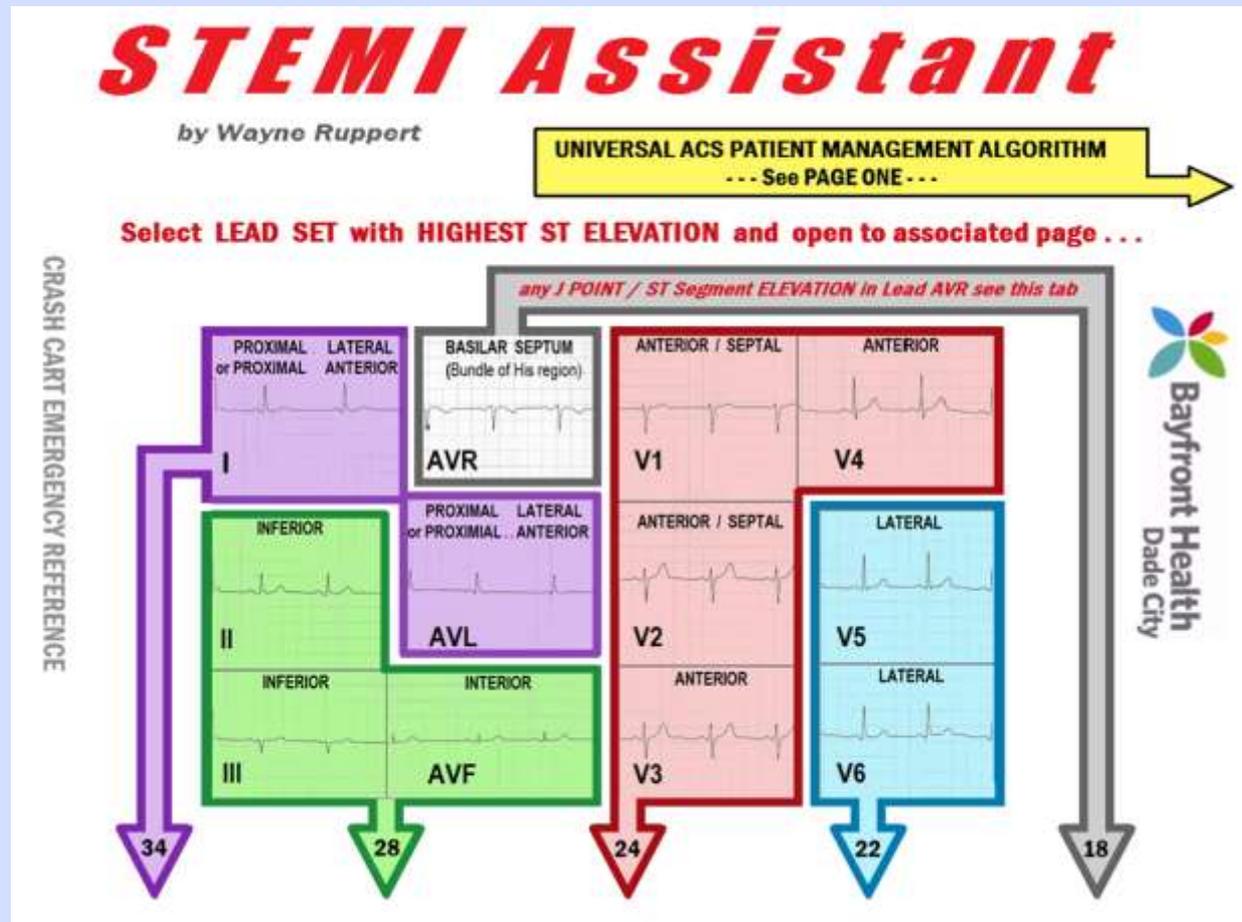
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William Parker, PharmD, CGP, Director of Pharmacy, Bayfront Dade City

Printed and Marketed Worldwide by The Ingram Book Company  
2015 - Current

# **STEMI Assistant:** an Emergency Crash Cart Interactive Reference Manual - free Download



**STEMI Assistant – Information Video**



**American College of Cardiology  
20<sup>th</sup> Congress 2017**

**Red Rock Resort, Las Vegas  
October 25 & 26, 2017**

**Advanced Telemetry & 12 Lead  
ECG Workshop – Parts 1, 2 & 3  
Observation Medicine Tract**

**By: Wayne W Ruppert, CVT, CCCC, NREMT-P**

# Wayne Ruppert bio:

- Cardiovascular Coordinator 2012-present (coordinated 5 successful accreditations)
- Interventional Cardiovascular / Electrophysiology Technologist, 1995-Present.
- Author of: “[12 Lead ECG Interpretation in Acute Coronary Syndrome with Case Studies from the Cardiac Cath Lab](#),” 2010, TriGen publishing / Ingram Books
- Author of: “[STEMI Assistant](#),” 2014, TriGen publishing / Ingram Books
- **Florida Nursing CE Provider # 50-12998**
- 12 Lead ECG Instructor, 1994-present (multiple hospitals, USF College of Medicine 1994)
- Website: [www.ECGtraining.org](http://www.ECGtraining.org)

[www.practicalclinicalskills.com](http://www.practicalclinicalskills.com)

[www.skillstat.com/tools/ecg-simulator](http://www.skillstat.com/tools/ecg-simulator)

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Navigation menu items: HOME, 12 LEAD ECG IN ACS, STEMI ASSISTANT, ACCREDITATION, WORKSHOPS, ECG ID OF SADS, WORKSHOP OBJECTIVES, TEXTBOOKS, PHYSICIAN REVIEWS, BIO OF WAYNE RUPPERT, TESTIMONIALS, **DOWNLOADS - PDF**, HELPFUL INFORMATION, CONTACT US

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[wayneruppert@aol.com](mailto:wayneruppert@aol.com)

# Today's Agenda:

- First half of class (Part 1):
  - 12 Lead ECG Basic Fundamentals
    - Electrophysiology (Depolarization & Repolarization)
      - Waveforms and Intervals Relevant to ACS
    - Cardiac Anatomical Correlations with 12 Lead ECG
- Second half of class (Part 2):
  - ECG indicators of ACS
  - Diagnosis of STEMI
    - With Wide QRS vs. Normal width QRS
    - Clinical Relevance: predicting specific complication based on region of infarction.

***Before we go  
any farther,  
you should  
know . . .***

***Sometimes,  
ECGs  
LIE to us !***

***ECGs and USED CAR SALESMEN  
often have MUCH in common !***



# **THE ECG in PERSPECTIVE:**

## **PROBLEMS with ECG:**

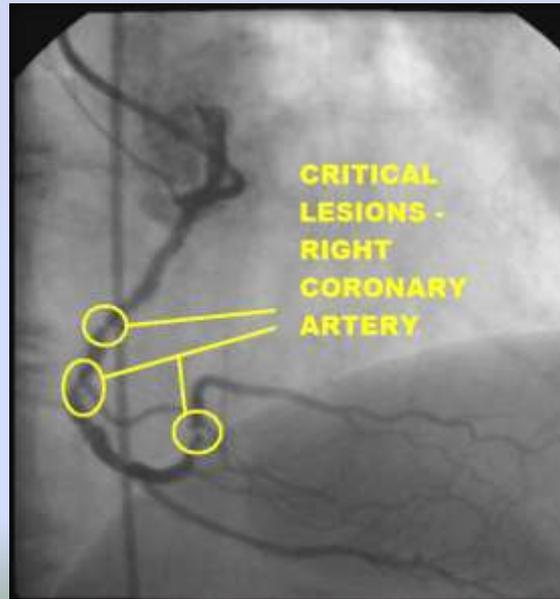
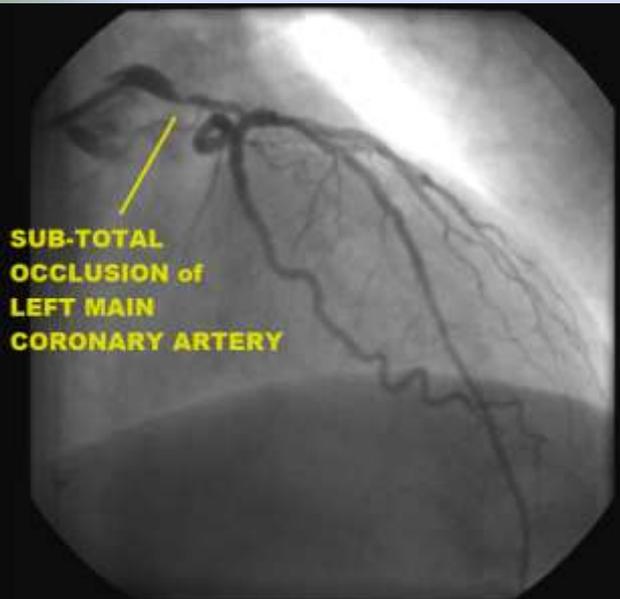
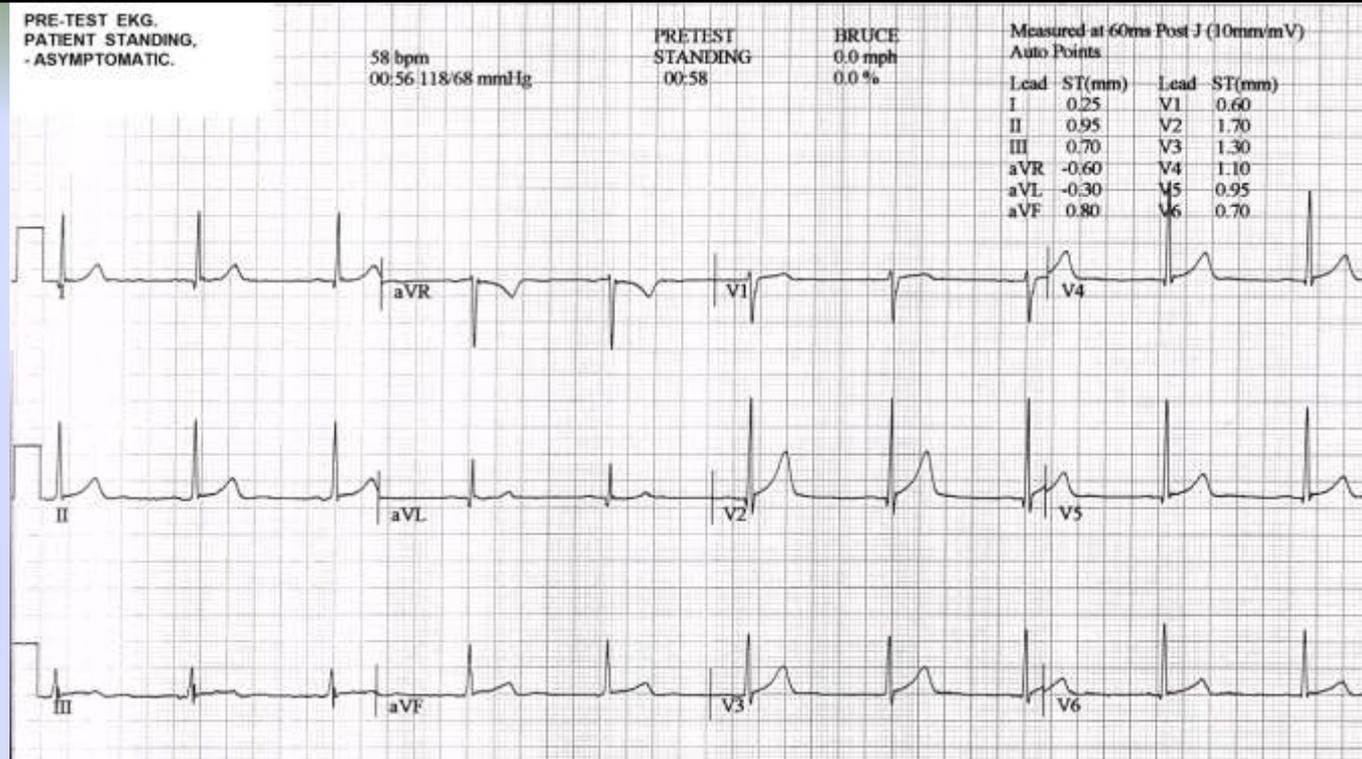
**↓ SENSITIVITY**  
**( FALSE NEGATIVES )**

**↓ SPECIFICITY**  
**( FALSE POSITIVES )**

**PROBLEMS WITH SENSITIVITY . . .**

**NORMAL ECG.**

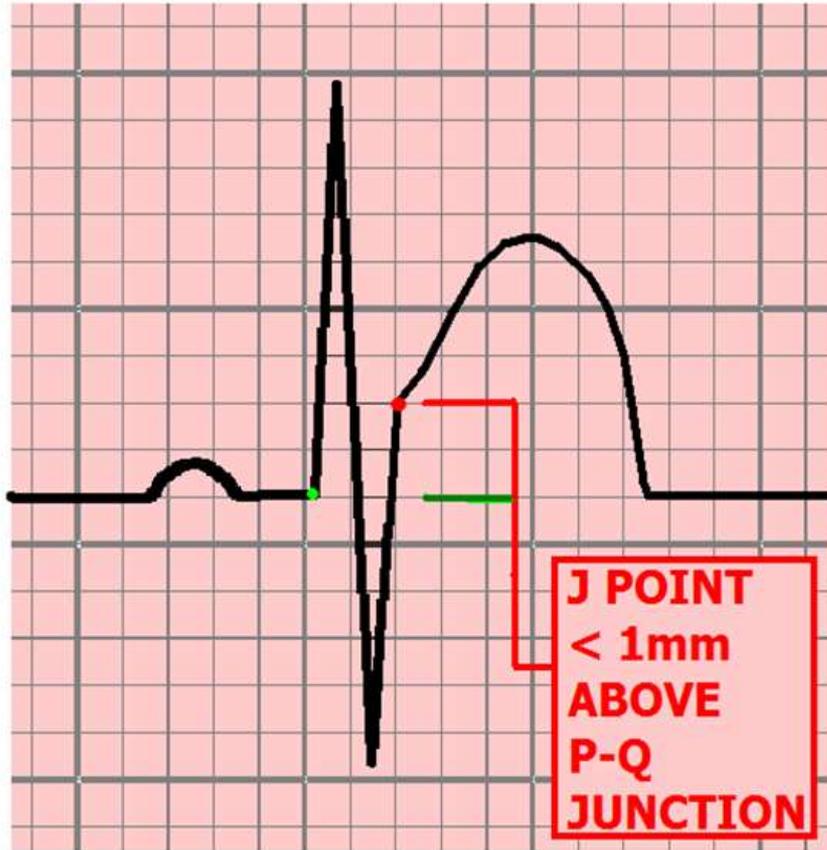
But . . . . .



**LETHAL  
TRIPLE  
VESSEL  
DISEASE**

# PROBLEMS WITH SPECIFICITY . . .

## S-T SEGMENT ELEVATION - COMMON ETIOLOGIES:

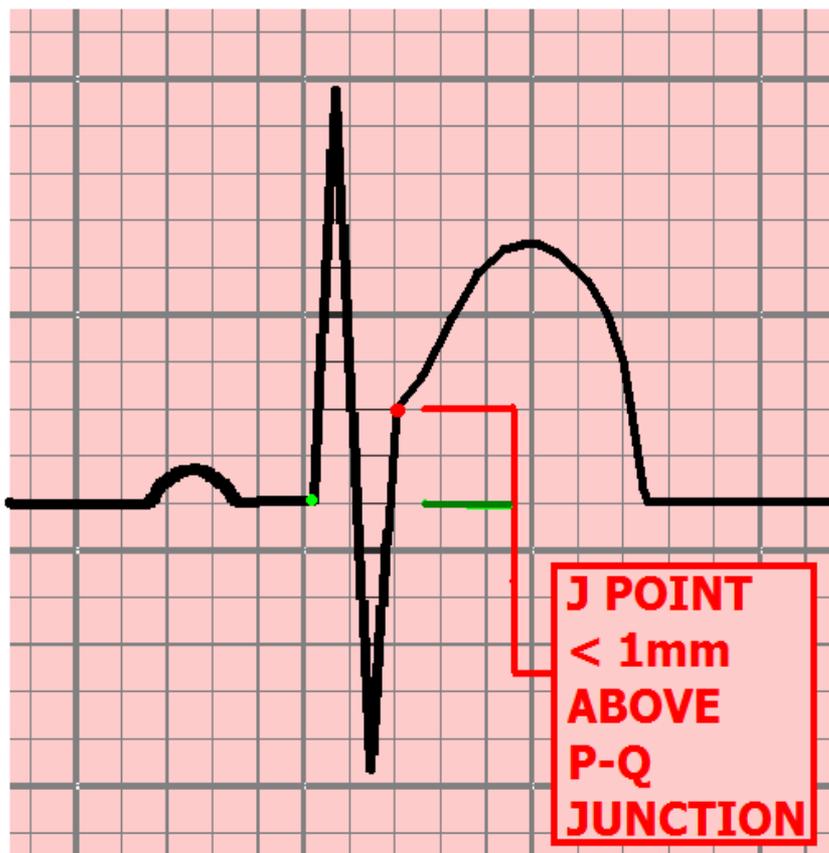


CONDITION:

- **ACUTE INFARCTION (STEMI)**

# PROBLEMS WITH SPECIFICITY . . .

## S-T SEGMENT ELEVATION - COMMON ETIOLOGIES:



### CONDITION:

- ACUTE INFARCTION
- HYPERKALEMIA
- BRUGADA SYNDROME
- PULMONARY EMBOLUS
- INTRACRANIAL BLEED
- MYOCARDITIS / PERICARDITIS
- L. VENT. HYPERTROPHY
- PRINZMETAL'S ANGINA
- L. BUNDLE BRANCH BLOCK
- PACED RHYTHM
- EARLY REPOLARIZATION & "MALE PATTERN" S-T ELEV.

1North (06)

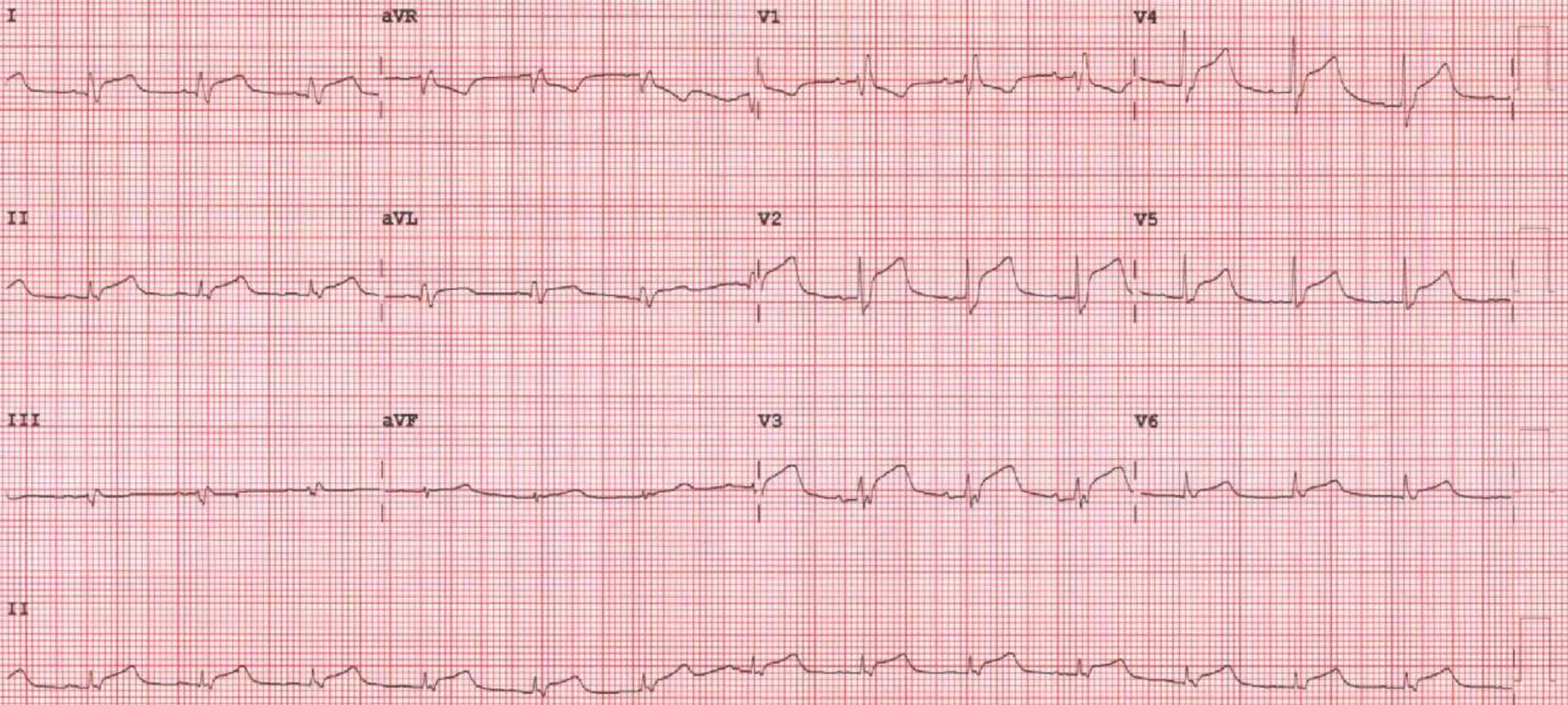
Rate 83 . SINUS RHYTHM.....normal P axis, V-rate 50- 99  
 . RIGHT BUNDLE BRANCH BLOCK.....QRSD>120, terminal axis(90,270)  
 PR 152 . ANTEROLATERAL INFARCT, ACUTE.....Q >35mS, ST >0.20mV, V2-V6  
 QRSD 122  
 QT 412  
 QTc 485

**FAXED**  
 10/9  
 @ 1023 07-02-15  
 J

--AXIS--  
 P 59  
 QRS 14  
 T 33  
 12 Lead; Standard Placement

- ABNORMAL ECG -  
 >>> Acute MI <<<

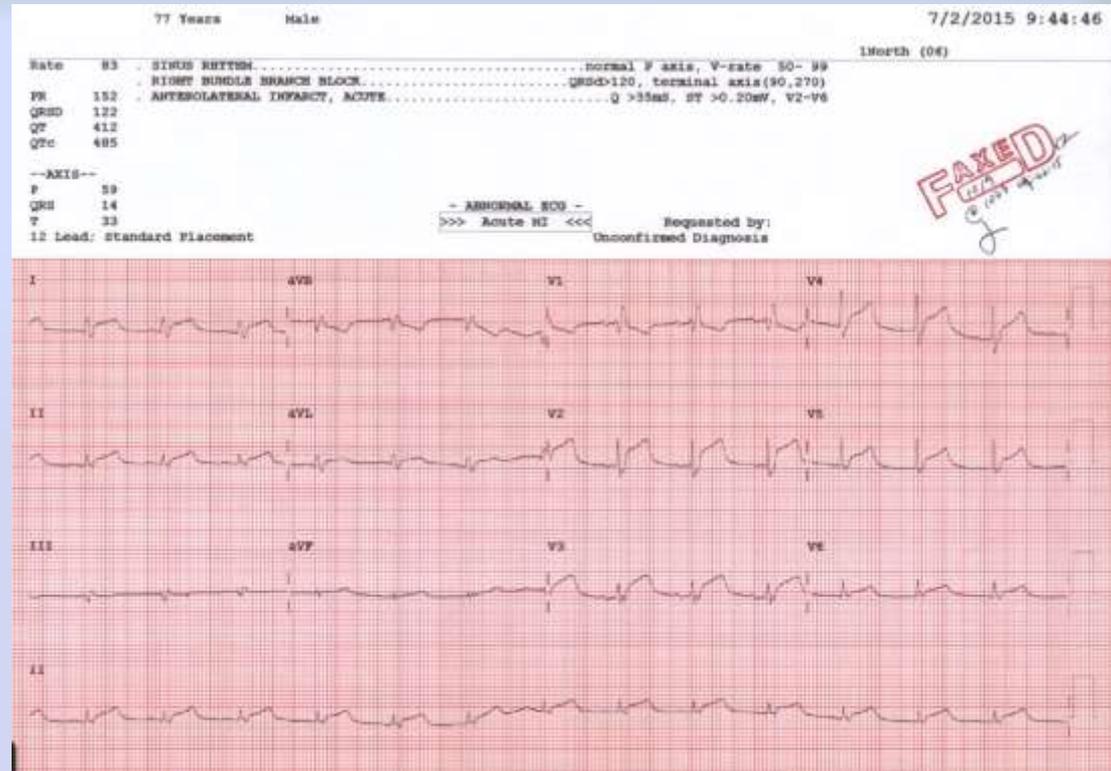
Requested by:  
 Unconfirmed Diagnosis



## Patient:

- Asymptomatic
- Troponin normal
- Cardiac Cath angiography = “no obstructive CAD.”
- Discharge diagnosis:

**EARLY REPOLARIZATION.** This degree of ST Elevation in early repolarization is **VERY RARE:** The only such ECG I have seen in approximately 13,000 cardiac catheterizations.



# S-T SEGMENT DEPRESSION - COMMON ETIOLOGIES:

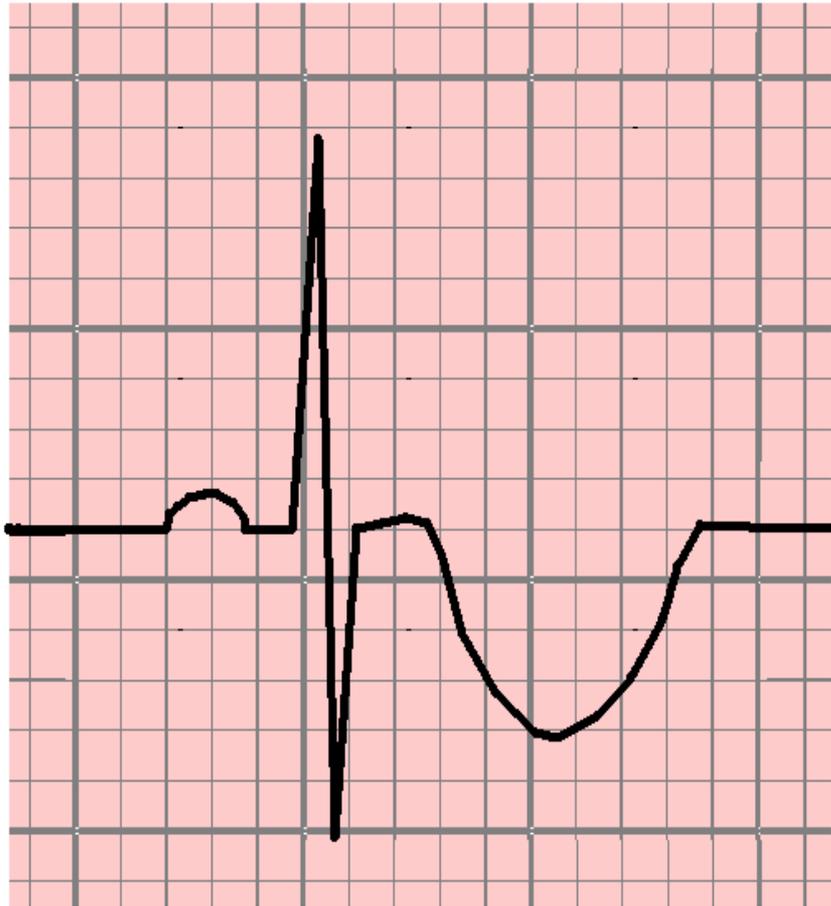


## CONDITION:

- **RECIPROCAL CHANGES of ACUTE MI**
- **NON-Q WAVE M.I. ( NON-STEMI )**
- **ISCHEMIA**
- **POSITIVE STRESS TEST**
- **VENTRICULAR HYPERTROPHY (STRAIN PATTERN)**
- **WOLFF-PARKINSON-WHITE**
- **OLD MI ( NECROSIS vs. ISCHEMIA )**
- **DIGITALIS**
- **R. BUNDLE BRANCH BLOCK**

# T WAVE INVERSION - COMMON ETIOLOGIES:

---



## CONDITION:

- **MYOCARDITIS**
- **ELECTROLYTE IMBALANCE**
- **ISCHEMIA**
- **POSITIVE STRESS TEST**
- **CEREBRAL DISORDER**
- **MITRAL VALVE PROLAPSE**
- **VENTRICULAR HYPERTROPHY**
- **WOLFF-PARKINSON-WHITE**
- **HYPERVENTILATION**
- **CARDIOACTIVE DRUGS**
- **OLD MI ( NECROSIS vs. ISCHEMIA )**
- **DIGITALIS**
- **R. BUNDLE BRANCH BLOCK**
- **NO OBVIOUS CAUSE**

**Despite the ECG's problematic  
issues with**

**Lack of Sensitivity**

**&**

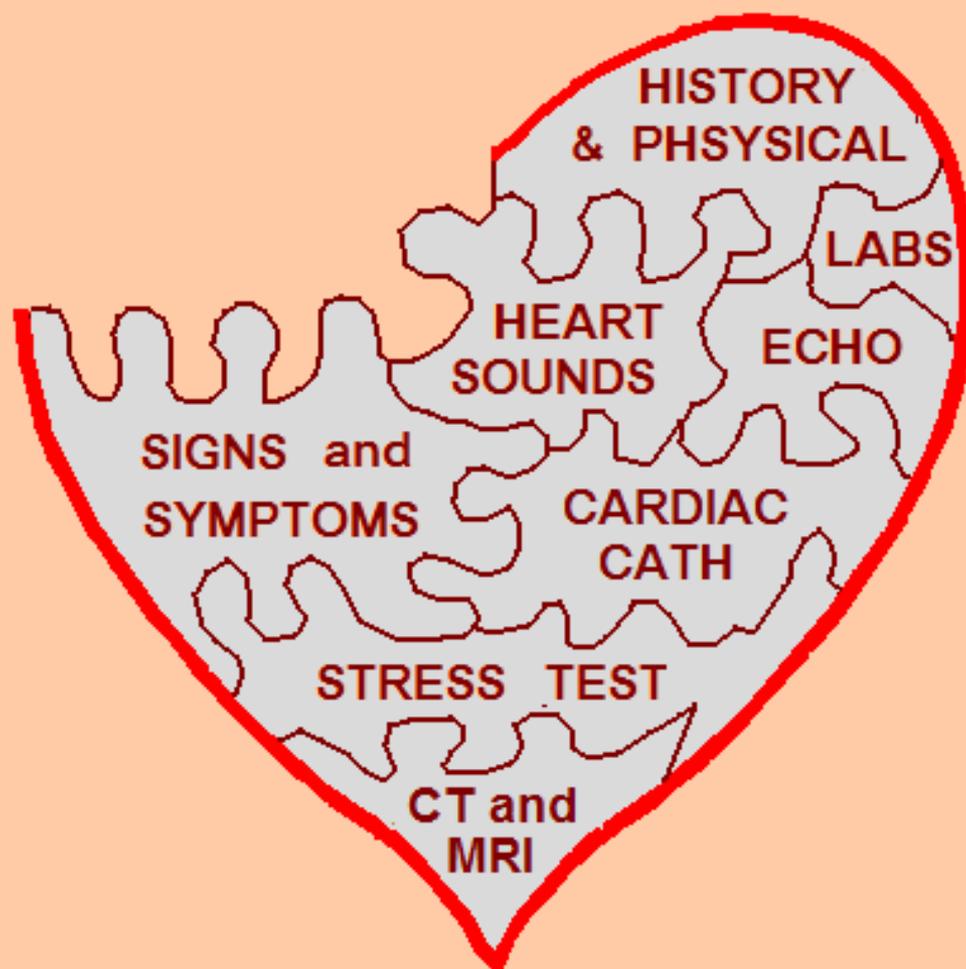
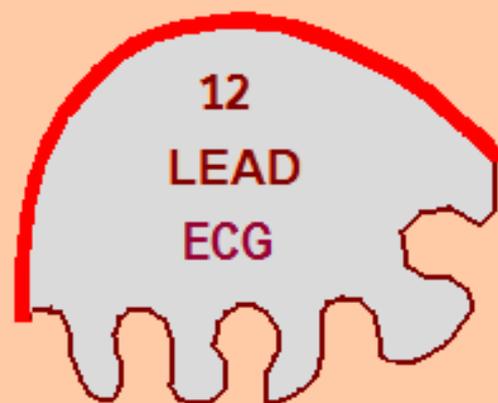
**Lack of Specificity,**

***The 12 Lead ECG remains  
one of our QUICKEST, most cost-  
efficient front-line Triage Tools  
that we have today.***



***So how do we know when the ECG is telling us the truth ???***

**REMEMBER . . . . Keep the ECG Results in  
PROPER PERSPECTIVE . . . .**



**REMEMBER . . .  
it's only  
ONE PIECE  
of the  
DIAGNOSTIC  
PUZZLE !**

# *The QUADRAD of ACS*

- PRESENTING SYMPTOMS**
- RISK FACTOR PROFILE**
- ECG ABNORMALITIES**
- CARDIAC MARKERS**

**A POSITIVE finding in TWO or MORE of the above categories indicates it is EXTREMELY LIKELY that ACS is present . . . . steps must be **AGGRESSIVELY TAKEN** to definitively **RULE OUT** the **PRESENCE** of ACS !**

- ***We utilize ACS Risk Stratification to compensate for the ECG's lack of sensitivity and specificity, to aid us in clinical decision-making and to improve our diagnostic accuracy.***



# HEART

HEART score for chest pain patients			
History	Highly suspicious	2	
	Moderately suspicious	1	
	Slightly suspicious	0	
ECG	Significant ST-deviation	2	
	Non specific repolarisation disturbance / LBTB / PM	1	
	Normal	0	
Age	≥ 65 years	2	
	> 45 and < 65 years	1	
	≤ 45 years	0	
Risk factors	≥ 3 risk factors or history of atherosclerotic disease*	2	
	1 or 2 risk factors	1	
	No risk factors known	0	
Troponin	≥ 3x normal limit	2	
	> 1 and < 3x normal limit	1	
	≤ 1x normal limit	0	
		<b>Total</b>	

**\*Risk factors for atherosclerotic disease:**

- |                      |                         |
|----------------------|-------------------------|
| Hypercholesterolemia | Cigarette smoking       |
| Hypertension         | Positive family history |
| Diabetes Mellitus    | Obesity                 |

## C-Statistic scores achieved in this study:

HEART: 0.83

TIMI: 0.75

GRACE: 0.70

## C-Statistic interpretation:

A score of “1.00” would mean the score predicts outcome with 100% perfection. A score of 0.50 is the same as a “50/50 coin toss.” A score of LESS THAN 0.50 means that the score predicts the opposite outcome.

# US HEART Score Validation

- 1,070 observation unit patients at Wake Forest
-  *Out performed clinician gestalt !*

Mahler et. al, Crit Path Cardiol, 2011

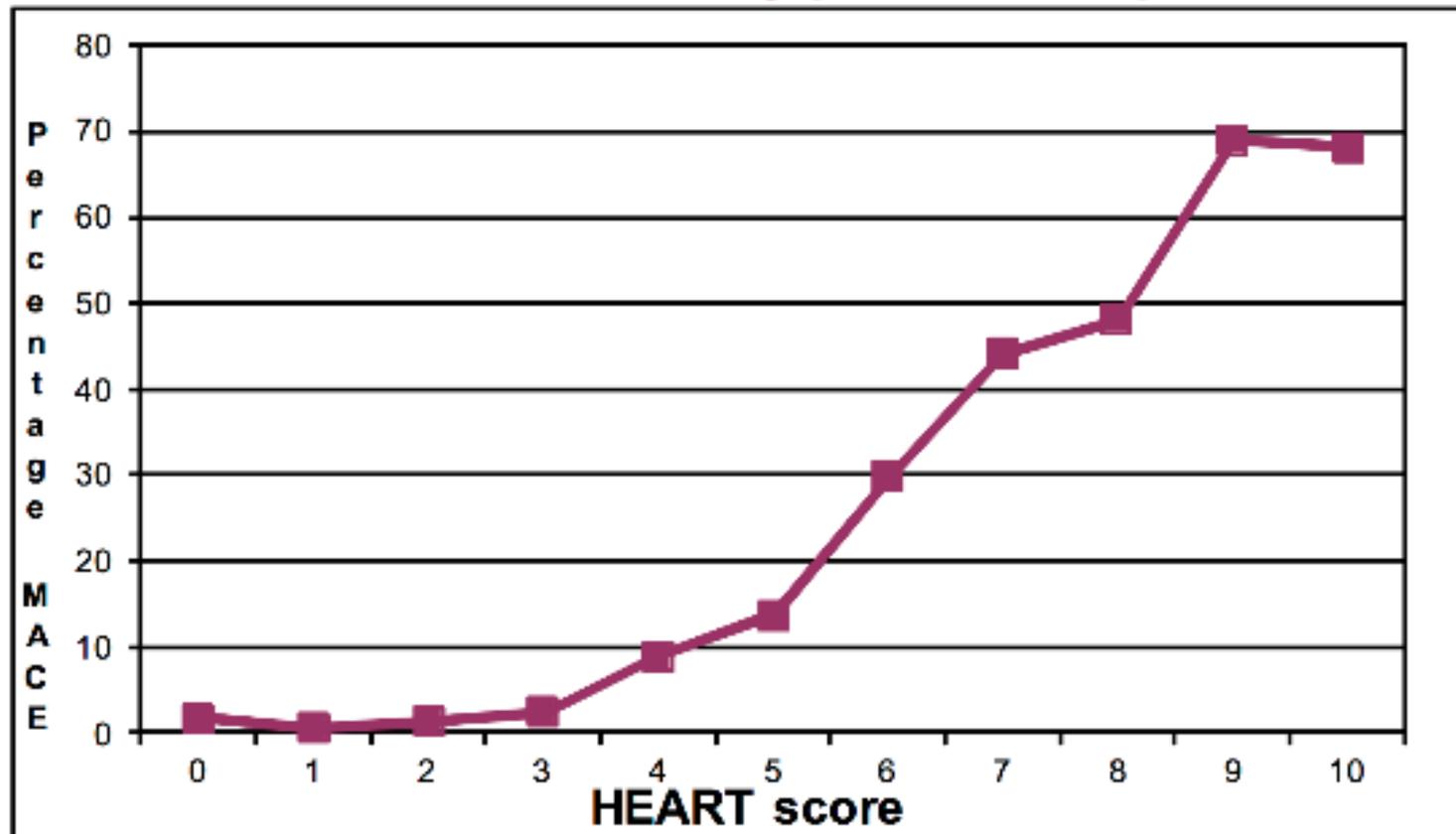
Mahler et. al, Int J Cardiol, 2013

# The HEART Score:

<b>Score</b>	<b>% pts</b>	<b>MACE/n</b>	<b>MACE</b>	<b>Death</b>	<b>Policy</b>
0-3	32%	38/1993	1.9%	0.05%	Discharge
4-6	51%	413/3136	13%	1.3%	Observation Risk management
7-10	17%	518/1045	50%	2.8%	Observation Treatment, CAG

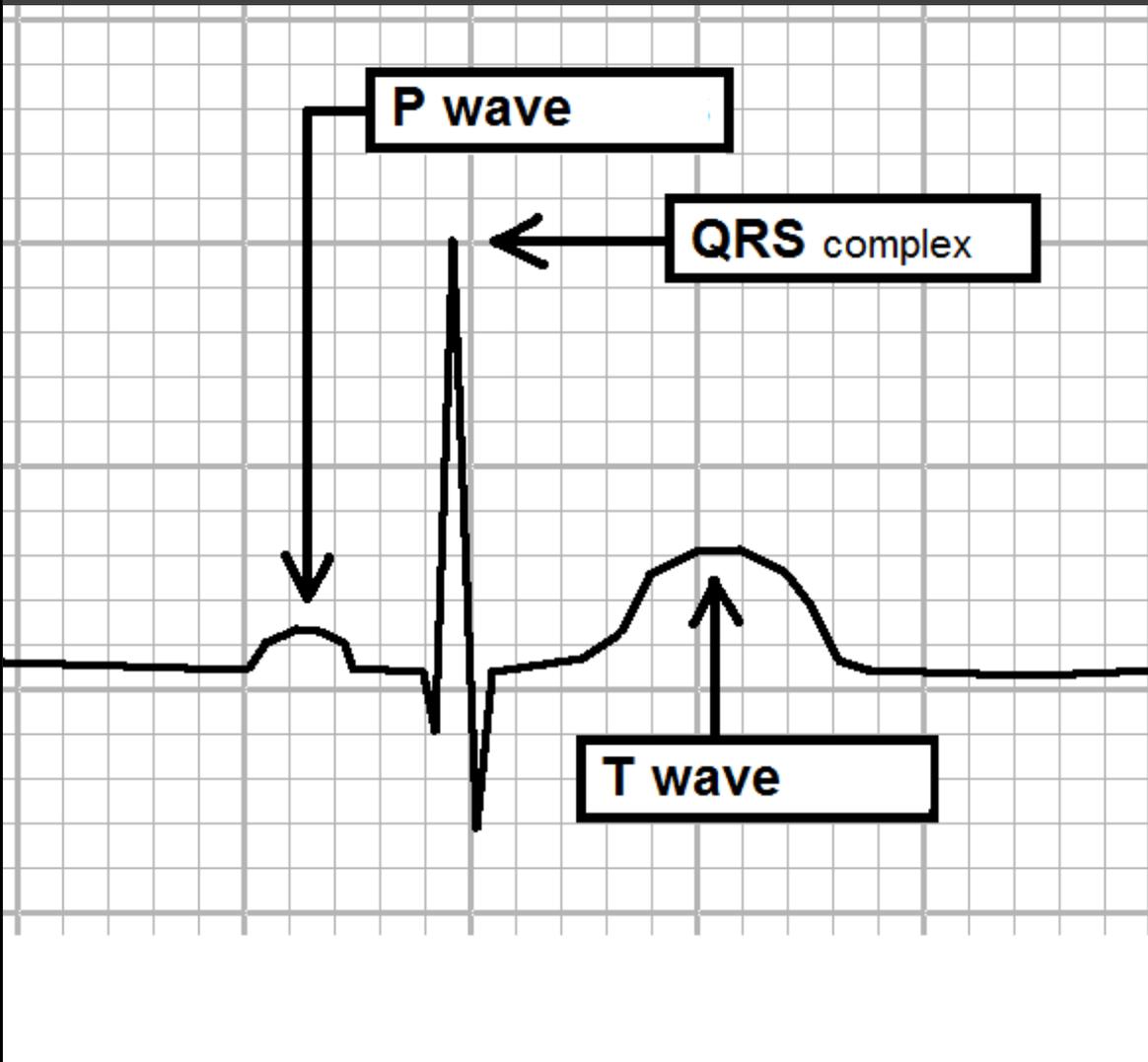
# Heart Score Reliability

## HEART score reliably predicts endpoints



# Myocardial Electrophysiology

# REVIEW of NORMAL ECG Waveforms:



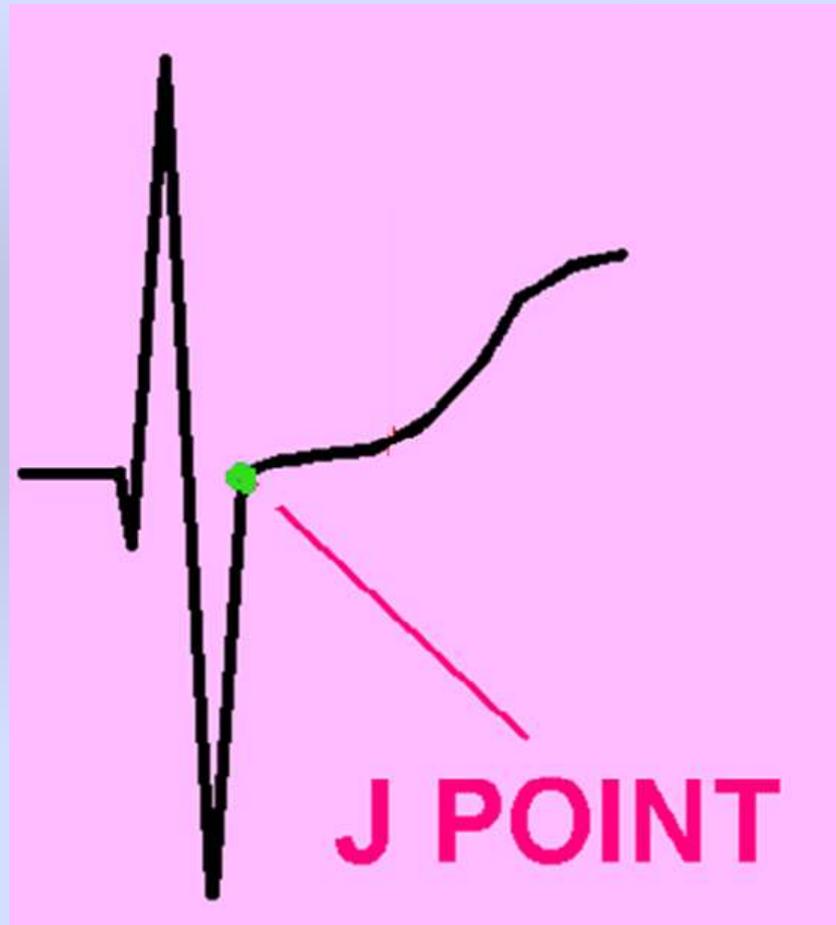
**P WAVE =**  
ATRIAL DEPOLARIZATION

**QRS COMPLEX =**  
VENTRICULAR  
DEPOLARIZATION  
(contracting)

**T WAVE =**  
VENTRICULAR  
REPOLARIZATION  
(recharging)

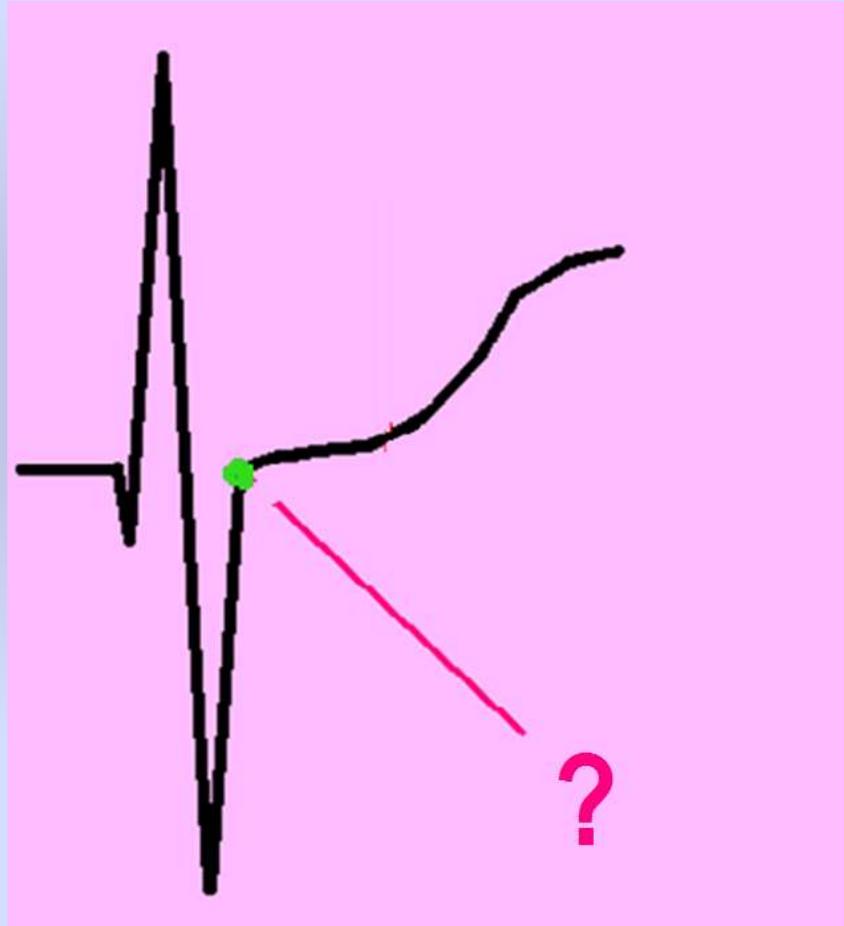
# The J Point

- The **J Point** is where the **QRS ends** and the **ST Segment Begins**.

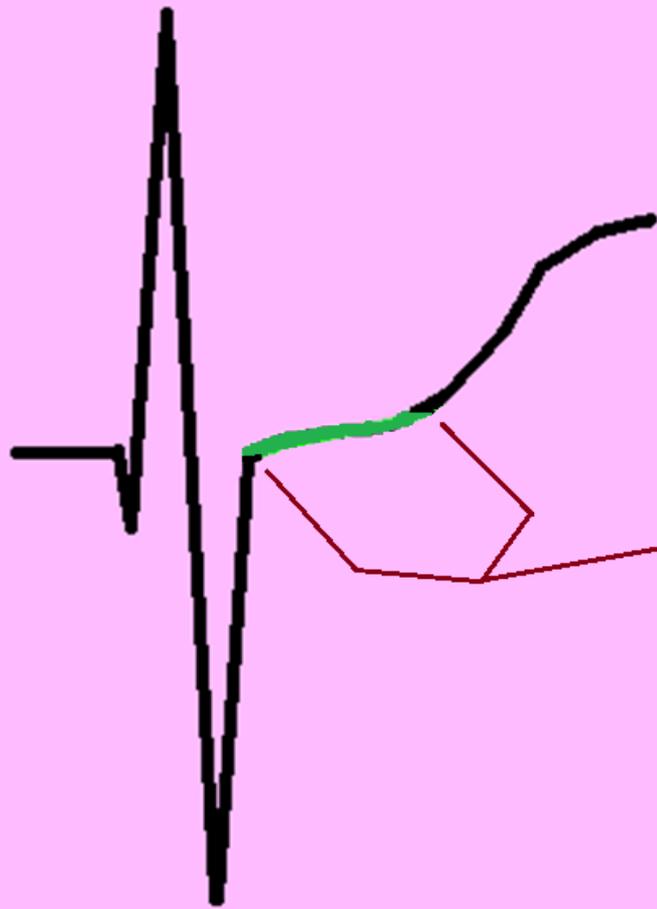


# The        ?

- The        is where the **QRS ends** and the **ST Segment Begins**.

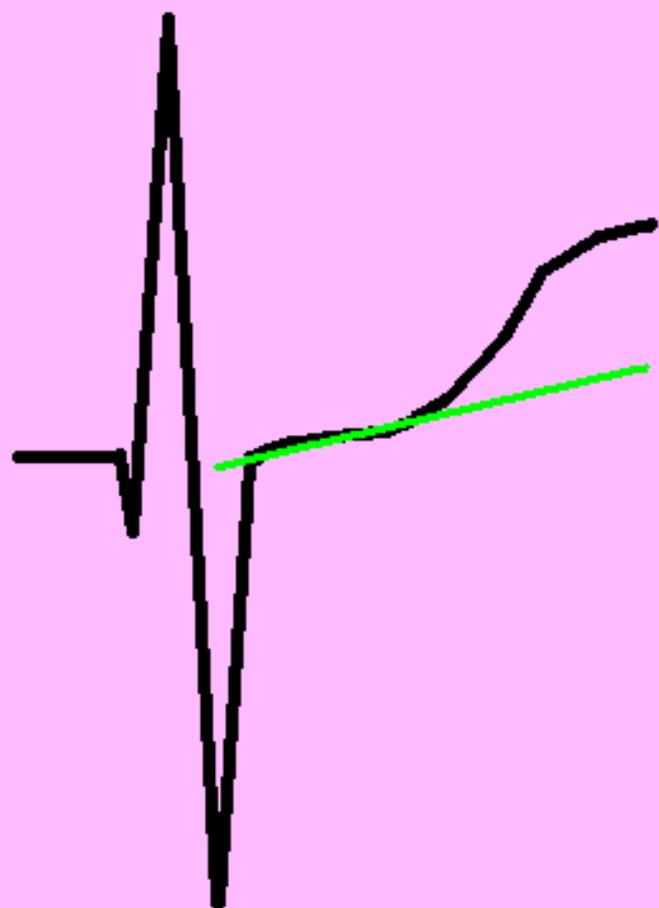


# THE S-T SEGMENT



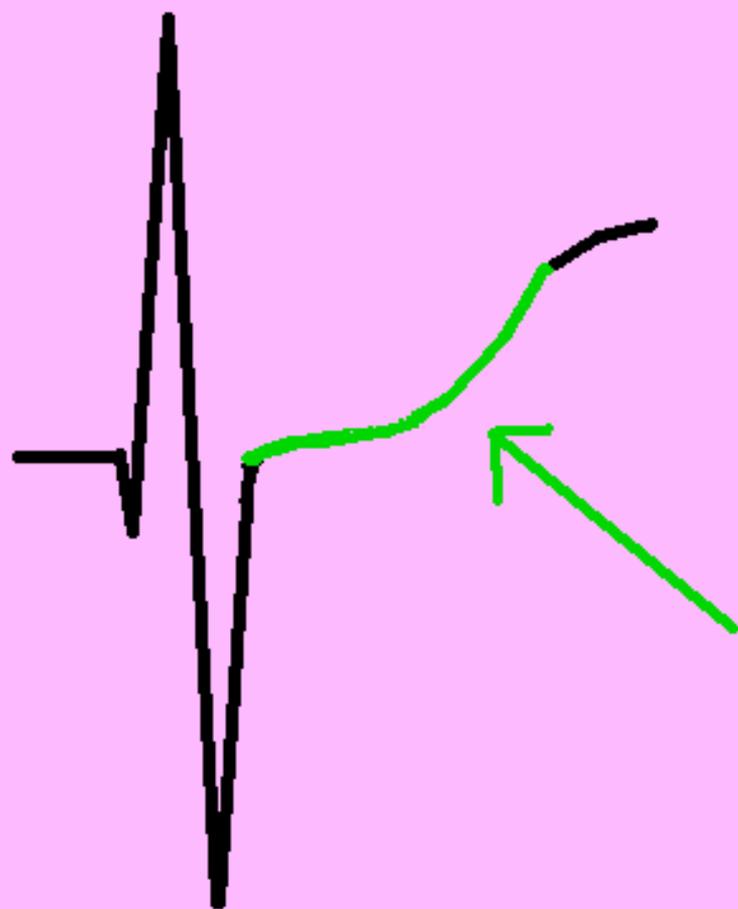
**Extends from the  
J POINT to the  
T Wave**

# THE S-T SEGMENT



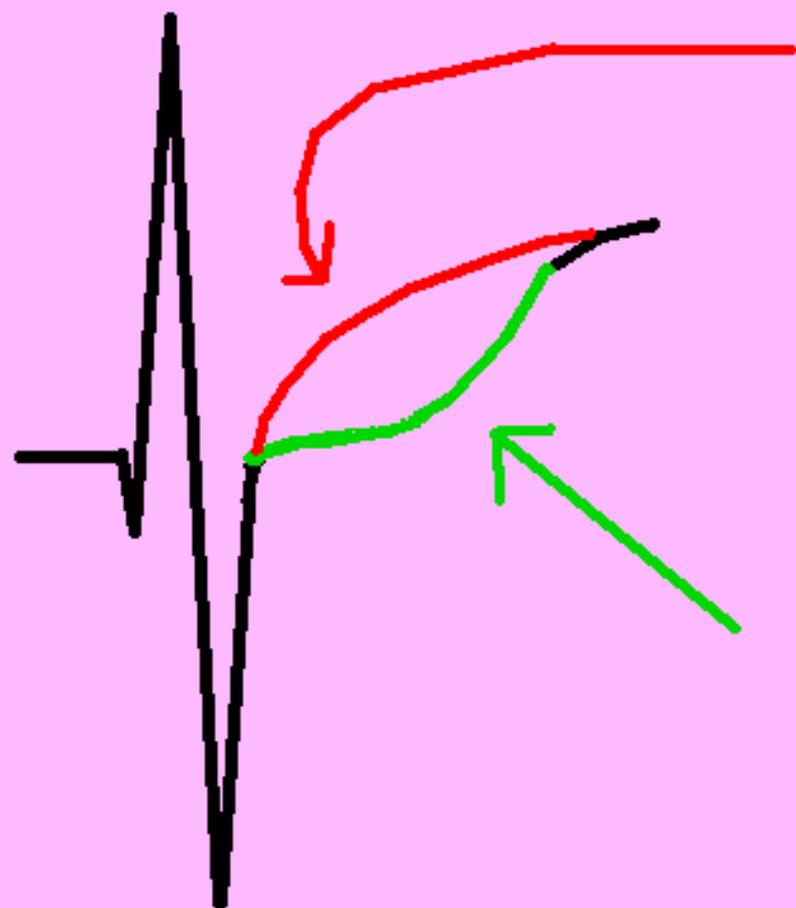
SHOULD HAVE  
A "SLIGHT POSITIVE"  
INCLINATION

# THE S-T SEGMENT



SHOULD BE  
"CONCAVE" IN  
SHAPE . . .

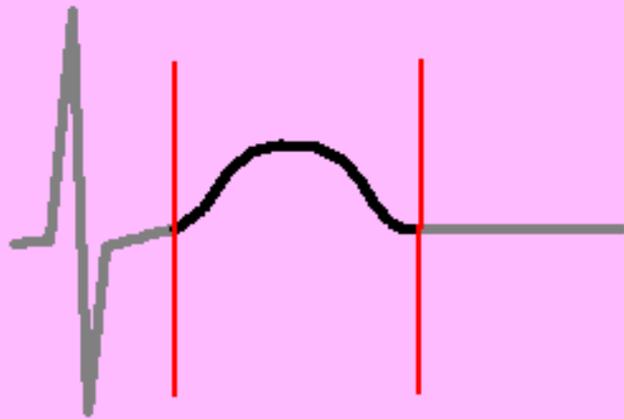
# THE S-T SEGMENT



AS OPPOSED TO  
"CONVEX" IN  
SHAPE

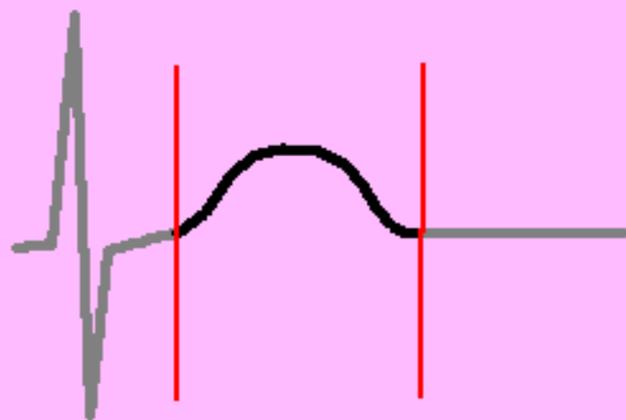
SHOULD BE  
"CONCAVE" IN  
SHAPE . . .

# THE T WAVE



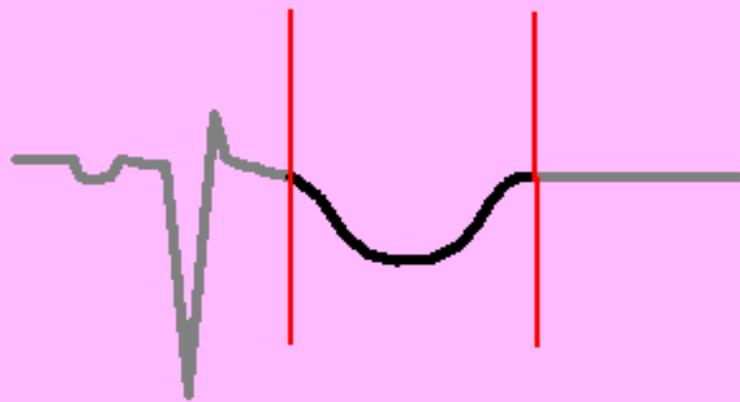
- SHOULD BE A "NICE," ROUNDED, CONVEX SHAPE
- SHOULD BE SYMMETRICAL

# THE T WAVE



- SHOULD BE A "NICE," ROUNDED, CONVEX SHAPE
- SHOULD BE SYMMETRICAL
- SHOULD BE UPRIGHT IN ALL LEADS, EXCEPT AVR

# THE T WAVE

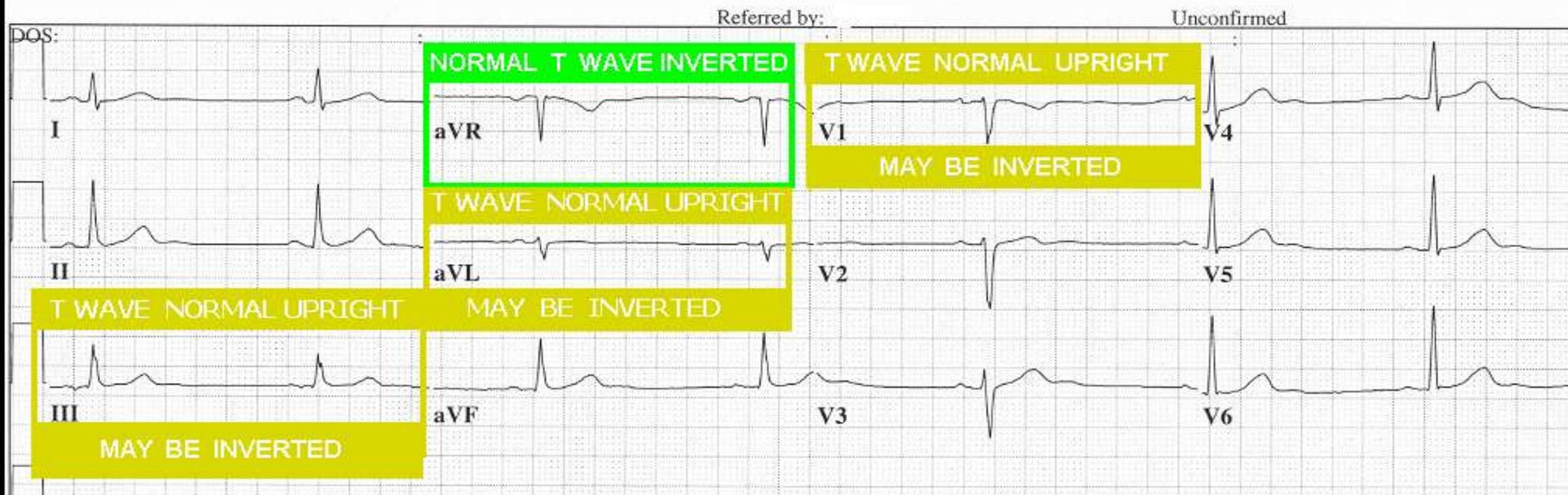


**LEAD  
AVR**

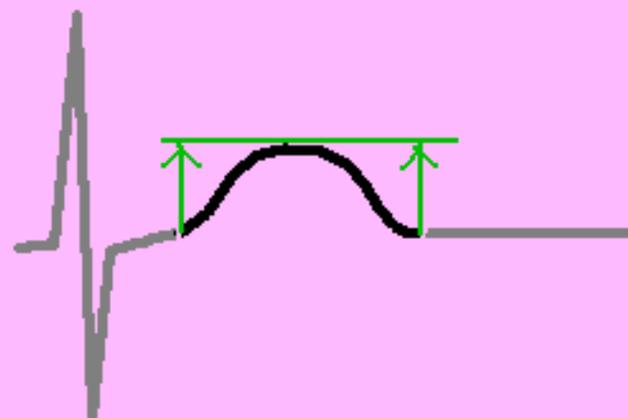
- **REMEMBER, IN LEAD AVR  
*EVERYTHING*  
IS  
"UPSIDE-DOWN"**

# Normal Variants: *T Wave Inversion*

Leads where the T WAVE may be  
**INVERTED:**



# THE T WAVE



## AMPLITUDE GUIDELINES:

- IN THE LIMB LEADS, SHOULD BE LESS THAN 1.0 mv ( 10 mm )
- IN THE PRECORDIAL LEADS, SHOULD BE LESS THAN 0.5 mv ( 5 mm )
- SHOULD NOT BE TALLER THAN R WAVE IN 2 OR MORE LEADS.

# The T Wave SHOULD NOT be:

- Inverted in TWO or more CONTIGUOUS LEADS
- Hyperacute (“Pointy” tipped)
- BiPhasic (half above and half below isoelectric line)

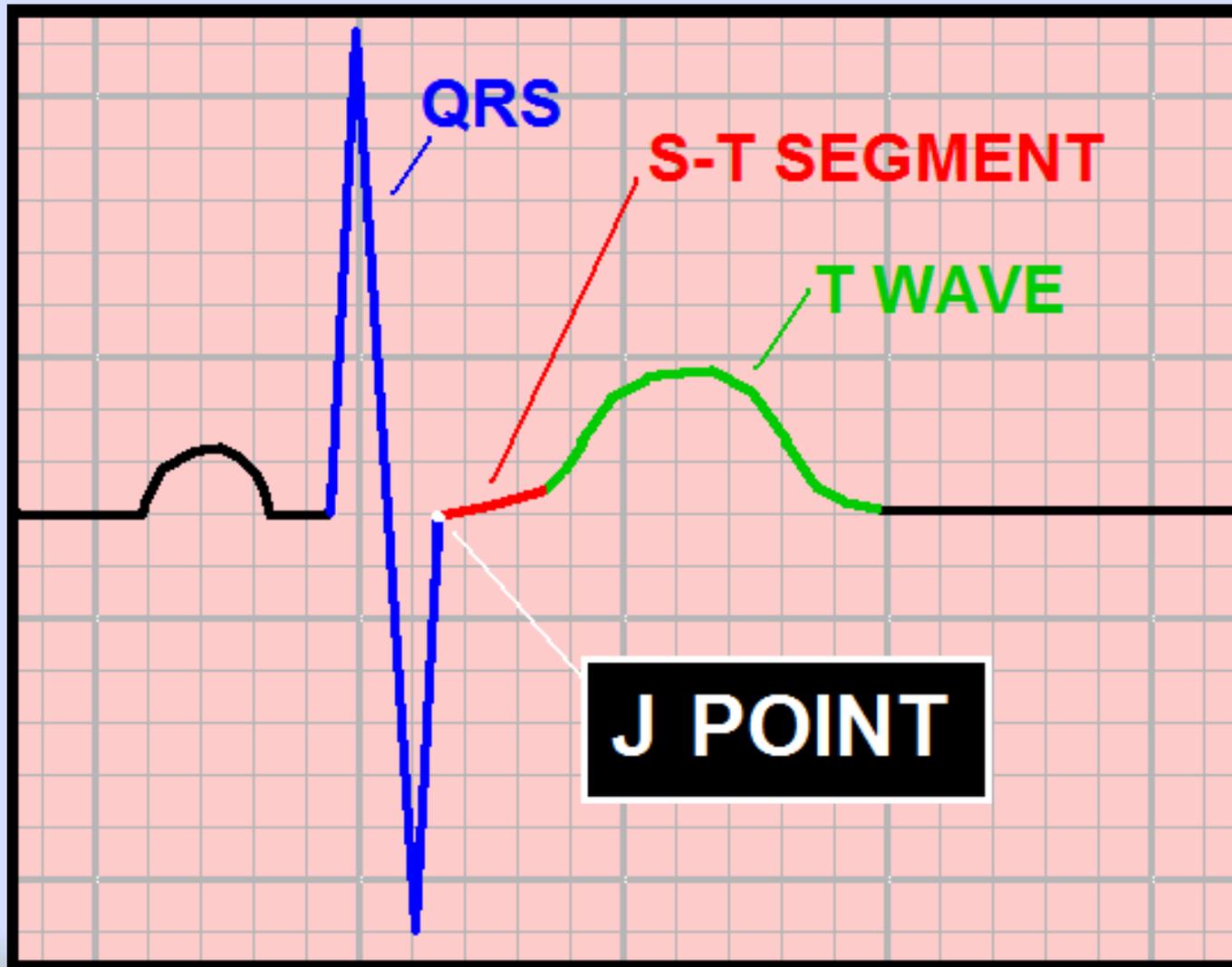
# The T Wave SHOULD NOT be:

- Inverted in \_\_\_\_\_ **CONTIGUOUS LEADS**
- \_\_\_\_\_ (“Pointy” tipped)
- \_\_\_\_\_ (half above and half below isoelectric line)

The next slide shows an ECG waveform with *normal* J Points, ST Segments and T waves.....

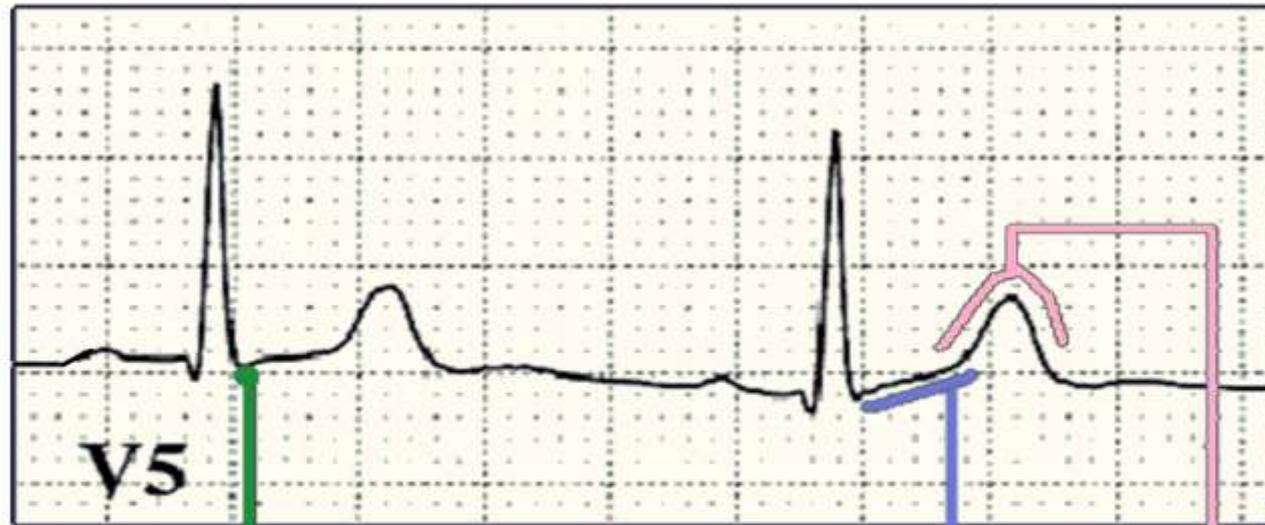
**THINK OF THIS AS YOUR “MEASURING STICK” of what a NORMAL ECG should look like !!!**

# The NORMAL ECG



# Patients with normal QRS duration ( QRS < 120 ms ) :

## ECG MARKERS of NORMAL PERFUSION



V5

J POINT ISOELECTRIC

ST SEGMENT: "MILD POSITIVE INCLINATION"

T WAVE: SAME POLARITY AS QRS

# ECG Indicators of NORMAL myocardial perfusion include:

- J Point isoelectric, or within 1mm of the ISOELECTRIC LINE
- ST Segment has a slight positive inclination where ST Segment and T Wave merge, the shape is CONCAVE (bowed downward).
- The T Wave is UPRIGHT (in all leads except for AVR), is not taller than the QRS, and is gently rounded (NOT “pointy”).

# ECG Indicators of NORMAL myocardial perfusion include:

- J Point isoelectric, or within \_\_\_\_\_ of the ISOELECTRIC LINE
- ST Segment has a slight \_\_\_\_\_ inclination where ST Segment and T Wave merge, the shape is \_\_\_\_\_ (bowed downward).
- The T Wave is \_\_\_\_\_ (in all leads except for AVR), is not taller than \_\_\_\_\_, and is \_\_\_\_\_ (NOT “pointy”).

**Q: If the previous slide showed what *normal* J Points, ST Segments and T waves look like, what is ABNORMAL ?**

**Q: If the previous slide showed what *normal* J Points, ST Segments and T waves look like, what is ABNORMAL ?**

**A: *EVERYTHING ELSE !!!***

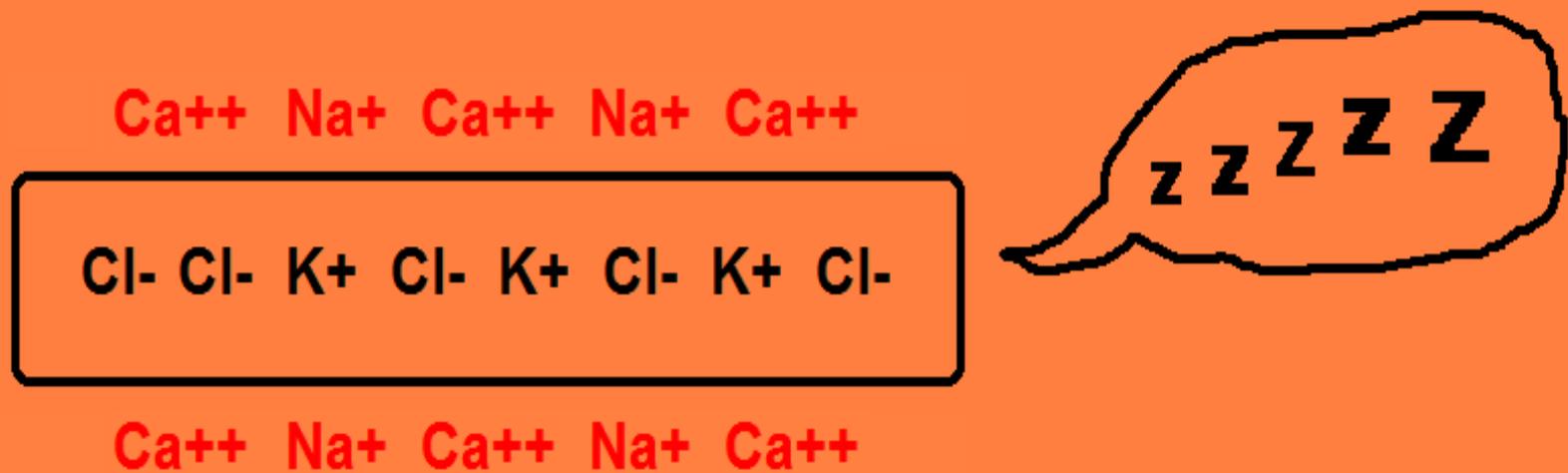
*(we get into many abnormal examples in Part 2, after lunch!)*

# Digging a Little Deeper . . .

- The cellular level: Ventricular Myocardial Cells

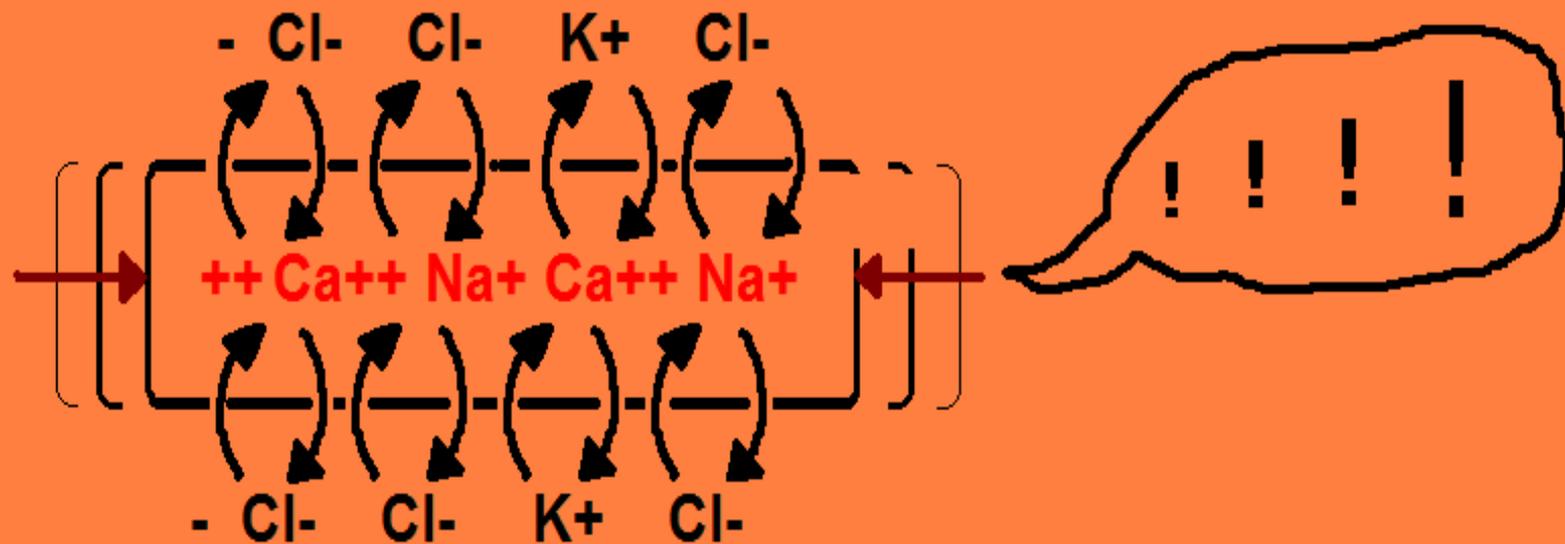
# CARDIAC ANATOMY and PHYSIOLOGY "101"

**CARDIAC CELLS AT REST** have **POSITIVE** charged IONS on the **OUTSIDE** of the cell membrane, and **NEGATIVE** charged IONS on the **INSIDE**



# CARDIAC ANATOMY and PHYSIOLOGY "101"

... when the IONS shift ... that is, the POSITIVE IONS that were on the outside TRADE PLACES with the NEGATIVE IONS that were on the INSIDE ....



... THE CELL CONTRACTS!

# CARDIAC ANATOMY and PHYSIOLOGY "101"

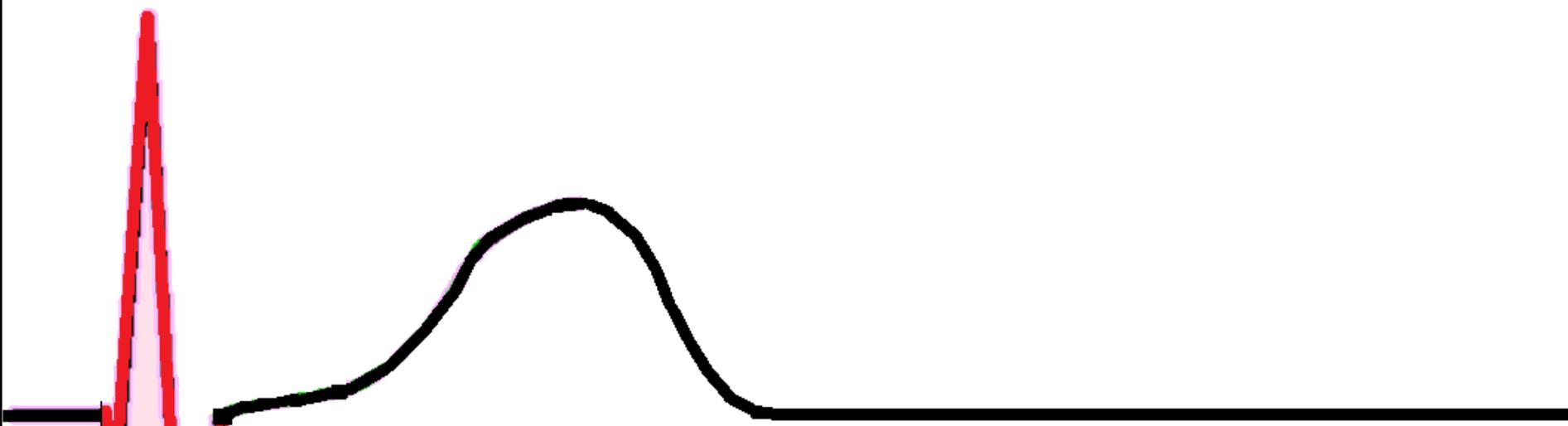
**THIS (OF COURSE) IS KNOWN AS . . .**

## **DEPOLARIZATION**

**WHEN EVERYTHING IS WORKING PROPERLY, THE WAVE OF DEPOLARIZING CELLS CAUSES THE HEART TO CONTRACT, AND PUMP BLOOD TO THE LUNGS AND THE SYSTEMIC CIRCULATION**

# **Depolarization** on the ECG:

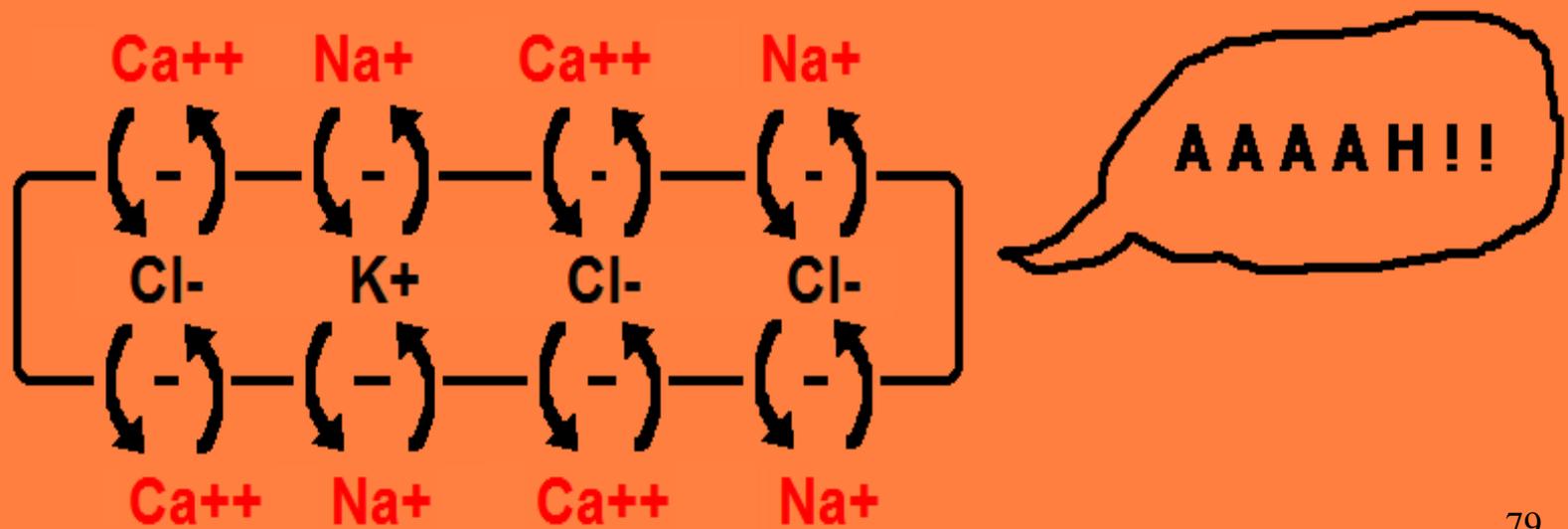
- Is represented by the **QRS Complex**



**QRS Complex = Ventricular Depolarization**

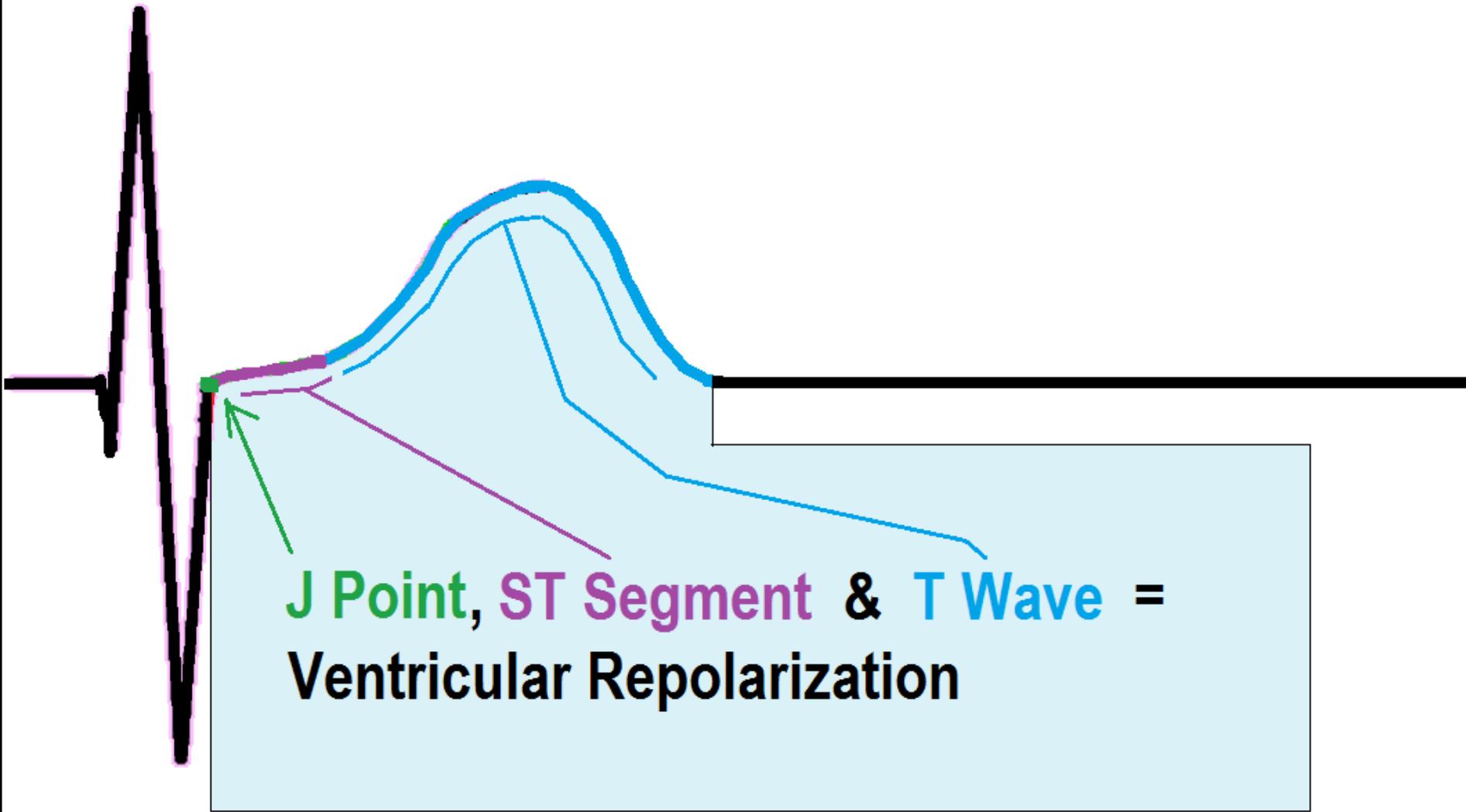
# CARDIAC ANATOMY and PHYSIOLOGY "101"

AFTER DEPOLARIZATION, THE CELLS RELAX.  
THE IONS RETURN TO THEIR ORIGINAL POSITIONS --  
THIS PROCESS IS KNOWN AS **REPOLARIZATION**



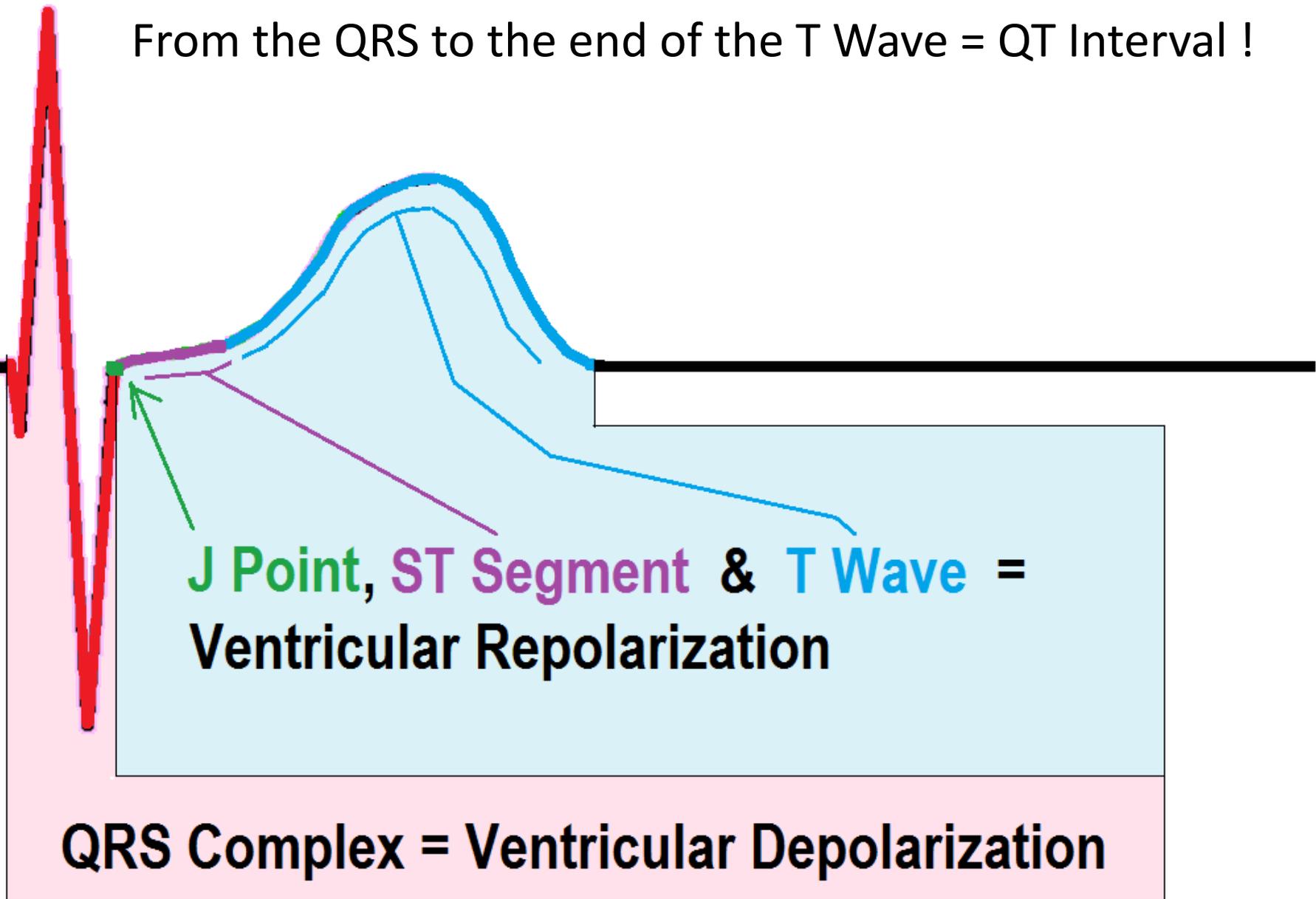
# **Repolarization** on the ECG:

- Is represented by the:
  - **J Point**
  - **ST Segment**
  - **T Wave**



**J Point, ST Segment & T Wave =  
Ventricular Repolarization**

From the QRS to the end of the T Wave = QT Interval !



**J Point, ST Segment & T Wave =  
Ventricular Repolarization**

**QRS Complex = Ventricular Depolarization**

# CARDIAC ANATOMY and PHYSIOLOGY "101"

## VENTRICULAR MUSCLE CELL ACTION POTENTIAL

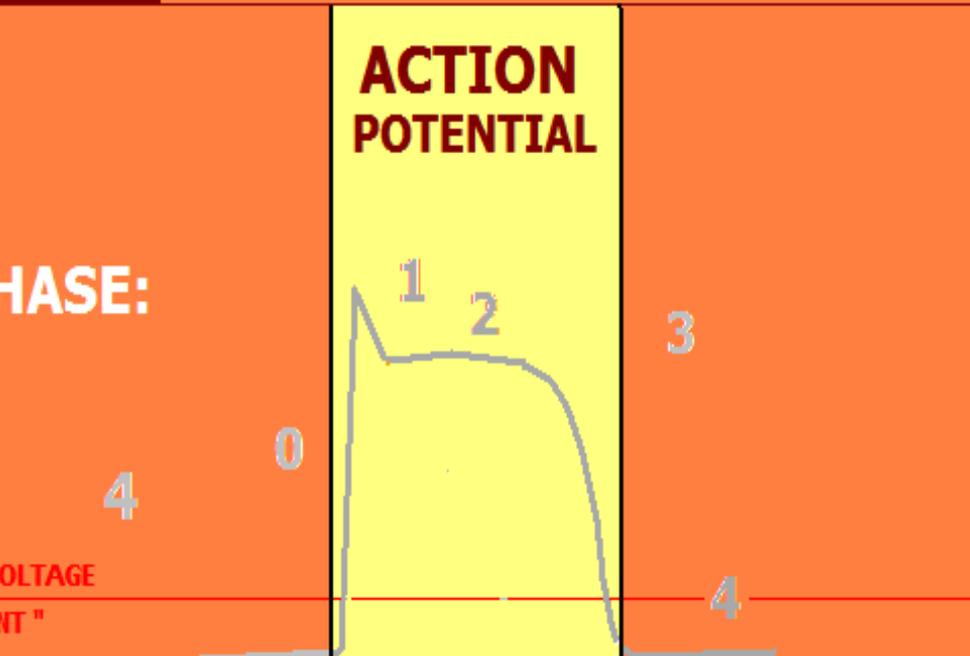
PHASE:

**ACTION  
POTENTIAL**

**CELL " STATUS: "**

- 4 • CELL REPOLARIZED
- -80 to -90 mV CHARGE
- SLIGHT " LEAKAGE " OF IONS
- 0 • RAPID INFLUX OF + CHARGED SODIUM IONS
- CELL DEPOLARIZATION
- 1 • SODIUM EXITS CELL
- REPOLARIZATION BEGINS
- 2 • CALCIUM IONS CONTINUE TO ENTER CELL
- 3 • CALCIUM CHANNELS CLOSE

THRESHOLD VOLTAGE  
" TRIGGER POINT "



ECG

QT



**THE ACTION POTENTIAL  
( OF VENTRICULAR MUSCLE CELLS )  
IS ROUGHLY EQUAL TO  
THE Q - T INTERVAL** 83

# ECG Intervals:

# P-R Interval

- The P-R Interval should be between **120-200ms**, (which is 3 – 5 little squares).



# P-R Interval

- The P-R Interval should be between      -      **ms**, (which is 3 – 5 little squares).



# QRS Duration (width):

- The Normal QRS should be NO WIDER than **120ms** (3 little squares).



# QRS Duration (width):

- The Normal QRS should be NO WIDER than ms (3 little squares).



# QRS Duration (width):

- If the QRS is WIDER than 120ms, it indicates the VENTRICLES are **DEPOLARIZING ABNORMALLY.**
- If the Ventricles are DEPolarizing ABNORMALLY, it causes them to **REPOLARIZE ABNORMALLY.**

# QRS Duration (width):

- If the QRS is WIDER than 120ms, it indicates the VENTRICLES are \_\_\_\_\_  
\_\_\_\_\_.
- If the Ventricles are DEPOLARIZING ABNORMALLY, it causes them to \_\_\_\_\_.

# QRS Duration (width):

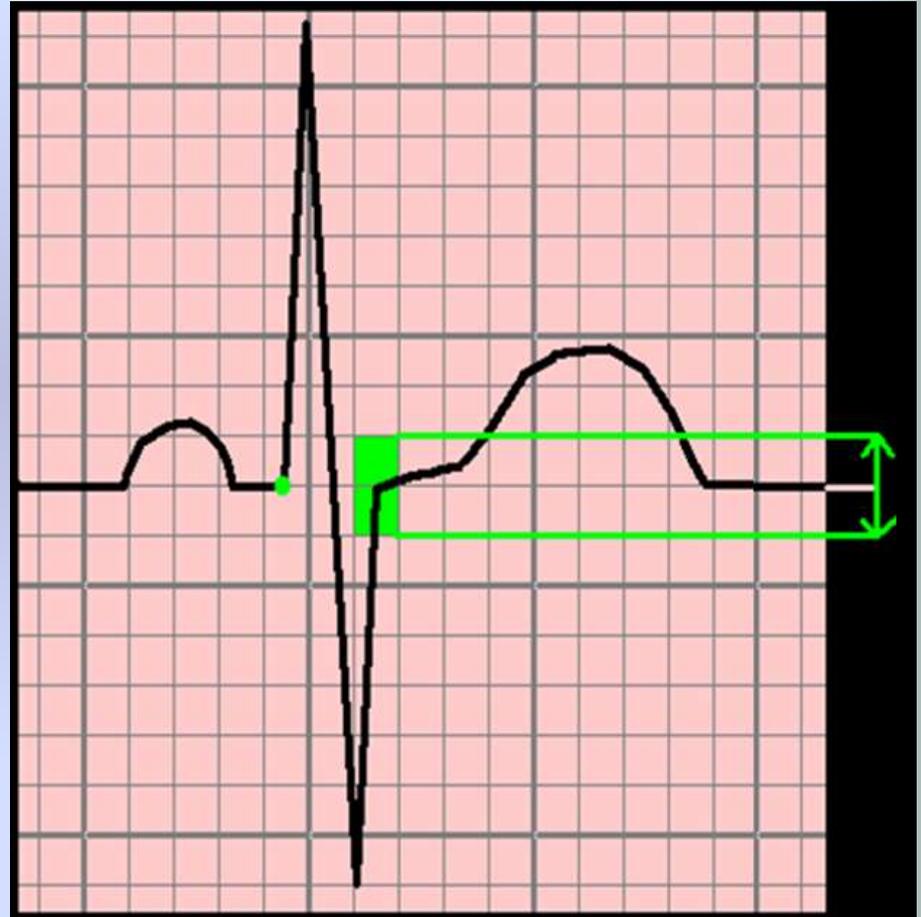
- When the **VENTRICLES REPOLARIZE ABNORMALLY** due to the QRS being TOO WIDE, it often causes **CHANGES to the:**
  - J Point
  - ST Segment
  - T Wave
- These changes are known as Secondary Repolarization Abnormalities.

# QRS Duration (width):

- When the **VENTRICLES REPOLARIZE ABNORMALLY** due to the QRS being TOO WIDE, it often causes **CHANGES to the:**
  - \_\_\_\_\_
  - \_\_\_\_\_
  - \_\_\_\_\_
- These changes are known as Secondary Repolarization Abnormalities.

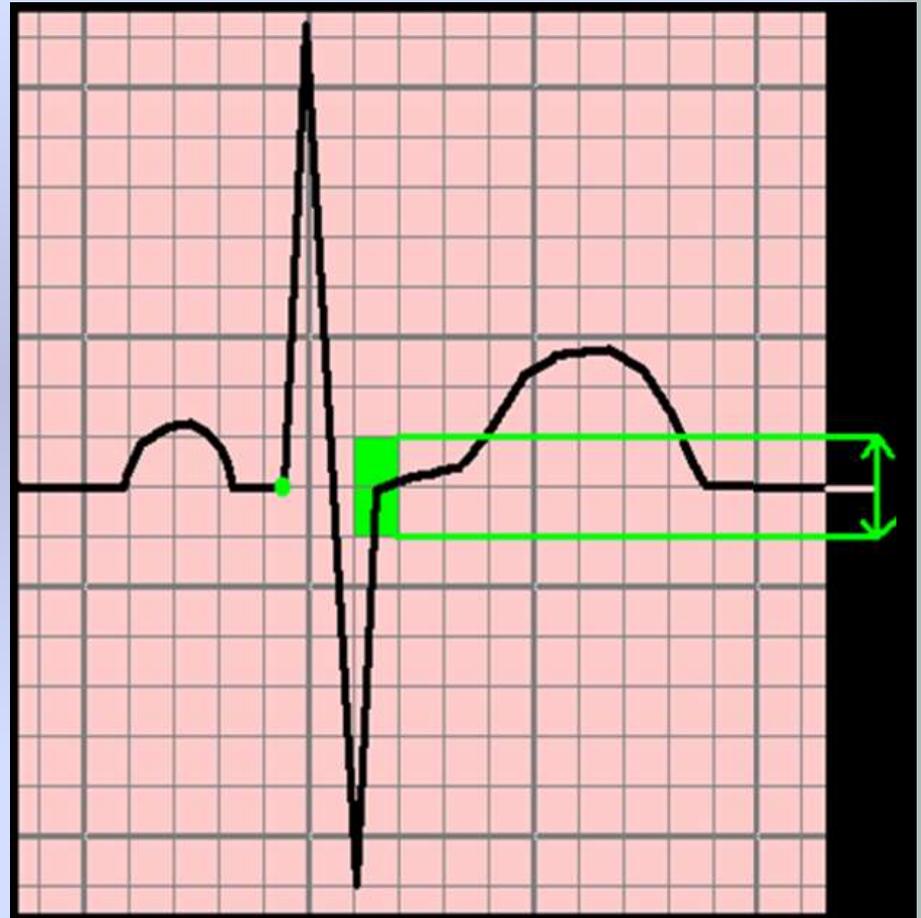
# The J Point

The **J Point** should be **WITHIN 1mm** of the **ISOELECTRIC LINE** (in *most, but not all* Leads).



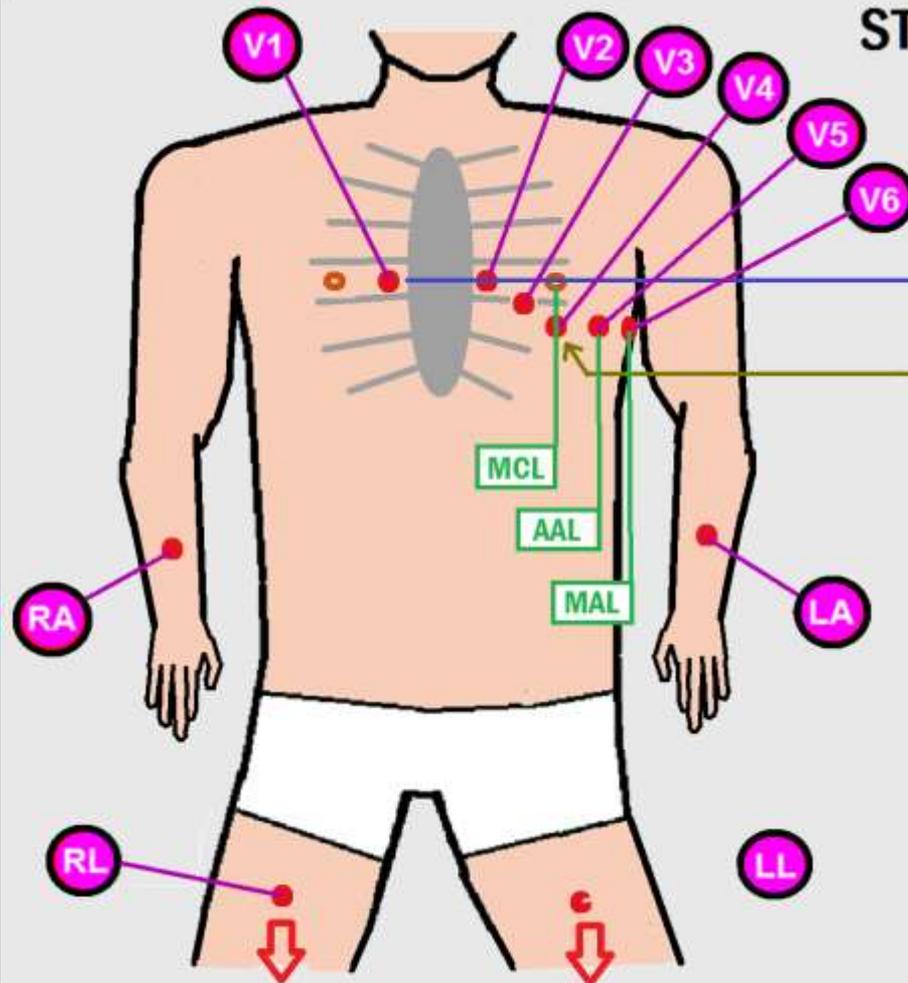
# The J Point

The **J Point** should be **WITHIN \_\_\_\_\_** of the **ISOELECTRIC LINE** (in *most, but not all* Leads).



# 12 Lead ECG: Proper Lead Placement

# Obtaining the 12 Lead ECG



## STANDARD LEAD PLACEMENT --- 12 LEAD ECG

4 th INTERCOSTAL SPACE

V4 is at 5th INTERCOSTAL SPACE. V5 & V6 are on the SAME HORIZONTAL PLANE.

- PATIENT SHOULD LAY AS FLAT AS POSSIBLE
- LIMB LEADS SHOULD BE PLACED AS DISTALLY AS POSSIBLE

# Obtaining the 12 Lead ECG

- **Limb leads should be on the limbs.**

# Obtaining the 12 Lead ECG

- **Limb leads should be on the limbs.**
  - **To minimize muscular artifact, place leads over bone (e.g. Tibia) or places with minimal muscle (palmar aspect [underside] of wrist)**

# Obtaining the 12 Lead ECG

Recent AHA/ACC/HRS literature indicates QRS AMPLITUDE, Q WAVE DURATION, AXIS and WAVEFORM DEFLECTION can be altered when limb leads are placed on the patient's torso (Mason-Likar lead placement).

*Therefore every effort should be made to place limb leads on the limbs.*

# AHA/ACC/HRS Scientific Statement

## Recommendations for the Standardization and Interpretation of the Electrocardiogram Part I: The Electrocardiogram and Its Technology

affected by monitoring lead placement; however, tracings that use torso electrodes differ in important ways from the standard 12-lead ECG. In addition to body position differences that affect the ECG,<sup>109</sup> monitoring electrodes placed on the trunk do not provide standard limb leads, and distortion of the central terminal alters the augmented limb leads and the precordial leads.<sup>110,111</sup> Tracings with Mason-Likar and other alternative lead placement may affect QRS morphology more than repolarization compared with the standard ECG; these differences can include false-negative and false-positive infarction criteria.<sup>81,112</sup> Motion artifact of the limbs is a particular problem for routine recording in neonates, infants, and

# AHA/ACC/HRS Scientific Statement

## Recommendations for the Standardization and Interpretation of the Electrocardiogram Part I: The Electrocardiogram and Its Technology

### *Recommendations*

ECGs recorded with torso placement of the extremity electrodes cannot be considered equivalent to standard ECGs for all purposes and should not be used interchangeably with standard ECGs for serial comparison. Evaluation of the effect of torso placement of limb leads on waveform amplitudes and

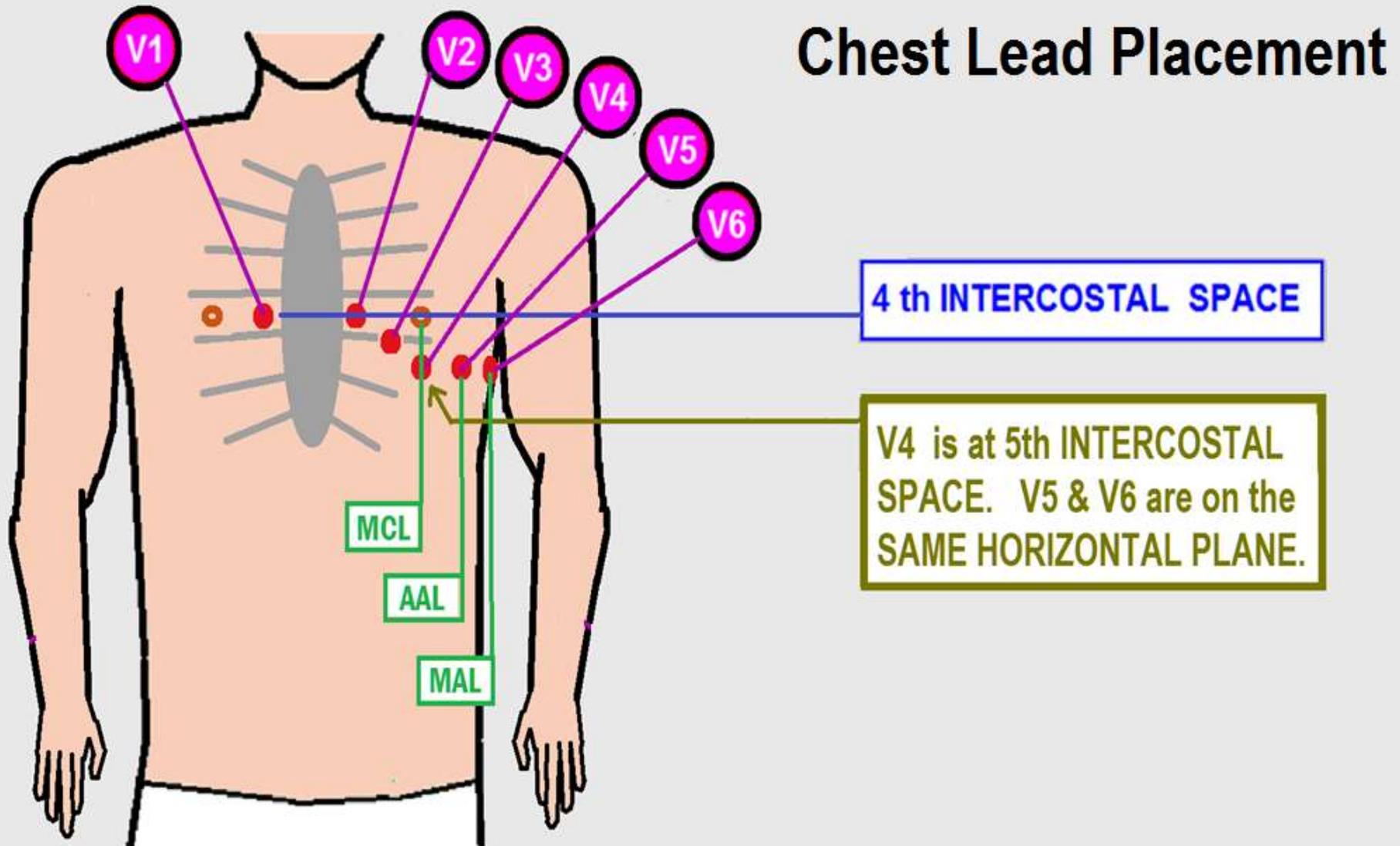
# Obtaining the 12 Lead ECG

- Limb leads should be placed on the limbs.
- When emergency circumstances dictate that limb leads be placed on patient's torso, the words "LIMB LEADS ON PATIENT'S TORSO" should be noted on the ECG.

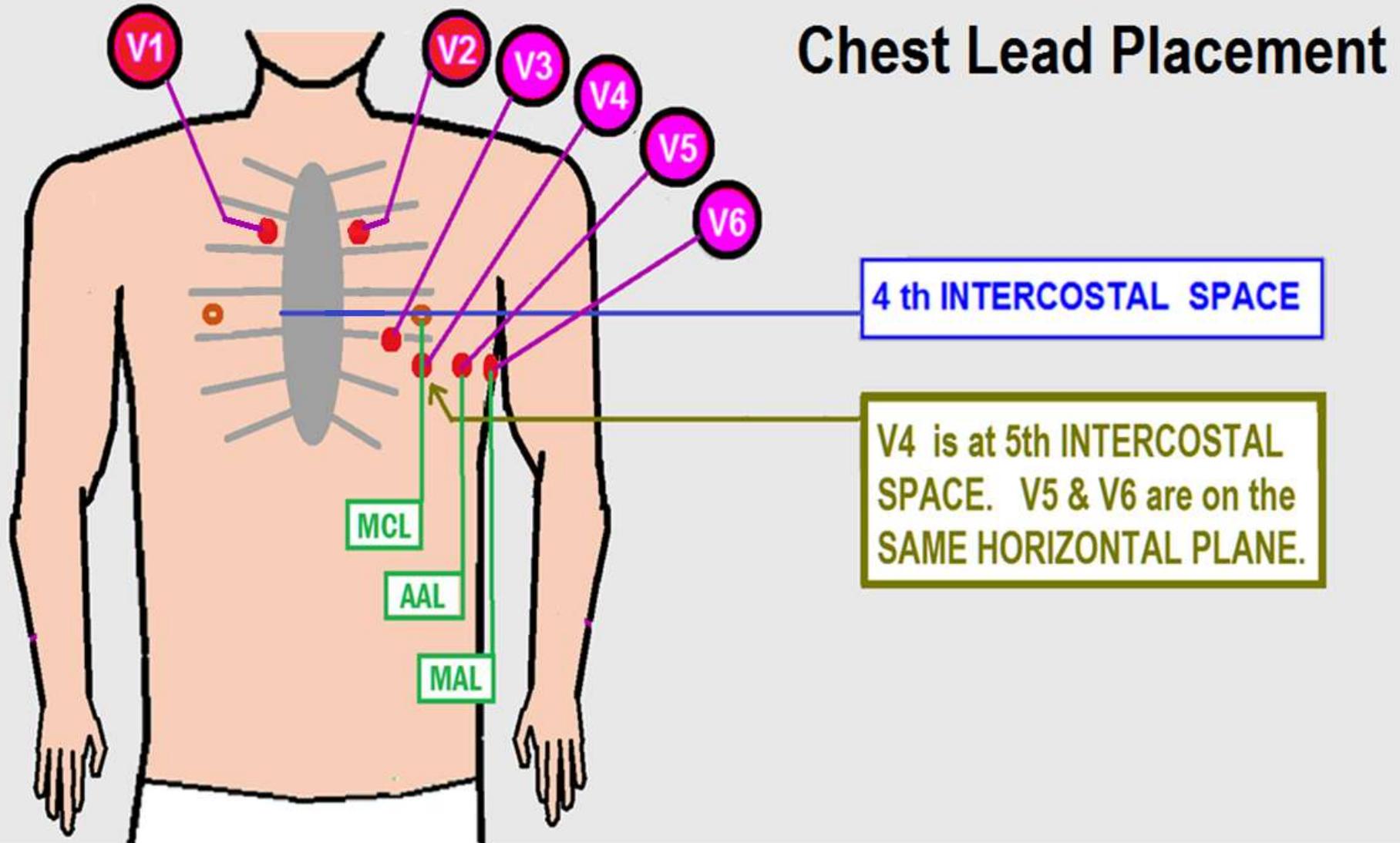
# Obtaining the 12 Lead ECG

- Limb leads should be placed \_\_\_\_\_.
- When emergency circumstances dictate that limb leads be placed on patient's torso, the words “ \_\_\_\_\_ ” should be noted on the ECG.

# CORRECT Lead placement:



# INCORRECT Lead placement:



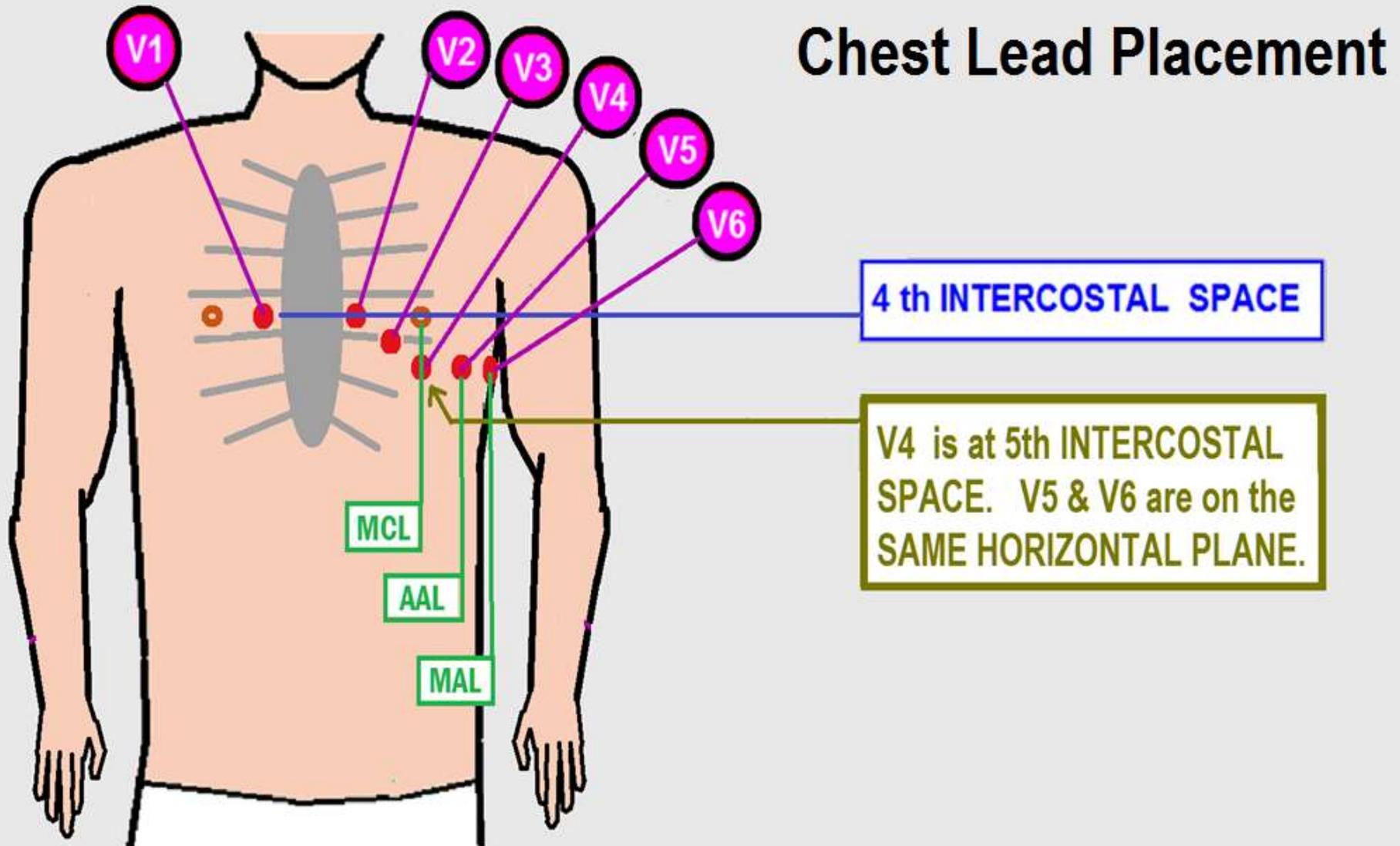
# AHA/ACC/HRS Scientific Statement

## Recommendations for the Standardization and Interpretation of the Electrocardiogram

### Part I: The Electrocardiogram and Its Technology

the often profound alterations in waveforms that can result from precordial electrode misplacement.<sup>85,86</sup> A common error is superior misplacement of  $V_1$  and  $V_2$  in the second or third intercostal space. This can result in reduction of initial R-wave amplitude in these leads, approximating 0.1 mV per interspace, which can cause poor R-wave progression or erroneous signs of anterior infarction.<sup>87</sup> Superior displacement of the  $V_1$  and  $V_2$  electrodes will often result in rSr' complexes with T-wave inversion, resembling the complex in lead aVR. It also has been shown that in patients with low diaphragm position, as in obstructive pulmonary disease,<sup>88,89</sup>

# CORRECT Lead placement:



DOB [REDACTED] 75 Years

Female

(2)

Rate 76 Sinus rhythm.....normal P axis, V-rate 50-99

PR 161  
QRSD 90  
QT 350  
QTc 394

TECH SD

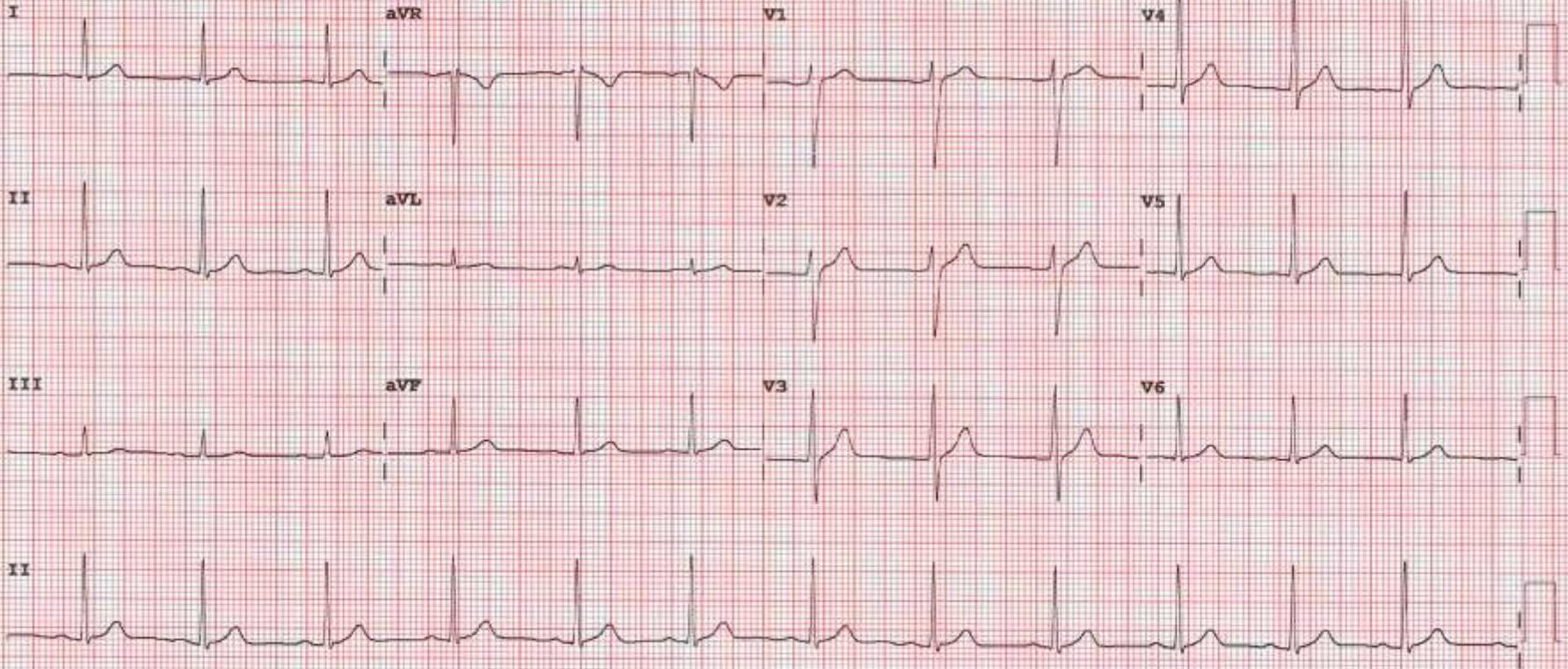
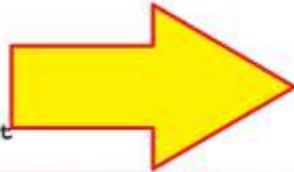
--AXIS--

P 50  
QRS 51  
T 44

- NORMAL ECG -

12 Lead; Standard Placement

Unconfirmed Diagnosis



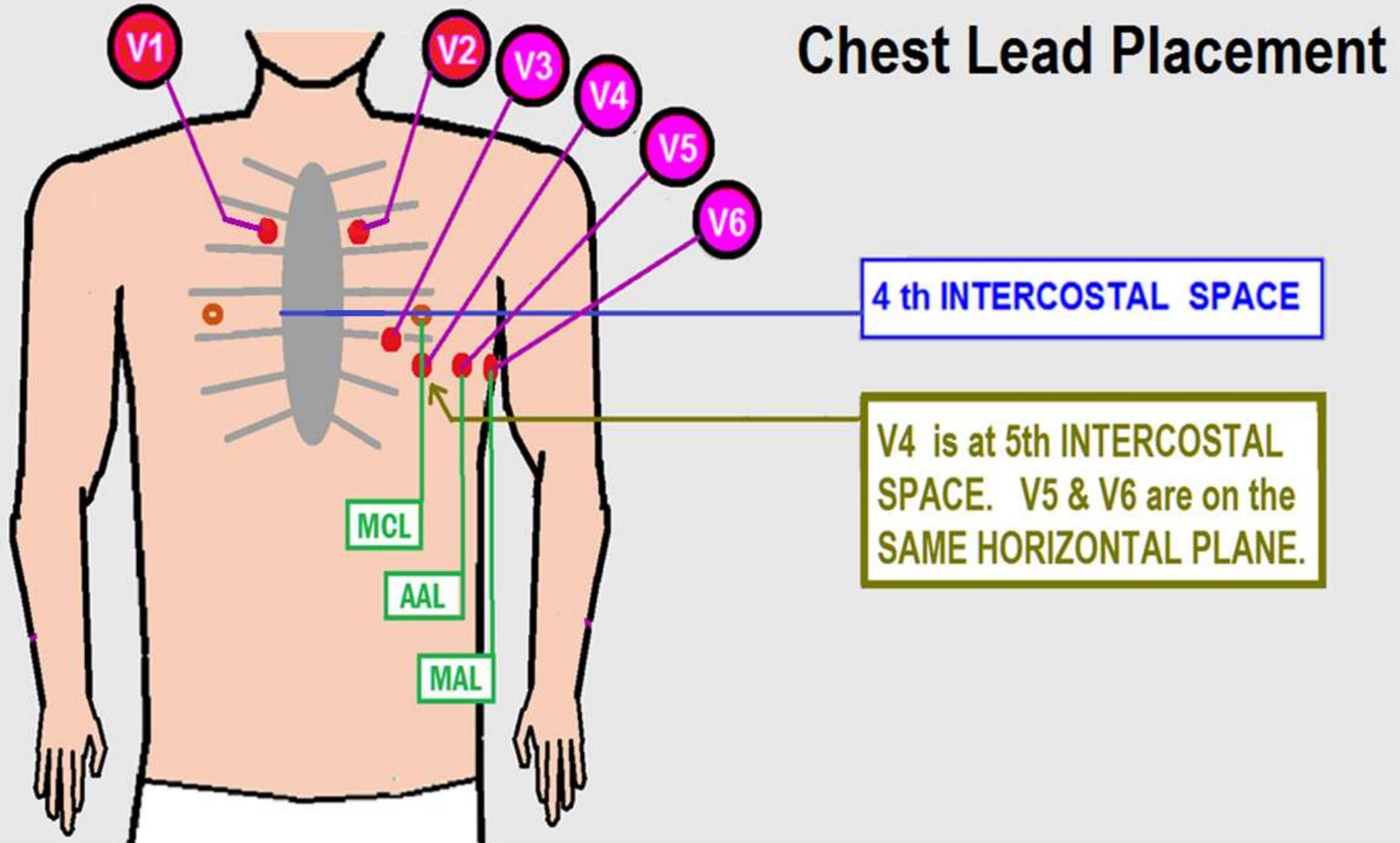
Device: Speed: 25 mm/sec Limb: 10 mm/mV Chest: 10.0 mm/mV

F 60- 0.15-100 Hz

100B CL

P?

# INCORRECT Lead placement:



DOB [REDACTED] 1988 30 Years

Female

5:20:58 AM

(1)

Rate 89 Sinus rhythm.....normal P axis V-rate 50- 99  
 Anteroseptal infarct, age indeterminate.....Q >35ms  
 PR 157  
 QRSD 96  
 QT 365  
 QTc 445

3NE

Tab

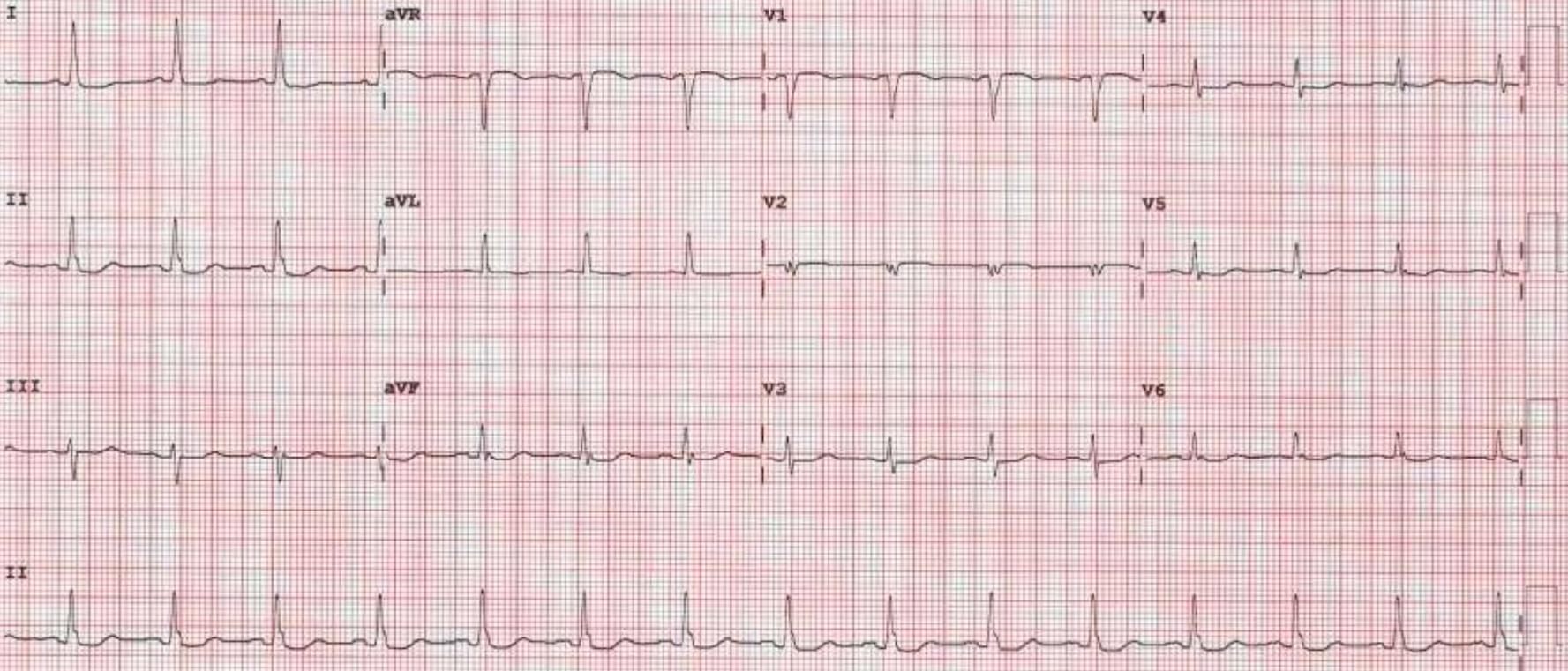
--AXIS--

P 46  
 QRS 24  
 T 86

- ABNORMAL ECG -

12 Lead; Standard Placement

Unconfirmed Diagnosis



Device

Speed: 25 mm/sec

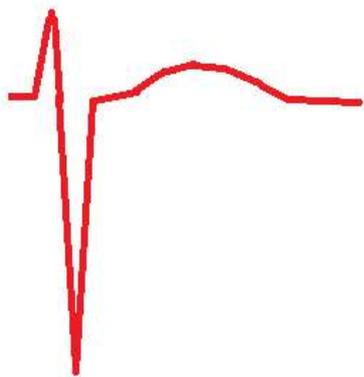
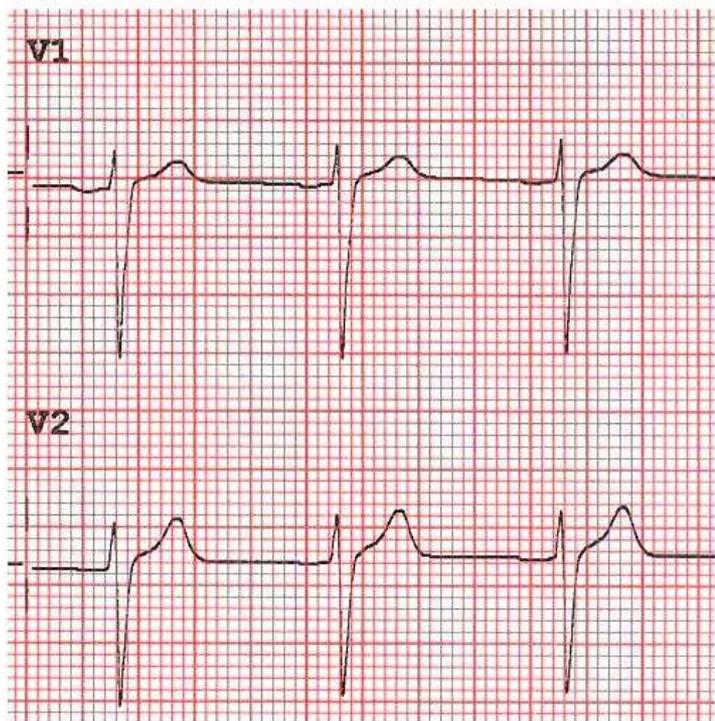
Limb: 10 mm/mV

Chest: 10.0 mm/mV

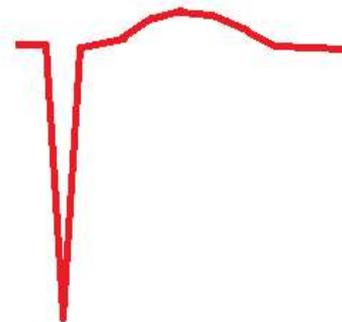
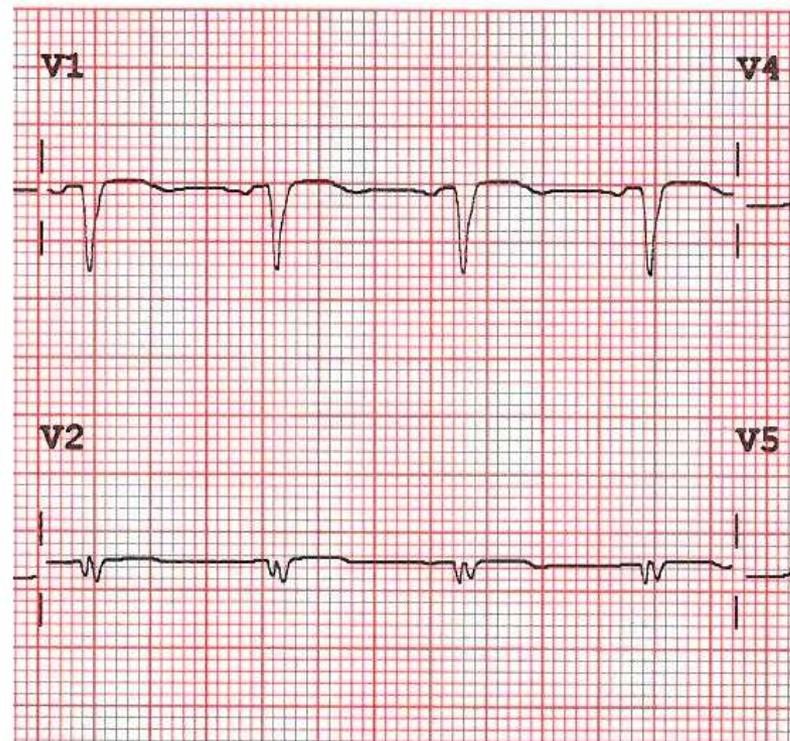
F 60~ 0.15-100 Hz

1^1^8 CL

P?



**RS = NO old MI**



**QS = old MI**

# Leads V1 & V2 on 12 Lead ECG:

- Proper lead placement of precordial Leads V1 and V2 are 4th intercostal space on opposite sides of the sternum.
- Incorrect placement of Leads V1 and V2 will result in *the presence of Q Waves* (indicator of necrosis) leading to misdiagnosis of previous anterior / septal infarction.

# Leads V1 & V2 on 12 Lead ECG:

- Proper lead placement of precordial Leads V1 and V2 are \_\_\_\_\_ on opposite sides of the sternum.
- Incorrect placement of Leads V1 and V2 will result in *the presence of Q Waves* (indicator of necrosis) **leading to misdiagnosis of** \_\_\_\_\_.

# The New England Medical Journal



# The 12 Lead ECG . . .

40years

Male Caucasian

Room:

Opt:

Vent. rate 65 bpm

PR interval 192 ms

QRS duration 104 ms

QT/QTc 362/376 ms

P-R-T axes 39 0 23

Normal sinus rhythm

Normal ECG

# NORMAL 12 LEAD ECG

6 LIMB LEADS - view the vertical axis

6 PRECORDIAL LEADS - view the horizontal axis

← 3 SECONDS →

D.O.S.: Tbs1

Referred by:

Reviewed by:

LEAD I

LEAD AVR

LEAD V1

LEAD V4

LEAD II

LEAD AVL

LEAD V2

LEAD V5

LEAD III

LEAD AVF

LEAD V3

LEAD V6

LEAD V1

LEAD II

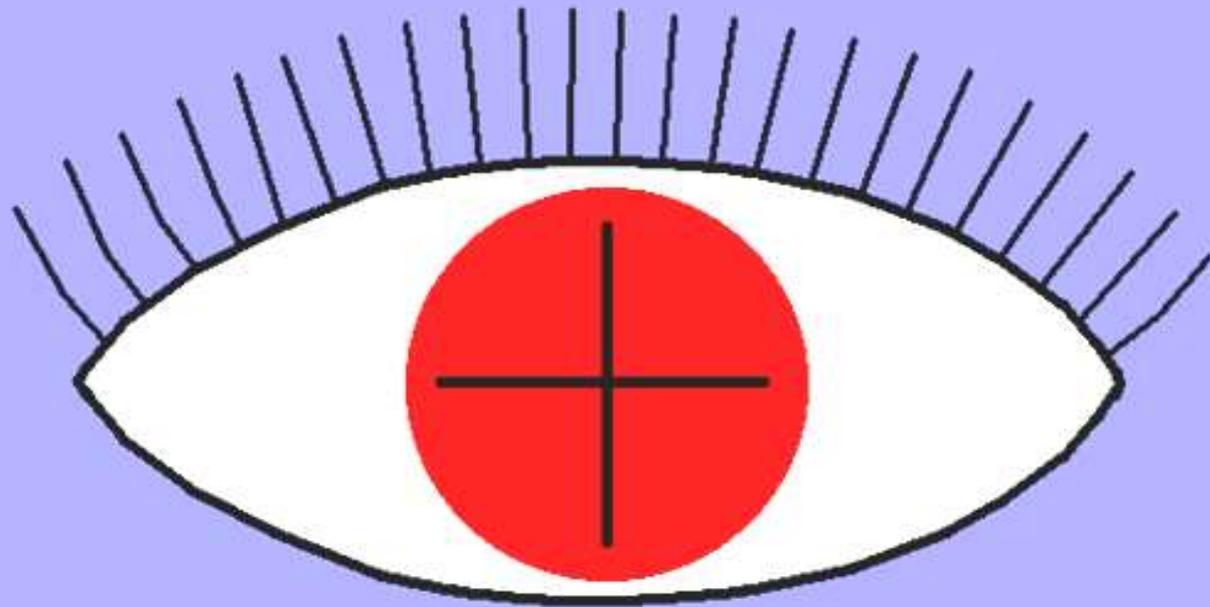
LEAD V5

1 or more CONTINUOUS RHYTHM STRIPS

40 Hz 25.0 mm/s 10.0 mm/mV

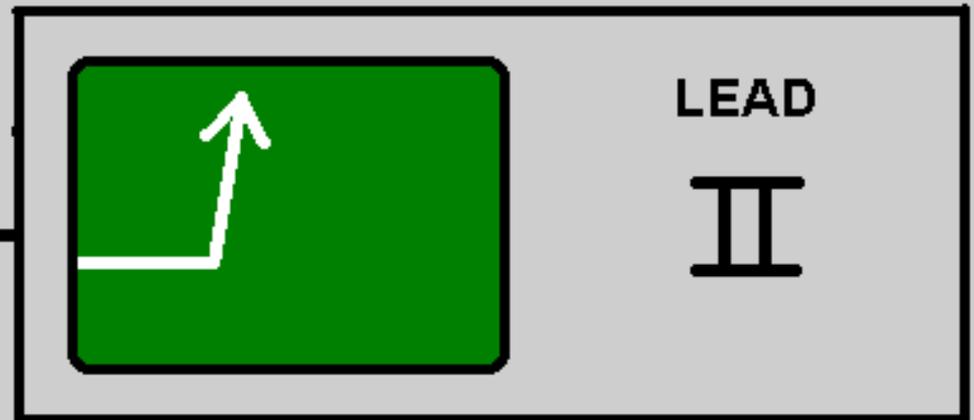
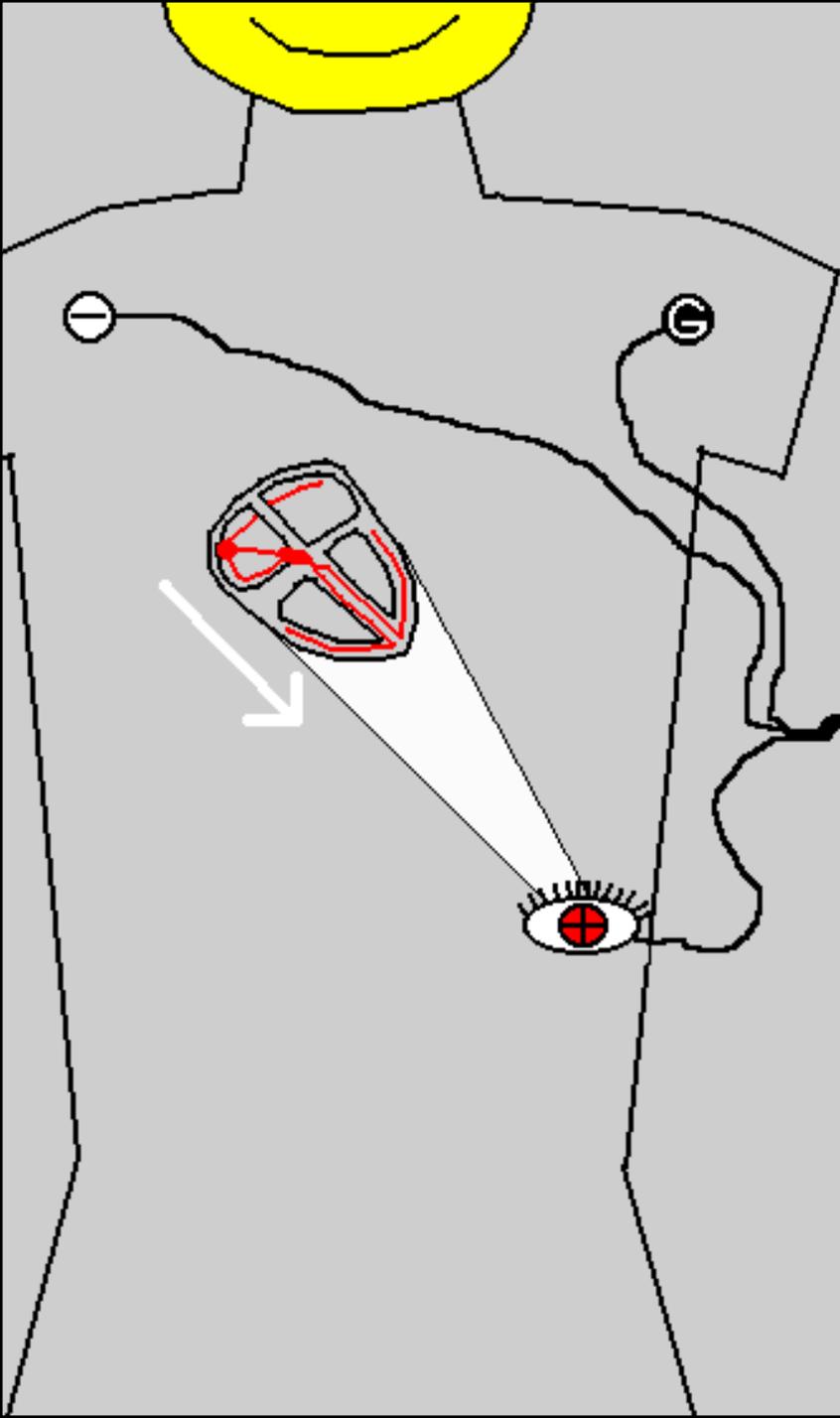
12SL™ v250

**THE POSITIVE ELECTRODE**



**IS THE "EYE" . . .**

**CURRENT MOVING  
TOWARD THE EYE  
(POSITIVE ELECTRODE)**



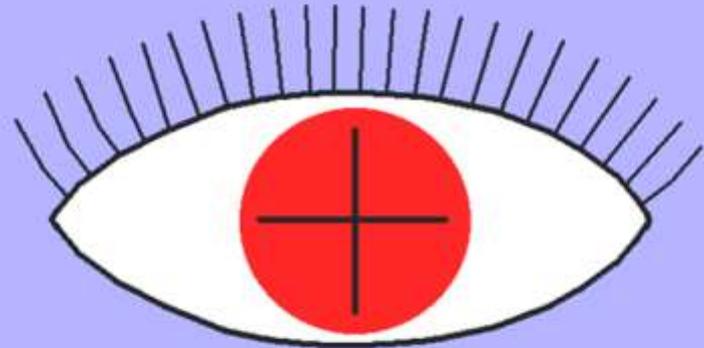
**RECORDS AN  
"UPWARD"  
DEFLECTION**



*Imagine a body made of clear glass, with only a HEART inside. We dip this body in liquid chocolate, and then scratch holes in each spot where we normally place the ECG leads . . . . .*

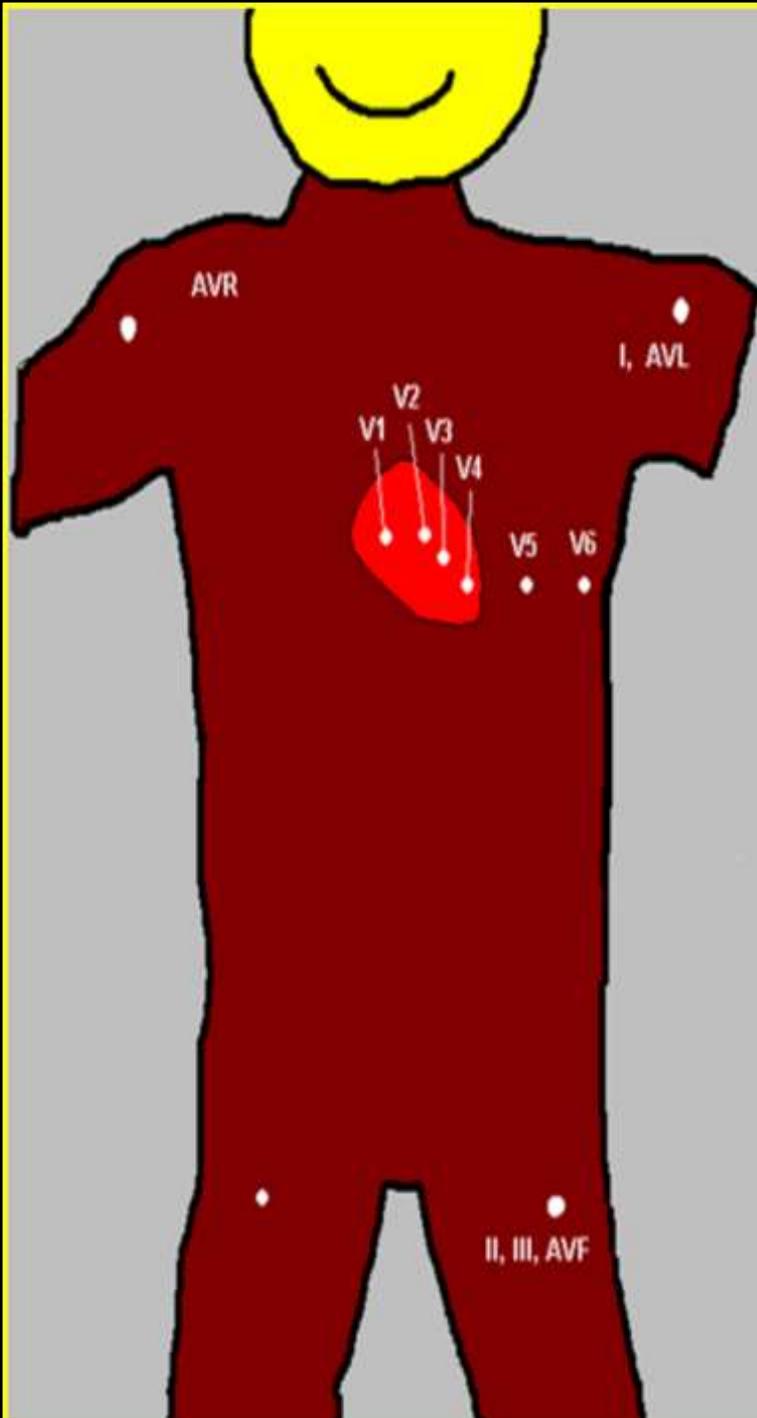
***What part of the HEART  
would each lead SEE ?***

THE POSITIVE ELECTRODE



IS THE "EYE" . . .

# AREAS VIEWED by 12 LEAD ECG



**Fill in the  
blanks as  
we  
proceed!**

AVR

AVL, I

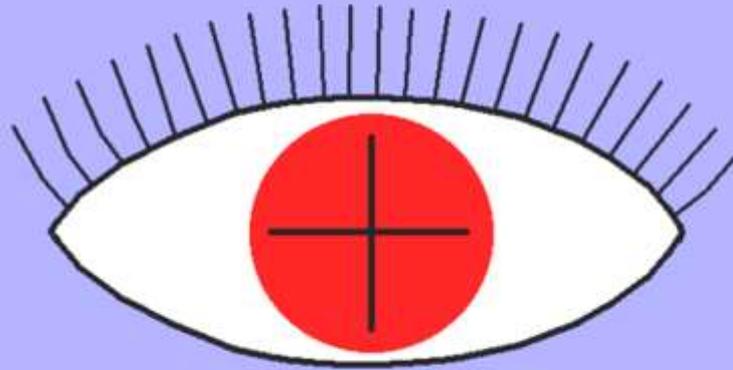
V1, V2

V3, V4

V5, V6

II, III, AVF

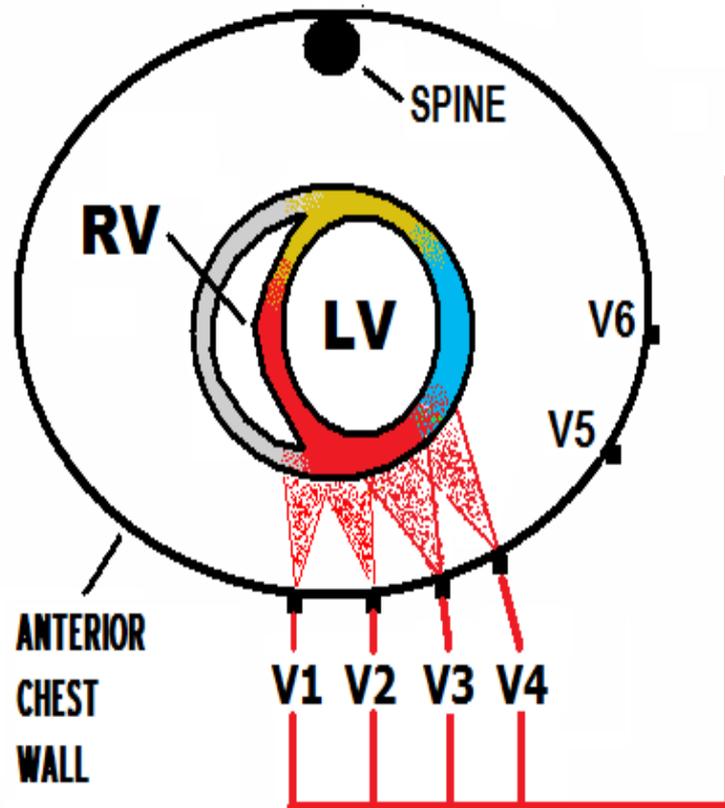
## THE POSITIVE ELECTRODE



**What each of the 12  
Leads “see,” in more  
detail . . . .**

# V1 - V4 VIEW THE ANTERIOR-SEPTAL WALL of the LEFT VENTRICLE

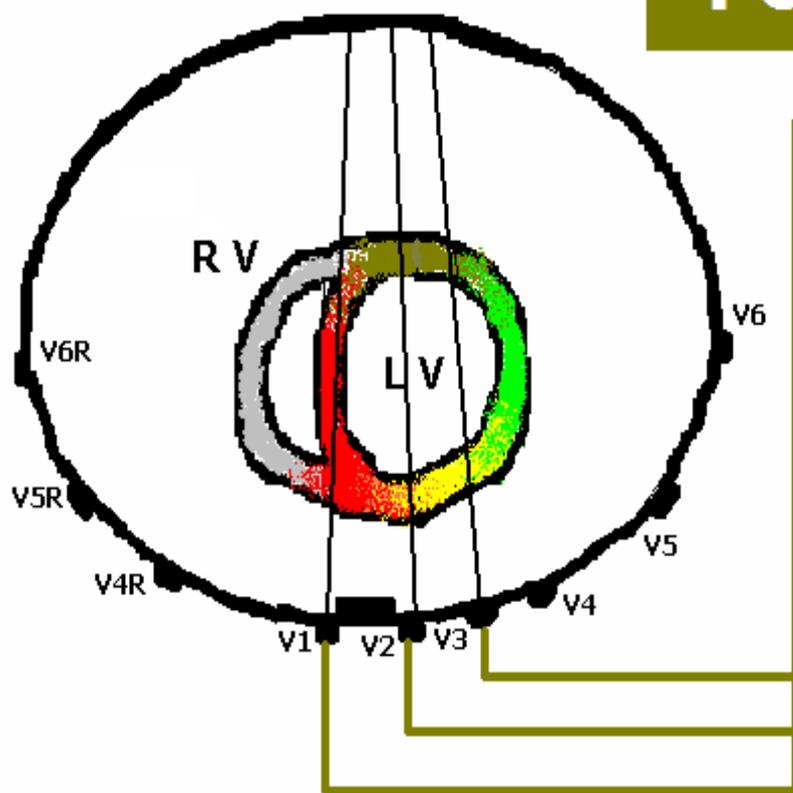
V1, V2 - ANTERIOR / SEPTAL  
V3, V4 - ANTERIOR



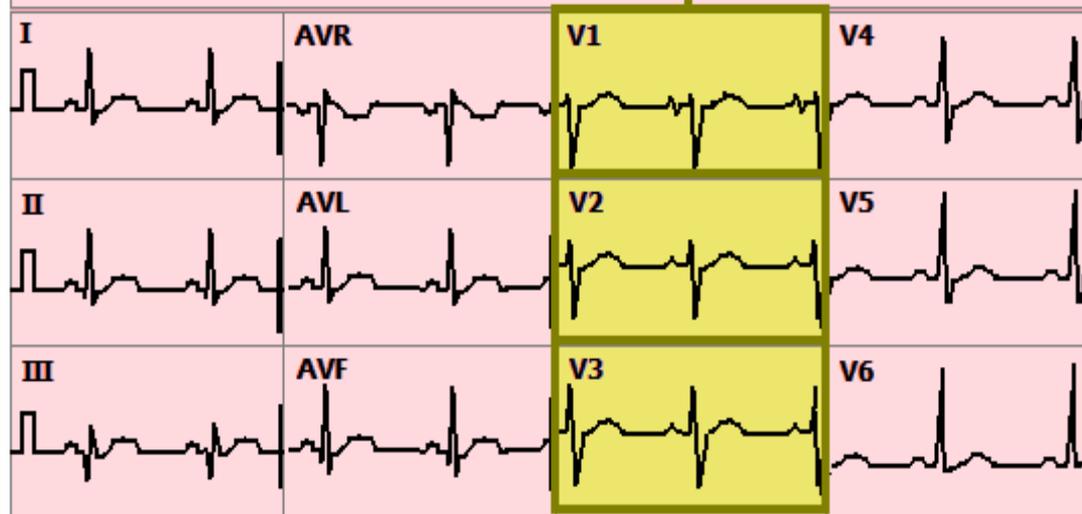
RUPPERT, WAYNE		ID: 7445683659	05-OCT-2006	JOHNS-HOPKINS UNIV.
38 Yrs MALE		Vent. Rate: 68 P-R Int.: 160 ms QRS: 100 ms	NORMAL SINUS RHYTHM Normal EKG Very Healthy Athletic EKG!	
I	AVR	V1	V4	
II	AVL	V2	V5	
III	AVF	V3	V6	

**LEADS V1 - V3** *view the*

**POSTERIOR WALL**



RUPPERT, WAYNE ID: 7445683659 05-OCT-2006 JOHNS-HOPKINS UNIV.  
38 Yrs Vent. Rate: 68 NORMAL SINUS RHYTHM  
MALE P-R Int.: 160 ms Normal EKG  
QRS: 100 ms Very Healthy Athletic EKG !

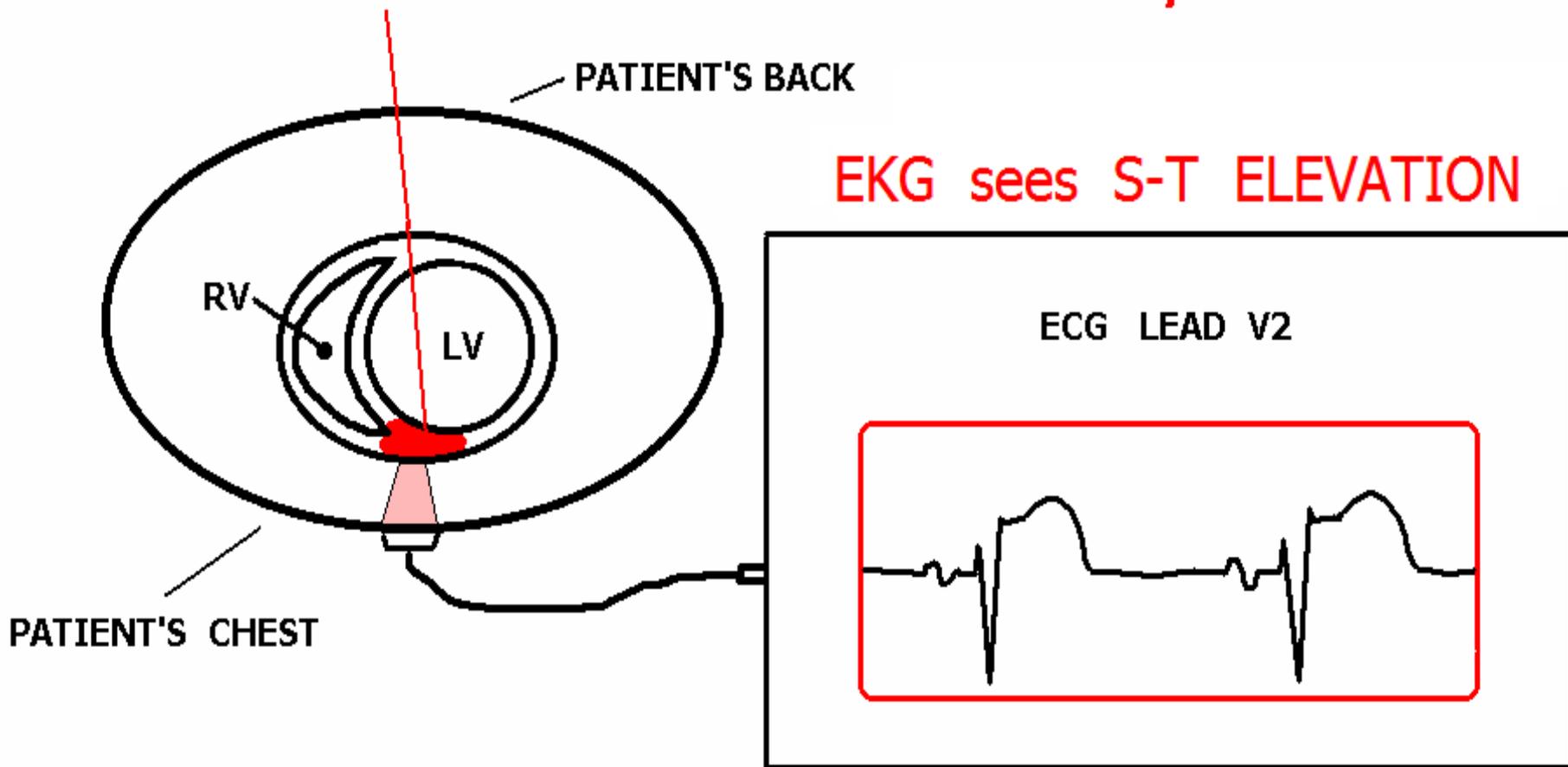


*via* **RECIPROCAL CHANGES.**

# HOW EKG VIEWS INDICATIVE CHANGES

**EXAMPLE:**

**AREA OF ACUTE INFARCTION - ANTERIOR/SEPTAL**



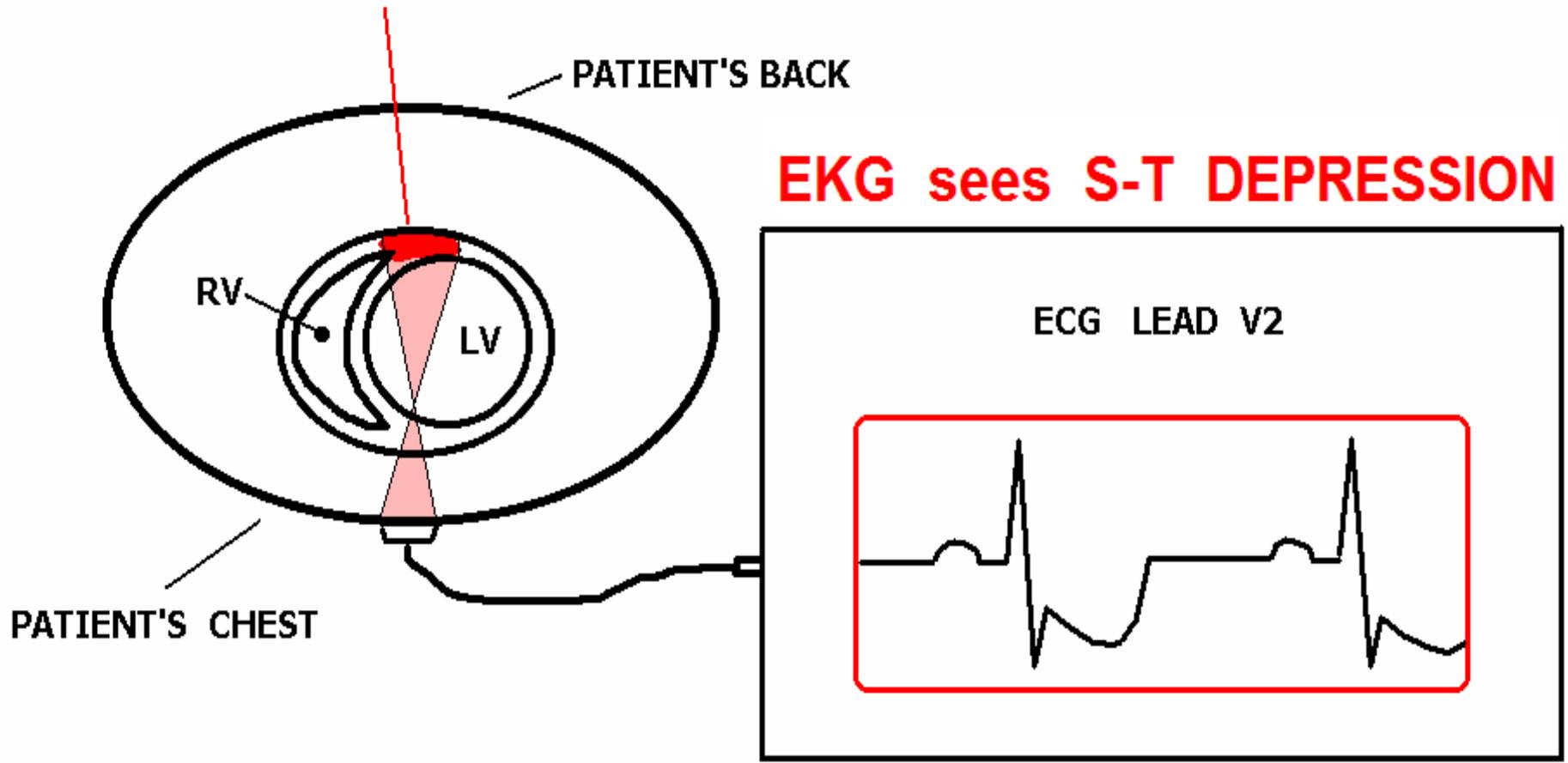
**EKG sees S-T ELEVATION**

ECG LEAD V2

# HOW EKG VIEWS RECIPROCAL CHANGES

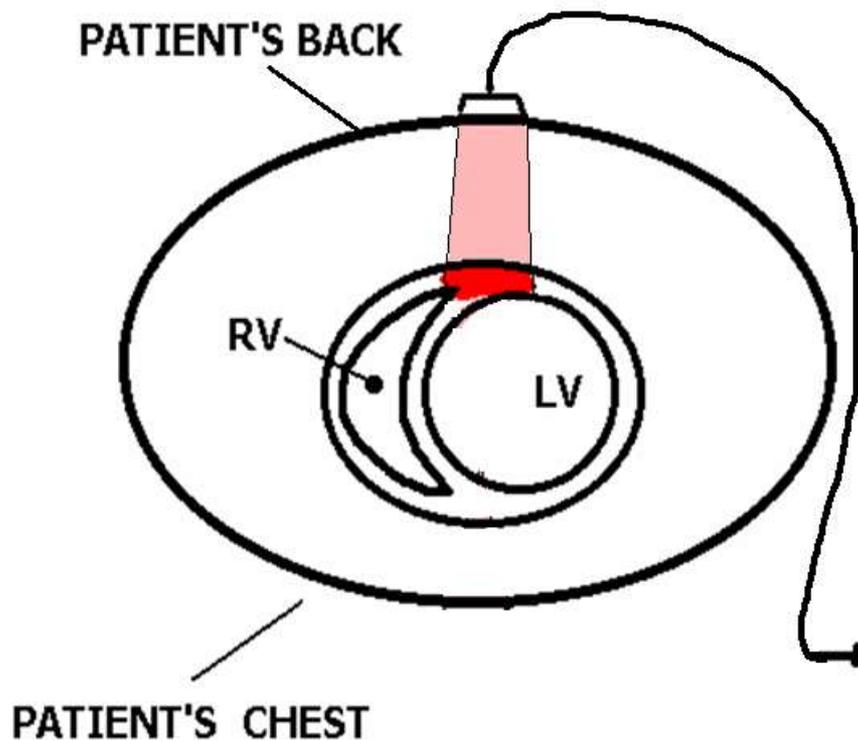
**EXAMPLE:**

**AREA OF ACUTE INFARCTION - POSTERIOR WALL**



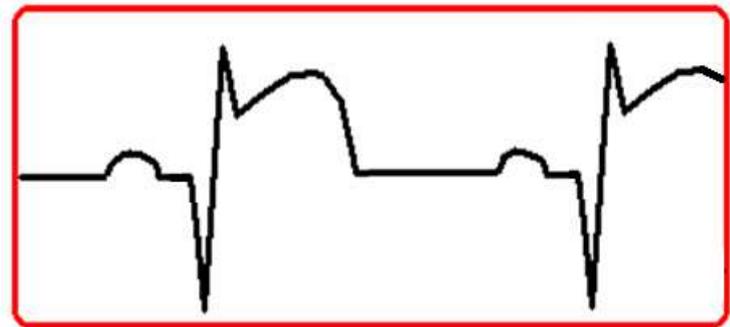
**EKG sees S-T DEPRESSION**

**If we put ECG leads on the BACK  
of a PATIENT who is having an  
ACUTE POSTERIOR WALL MI . . . . .**



**EKG sees S-T ELEVATION**

ECG LEADS: V7, V8 or V9



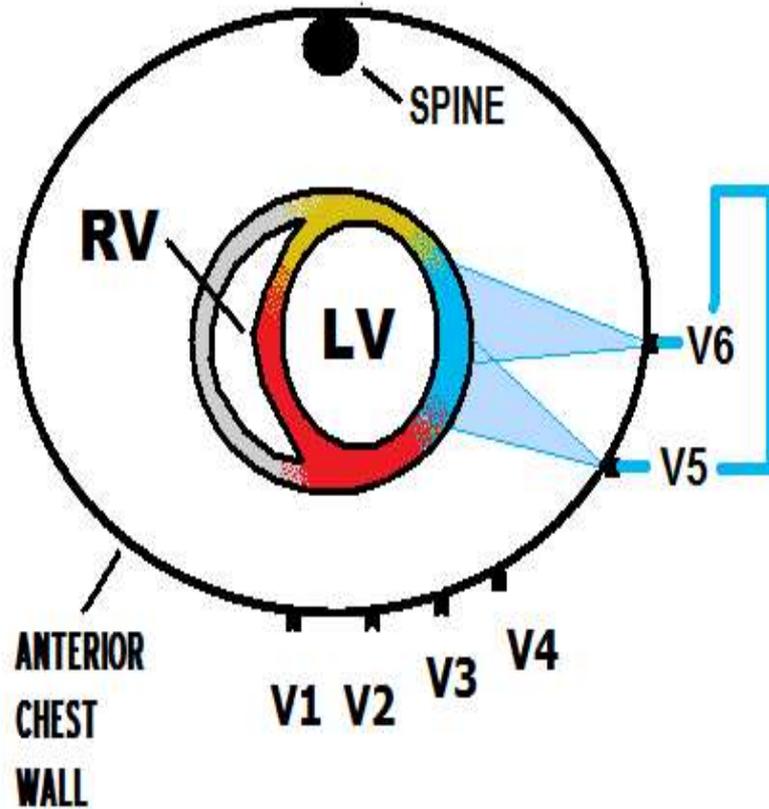
## Leads V1-V4:

- V1 – V4 view the ANTERIOR WALL of the Left Ventricle.
- V1 and V2 also view the SEPTAL WALL
- V1 – V3 view the POSTERIOR WALL via Reciprocal Changes.

## Leads V1-V4:

- V1 – V4 view the \_\_\_\_\_ of the Left Ventricle.
- V1 and V2 also view the \_\_\_\_\_
- V1 – V3 view the \_\_\_\_\_ via Reciprocal Changes.

# V5 - V6 VIEW THE LATERAL WALL of the LEFT VENTRICLE



RUPPERT, WAYNE		ID: 7445683659	05-OCT-2006	JOHNS-HOPKINS UNIV.
38 Yrs MALE		Vent. Rate: 68 P-R Int.: 160 ms QRS: 100 ms	NORMAL SINUS RHYTHM Normal EKG Very Healthy Athletic EKG!	
I	AVR	V1	V4	
II	AVL	V2	V5	
III	AVF	V3	V6	

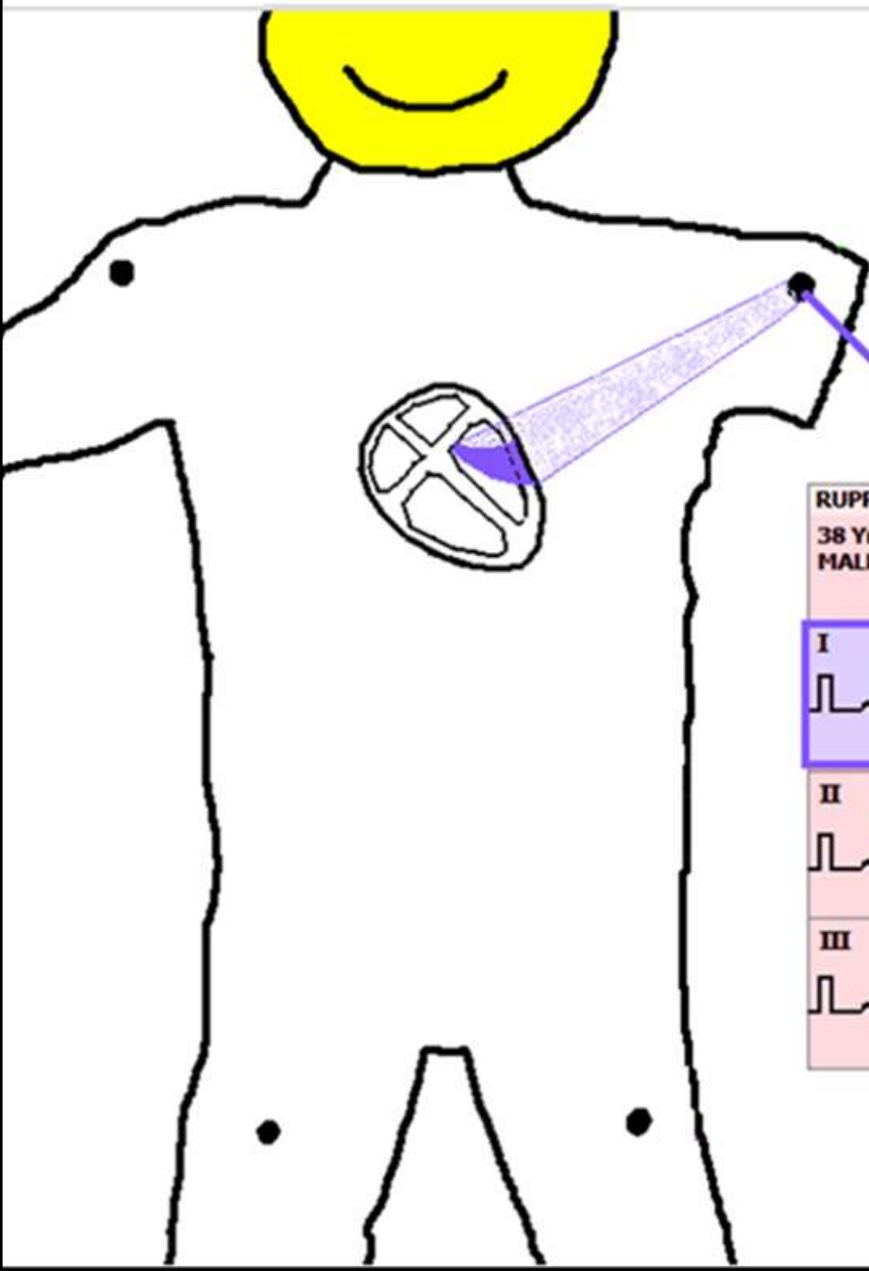
## Leads V5 & V6:

- V5 & V6 view the LATERAL WALL of the Left Ventricle.

## Leads V5 & V6:

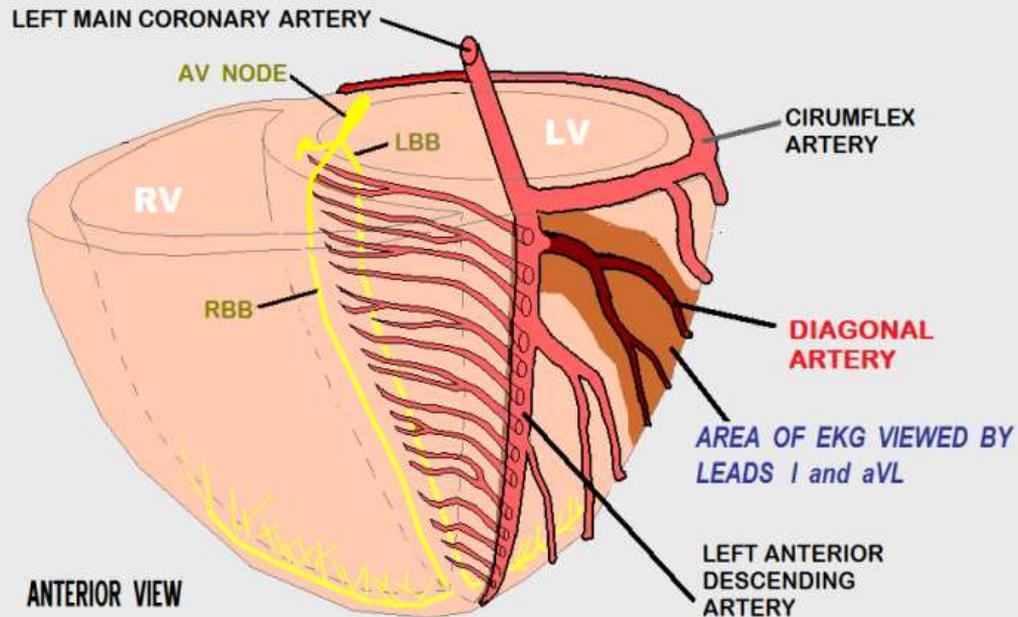
- V5 & V6 view the \_\_\_\_\_ of the Left Ventricle.

# Leads I & AVL View: Proximal Lateral / Anterior Wall

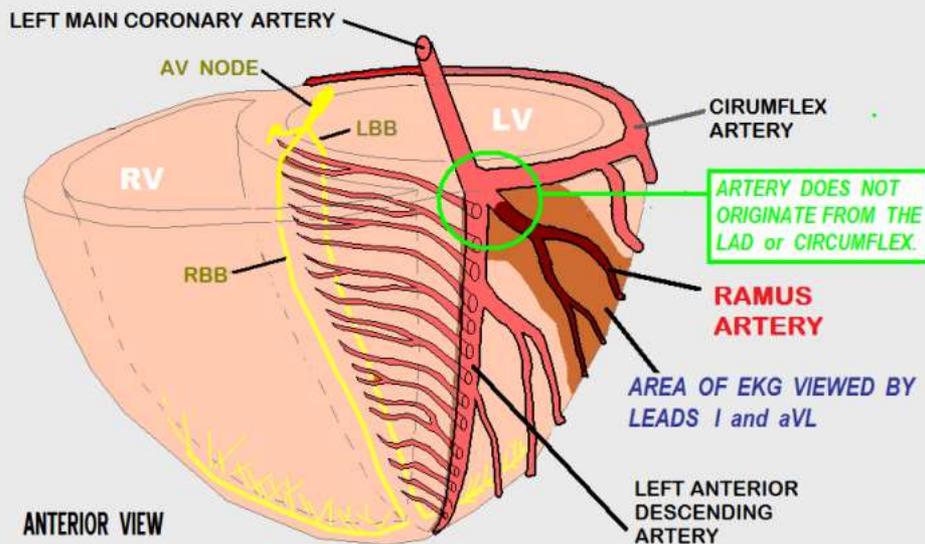


RUPPERT, WAYNE		ID: 744568369	05-OCT-2006	JOHNS-HOPKINS UNIV.
38 Yrs MALE		Vent. Rate: 68 P-R Int.: 160 ms QRS: 100 ms	NORMAL SINUS RHYTHM Normal EKG Very Healthy Athletic EKG !	
I	AVR	V1	V4	
II	AVL	V2	V5	
III	AVF	V3	V6	

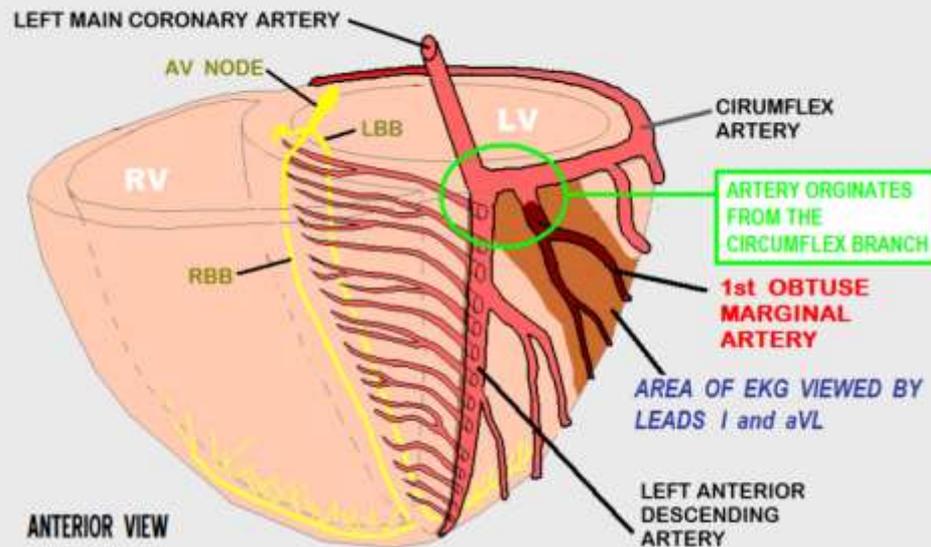
## OCCUSION of DIAGONAL ARTERY



## OCCUSION of RAMUS ARTERY



## OCCUSION of OBTUSE MARGINAL ARTERY



# Leads I and AVL:

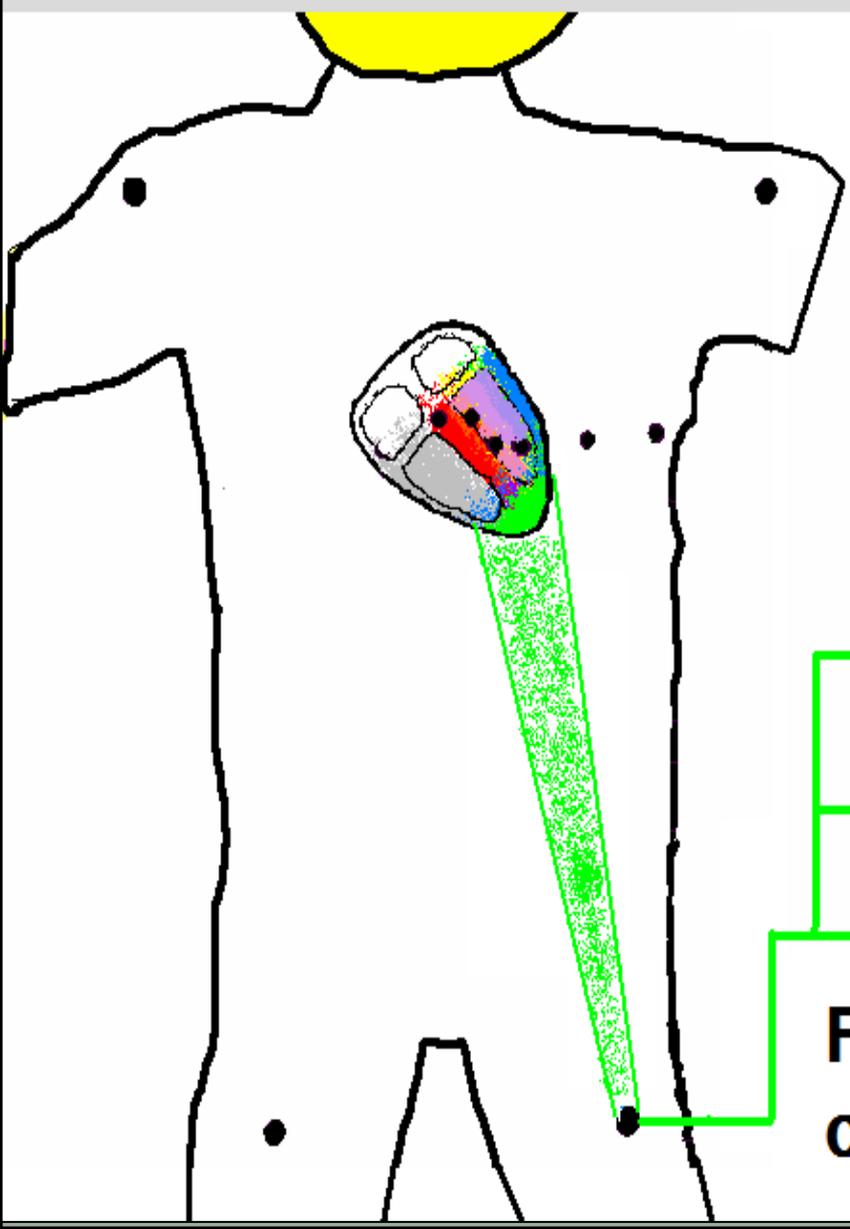
- Leads I and AVL view the **PROXIMAL aspect** of the **LATERAL** and **ANTERIOR WALLS**
- I and AVL can be associated with EITHER the **LATERAL WALL**, the **ANTERIOR WALL**, or BOTH the **LATERAL** and **ANTERIOR WALLS**.

# Leads I and AVL:

- Leads I and AVL view the **PROXIMAL aspect** of the \_\_\_\_\_ and \_\_\_\_\_ **WALLS**
- I and AVL can be associated with EITHER the \_\_\_\_\_, the \_\_\_\_\_, or BOTH the \_\_\_\_\_ **and** \_\_\_\_\_.

# LEADS II, III, and aVF VIEW

## INFERIOR WALL of the LEFT VENTRICLE



RUPPERT, WAYNE		ID: 7445683659	05-OCT-2006	JOHNS-HOPKINS UNIV.
38 Yrs	MALE	Vent. Rate: 68	P-R Int.: 160 ms	QRS: 100 ms
		NORMAL SINUS RHYTHM Normal EKG Very Healthy Athletic EKG !		
I	AVR	V1	V4	
II	AVL	V2	V5	
III	AVF	V3	V6	

**FED by the RCA ( 75 - 80 % pop )  
or the CIRCUMFLEX ( 10 - 15 % )**

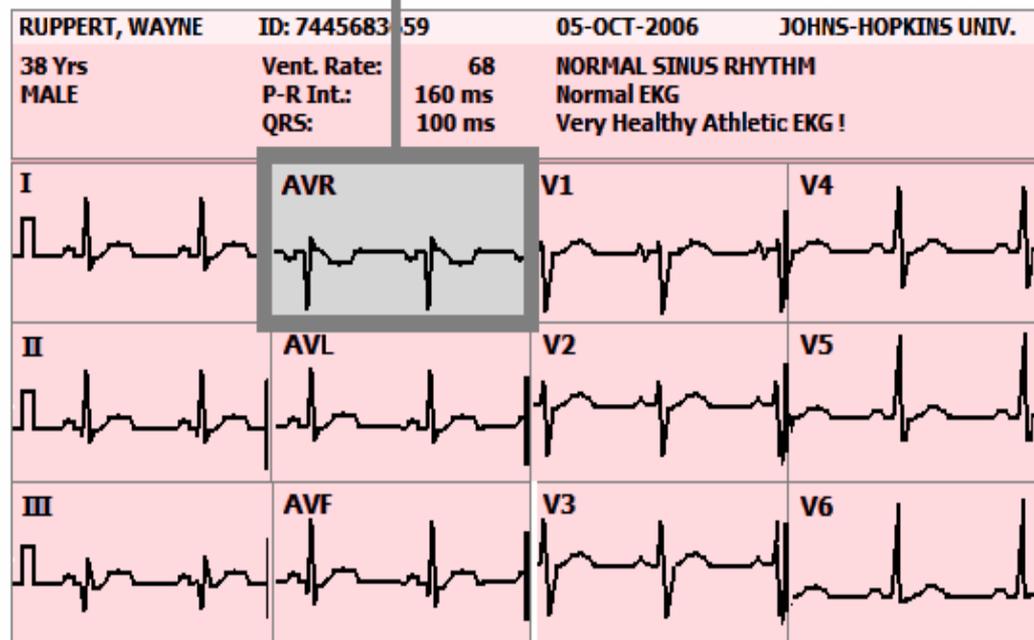
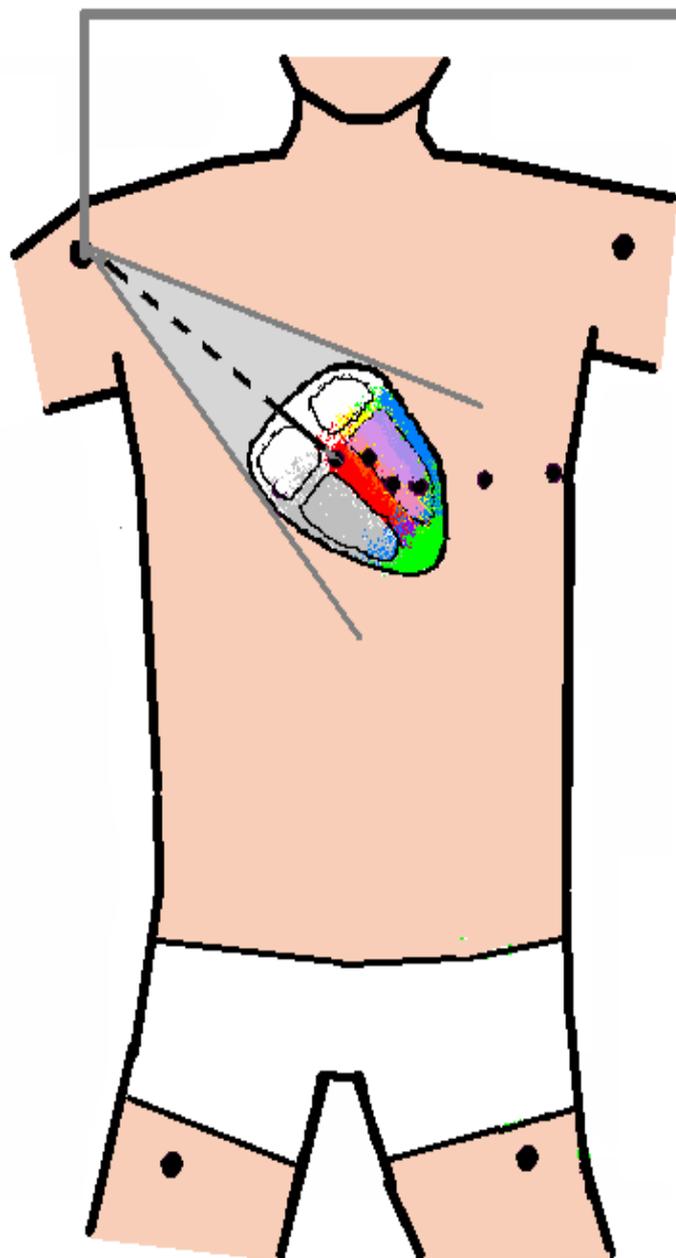
# Leads II, III, and AVF:

- Leads, II, III, and AVF view the INFERIOR WALL of the Left Ventricle.

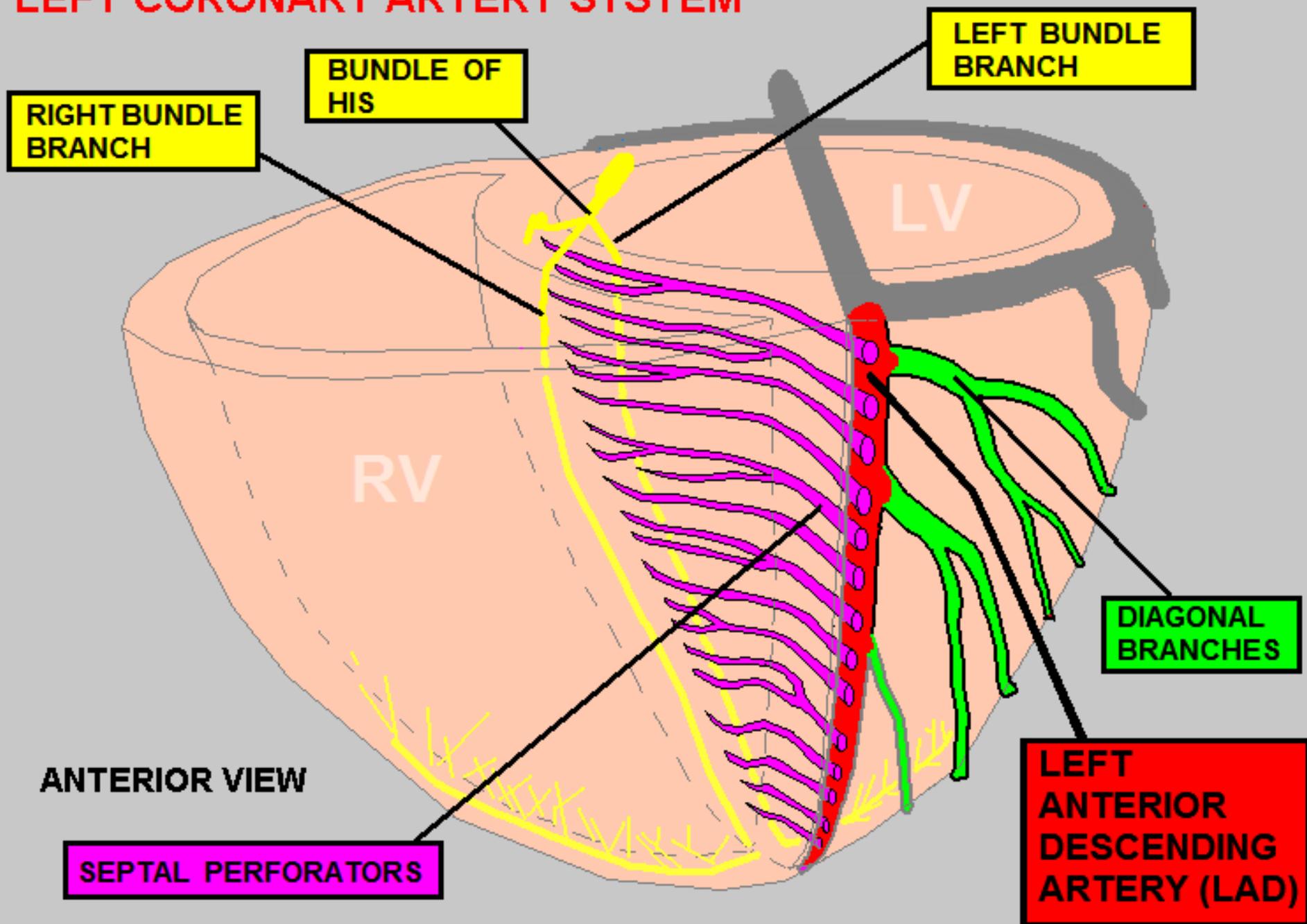
# Leads II, III, and AVF:

- Leads, II, III, and AVF view the \_\_\_\_\_  
of the Left Ventricle.

# Lead AVR Views the BASILAR SEPTUM (region of the Bundle of His):



# LEFT CORONARY ARTERY SYSTEM



# Lead AVR:

- Lead AVR views the **BASILAR SEPTUM**.
- The **BASILAR SEPTUM** is the area where the **BUNDLE of HIS** is typically located.

# Lead AVR:

- Lead AVR views the \_\_\_\_\_.
- The \_\_\_\_\_ is the area where the \_\_\_\_\_ is typically located.

# Lead AVR:

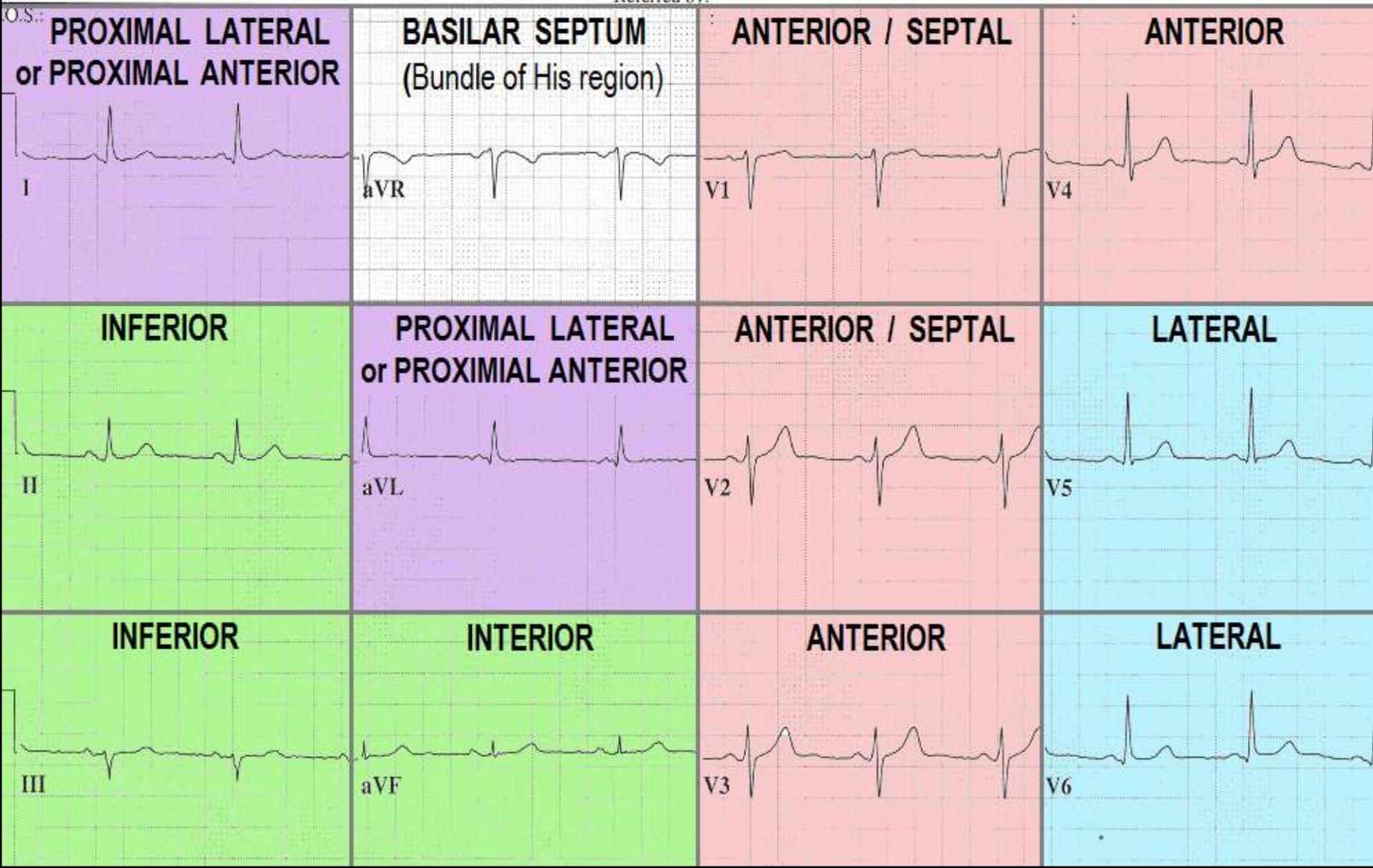
- ST Elevation in Lead AVR during Acute STEMI is associated with LEFT MAIN CORONARY ARTERY obstruction, which has a 75% mortality Rate.
- ST Elevation of Lead AVR when STEMI is NOT present is often associated with CRITICAL TRIPLE VESSEL disease, and/or CRITICAL OCCLUSION of the LEFT MAIN CORONARY ARTERY: both require Coronary Artery Bypass Graft (CABG) Surgery!!

# Lead AVR:

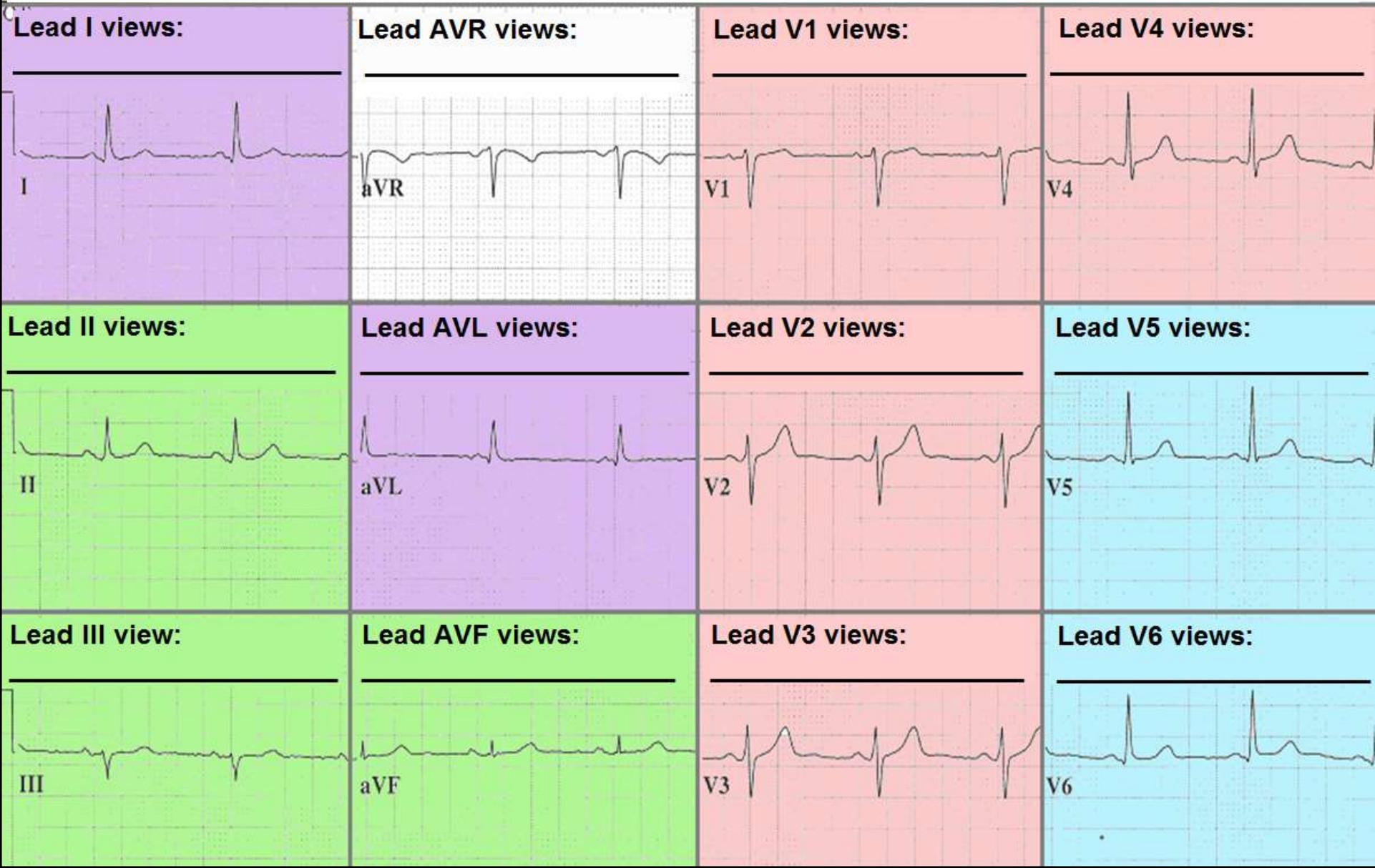
- ST Elevation in Lead AVR during Acute STEMI is associated with \_\_\_\_\_  
\_\_\_\_\_ obstruction, which has a \_\_\_% mortality Rate.
- ST Elevation of Lead AVR when STEMI is NOT present is often associated with \_\_\_\_\_  
\_\_\_\_\_ disease, and/or CRITICAL OCCLUSION of the \_\_\_\_\_  
\_\_\_\_\_: both require Coronary Artery Bypass Graft (CABG) Surgery!!

Vent. rate	64	BPM	Normal sinus rhythm
PR interval	130	ms	Normal ECG
QRS duration	96	ms	No previous ECGs available
QT/QTc	396/408	ms	
P-R-T axes	40 11 61		

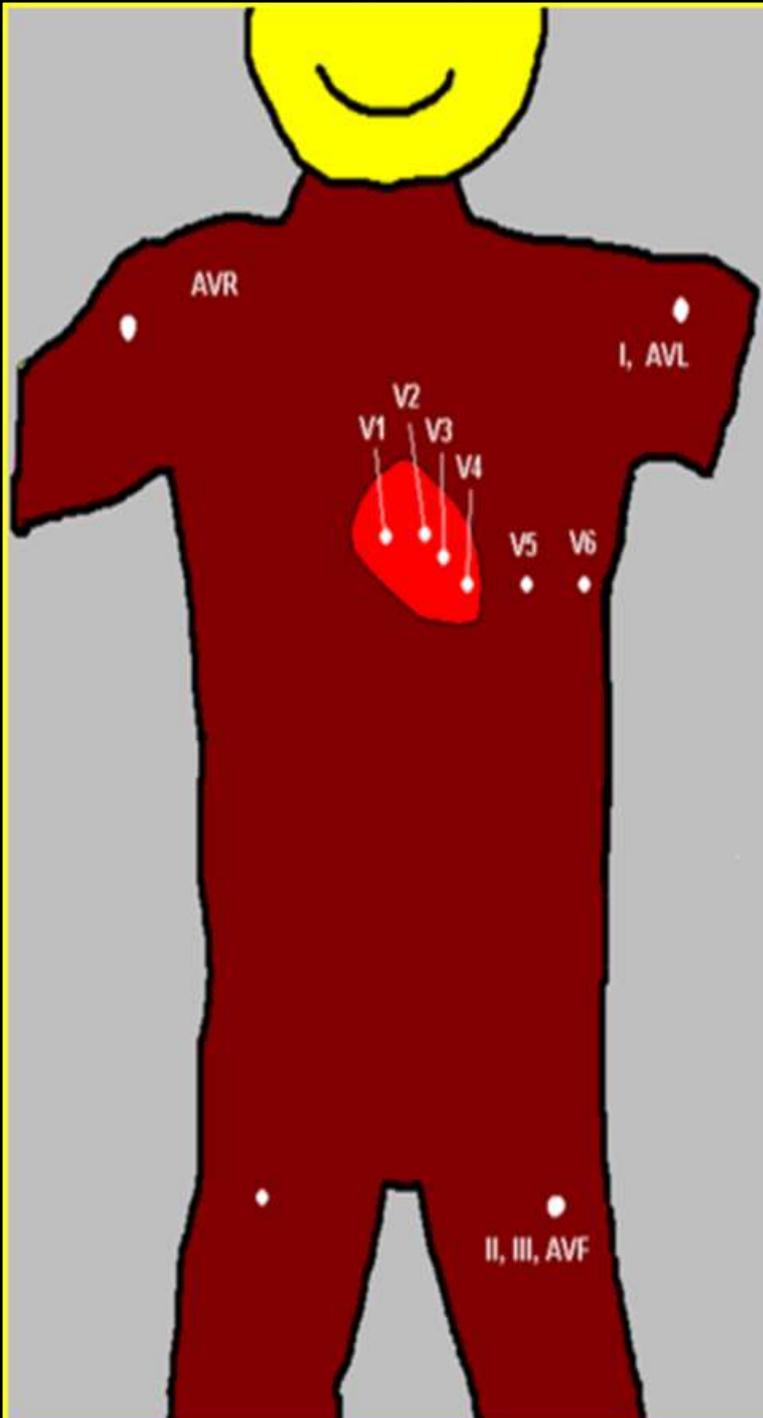
Referred by:



# What REGION of the HEART does EACH LEAD VIEW ??



# AREAS VIEWED by 12 LEAD ECG



AVR *BASILAR SEPTAL*

AVL, I *PROXIMAL  
LATERAL-ANTERIOR*

V1, V2 *ANTERIOR*

*SEPTAL*

*POSTERIOR (recip.)*

V3, V4 *ANTERIOR*

V5, V6 *LATERAL*

II, III, AVF *INFERIOR*

# AREAS VIEWED by 12 LEAD ECG



AVR

AVL, I

V1, V2

V3, V4

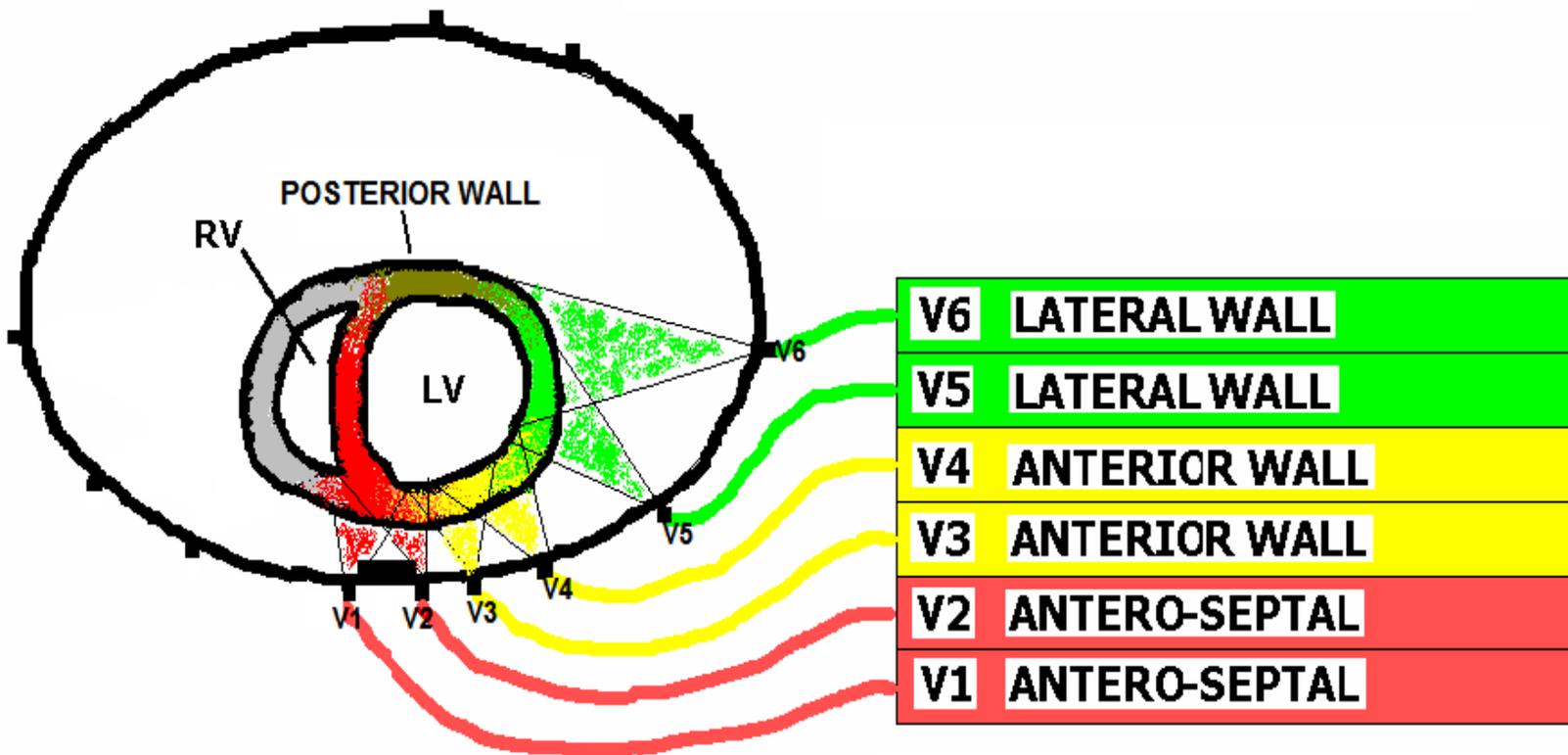
V5, V6

II, III, AVF

THE 12 LEAD ECG HAS TWO MAJOR BLIND SPOTS ..

## CHEST LEADS V1 - V6

WHAT EACH LEAD "SEES" ...

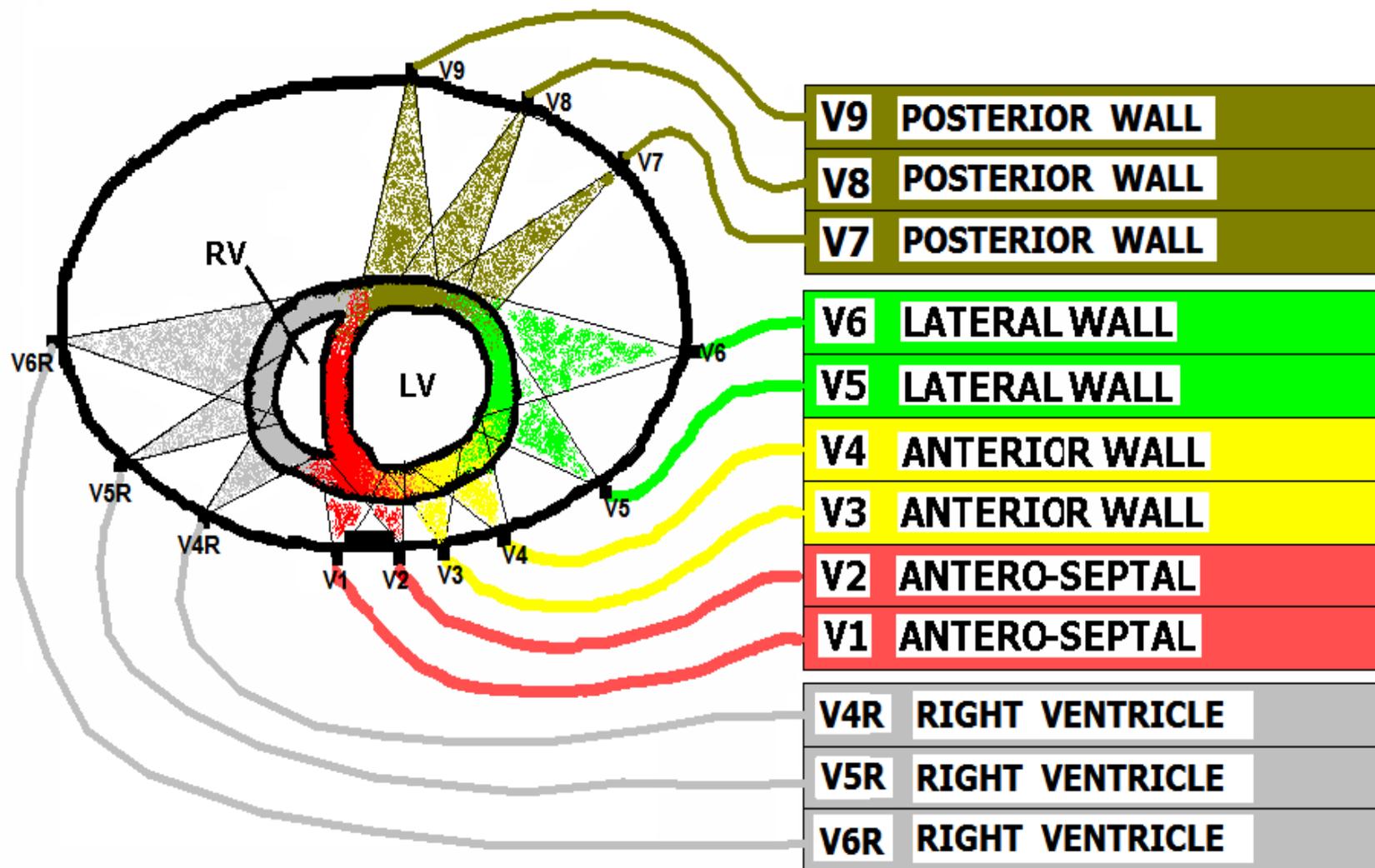


**The TWO major BLIND SPOTS of  
the 12 Lead ECG are the  
POSTERIOR WALL and the  
RIGHT VENTRICLE.**

**The TWO major BLIND SPOTS of  
the 12 Lead ECG are the  
\_\_\_\_\_ and the  
\_\_\_\_\_.**

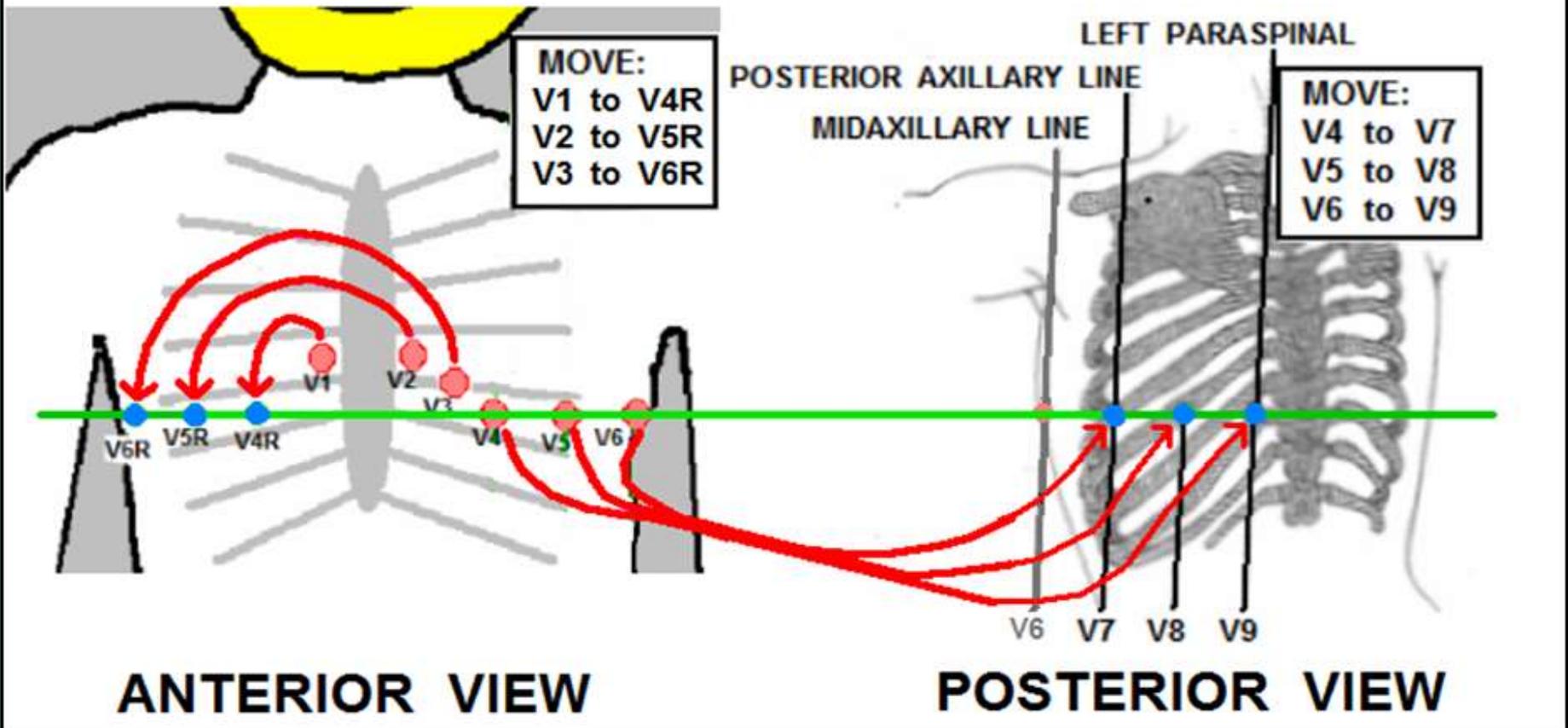
# THE 18 LEAD ECG COVERS THE ENTIRE HEART ..

CHEST LEADS V1 - V6 PLUS V4R, V5R, V6R, and V7, V8, V9  
 WHAT EACH LEAD "SEES" ...

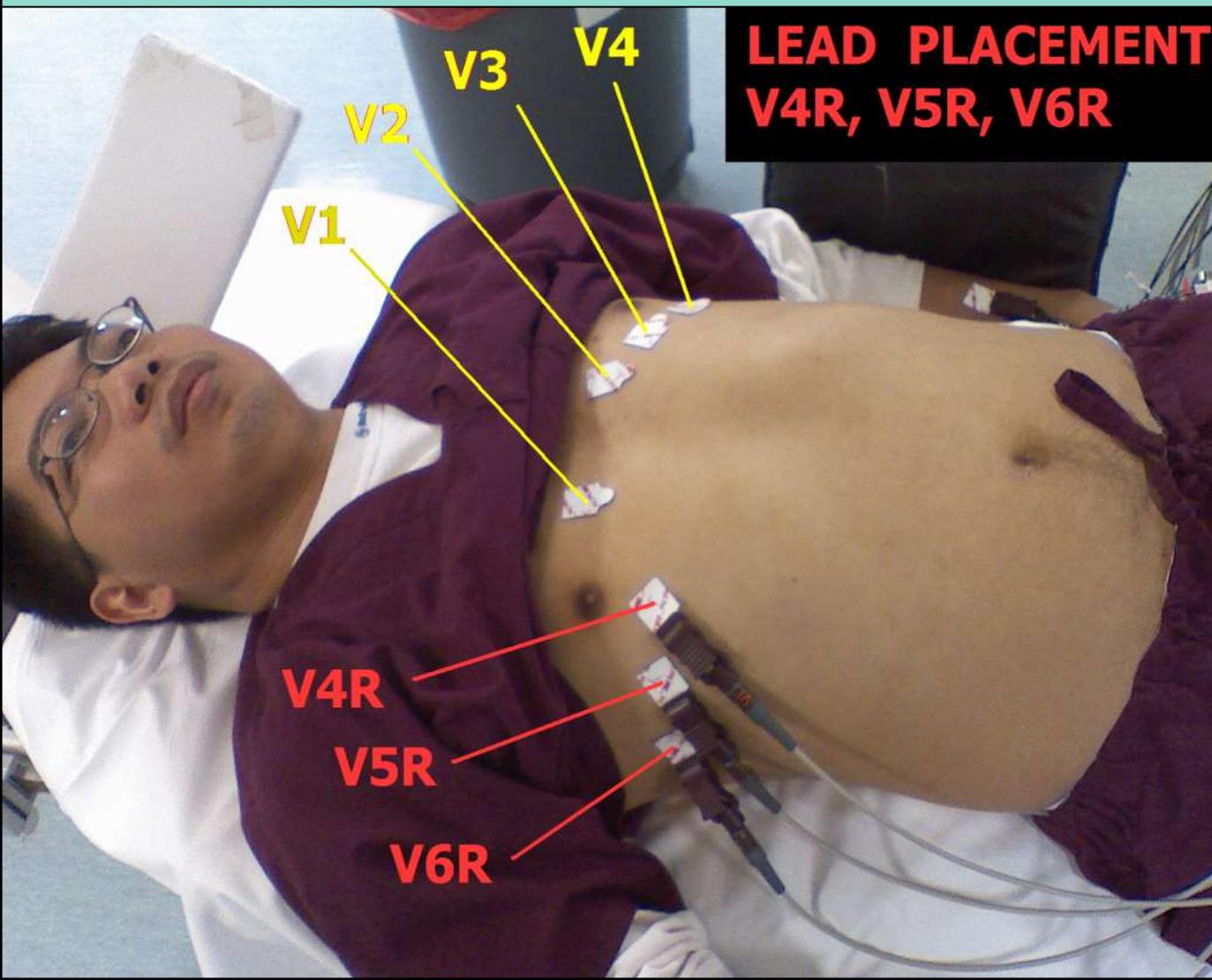


To do 18 Lead ECG with 12 Lead machine – after you obtain 12 Lead, reposition CHEST LEADS to this configuration, then print !

## HOW TO REPOSITION 6 CHEST LEADS to OBTAIN 3 R VENTRICLE and 3 POSTERIOR LEADS



# LEAD PLACEMENT for obtaining RIGHT VENTRICULAR ECG:



V4R – V6R

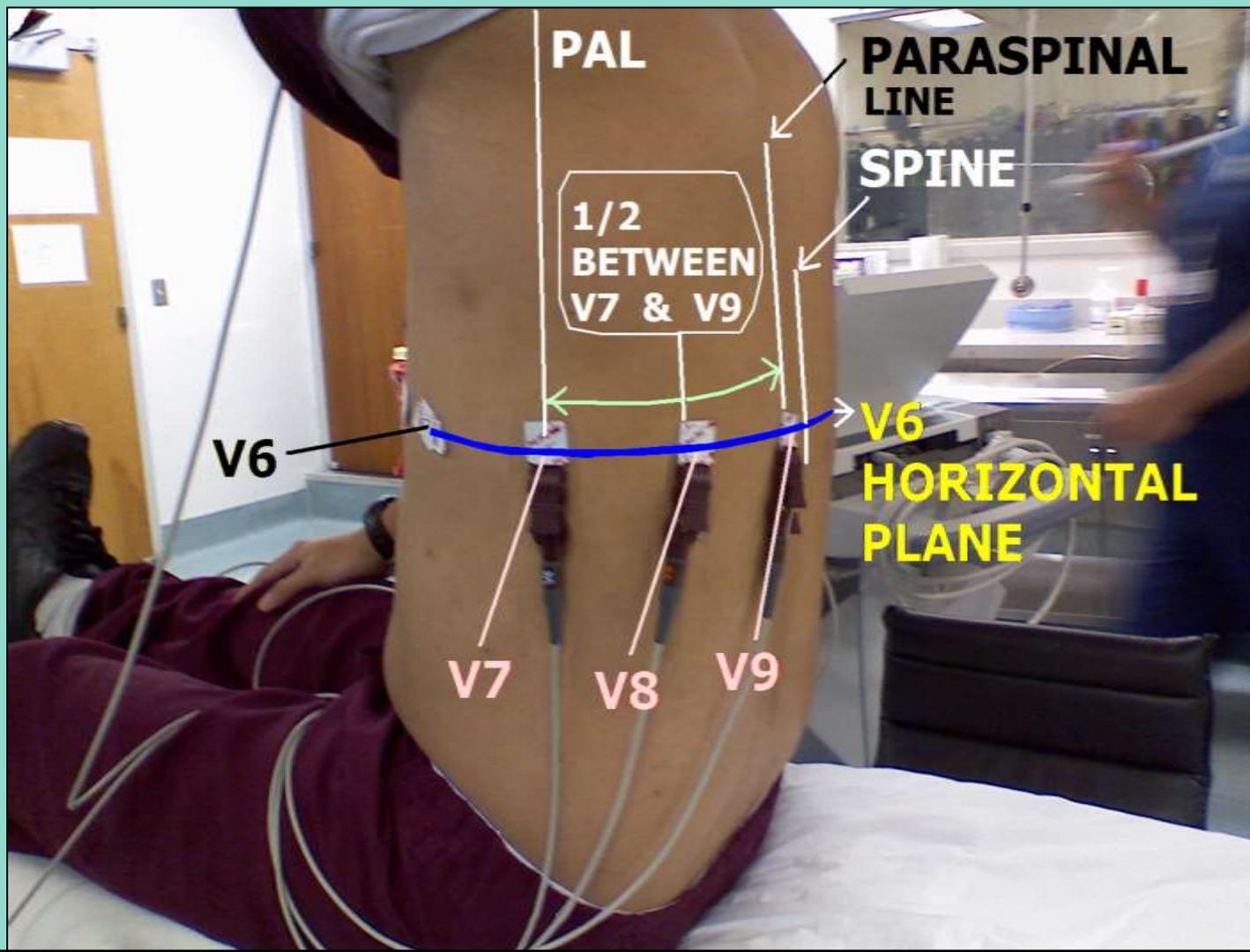
**The INDICATION for obtaining a  
RIGHT VENTRICULAR ECG is  
INFERIOR WALL STEMI.**

**The INDICATION for obtaining a  
RIGHT VENTRICULAR ECG is**

**\_\_\_\_\_.**

# LEAD PLACEMENT for obtaining a POSTERIOR ECG.

Leads  
V7 – V9



**The INDICATION for obtaining a  
POSTERIOR LEAD ECG is  
ST Depression in Leads V1-V4.**

**The INDICATION for obtaining a  
POSTERIOR LEAD ECG is**

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•

# Coronary Artery Anatomy

# *THE CORONARY*

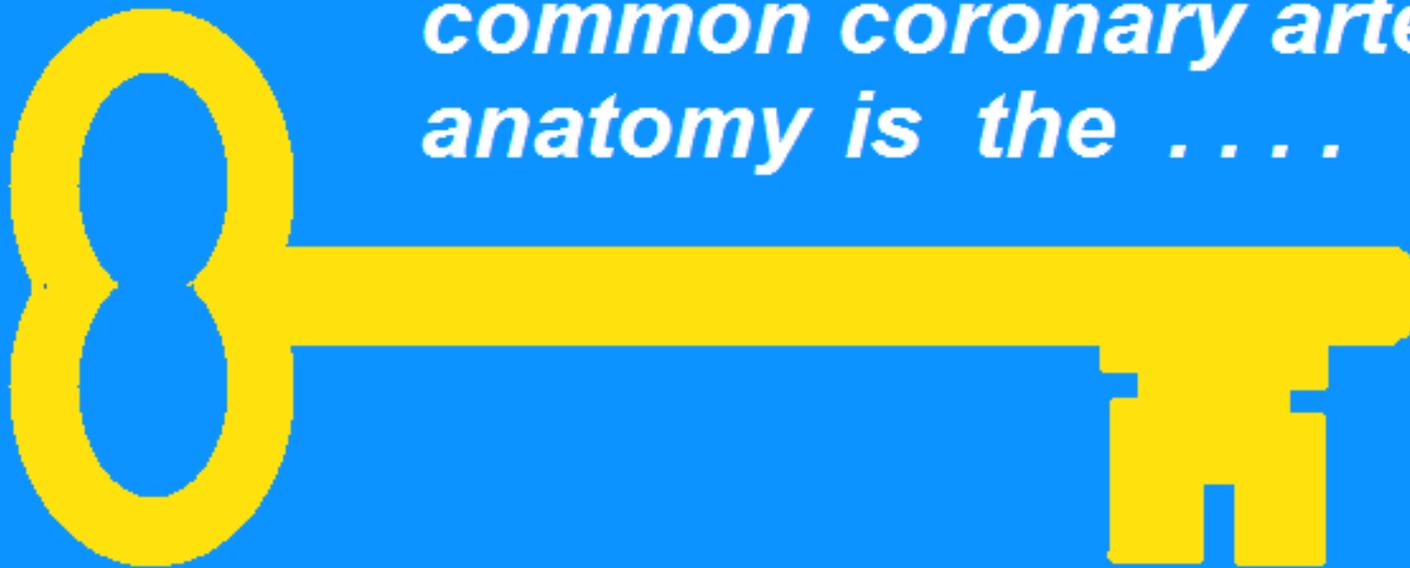


*ARTERIES*

**There are MULTIPLE anatomic variations in Coronary Artery Anatomy.**

**This curriculum reviews the TWO most common, which account for approximately 90% of the population.**

*"Having knowledge of  
common coronary artery  
anatomy is the . . . .*



*to understanding the **PHYSIOLOGICAL  
CHANGES** that occur during **ACUTE MI.**"*

*"**INVALUABLE ASSET** for **ALL MEDICAL PROFESSIONALS** who  
provide direct care to **STEMI patients !**"*

The 12 Lead ECG becomes your “crystal ball !!”

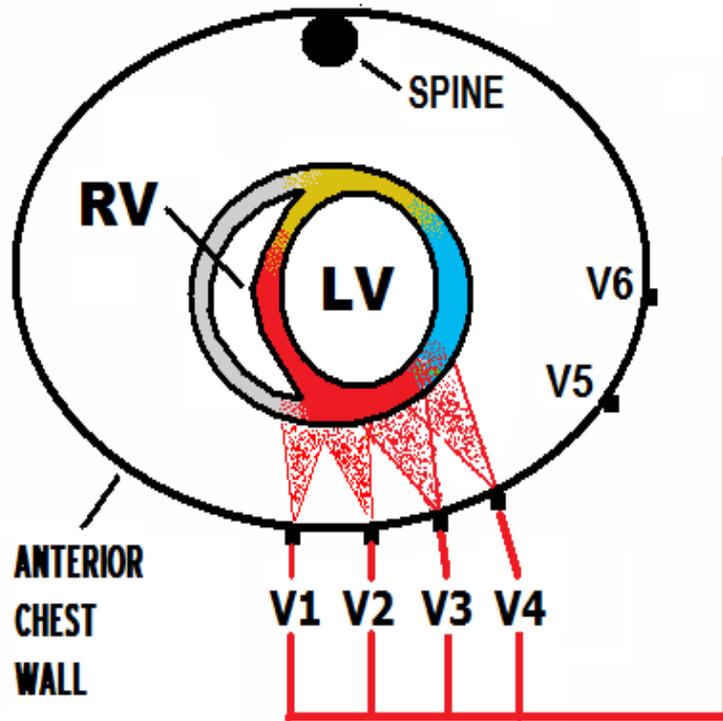


# INTERPRET THE EKG, THEN:

- KEY IDENTIFY THE AREA OF THE HEART WITH A PROBLEM ...
- KEY RECALL THE ARTERY WHICH SERVES THAT REGION ...
- KEY RECALL OTHER STRUCTURES SERVED BY THAT ARTERY ...
- KEY ANTICIPATE FAILURE OF THOSE STRUCTURES ...
- KEY INTERVENE APPROPRIATELY!

# V1 - V4 VIEW THE ANTERIOR-SEPTAL WALL of the LEFT VENTRICLE

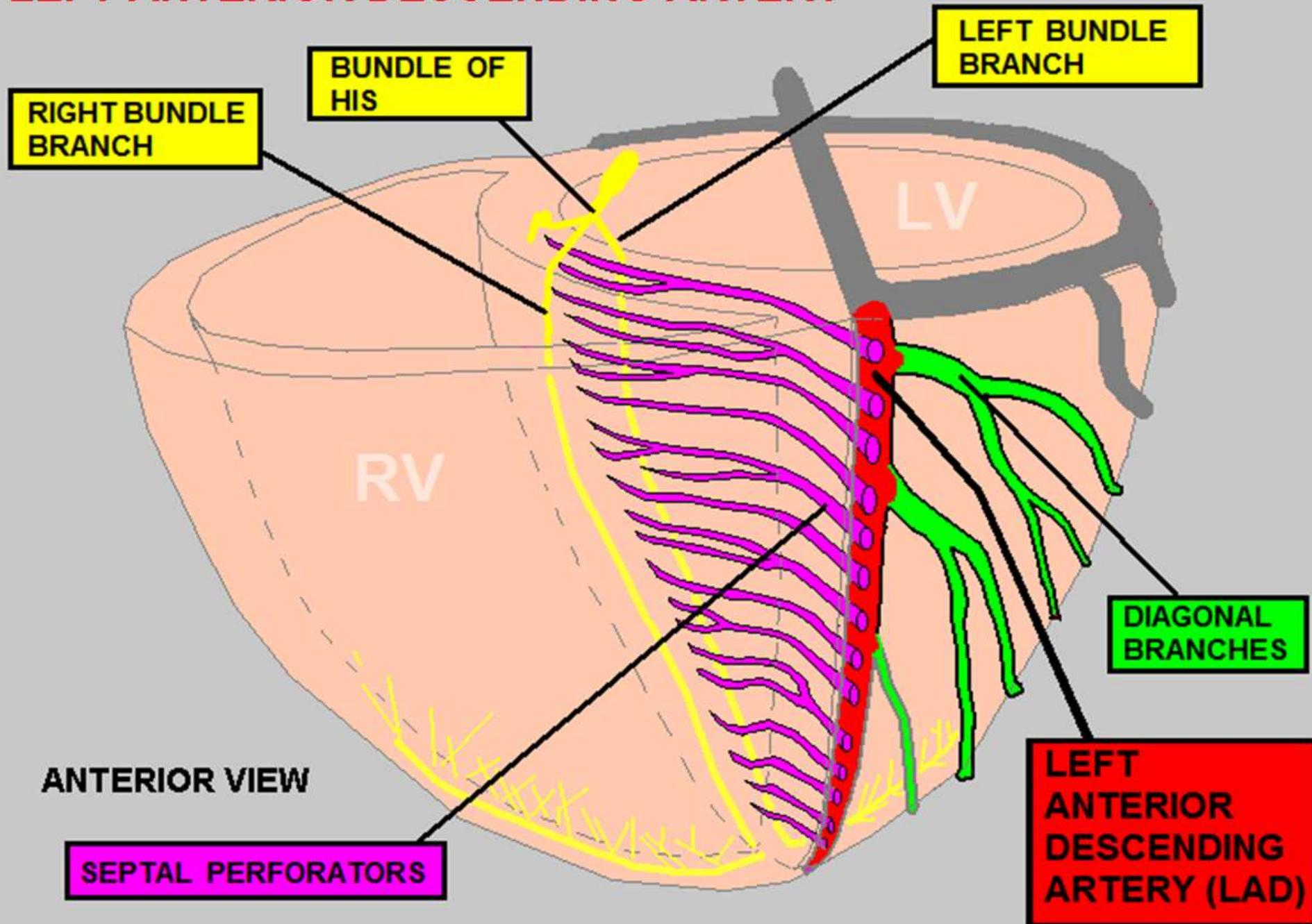
V1, V2 - ANTERIOR / SEPTAL  
V3, V4 - ANTERIOR



RUPPERT, WAYNE		ID: 7445683659	05-OCT-2006	JOHNS-HOPKINS UNIV.
38 Yrs MALE		Vent. Rate: 68 P-R Int: 160 ms QRS: 100 ms	NORMAL SINUS RHYTHM Normal EKG Very Healthy Athletic EKG!	
I	AVR	V1	V4	
II	AVL	V2	V5	
III	AVF	V3	V6	

Leads V1 – V4 are associated with the Left Anterior Descending Artery

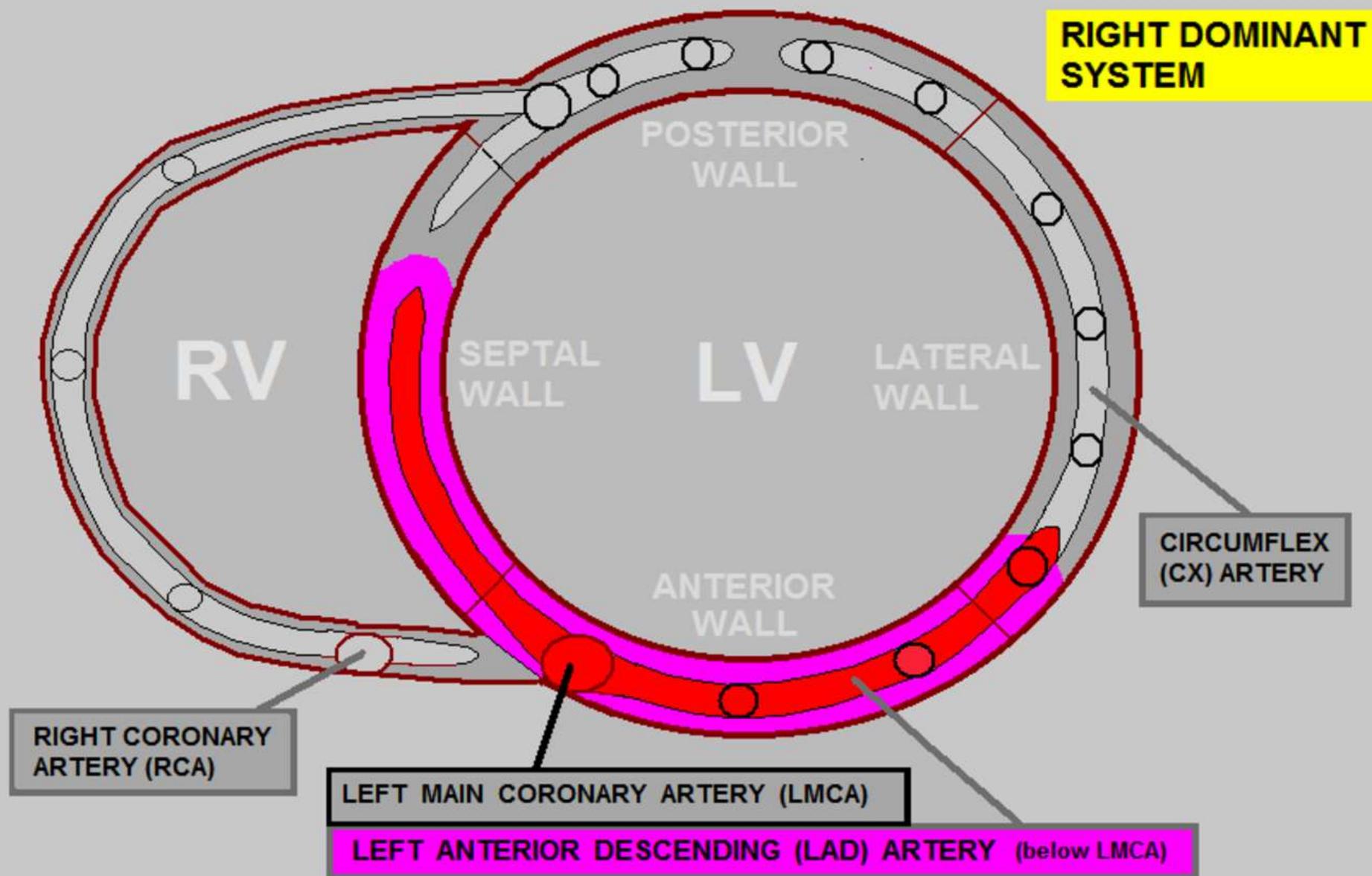
# LEFT ANTERIOR DESCENDING ARTERY



cutaway view of the

## LEFT ANTERIOR DESCENDING ARTERY (LAD)

👉 SUPPLIES APPROX. 45% of the LV MUSCLE MASS



# Left Anterior Descending Artery

The LAD supplies blood to the ANTERIOR and SEPTAL walls, and includes the following CRITICAL STRUCTURES:

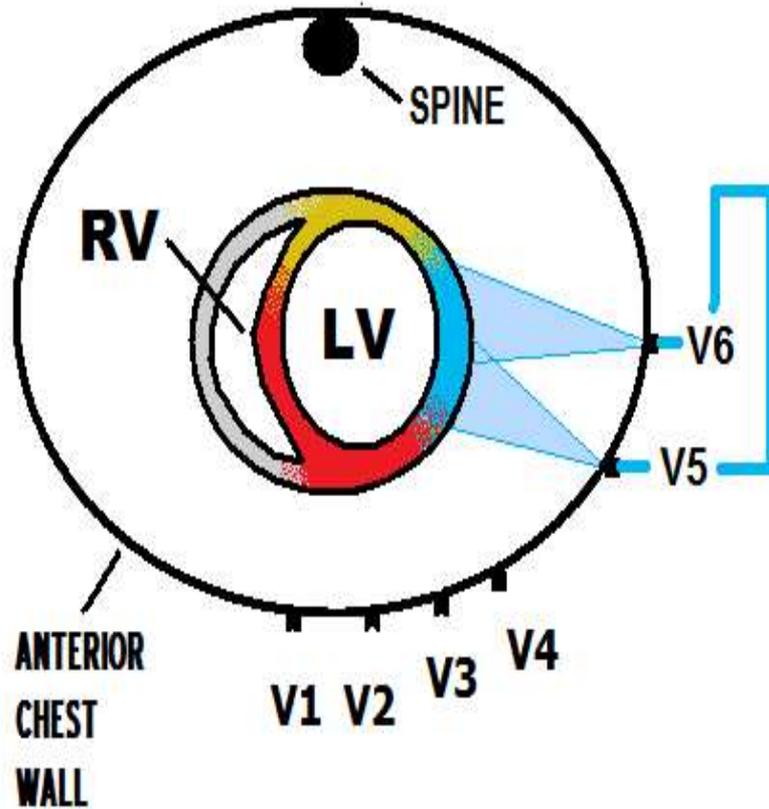
- Approximately 45% of the Left Ventricle
- Bundle of His
- Bundle Branches

# Left Anterior Descending Artery

The LAD supplies blood to the ANTERIOR and SEPTAL walls, and includes the following CRITICAL STRUCTURES:

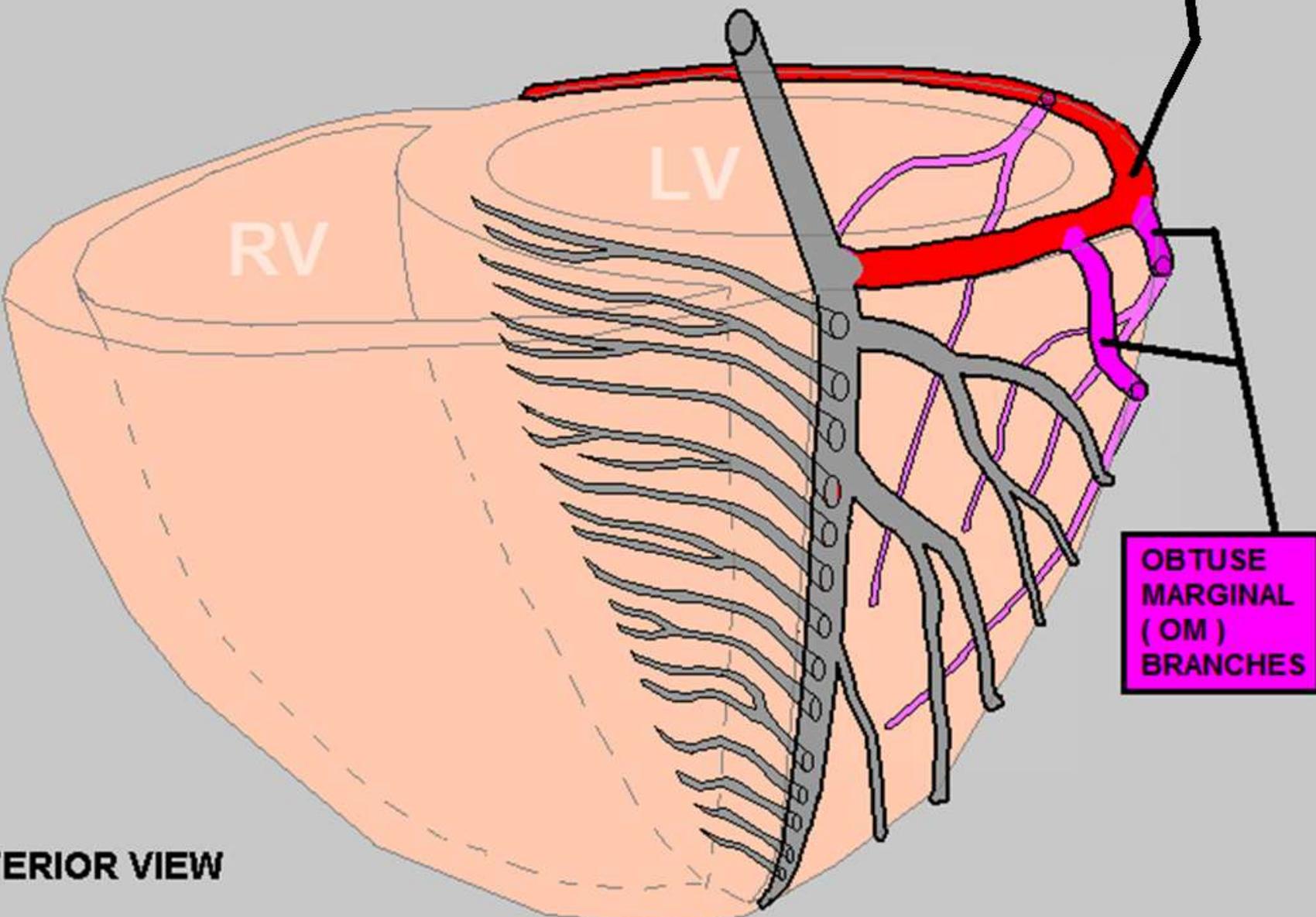
- Approximately \_\_\_\_\_ of the Left Ventricle
- \_\_\_\_\_
- \_\_\_\_\_

# V5 - V6 VIEW THE LATERAL WALL of the LEFT VENTRICLE



RUPPERT, WAYNE		ID: 7445683659	05-OCT-2006	JOHNS-HOPKINS UNIV.
38 Yrs MALE		Vent. Rate: 68 P-R Int.: 160 ms QRS: 100 ms	NORMAL SINUS RHYTHM Normal EKG Very Healthy Athletic EKG!	
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III	AVF	V3	V6	

# CIRCUMFLEX ARTERY



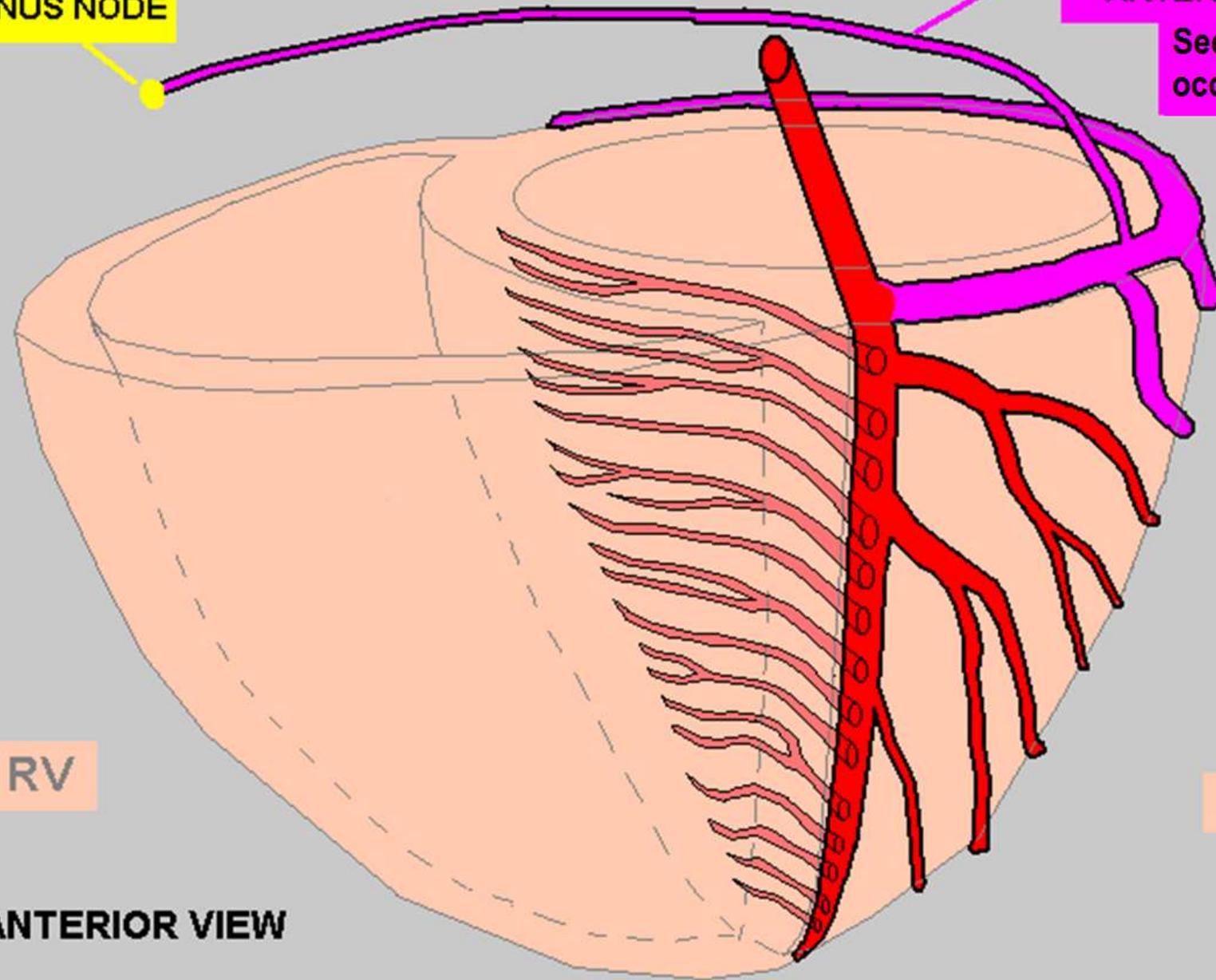
ANTERIOR VIEW

# CIRCUMFLEX ARTERY

SINUS NODE

SINUS NODAL ARTERY

Seen occasionally



RV

LV

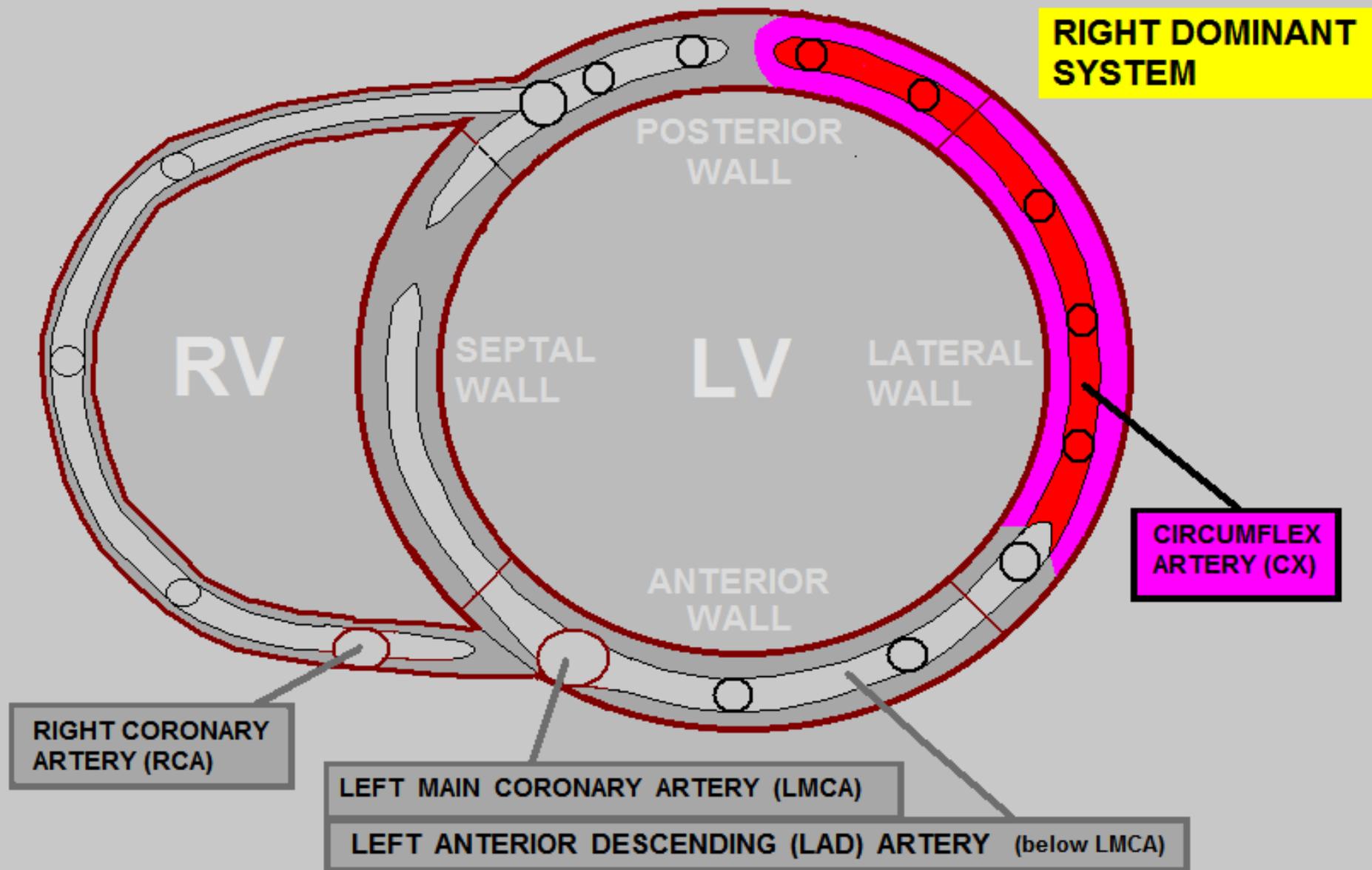
ANTERIOR VIEW

cutaway view of the

## CIRCUMFLEX ARTERY (CX) DISTRIBUTION



**SUPPLIES 20 - 30 % of the LV MUSCLE MASS**



# Circumflex (Cx) Artery

In patients with a Right Dominant coronary artery system, the Circumflex supplies blood to:

- Approximately 20-30% of the Left Ventricle, which includes:
  - Lateral Wall of Left Ventricle
  - Approx ½ of Posterior Wall
- On rare occasion, the SINUS NODE

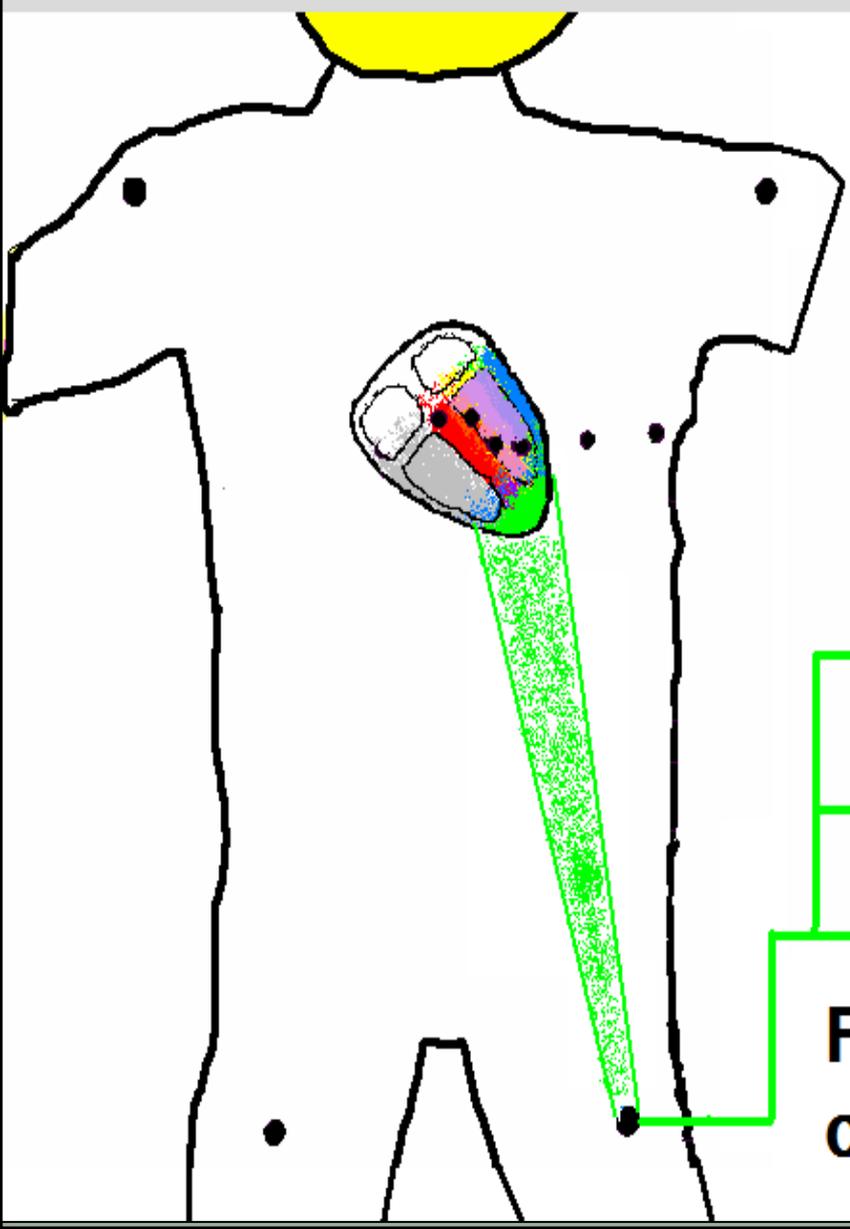
# Circumflex (Cx) Artery

In patients with a Right Dominant coronary artery system, the Circumflex supplies blood to:

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  - \_\_\_\_\_ of Left Ventricle
  - \_\_\_\_\_
- On rare occasion, the \_\_\_\_\_

# LEADS II, III, and aVF VIEW

## INFERIOR WALL of the LEFT VENTRICLE



RUPPERT, WAYNE		ID: 7445683659	05-OCT-2006	JOHNS-HOPKINS UNIV.
38 Yrs MALE		Vent. Rate: 68	NORMAL SINUS RHYTHM	
		P-R Int.: 160 ms	Normal EKG	
		QRS: 100 ms	Very Healthy Athletic EKG !	
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III	AVF	V3	V6	

**FED by the RCA ( 75 - 80 % pop )  
or the CIRCUMFLEX ( 10 - 15 % )**

# **DOMINANT RIGHT CORONARY ARTERY**

**SA  
NODE**

**A-V NODE**

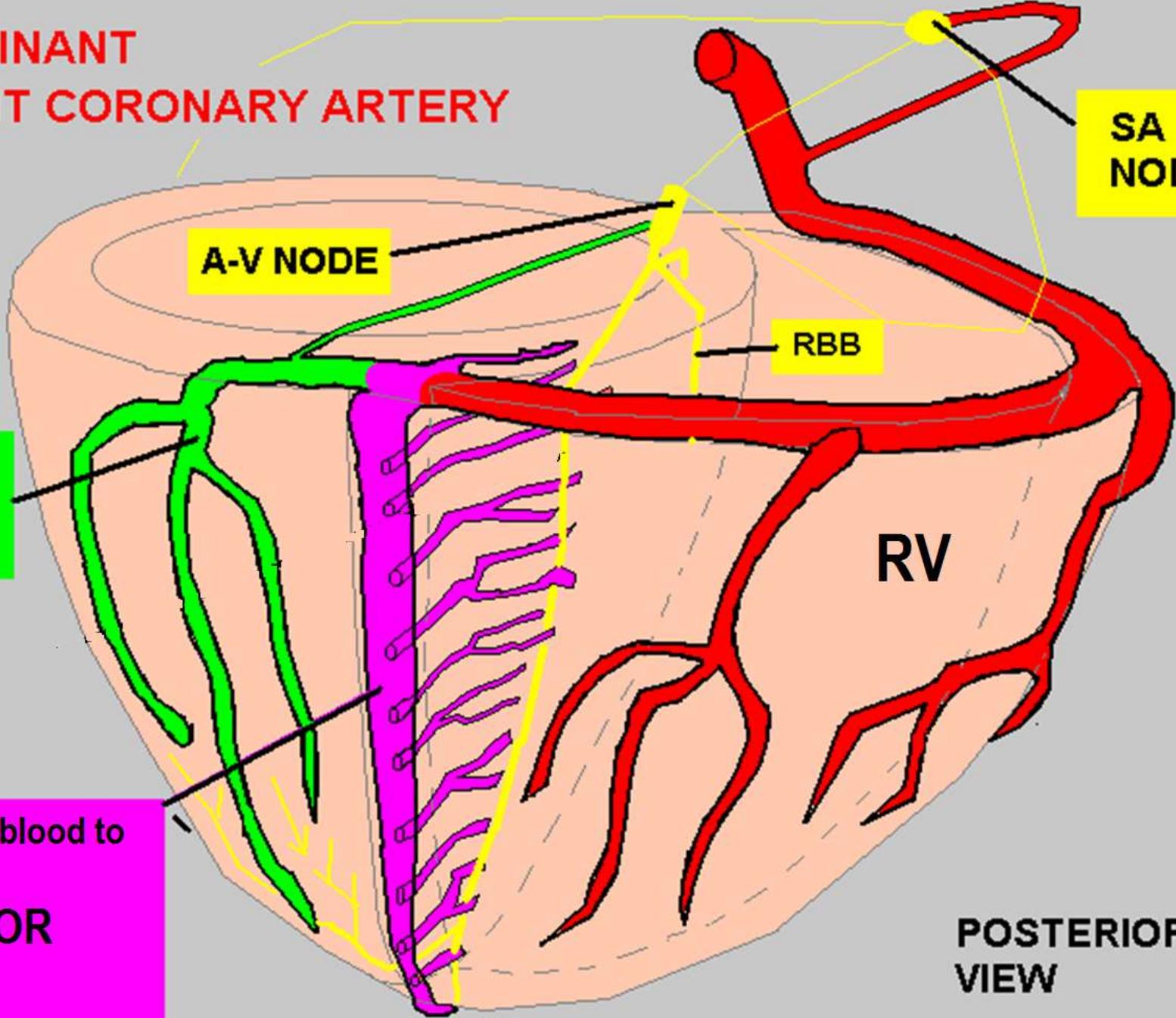
**RBB**

**RV**

Supplies  
Blood  
to:  
Approx 1/2  
of  
POSTERIOR  
WALL

Supplies blood to  
the  
INFERIOR  
WALL

**POSTERIOR  
VIEW**



# Right Coronary Artery (RCA)

In patients with a RIGHT DOMINANT system, the RCA supplies blood to the following cardiac structures:

- Sinus Node
- Right Ventricle
- AV Node
- Approximately 15-25% of the Left Ventricle
  - INFERIOR Wall
  - ½ POSTERIOR WALL

# Right Coronary Artery (RCA)

In patients with a RIGHT DOMINANT system, the RCA supplies blood to the following cardiac structures:

- \_\_\_\_\_
- \_\_\_\_\_
- \_\_\_\_\_
- Approximately \_\_\_\_\_% of the Left Ventricle
  - INFERIOR Wall
  - ½ POSTERIOR WALL



MOM and DAD at Lee's Diner, York, PA 2006