12 Lead ECG Interpretation Workshop

For Acute and Critical Care Providers

Presented by Bob Page, M.Ed, NRP, CCP, NCEE

12 Lead ECG Interpretation for Acute and Critical Care Providers
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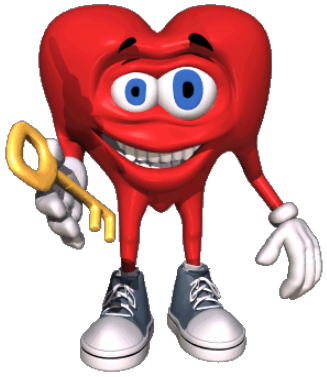


Learning Objectives

At the end of this course, the participant will be able to

1. Describe the fundamental principles of Acute Coronary Syndrome (ACS) assessment.
2. Demonstrate proper lead placement for 12 and 15 lead ECG.
3. Correctly label ECG waves, such as P wave, QRS complex, T waves and J point.
4. Describe how to validate a 12 lead ECG.
5. On a 12 lead or 15 lead, identify ST changes that indicate STEMI (ST segment myocardial infarction), NSTEMI (Non-STEMI), or unstable angina.
6. Given a simple chart, identify the location of the STEMI based on 12 lead ECG findings.
7. Describe the possible complications of the various infarct locations.
8. Describe the importance of a 15 lead ECG in the assessment of the ACS patient.
9. Using a simple chart and a 12 lead ECG, correctly identify axis deviation and possible ("hemiblock") or fascicular block.
10. Describe the clinical significance of axis deviation in the cardiac patient.
11. Using lead V1 and the turn signal criteria, correctly identify left and right bundle branch blocks.
12. Using ECG and other criteria, determine which LBBB may be a candidate for early intervention.
13. Identify other STEMI mimics such as pericarditis, ventricular, LVH, and early repolarization variant.
14. Describe criteria for proving ventricular tachycardia with a 12 lead ECG.
15. Describe the QT interval and discuss the importance of it in the management or the cardiac patient.
16. On a 12 lead, identify the QT/QTc and determine if it is prolonged.
17. Describe a systematic assessment of a 12/15lead ECG in ACS.

About this workbook

This workbook is designed for participants of the Multi-Lead Medics, 12 Lead ECG Interpretation for Acute and Critical Care Providers live workshop. It is not designed as a stand alone course without examples provided in the workshop. Many details are brought out in the workshop. This represents a relief from note taking, whereas the participant can focus on the talk and demonstrations, only having to take minimal notes. More comprehensive information can be found in Bob's Textbook **12 Lead ECG for Acute and Critical Care Providers:** A Brady/Pearson title available in most bookstores and online through Amazon or others.

The best way to learn 12 lead Interpretation is through practice. In the workshop, you will be involved in a classroom discussion, on screen practice and interactive evaluation. After class, it is highly recommended you get the book, which has over 450 practice 12 leads to help you master the skills of 12 lead interpretation.

PART 1: Get it Right!

RECOGNITION – ACTIVATION – INTERVENTION

These are the three tenants of the assessment and management of the acute coronary syndrome patient.

Triage and Assessing the Patient

A cardiac monitor (Lead II) will show changes in electrical activity. It cannot detect a heart attack and is not useful in finding one. From the start many have been taught that lead II will tell us all we need to know. That is because it was all we had. There is much useful and potentially life saving information that can be gained from running a 12 lead ECG first. I call this THROWING DOWN!

This is why I say **IN LEAD II, YOU GOT NO CLUE!**

To **THROW DOWN** represents a fundamental paradigm shift. What I am suggesting is that we acquire a 12 lead on every patient with a PULSE and a PROBLEM related to a cardiovascular problem. Remember an Acute Coronary Syndrome is not just a STEMI, but is also TACHY, or a BRADY, or a BLOCK. This should be done first, within the first 5 minutes after patient contact by the first person with a 12 lead capable device. The 12 lead should be read and triaged for STEMI this is called **RECOGNITION** and if found, the appropriate facility should be notified and resources activated *from the field*. This is called **ACTIVATION.** The following statement is from the AHA's 2010 guidelines:

Out-of-Hospital 12-Lead ECGs

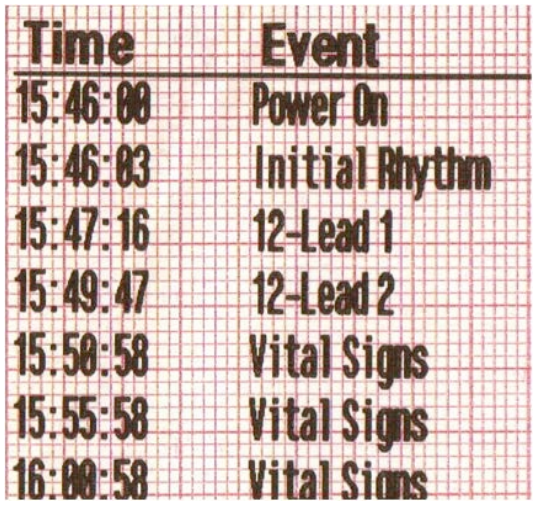
An important and key component of STEMI systems of care is the performance of out-of-hospital 12-lead ECGs with transmission or interpretation by EMS providers and with advance notification of the receiving facility. Use of out-of-hospital 12-lead ECGs has been recommended by the AHA Guidelines for CPR and ECC since 2000 and has been documented to reduce time to reperfusion with fibrinolytic therapy. More recently, out-of-hospital 12-lead ECGs have also been shown to reduce the time to primary PCI and can facilitate triage to specific hospitals when PCI is the chosen strategy. When EMS or ED physicians activate the cardiac care team, including the cardiac catheterization laboratory, significant reductions in reperfusion times are observed.

It has been stated: *"every second that passes that a cardiac cath lab is not activated, 500 heart cells die"* This is evident as the AHA criteria show "significant" reductions in reperfusion times when the cardiac cath lab is activated. In my home state of Missouri, the TCD (Time Critical Diagnosis) criteria states for EMS to *"acquire a 12 Lead and notify the appropriate receiving facility within 5 minutes of patient contact!"*

Below is a comparison of two EMS agencies that demonstrate the differences in priority of 12 lead acquisitions.

Time	Event
11:13:04	Power On
11:13:27	Print 1
11:18:02	Vital Signs
11:18:58	Initial Rhythm
11:20:14	Print 2
11:23:02	Vital Signs
11:24:07	Print 3
11:25:36	12-Lead 1
11:28:02	Vital Signs
11:28:35	NIBP

Time to first 12 lead was 12:32!



Time	Event
15:46:00	Power On
15:46:03	Initial Rhythm
15:47:16	12-Lead 1
15:49:47	12-Lead 2
15:50:58	Vital Signs
15:55:58	Vital Signs
16:00:58	Vital Signs

Time to first 12 lead was 76 seconds!
Time to 15 Lead was 3:47

The time difference from **(First Medical Contact) FMC** to the first 12 lead was over 11 minutes! Both of these services are in the same city, going to the same hospital with the same ETA and similar patient presentations. The truth is that it is very much possible for all EMS or First Responder agencies, and even hospital triage desks to adopt this philosophy. The 76 second 12 lead time was made possible because the agency did a 12 lead FIRST whereas the other service ran up to 4 rhythm strips BEFORE they ran a 12 lead. The savings was over 330,000 heart cells, just by running the 12 lead first!

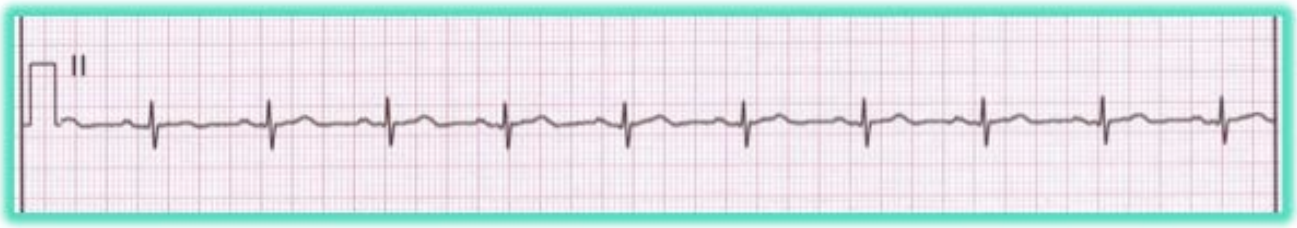
Furthermore, recent (2015) AHA guidelines suggest that using a machines interpretation of "Acute MI Suspected" alone is not enough to call a STEMI. (Class 3, Not helpful/possibly harmful). It suggested either transmitting the 12 lead to the hospital or EMS interpretation and calling the hospital (Both class 2A, helpful) is the way to go.

It's all about TRIAGE

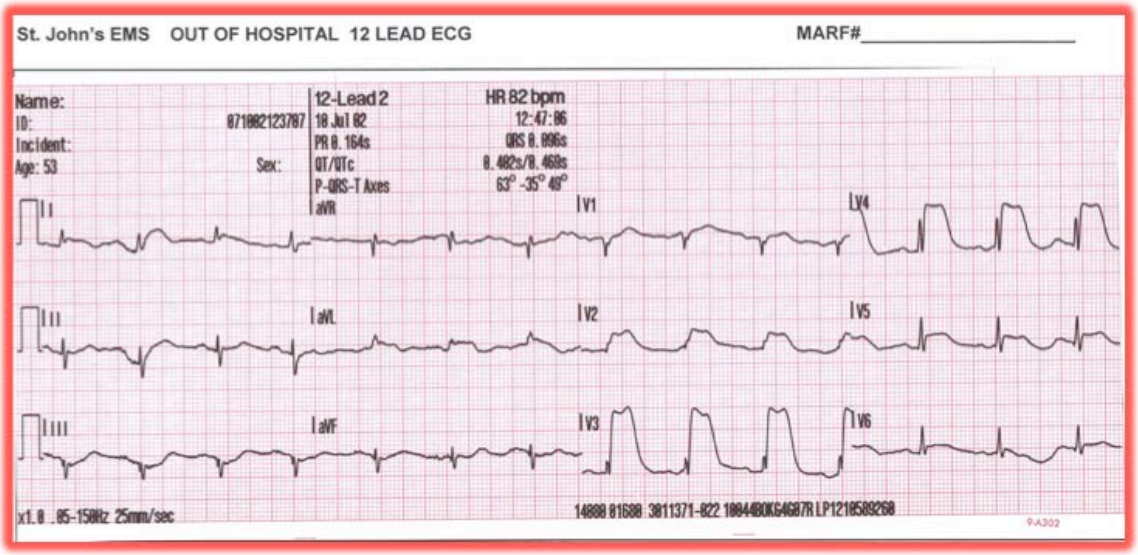
This is a case of 53-year-old woman with diabetes that invited the crew over for breakfast (her cousin is a paramedic with the service). She asked if they would check her blood sugar because she felt "goofy" earlier and thought her glucometer was wrong. The crew agreed to do this for her. It read 110, the same on both machines. She was relieved because she thought her machine was wrong. They were thanked for their time and were about to go back to the station. The paramedic suggested that they check her out more with an ECG and the woman agreed.

Here is her rhythm strip as they "checked out" her ECG.

Initial Lead II rhythm strip: Looks pretty normal huh?



Then they decided to run a 12 lead!



I think you can see the outcome here. The patient had a massive antero-septal STEMI (ST elevation in V2-V4). This is the proof. In LEAD II, YOU GOT NO CLUE! You cannot TRIAGE anyone with a Lead II strip so "putting a patient on the monitor" initially is useless and a waste of time in my opinion. This practice needs to change in favor of a more comprehensive triage methodology using a 12 lead ECG. It starts with you. Only your understanding of the value of the 12 lead ECG will change your practice.

The patient was flown to the cardiac catheterization lab (PCI) hospital where stents were placed and the patient did well and was released home a few days later. Remember, this patient did not complain of chest pain. However, "a sick diabetic is always sicker than they appear." This prompted the paramedic to do the 12 lead. The use of 12 Leads should not be limited to those with "Chest Pain" as many patients would not qualify. Diabetes, women, and the elderly frequently have atypical presentations; that is without chest pain.

By the same token, age should not be a limitation for 12 lead acquisition, while statistically speaking the young (<35 y/o) are not as likely to have a heart attack as their elders, they do have them, and the cause of their chest pain could be other conditions that only a 12 lead could discover: i.e., tachycardia, WPW, prolonged QT syndrome, etc. Some popular drugs, cocaine and methamphetamines also produce cardiac problems in the very young.

Proper Lead Placement for Diagnostic 12 Lead ECG

A 12 lead ECG is a diagnostic test which results can move thousands of dollars in men, women and resources to save a life or a lifestyle. It is on the same diagnostic order as a CT for an acute stroke to rule out a bleed. Therapy is time critical. That is why the procedure must be done right and done quickly as possible after onset of symptoms. In other words, if we don't do this right, no-one can read the ECG and the patient will suffer the consequences.

Procedure:

TIPS for Patient position and skin preparation for First Pass Success

- Run the 12 lead in the position of comfort for the patient.
- Clip away chest hair where necessary with surgical clippers.
- Dry diaphoretic skin with a towel.
- The use of skin prep tape or another abrasive pad to remove the dead skin (epidermis) will help a lot, especially if you get those "Noisy data, or waiting for good data" errors on your 12 lead machine, or if you get excessive artifact. A brief "dry rub" of an abrasive pad on each location will save you from replacing electrodes or delaying a good tracing of the 12 lead.
- Consider alcohol wipes, or betadine prep can help electrodes stick better, but the dead skin (epidermis) is what gives the error messages due to poor conduction.

The 12 Lead ECG only uses 10 electrodes.
Limb leads: 4 leads give you 6 views.
Leads I, II, III (standard bipolar limb leads)
Augmented Voltage (unipolar limb leads) **aVF, aVL, and aVR.**

Limb leads go on the limbs!

A 1975 study/paper, the lead placement for a diagnostic 12 lead was defined. It stated that: "Limb Leads go on the limbs." That is anywhere on the limbs as long as you are off the shoulders and below the inguinal ligament (where your legs attach to your body)
Most modern 12 lead machines have the lead location stamped on the electrodes. The study gave two reasons the limb leads have to go on the limbs: **Angle and Amplitude**. The ***angle*** that the limbs leads "see" the heart from is altered with abdominal or thoracic limb lead placement. The ***amplitude*** is also skewed as limb leads are augmented to make them bigger since they are on the limbs. Taking limb leads off the limbs can lead to over augmentation. This can lead to a false positive, meaning exaggerated ST segments and size of the ECG, making the 12 lead ECG non-diagnostic. Keep the arm leads above the elbow. When a patient "holds still" they usually grip something causing artifact below the elbow.

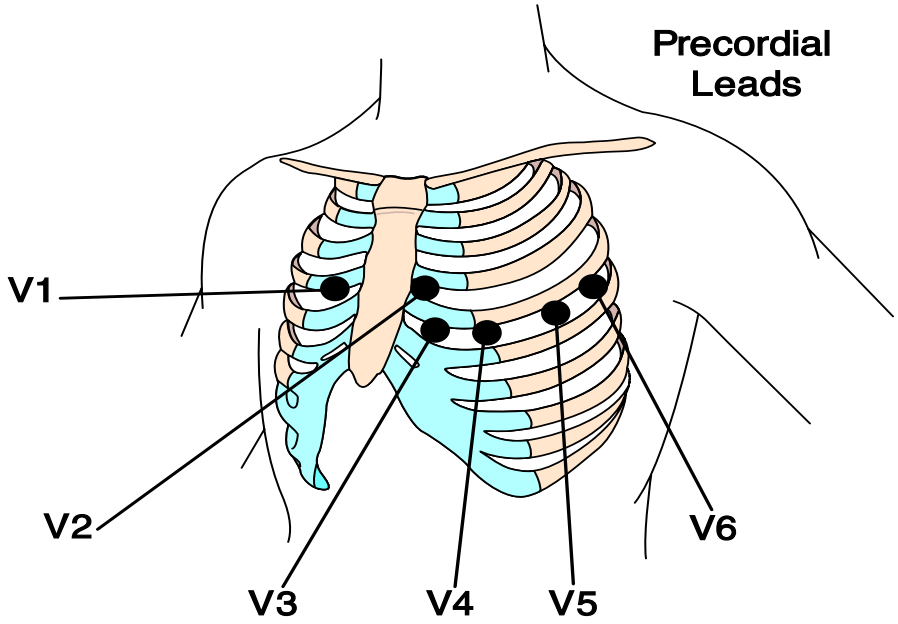
- ♥ RA - white electrode - means Right ARM
- ♥ LA - black electrode - means Left ARM
- ♥ LL - red electrode - means Left LEG
- ♥ RL - green electrode means Right LEG

So why do so many people put the electrodes on the chest? This is an example of another paradigm or "the way we've always done it!" In all fairness, the leads were moved into the chest to reduce artifact in the hospital setting where remote monitoring is allowed. However, by placing the electrodes on the chest, you can only ***monitor*** the rhythm. In order to ***assess*** for the electrical axis, hemiblocks and bundle branch blocks, and STEMI recognition you must have the leads on the LIMBS! Oh, by the way, if artifact is a problem, have the patient lie still while you get the ECG! If their hands are shaking, hold their hands while acquiring the 12 lead. If they are too sweaty, hold them on with your fingers! It doesn't superimpose your sinus tachycardia on their sinus rhythm!

Precordial Leads (V or voltage leads) These leads are to be "meticulously placed based on topographical anatomical location and as little a 2cm deviation can affect diagnosis."

V1, - 4th IC space, right side of sternum
V2, - 4th IC space, left side of sternum
V3, - between V4 and V2
V4, - 5th IC space, mid clavicular line
V5, - 5th IC space, anterior axillary line
V6, - 5th IC space, mid axillary line
V4, 5, 6, should be in a straight line in the 5th intercostal space.

Each person is unique whereby their external landmarks correspond with their internal anatomy. These leads have to be accurately placed or a STEMI could be missed all together.



It is good practice to put the patient in a hospital gown if available. With women the bra should be removed and replaced with a gown. Leads are not placed on the breast rather below them. Large breasts may need to be lifted to expose the 5th IC space The 5th IC space on a women is the crease where her breast tissue meets her chest wall. Then lead V3 is placed to the right of V4 in the same space between V2 and V4. It is normal for the leads to not be equally spaced apart on most people. Anatomical landmarks are unique to that person. For this reason, all in one lead systems have been found to have inaccurate lead positions in most cases and should not be used at all for diagnostic 12 lead ECG's.

Review of Proper 12 Lead ECG acquisition.

1. Prep the skin: dry wet skin and abrade each area.
2. Place limb leads on the limbs, off the shoulder and above the elbow and below the inguinal ligament.
3. V Leads should be meticulously placed on the correct anatomical landmarks.
4. Patient should be placed in a hospital gown for transport. This can save up to 5 minutes at the hospital.

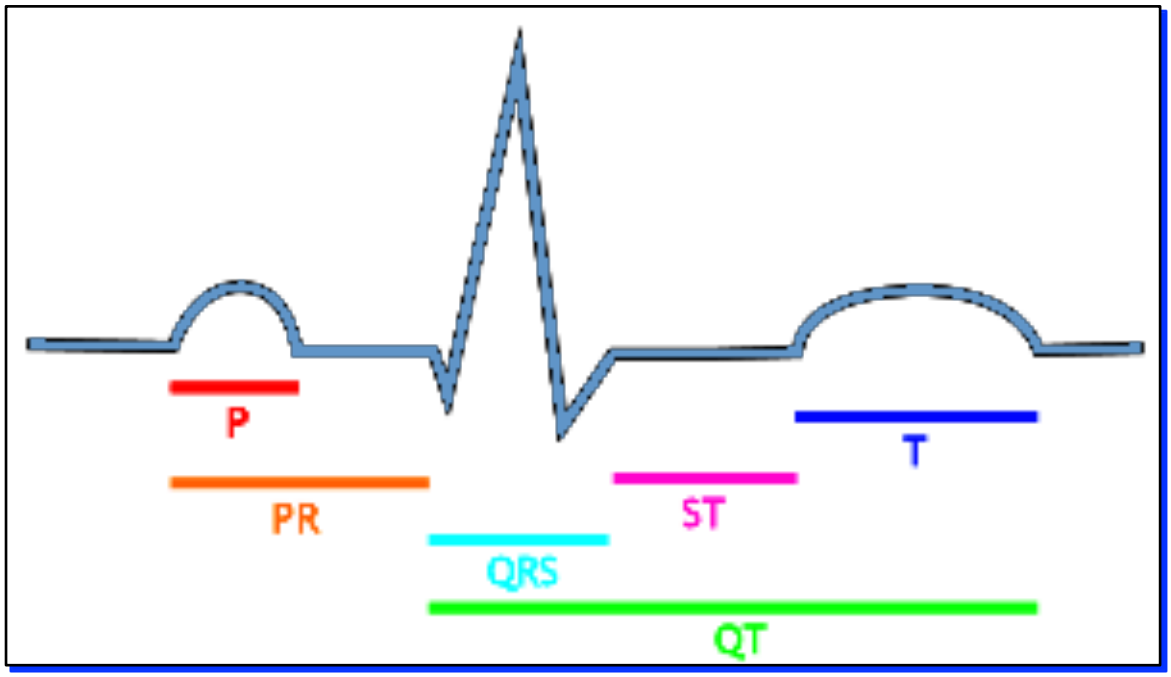
Once the skin preparation and the placement is correct, have the patient hold still and get the 12 lead printout. Most machines require 10 seconds to record a 12 lead, some only 3 seconds. Be sure to get the *printed* 12 lead. Reading from the scope real time is NOT diagnostic.

Labeling an ECG

The electrocardiogram is a voltmeter that does two things. Both are essential to ECG interpretation.

1. It measures precision intervals and voltage
2. It draws a shape (morphology of an ECG pattern)

The Basic Cardiac Cycle has the following components



P waves represent Atrial depolarization

The *PR interval* is the time between the atrial firing (P) and the ventricles firing (QRS). This is used in rhythm interpretation. Normal is 120 – 200ms.

QRS Complex represents ventricular depolarization. Normal is <120ms (adults)

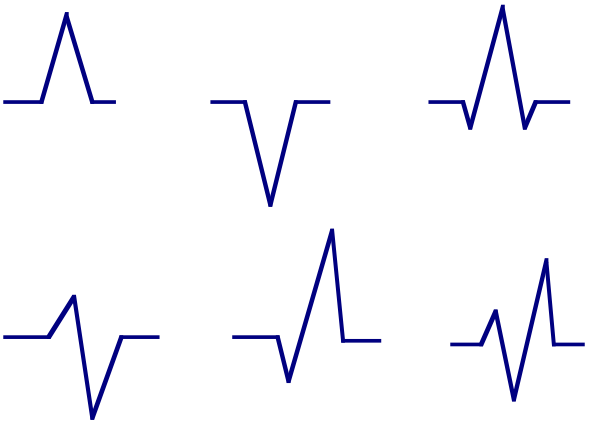
The *ST segment* is where we look to triage for possible STEMI (ST Elevation Myocardial Infarction) or NSTEMI (Non ST Elevation Myocardial Infarction)

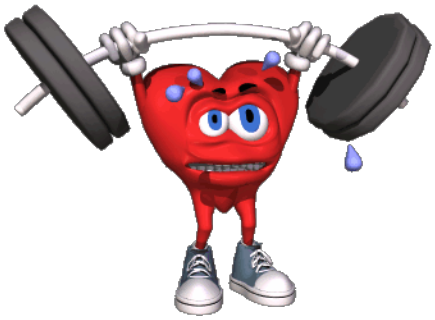
T waves represent ventricular repolarization.

QT Interval is measured from the start of the QRS complex to the end of the T wave. The represents total ventricular refractory time and is an important finding to ALS providers considering medication therapy. Should be <460ms for all heart rates.

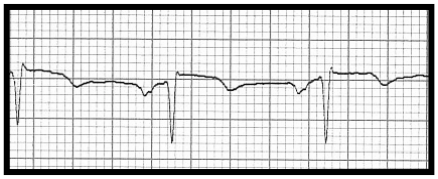
Labeling the complex

QRS Morphologies
Can you label these complexes?



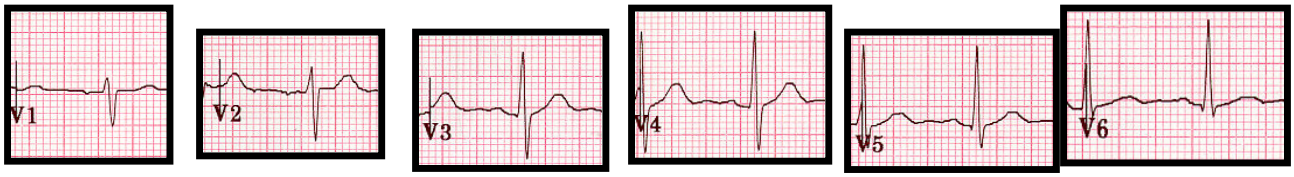


Validating the 12 lead.
Before reading the 12 lead it should be validated. If the limbs leads are off the limbs then the 12 lead is invalid.

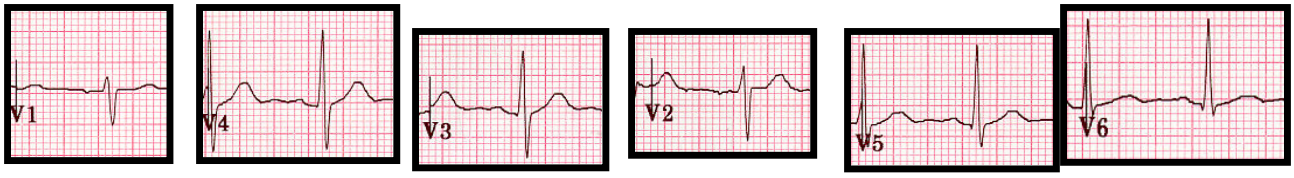


First look at Lead I. If the P, QRS complex and T wave are all upside down this is *global negativity* meaning the upper limb leads are switched.

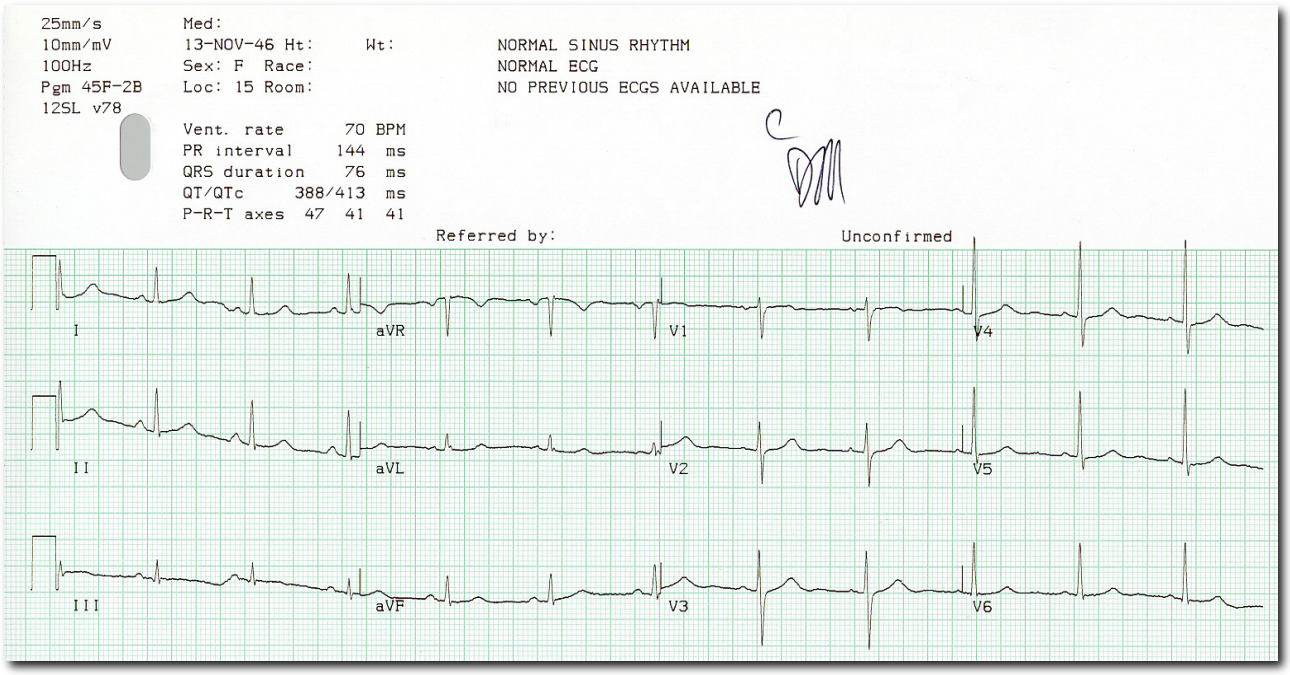
In the pre-cordial leads (V Leads) we look for "*R Wave Progression*" to confirm proper lead placement. Notice how the size of the r wave increases in size until between leads V3 and V4, the "QRS" deflection goes from one that is negative to one that is positive.



Poor R wave progression can occur when the wires are misplaced on the wrong site, (V2 on V4 for example) If you see poor r wave progression, look to see if the wires are in the right location, If they are then this could indicate pathology. We don't want to make this call because we have our wires crossed (so to speak).



The Normal 12 Lead



Leads I, II, and III are bipolar limb leads. They are augmented so they make the waves and complexes bigger.
Leads aVR, aVF, and aVL are augmented limb leads as well. All limb leads must go on the limbs for this reason.
Leads V1-V6: The precordial leads that are unipolar. (no augmentation necessary)

The voltmeter function measures the intervals such as PR, QRS, and QT. These numbers are as a rule fact and accurate. It also calculates axis that is also accurate as long as the limb leads are on the limbs.

The machines interpretation can be right, wrong, or deadly wrong. This means that we must learn how to interpret a 12 lead so we can see when a machine interpretation makes no sense or could be wrong. Using the machine interpretation alone is NOT recommended.

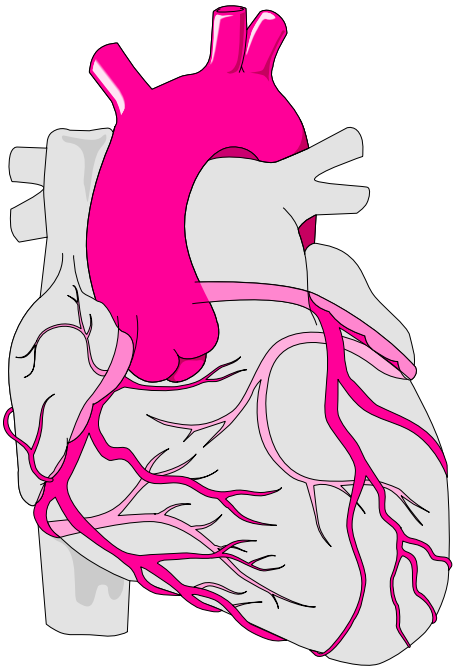
Summary of Labeling and Validation

1. First deflection of the complex, if negative, is the only time a Q wave can exist
2. First upright deflection is called an R wave.
3. Negative deflection after an R or Q wave is called an S wave.
4. A second R wave that occurs after an S wave is labeled R' (prime)
5. Validate all 12 leads, limb leads on correct limbs and R wave progression

PART 2: STEMI Recognition

Coronary Arteries

Myocardial Blood Supply:



Right Coronary Artery (RCA)
- **Inferior wall** of the left ventricle
- **Posterior Wall** of LV
- **Right Ventricle**
- SA Node in 50% of folks
- AV node in 90 % of folks

Left Anterior Descending (LAD) "widow maker"
- **Anterior wall** of the left ventricle
- intraventricular septal artery **(septum)**
- RBB, LBB, both fascicles of the LBB

Left Circumflex Artery (LCX)
- **Lateral wall** of the left ventricle
- **Posterior Wall of LV**
- SA node in 45% of patients
- AV node in 10% of patients

Why do you need to know this?

If you know the blood supply, then ECG changes can help you predict which areas of the heart may give you trouble either as infarct or conduction deficits. It always helps to be prepared for the worst. This preparation comes through a sound working knowledge of cardiovascular pathophysiology, and electrocardiography.

Genesis of an AMI

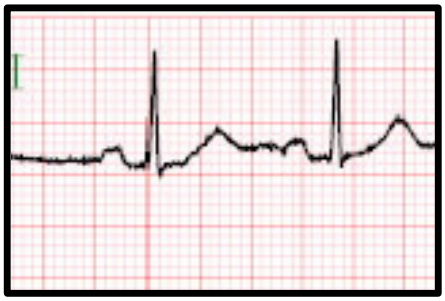
1. Atherosclerotic plaque formation on the inside of a coronary artery.
2. Plaque ruptures
   - Lesion sets off cascade of clot forming biochemistry
   - Clot forming is a dynamic process
   - Process can be interrupted with anti-platelets (ASA) and anti-coagulants (Heparin, Plavix)
3. Occlusion data
   - Symptoms on exertion = 70 - 85% occlusion
   - Symptoms at rest = 90% occlusion
   - Symptoms that do not resolve with NTG = 100% occlusion

Remember, not everyone with an ACS will complain of "chest pain", some may be atypical or silent. Any patient with a *"pulse and a problem between nose and naval"* should get an immediate 12 Lead ECG.

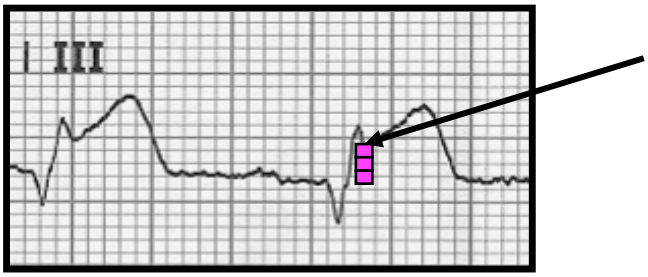
Finding and Locating the STEMI (ST elevation myocardial infarction)

The key to survival from an acute coronary syndrome is best summarized in the tenet: RECOGNITION, ACTIVATION, INTERVENTION.

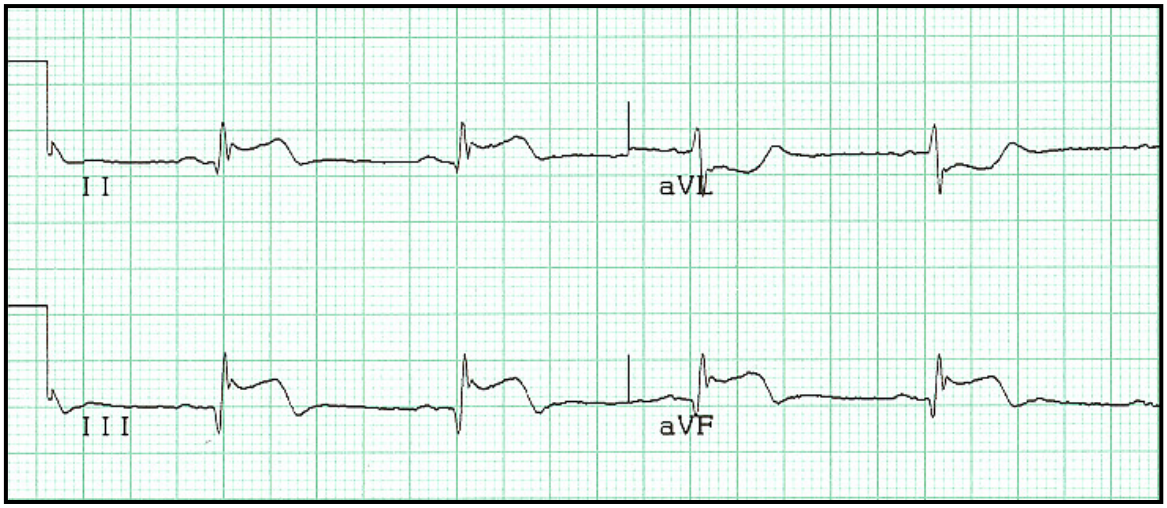
The 12 Lead ECG was invented to be able to put a lead on an area of the heart that might be having active ischemia or injury. This would allow us to "look" for damage in that area. Based on the way that electricity travels through normal and ischemic heart tissue, changes in the shape of the complex, particularly the ST segment would be evident. Areas having injury would show ST Segment elevation. If this elevation is seen in 2 or more leads in the same location, then the patient is having a ST elevation myocardial infarction or STEMI as it has become known. **RECOGNITION**. This ECG evidence alone is enough to activate the hospital resources to be ready ASAP. **ACTIVATION.**



Normal ST segment



ST segment Elevation

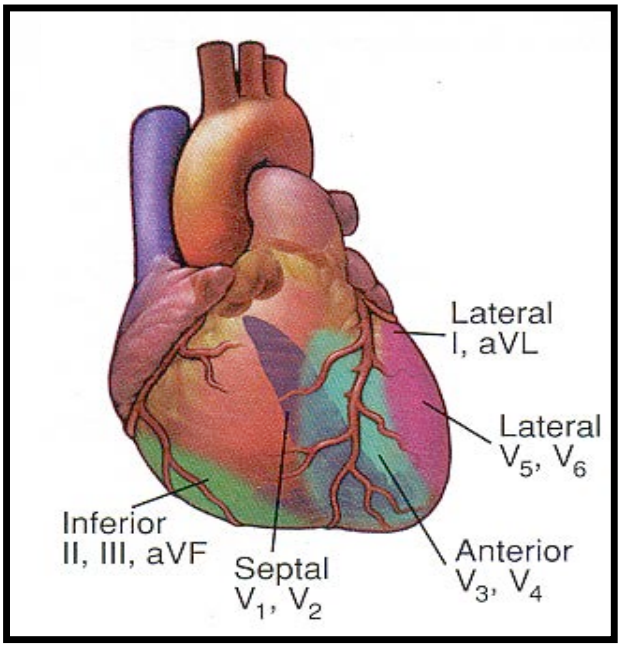


ST Elevation in Leads II, III, and aVF indicating STEMI. Also note ST depression in lead aVL. This is called reciprocal change and indicates a full thickness heart attack. Leads II, III, and aVF are from the same lead group called the inferior leads. This would be called an inferior wall MI. This should be immediately called in to **ACTIVATE** the Cath Lab!

Locating the STEMI

Each lead on a 12 lead ECG represents a "look" at that location on the heart. This why it is important that lead placement is meticulous. To locate the heart attack, see what leads show ST segment elevation. The following chart can be useful in helping to find the location of the heart attack. This information can help predict possible complications.

Acute MI Locator ST↑elevation		
Location	**Leads**	**Recip.**
Inferior (RCA)	II,III, F	I, AVL
Septal (LAD)	V1, V2	
Anterior (LAD)	V3,V4	II, III, F
Lateral (CIRC)	V5,V6, I, L	II, III, F
Posterior (RCA)	V8,V9 R>S in V1	ST↓ V1 - 4
Right Vent. (RCA)	V4R	

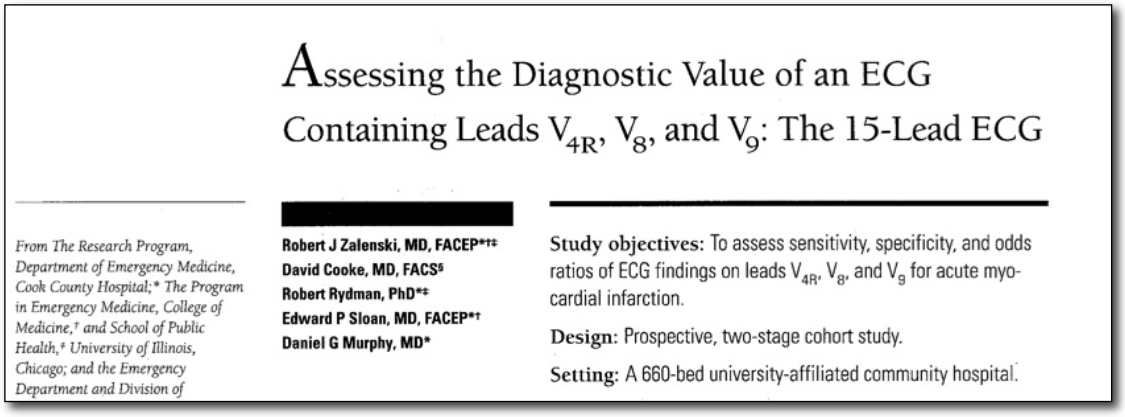


When 12 Leads are Not Enough. The 15 lead ECG

The importance of running a 12 lead ECG early to triage for STEMI cannot be overstated. Unfortunately the 12 lead ECG has a notorious lack of sensitivity. That is that only 50% of heart attacks will show STEMI on the 12 lead. This is in large part due to the fact that the standard 12 lead does not look at the entire heart. It only looks at the inferior, septal, anterior and lateral heart. This is why we should run a 15 lead ECG. A study published on the Annals of Emergency Medicine first documented the benefit of the 15 lead ECG and defined what it is and how to use it.

A 15 Lead ECG can help to find three conditions that are not possible to find with a standard 12 Lead ECG. These are all critical findings that could alter the course of treatment.

1. Right Ventricular Infarction
2. Isolated Posterior Wall MI
3. Dissecting Thoracic Aortic Aneurysm (DeBakey 1 ascending)



Assessing the Diagnostic Value of an ECG Containing Leads V_{4R}, V_8, and V_9: The 15-Lead ECG

From The Research Program, Department of Emergency Medicine, Cook County Hospital;* The Program in Emergency Medicine, College of Medicine,† and School of Public Health,‡ University of Illinois, Chicago; and the Emergency Department and Division of

Robert J Zalenski, MD, FACEP*†‡
David Cooke, MD, FACS§
Robert Rydman, PhD*‡
Edward P Sloan, MD, FACEP*†
Daniel G Murphy, MD*

Study objectives: To assess sensitivity, specificity, and odds ratios of ECG findings on leads V_{4R}, V_8, and V_9 for acute myocardial infarction.

Design: Prospective, two-stage cohort study.

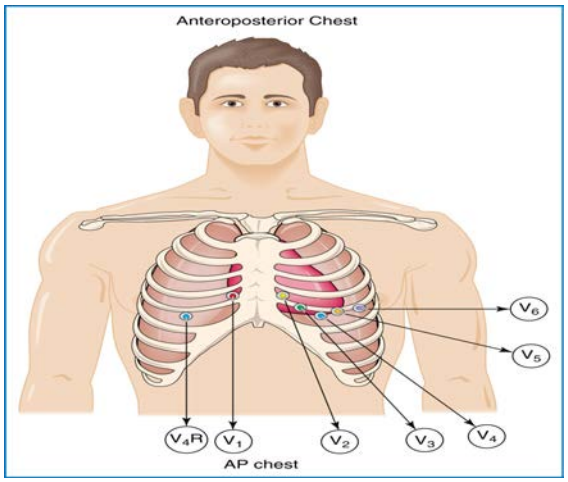
Setting: A 660-bed university-affiliated community hospital.

A 15 lead ECG should be performed on all patients with an inferior wall MI, normal 12 lead ECG, and those with a strong suspicion of having posterior or right ventricular involvement.

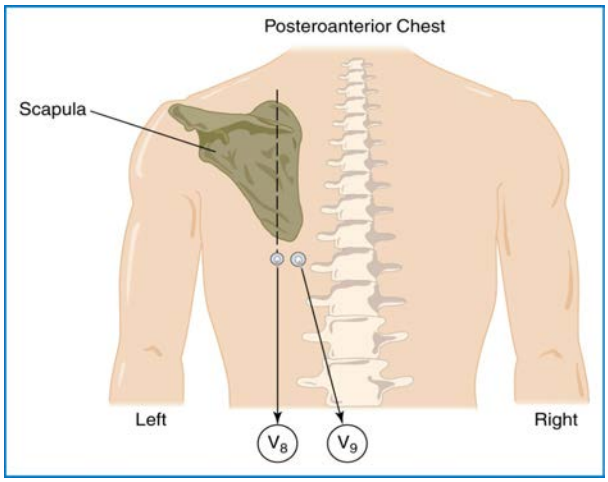
A 15 lead looks at two areas of the heart not seen by the 12 lead: The posterior wall (V8-V9) of the left ventricle and the right ventricle (V4R). Standard 12 lead machines only have 10 wires so there are not enough wires to run a 15 lead in one pass. It will be necessary to run a second 12 lead to capture the last three leads.

Running the 15 lead (It only takes 20 seconds to do this)
Run the first 12 lead as always
Unsnap wires for V4, V5, and V6 (leave the others where they are)
Place V4 on V4R (This looks at the Right ventricle)
Place V5 on V8, V6 for V9 as below. Run 12 lead #2 (which is now the 15 lead

V4R - 5th IC space, mid clavicular line ***right*** side (same a V4 on the left)
V8 - 5th IC space mid scapular
V9 - 5th IC space between V8 and spine

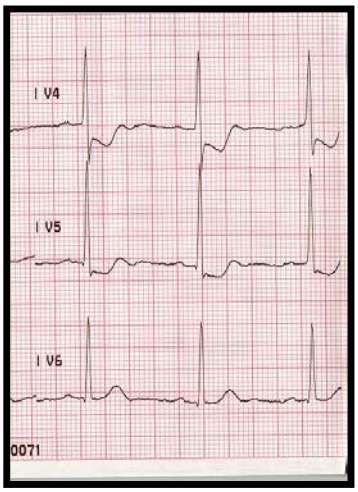


Lead Placement for V4R



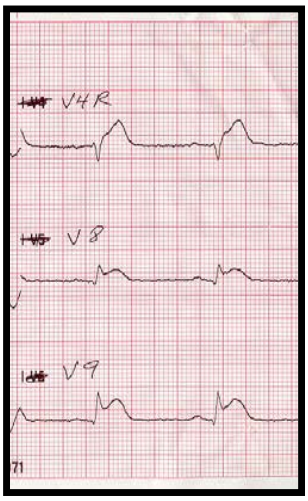
Lead Placement for V8-V9

Once you acquire the 15 lead it is very important to immediately re-label the leads for V4, V5, and V6 as V4R, V8 and V9. If you fail to re-label them, then the second 12 lead will be dramatically different then the first one in those three leads.



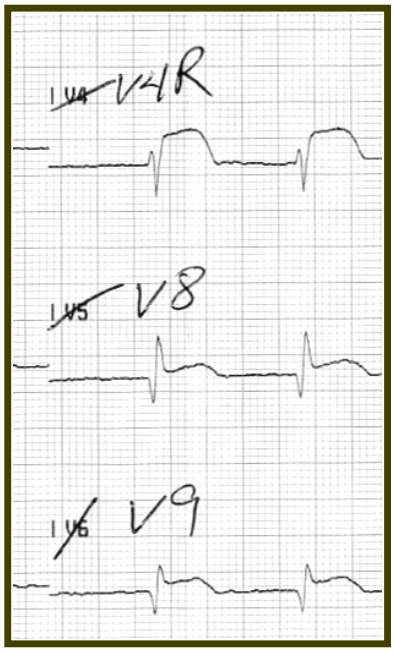
12 Lead # 1 shows V4, V5 and V6

15 lead relabeled shows V4R, V8 and V9. Low voltage is common for V8 and V9.



What do you look for on a 15 lead? The purpose of running the 15 lead is to increase the sensitivity of STEMI recognition. So, we are looking for ST segment elevation. ST elevation in lead V4R alone is diagnostic for Right Ventricular Infarction (RVI). ST elevation in Leads V8 and V9 are diagnostic of posterior wall MI (PWMI).

The Importance of a 15 Lead ECG



* Posterior Wall MI (V8-V9)
  * Run on all non diagnostic 12 leads
  * Can locate ***isolated posterior MI***
  * Use leads V8 and V9
  * Increases sensitivity by 23%RCA - 86% CRX
  * Can't see posterior wall directly on a 12 lead
  * ST depression in leads V1-V3 is neither specific nor sensitive for posterior wall MI, with or without inferior wall MI. **NO ECG FLIPPING!!**

* Right Ventricular Infarction (V4R)
  * 50% of Inferior wall MI (ST elevation in Leads II, III, and aVF) **have Right Ventricular involvement.**
  * Right ventricular infarction is a preload problem and could cause dramatic hypotension even death with nitroglycerin. Heart association calls RVI a contraindication for nitrates and morphine

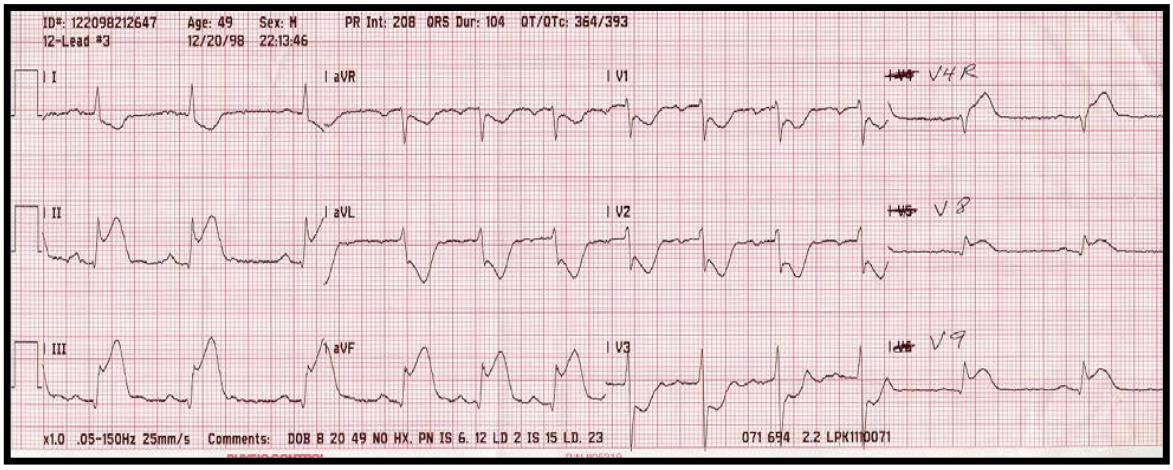
In the case of inferior wall MI, or normal 12 lead, DO NOT GIVE NITRO or MORPHINE without first running a 15 lead to find RVI.

Management of RVI

Since this is a huge preload problem, the body could be in compensated shock due to reduced filling. Acute management for some providers includes rapid infusion of normal saline (as much as 1-2 liters) or more. This increases RV filling thus recruiting the Starling forces increasing contractility. Always assess and re-evaluate your patient and follow your local protocols. Check with your medical authority to see what they recommend for right ventricular infarction. This may be very different from the standard chest pain care. Some services allow NTG drips (infusions) at a start rate of 5mcg/min to allow the benefits of NTG with the drop in pressure with higher doses. NTG spray or tablets are absorbed at a rate of 200mcg/min.

Summary of a 15 lead ECG

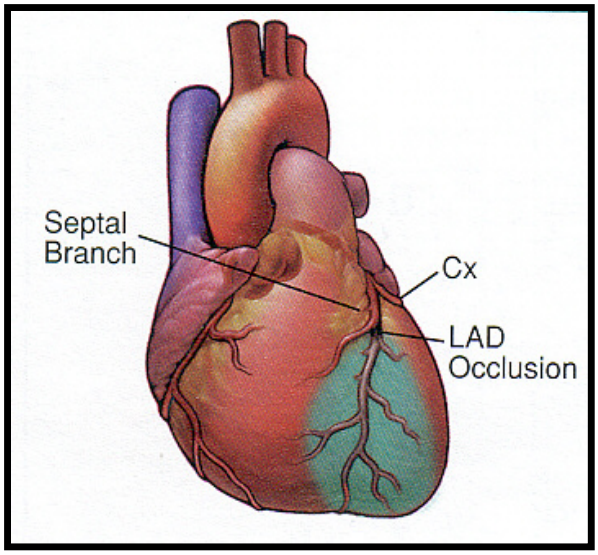
Taking only 20 seconds at a cost of 21 cents to run, and with the benefits of 86% increase in sensitivity for PWMI, and detecting right ventricle MI preventing a potentially deadly drug error with Nitrates, Why would anyone not run a 15 lead?

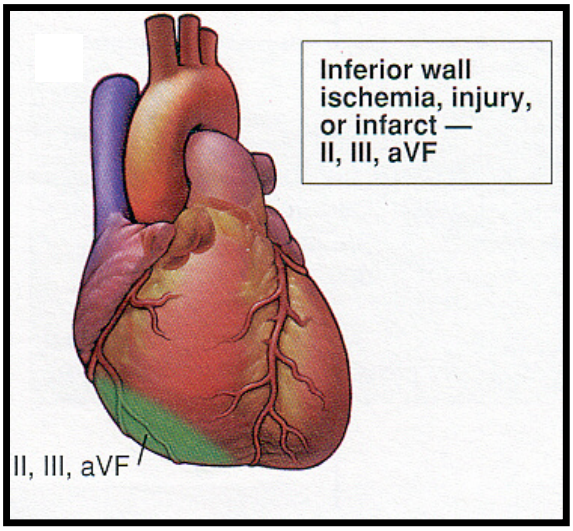


Another question that comes up is how do we transmit the 15 lead labeled as a 15 lead? Chances are your current machines will not do that. Various agencies have come up with many ways to get the information to the receiving facility from simply calling when they send the ECG, to labeling in the comments section (shown above), to smart phone software systems that you can photograph the ECG and send the relabeled one to the hospital with other pertinent patient information. **No matter what your solution, the limitation of your machines should NOT prevent you from running the 15 lead ECG.** Good communication and rapport among the entire team will eliminate surprises when performing skills such as 15 leads that are not typically done in the hospital or out of hospital setting.

Why is it important to locate the STEMI? The area of infarction can gives us insight as to the complications we can expect.

- **Anterior MI**
  - Most lethal (highest mortality)
  - Can suddenly develop, CHB or VF, VT
  - If presents with hemiblocks or BBB, apply quick combo pads to the patient and prepare for the worst
  - Can extend to septum (anteroseptal) and / or lateral (anterolateral) walls
  - Nitrates are great, fluids are spared





Inferior MI

- Most common seen
- Can be very lethal
  50% have RVI with risk for hypotension
- Could also have 1 degree AV
- delays or 2nd degree 1
- Nausea is a common finding:
- Anti-emetics are helpful
- Look for RVI with V4R, nitrates with caution. Fluids!

Posterior wall

- A 15 lead ECG (V8 and V9) will show the ST Elevation
  - Can occur alone with a normal 12 lead, so always do a 15 lead on all normal 12 leads!
  - Only 8% of the time will it have reciprocal changes in V1-V3.

Lateral and Septal Wall STEMI

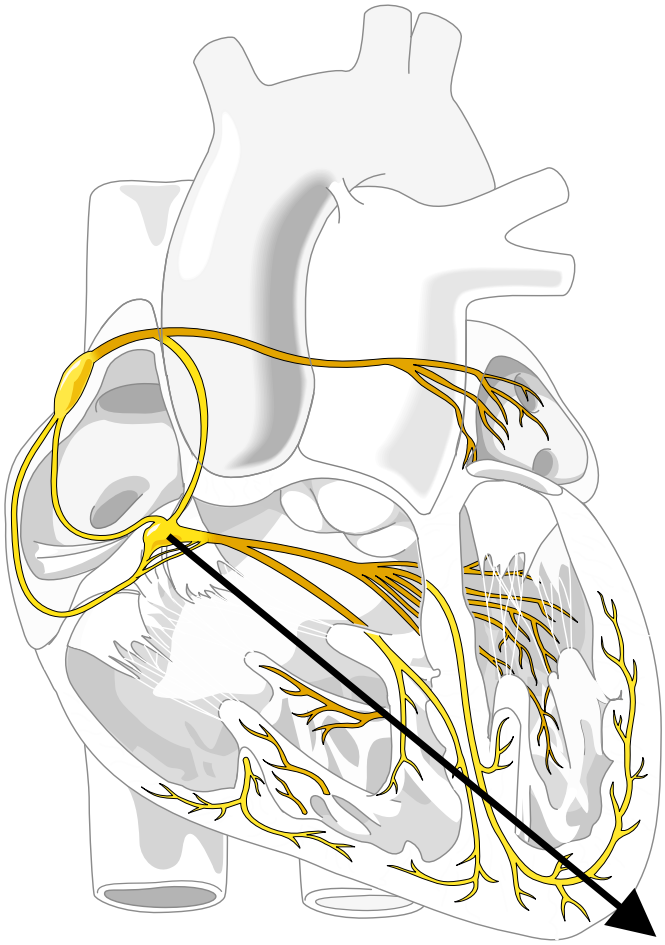
Rarely occur alone, usually an extension of anterior of inferior MI

SUMMARY:
Look for STEMI (ST segment elevation in two or more leads) then locate the infarction and be prepared for complications or even be proacative!

Rapid Axis and Hemiblock Determination

Axis is the predominant direction of flow of the impulses in the heart.

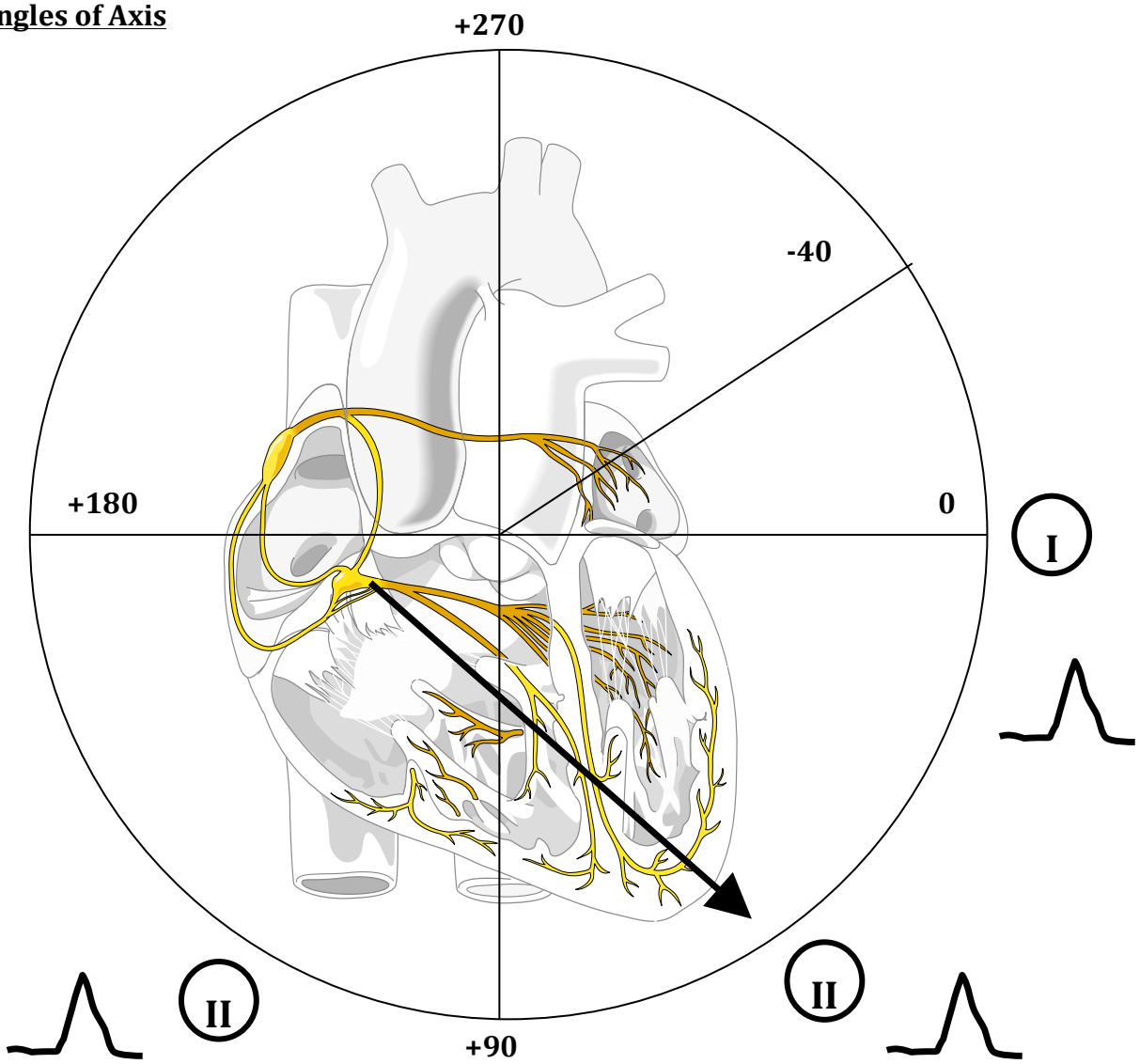
Axis can be significant:
- It can help you diagnose V-Tach
- It can be used to see chamber enlargement (hypertrophy)
- Used to diagnose hemiblocks
- It can help you identify which patients are at high risk for complete heart block or for becoming hemodynamically unstable.



Basic Concept of Electricity and ECG Signal
As an impulse moves towards a positive electrode, it makes a positive deflection on the ECG

Normal direction (vector) of electricity in the heart. Although electricity moves in many different directions as it depolarizes the heart, it moves in one general direction. This is called AXIS!

The Angles of Axis



It would be nice to be able to "see" the "arrow" on the chest of a patient that indicated the direction of travel. Well, we may not be able to see the direction, but we can track it! Using the basic concept of electrical signals from page 8, we can place three leads around the heart. Limb leads, I, II, and III are shown here. The position represents the relative location of the positive electrode in each of those three leads. Each location will show us by the net deflection of the QRS complex whether the impulse is coming towards or going away from its respective location!

In this example, Lead one is on the left side of the heart and looks at the entire left side, so if the impulse is traveling towards the left side, it will show a positive (UP!) deflection. Lead II see the impulse coming straight at it so it will show positive (UP!) also. Lead III still shows it coming in its general direction so we would see a positive (UP) deflection as well.

This finding, **Up** in leads I, II, and III are considered a NORMAL finding in Adults.

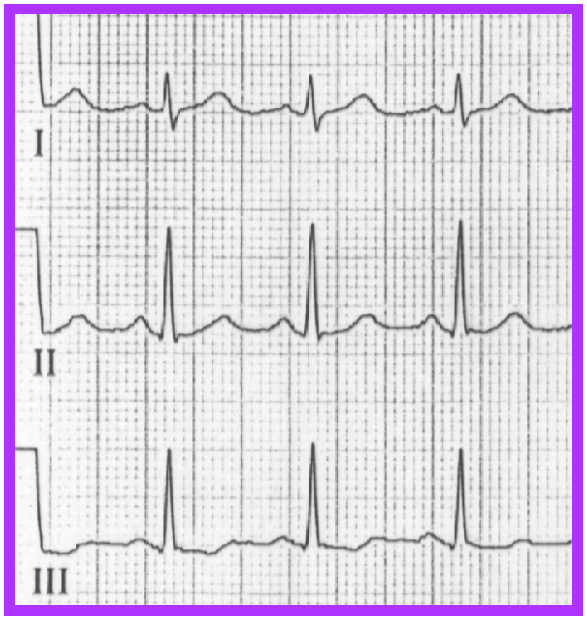
How to Determine Axis:

1. Run leads I, II, III. (make sure your leads are correctly placed)
2. Determine the mean QRS deflection in each lead (up or down?)
3. Compare it to the chart below and presto - instant axis!

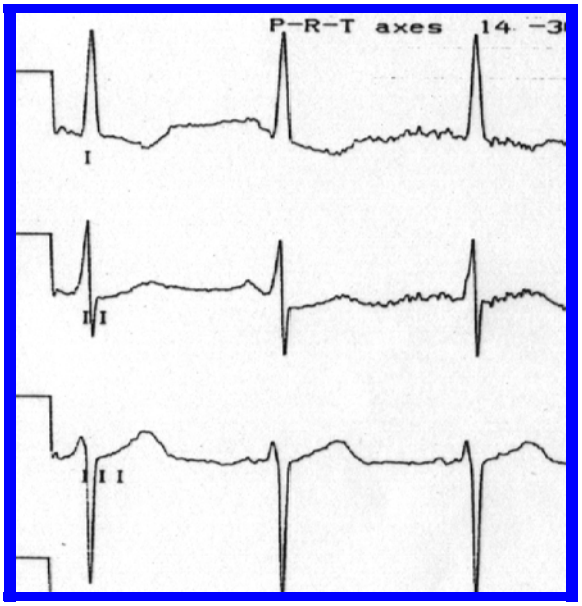
Rapid Axis and Hemiblock Chart

Axis	Lead I	Lead II	Lead III	Comments
Normal Axis 0 - 90				
Physiologic Left Axis 0 to -40				
Pathological Left Axis -40 to -90				Anterior Hemiblock
Right Axis 90 - 180				Posterior Hemiblock
Extreme Right Axis no man's land				Ventricular in origin

Normal Axis Variants

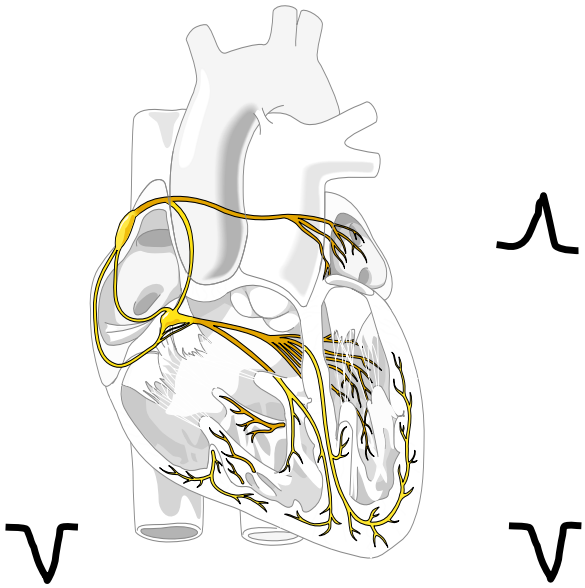


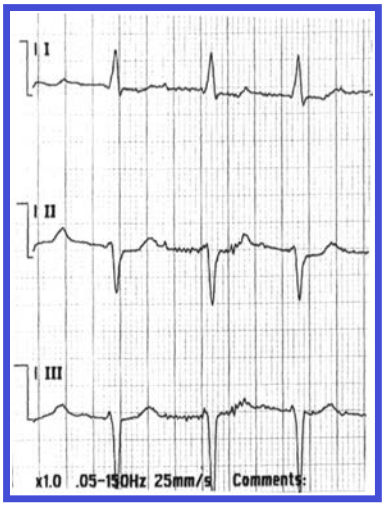
NORMAL AXIS



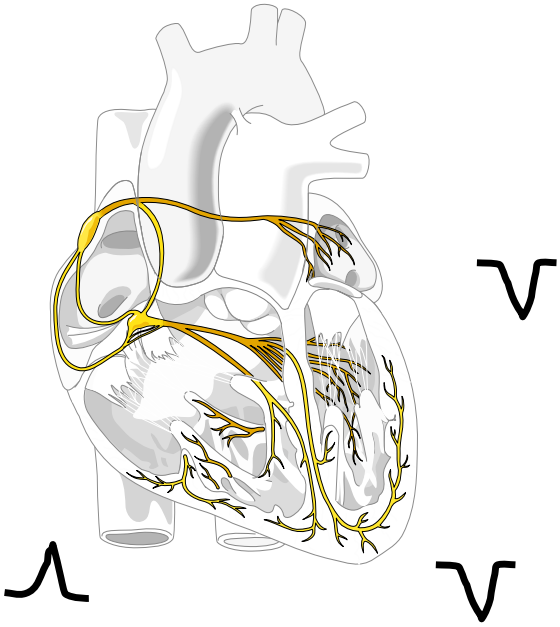
Physiological Left

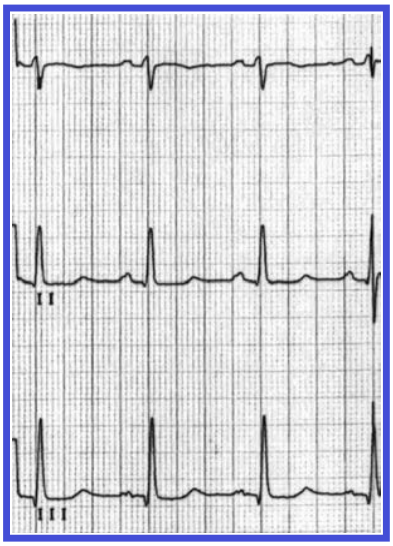
Pathological Axis





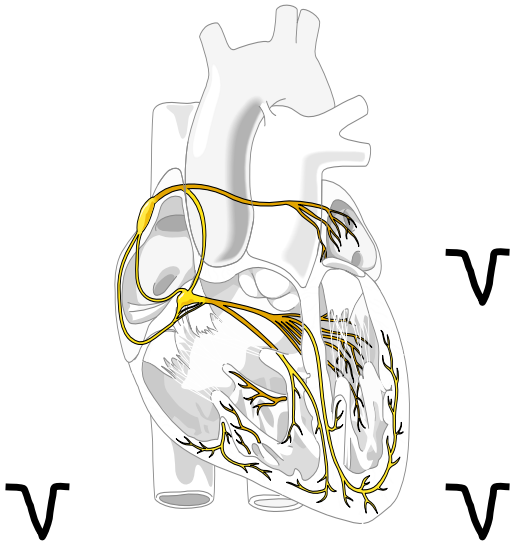
Draw the Axis arrow for this example!

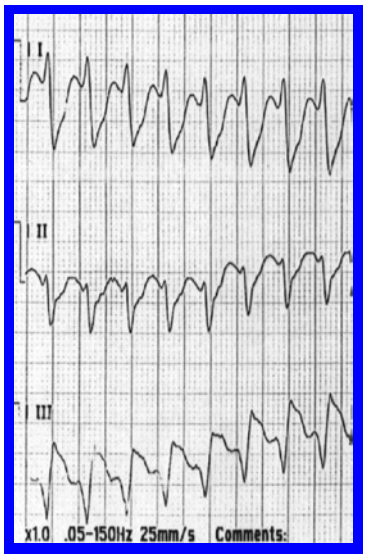




Right Axis

Draw the Axis arrow for this example!



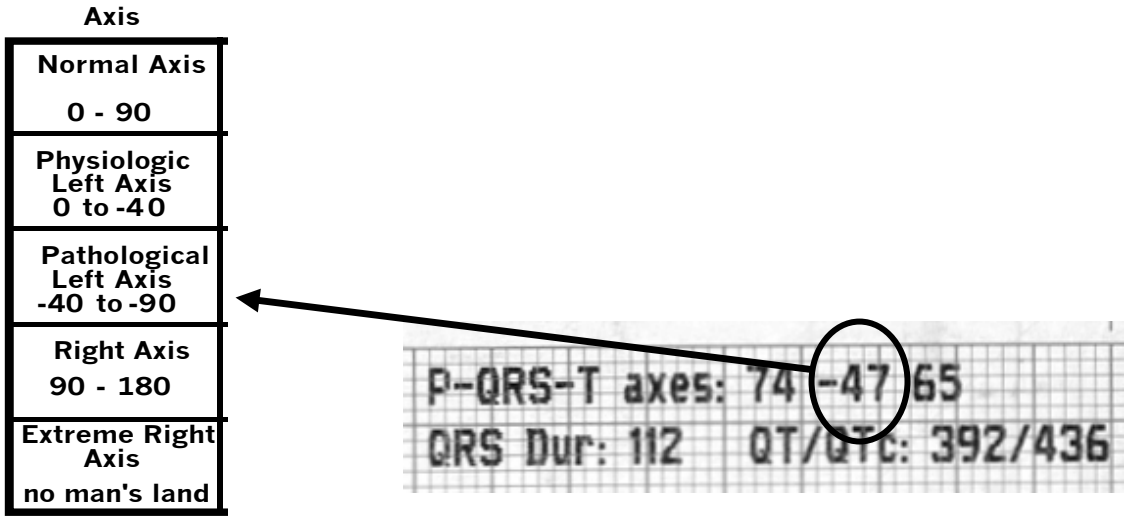


Extreme
Right ERAD

Draw the Axis arrow for this example!

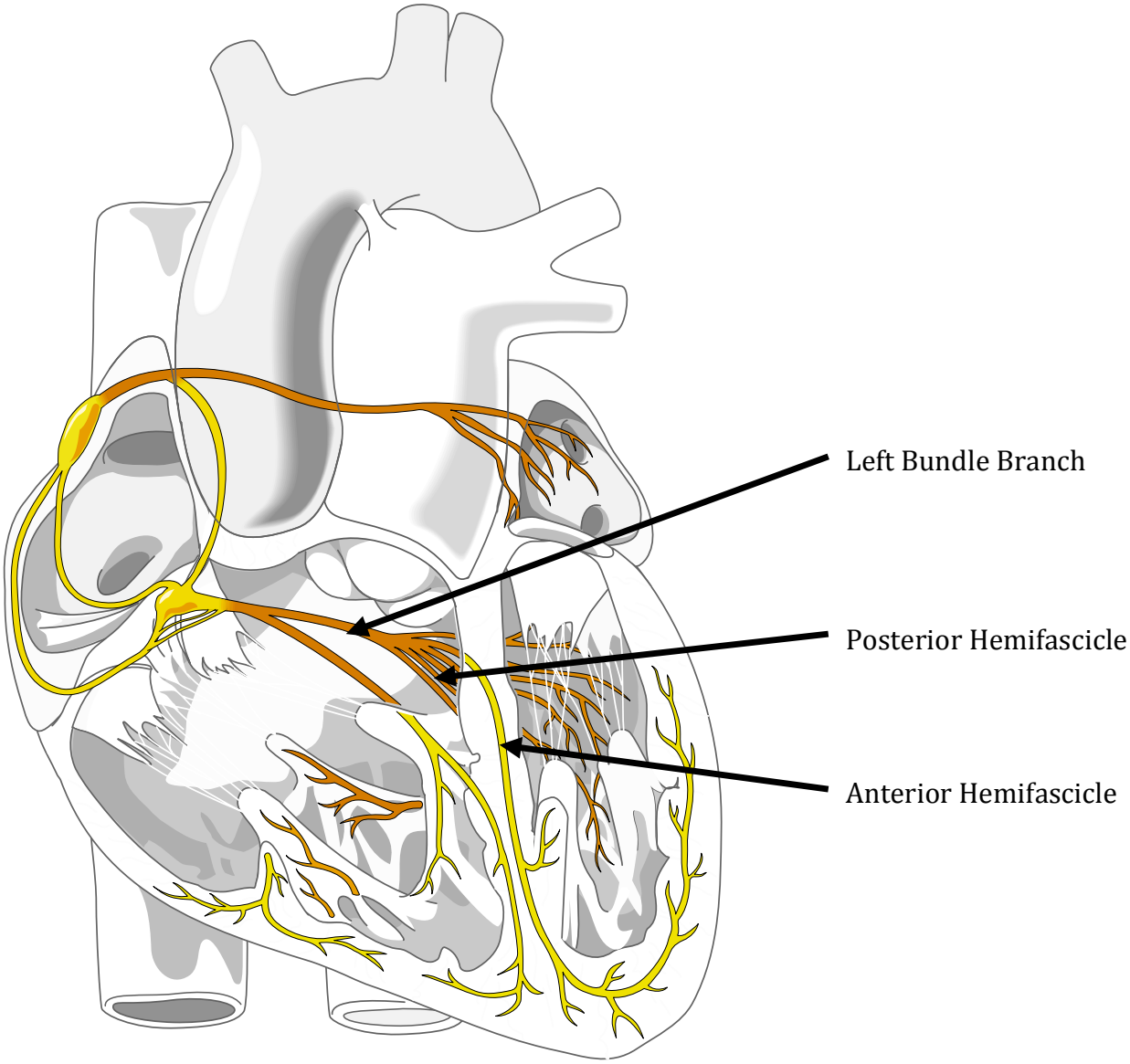
An easier way that is very accurate!

If you have a machine that gives you the axis information recognized as the "R" axis or QRS axis that is expressed as a number, use it! Simply look at the number and compare it to the range of axis found on your **Rapid Axis and Hemiblock Chart** and you can call the axis that way. You will find this will speed up your axis assessment, especially when there is a wide complex tachycardia when up and down are not so clear. ***For this to be accurate the limb leads must be on the limbs!***

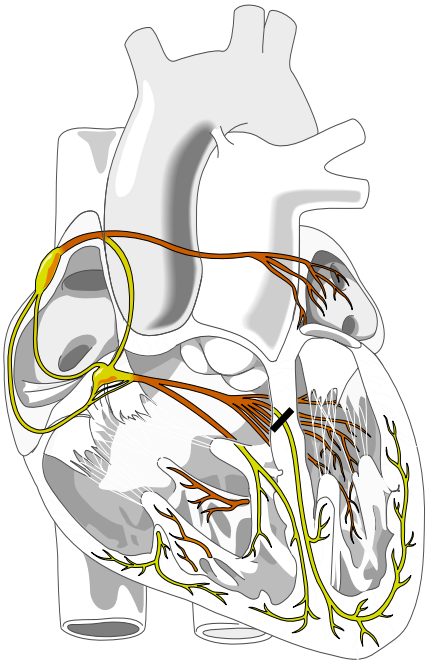


Hemiblocks:
A hemiblock is a block of one of the fascicles of the left bundle branch.
A hemiblock is a diagnosis made on ECG!

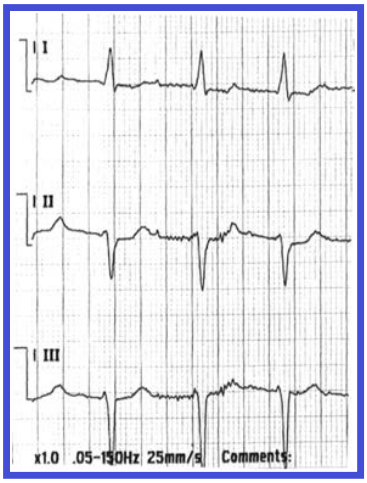
Significance: A hemiblock can be an indicator of conduction risks and severity of acute conditions such as AMI's. A hemiblock in the setting of an AMI means 4 times greater mortality

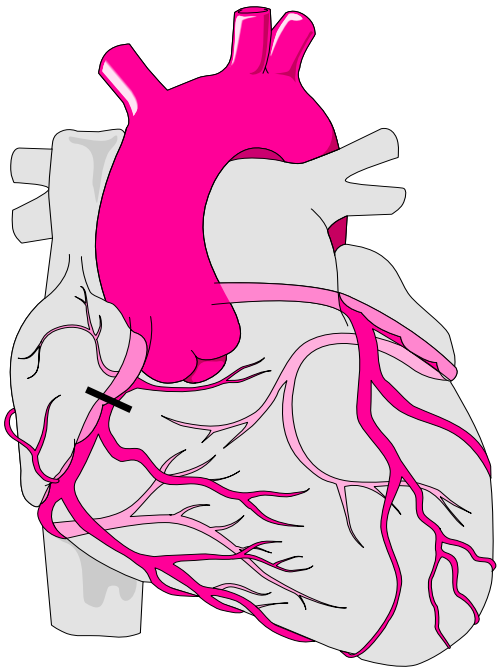


To Determine Hemiblocks:
1. Determine Axis
2. Look on the chart to determine hemiblock.



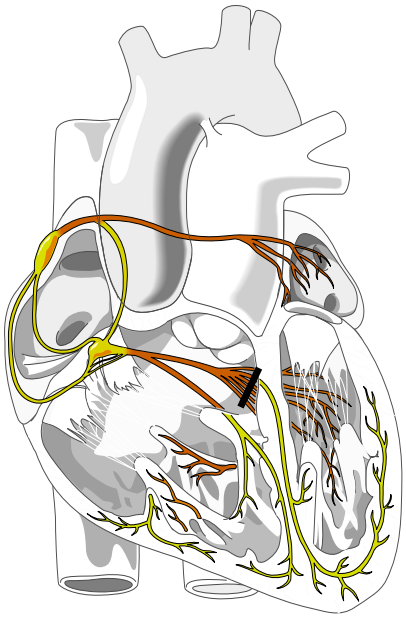
Anterior Hemiblock:
- Pathological Left Axis deviation
- Can also have small q in lead I and a small "r" in lead III.
- Common block
- 4 x higher mortality rate when associated with an AMI

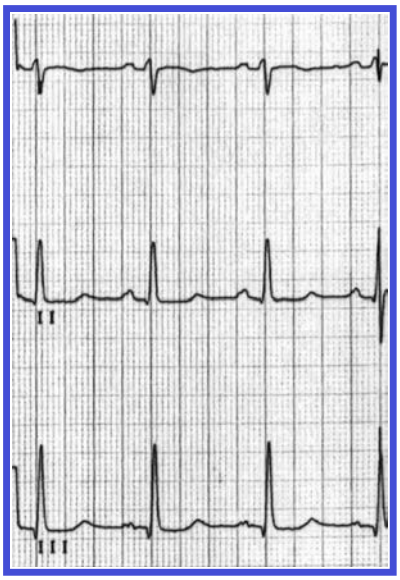




Higher Mortality:
A hemiblock or other conduction system problem when associated with S/S of an AMI can indicate a proximal occlusion of a coronary artery.

The hemifascicles get their blood supply from a proximal artery branch. Therefore we assume a proximal occlusion has occurred. Mortality rate is higher because with a proximal occlusion, the risk of lethal arrhythmias is higher due to a larger area of ischemia.





Posterior Hemiblock

- ♥ Right Axis Deviation
- ♥ Can also have a small "r wave" in lead I: and a small "q wave" in lead III.
- ♥ Very high mortality rate when seen with S/S of an AMI. 70%+
- ♥ Two coronary arteries involves: Left anterior descending and Right coronary artery
- ♥ Posterior hemiblock is a rare occurrence. (Thank goodness!)

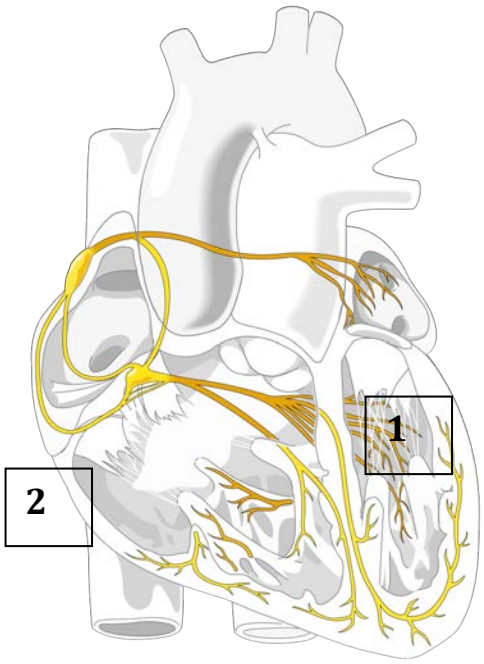
SUMMARY of AXIS and HEMIBLOCKS

- ♥ **Use your chart** to help you determine axis.
- ♥ People can live just fine and be asymptomatic with a hemiblock or axis deviation. It becomes relevant only when accompanied by the S/S of an AMI. Remember, **pay attention to your patient!** Keep the ECG findings in the back of your mind
- ♥ A right axis deviation is a normal finding in children.
- ♥ A right axis deviation in adults is always pathological. Besides a posterior hemiblock, it can also be indicative of a pulmonary embolism, right heart failure (Cor Pulmonale).

Bundle Branch Blocks

A bundle branch block is a block of either the right or left bundle branch system.
A working knowledge of bundle branch blocks will help the clinician to determine:

1. Who's at risk for hemodynamic compromise?
2. Who's at risk for complete heart block?



The Bundle Branch System is made up of 2 main branches, right and left. The left bundle branch system is further divided into two hemi-fascicles, the anterior and posterior.

The purpose of the bundle branch system is to facilitate the entire ventricular mass to get the impulse to contract at the same time. This produces a phenomenon known as ***syncytium*** (both firing at the same time). Syncytium is very important to the cardiac output. In the cases of a **bundle branch block**, the ventricles are not in "sync." The preload could be reduced due to inadequate filling time. If the ventricles take a prolonged time to contract, then the force of the contraction will be reduced.

<u>What Happens During A Bundle Branch Block?</u>

A block of one of the fascicle of the bundle branch system can be caused by myocardial infarction (old or new), congenital defects or by ischemic tissue. In a few cases, people have acquired a BBB secondary to a procedure known as RF (radio frequency) ablation. This procedure is performed to destroy cells (which happen to be part of the bundle branch) that cause ectopy or dangerous rhythms such as VT. Some BBB's only occur during fast heart rates and can have defined "start and stop" rates. Nonetheless, a bundle branch block represents an increased severity risk for complete heart block, hemodynamic compromise, and of course sudden death when associated with an MI due to the proximal occlusion of the LAD coronary artery.

As the impulse coming from the AV node travels down the bundles, it reaches the tissue that is blocked on one side. The impulse stops on that side. The other side proceeds to depolarize as normal. (1) The wave of depolarization eventually works it way across to the blocked side causing a delayed depolarization. (2) As you might guess, the ventricles contract out of sync. The more diseased the muscle, the longer

it will take to completely depolarize the heart. If the total time to depolarize the ventricles are longer than 120ms or .12 sec, then criteria is met for a bundle branch block.

So Who's at Risk for Hemodynamic Compromise?

HEMODYNAMICS 101

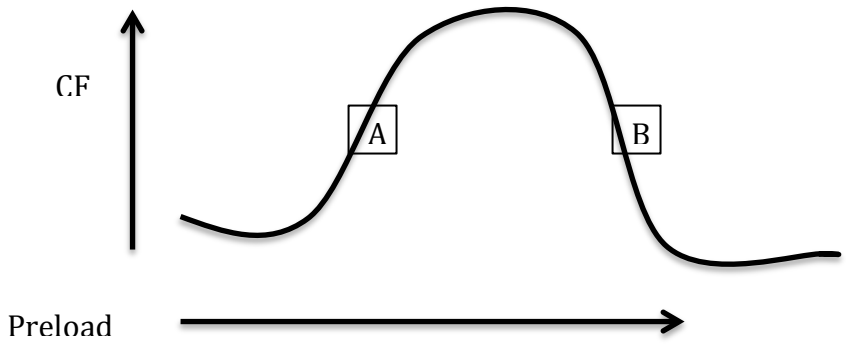
CO (cardiac output) = HR (heart rate) x SV (Stroke Volume)

Preload: Volume and pressure on LV
Afterload: Vascular tone
Contactile force: Inotropic State

If the QRS duration is > 120ms (.12sec) (3 little boxes) then at the least a BBB exists. The ventricles, being out of sync have reduced preload.
If the QRS is > 170ms then the *Ejection Fraction is 50%* at the MOST. *Ejection fraction* is the volume percent of blood the heart can pump out. Healthy people at rest and awake have an ejection fraction between 60-75%. This results from reduced contractility because it takes so much time to depolarize; the contraction is also slow and weak.

The Starling "Curve"

The "Starling Curve" can be appreciated by this graphic. The more you increase preload, to a point, the greater the force of contraction. If a patient has right sided issue (A), increasing preload would increase contractile force, thus making them better. But if the patient has a left sided issue, (B), then preload increase would decrease the contractile force leading to worsening heart failure. See how important the 12 and 15 lead ECG are now in helping you determine where on the curve the patient may be?



What does this mean to you, the Acute Care Provider??

1. Before you give any medications, make sure you determine the presence or absence of Bundle Branch Block.
2. If the QRS is wider than 170ms and you are going to give a vasoactive drug such as Nitroglycerin;
3. REMEMBER
    a. People with wide QRS (>170ms) or those with Crackles in the posterior lung fields are at high risk for heart failure
    b. If their blood pressure crashes or is low from the start, they may not be able to handle fluids. Be prepared to use an inotropic drug such as dopamine or whatever local medical control advises.
    c. Since a bundle branch block is a heart block, be careful of anti-arrhythmia medications for risk of complete heart block.
4. A Bundle Branch Block that comes on with a really fast heart rate is called a ***rate dependent bundle branch block.*** This can mimic VT and is usually associated with Atrial fibrillation and Atrial Flutter. This is the biggest danger in assuming that everything wide and fast has to be VT. A rate dependent BBB, is also the number one arrhythmia mistaken as VT in emergency medicine.

Since the left side has two fascicles and the right side has just one, a left bundle branch block has a higher mortality rate. It is important for the acute care provider to understand bundle branch blocks and be able to rapidly identify and differentiate left from right.

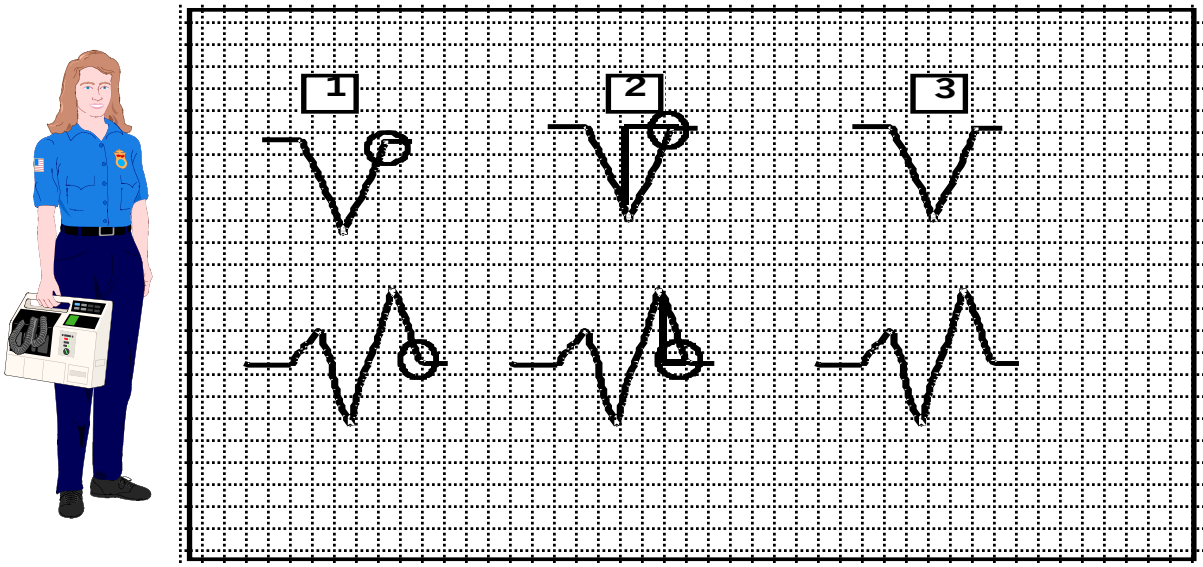
The methods presented in this session may seem ridiculously simple, but they are very accurate.

The "Turn Signal Criteria" For Bundle Branch Blocks.

This criterion is incredibly accurate and has been proven. Its method is non-traditional and has nothing to do with medicine. It is simply an analogy. It does involve medical terms such as J point and terminal deflection

In using this criteria there are 2 main rules:

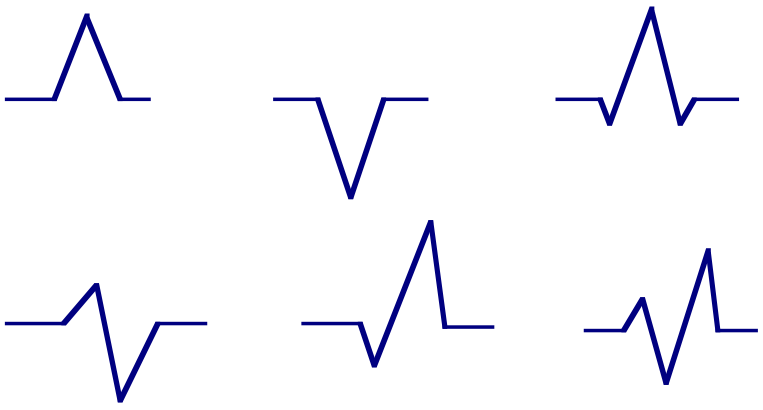
1. It must be a supraventricular QRS complex > .12 seconds wide (120ms).
2. You must use lead V1 for this theory to work.



Step 1: Find the "J point" and circle it
Step 2: Draw a line into the QRS complex until halfway through the terminal wave and then down or up depending on the complex
Don't cross over any lines with yours.
Step 3: Shade in the arrow that this line makes.

If the arrow points up ---> Right Bundle Branch Block
If the arrow points down ---> Left Bundle Branch Block

Can you label these bundle branch blocks?
Assume all are lead V1 and are at least 120ms wide



Patterns?

A real, actual "QRS" complex in Lead V1, wider than 120ms is a LBBB.

A real, actual RSR' complex in lead V1, wider than 120ms is a RBBB.

An Enigma inside a Dilemma

The LBBB has ST segment elevation normally and is considered one of the more common STEMI mimics. A 1996 study by Sgarbossa at others developed and validated a clinical prediction rule for diagnosing an AMI in a LBBB.

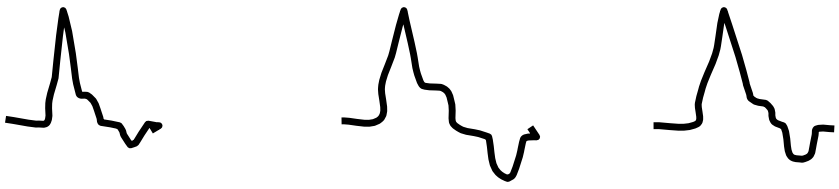
Another Way to Determine the Likelihood AMI in LBBB and Chest Pain

Question	Yes	No	Answer							
ST seg. elev. >= 1mm and is concordant with QRS axis	+5	+0	Y	Y	Y	Y	N	N	N	N
ST seg. depr. >= 1mm in V1, V2, or V3	+3	+0	Y	Y	N	N	Y	Y	N	N
ST seg. elev. >= 5mm and is discordant with QRS axis	+2	+0	Y	N	Y	N	Y	N	Y	N
	Score:		10	8	7	5	5	3	2	0
	%MI:		100	92	93	88	100	66	50	16
	Patients/Controls:		4/0	22/2	26/2	43/6	1/0	6/3	9/9	20/109

Sgarbossa, Pinski, Barbagetata, et al developed this simple table: The evidence came about during the GUSTO-1 trial.

Basically, The interpreter is to determine 3 things looking at an ECG with a LBBB.

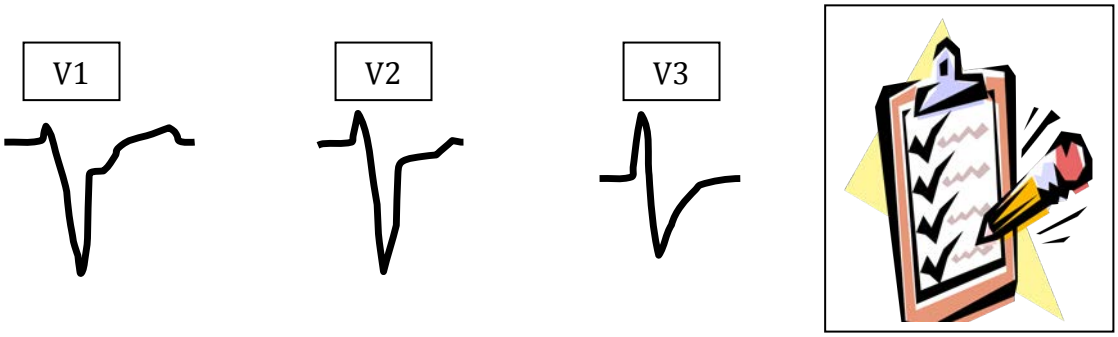
1. ***Is there ST segment elevation >= 1mm and is concordant with QRS axis?*** This means that the elevation is in the same direction as the QRS deflection.



II III aVF

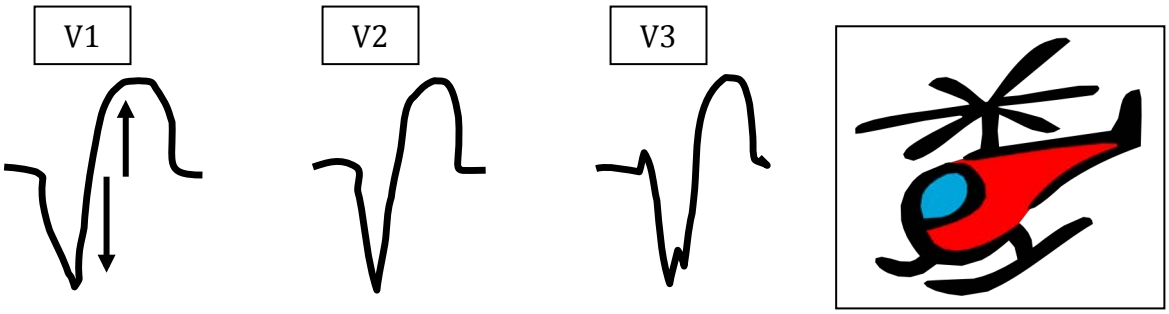
If this criterion is met, it is worth 5 points. This is the most heavily weighted criterion of the three that are listed.

2. ***Is there ST Segment Depression >= 1 mm in V1, V2, or V3?*** This simple criterion can be seen in either of these leads. Remember to find the J point when looking for the point of ST depression.



If this criterion is met, it is worth 3 points.

3. ***Is there ST Segment elevation >= 5mm discordant from the QRS axis?*** This means that the ST elevation goes up and the QRS deflection is down.



This criterion is worth 2 points if present.

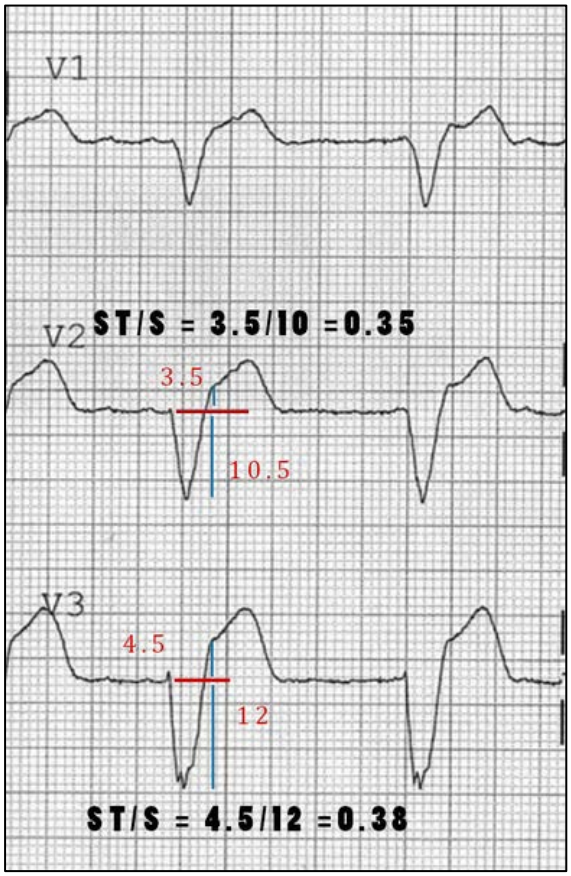
There are various combinations that can be present. It is important that you use the chart to help you determine the likelihood of an AMI.

Furthermore, the chart has relatively high reliability as ECG goes. As long as the score total is at least 3, the sensitivity is 78%. This means that 22% would be missed or would not meet the criteria, but still be having an AMI. The specificity is 90%. In other words, if the score totals at least 3, then 90 out of 100 would have accuracy that the table suggests.

This is a very promising method that is easy to use. In light of current practice that renders an ECG with a LBBB non-diagnostic, this new development brings new hope.

Recently, the Sgarbossa criterion was modified by Smith to examine the ST/S ratio to increase the sensitivity of the overall criteria.

Modified ST/S ratio. In a discordant complex, measure the height of the ST Segment elevation then divide that by the depth of the s wave in that lead. If it is more that .25, then that criterion is met. It is much more sensitive than just looking for ST elevation greater than 5mm.



As with any new procedure, make sure you discuss this with the physicians and staff at your receiving facilities. Some may not be aware of the criteria presented here. The research is available for download from my website.

The fact that we can now use criteria to help these folks with a LBBB and AMI, that would ordinarily have to wait hours for enzyme tests results is a major step forward in STEMI care.

Some Closing Thoughts on Bundle Branch Blocks

- ♥ Bundle branches are living breathing cells of the cardiac conduction system.
- ♥ They don't "hurt" they just "won't work" if damaged.
- ♥ Syncytium is necessary from crisp contractions and good cardiac output.
- ♥ A BBB can cause a reduction in preload and contractility.
- ♥ A very wide QRS (>170ms) means reduced ejection fraction to below 50%.
- ♥ You can't accurately or consistently call a LBBB or RBBB from a lead II strip!
- ♥ A BBB is a risk factor for complete heart block.
- ♥ A BBB that has am extreme tachycardia is called a rate dependent BBB and can mimic VT!
- ♥ BBB means at least 25% greater mortality, 50% with a new onset LBBB!
- ♥ Use the Sgarbossa and modified criteria to help find the hidden MI with the LBBB.
- ♥ Like hemiblocks, people can live asymptomatic with BBB's. A BBB usually affects their lifestyle more however. Due to the hemodynamic effects mentioned earlier, the BBB will not allow much strenuous activity before putting the patient supine!
- ♥ As always, pay attention to your patient, keep this information in the back of your mind as you consider the treatment options and possible problems.

Wide Complex Tachycardia: Are you ready?

The only life threatening arrhythmia that can have a pulse is ventricular tachycardia (VT). It is deceptive and patients can have it while looking and acting asymptomatic with normal vital signs. Furthermore, a *rate dependent BBB* can mimic VT and to misdiagnose this could lead to disaster in management. The 2010 and 2015 ACLS Guidelines for tachycardia clearly spelled out what is to be done. My interpretation is as follows.

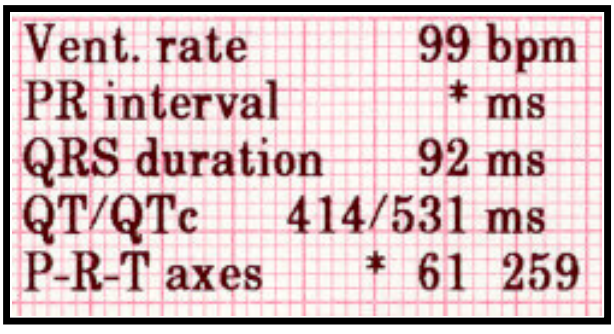
1. All tachycardia with a pulse will get a 12 lead first.
2. With the 12 lead, you will PROVE VT, (by criteria) or give adenocard.
3. Grossly unstable patients will be cardioverted.
4. Stable patients may be medicated, (if possible).
5. The 12 lead machine's interpretation is class III, (harmful, not helpful)

Medications

The 2010 and 2015 guidelines for tachycardia essentially eliminated **lidocaine** as a therapy for stable VT. This was for lack of prospective clinical trials proving efficacy. **Procainamide and Amiodarone** are the recommended drugs. Both of these drugs are clinically proven and are also very potent. There are some things we need to know before giving these drugs to *patients with a pulse*.

1. **They are infusions and must be given via volumetric pumps!** They have narrow therapeutic ranges and can prolong the QT interval. If you give them too fast they cause Torsades de Pointes and arrest. To slow and they do not work. Even if you give them correctly you have to watch the QT interval.
2. **If the patient already had a prolonged QTc, you cannot give the drug, you cardiovert.** As a rule of thumb, a QTc that is greater than 460ms is considered prolonged at any heart rate. If the QTc exceeds 460, then the patient should be cardioverted. DC cardioversion is the only therapy for tachycardia that does not prolong the QT or make the arrhythmia worse. Again with any treatment option considered, ***always*** check with local medical protocols in your area.

This is an example of the QTc printout on the machine. These volt meter measurements are accurate only if the limb leads are on the limbs. The QT is the actual measurement; the QTc is the QT corrected for heart rate and is what we are looking at.



3. **Finally, you must check the patient's meds list against drugs that prolong QT.** One such list is found on the website QTdrugs.org. From this site you can download a list of meds that are clinically known to prolong QT intervals and therapeutic dosages. In other words, if the patient is taking one of these drugs, then you cannot give them a drug that prolongs the QT.

   Common medications that prolong QT. Recognize any of these?

Amiodarone	Procainamide	Erythromycin
Zofran	Z-Packs	Cocaine
Methadone	Haldol	

Criteria for Proving VT

Why even mess with a 12 lead? Can't we see it most of the time in Lead II?

Dr. Marriott had a compelling study that demonstrated that Lead II's diagnostic accuracy for VT as being only 34%. That means when faced with a decision about a wide complex rhythm, you would guess wrong 66% of the time.

The most common pitfalls made in VT (or wide complex tachycardia WCT) diagnosis are as follows:

1. **Reliance upon Lead II.**
2. **Reliance upon the machine to interpret it.**
3. **Thinking the vitals has to be horrible or the patient has to be symptomatic to be VT**
4. **Getting in too big of a hurry.**
5. **Not playing the odds.**
6. **Forgetting about Atrial Fibrillation (rate dependent BBB)**

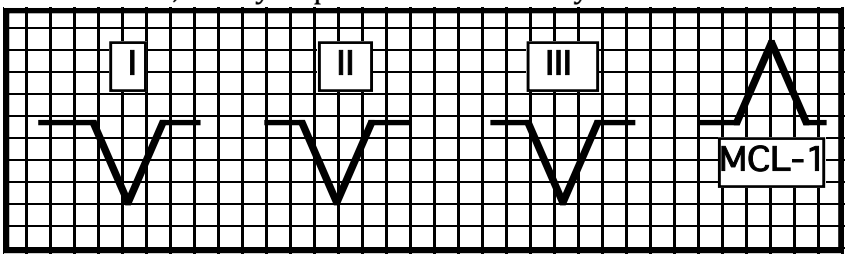
Besides, there is now more benefit and less risk in knowing the arrhythmia. The patient will further benefit form the 12 lead because you may be the only one to see that arrhythmia. If you have a 12 lead it will help the cardiologist determine the origin of the arrhythmia.

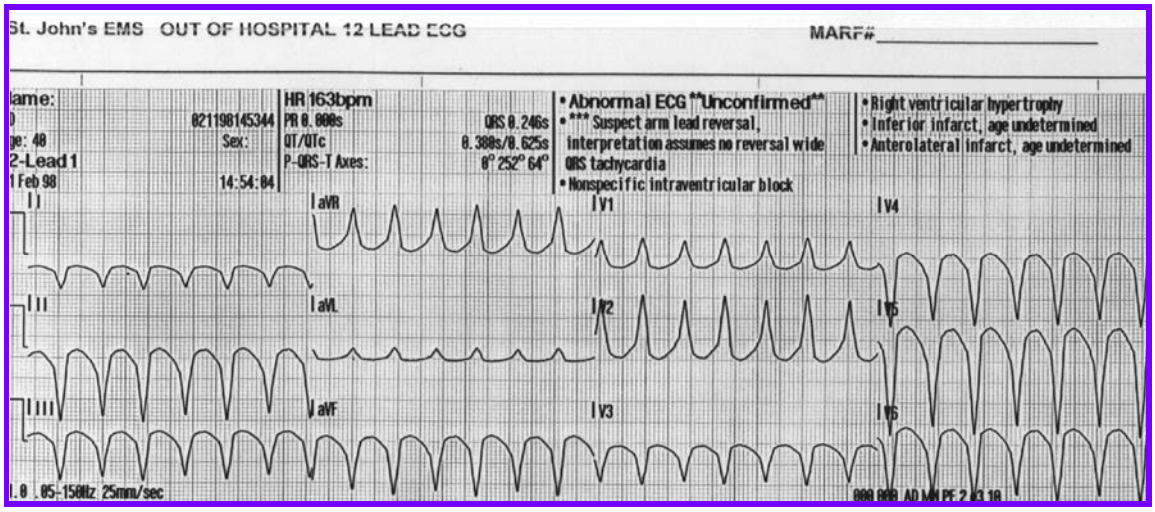
Remember, here is our general approach for all tachycardia:

1. **A 12 Lead ECG should be done on all tachycardia**. If the 12 lead is wide, it must be read before you go any further. If the rhythm is VT, it must be corrected. A rhythm that is ventricular in origin cannot be read for anything else but ventricular.
2. **PROVE VT by criteria or give adenosine**. Don't forget about the rate dependent BBB. If you cannot prove VT, then don't treat for VT! Give adenosine, it will bring out a rate dependent BBB every time.

ECG CRITERIA that proves VT

Extreme Right Axis deviation and Upright V1 (MCL-1)
If this is true, then you proven VT. If not try another.

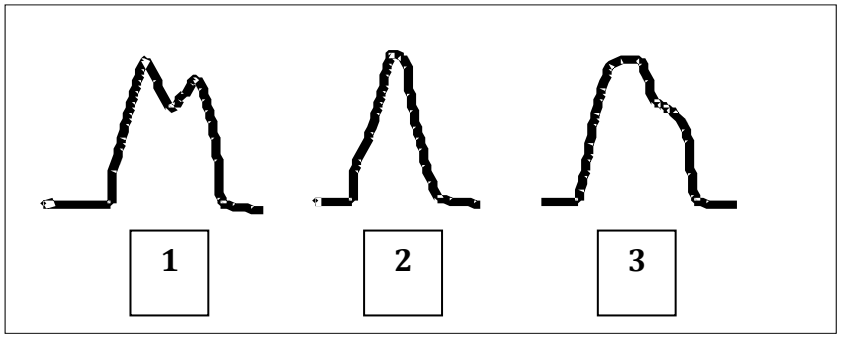




Notice the axis is 252, extreme right axis, and the complex in V1 is upright. VT!
Did you notice the QTc? (625) prolonged!

Lead (V1) Morphology Criteria

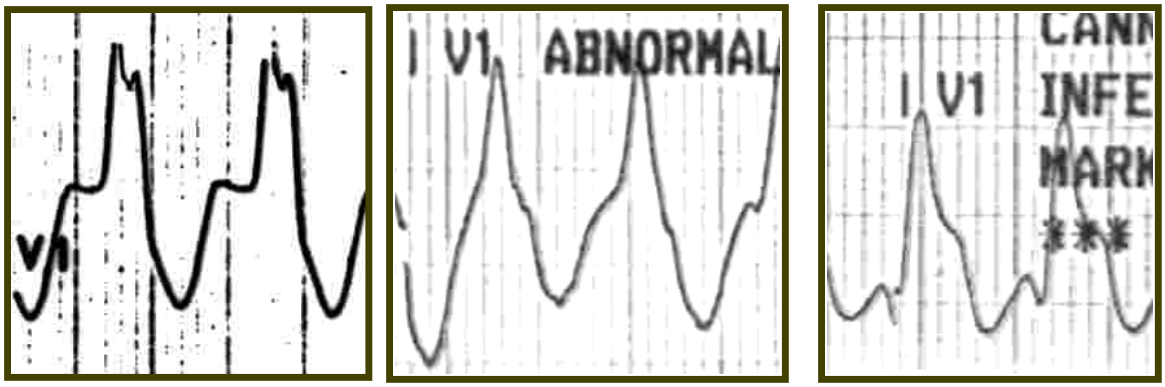
If lead (V1) is an upright complex….



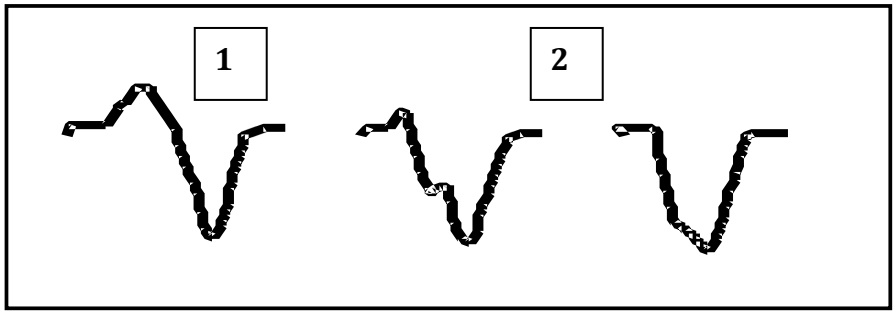
1. **Taller left peak than right, "BIG mountain little mountain"**
2. **Single upright peak, "steeple sign"**

3. Single peak with a slur, "fireman's hat"

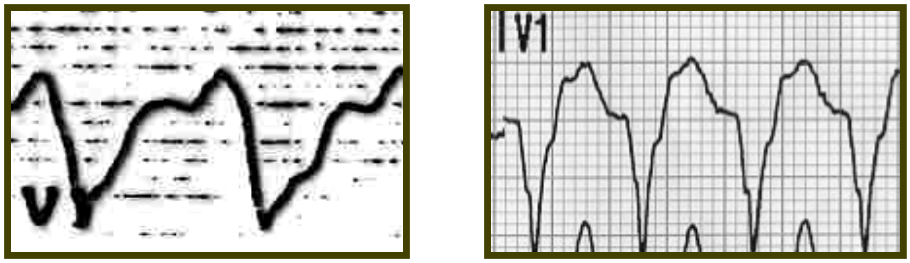
If they look like this in a wide complex tachycardia, treat for VT!



If Lead (V1) is a negative deflection…



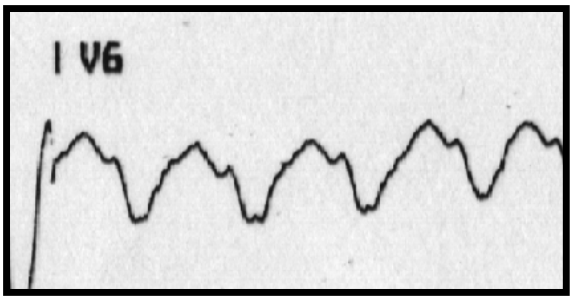
1. **Fat "R" wave – the r wave is more than 40ms (one little square) wide.**
2. **Slurring or notching to the initial downstroke (q or s wave)**



You only have to prove VT with one criteria. It does not have to meet all criteria, most of the time it does not. **VT criteria CANNOT RULE OUT VT, it can only prove it is VT.**

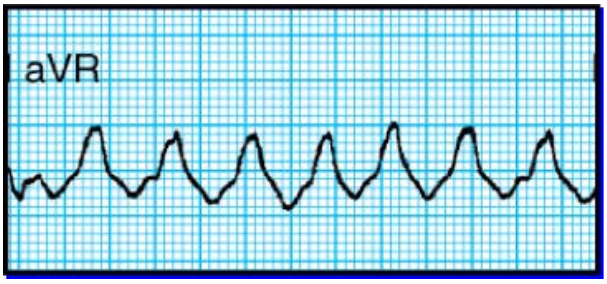
Lead V6 Criteria

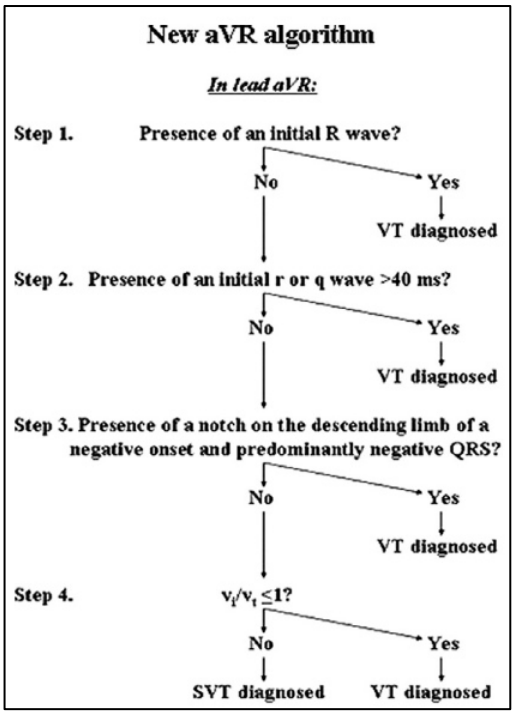
A negatively deflected complex is VT.



Lead aVR. The new Kid on the block

The first new criterion for WCT in almost 40 years has been published. The entire algoritm from the study is below.
It uses lead aVR, the forgotten lead. Not anymore.
R wave in aVR is 98% accurate for VT. Not all VT will have this but if they do, they are VT!





What if you still can't prove VT by these criteria? Well, chances are it could also be a rate dependent BBB. In which case the safe play is to give adenosine first. The 2010 AHA tachycardia guideline states that stable wide and monomorphic tachycardia can get adenosine first as this will bring out the BBB.

With these criteria at the ready and a 12 lead in your hand you should have no trouble proving or not proving VT.

Final thoughts

With this handout that you got a one of my seminars, you now have new skills sets. The only way to master the skills is by practice! I've been doing this class over 25 years and no matter how good I think it is, if you do not start practice within about 2 weeks, you will start to lose your new skills.

Putting it all together:
With all of the skills you learned today, it would be helpful to have a road map. Here is a map on the next page that will help you read through a 12 lead in no time. Once you've traveled this path about 50 times, you can easily do it without a map.

Be sure to get a copy of my book or electronic versions through Amazon or other places books are sold.

12 Lead ECG for Acute and Critical Care Providers

Also visit my website at www.multileadmedics.com for other course reference material, free downloads and other information.

Want to schedule this class in your area? Contact me through my website of just drop me an e-mail at lead2noclue@mac.com