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Rhythm Interpretation

12 Lead Interpretation

Primary Care Paramedicine

Module: 12

Section: 04d

12 Lead Electrocardiogram

- Goals
  - 12-lead technology
  - Interpretation
  - STEMI recognition
  - Other 12-lead findings

Rapid Identification

- An Acute Myocardial Infarction (AMI) is one of the leading causes of morbidity and death
- In 2013, in Canada alone, there were 206 people per 100,000 who were admitted with an AMI
  - Equates to approximately 72,000 admissions total across Canada per year
    - This is average for both sexes
    - For Males alone = 290/100,000
    - For Females alone = 130/100,000

Rapid Identification

- If not fatal, an AMI has a negative impact on the remaining quality of life of a patient
- Myocardial damage results in decreased functionality which can lead to:
  - Decreased contractility
  - Future ischemia
  - Arrhythmias
  - Cardiac rupture
  - Heart failure
  - Valve dysfunctions
  - Ventricular thrombus

Rapid Identification

- Rapid identification and treatment of an AMI prehospitally may reduce myocardial damage and limit function loss

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Who Needs A 12-lead?

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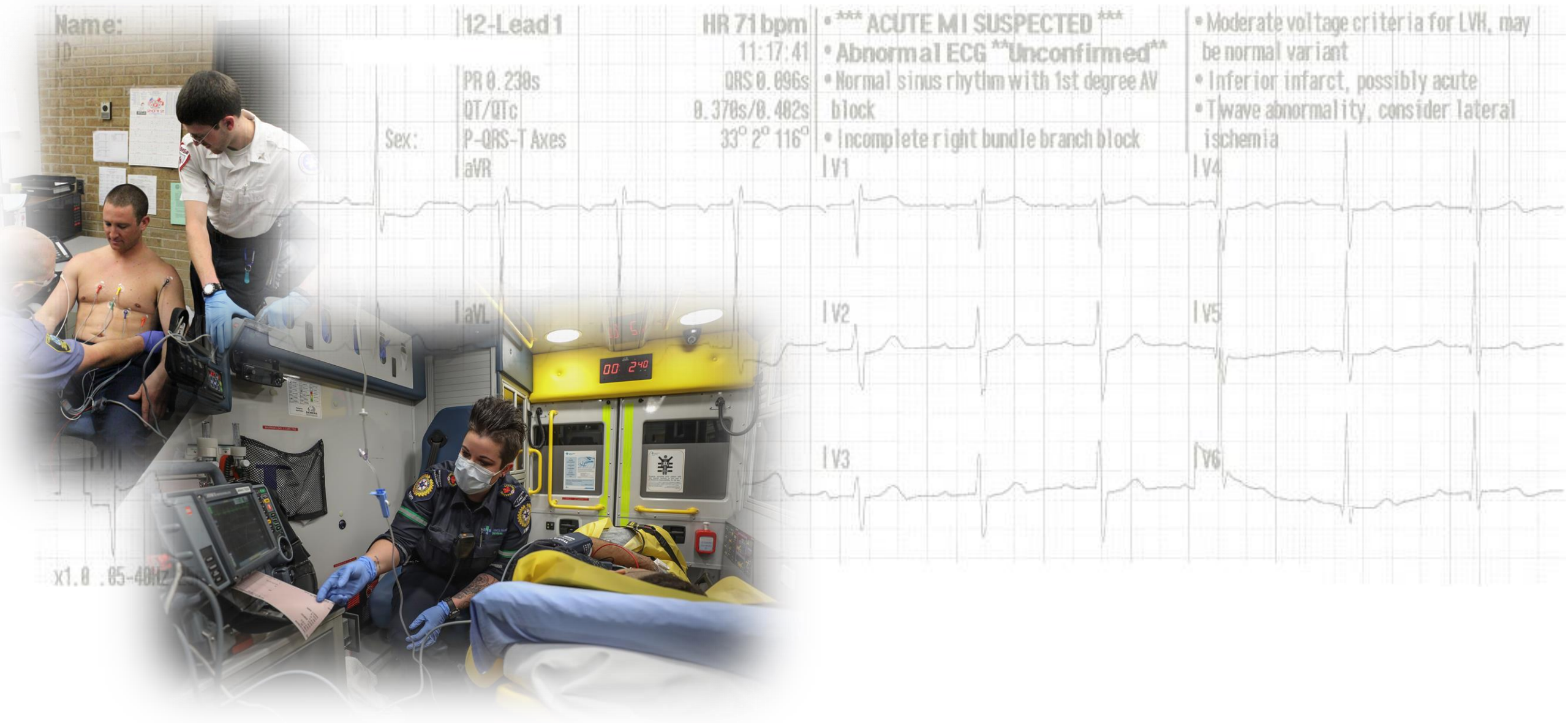
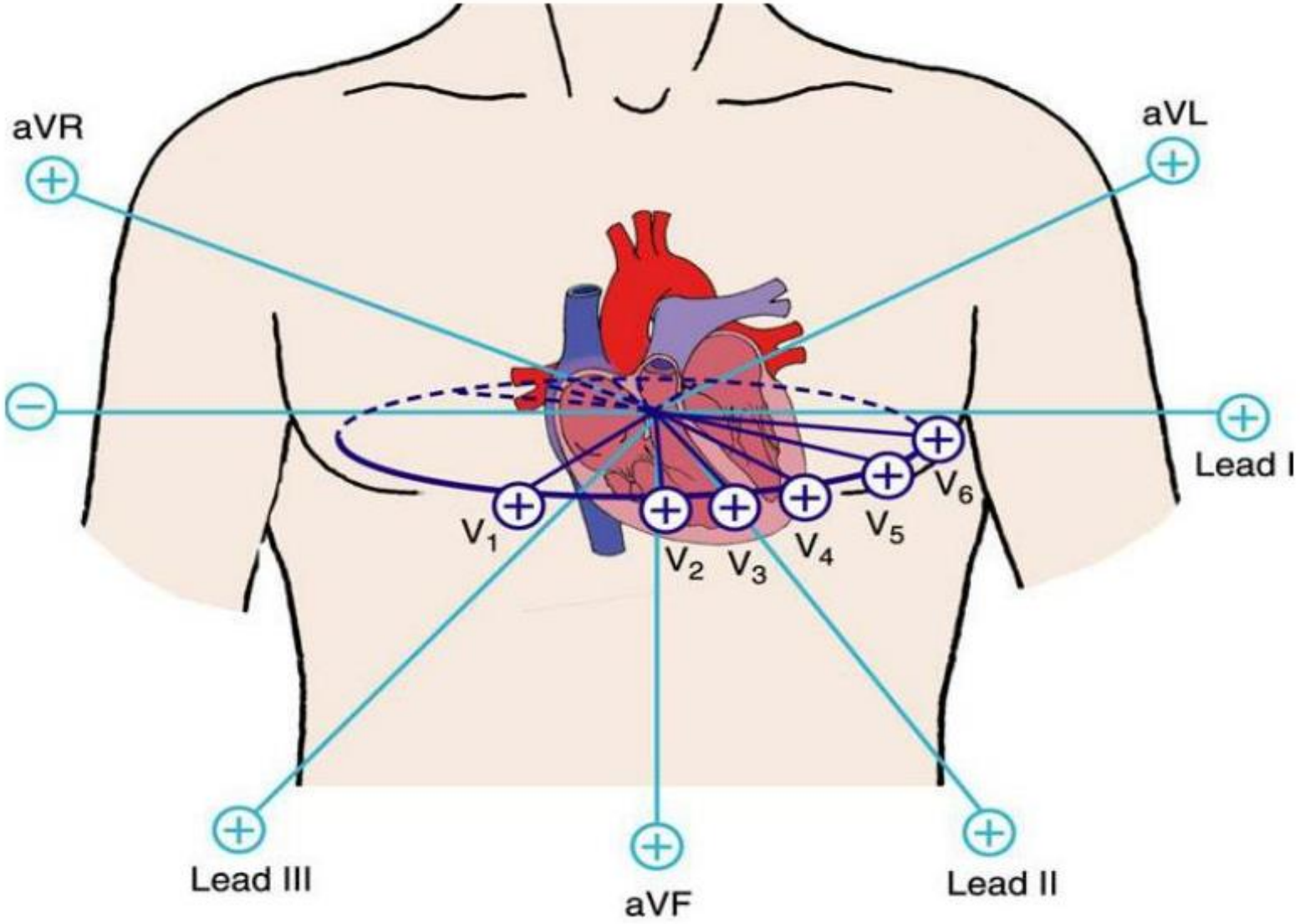
Why?



3-lead vs 12-lead



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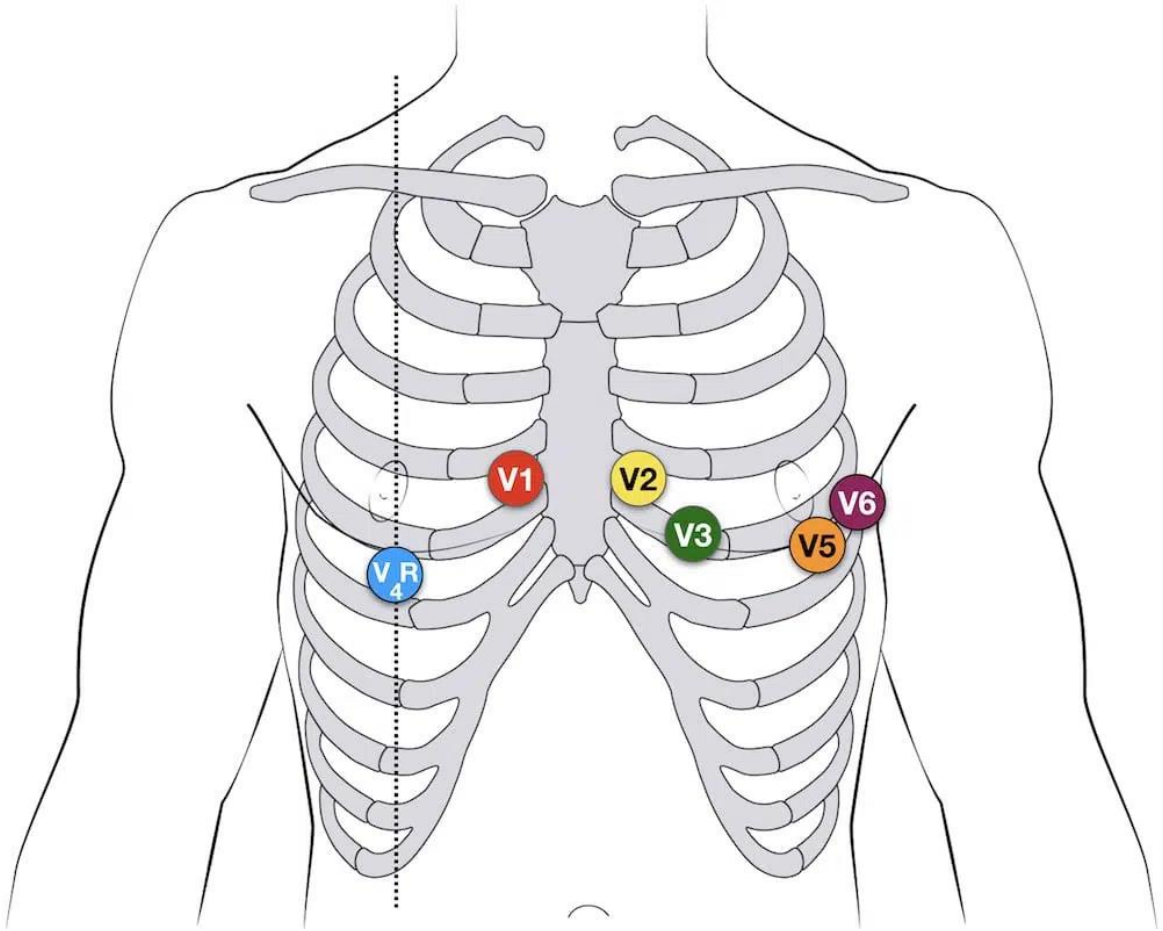
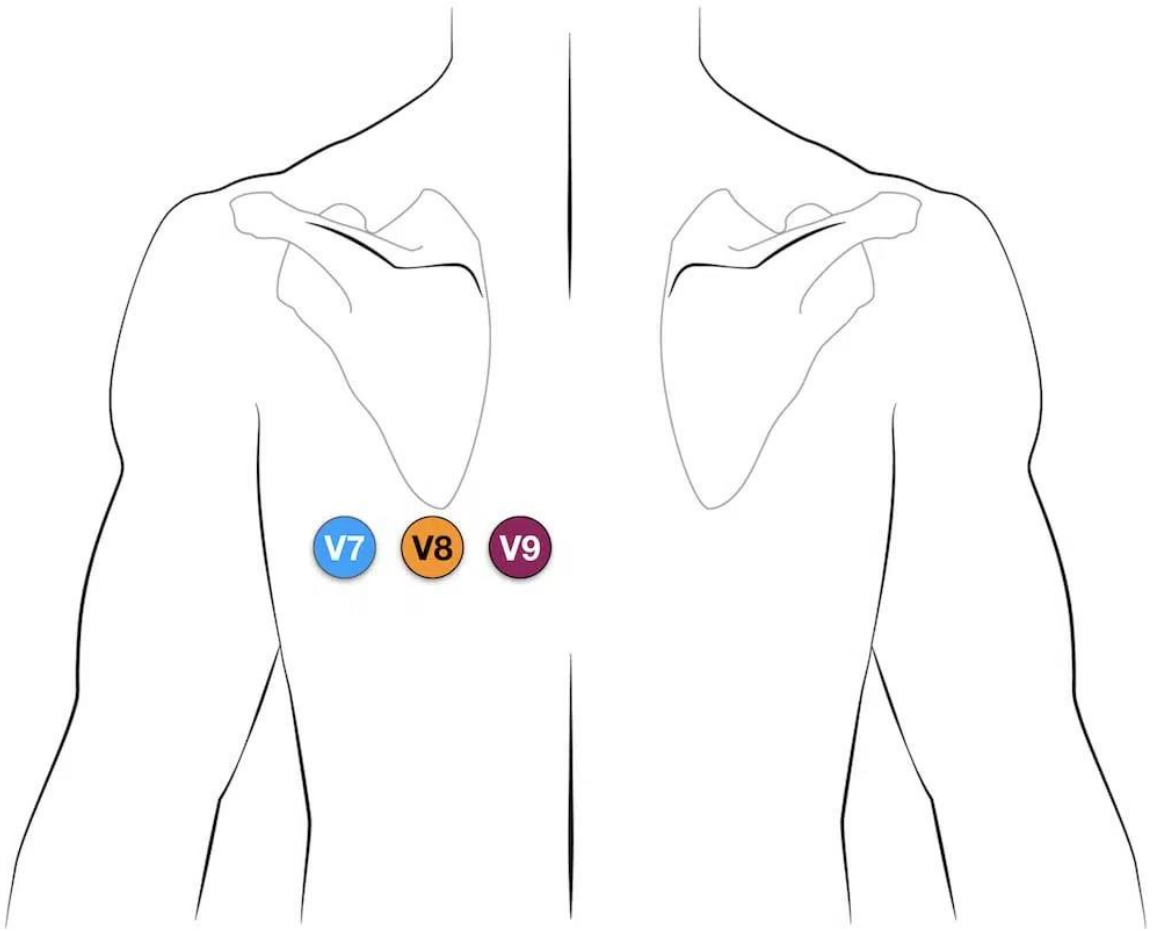
15 and 18-lead ECG's





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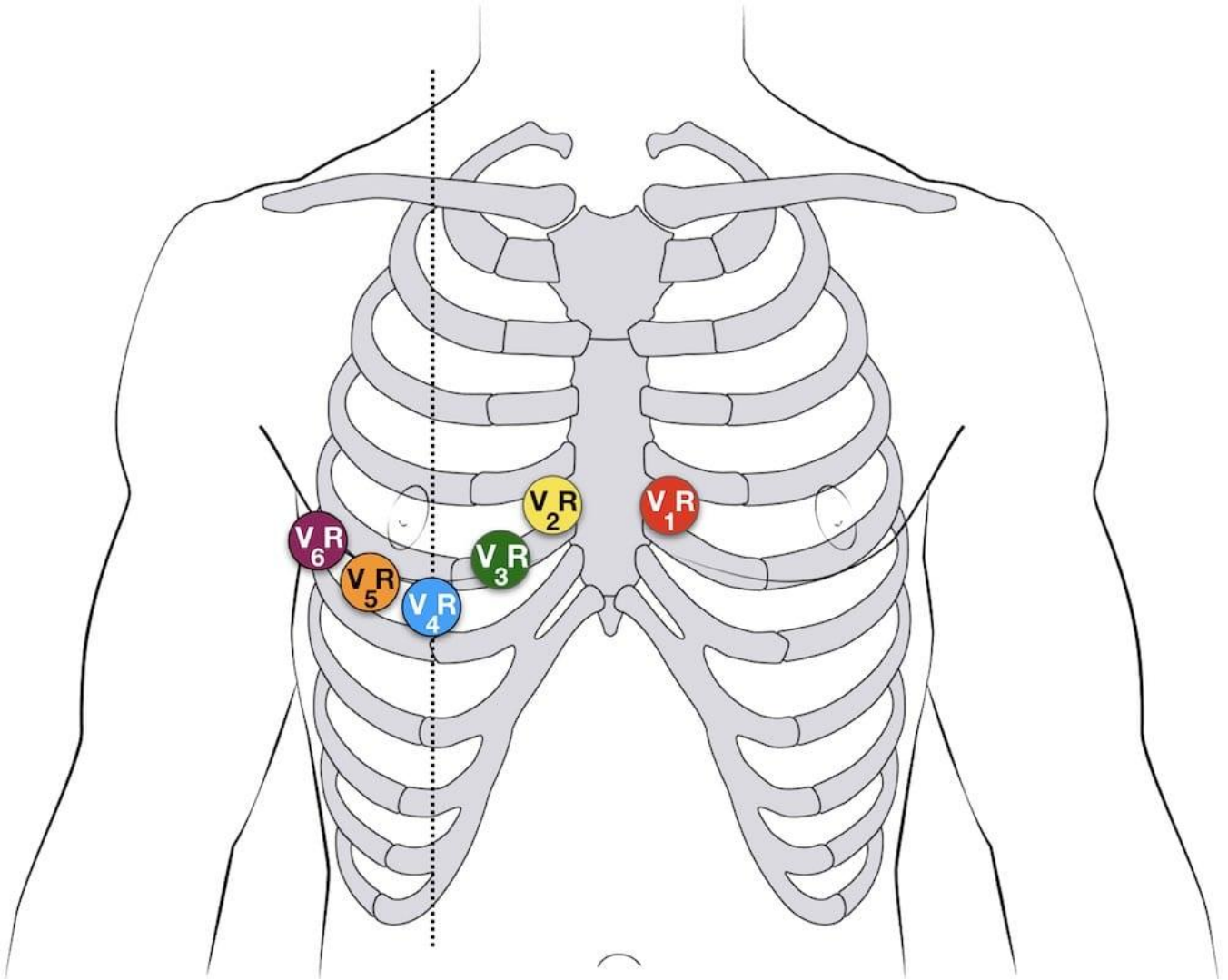
Right sided ECG



12 Lead Interpretation

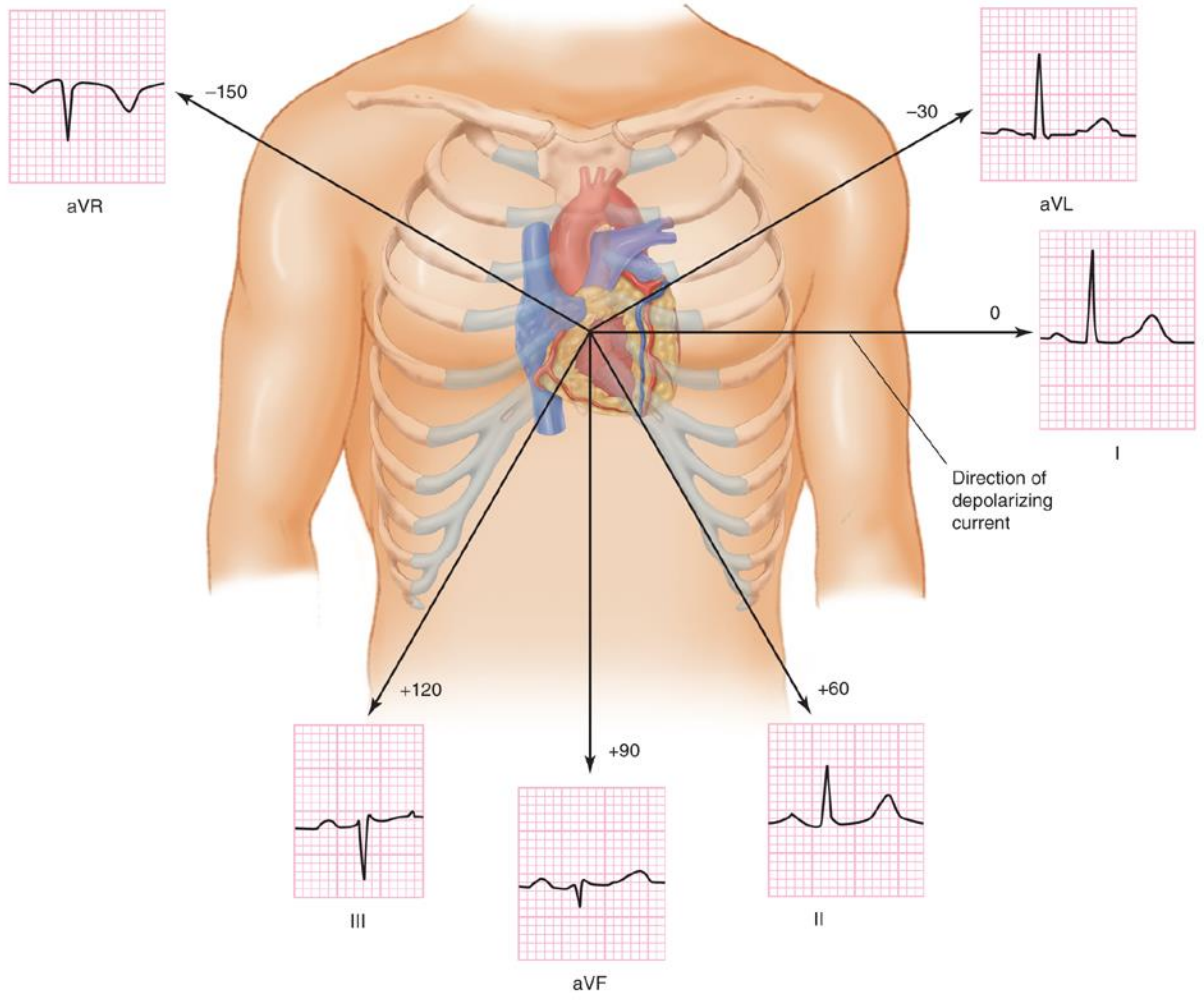
12-LEAD TECHNOLOGY

What Do ECG Leads Record?

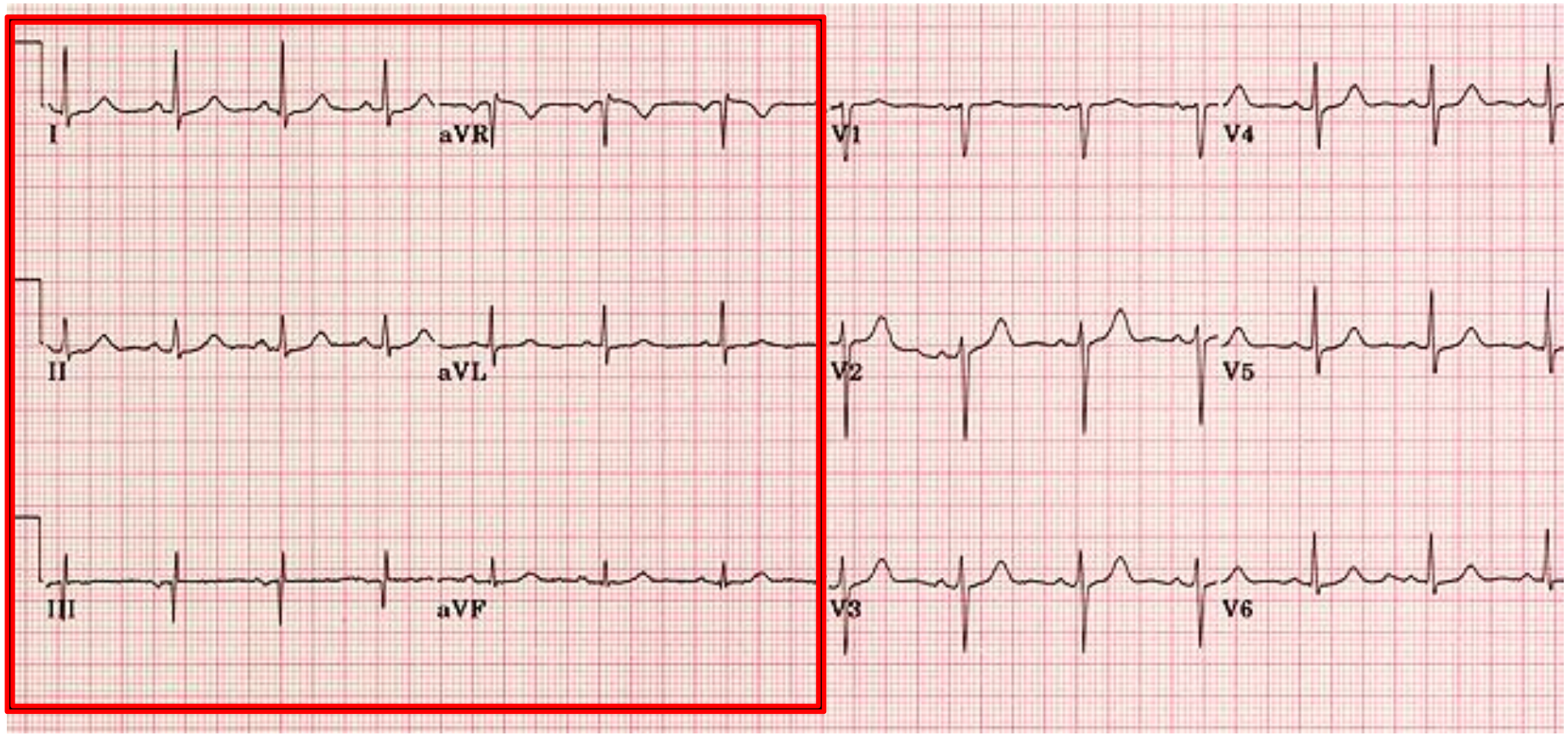
- In the standard 12-lead ECG, you record 12 leads
  - Provides an electrical picture of the heart taken from a specified vantage point
  - Three types of leads:
    - Bipolar limb leads
    - Unipolar augmented limb leads
    - Precordial leads

What Do ECG Leads Record?

- Limb leads
  - Six of the leads (I, II, III, aVR, aVL, and aVF)

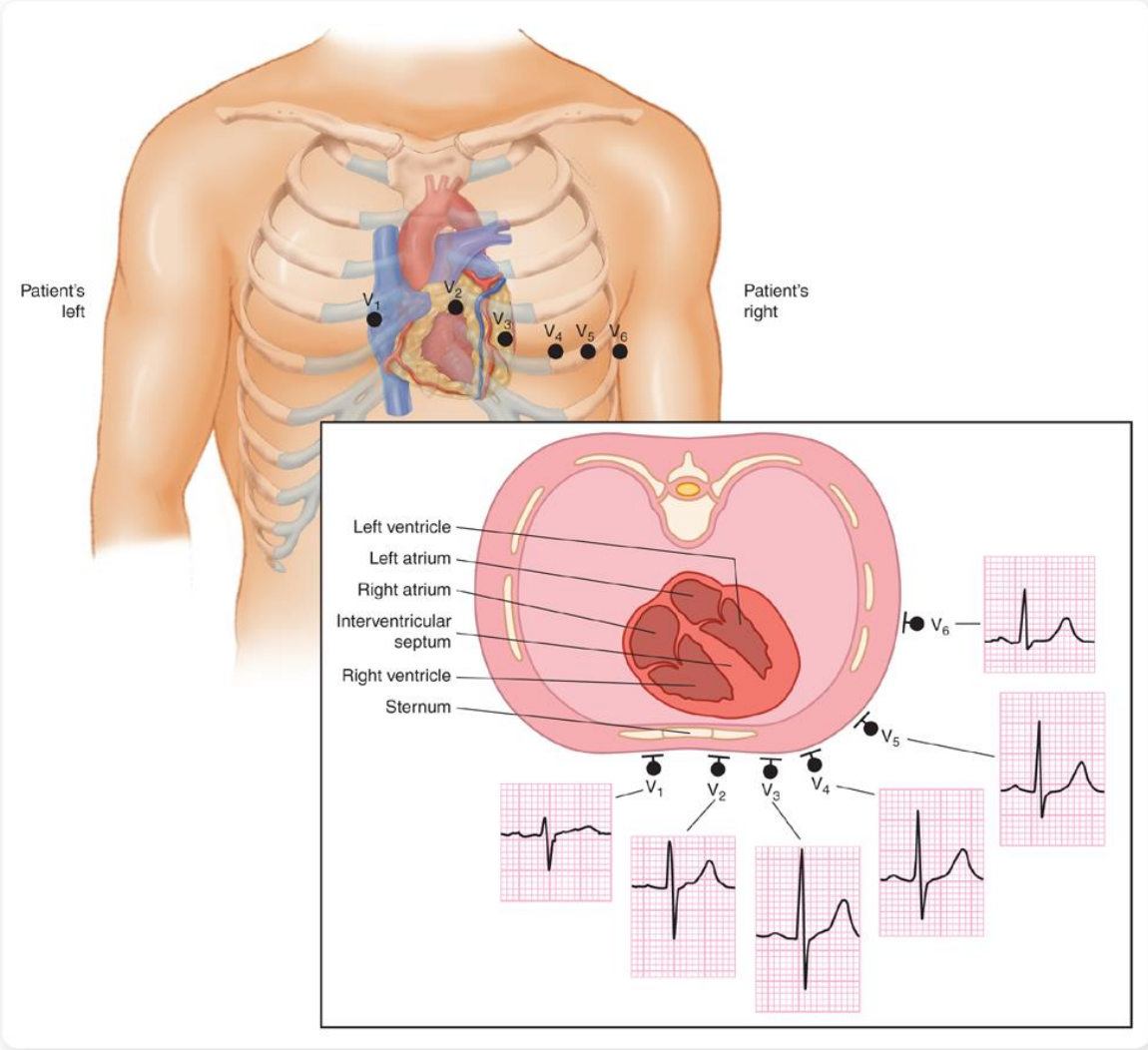


12-Lead Technology



What Do ECG Leads Record?

- A 12-lead ECG adds six precordial leads.
  - V1 to V6

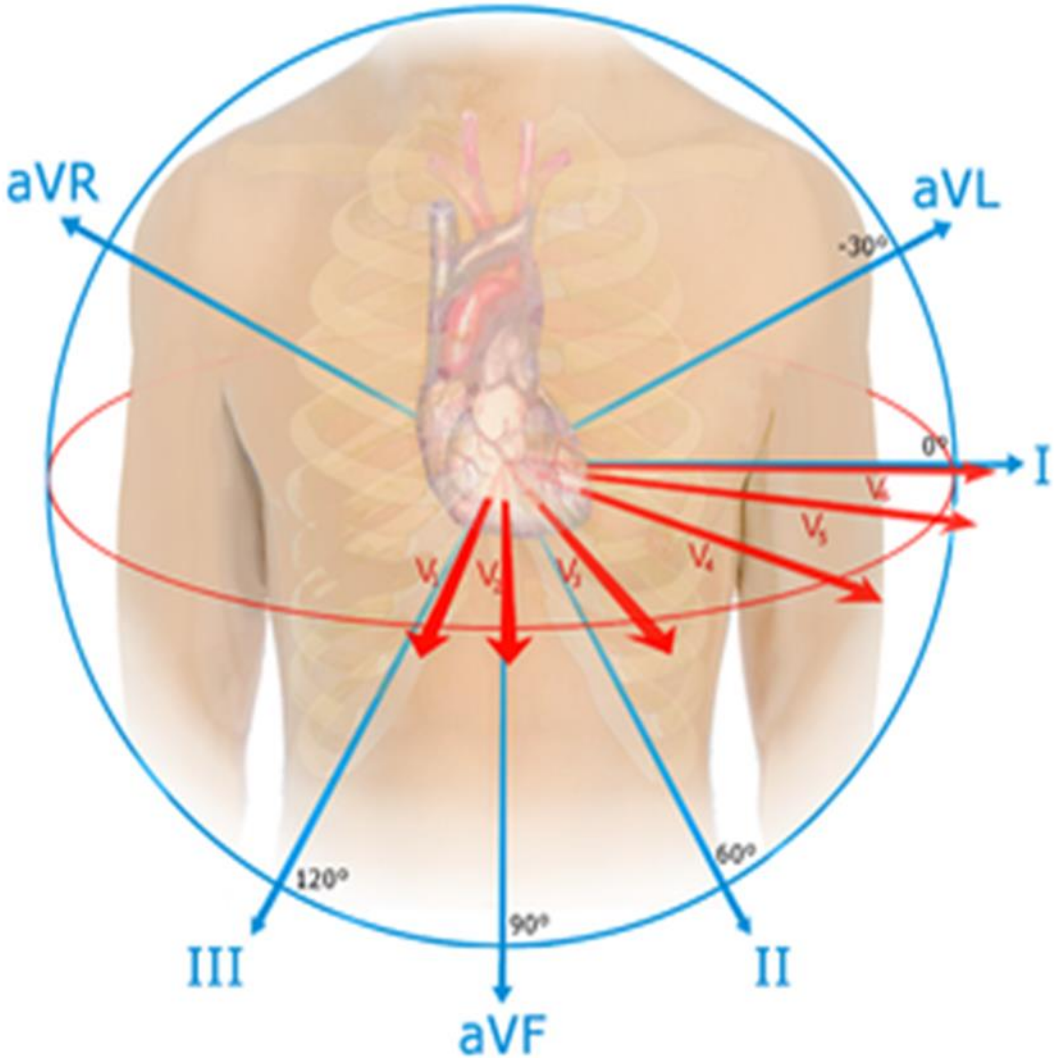


12-Lead Technology

- For a 12-lead ECG, the final 6 leads are obtained by placing 6 electrodes on the chest
- These leads function slightly different than the 3-lead electrodes
  - View the heart in a horizontal (transverse) plane
  - Referred to as V1 – V6
  - Are connected to the 3-lead
  - cables

12-Lead Technology

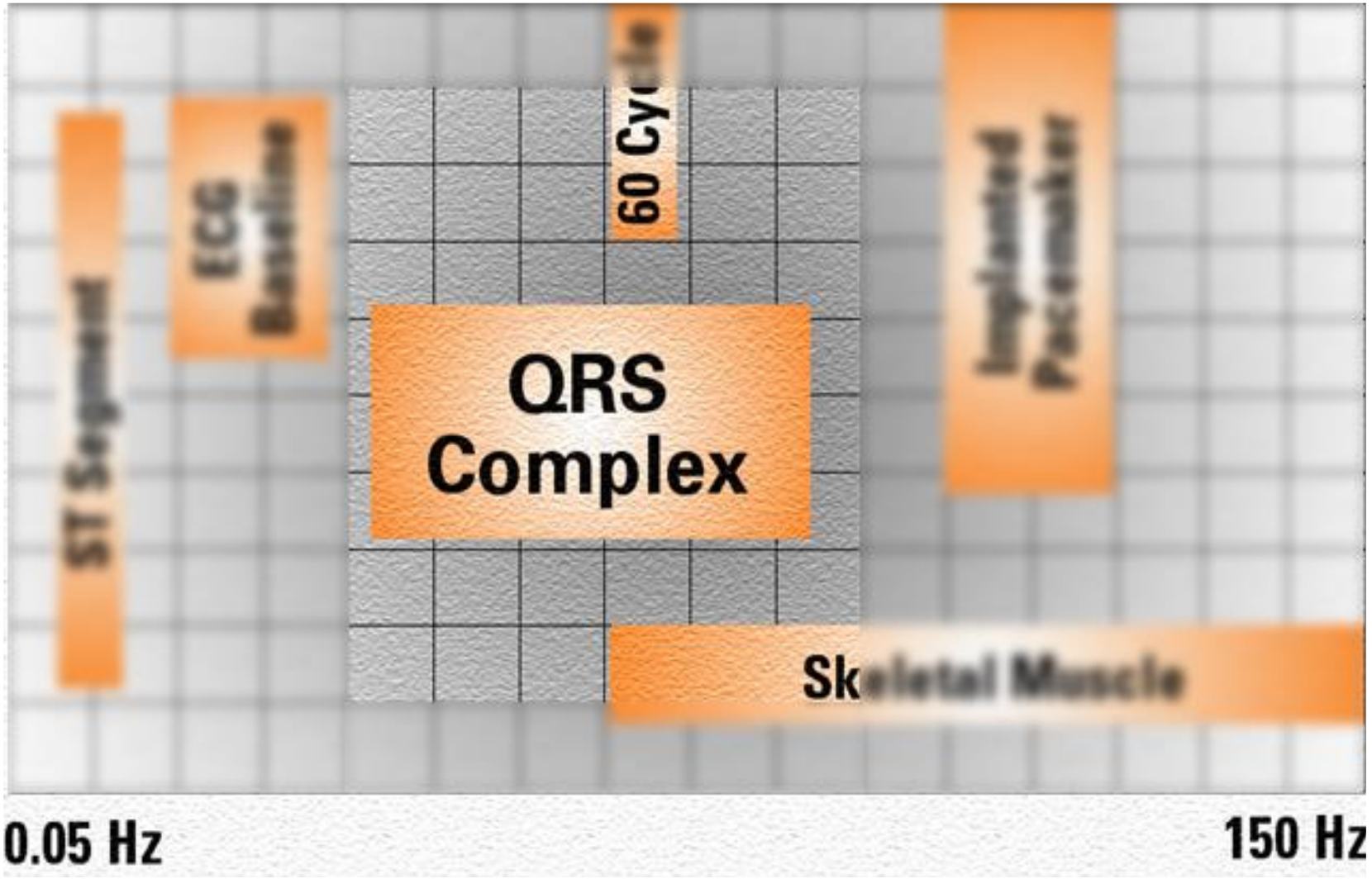
- Precordial leads (red) view heart in horizontal (transverse) plane
- Limb leads (blue) view heart in vertical (frontal) plane



12-Lead Technology

- ECG machinery can record in either Monitor or Diagnostic quality
  - **Monitor quality**
    - Utilized for rate/rhythm interpretation on 3-lead ECGs
    - Has a more narrow bandwidth for frequency response (1.0 – 30Hz)
      - Allows for ‘filtering out’ of some artifact and stabilization of baseline
      - However, reduces clarity and ability to recognize subtle changes
    - Cannot diagnose STEMI (among other ECG changes) while in Monitor mode

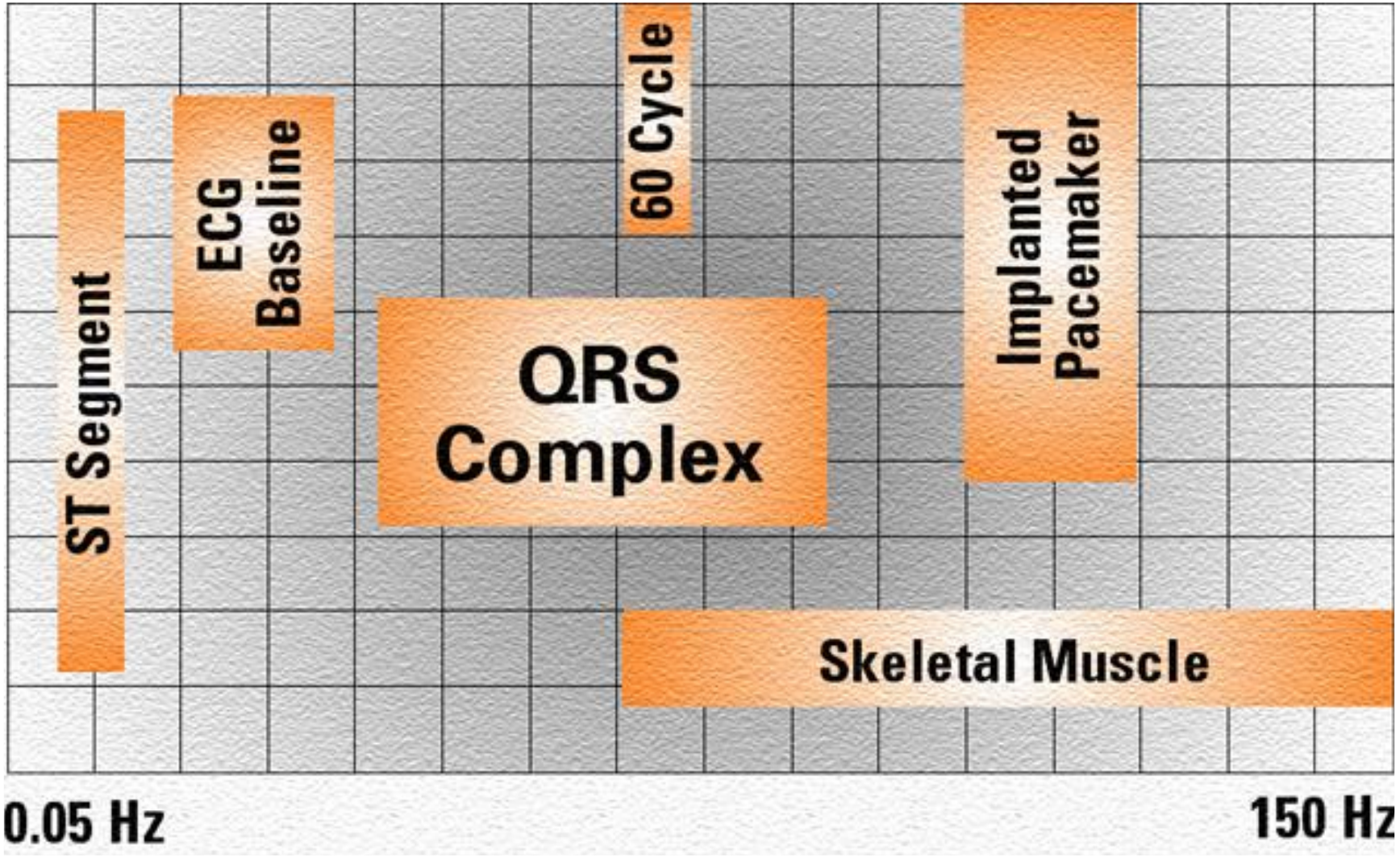
Monitor Mode



12-Lead Technology

- **Diagnostic quality**
  - Utilized for evaluation of QRS-T waveforms on 12-lead ECGs
  - Has a wider bandwidth for frequency response (0.05 – 150Hz)
    - Allows for more accurate evaluation of QRS complexes, T wave abnormalities and most importantly ST segment changes
  - Diagnostic mode is only mode to accurately recognize a STEMI

Diagnostic Mode



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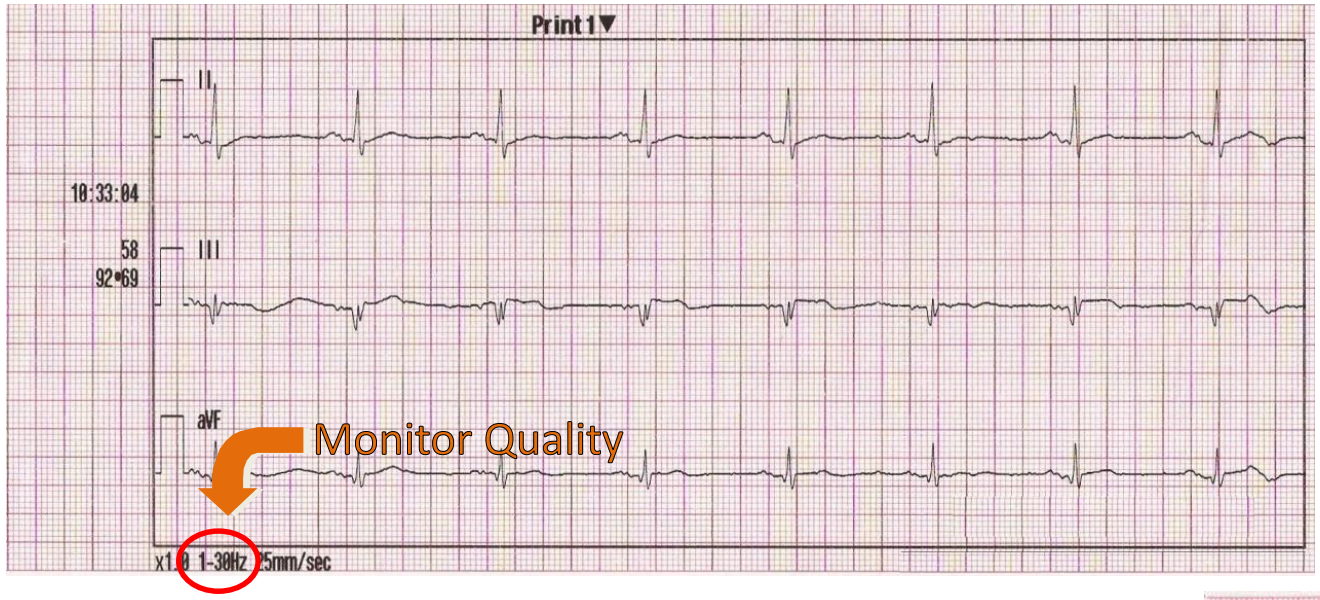
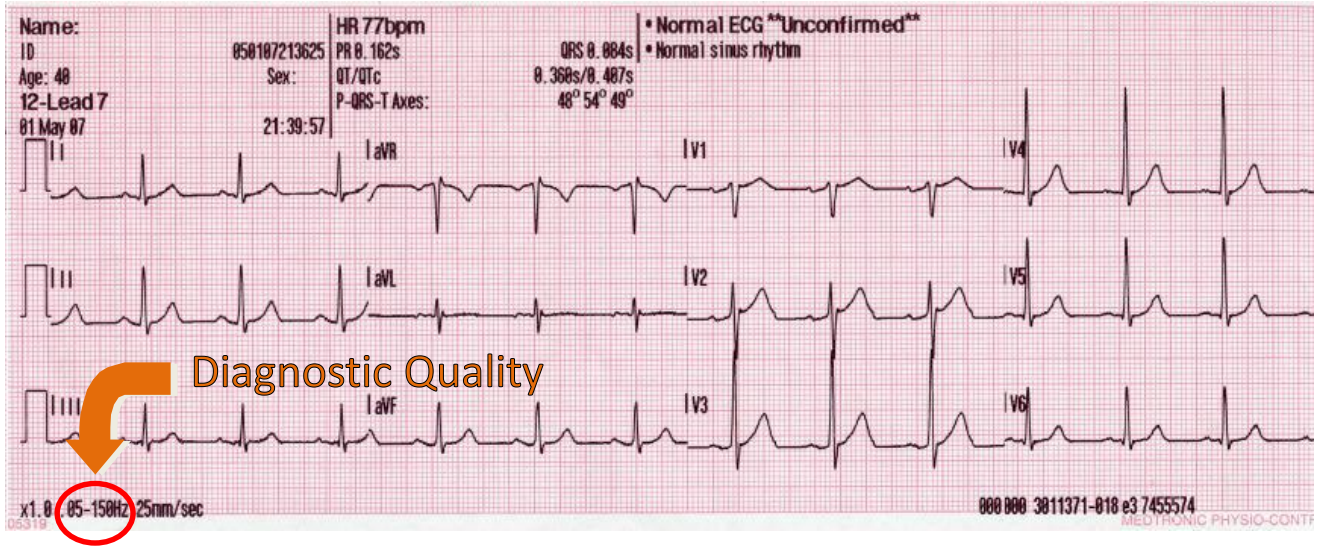
Frequency Response





Accuracy

- In order to ensure accurate and repetitive 12-lead capture quality, certain standards have to be met
  - Preparation steps
  - Lead placement
  - Frequency response
  - Calibration
  - Paper speed

Accuracy

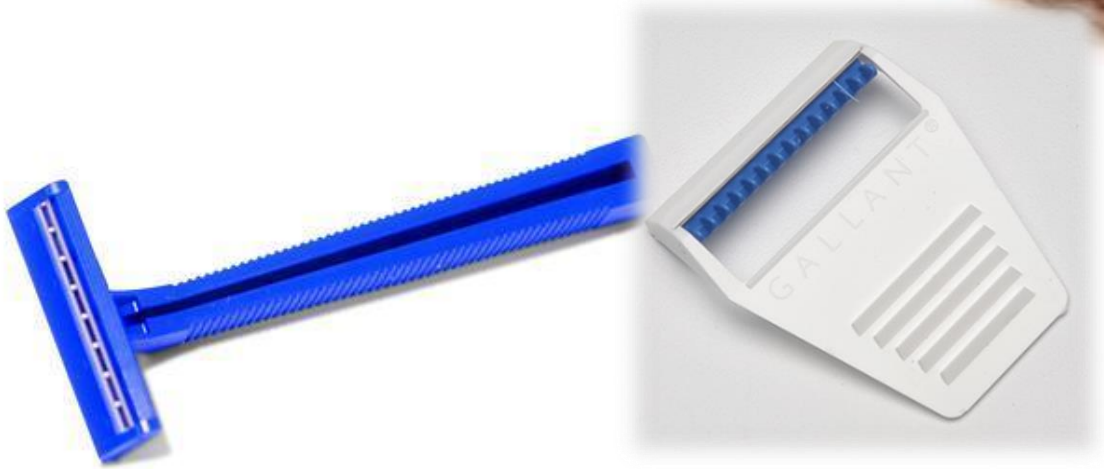
- Preparation steps
- Lead placement
- Frequency response
- Calibration
- Paper speed

Preparation

- Although diagnostic mode enables a more accurate tracing for interpretation, it is only as good as the preparation you take
- In order to optimize tracing quality and minimize artifact consider:
  - Hair removal
  - Skin preparation
  - Limiting patient movement during printing
  - Ensuring no movement of 12-lead device

Hair Removal

- Some patients require hair removal from chest to allow proper adherence of precordial leads
- Options can include:
  - Clipper over razor
  - Disposable razor



Skin Preparation

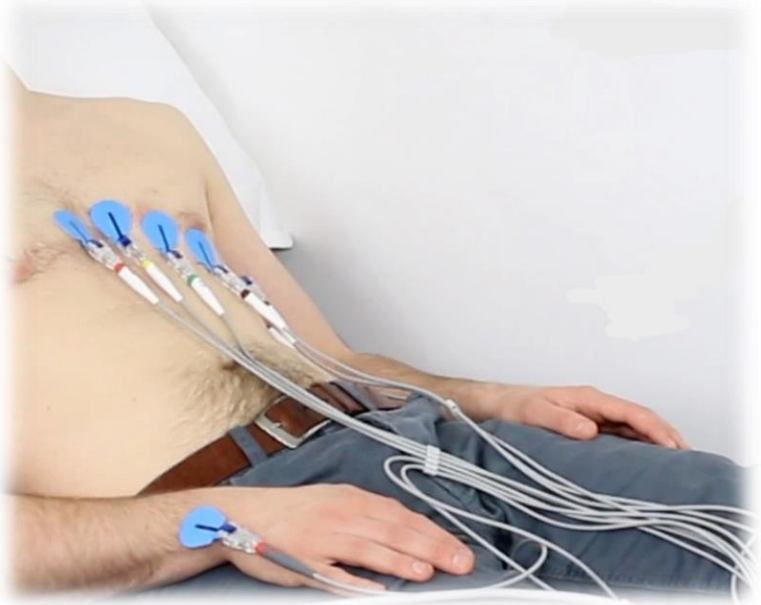
- Shave excess hair at electrode site
- Avoid placing electrodes over broken skin, tendons or major muscle masses (if possible)
- Gently scrape skin to remove layer of dead cells
- Clean & dry skin
  - Use towel, gauze and/or alcohol wipe
    - Helps to remove oils, dirt and debris

Skin Preparation

- Electrodes have conductive gel that allows for transmission of the heart's electrical activity
  - There needs to be sufficient adhesion to the skin surface to allow for signal transmission

Patient Movement

- Make patient as comfortable as possible
  - Supine preferred
  - Have patient remain stationary and quiet during 12-lead capture
    - Do not instruct patient to hold their breath
- Troubleshoot artifact if present
  - May have to move limb leads higher up on legs/arms
    - Do not place limb leads on torso when obtaining a 12-lead



Patient Movement

- Check for subtle patient movements
  - Toe tapping
  - Shivering
- Look for muscle tension
  - Hand grasping rail
  - Head raised to “watch”
- If patient is tremulous, may need to place flannel over electrode sites

Device Movement

- Ensure the cables that connect the electrodes to the defibrillator have some slack in them
  - When cables are taut, even small movements cause artifact
  - Not too much slack which can cause cables to drag on floor or strike other objects

Vehicle Movement

- Acquisition in a moving vehicle
  - Depending on speed, terrain, etc. acquisition of 12-lead may not be possible when moving
    - Movement of vehicle can transmit to movement of the device and/or cables
  - May need to pull over for 10-15 seconds to capture
  - May also be able to utilize stop signs/traffic lights for capture

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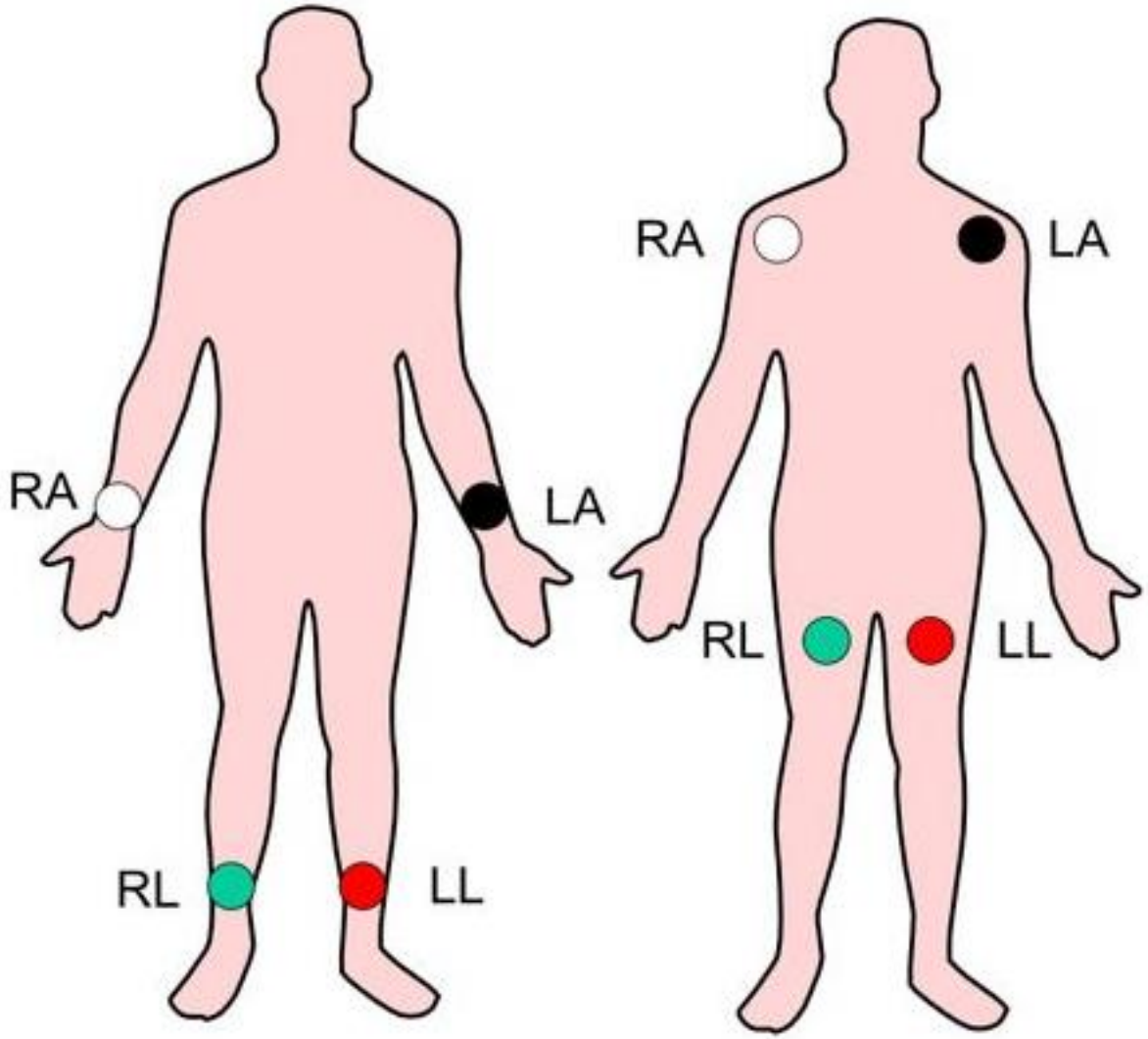
Accuracy

- Preparation steps
- Lead placement
- Frequency response
- Calibration
- Paper speed

Limb Lead Placement



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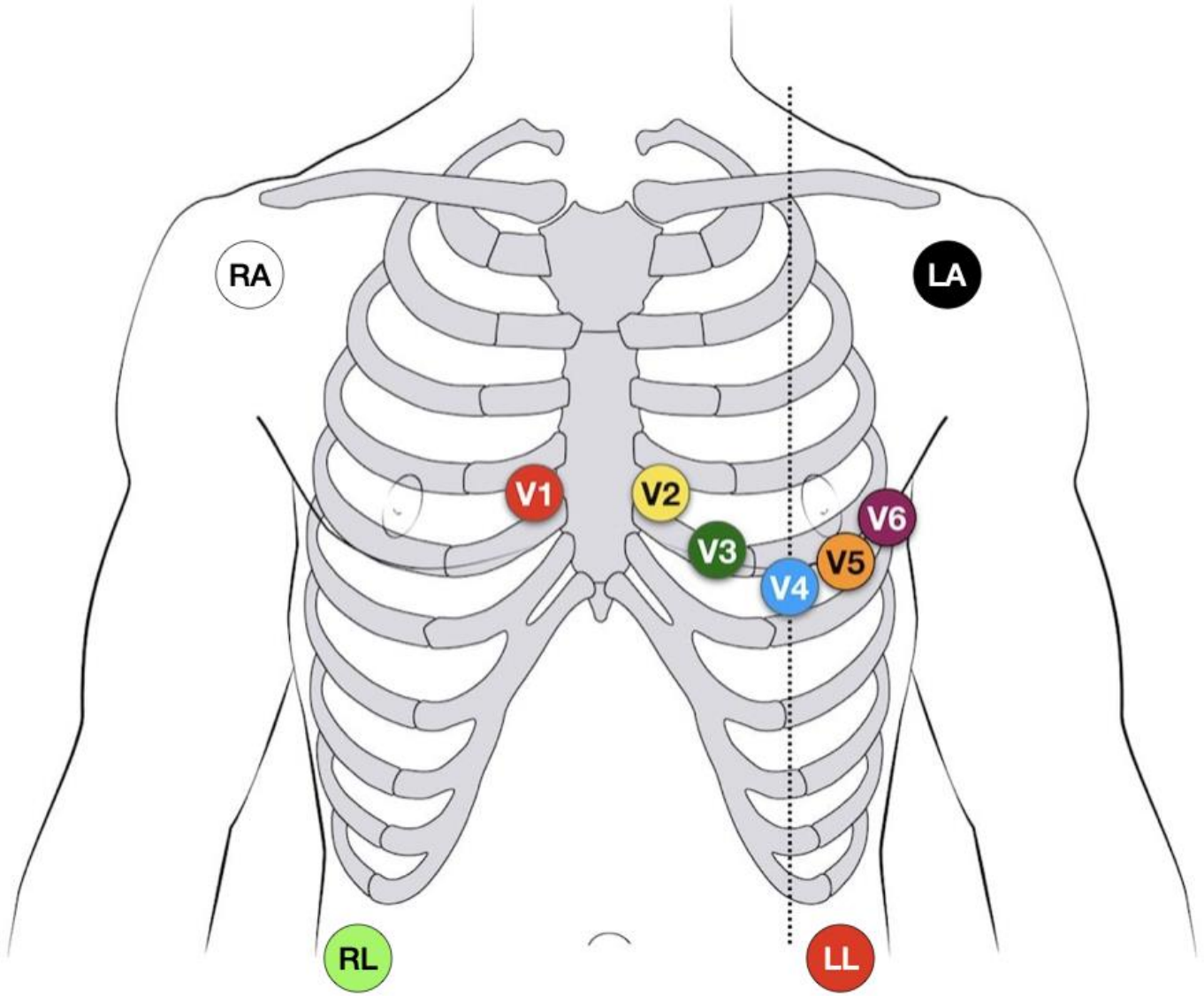
Chest Lead Placement



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12-Lead ECG Lead Placement

Table 30-15 Focus of ECG Leads

Leads	Area of Damage	Coronary Artery Involved	Possible Complications
II, III, and aVF	Inferior wall LV	RCA, distal (or LCx)	Hypotension, bradycardia, SA and AV blocks, RV failure if RVMI also
V_1 and V_2	Septum	LAD, septal	Infranodal blocks and BBBs
V_3 and V_4	Anterior wall LV	LAD	LV failure, heart failure, BBBs, third-degree AV block, ventricular dysrhythmias
V_5 and V_6	Lateral wall LV	LCx	LV dysfunction
I and aVL	High lateral wall LV	LCA diagonal or LCx OM	AV nodal block in some patients
V_4R (with II, III, aVF)	RV	RCA, proximal	RV failure, hypotension, SA and AV blocks, atrial dysrhythmias
V_8 and V_9 (reciprocal V_1 and V_2)	Posterior LV	RCA (or LCx)	Complications same as associated with inferior wall (or lateral wall) MI

Abbreviations: AV, atrioventricular, BBB, bundle branch block; LAD, left anterior descending artery; LCA, left coronary artery; LCx, left circumflex artery; LCx OM, left circumflex artery, obtuse marginal branch; LV, left ventricle; MI, myocardial infarction; RCA, right coronary artery; RV, right ventricle; RVMI, right ventricular myocardial infarction; SA, sinoatrial.

Accuracy

- Preparation steps
- Lead placement
- Frequency response
- Calibration
- Paper speed

Frequency Response

- As mentioned previously, 12-lead interpretation must only be done while in Diagnostic mode
- Most devices will automatically switch to Diagnostic mode when capturing a 12-lead
  - However, display screen is non-diagnostic (monitor mode)
- Diagnostic mode can be confirmed by reading frequency response at bottom of 12-lead

Accuracy

- Preparation steps
- Lead placement
- Frequency response
- Calibration
- Paper speed

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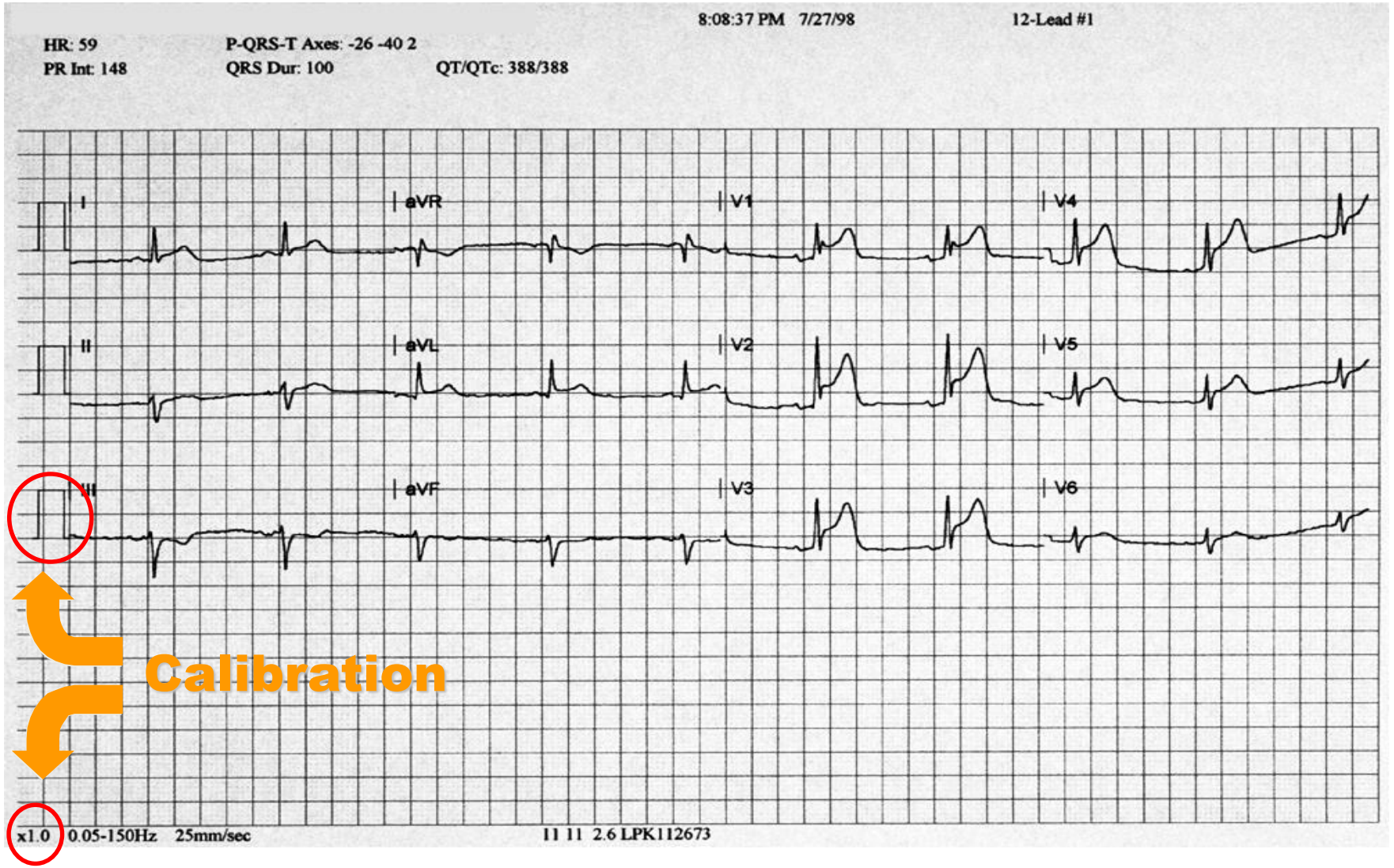
Calibration



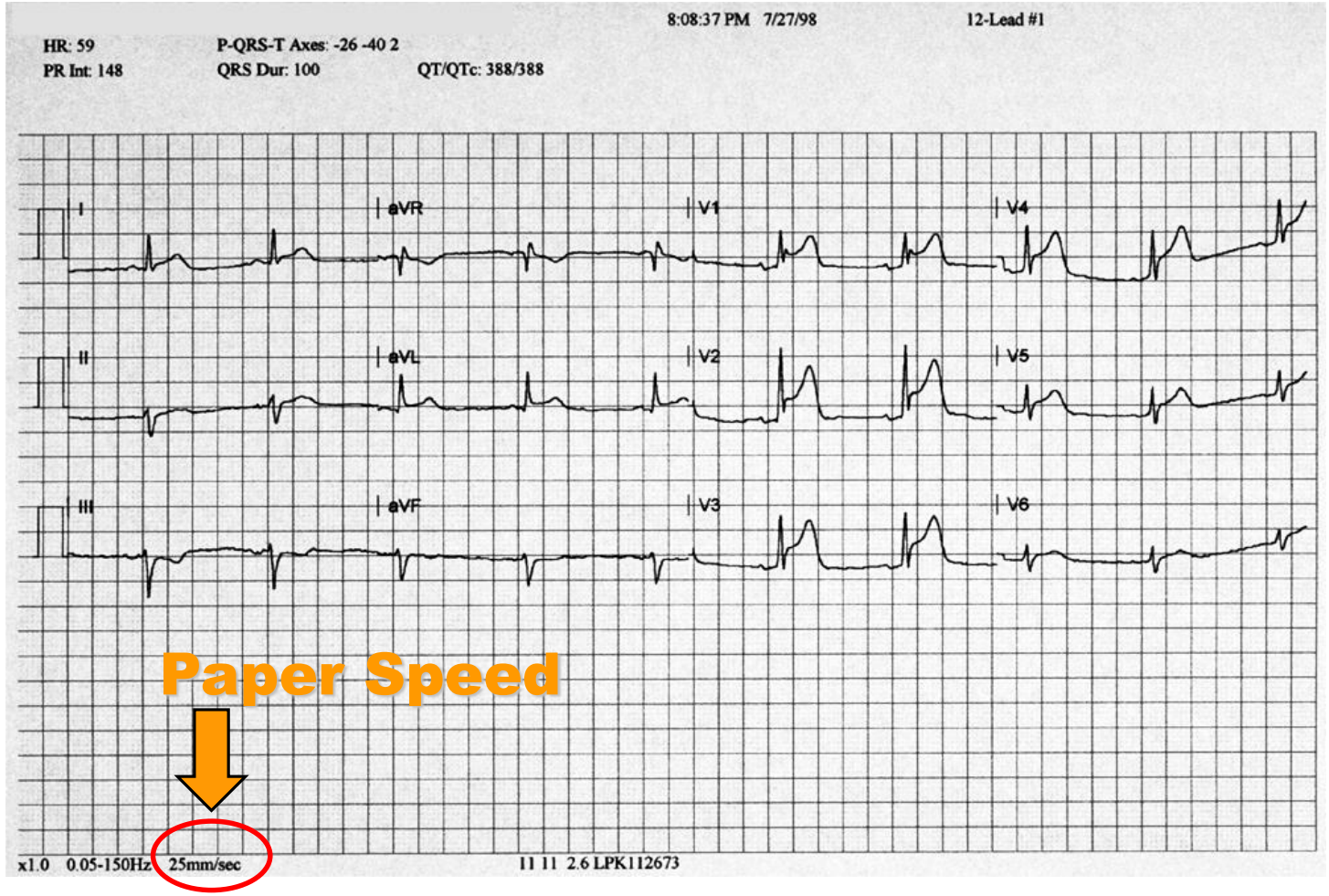
Accuracy

- Preparation steps
- Lead placement
- Frequency response
- Calibration
- Paper speed

Paper Speed

- The speed at which the paper prints must be standard
  - If not, interpretation or wave width and segment times will be altered
- Standard paper speed is 25 mm/sec
- This can be confirmed two ways
  - Paper speed is printed at the bottom of the ECG
  - The calibration wave represents 0.04s
    - Therefore it should cover 5 small boxes

Paper Speed


8:08:37 PM 7/27/98
12-Lead #1
HR: 59
PR Int: 148
P-QRS-T Axes: -26 -40 2
QRS Dur: 100
QT/QTc: 388/388
I
aVR
V1
V4
II
aVL
V2
V5
III
aVF
V3
V6
Paper Speed
x1.0 0.05-150Hz 25mm/sec
11 11 2.6 LPK112673

Clear ECG

- Once a 12-lead ECG has been printed, ensure it is clear enough for interpretation
- Assess 12-lead for:
  - Little or no artifact
  - Steady baseline

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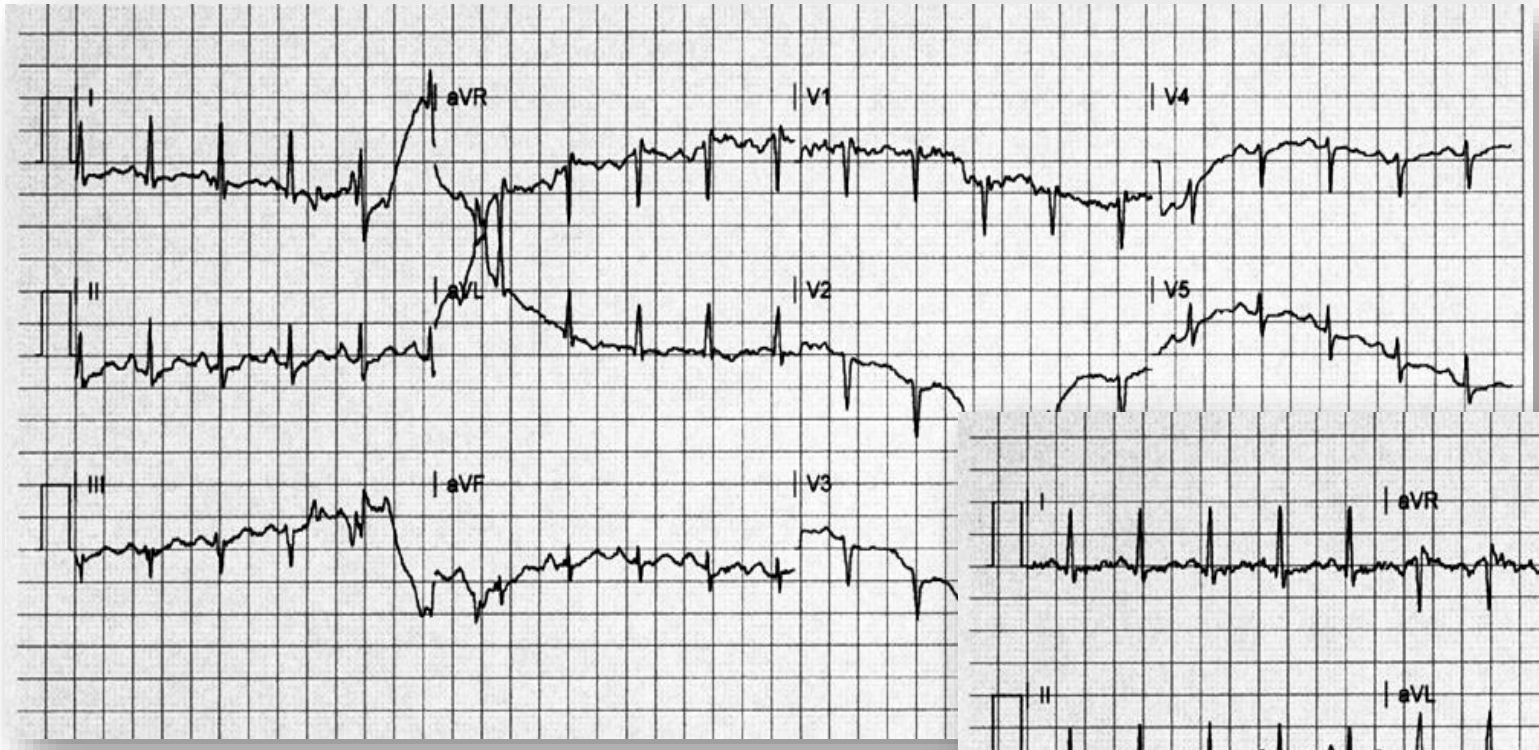
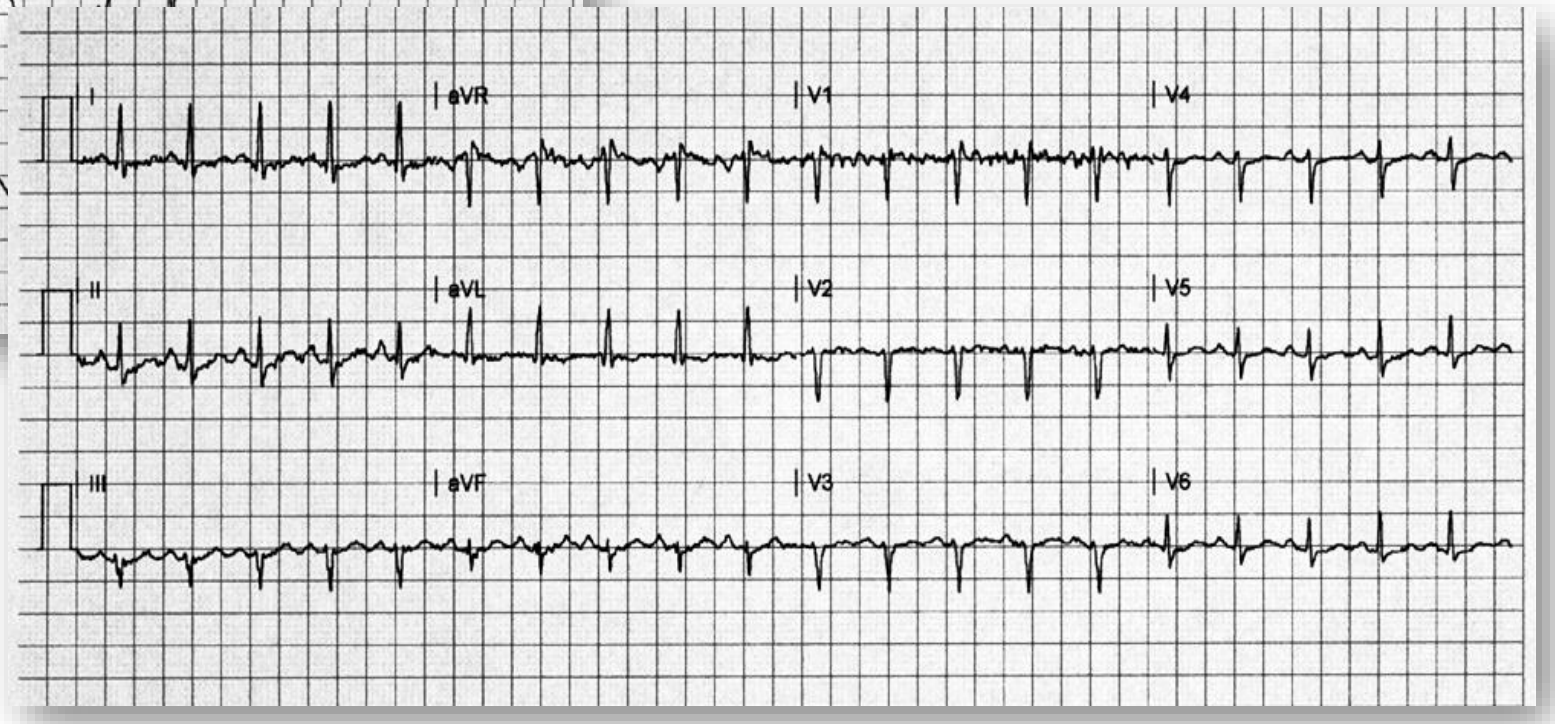
Artifact vs Clean ECG





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12-Lead ECG Application

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Cardiac

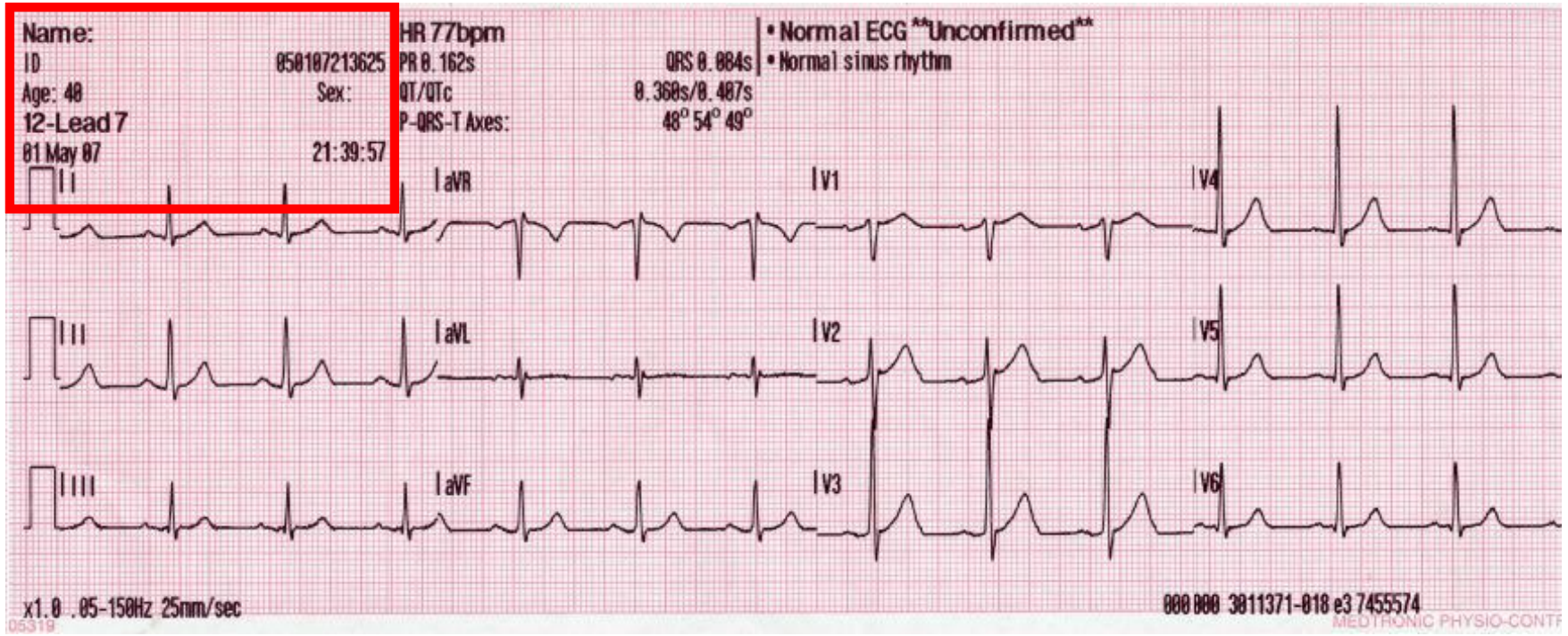
12-LEAD INTERPRETATION

12-Lead Interpretation

- Once a 12-lead ECG tracing has printed, the next step is interpretation of the results
- Similar to the process of 3-lead rhythm interpretation, following a systematic assessment of all 12-leads will improve efficiency and accuracy

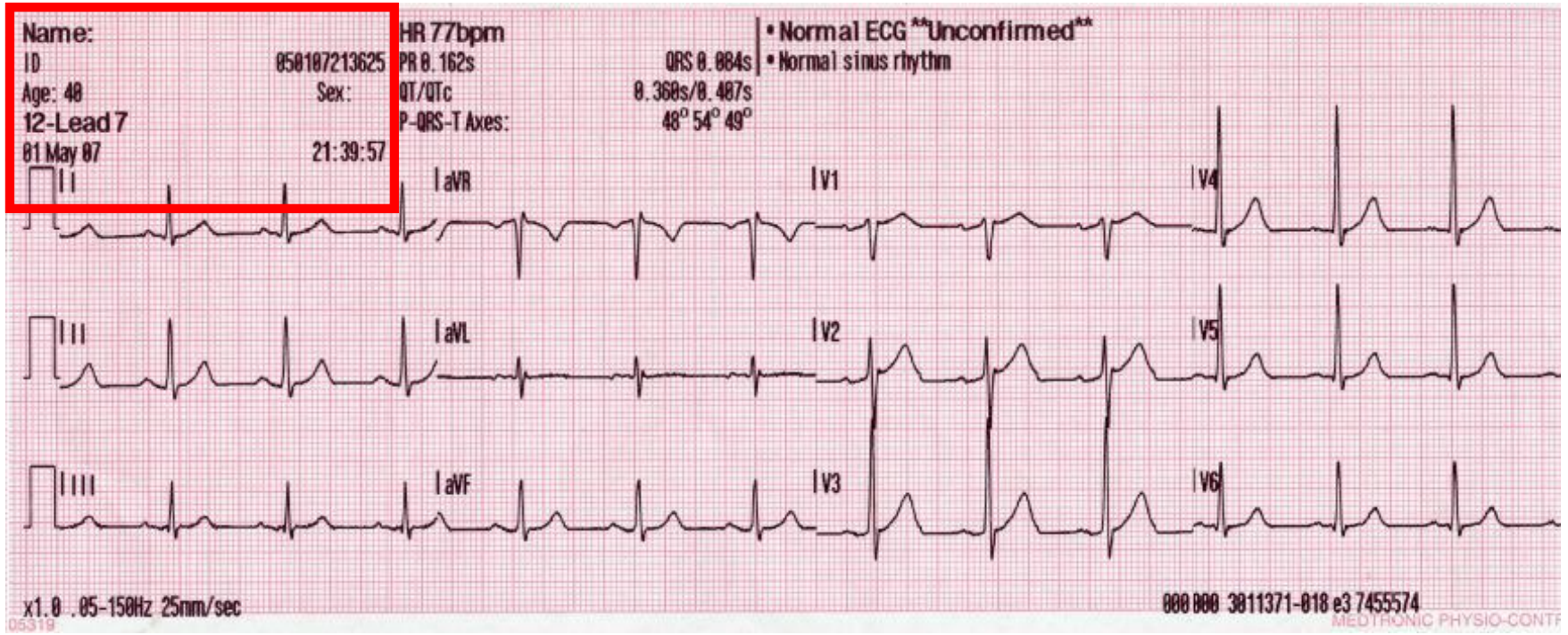
Anatomy of a 12-lead

- First section contains:
  - Fillable fields such as patient name, age, sex
  - A unique serial number based on when the machine was turned on



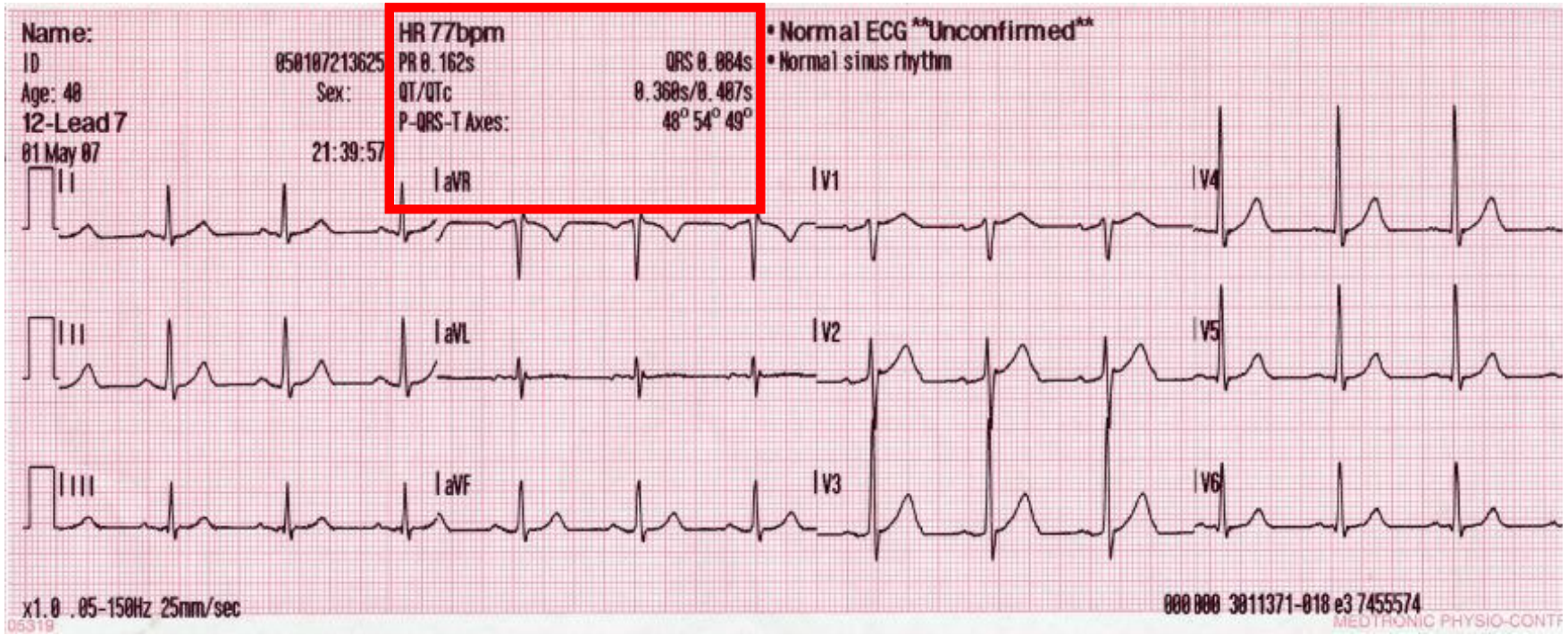
Anatomy of a 12-lead

- The number corresponding to which of the patient's serial 12-leads you are interpreting
- Date and time of 12-lead print



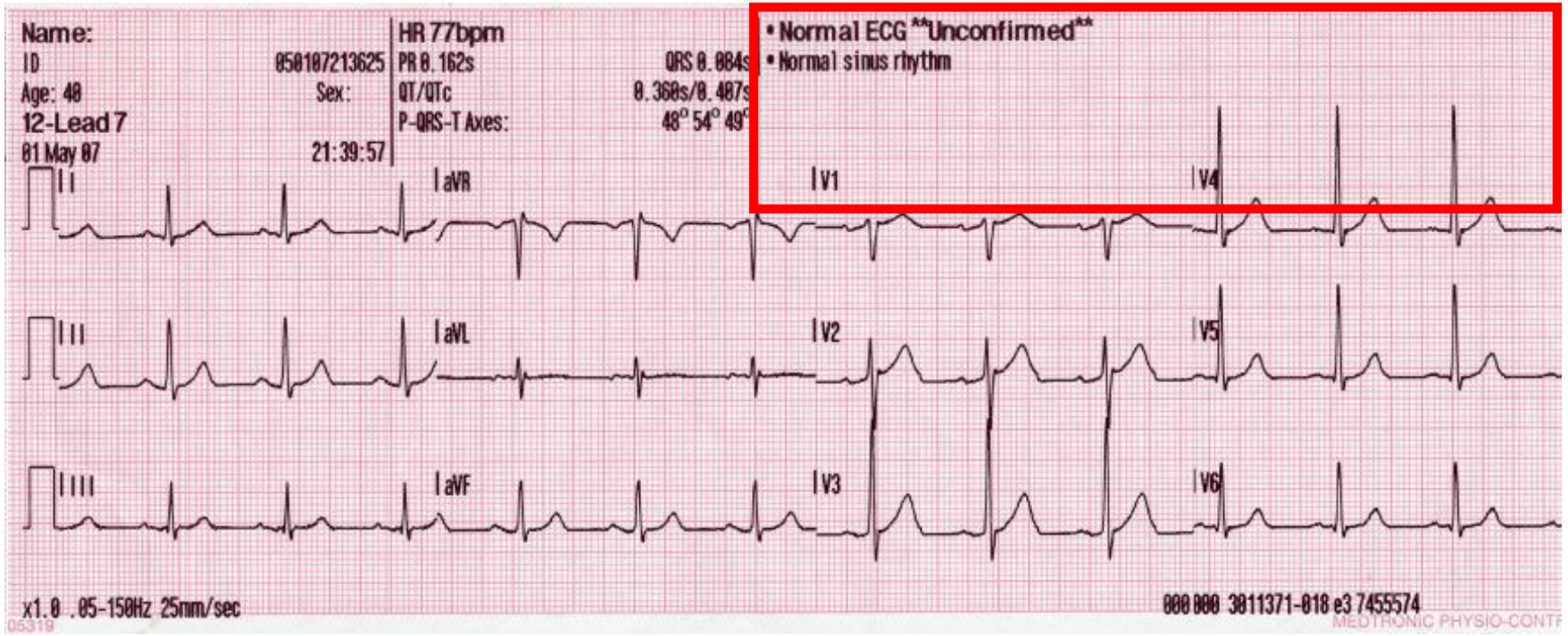
Anatomy of a 12-lead

- Second section contains:
  - Patient's HR (based on # of QRS segments - more on this later)
  - Values for PRI, QT/QTc and electrical axis



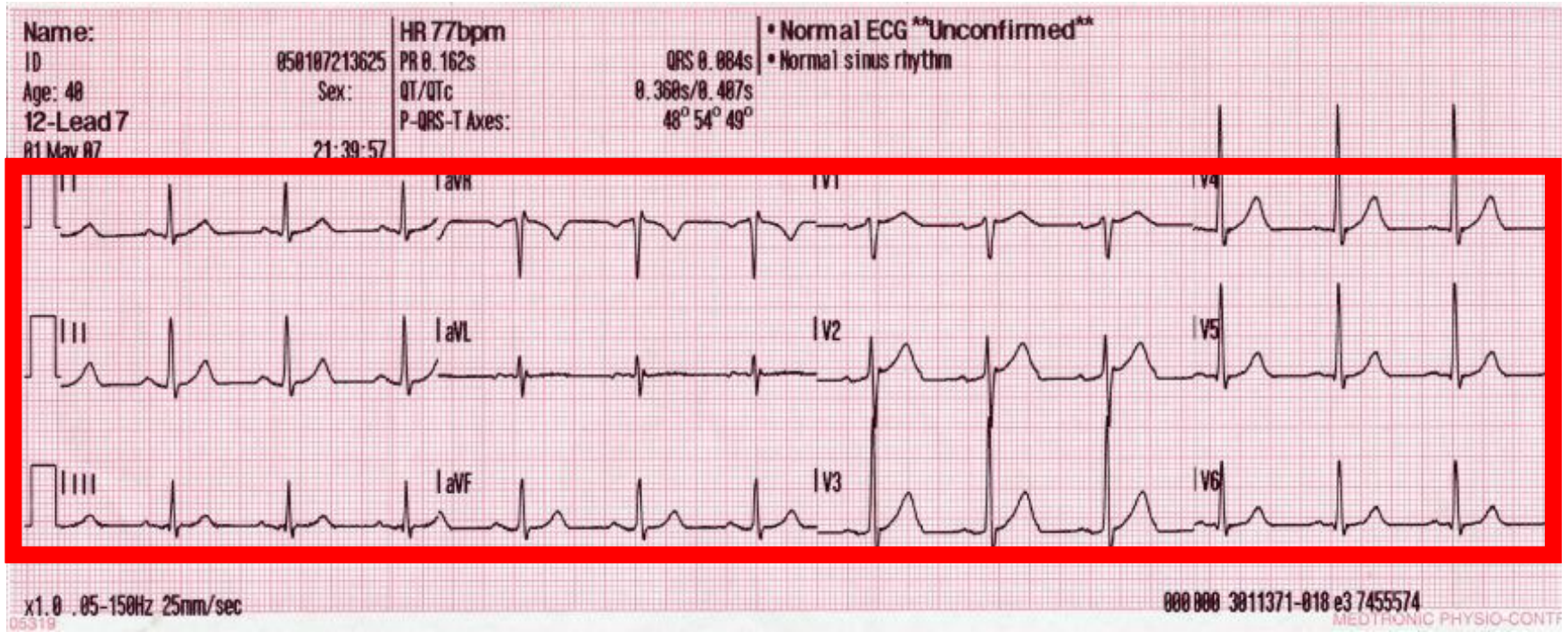
Anatomy of a 12-lead

- Third section contains:
  - The device's interpretation of the underlying rhythm and any electrical abnormalities



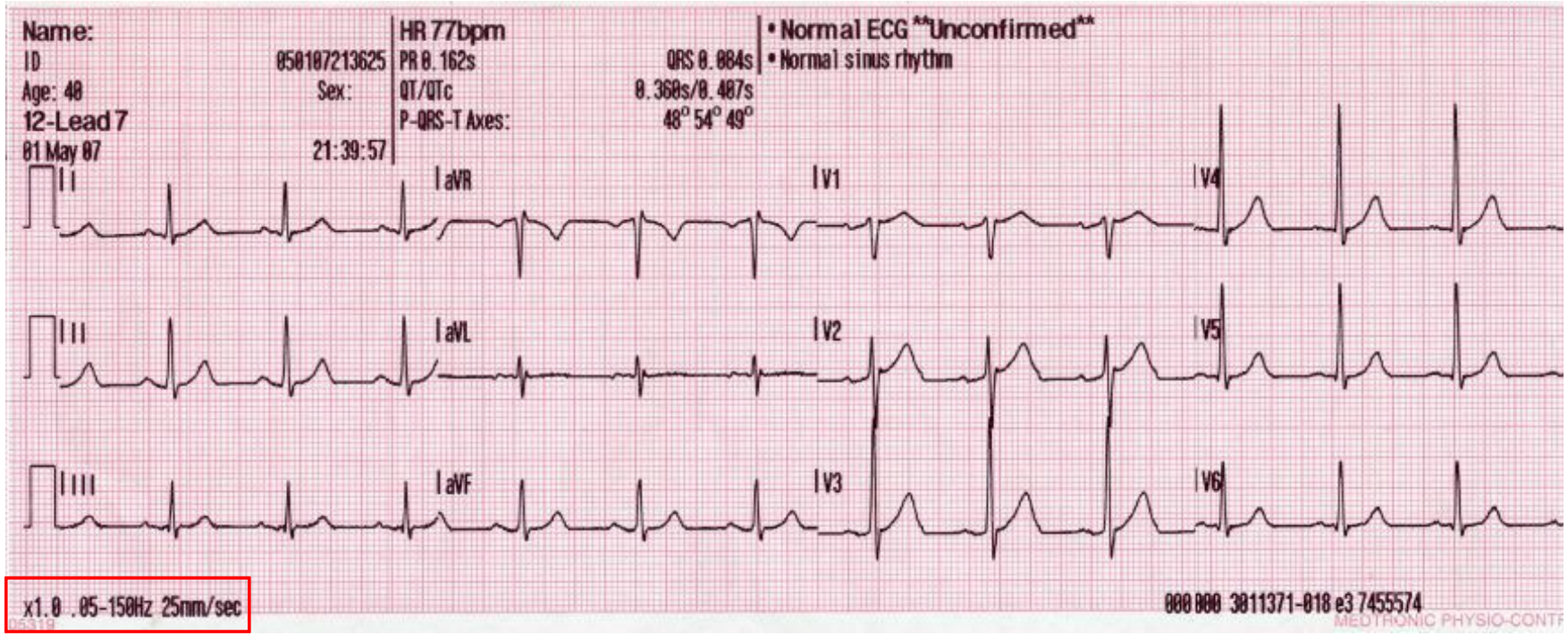
Anatomy of a 12-lead

- The middle section contains the 12 different views of the heart's electrical activity
  - This will be used for interpretation



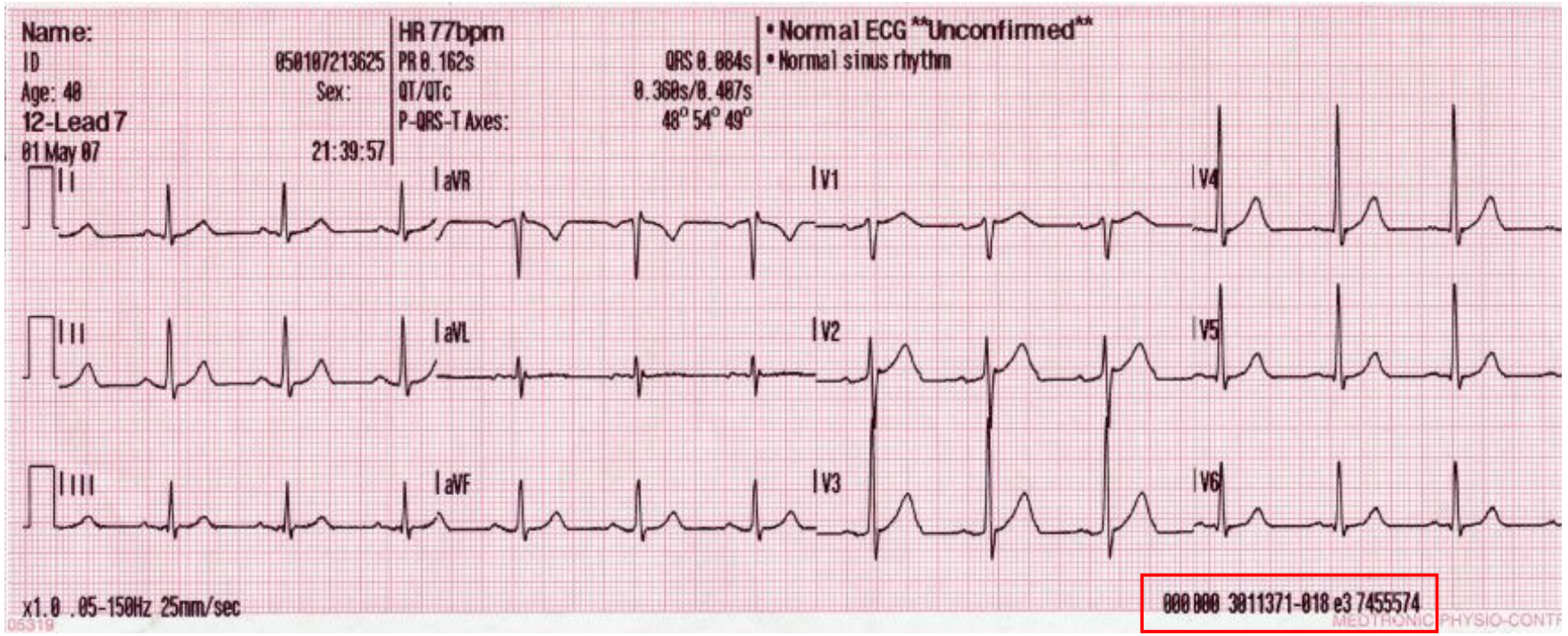
Anatomy of a 12-lead

- As discussed earlier, the bottom left corner contains information such as calibration, frequency response and paper speed



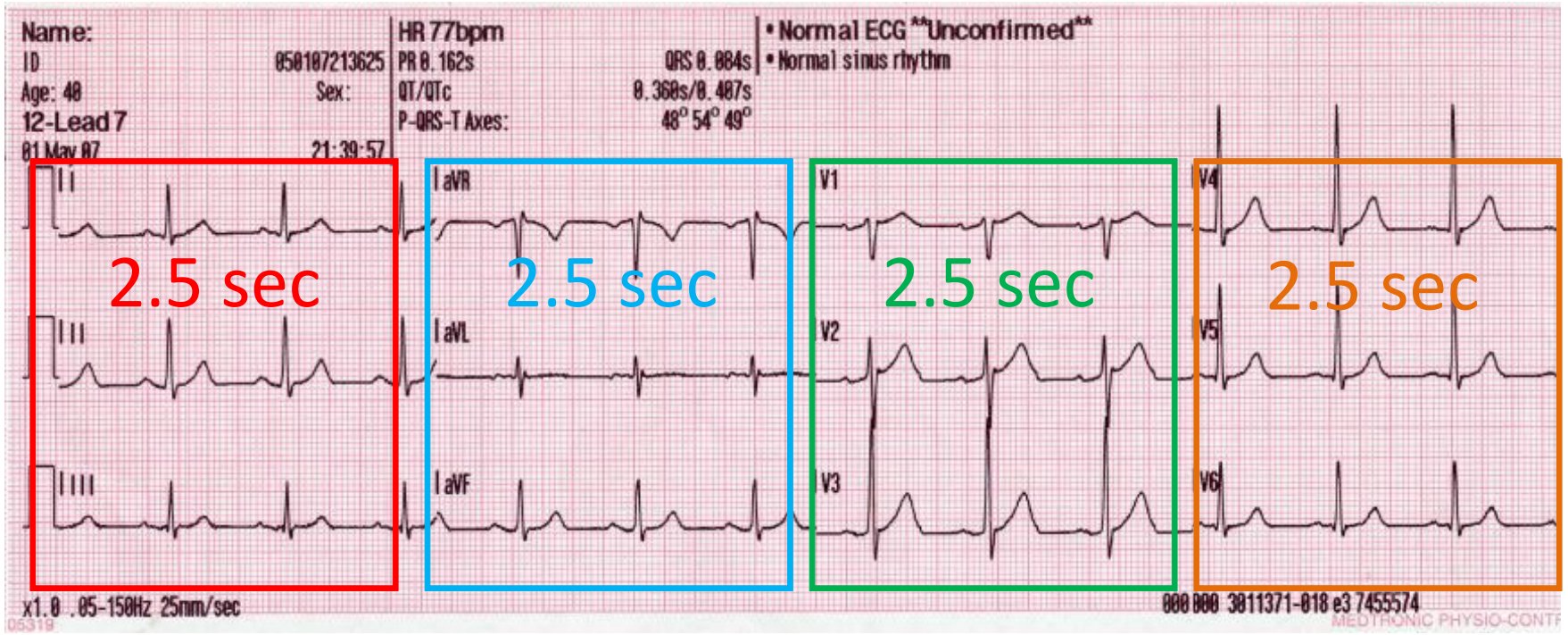
Anatomy of a 12-lead

- Finally, the information in the bottom right corner contains serial number information for the device



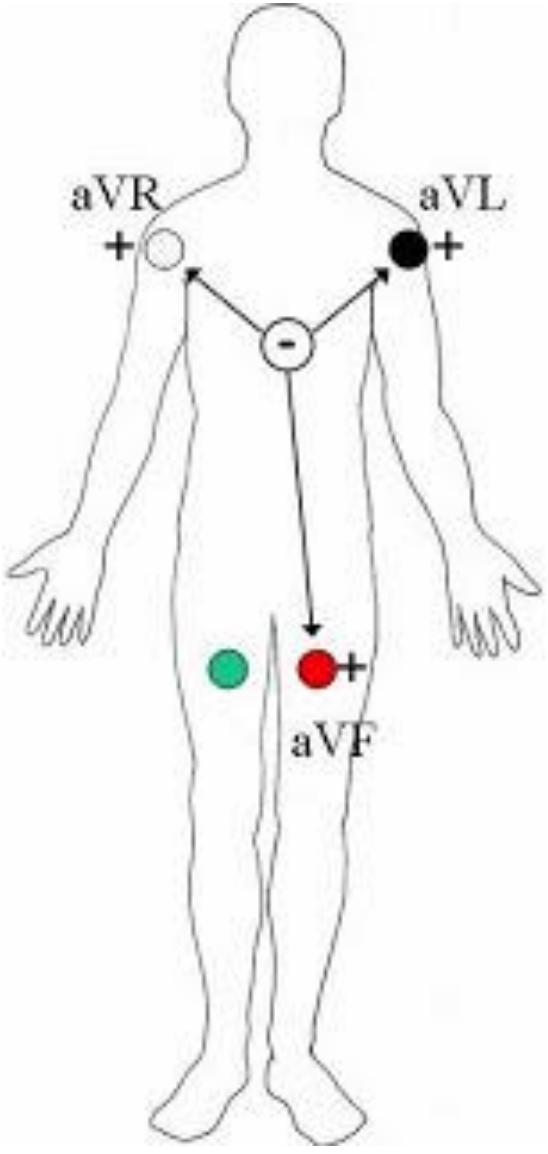
Anatomy of a 12-lead

- Keep in mind, a 12-lead represents four consecutive 2.5 second intervals
  - An entire 12-lead only represents 10 seconds of electrical activity
  - Therefore, do not use 12-leads for underlying rhythm interpretation



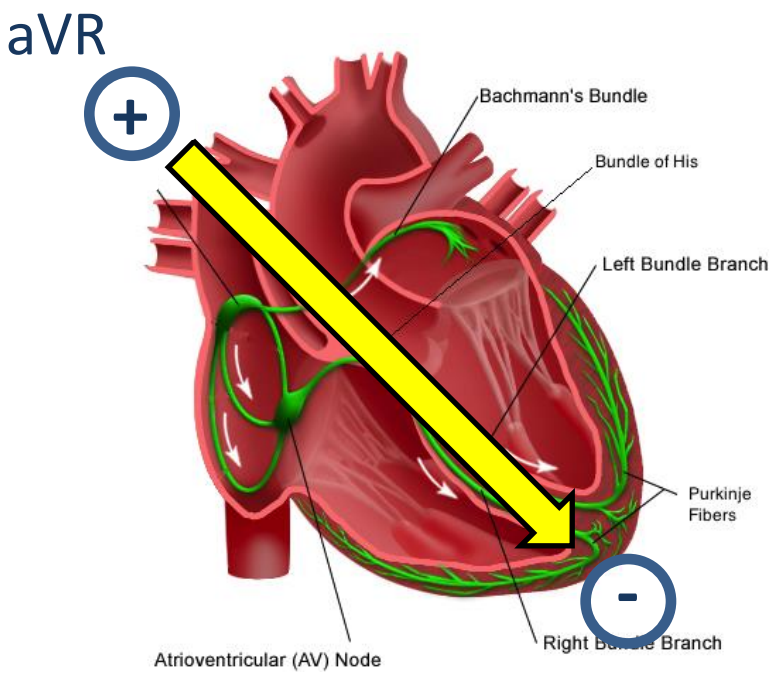
12-lead Interpretation Steps

- Recall:
  - When electrons flow away from a positive electrode it shows as negative deflection on an ECG
  - aVR is an augmented lead in which the heart is considered the negative electrode and the right shoulder is the positive electrode
  - The normal electrical pathway of the heart is moving



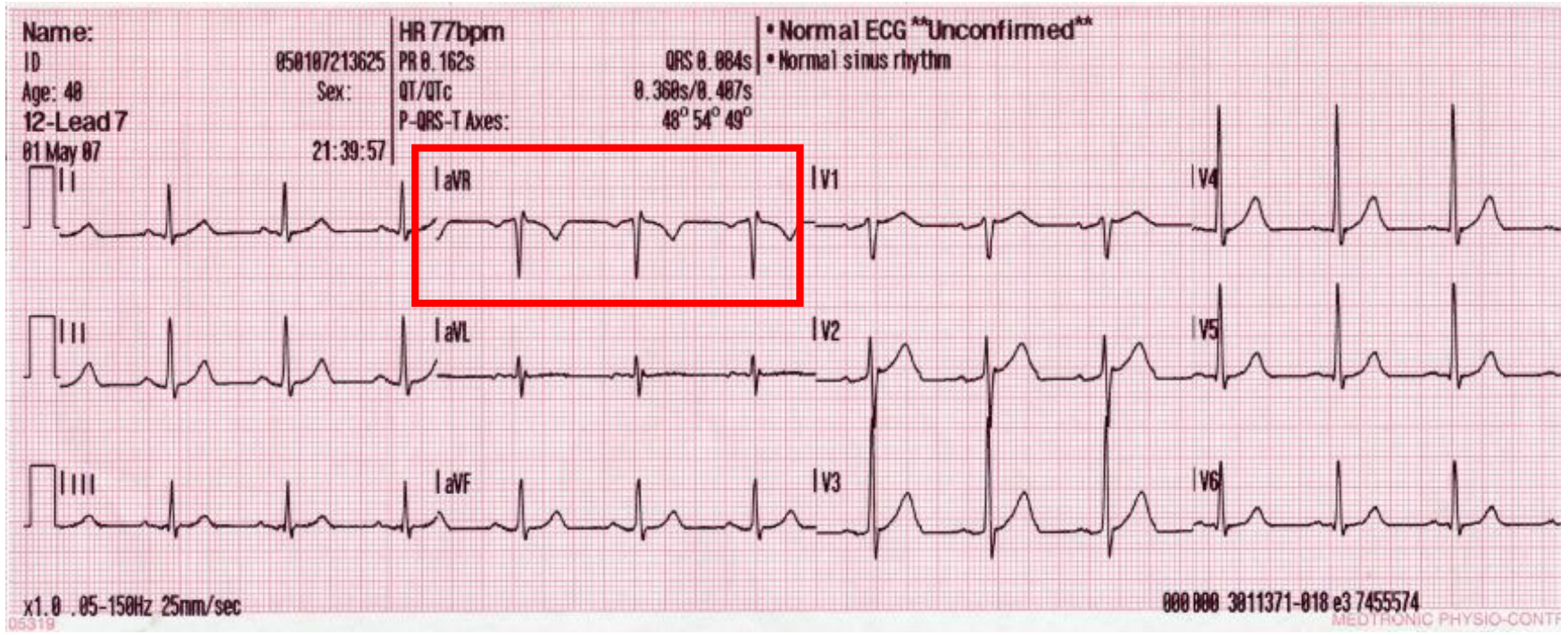
12-lead Interpretation Steps

- Recall:
  - The normal electrical conduction of the heart is moving from the patient's right shoulder toward the left foot
- As a result, the heart's normal electrical conduction should be moving in the complete opposite direction as the positive electrode of aVR
  - Therefore, aVR should be negatively deflected



12-lead Interpretation Steps

- The first lead to look at when interpreting a 12-lead is aVR
  - Confirm that aVR is predominantly negatively deflected



aVR

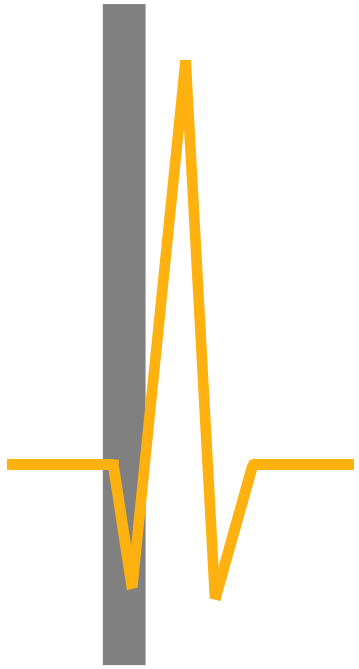
- What if aVR is positively deflected?
  - Check limb lead placement
    - Most common cause is reversed limb leads on patient
- More recently however, evidence has shown an increased use of aVR in:
  - STEMI recognition
  - PE diagnosis
  - TCA OD
  - Dextrocardia

12-lead Interpretation Steps

- After reviewing aVR start at Lead I and sequentially move through the remaining leads
  - When doing so, the primary goal is to assess for an acute STEMI or signs of an evolving MI
  - This includes:
    - Observation of the ST segment for any changes in height (elevation or depression)
    - Observation of the QRS complexes and T waves for evolutionary changes
  - Analyzing for other 12-lead findings will be discussed later

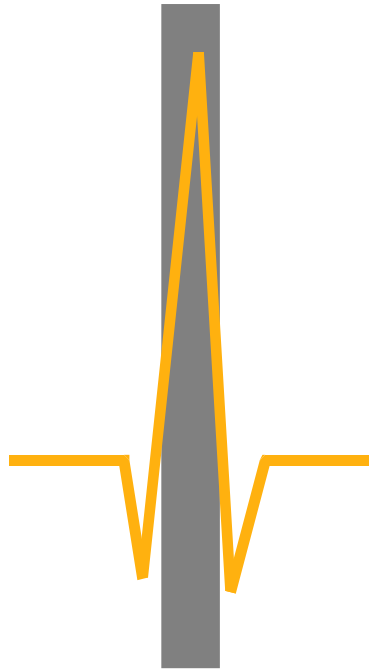
Q Wave

- Q Wave: A negative deflection preceding the R wave
  - If there is any negative deflection in front of the R wave, it is labeled the Q wave
  - The Q wave includes the negative down stroke and the return to baseline



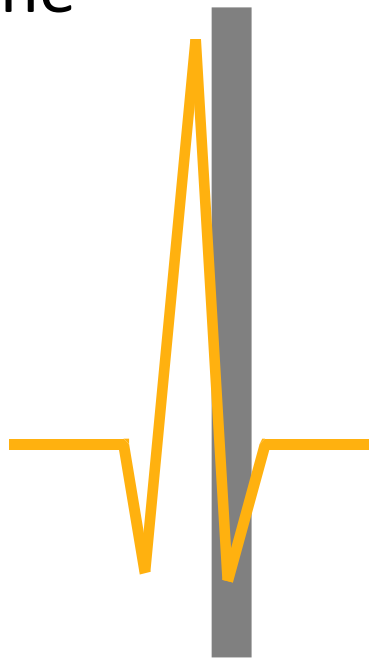
R Wave

- R wave: The first positive deflection
  - No matter where it occurs in the complex, the first positive deflection is called the R wave
  - The R wave includes not only the upstroke of the positive deflection, but the down stroke returning to the baseline as well



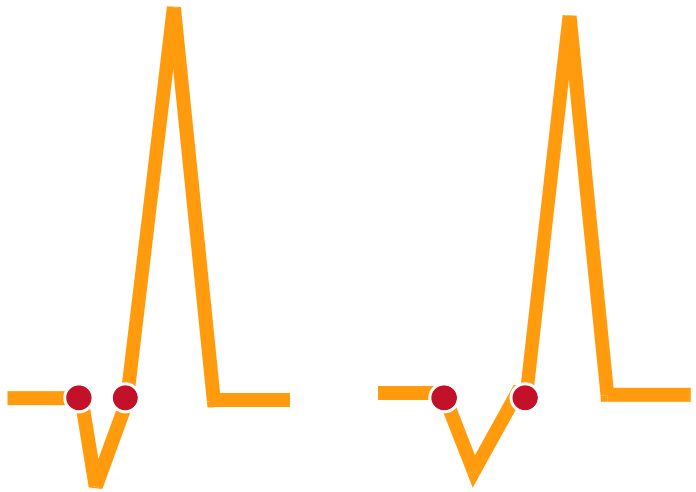
S Wave

- S wave: A negative deflection following the R wave
  - Like the Q wave and the R wave, the S wave includes both the departure from and return to the baseline



QRS

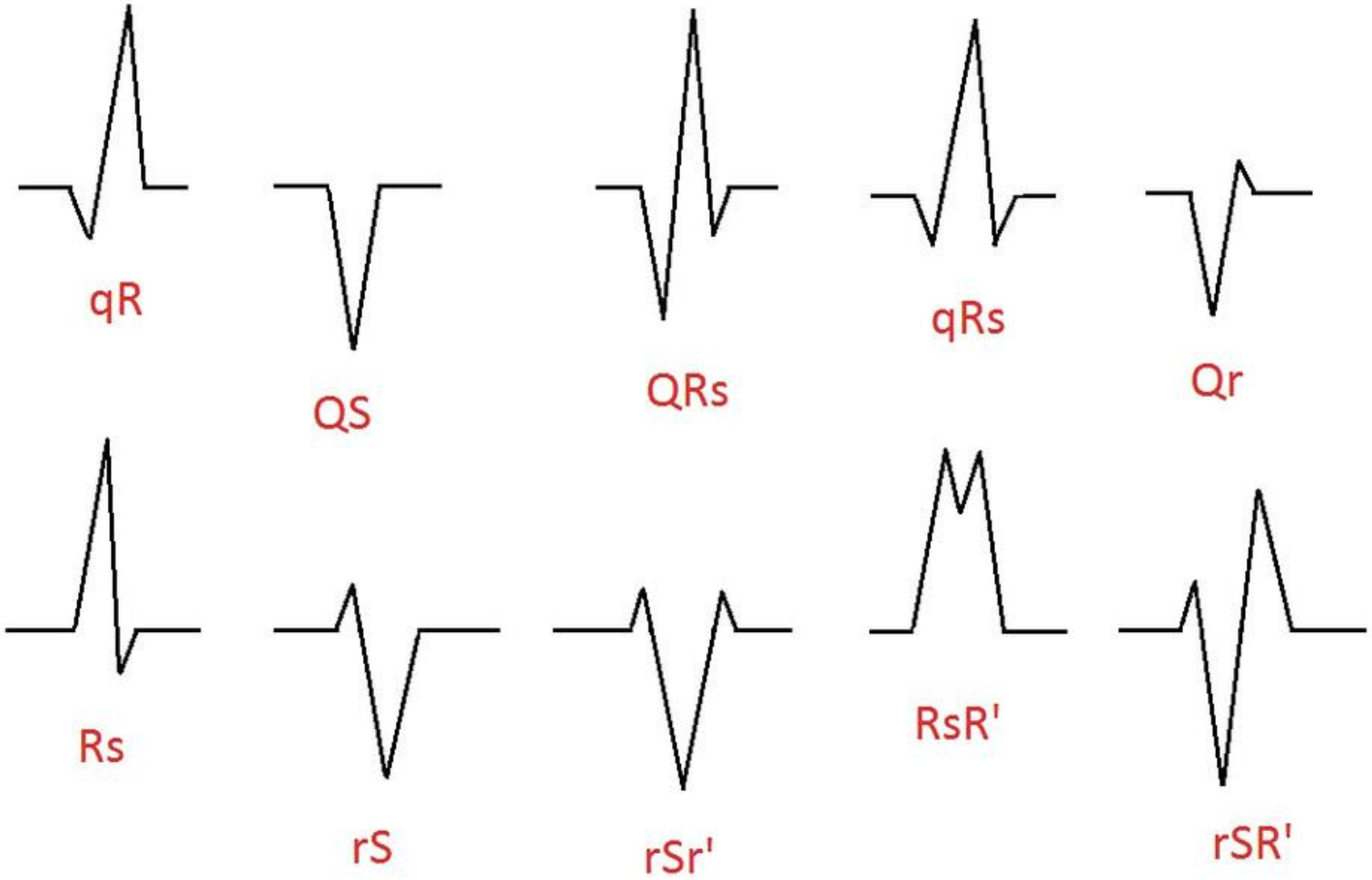
- Q wave
  - When a Q wave is noted in any lead, always measure its width
  - A physiologic Q wave is very narrow, usually less than 30 ms (0.03 seconds)
  - A Q wave is considered pathologic when it equals or exceeds 40 ms (0.04 seconds). (one small box on the ECG grid)



QRS

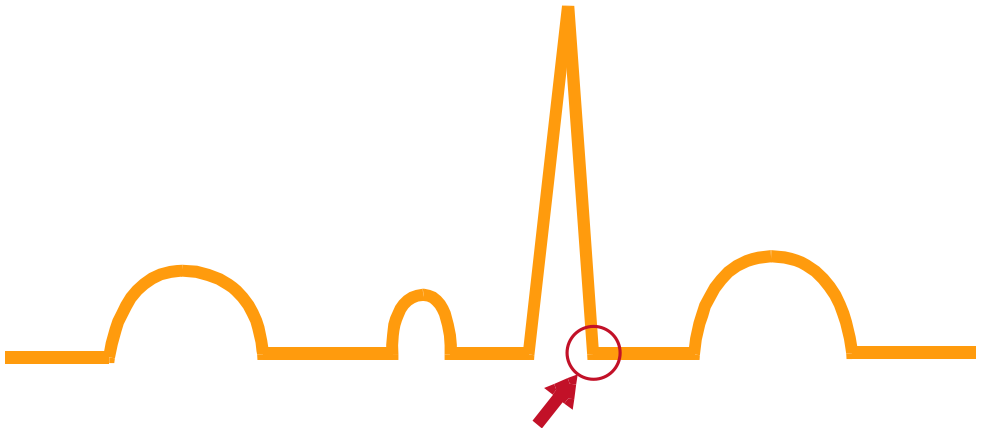
- Q waves
  - Physiologic Q waves
    - Q waves can occur normally in several leads (I, III, aVL, aVF, V5, V6)
    - Normal if < 0.04 sec (40ms)
  - Pathologic Q waves
    - If >0.04 sec (40 ms)
    - Pathology (including myocardial infarction) can place a Q wave in any lead
  - It is possible to examine the Q wave and, based upon its width, speculate whether it is pathologic or physiologic

Other QRS Morphologies



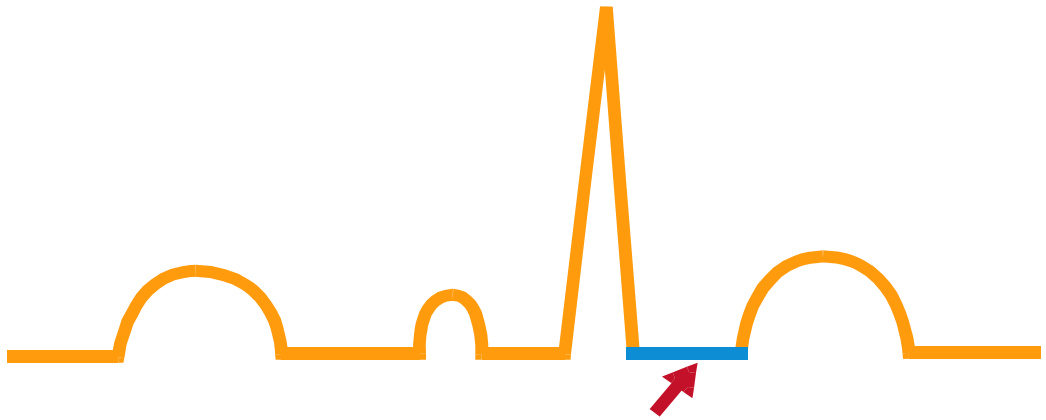
J-Point

- When assessing the ST for changes, it is important to recognize the starting point
  - This is referred to as the J-Point
    - Found at the junction between the end of the QRS and the beginning of the ST segment
    - Found by looking for the point where the QRS stops and makes a sudden sharp change of direction



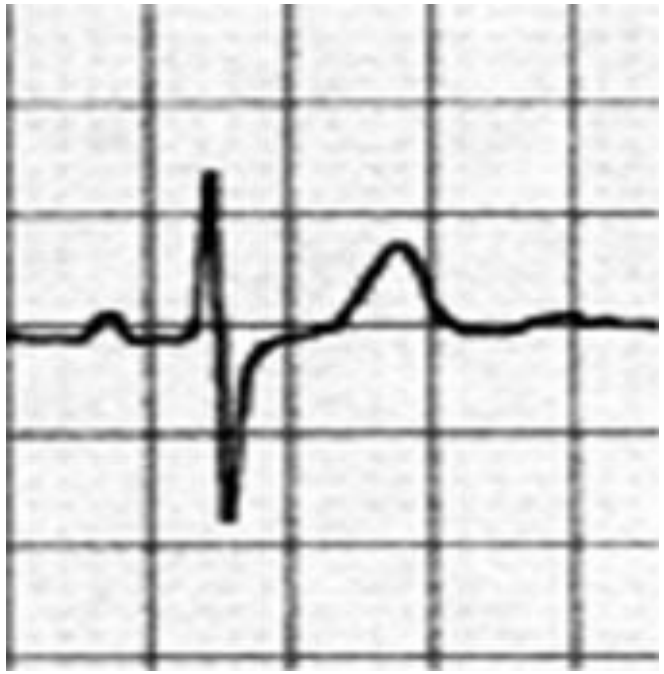
ST Segment

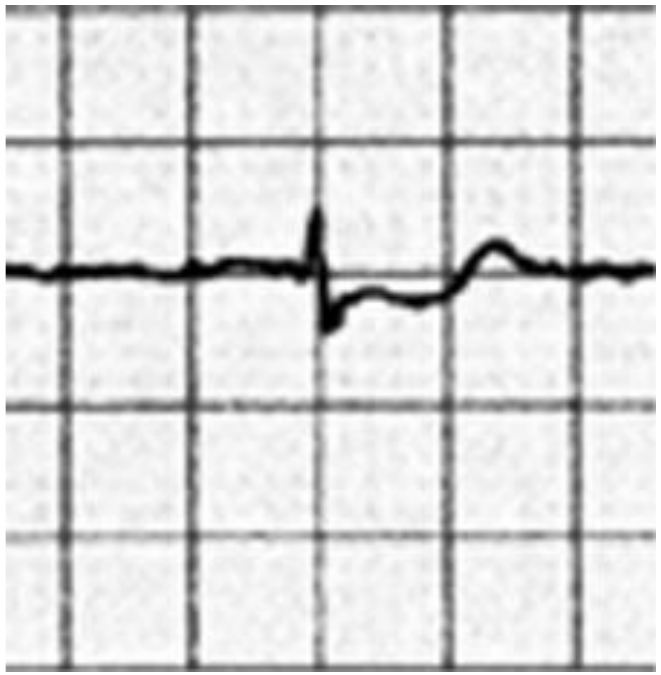
- The ST segment represents the portion of the ECG tracing between the J-point and the beginning of the T wave
  - The ST segment is one of the most important elements to identify on the ECG when looking for evidence of AMI



Practice

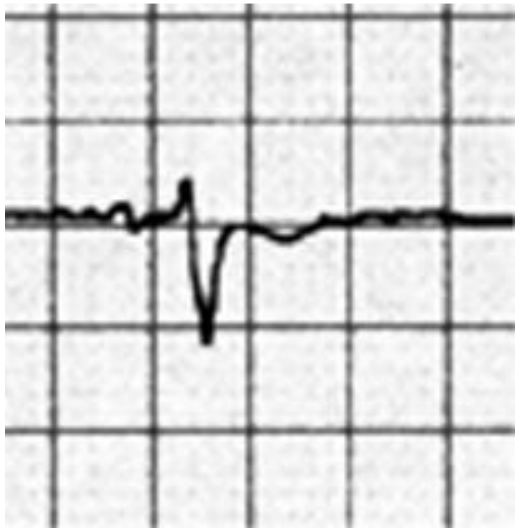
- Find J-points and ST segments

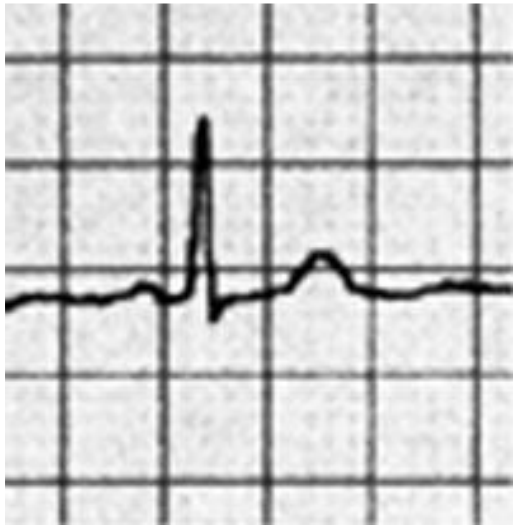


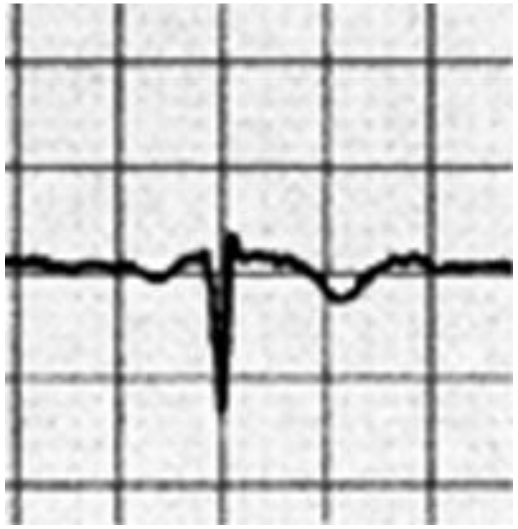


Practice

- Find J-points and ST segments

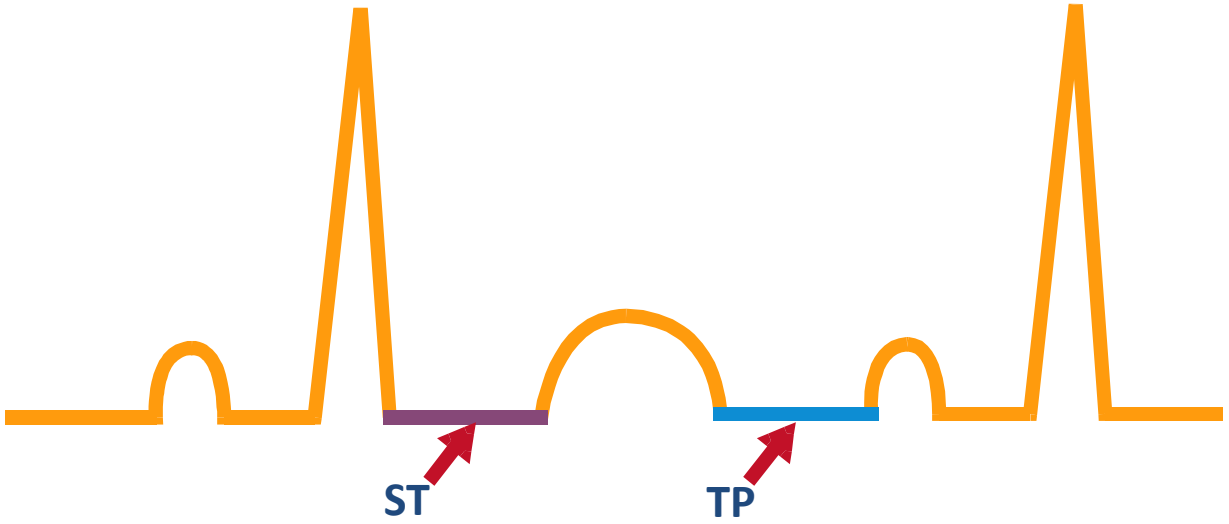






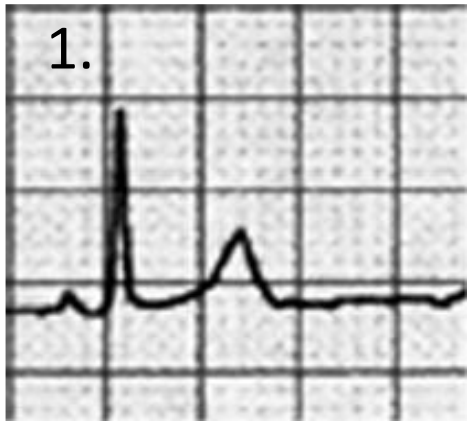
ST Segment

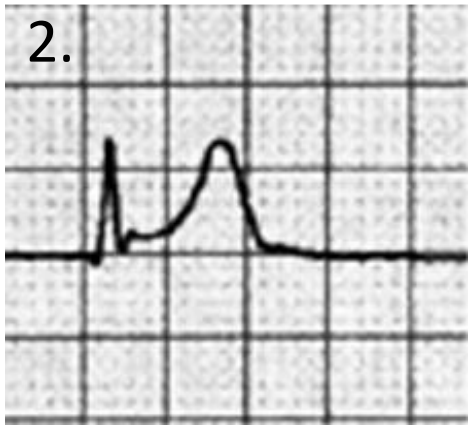
- When determining if ST segment is elevated, depressed, or normal it needs to be compared to the isoelectric line (baseline)
- The best way to do this is to compare the ST segment to the preceding TP segment

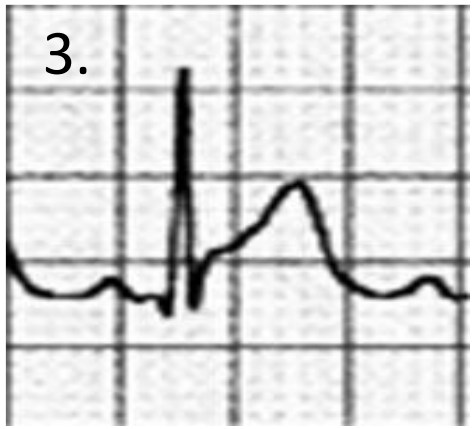


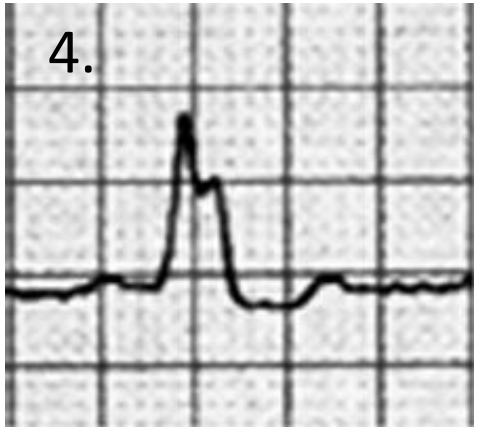
ST Segment Analysis

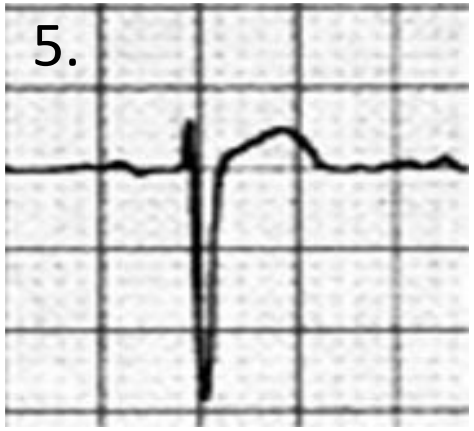
- Is there ST segment elevation?

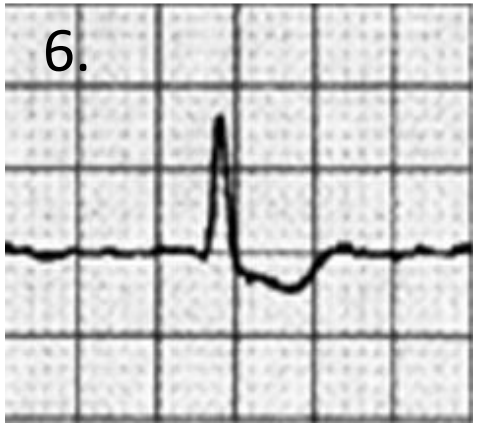










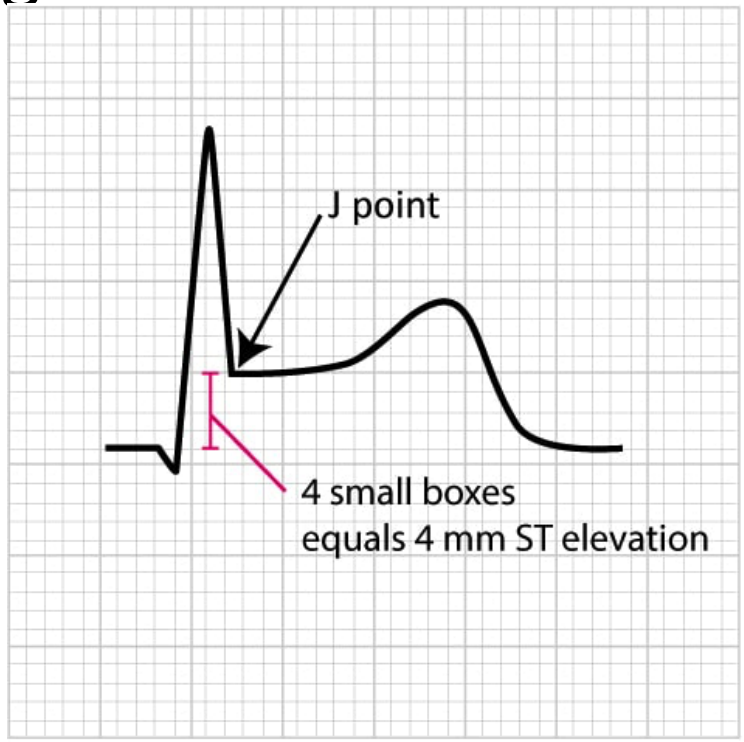


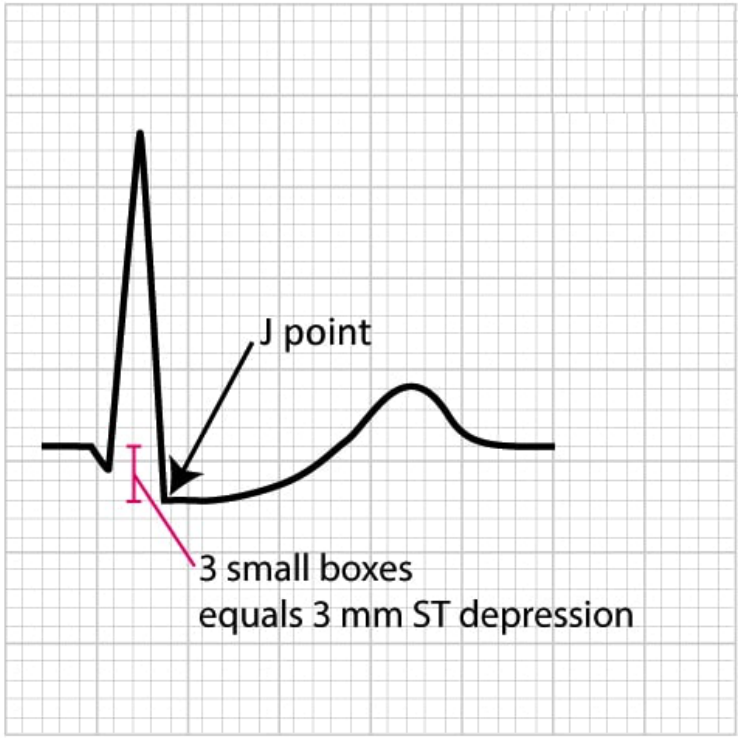
ST Segment Changes

- So what does it mean if there are ST changes?
- The most common cause of ST changes, elevation or depression, is myocardial ischemia
- If you note elevation in the ST segment, it is also important to measure the total elevation
  - How do we measure ST elevation?

ST Segment Changes

- Remember to use the height of the ECG paper boxes to your advantage





1 small box = 1mm
1 large box = 5mm

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12 Lead Interpretation

STEMI RECOGNITION

The 12-Lead ECG in Ischemia and Infarction

- In the prehospital environment
  - Keep it simple.
  - Look for evidence of a STEMI.
  - Focus on three parts:
    - ST segment
    - Q wave
    - T wave

The 12-Lead ECG in Ischemia and Infarction

- ECG provides a graphic record of the sequence of events leading to an AMI.

Table 30-17 Evolution of an AMI on the ECG

Stage	ECG Changes in Overlying Leads*	Timing
Ischemia	T-wave inversion ST-segment depression	With the onset of ischemia
Injury	Peaked T waves ST-segment elevation	Minutes to hours
Infarction	Q waves appear	Within several hours to several days

Abbreviations: AMI, acute myocardial infarction; ECG, electrocardiogram
*Reciprocal changes will be seen in opposite leads.

STEMI Recognition

- Using ST segment elevation values, one can determine the presence of an ST segment Elevation Myocardial Infarction (STEMI)
- A 12-lead can be used, in addition to a thorough patient assessment, to be able to determine the presence of a STEMI in the prehospital setting and initiate treatment early

STEMI Recognition

- A patient is considered to being having a STEMI if their symptoms have been existent for more than 20 minutes (but less than 12 hours) and they have one of the following ECG changes:
  - One (1) or more millimeter of ST elevation in two anatomically contiguous limb leads
- or
  - Two (2) or more millimeters of ST elevation in two anatomically contiguous precordial leads

STEMI Recognition

- Anatomically contiguous leads refers to two or more leads that ‘view’ the same portion of the heart
  - Ex. Two leads that both look at the inferior wall are considered anatomically contiguous (Lead II & Lead III)
  - Ex. Two leads that are anatomically next to each other (but don’t look at the same portion of the heart) are considered anatomically contiguous (V2-Septal & V3-Anterior)

STEMI Recognition

- It is important to also understand the various ‘views’ of the heart that are obtained with a 12-lead ECG as it will:
  - Allow for better understanding of anatomically contiguous leads
  - Allows for determination of the area of myocardium affected
  - Help deduce which coronary artery/branch is occluded
    - Can further decrease time to definitive care

Lead "Views"

- The various views found on a typical 12-lead are:
  - Inferior wall
  - Septal wall
  - Anterior wall
  - Lateral wall

- It is possible to view other areas of the heart (i.e. posterior wall, right side)
  - Doing so requires addition of electrodes in different areas
    - Basis for 15 & 18-lead ECGs

12-Lead Groups

- The normal layout of lead groups are positioned as follows on a 12-lead:

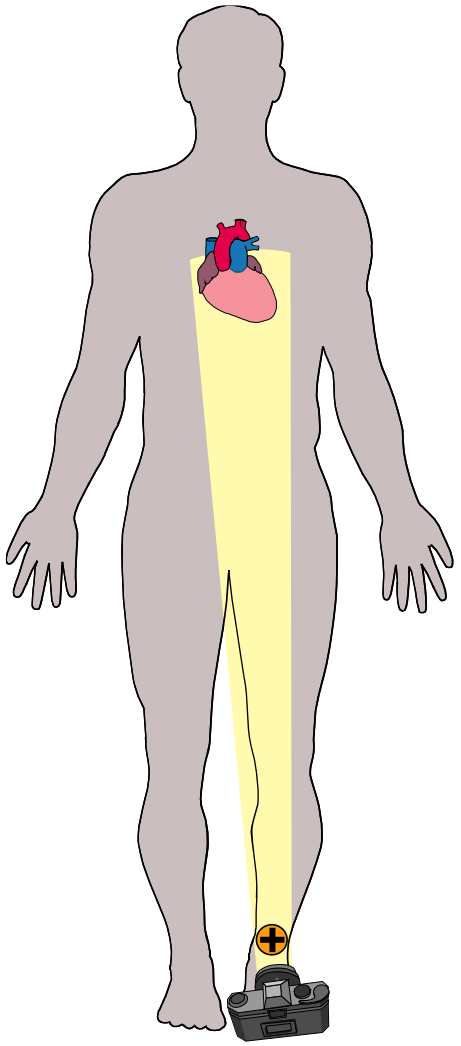
I	aVR	V1	V4
II	aVL	V2	V5
III	aVF	V3	V6

Limb Leads **Chest Leads**

= Inferior Wall
= Septal Wall
= Anterior Wall
= Lateral Wall

Inferior Wall

- II, III, aVF
  - Positive electrodes near left leg
  - Looking up from the left leg produces an image of the inferior wall of the heart

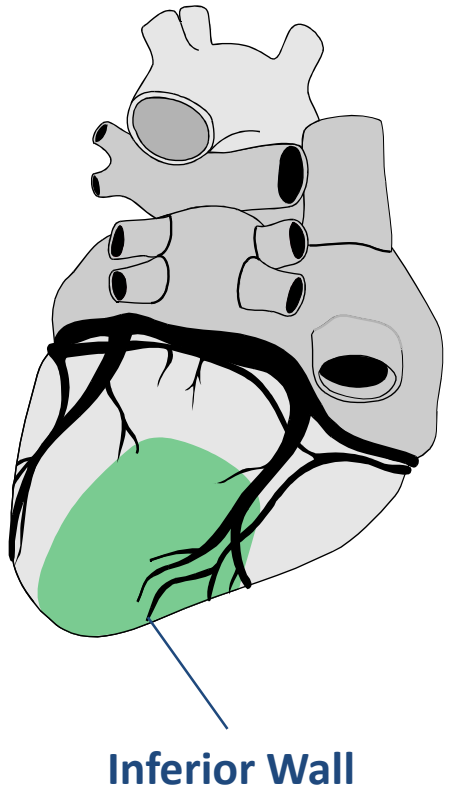


I	aVR	V1	V4
II	aVL	V2	V5
III	aVF	V3	V6

Inferior Wall

- The inferior wall of the heart is the portion that rests on the diaphragm
- Represents a large portion of the LV

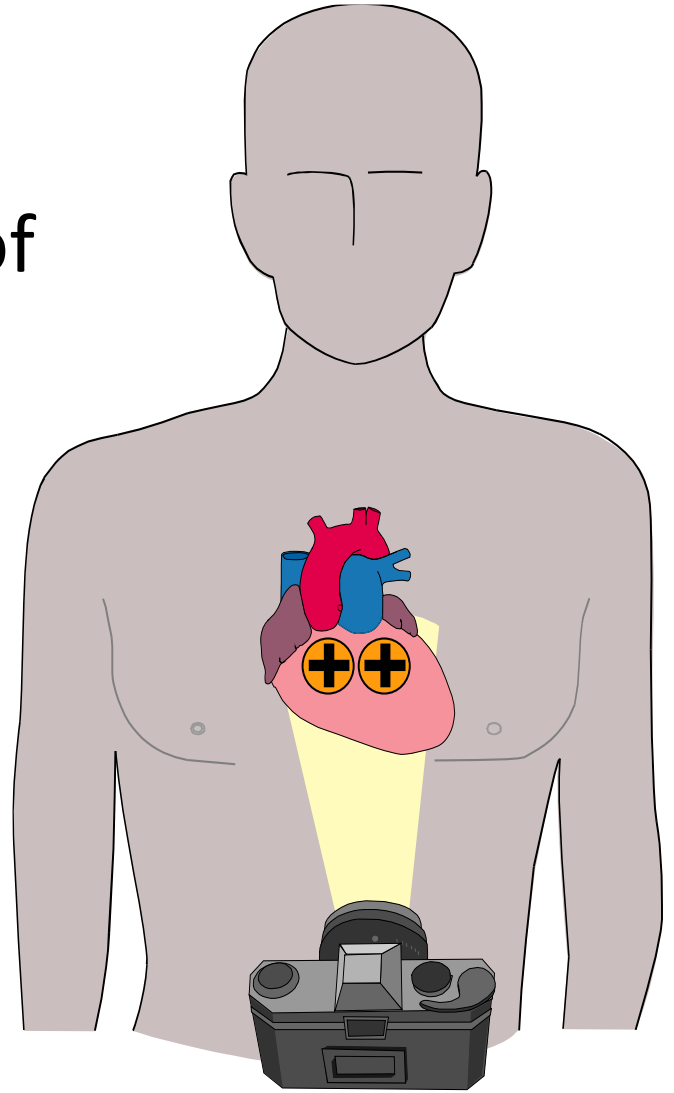
I	aVR	V1	V4
II	aVL	V2	V5
III	aVF	V3	V6



Septal Wall

- V1, V2
- Positive electrodes are located on either side of the body of the sternum
- Look directly at the septum of the heart

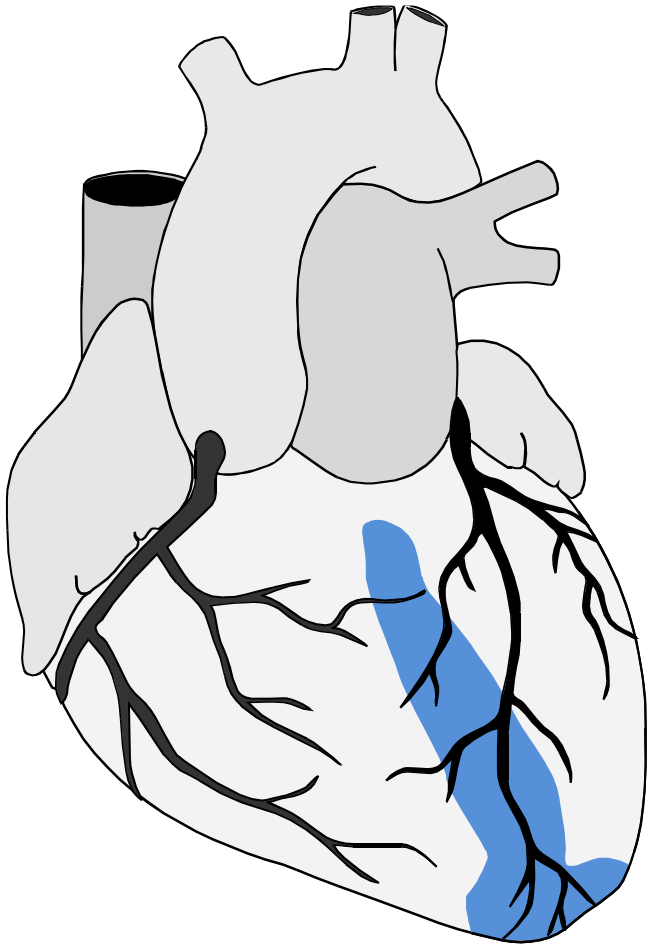
I	**aVR**	**V1**	**V4**
II	**aVL**	**V2**	**V5**
III	**aVF**	**V3**	**V6**



Septal Wall

- V1, V2 “look” through the RV to the septum
- Since the normal electrical conduction runs primarily through the septum, V1, V2 observe normal conduction at a 90◦ angle
  - As a result, normally R waves are smallest here

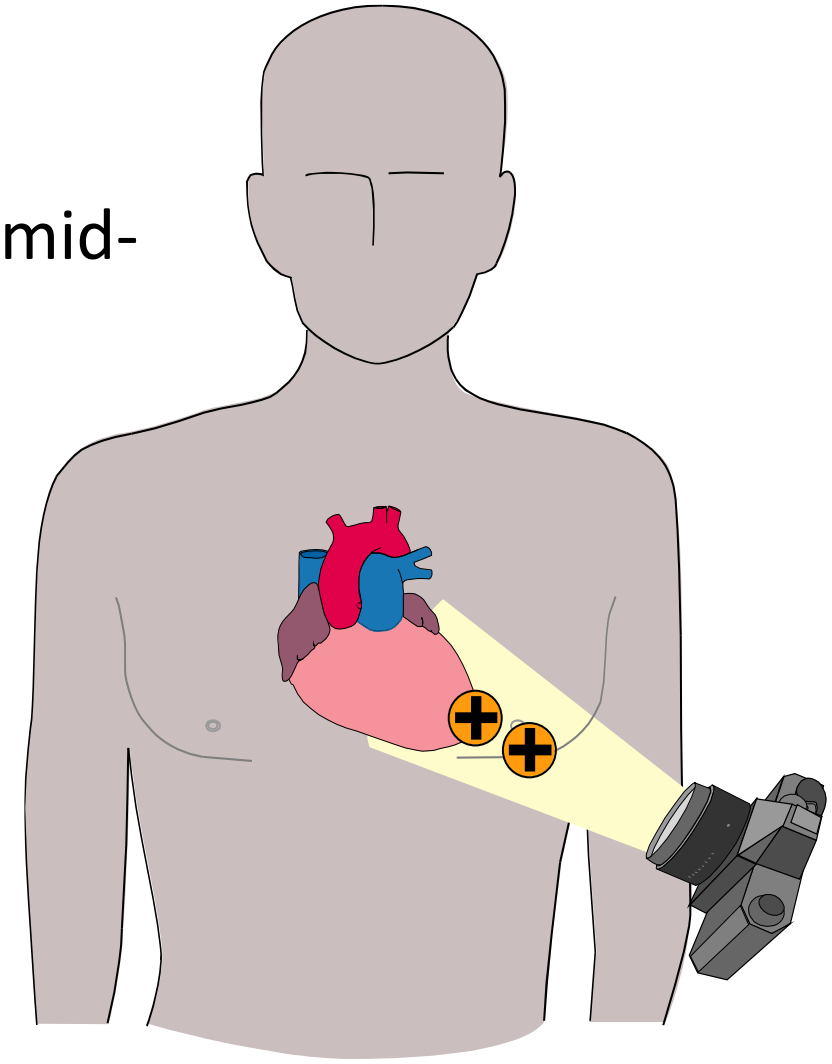
I	**aVR**	**V1**	**V4**
II	**aVL**	**V2**	**V5**
III	**aVF**	**V3**	**V6**



Anterior Wall

- V3, V4
  - Positive electrodes are located approximately mid-clavicular
  - View the anterior wall

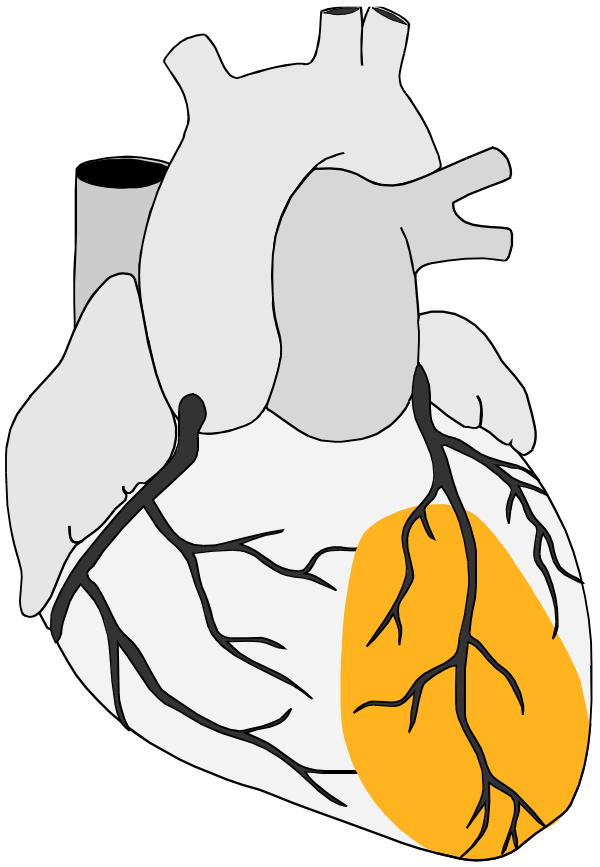
I	**aVR**	**V1**	**V4**
II	**aVL**	**V2**	**V5**
III	**aVF**	**V3**	**V6**



Anterior Wall

- V3, V4 observe the anterior wall which is the region between the septum and interior wall
  - Primarily composed of LV

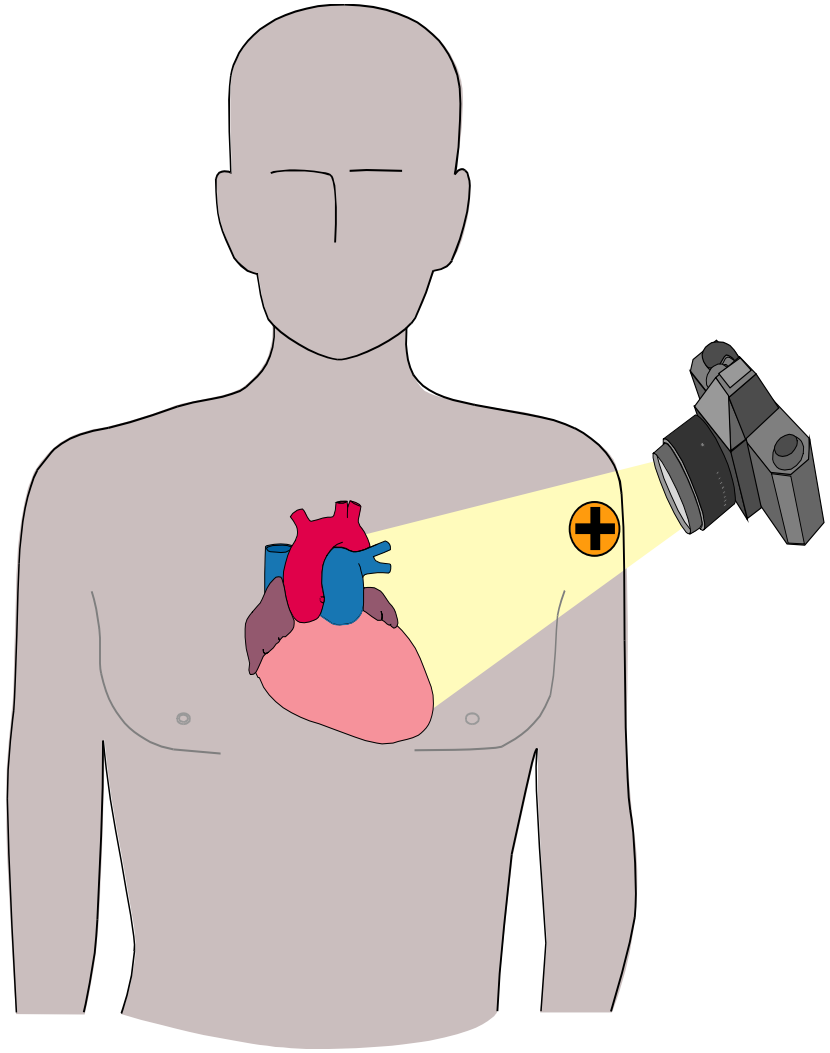
I	**aVR**	**V1**	**V4**
II	**aVL**	**V2**	**V5**
III	**aVF**	**V3**	**V6**



Lateral Wall

- I and aVL
  - Positive electrode for both are located on the left arm
    - Remember these are limb leads
      - Therefore, only need 1mm of STE
  - Considered “high-lateral” leads

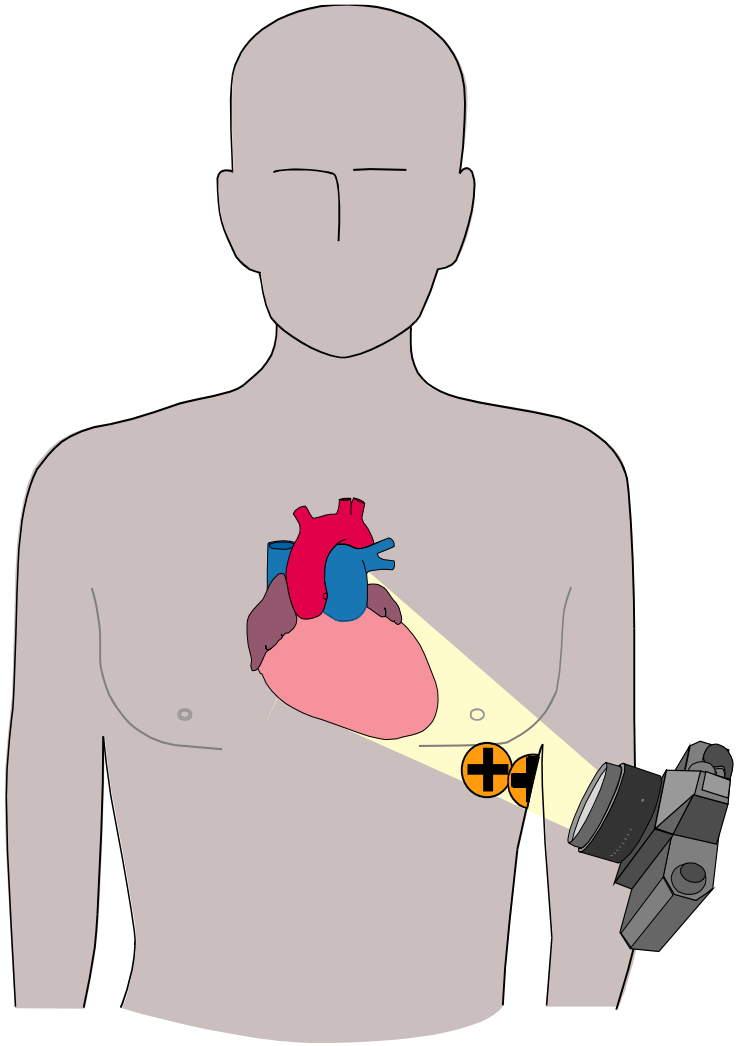
I	**aVR**	**V1**	**V4**
II	**aVL**	**V2**	**V5**
III	**aVF**	**V3**	**V6**



Lateral Wall

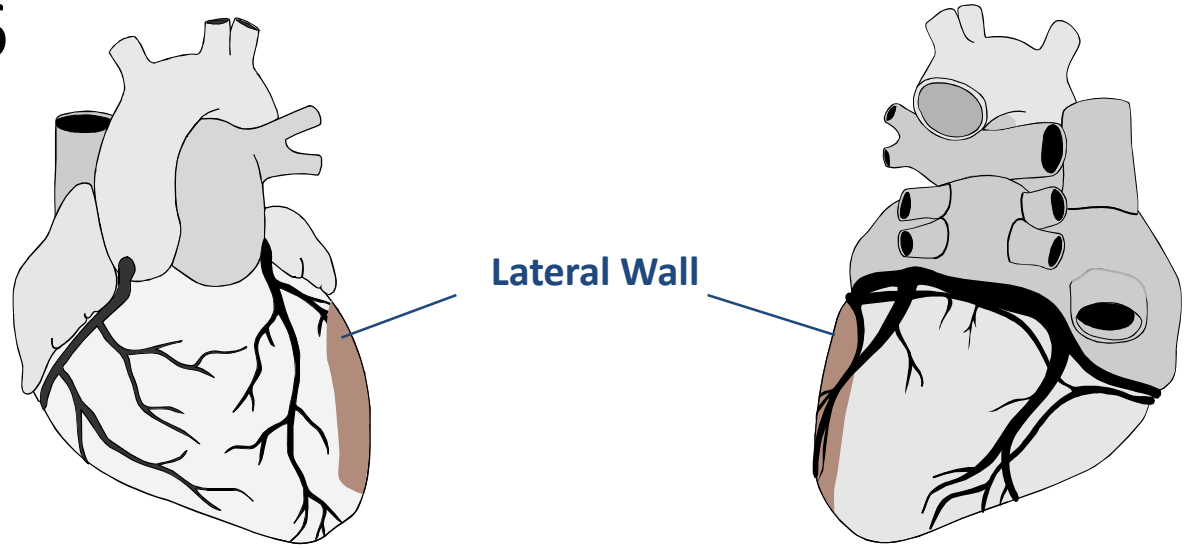
- V5, V6
  - Positive electrodes are located in axillary region
    - Still view the lateral wall, but from a lower angle
    - Considered the ”low lateral” leads

I	**aVR**	**V1**	**V4**
II	**aVL**	**V2**	**V5**
III	**aVF**	**V3**	**V6**



Lateral Wall

- I, aVL, V5, V6



I	**aVR**	**V1**	**V4**
II	**aVL**	**V2**	**V5**
III	**aVF**	**V3**	**V6**

STEMI Recognition

I (Lateral)	**aVR**	**V1** (Septal)	**V4** (Anterior)
II (Inferior)	**aVL** (Lateral)	**V2** (Septal)	**V5** (Lateral)
III (Inferior)	**aVF** (Inferior)	**V3** (Anterior)	**V6** (Lateral)

Memory Aid

- Various mnemonics or tools can be used to recall which regions of a 12-lead represent which areas of the heart
  - SALIP
  - I See All Leads

SALI P

S	A	L	I	P*
V1	V3	V5	II	↓ V1
V2	V4	V6	III	↓ V2
		I	aVF	↓ V3
		aVL		↓ V4

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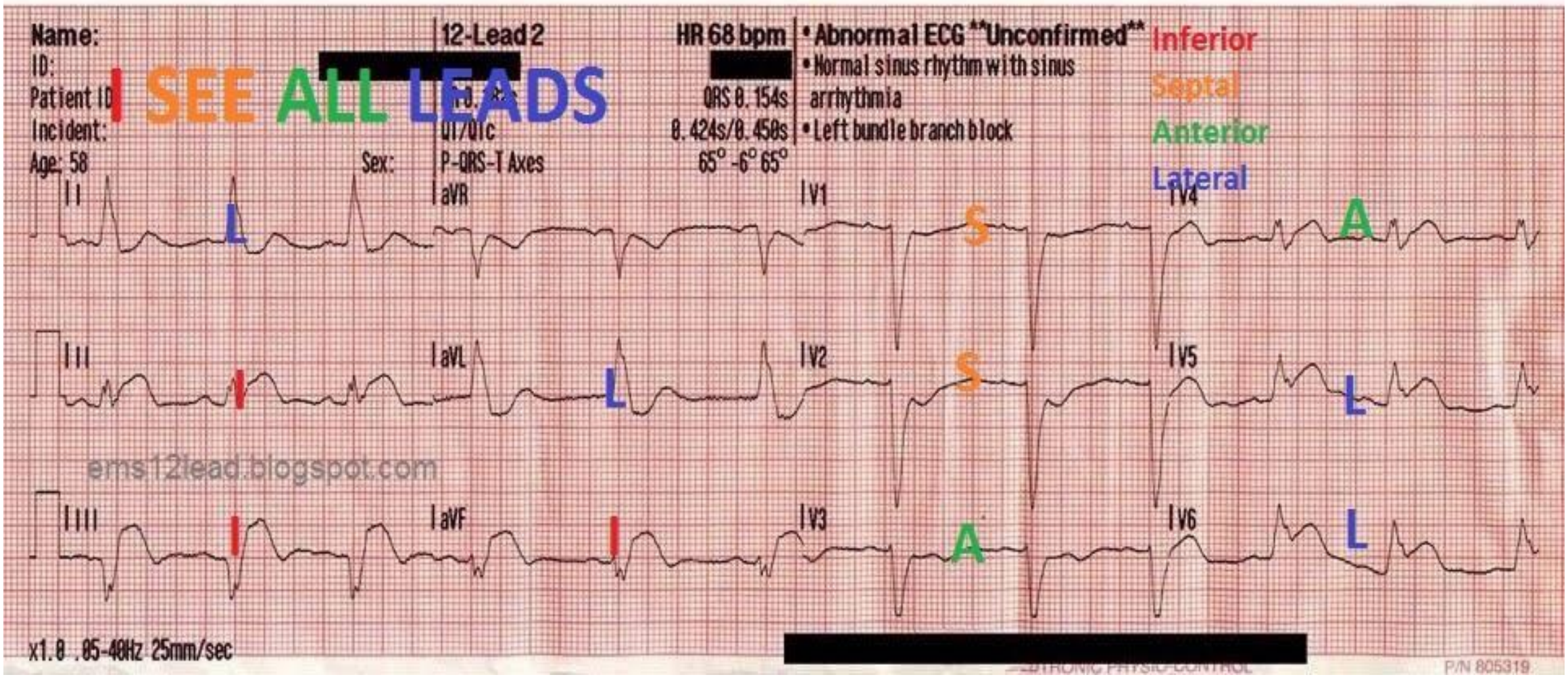
I See All Leads



STEMI Recognition

- Anatomically contiguous leads are leads that:
  - View the same portion of the heart
    - Ex. V1/V2 (septal) or V5/aVL (anterior)
  - Are anatomically adjacent
    - Ex. V2/V3 (antero-septal) or V4/V5 (antero-lateral)

STEMI Recognition

- Although a normal 12-lead ECG, when applied correctly, views a great deal of heart tissue, some tissue is missed
  - A 12-lead ECG does not view a large portion of the posterior aspect of the heart
  - Isolated posterior STEMIs are rare (3-11%) so chances are if there is posterior involvement you will see STE in other leads
    - Typically associated with inferior or lateral STEMIs
  - For the isolated posterior STEMIs there are ECG changes we can note on a 12-lead that indicate posterior

STEMI Recognition

- For an isolated posterior STEMI there are ECG changes we can note on a 12-lead that may indicate the posterior infarct
  - i.e. Reciprocal changes (more to follow)
- Utilization of a 15-lead ECG can allow for posterior view
  - Can be done with standard 12-lead technology

Evolution of a STEMI

- It may be possible that you arrive to a patient and acquire a 12-lead ECG during an evolving STEMI
  - The ischemia is occurring but has not yet resulted in STE
- There are changes that can be noted on a 12-lead ECG that suggest the presence of an evolving STEMI

Evolution of STEMI

- Hyperacute T waves
  - earliest ECG change suggestive of AMI would be the T wave becoming tall and peaked
  - Observed only in leads “looking” at the infarcting area
    - Differentiate from peaked T waves in hyperkalemia

Evolution of STEMI

- True hyperacute T waves are identified not only by their height, but by their shape as well
  - How tall is considered tall?
- As a rule of thumb T wave height can normally be up to 5 millimeters in the limb leads and 15 millimeters in the chest leads

Evolution of STEMI

- Acute
  - ST segment elevation is the next probable ECG change
  - ST segment elevation implies at least three things:
    - 1. Myocardial tissue injury is presently occurring
    - 2. This injury is probably due to an occluded coronary artery
    - 3. Unless corrected, this condition will lead to tissue necrosis
  - Therefore, even though necrosis has not yet occurred, we say that ST segment elevation is “presumptive evidence” of an AMI
  - When the ST segment is elevated we assume that the infarct is acute rather than old.

Evolution of STEMI

- We therefore assume that the infarct is acute (occurring right now).
- We will then note the presence of a Q wave that is at least 40ms (pathologic Q wave)
  - Associated with cellular necrosis

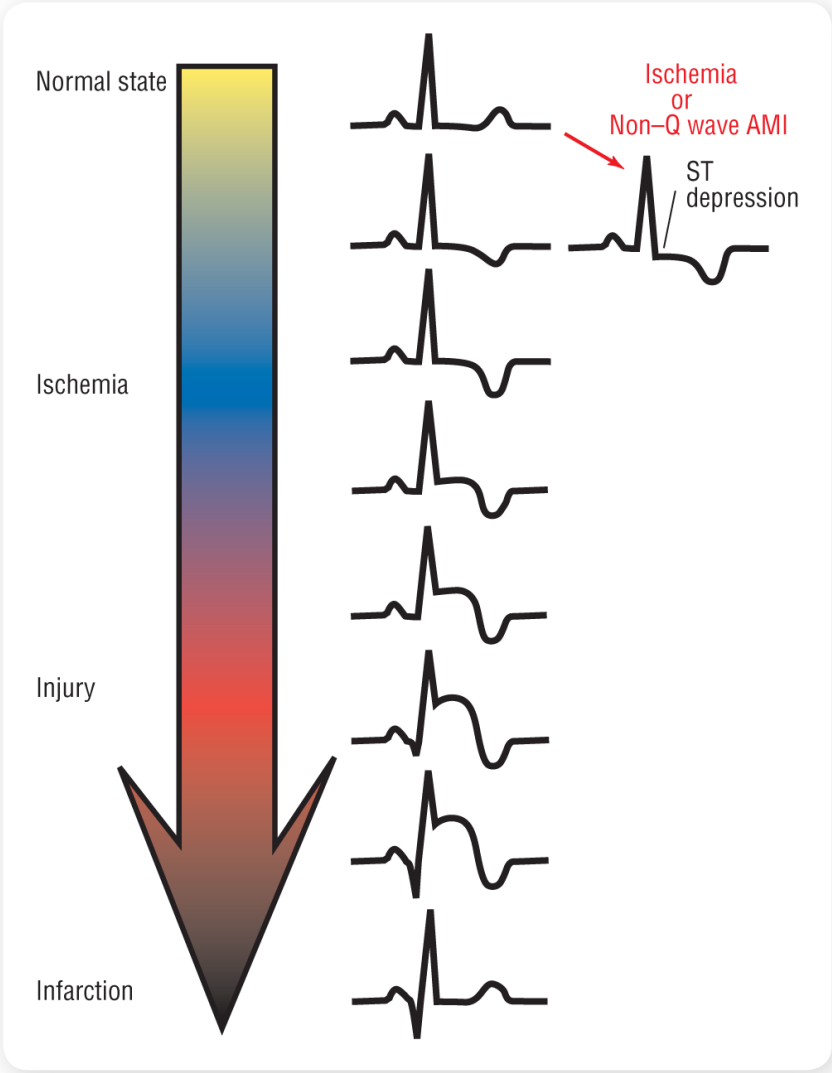
Evolution of STEMI

- If looking at the interpretation of the 12-lead by the device, you may note the term “Age Undetermined”
- This is the device interpreting the ECG changes as a result of a previous (old) MI

Evolution of STEMI

- A pathological Q wave (>40ms) in the absence of STE is associated with damage from a previous MI
  - It is not possible to determine when this infarct may have occurred, so it is described as “age undetermined” rather than “an old MI”

Evolutionary pattern of acute myocardial infarction



STEMI Recognition

- Keep in mind that although we can detect the presence of an evolving STEMI or an Acute STEMI, a normal 12-lead ECG DOES NOT rule out AMI

- Not all infarcts result in ST changes and can only be determined through blood work
  - i.e. NSTEMI

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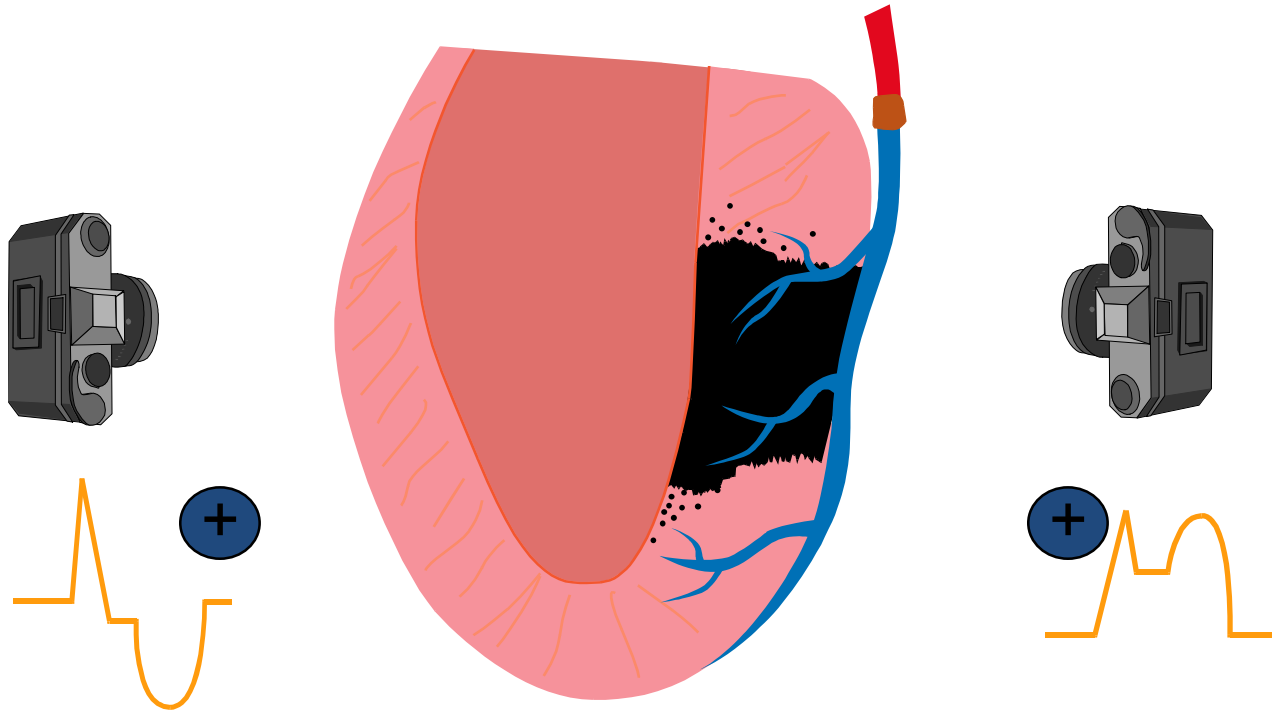
12 Lead Interpretation

RECIPROCAL CHANGES

Reciprocal Changes

- Up until now we have discussed looking for STE amongst the various leads on a 12-lead ECG to determine the presence of a STEMI
- However, if a lead that is viewing the infarct from one angle produces positive deflection and corresponding STE, what would we expect to see in a lead viewing the heart from the opposite angle?

Reciprocal Changes



Reciprocal Changes

- This is the premise behind reciprocal changes
  - We expect to see corresponding ST depression in the opposite leads that show STE
  - By understanding which pairs of leads are opposite (reciprocal), we can exam a 12-lead for ST depression in those areas
    - The presence of reciprocal changes adds validity to our conclusion of a STEMI
    - However, the absence of reciprocal changes does not mean a STEMI is not occurring

Reciprocal Changes

SITE	FACING	RECIPROCAL
Septal	V1, V2	NONE
Anterior	V3, V4	NONE
Anteroseptal	V1, V2, V3, V4	NONE
Lateral	I, aVL, V5, V6	II, III, aVF
Anterolateral	I, aVL, V3, V4	II, III, aVF
Inferior	II, III, aVF	I, aVL
Posterior	NONE	V1, V2, V3, V4

Reciprocal Changes

- Recall from earlier, we mentioned there may be ECG changes that indicated posterior infarction
  - If we observe ST depression in leads V1-V4 these may be the reciprocal changes of what would be STE in posterior leads (if we had applied electrodes to the back)
  - Confirmation can be obtained by capturing a 15-lead ECG

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12 Lead Interpretation

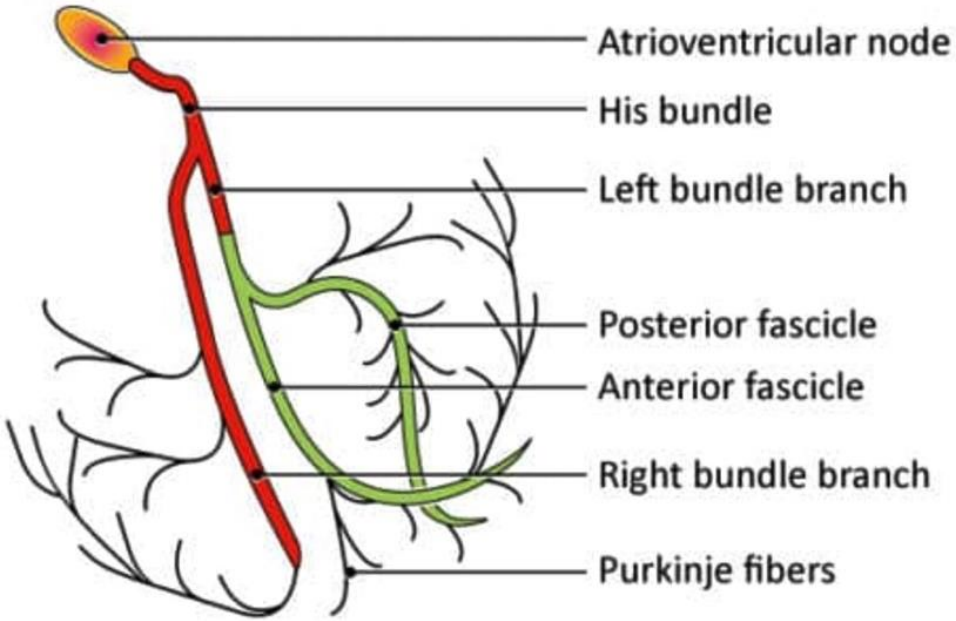
OTHER ECG FINDINGS

AMI Recognition

- Although STE is a strong indicator of an infarct, various other conditions can imitate infarct results or obscure STE such as:
  - BBB
  - LVH
  - Ventricular beats
  - Pericarditis
  - Early Repolarization
- However, a patient may also be experiencing an infarct in addition to one of the above imitators

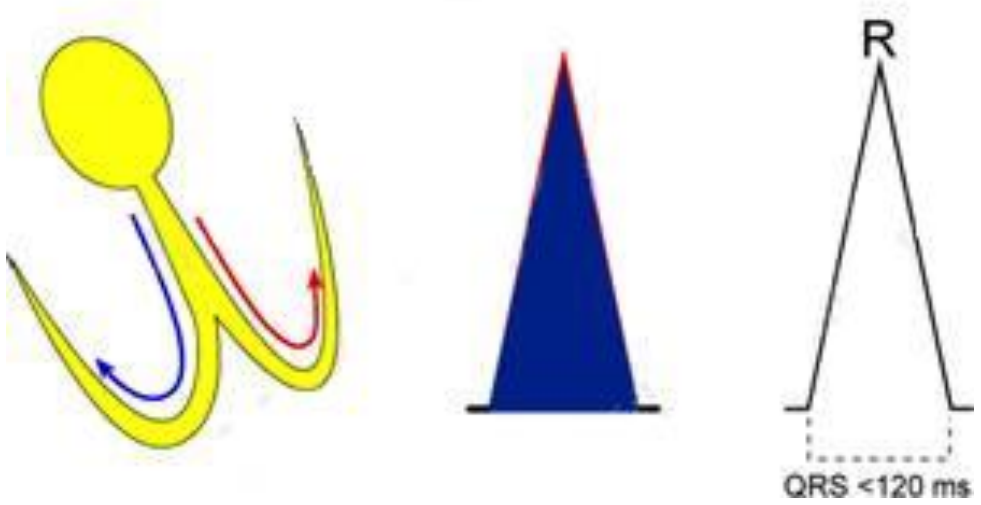
Bundle Branch Blocks

- A bundle branch block (BBB) is a conduction block in a portion of the bundle branches that connect the Bundle of His to the Purkinje fibers
- Recall from A&P:



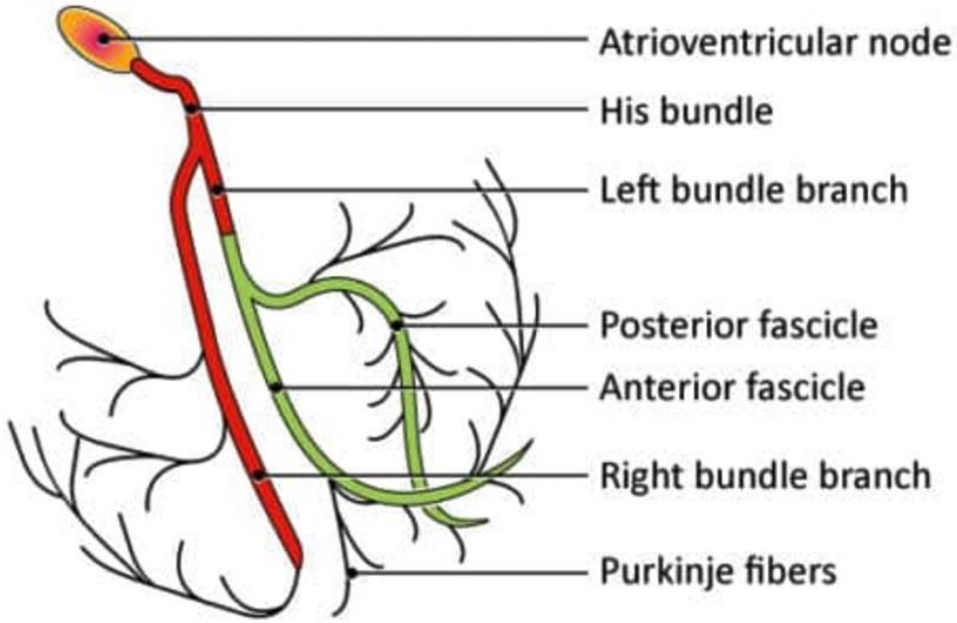
Bundle Branch Blocks

- Normally when the impulse leaves the Bundle of His, it travels down both bundle branches and depolarizes both ventricles simultaneously
- This results in two overlapping QRS complexes on an ECG which we only see as one



Bundle Branch Blocks

- A conduction block can occur in any portion of the bundle branches which would stop conduction to distal tissue
- As a result, that tissue must be stimulated by other means
- The spread of conduction through adjacent tissue (rather than the normal pathway) eventually stimulates the affected tissue

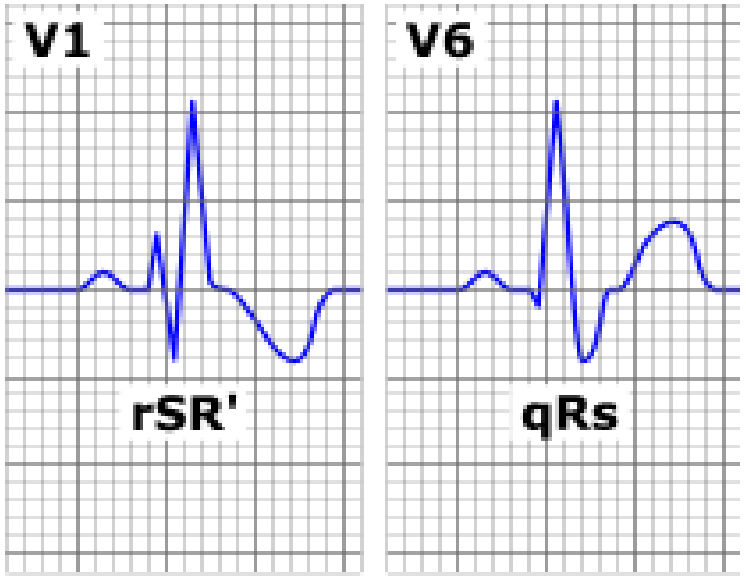


Bundle Branch Blocks

- Right bundle branch block (RBBB)
  - Right bundle only has 1 branch
  - When blocked it no longer conducts impulse to the RV
  - The RV is then only stimulated by the spread of impulse from the LV
  - This causes a slight delay in the depolarization of the RV (compared to the LV)
    - Produces the ECG changes associated with a RBBB

Bundle Branch Blocks

- Right bundle branch block (RBBB) criteria
  - RSR' in V1-2
  - Broad S in I or V6
  - Broad R in aVR
  - TWI in V1 or V2; sometimes ST depression
  - "Complete"
    - RBBB--QRS > 0.12 sec
  - "Incomplete" RBBB
    - aka "borderline"
    - QRS 0.09-0.12 sec

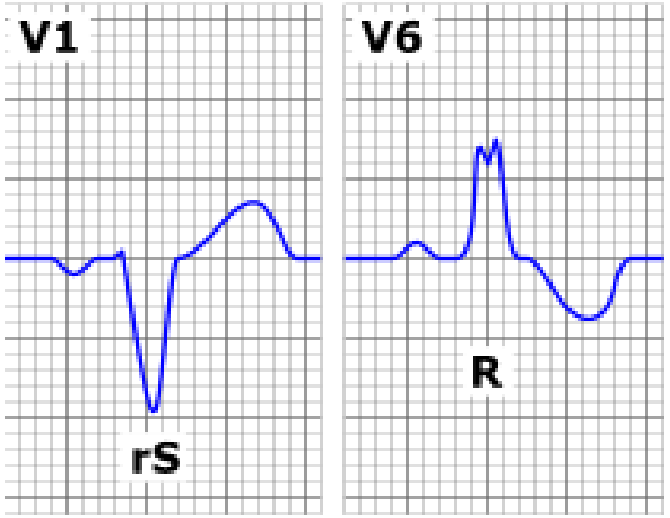


Bundle Branch Blocks

- Left bundle branch block (LBBB)
  - Left bundle has 2 branches (fascicles)
    - Anterior fascicle & Posterior fascicle
  - Blockage can occur in either fascicle or high enough in the left bundle to block both
  - When blocked it no longer conducts impulse to the LV
  - The LV is then only stimulated by the spread of impulse from the RV
  - This causes a slight delay in the depolarization of the LV (compared to the RV)
    - Produces the ECG changes associated with a LBBB

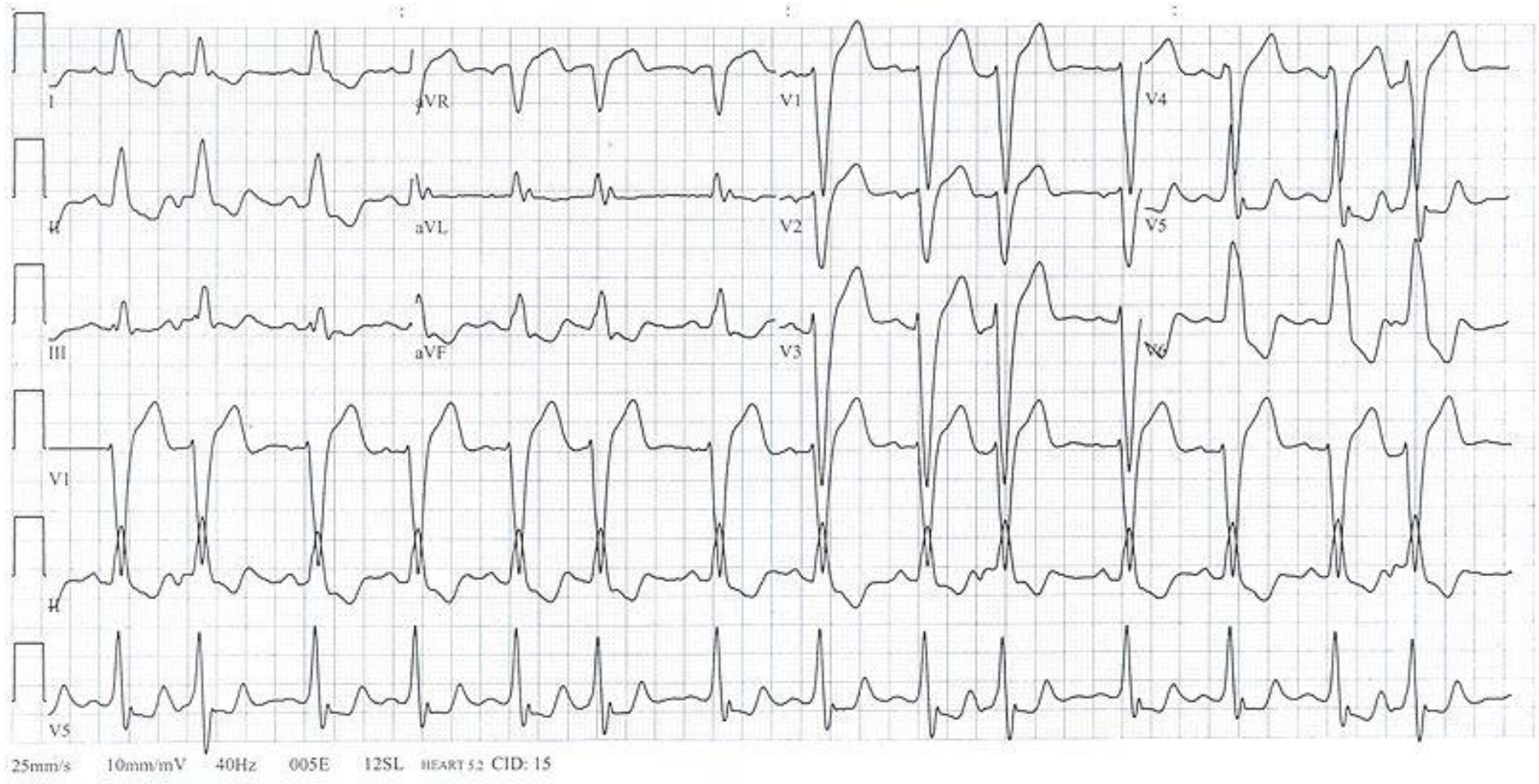
Bundle Branch Blocks

- Left bundle branch block (LBBB)
  - QRS duration > 0.12sec (us. widest in I and V6)
  - RSR' in V5 or V6; may just see flattened peak with small notch between R and R'
  - Deep S in V1-3
  - Upright QRS in I or V6 with no Q in either lead
  - QRS in V1 predominantly negative; may have small R wave
  - Small R in V1-3
  - LAD (often)
  - Absence of the small "septal" Q's in I, aVL, and V5-6
  - ST depression & TWI's in many leads
  - May be intermittent, e.g. rate-related



Bundle Branch Blocks

- Is this a BBB? If so, what type?



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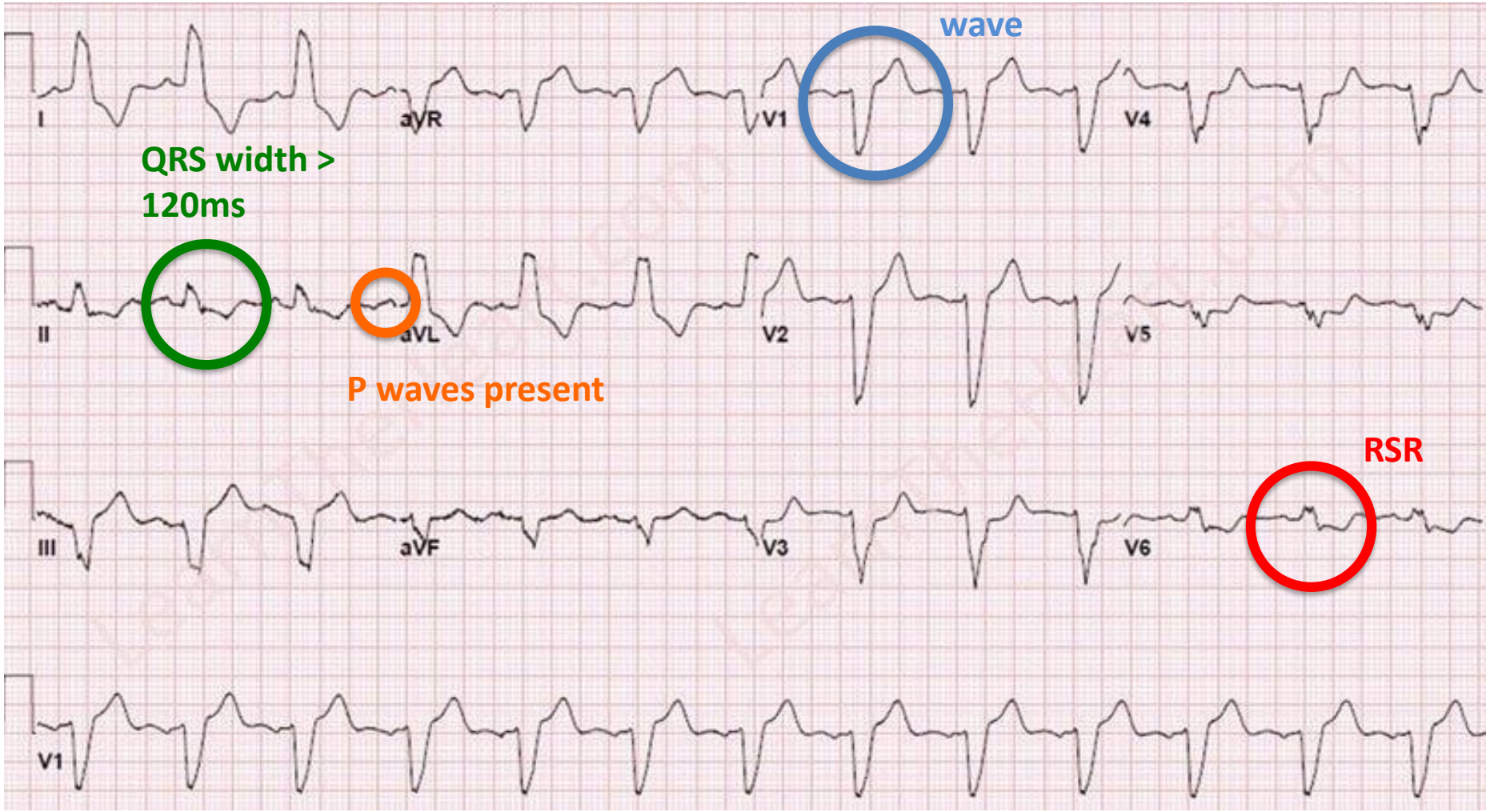
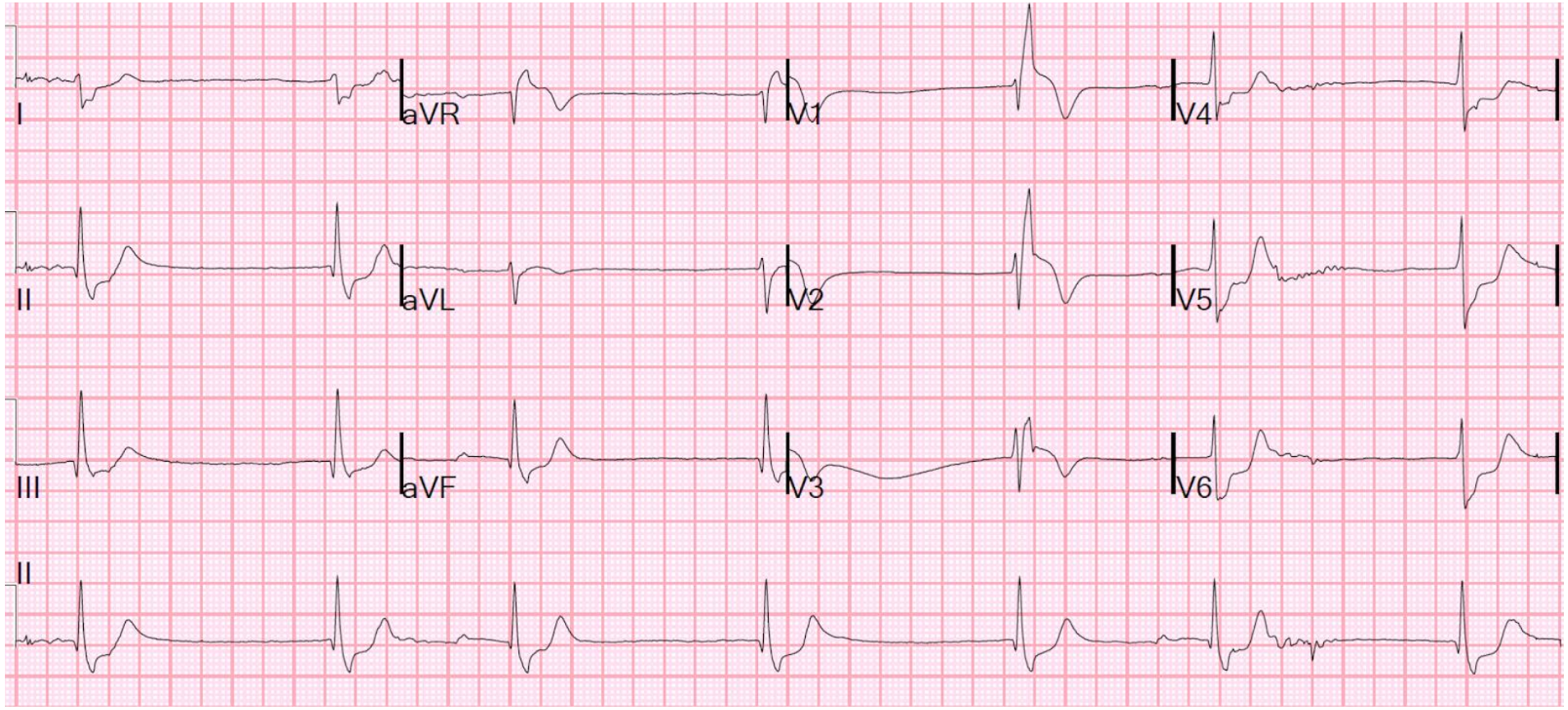
Bundle Branch Blocks



Bundle Branch Blocks



Memory Aid

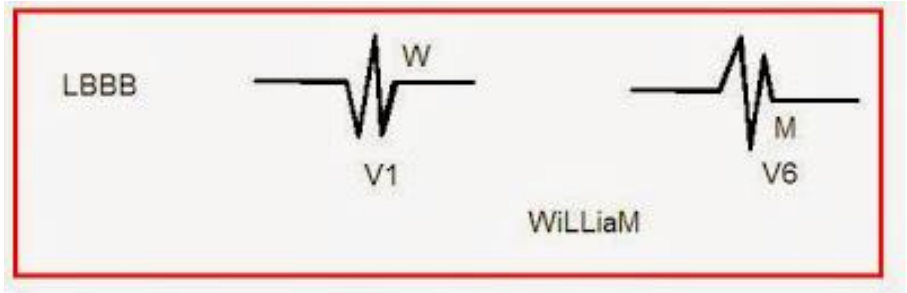
- Two memory aids for determining if a BBB is Left or Right are:
  - Turn signal method
  - William Morrow

Turn Signal Method

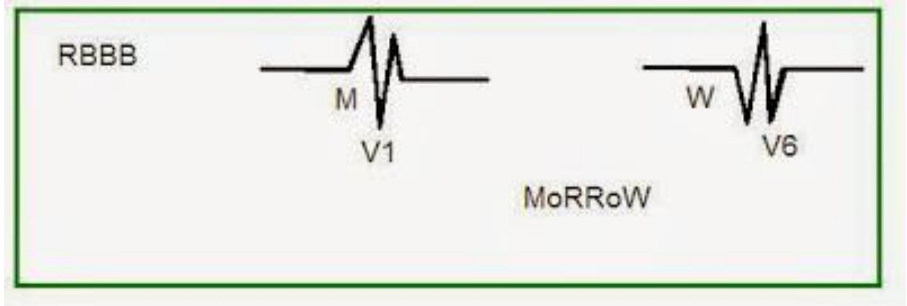
- Once you have note the presence of a BBB observe the QRS complexes in V1
- Think about how you would initiate a car's turn signal and which way you would turn
  - To turn left, you would press the turn signal down
    - Therefore, if the QRS complex is predominately negatively deflected = LBBB
  - To turn right, you would press the turn signal up
    - Therefore, if the QRS complex is predominately positively deflected = RBBB

William Morrow

- For this method, look at V1 and V6
- Keep in mind the name WiLLiaM MoRRoW
  - If V1's QRS appears like a W and V6's QRS appears like a M it is LBBB

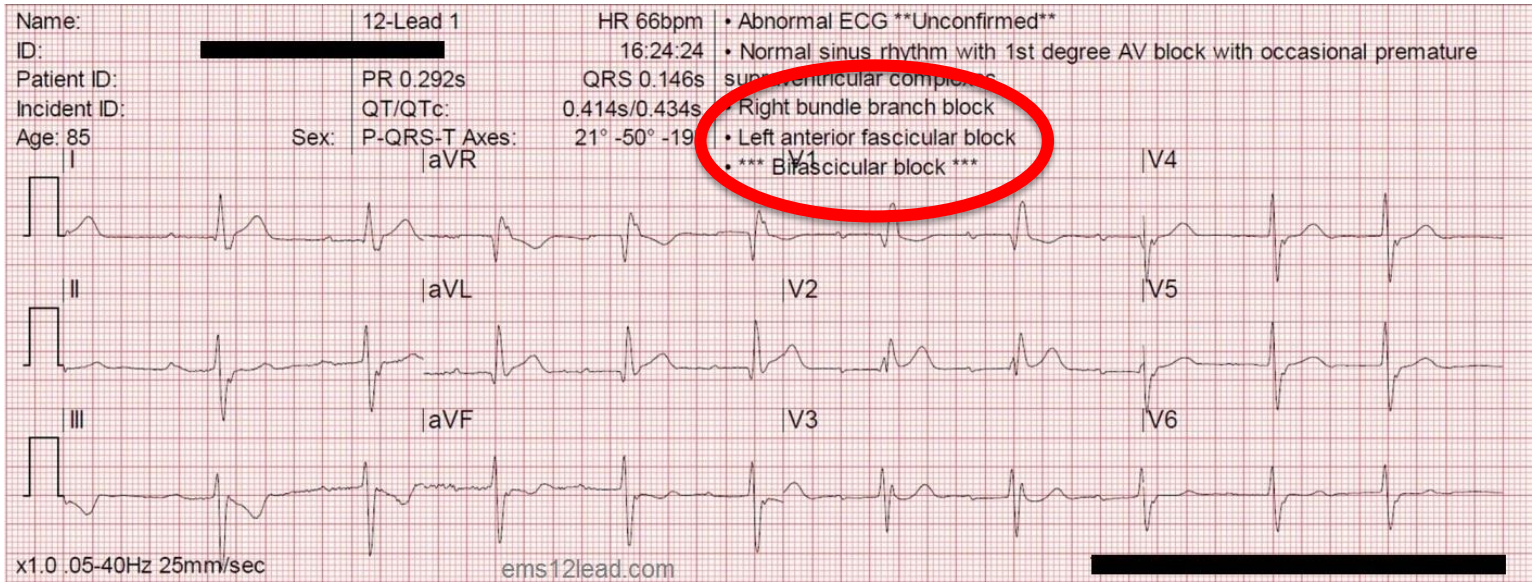


  - If V1's QRS appears like a M and V6's QRS appears like a W it is RBBB



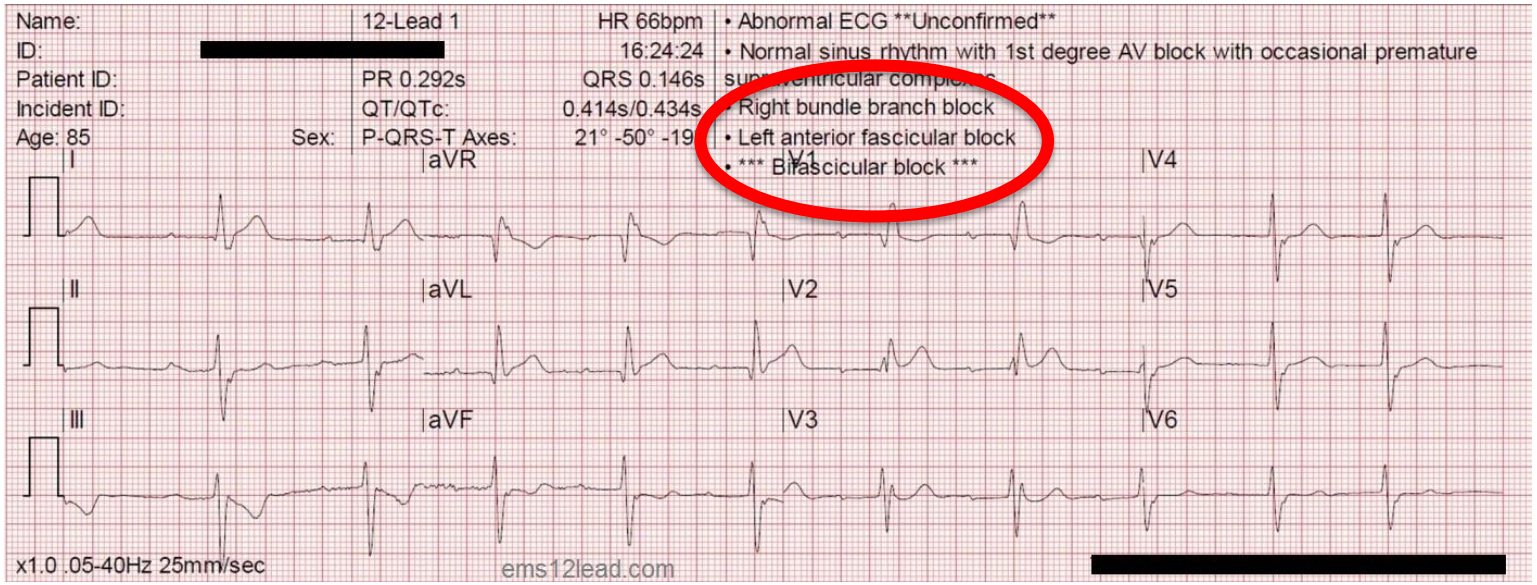
Bundle Branch Blocks

- You may also see your device interpret a rhythm as having a ‘bifascicular block’
  - This occurs when there is a RBBB (1 fascicle) plus a blockage of either the anterior or posterior fascicle of the left bundle branch



Bundle Branch Blocks

- A bifascicular block is a sign of extensive conduction dysfunction
  - Now all ventricular tissue is only being stimulated by impulse through the one remaining fascicle

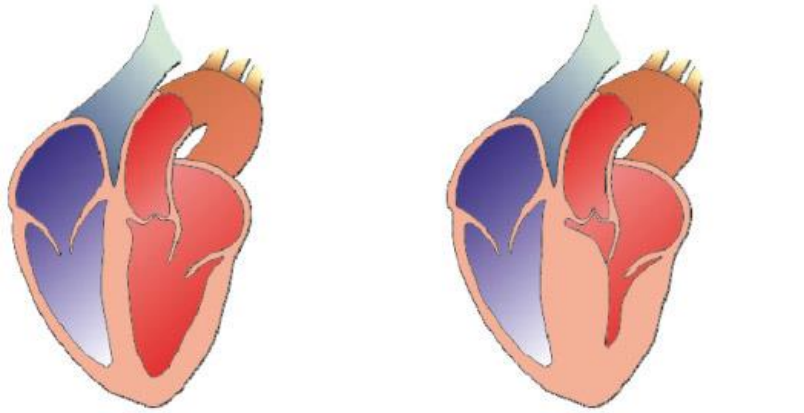


Hypertrophy

- Like any other muscle tissue in the body, the areas of the myocardium can undergo hypertrophy based on usage
- This increased size of the myocardium results in conditions such as:
  - Right Atrial Hypertrophy
  - Left Atrial Hypertrophy
  - Right Ventricular Hypertrophy
  - Left Ventricular Hypertrophy

Hypertrophy

- With muscular hypertrophy the side effect is that as the muscle grows in size it decreases the available volume of the chamber
- This decreases the amount of blood that can fill (preload) therefore decreasing cardiac output

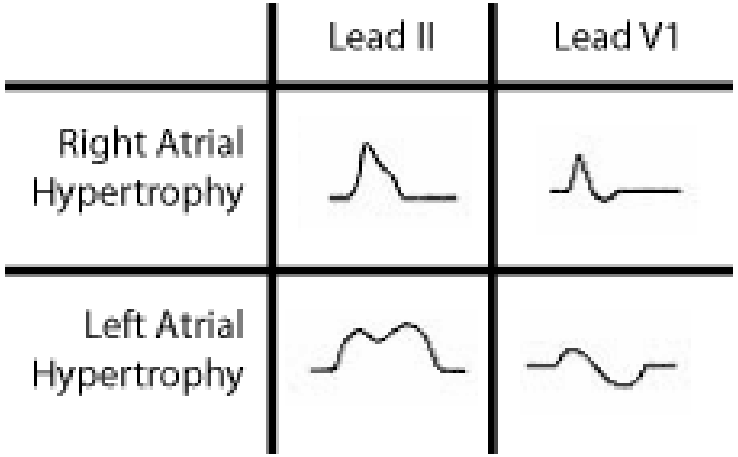


Normal heart

Heart with
left ventricular hypertrophy

Atrial Hypertrophy

- Atrial Hypertrophy criteria:
- Leads II and V1
  - Right atrial hypertrophy
    - Peaked P wave in lead II > 2.5mm
    - V1 has increase in the initial positive deflection
  - Left atrial hypertrophy
    - Notched wide (> 3mm) P wave in lead II
    - V1 has increase in the terminal negative deflection

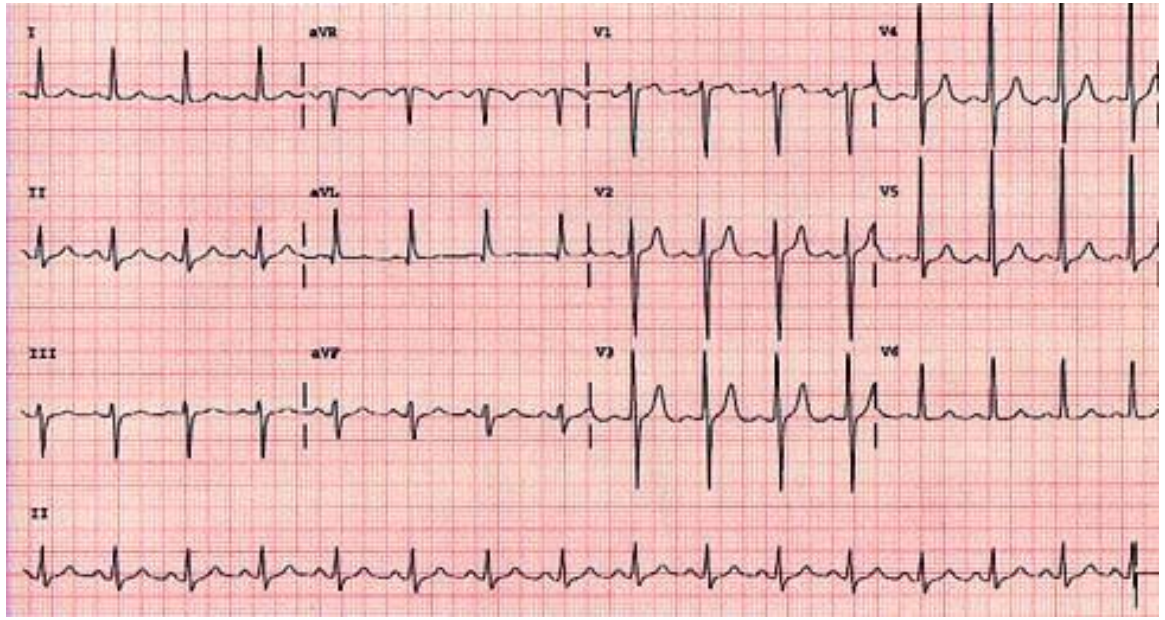


LV Hypertrophy

- LVH criteria:
  - Since hypertrophy slows the conduction the R wave amplitude is increased
  - There are various ways of determining if amplitude increase meets ‘voltage criteria’ to be considered LVH
  - Most common is Sokolow-Lyon criteria

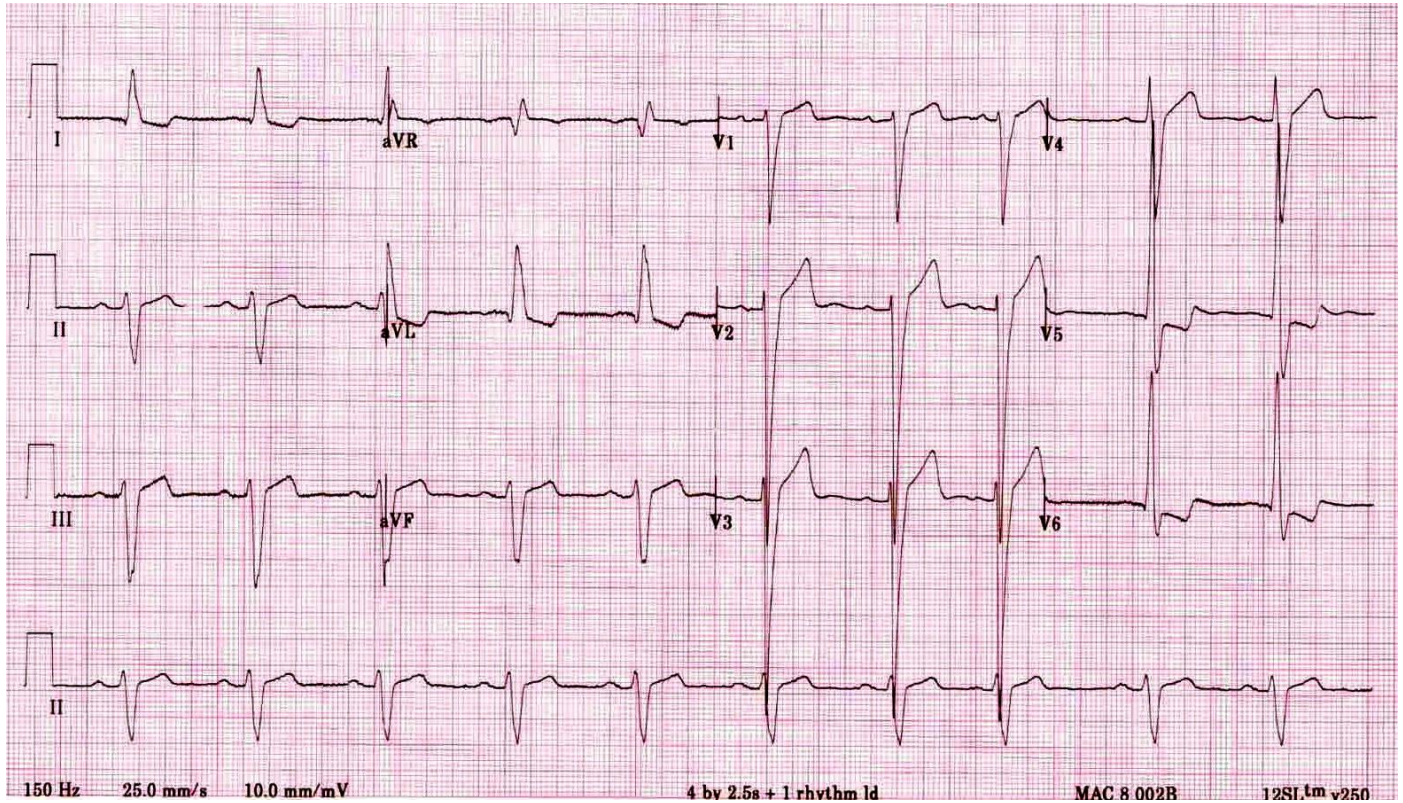
LV Hypertrophy

- Sokolow-Lyon criteria
  - If the S wave depth of V1 + tallest R wave height in V5-V6 is greater than 35mm voltage criteria met
    - Considered LVH



LVH?

- Is this LVH?
- What else does it look like?



RV Hypertrophy

- RVH criteria:
  - R/S ratio greater than or equal to 1 in lead V1 (without a posterior MI or RBBB)
  - R wave > 7mm tall in V1 (without RBBB)
  - S wave > 7mm deep in V5 or V6
  - Right axis deviation > 90◦

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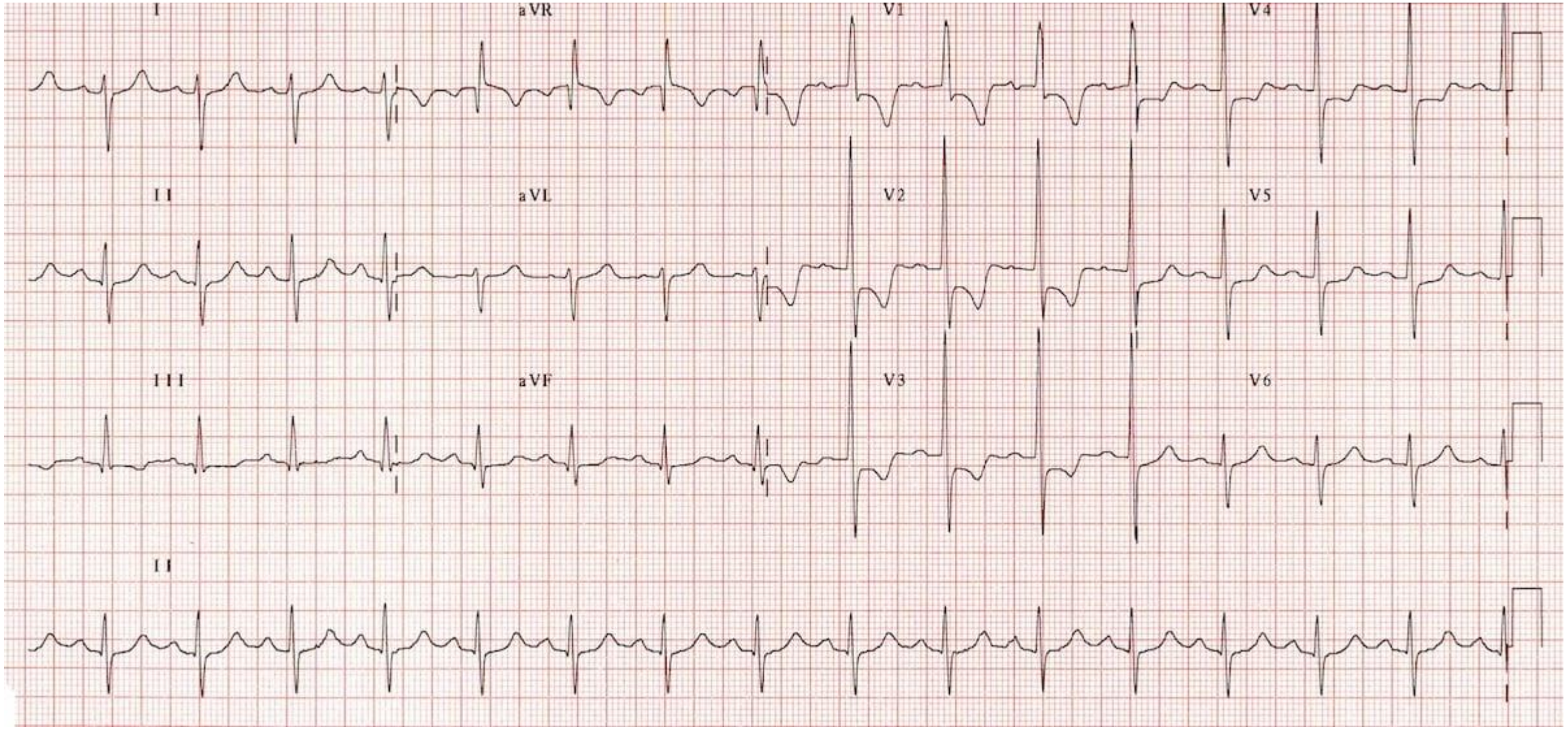
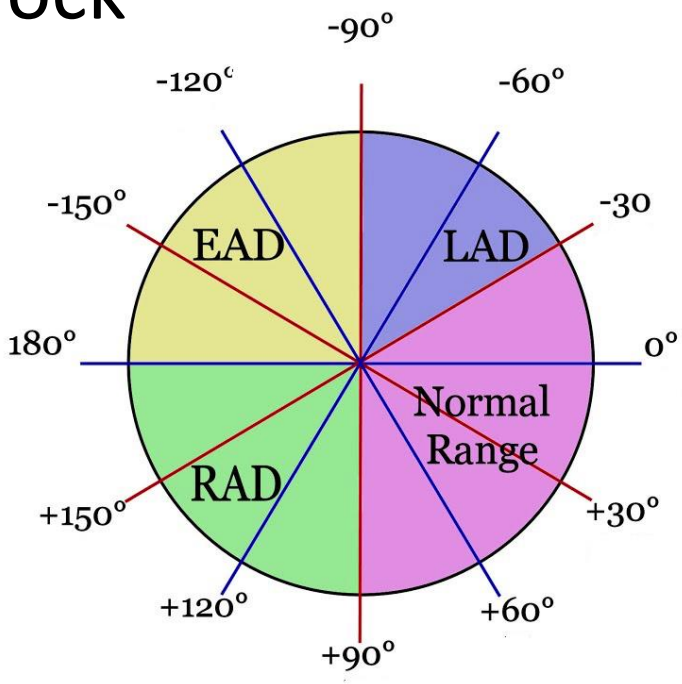
RVH



Axis Deviation

- QRS axis is the “average” direction of electrical activity during ventricular depolarization
- This axis may shift due to physical change in the position of the heart, chamber hypertrophy, or conduction block
- Normal QRS axis is from
- around -30◦ to +90◦



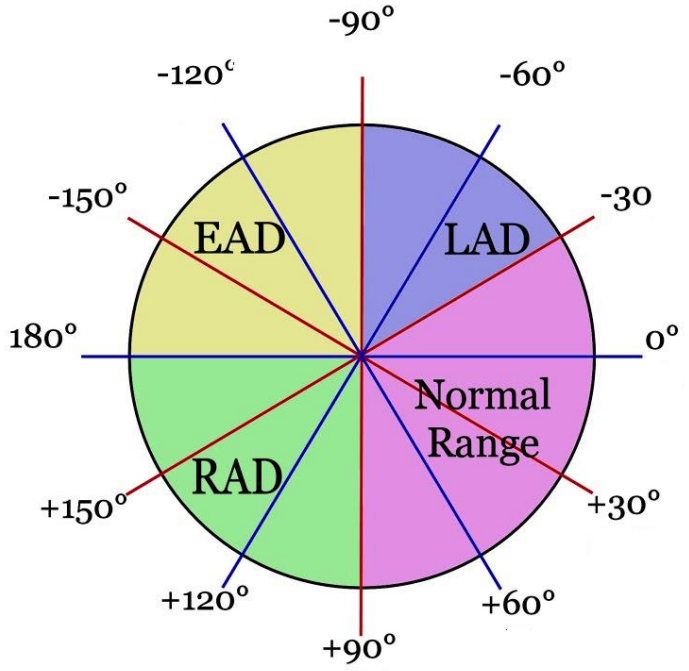
Axis Deviation

- Axis Deviation is classified based on the direction it deviates
  - Left Axis Deviation = -30◦ to -90◦
  - Right Axis Deviation = +90◦ to 180◦
  - Extreme Axis Deviation = 180◦ to -90◦

- BBB makes it difficult (because there are 2 separate QRS vectors overlapping in time)

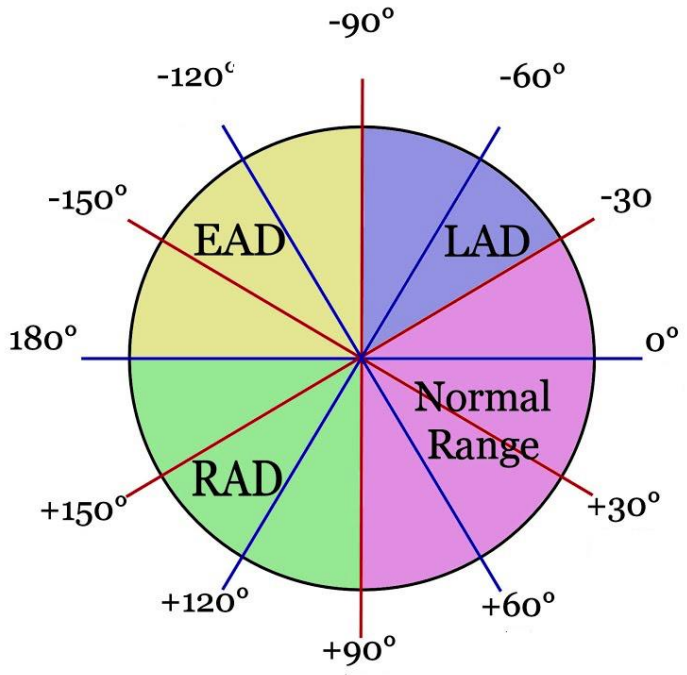
Axis Deviation

- Left Axis Deviation (-30◦ to -90◦)
  - Causes include:
    - Past inferior MI
    - Left anterior fascicular block
    - Ventricular pacing
    - Emphysema
    - Hyperkalemia
    - WPW
    - Tricuspid atresia (Closed)
    - Ostium primum atrial septal
    - defect



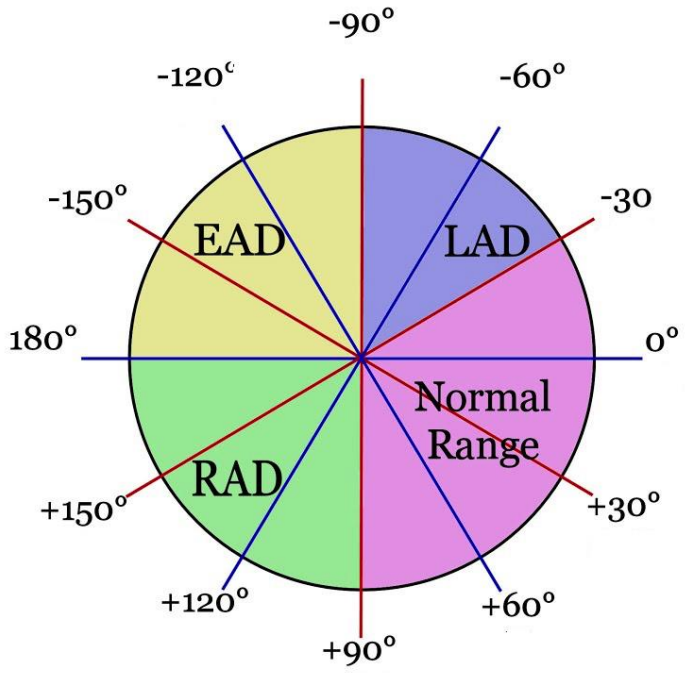
Axis Deviation

- Right Axis Deviation (+90◦ to 180◦)
  - Causes include:
    - Normal in kids and tall, thin adults
    - RVH
    - COPD
    - Previous anterolateral MI
    - Left posterior fascicular block
    - Pulmonary embolus
    - WPW
    - Atrial or Ventricular Septal Defect
    - Reversed arm leads



Axis Deviation

- Extreme Axis Deviation (-90◦ to 180◦)
  - Also known as “No Man's Land” or “Northwest Axis Deviation”
  - Causes include:
    - Emphysema
    - Hyperkalemia
    - Lead transposition
    - Ventricular pacing
    - Ventricular arrhythmia

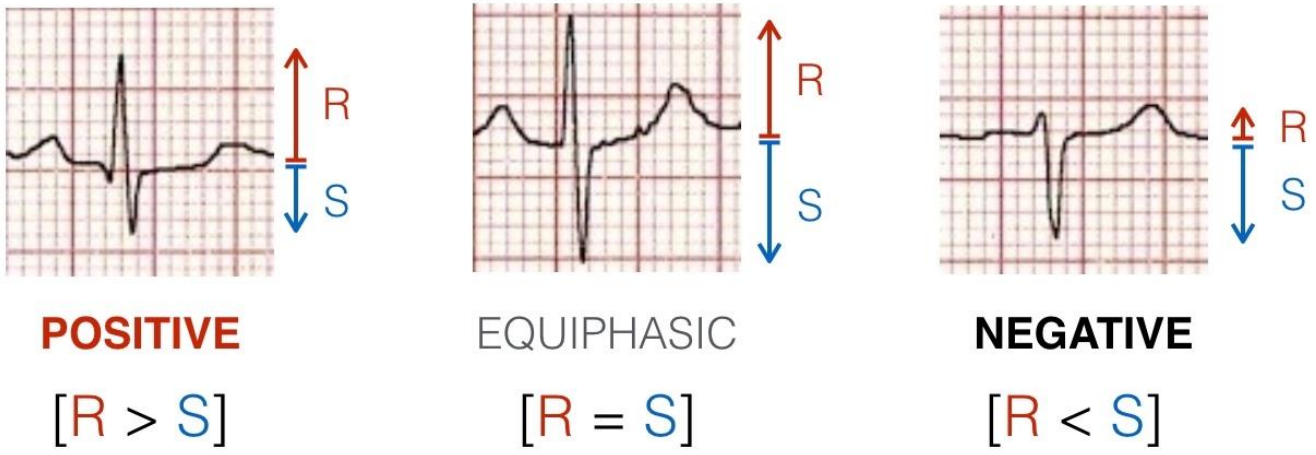


Axis Deviation

- There are multiple methods to determine the presence and direction of axis deviation including:
  - Quadrant method
  - Three lead method
  - Isoelectric lead method

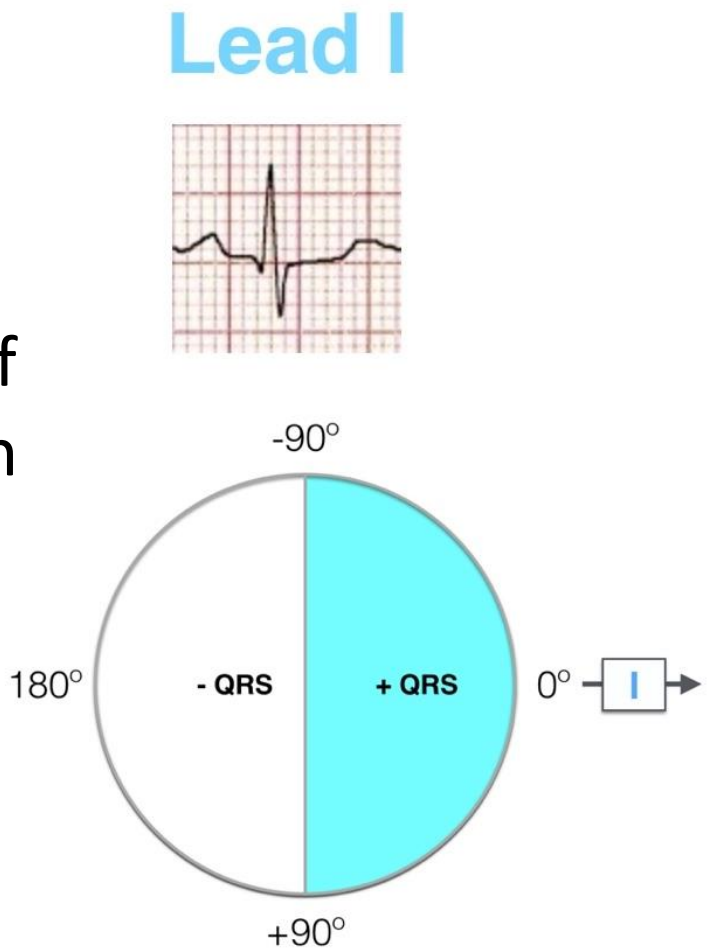
Axis Deviation

- Quadrant method
  - Most efficient way to estimate axis
  - Look at Leads I and aVF
    - Determine if QRS complex in each is mostly positively deflected, negatively deflected or equiphasic



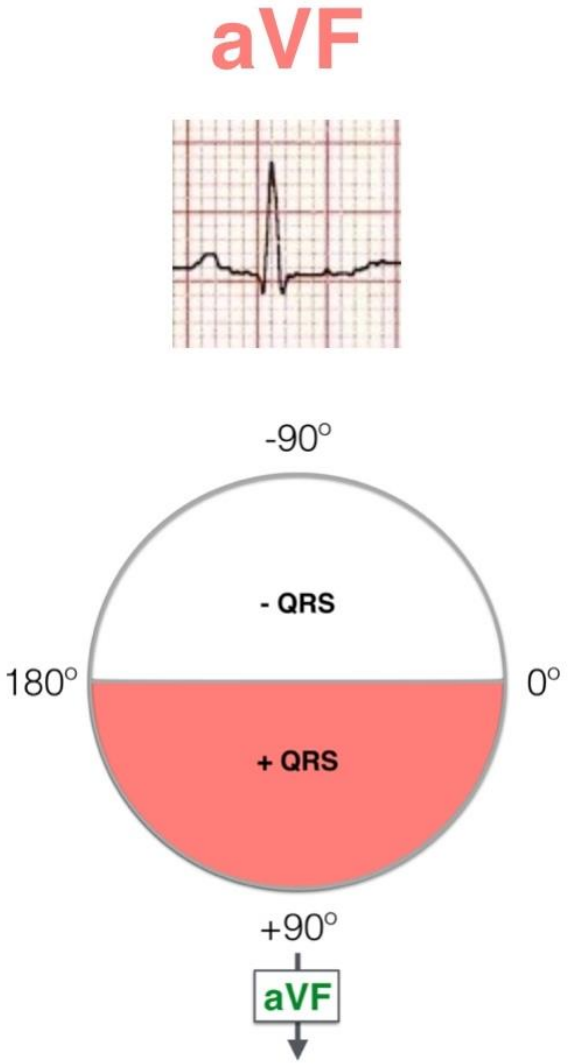
Axis Deviation

- Since Lead I looks at the heart from approximately 0◦ if the QRS is positive, the impulse is moving toward it
  - Therefore we know the horizontal component of the axis is toward the left if the QRS is positive in Lead I



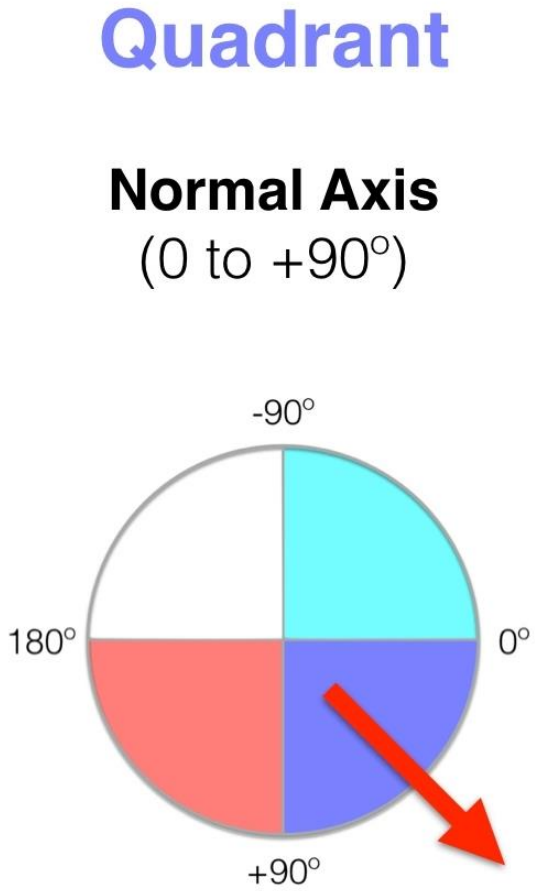
Axis Deviation

- Since Lead aVF looks at the heart from approximately +90◦ if the QRS is positive, the impulse is moving toward it
  - Therefore we know the vertical component of the axis is downward if the QRS is positive in Lead aVF



Axis Deviation

- So adding these together, we can create 4 different quadrants
  - Based on the QRS complexes in Leads I and aVF we can determine which of the four quadrants the axis is
  - This provides a rough idea, but not a specific measurement



Axis Deviation

- Adding everything together:

	Axis Deviation Type			
	Normal	Left	Right	Extreme
Lead I QRS Deflection	Positive	Positive	Negative	Negative
Lead aVF QRS Deflection	Positive	Negative	Positive	Negative