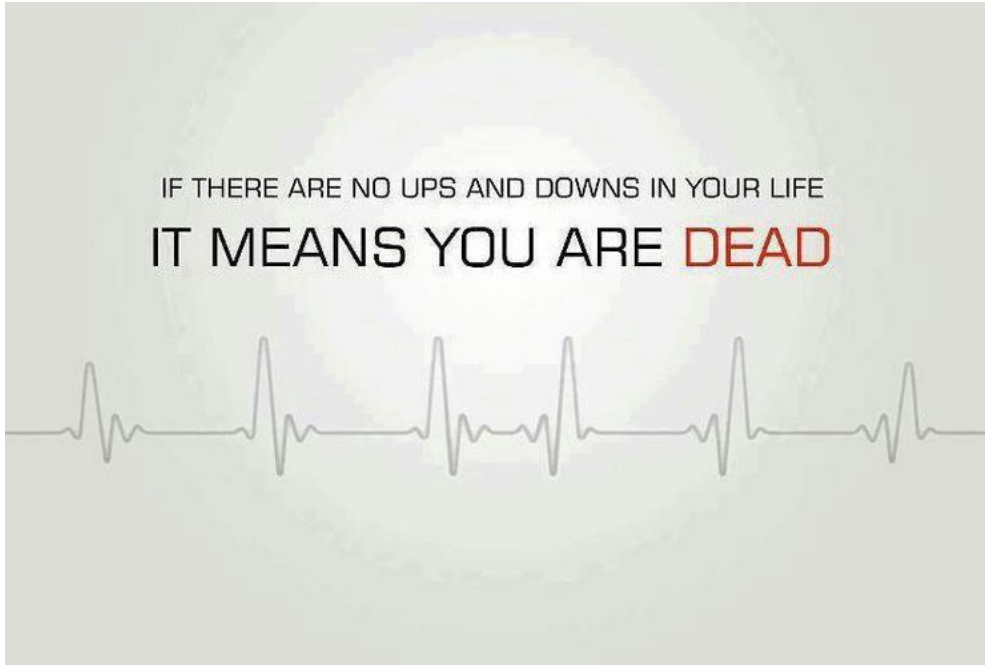
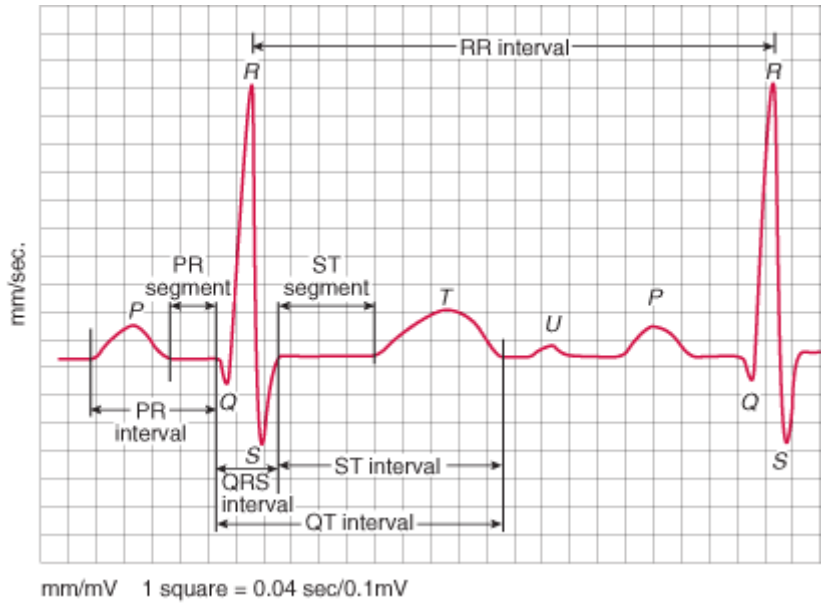
Don’t Fear The ECG



The Basics


RR interval
R
R
PR segment
ST segment
P
T
U
P
Q
Q
PR interval
S
S
ST interval
QRS interval
QT interval
mm/sec.
mm/mV 1 square = 0.04 sec/0.1mV

The Basics

ECG Paper and Measurements

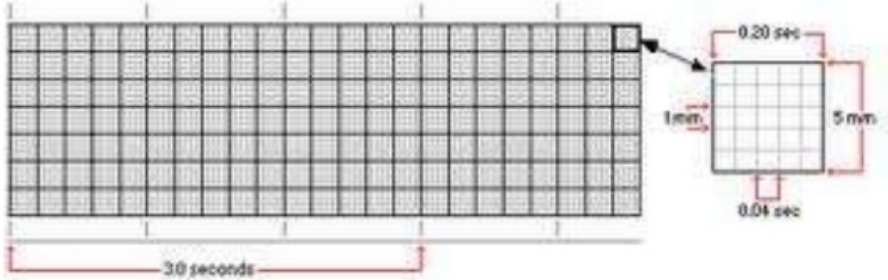
*2 small boxes = 1mm

Time Equivalents of Small Boxes

- 1 small box = 0.04 second
- 2 small boxes = 0.08 second
- 3 small boxes = 0.12 second
- 4 small boxes = 0.16 second
- 5 small boxes = 0.20 second

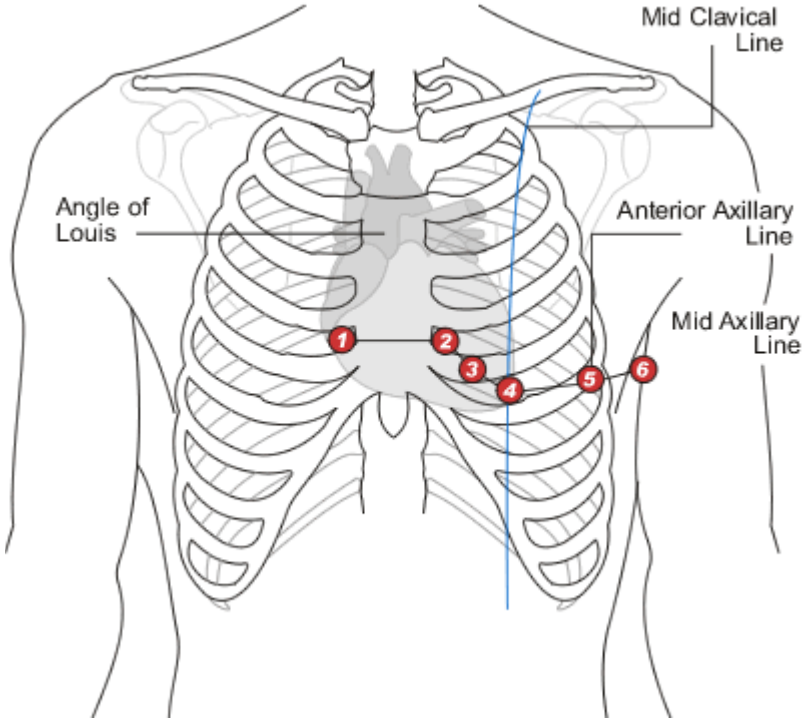
Time Equivalents of Large Boxes

- 1 large box = 0.20 second
- 5 large boxes = 1 second
- 15 large boxes = 3 seconds
- 30 large boxes = 6 seconds



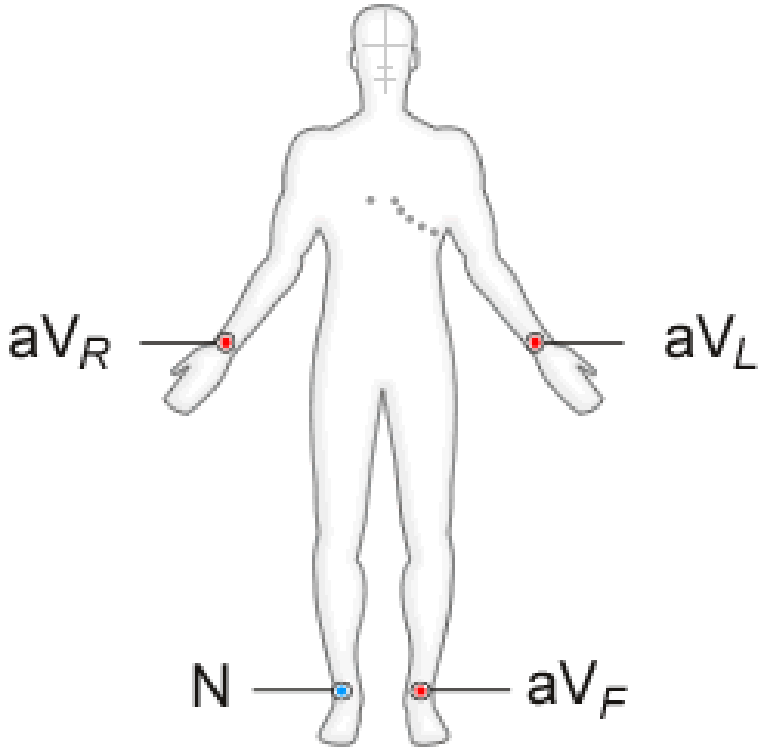
Leads And More Leads

- Chest leads:



Leads And More Leads

- Limb leads:



•information between AVr and AVl is known as lead I.
•Information between AVr and AVf is known as lead II
•Information between AVl and AVf is known as lead III

The Basics – summary

The six limb leads (I, II, III, aVR, aVL and aVF ->
a indicates augmented, V indicates voltage, L indicates left arm, R indicates R arm, F indicates foot)
Provide a view of the heart in a vertical plane (frontal).
Precordial leads (V1 to V6). *(precordial = in front of the heart)*

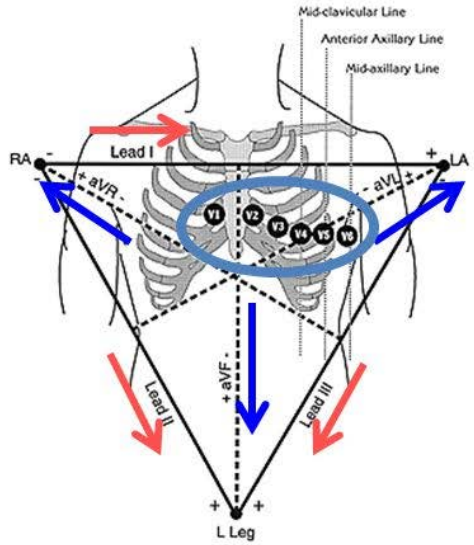
The 12-Leads

The 12-leads include:

–3 Limb leads
(I, II, III)

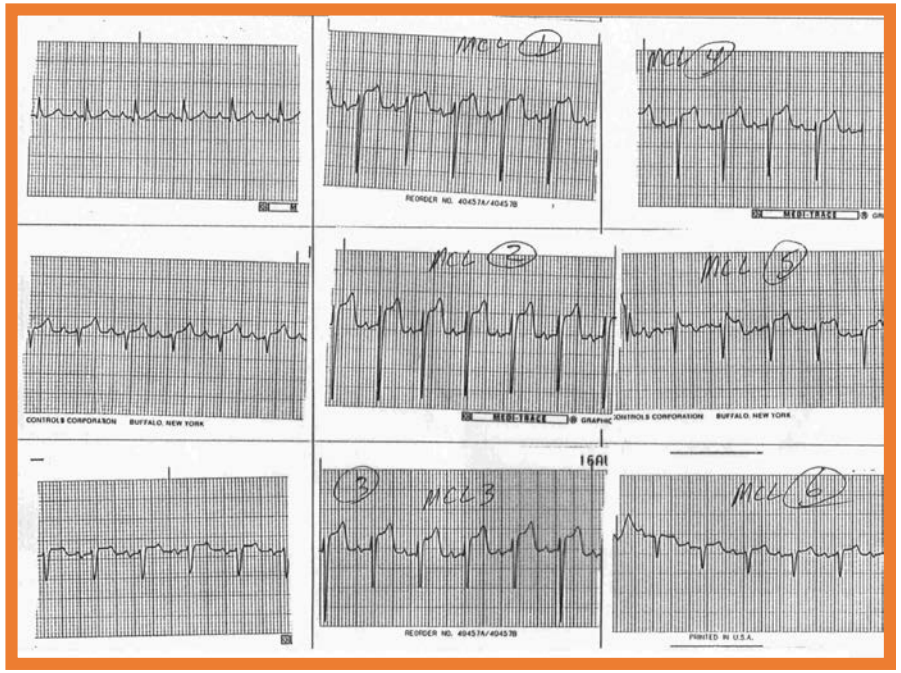
–3 Augmented leads
(aVR, aVL, aVF)

–6 Precordial leads
(V_1- V_6)



How to obtain a 12 lead without a 12 lead machine?

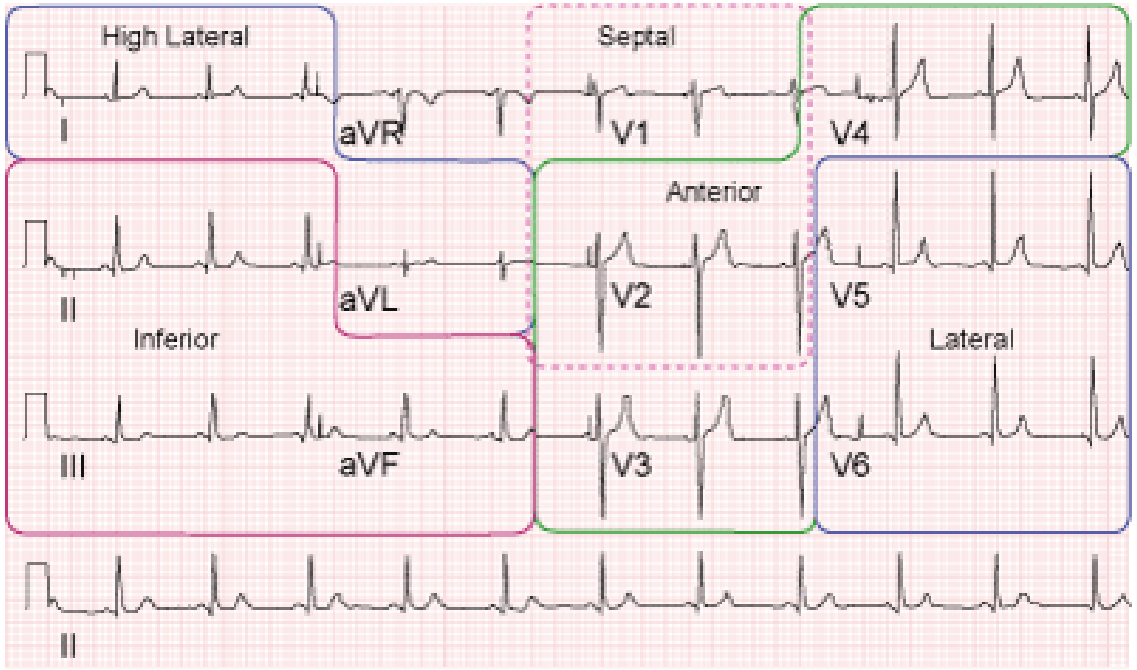
1. Place the 3 leads on the patient as usual
2. Leave monitor in lead III
3. Move the LL electrode to positions V1-V6, printing a short strip of each



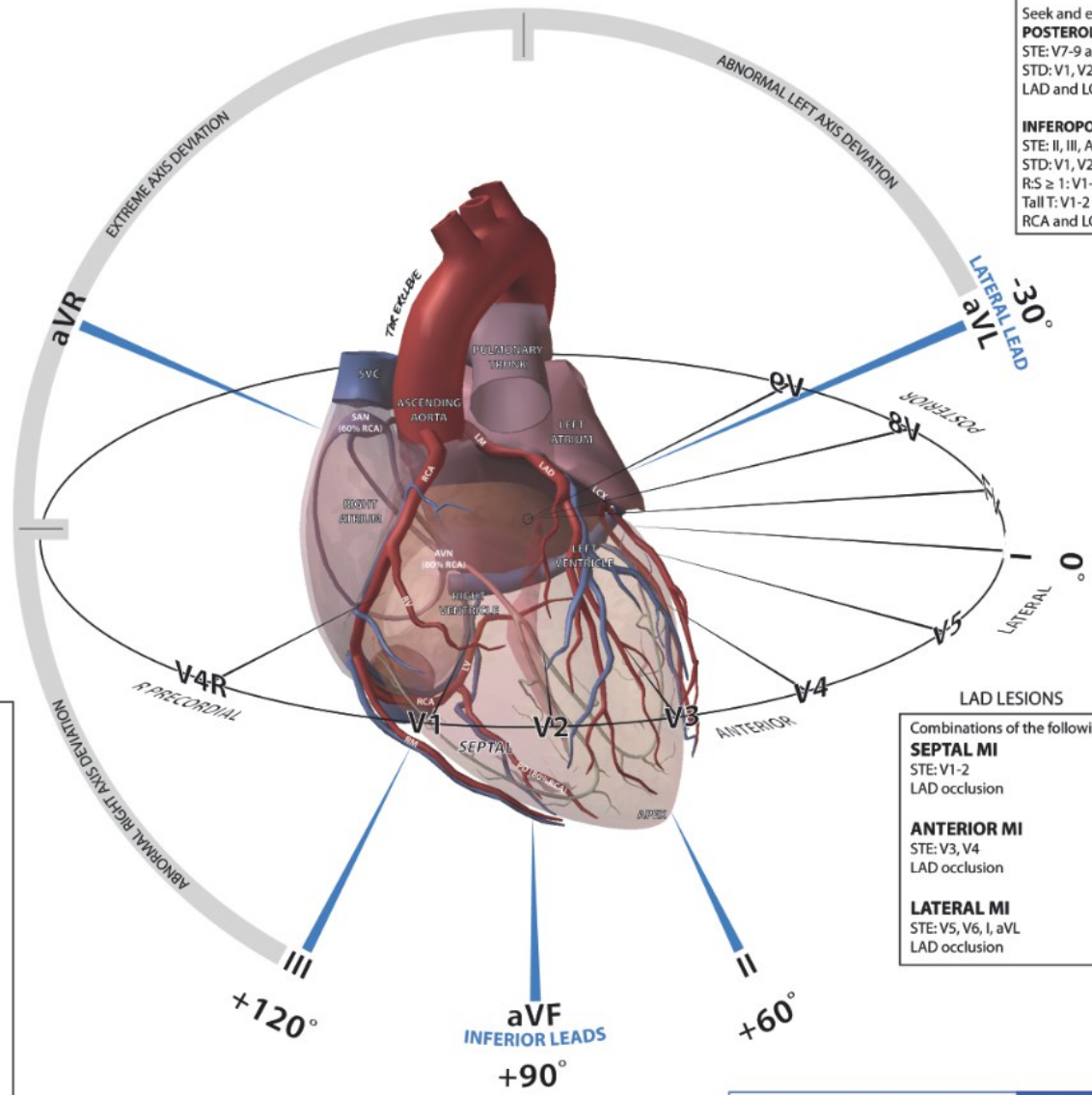
Speaking The Same Language

- What are contiguous leads?
  - *Contiguous leads are next to one another anatomically speaking. They view the same general area of the heart (specifically the left ventricle).*
    - The inferior leads (II, III and aVF) view the inferior wall of the left ventricle.
    - The septal leads (V1 and V2) view the septal wall of the left ventricle. They are often grouped together with the anterior leads.
    - The anterior leads (V3 and V4) view the anterior wall of the left ventricle. When there is ST-segment elevation in leads V1-V4 we often simply say “LAD occlusion.”
    - The lateral leads (I, aVL, V5 and V6) view the lateral wall of the left ventricle. Leads I and aVL are often referred to as the “high lateral” leads, because their positive electrode is on the left shoulder. Leads V5 and V6 are often referred to as the “low lateral” leads because their positive electrodes are on the lateral left chest.
    - In addition, any two precordial leads that a next to one another are contiguous. In other words, V4 and V5 are contiguous, even though V4 is an anterior lead and V5 is a lateral lead. This makes sense when you consider that leads V4 and V5 are next to each other on the patient’s chest.

Speaking The Same Language



AMI ECG, ANATOMY AND PATHOLOGY



LCX LESIONS ±

POSTERIOR MI
STE: V7-9
STD: V1-2 (reciprocal STE)
R:S ≥ 1: V1-2
Tall T: V1-2
RCA and LCX occlusion

Seek and exclude
POSTEROLATERAL MI
STE: V7-9 and I, aVL, V5-6
STD: V1, V2
LAD and LCX occlusion

INFEROPOSTERIOR MI
STE: II, III, AVF and V7-9
STD: V1, V2 (reciprocal STE)
R:S ≥ 1: V1-2
Tall T: V1-2
RCA and LCX occlusion

RCA 'TYPE' LESIONS ±

INFERIOR MI
STE: II, III, aVF
STD: aVL (reciprocal STE)
RCA occlusion distal to RV
58% of MI

Seek and exclude
INFERIOR AND RV MI
STE: II, III, aVF and V1, V4R
RCA occlusion proximal to RV
40% of Inferior MI
Increased mortality risk

INFEROLATERAL MI
STE: II, III, AVF and I, aVL, V5, V6 ± V4R
LAD and LCX occlusion
in a L dominant system

INFEROPOSTERIOR MI
STE: II, III, AVF and V7-9
STD: V1, V2 (reciprocal STE)
R:S ≥ 1: V1-2
Tall T: V1-2
RCA and LCX occlusion

LAD LESIONS

Combinations of the following
SEPTAL MI
STE: V1-2
LAD occlusion

ANTERIOR MI
STE: V3, V4
LAD occlusion

LATERAL MI
STE: V5, V6, I, aVL
LAD occlusion

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Gates, Int Med J 2005;35:263-266
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Originally posted at Lifeinthefastlane.com

The Basics – breaking it down

- Lead View of the heart:

Lead	Area of the heart
II, III, aVF	Inferior wall of the left ventricle
V1, V2	Septum
V3, V4	Anterior wall of the left ventricle
I, V5, V6, aVL	Lateral wall of the left ventricle

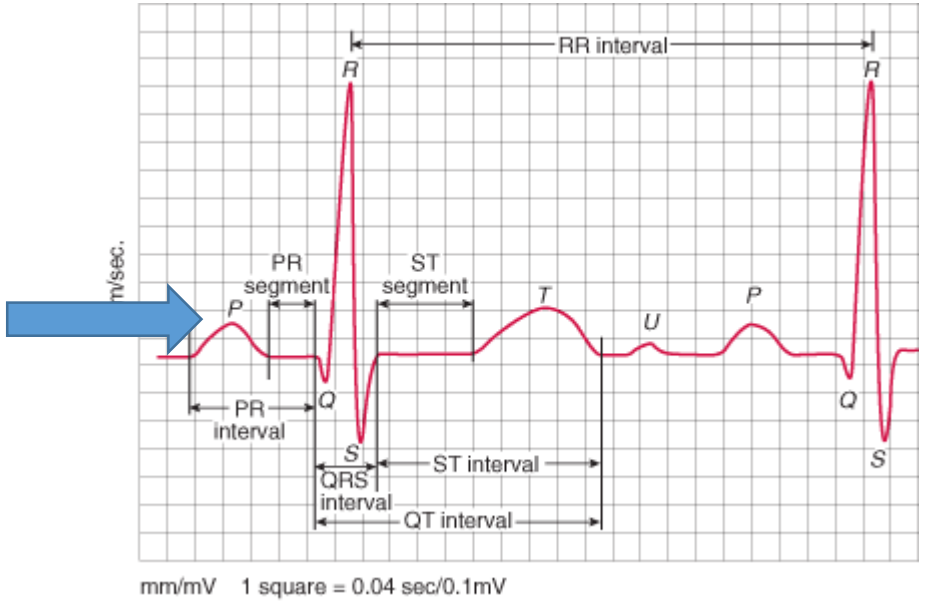
The Basics – breaking it down

- Lead deflections in a normal 12 lead

Upward (positive)	Downward (negative)
I, II, III, aVF, aVL	aVR
V2 through V6	V1

The Basics – breaking it down

- **The P wave** is the first positive deflection on the ECG
- It represents atrial depolarization. Atrial depolarization proceeds from right to left.
- Normal P wave axis is between 0 and +75
- Should not be larger than 3mm

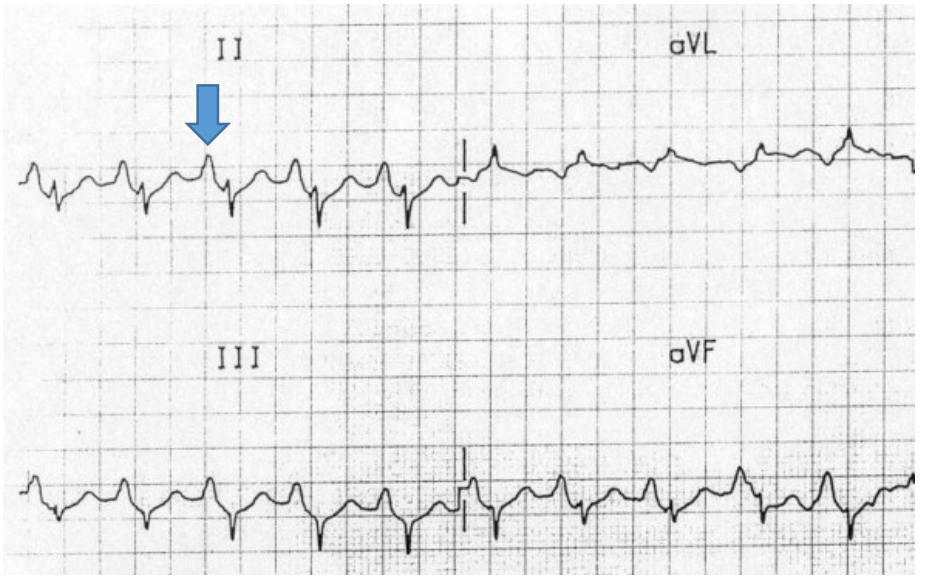


The Basics – breaking it down

- Common P wave abnormalities:
  - P mitrale: broad, notched P waves in lead II is a sign of left atrial enlargement, usually caused by mitral stenosis.

The Basics – breaking it down

- Common P wave abnormalities:
  - P Pulmonale: tall, peaked P waves in lead II is a sign of right atrial enlargement usually due to pulmonary hypertension.

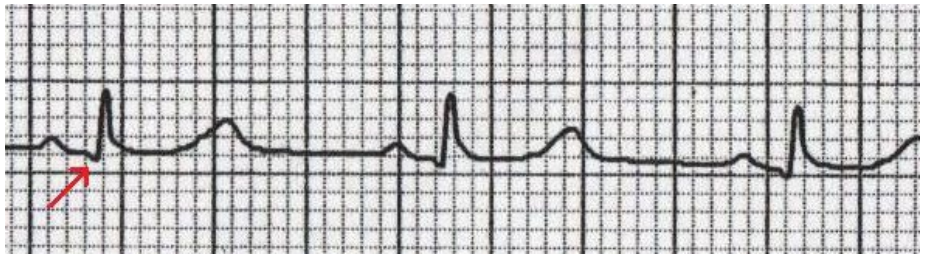


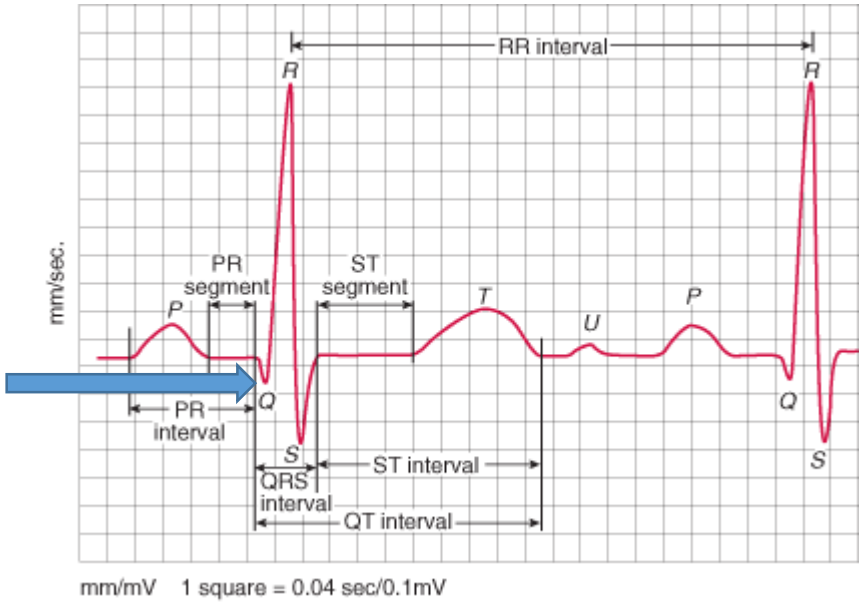
The Basics – breaking it down

- Common P wave abnormalities:
  - Inverted P waves
  - Variable P wave morphology which can be seen in MAT

The Basics – breaking it down

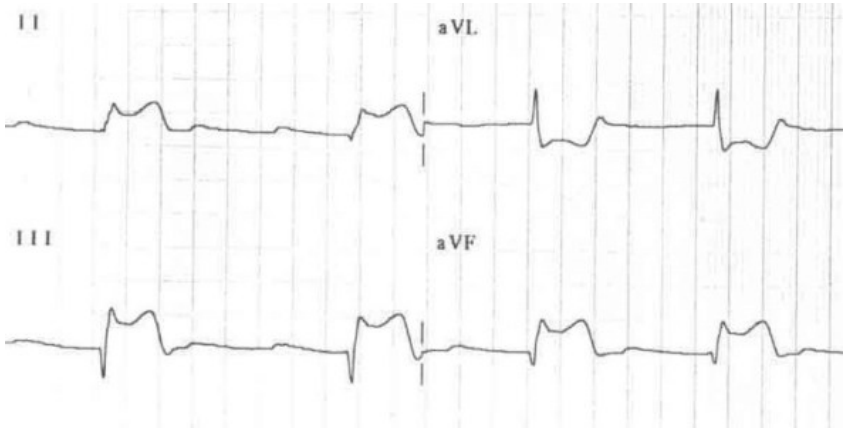
- **The Q wave** is any negative deflection that precedes an R wave.
- The Q wave represents the left to right depolarization of the interventricular septum.





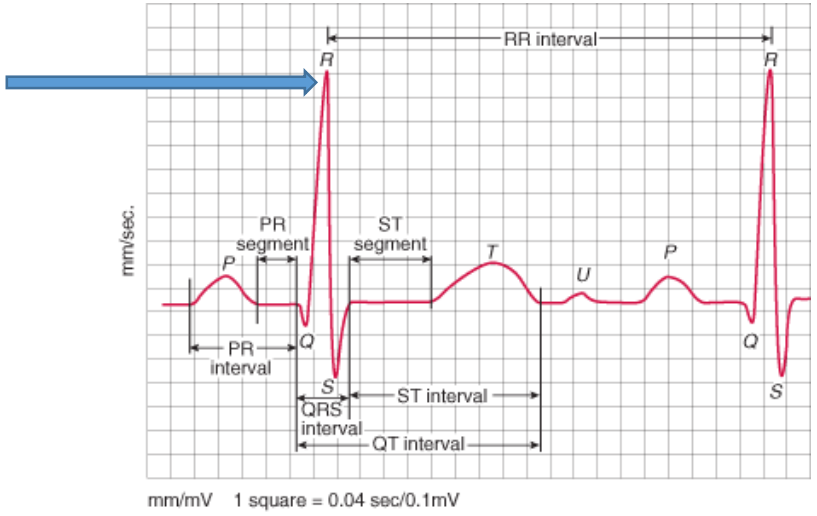
The Basics – breaking it down

- Pathological Q waves:
  - Usually indicate current or prior myocardial infarction.
  - >40ms (1mm) wide
  - >2mm deep
  - >25% of depth of QRS complex
  - Seen in V1-3



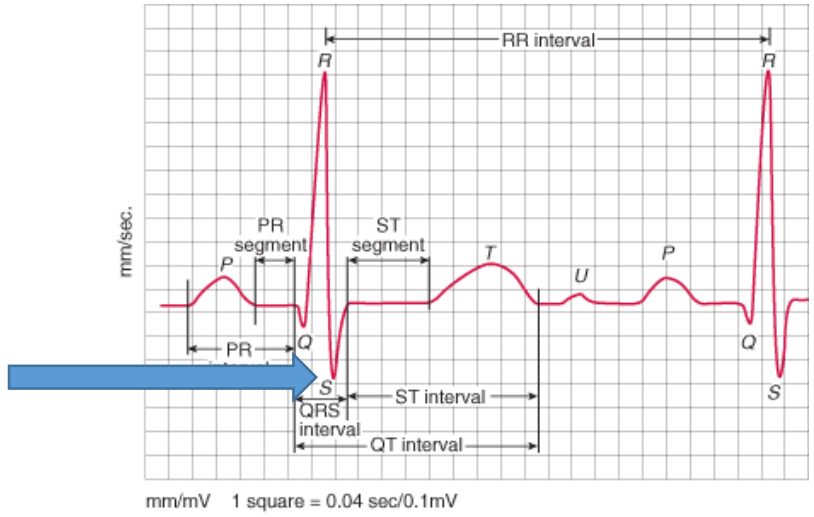
The Basics – breaking it down

- **The R wave** is the first upward deflection after the P wave (even if Q waves are absent).
- Represents early ventricular depolarization.
- Abnormalities of the R wave:
  - Dominant R wave in V1 (normal in children, RBBB, WPW, dextrocardia)
  - Poor R wave progression



The Basics – breaking it down

- **The S wave** is the first negative deflection after the R wave.
- It represents the late ventricular depolarization.



The Basics – breaking it down

- **The T wave** is the positive deflection after each QRS complex.
- It represents ventricular repolarization.
- Upright in all leads except aVR and V1.
- T wave abnormalities:
  - Hyperacute T waves (early stages of MI)
  - Inverted T waves (myocardial ischemia and infarction, BBB, PE, increased ICP)

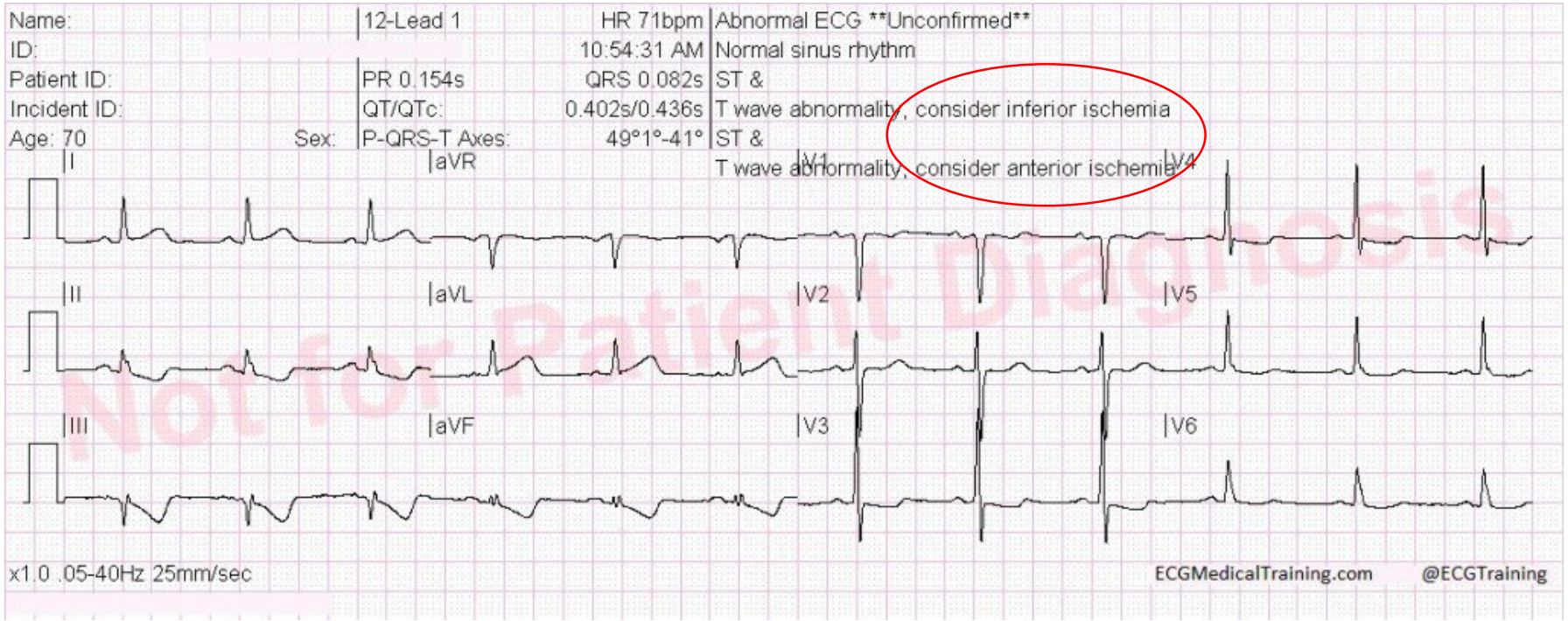
Computer Interpretation – not so fast

T wave abnormality, consider inferior ischemia.

Ischemia does not localize on the 12 lead ECG.

Be aware of inferior ischemia. It could be reciprocal changes from the sometimes silent high lateral leads I and aVL (high lateral STEMI).

Computer Interpretation – not so fast



Typical for electrocardiographically silent high lateral STEMI.

ST-segment depression in leads II, III, and aVF that is reciprocal to high lateral STEMI.

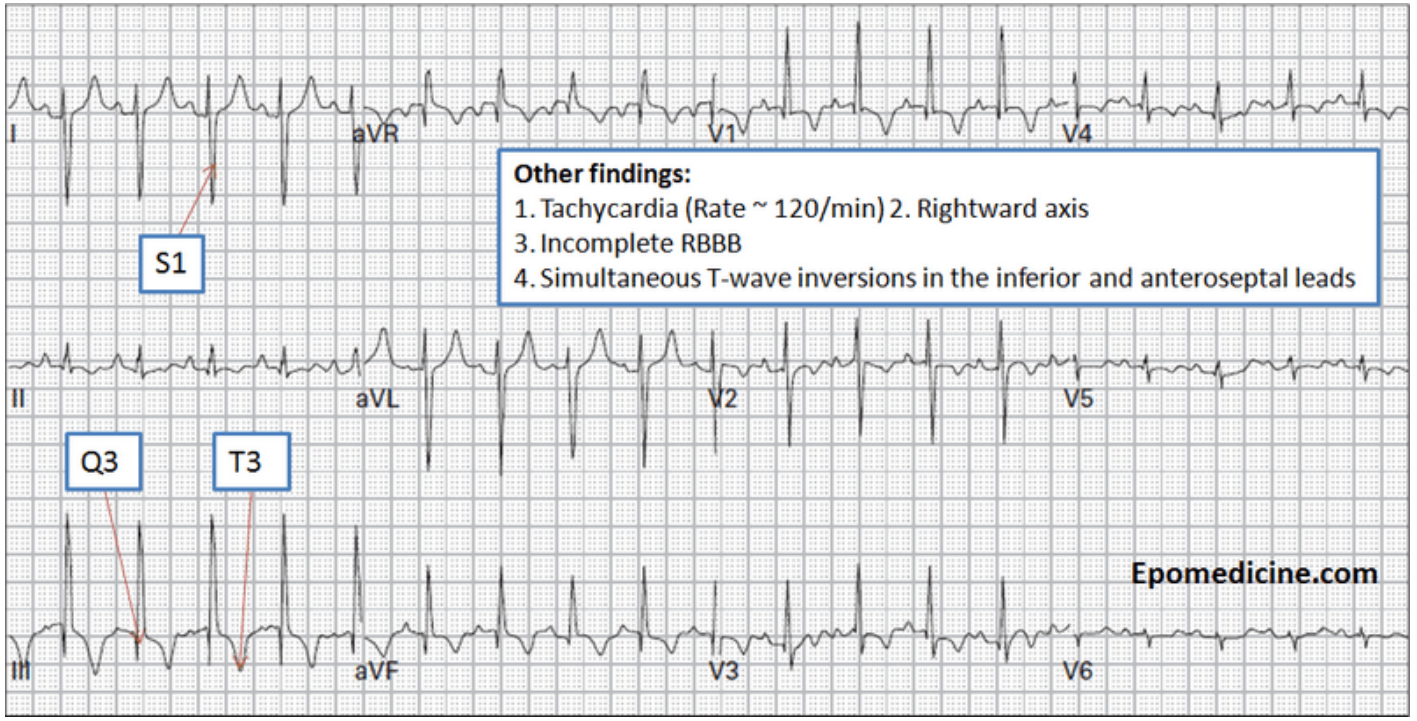
The LCX was 100% occluded.

Electrocardiographically silent?

- The lateral wall stretches far around to the posterior wall. I, aVL, V5, and V6 just don't go posterior enough. Posterior leads may help with this.
- As you go lateral, the heart has more lung between it and the chest wall, so lead strength is buffered by air.

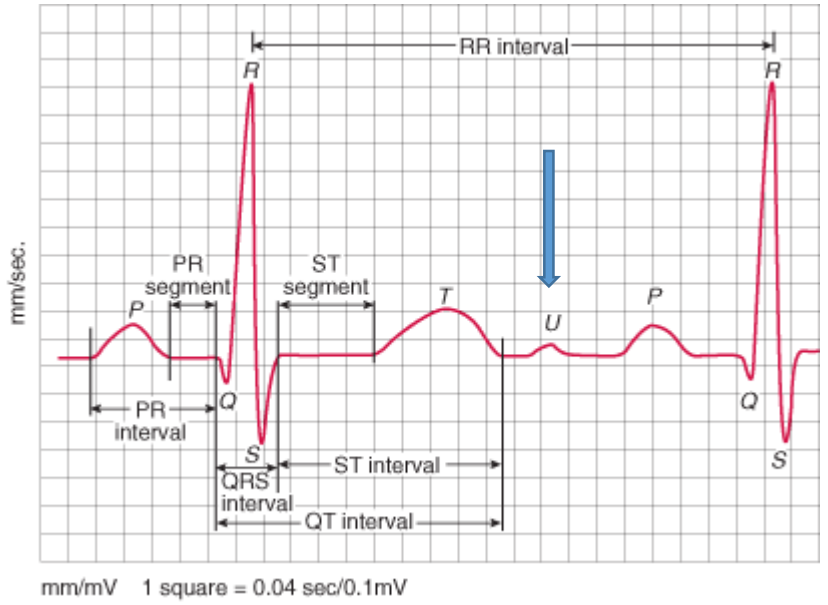
The Basics – breaking it down

- **Possible** ECG changes in acute PE: *(about 40% of all cases)*
  - SI-QIII-TIII pattern
    - Deep S wave in lead I
    - Q wave in lead III
    - T wave inversion in lead III



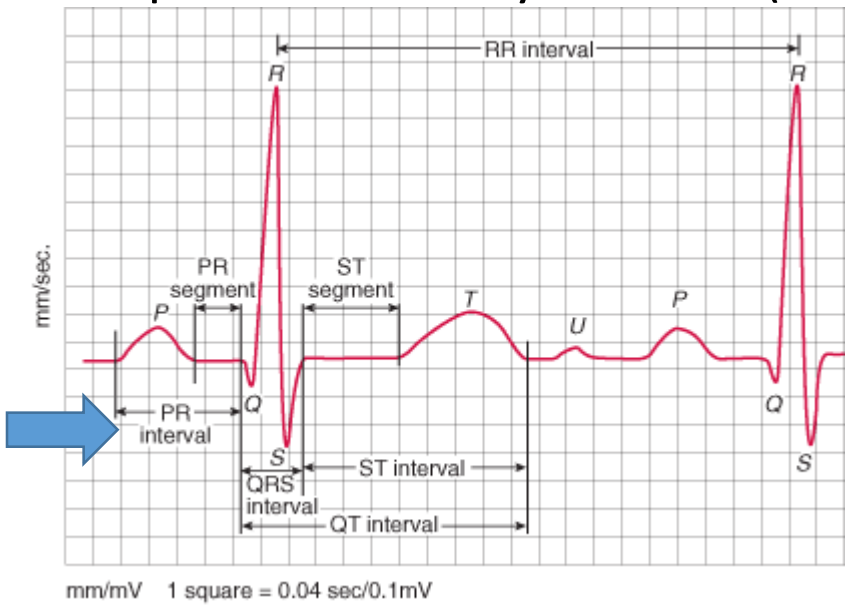
The Basics – breaking it down

- The U wave:
  - Source of U wave is unknown (possibly delayed repolarization of Purkinje Fibers)
  - Abnormal findings: prominent and inverted U waves



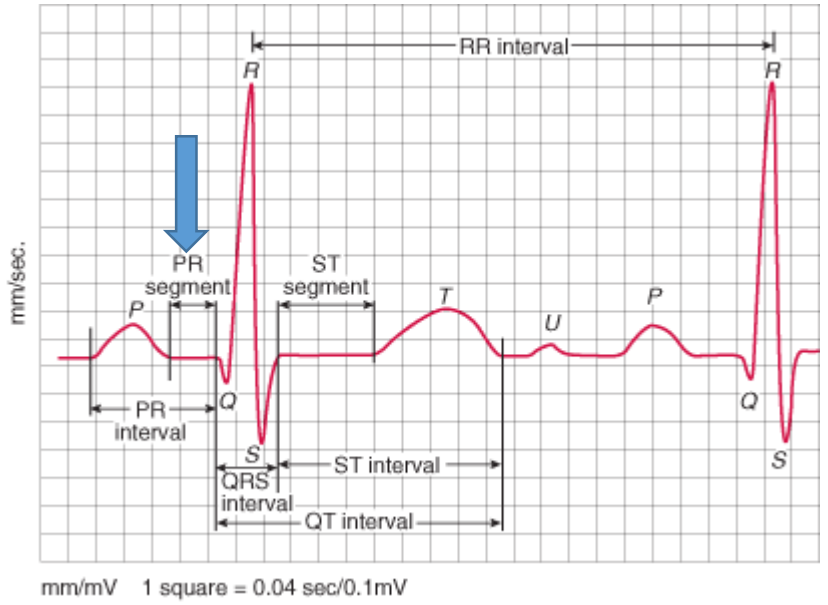
The Basics – breaking it down

- **The PR interval** is the time from onset of the P wave to the start of the QRS complex.
- It reflects conduction through the AV node.
- The normal PR interval is between 120-200ms (prolonged PR interval think heart block).
- Short PR intervals <120ms think pre-excitation syndromes (WPW, LGL)



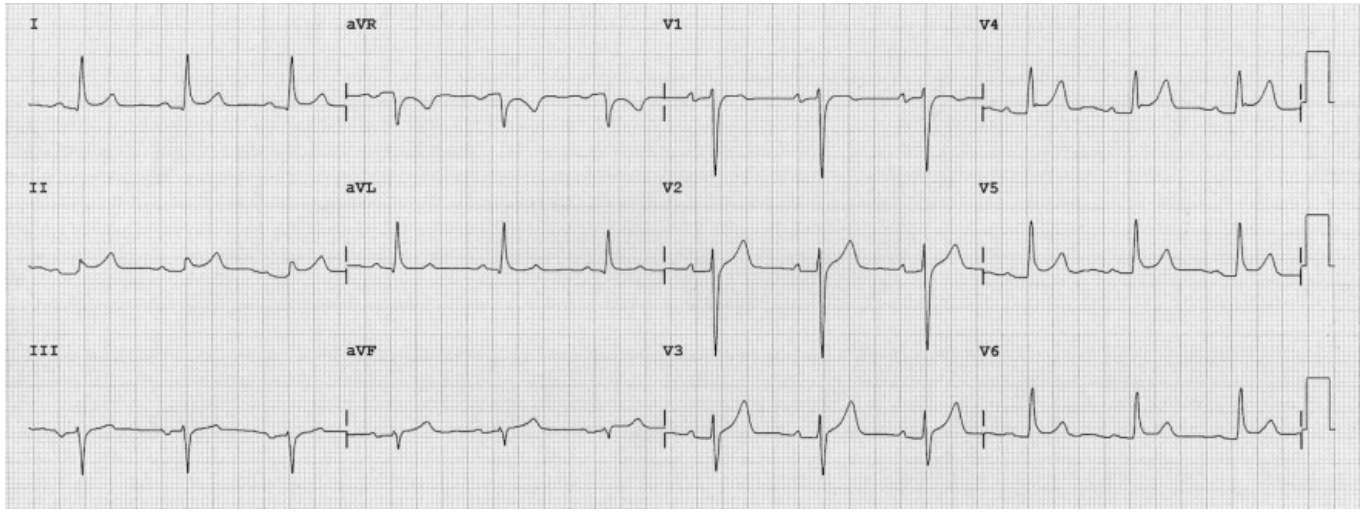
The Basics – breaking it down

- **The PR segment** is the flat, isoelectric segment between the end of the P wave and the start of the QRS complex.
- PR segment abnormalities occur in pericarditis and atrial ischemia (MI).



The Basics – breaking it down

- Possible ECG changes in pericarditis:
  - **PR segment** depression
  - Saddle shaped ST elevation
  - Absence of reciprocal ST depression

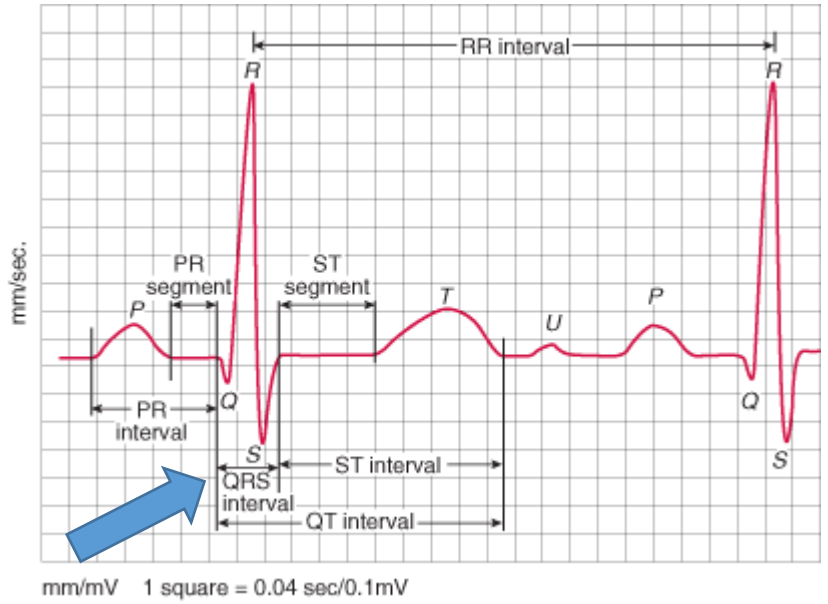


The Basics – breaking it down

- The QT interval is the time from the start of the Q wave to the end of the T wave.
- It represents ventricular depolarization and repolarization.
- Normal QT values:
  - Prolonged >440ms in men or >460ms in women; causes include electrolyte imbalances (hypokalemia, hypomagnesemia), MI, post cardiac arrest, increased ICP, congenital QT syndrome, drugs)
  - Greater >500ms increased risk for torsades.
  - Short < 350ms; causes include hypercalcemia, congenital short QT syndrome, digoxin

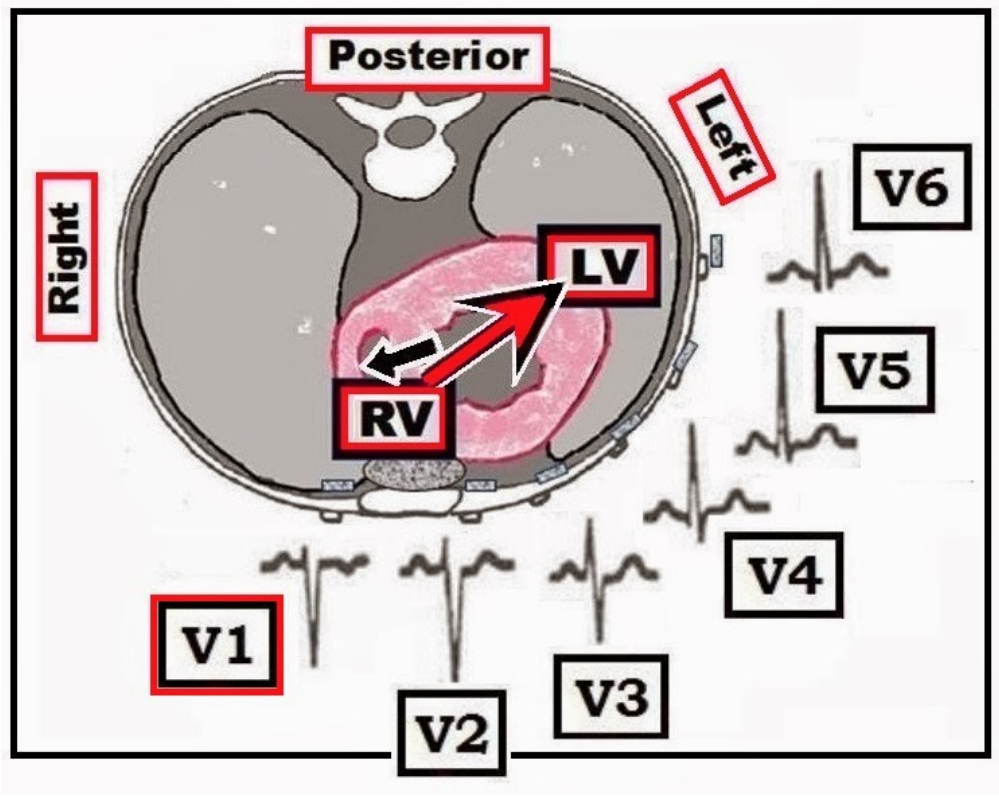
The Basics – breaking it down

- **The QRS segment**, normal width is 70-100ms. Narrow complexes (QRS <100ms), broad complexes (QRS >100ms).



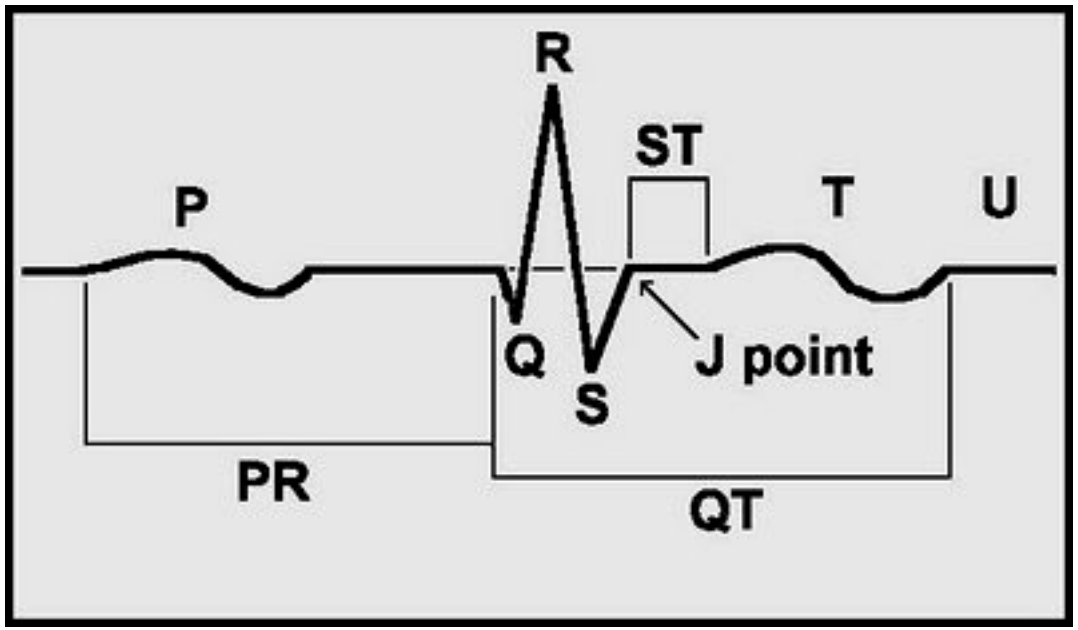
The Basics – breaking it down

- Normal QRS appearance:



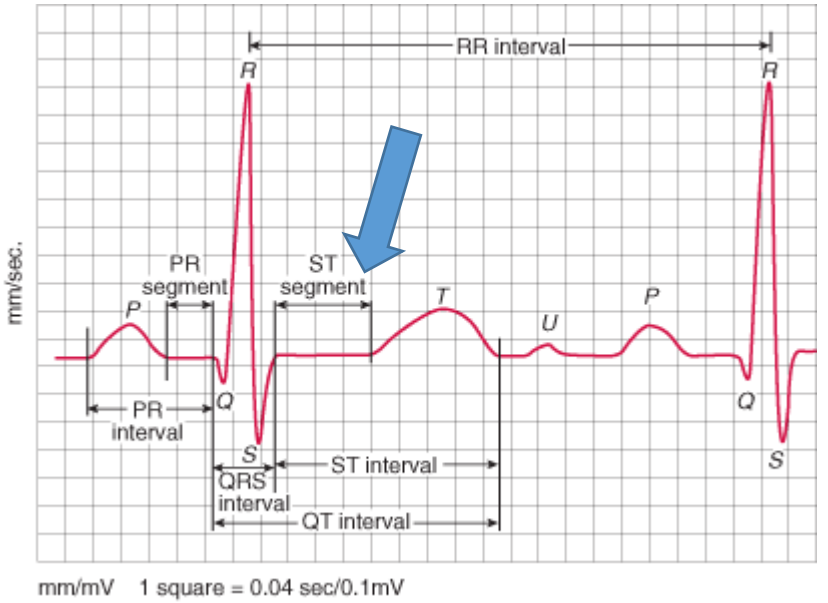
The Basics – breaking it down

- **The J point** is the junction between the termination of the QRS complex and the beginning of the ST segment.



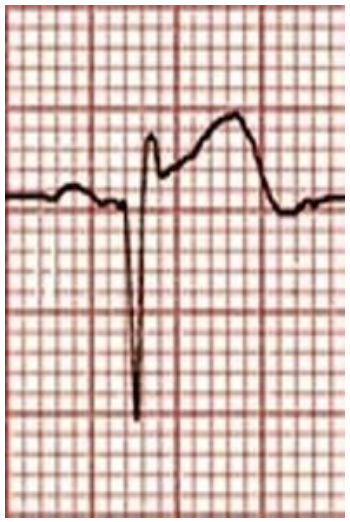
The Basics – breaking it down

- **The ST segment** is the flat, isoelectric section of the ECG between the end of the S wave (the J point) at the beginning of the T wave.
- It represents the interval between ventricular depolarization and repolarization.
- The most important cause of ST segment abnormality (elevation or depression) is myocardial ischemia or infarction.
- Causes of ST segment elevation:
  - Acute MI
  - Coronary vasospasm (Printzmetal's angina)
  - Pericarditis
  - Benign early repolarization
  - LBBB
  - Left ventricular hypertrophy
  - Ventricular aneurysm
  - Brugada syndrome
  - Ventricular paced rhythm
  - Raised ICP



The Basics – breaking it down

- **Acute STEMI** may produce ST elevation w either concave, convex, or oblique morphology :

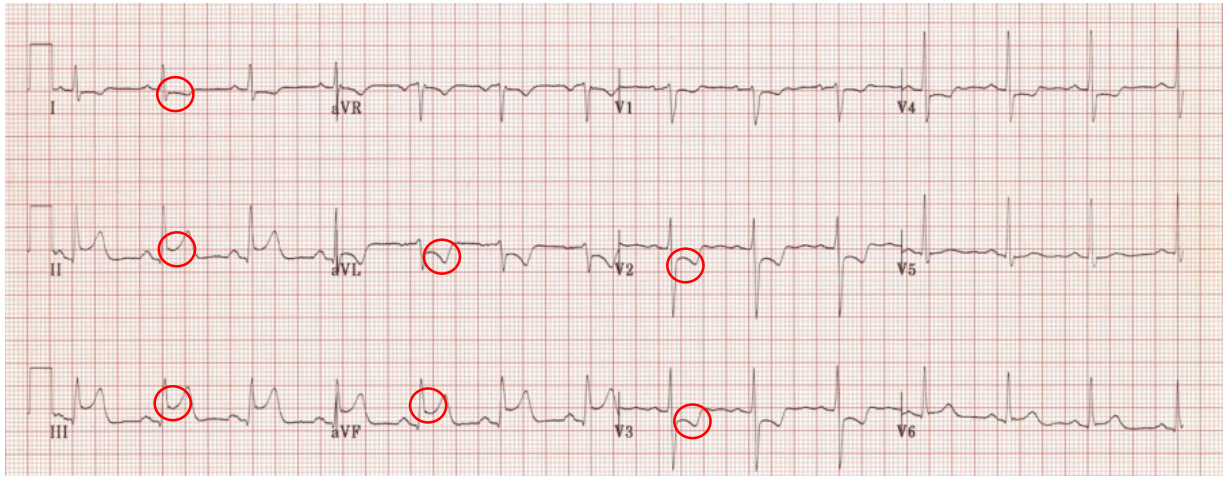


The Basics – breaking it down

- Acute ST elevation myocardial infarction (STEMI):
  - Anterior MI:
    - Anterior STEMI results from occlusion of the left anterior descending artery (LAD).
    - Anterior myocardial infarction carries the worst prognosis of all infarct locations, mostly due to larger infarct size.
    - Risk for v-fib, v-tach and sudden CHF.
    - **How to spot an anterior STEMI:**
    - **ST segment elevation V1, V2, V3, V4.**
      - **(ST depression in the inferior leads II, III and aVF and ST elevation in I, aVL, V3, V4, V5, V6 -> think anterolateral)**
      - *the magnitude of the reciprocal change in the inferior leads is determined by the magnitude of the ST elevation in I and aVL (as these leads are electrically opposite to III and aVF), hence may be minimal or absent in anterior STEMIs that do not involve the high lateral leads.*

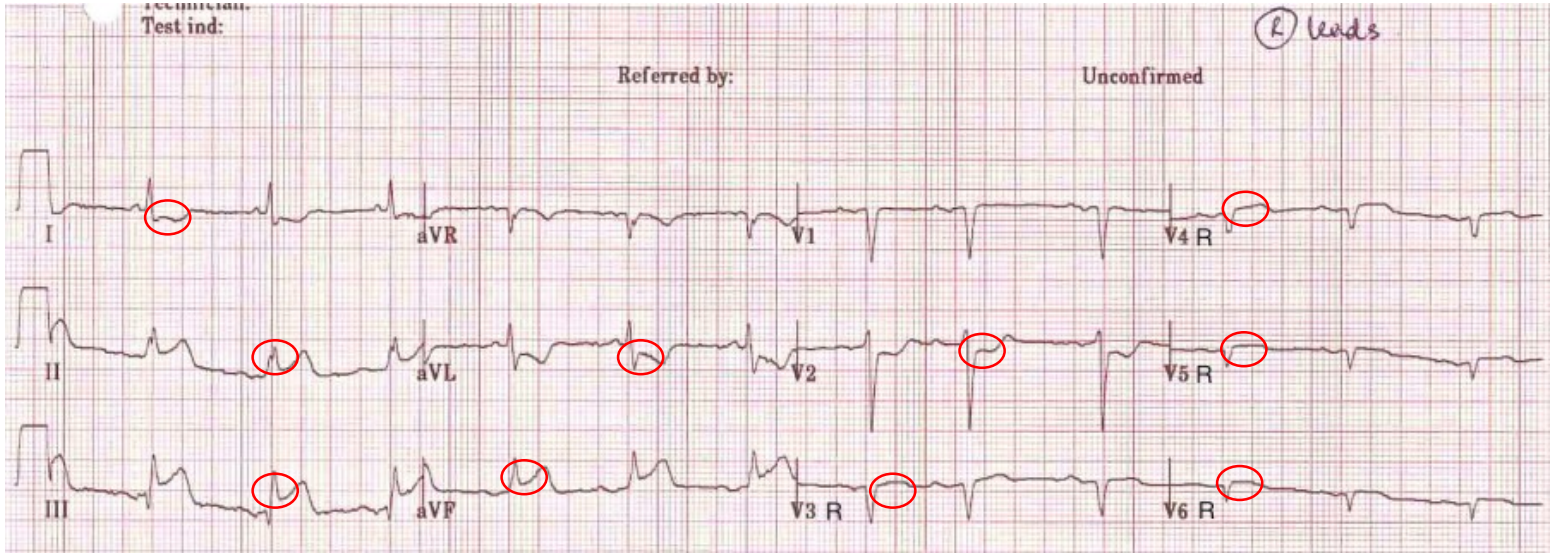
The Basics – breaking it down

- Inferior STEMI's account for 40-50% of all MI's.
- Caused by occlusion of the RCA.
- Up to 40% of patients w an inferior STEMI will have a concomitant right ventricular infarction.
- Inferior STEMI may also be associated w posterior infarction.
- **How to spot an inferior MI:**
  - **ST segment elevation in II, III, aVF**
  - **ST segment depression in I, aVL (V2, V3)**



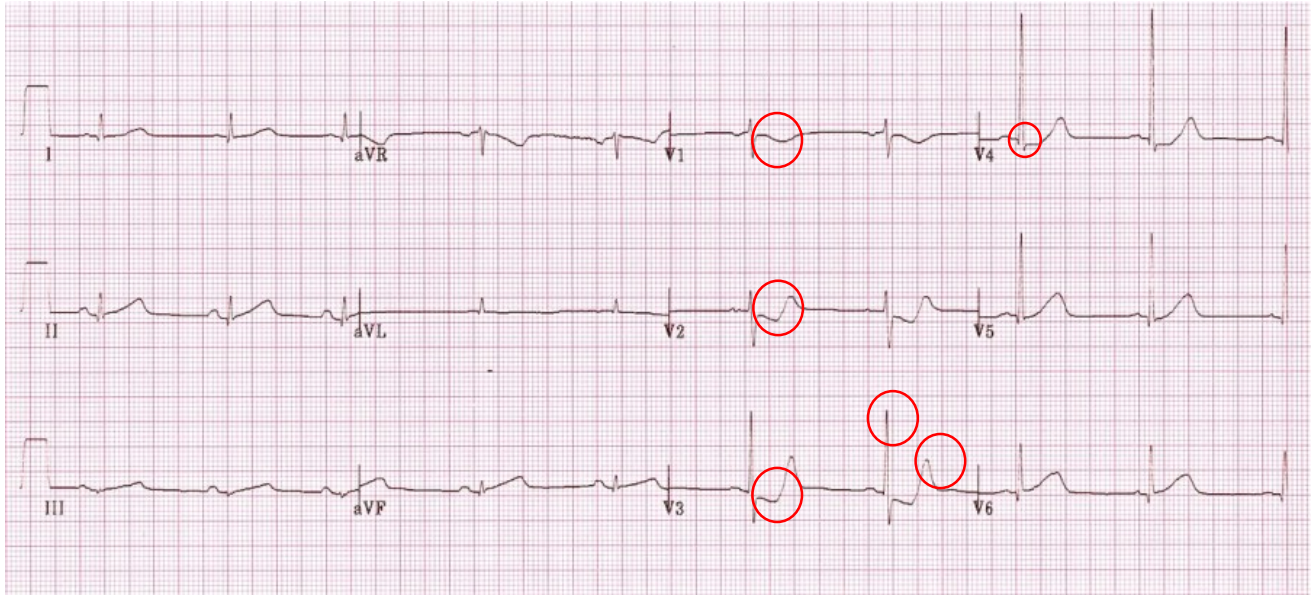
The Basics – breaking it down

- **Always suspect right ventricular infarction in a pt w inferior STEMI!**
  - Right ventricular infarction is confirmed by the presence of ST elevation in the right-sided leads. ST elevation in V4R has a 88% sensitivity and diagnostic accuracy of 83%.
  - ST elevation in V1 (only lead that looks directly at the R ventricle)
  - ST elevation in lead III (lead III is more rightward facing)
  - ST elevation in V1 + ST depression in V2, V3



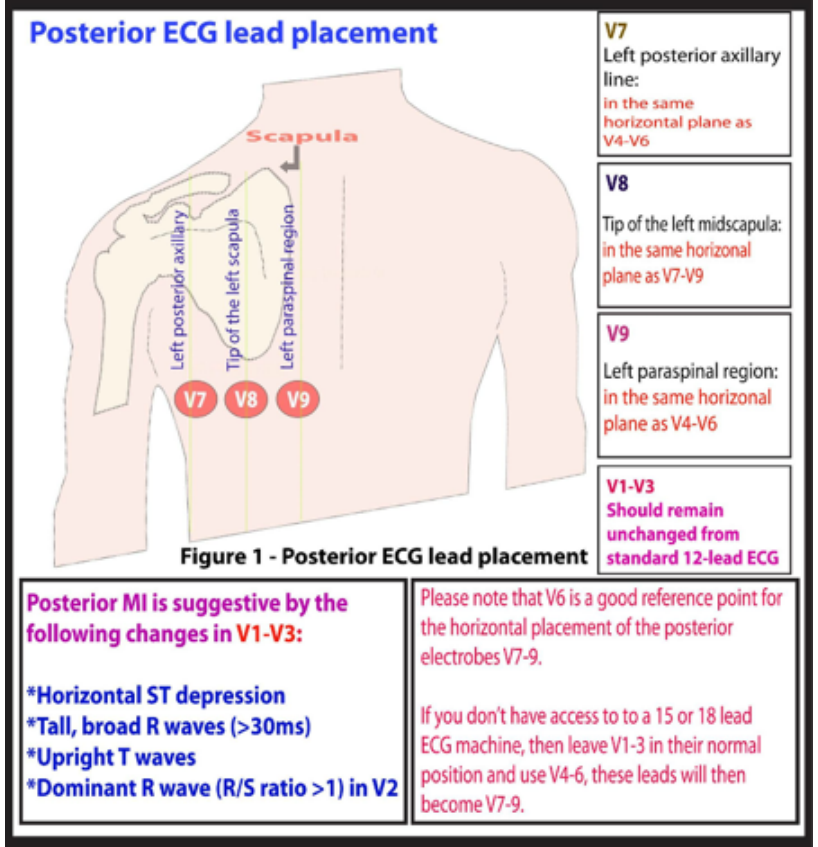
The Basics – breaking it down

- Posterior infarction accompanies 15-20% of inferior or lateral infarction.
- **How to spot a posterior MI:**
  - **The posterior myocardium is not directly visualized by the standard 12 lead ECG, look for reciprocal changes in the anteroseptal leads V1-4.**
  - **Look for changes in V1-4**
    - **Horizontal ST depression**
    - **Tall, wide R waves**
    - **Upright T waves**
    - **Dominant R wave in V2**
    - ***(Inferior or lateral wall MI)***



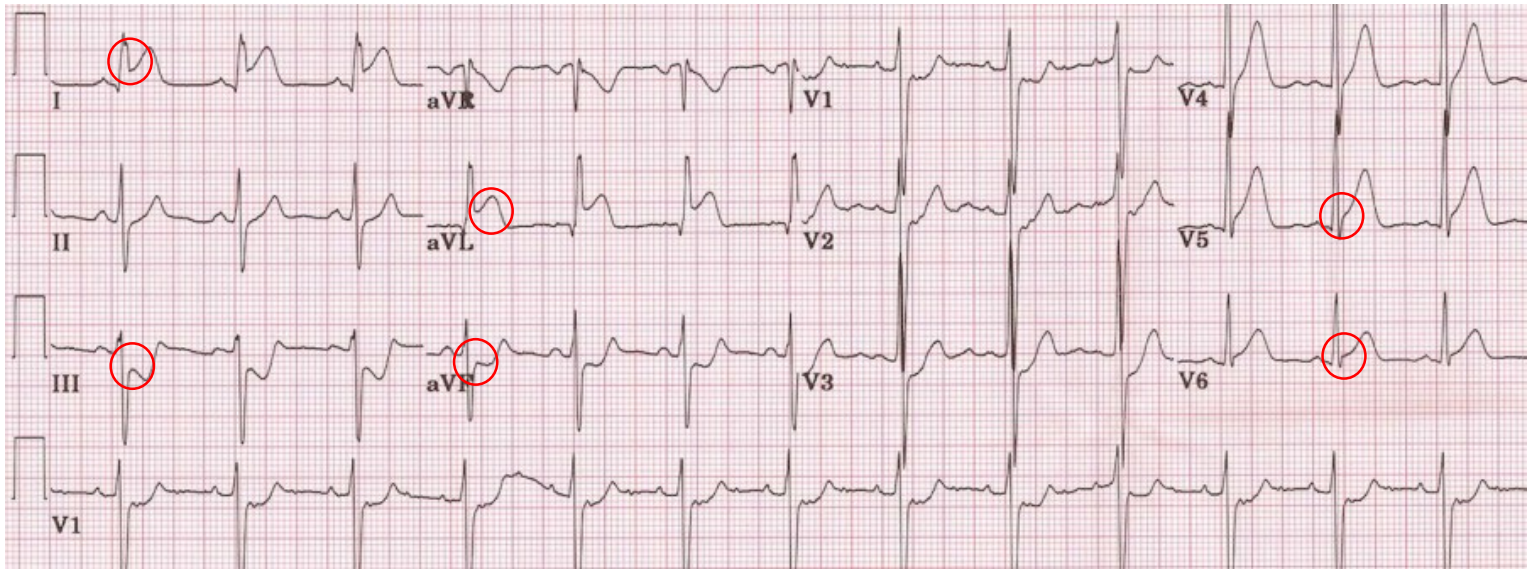
The Basics – breaking it down

- Lead cable V6 connects to electrode V9
- Lead cable V5 connects to electrode V8
- Lead cable V4 connects to electrode V7
- Lead cables V1-V3 are connected the same way as when obtaining a standard 12-lead ECG



The Basics – breaking it down

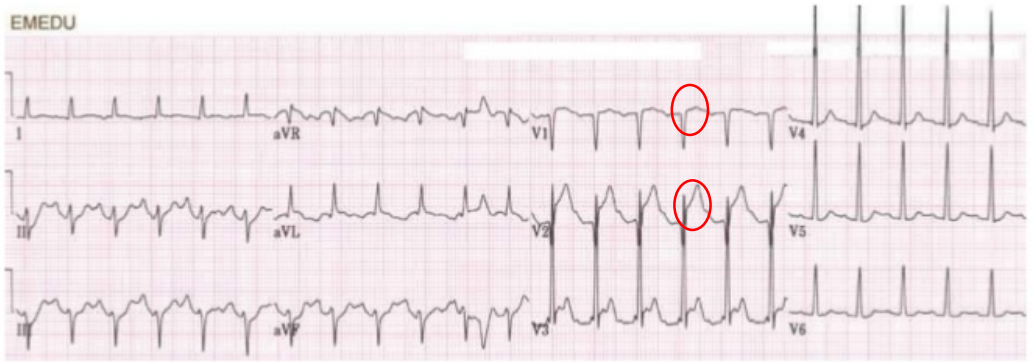
- The lateral wall of the LV is supplied by branches of the left anterior descending (LAD) and left circumflex arteries.
- Usually seen as an extension of anterior or inferior MI.
- **How to spot a lateral STEMI:**
  - **ST elevation in the lateral leads (I, aVL, V5-6).**
  - **Reciprocal ST depression in the inferior leads (II, III and aVF).**



The Basics – breaking it down

- How to spot a septal MI:
  - **ST elevation in V1 and V2**
  - No reciprocal changes

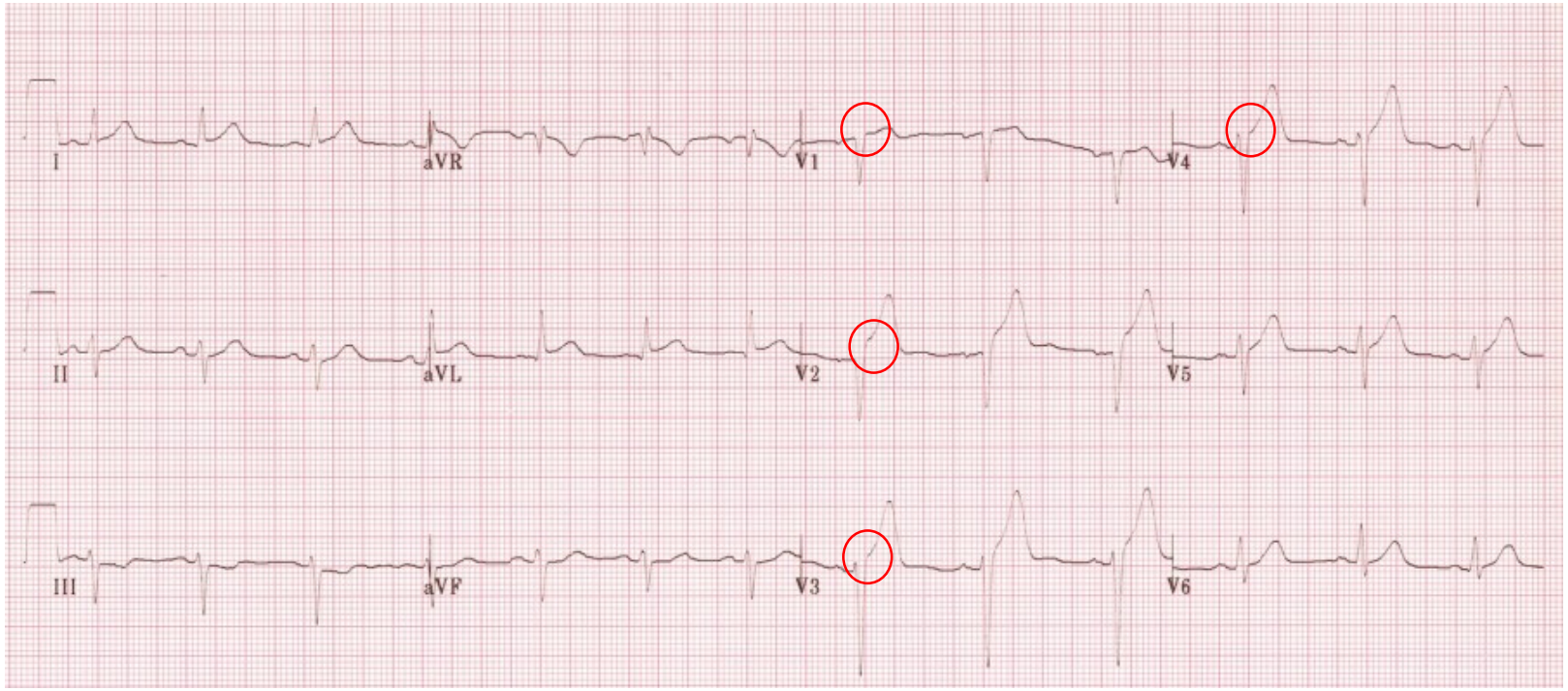
Septal MI



Which leads are the septal leads?

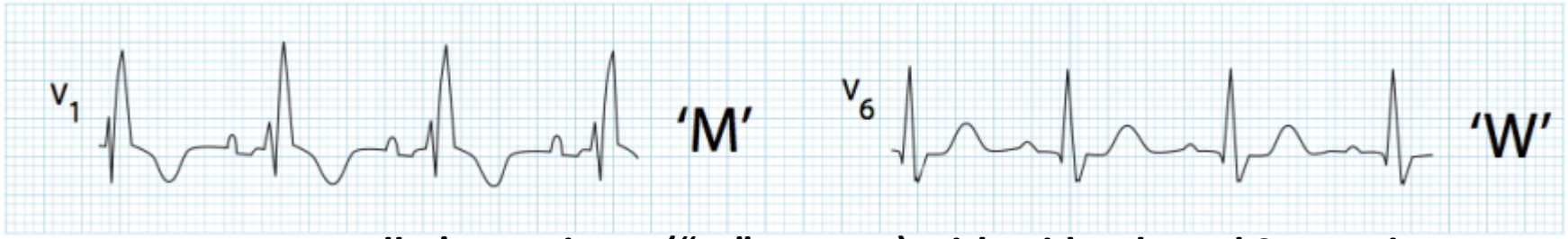
The Basics – breaking it down

- How to spot an anteroseptal MI:
  - **ST elevation V1-V4**
  - Peaked T waves in V2-V4
  - No reciprocal ST depression



The Basics – breaking it down

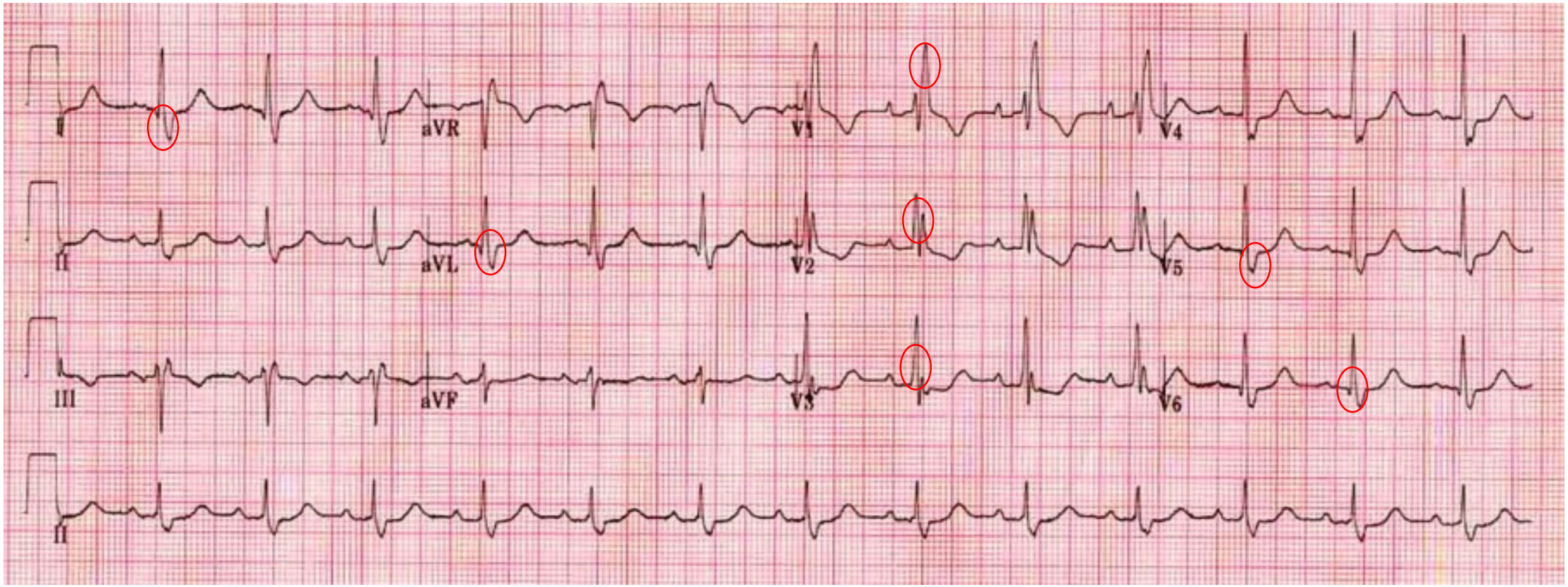
- RBBB
  - Block in electrical conduction of the right ventricle.



Tall R' wave in V1 ("M" pattern) with wide, slurred S wave in V6 ("W" pattern)

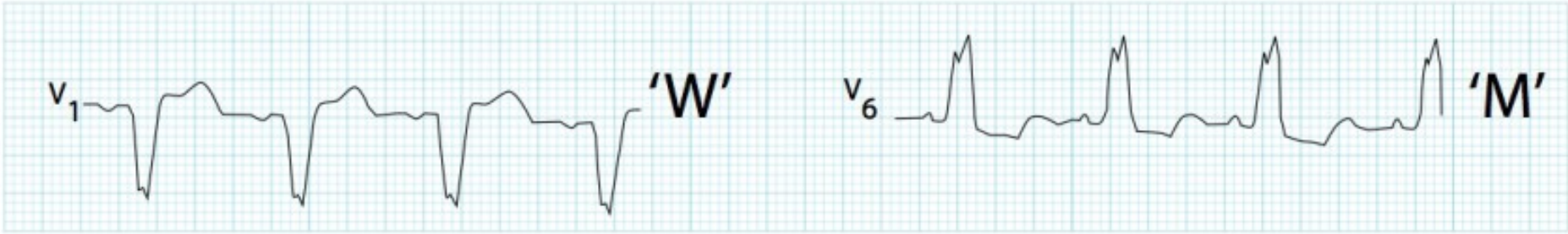
- Broad QRS > 120 ms (0.12 seconds)
- RSR' pattern in V1-(3) ('M-shaped' QRS complex)
- Wide, slurred S wave in the lateral leads (I, aVL, V5-6)

The Basics – breaking it down



The Basics – breaking it down

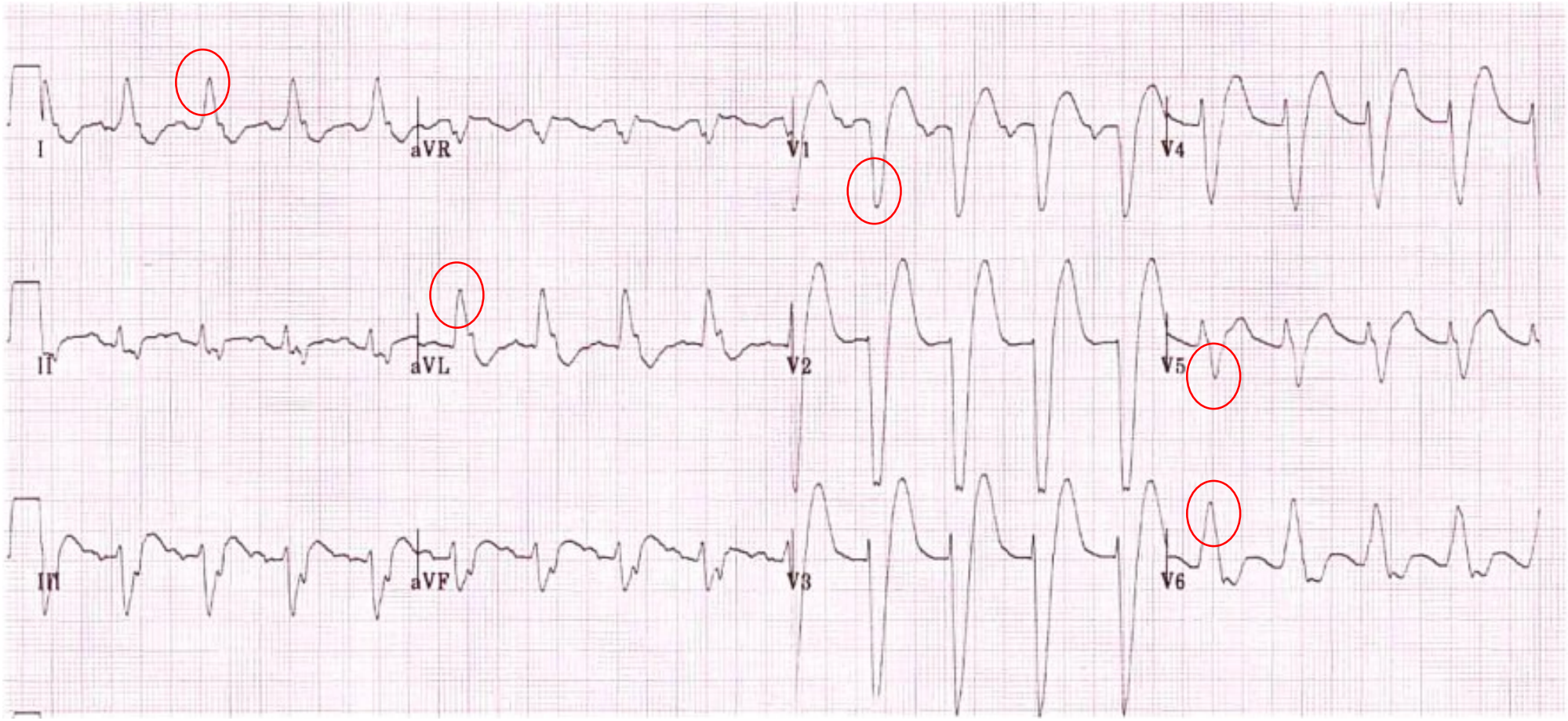
- LBBB:
  - A LBBB is caused by a disruption of the electrical conduction of the LB or both fascicles.



Dominant S wave in V1 with broad, notched ('M'-shaped) R wave in V6

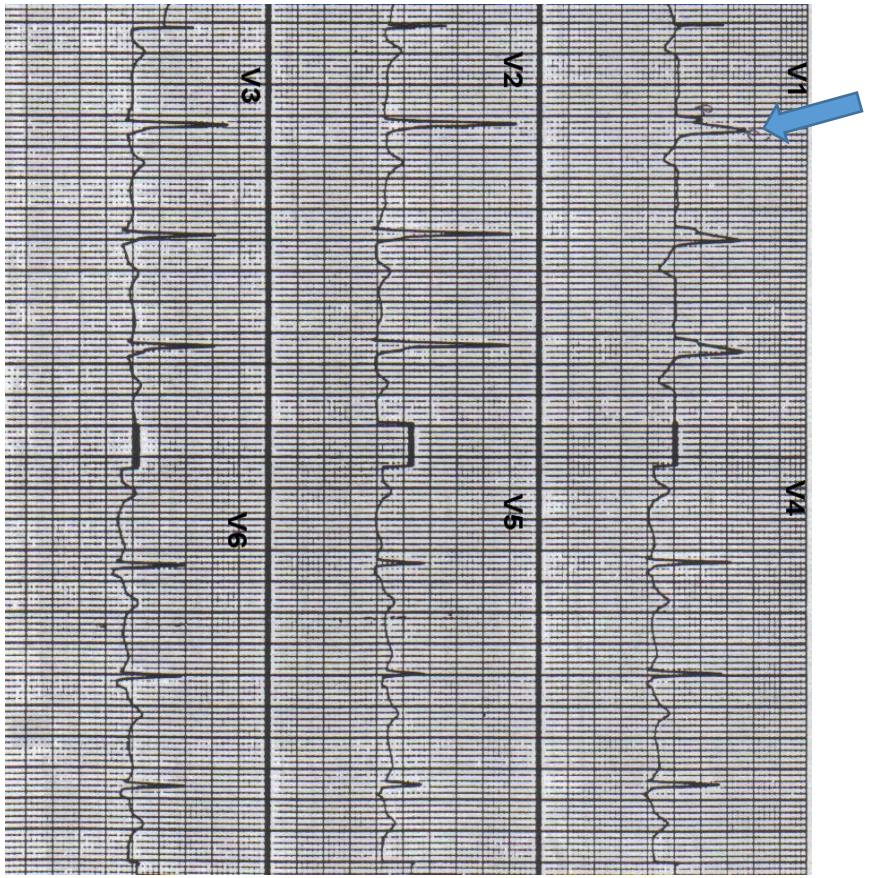
- QRS duration of > 120 ms
- Dominant S wave in V1
- Broad monophasic R wave in lateral leads (I, aVL, V5-V6)
- Absence of Q waves in lateral leads (I, V5-V6; small Q waves are still allowed in aVL)

The Basics – breaking it down



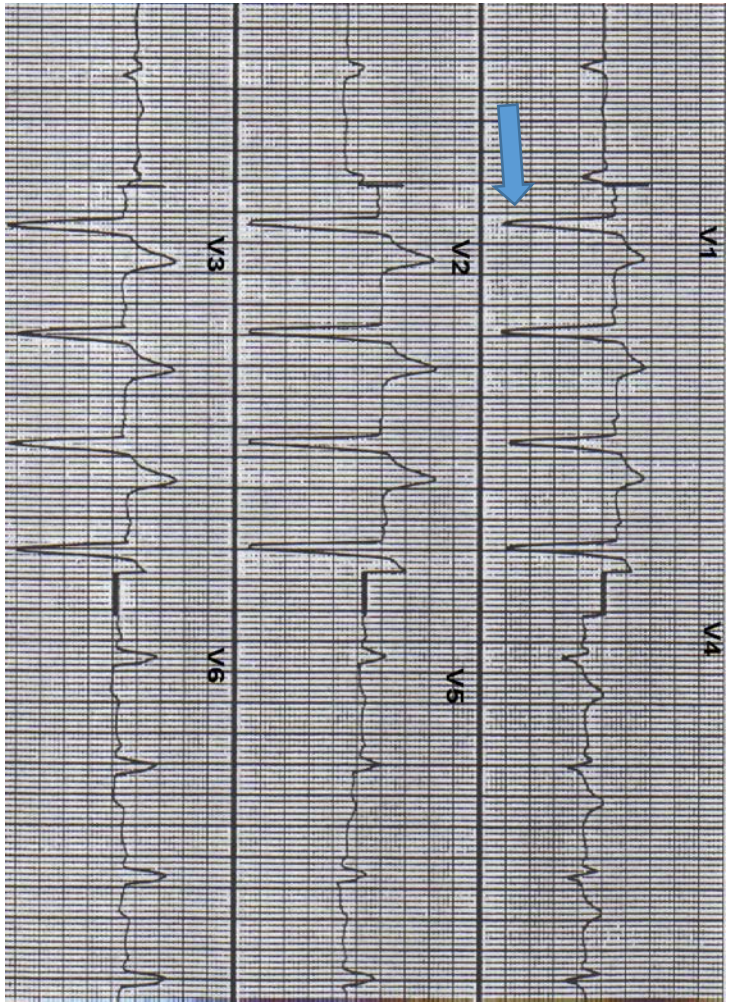
The Basics – breaking it down

- If everything else fails… use the turn signal approach:
    - QRS must be >.12 seconds
    - Turn 12 lead page so that the top is to the right
    - Look at **V1 ONLY**
    - Which way is the QRS complex pointing?
        - In this case it is to the right so this is a right BBB



The Basics – breaking it down

- And another one…..
  - Turn the page
  - Look at V1
  - The QRS is pointing to the left
    - Left BBB



Systematic Approach

- Know the relationship between leads and views of the heart.
- Verify that aVR is negative (ensure proper lead placement)
- Assess rate and rhythm
- Find signs of ischemia, injury and infarction
  - T wave inversion
  - ST segment elevation
  - Significant Q waves
- Identify acute MI patterns (elevations and depression)

- http://hqmeded-ecg.blogspot.com/
- https://www.ecgmedicaltraining.com/
- http://www.nottingham.ac.uk/nursing/practice/resources/cardiology/function/bipolar_leads.php
- http://www.fireemsblogs.com/
- http://lifeinthefastlane.com/ecg-library/
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- AAOS Critical Care Transport