

EKG Morphology Lecture



The “P’s” to Practice by

Recap from last session: First 2 Steps

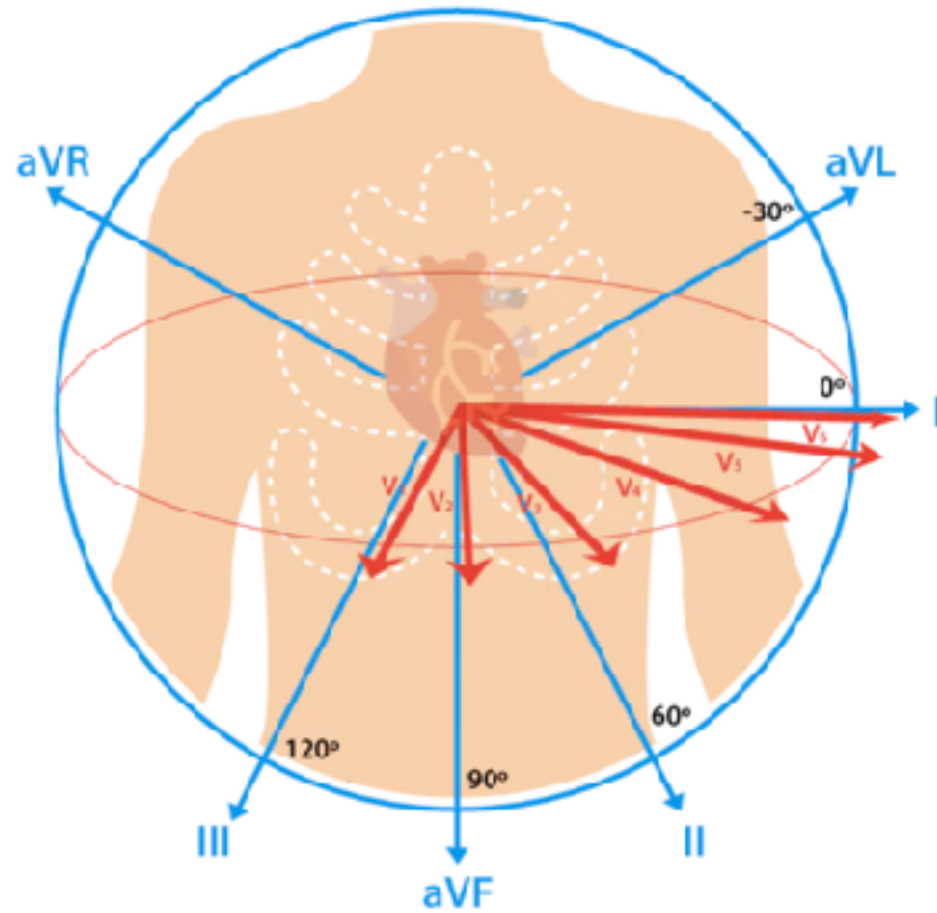
- **Step 1: What is the heart rate?**

- *What are the 2 methods we discussed?*

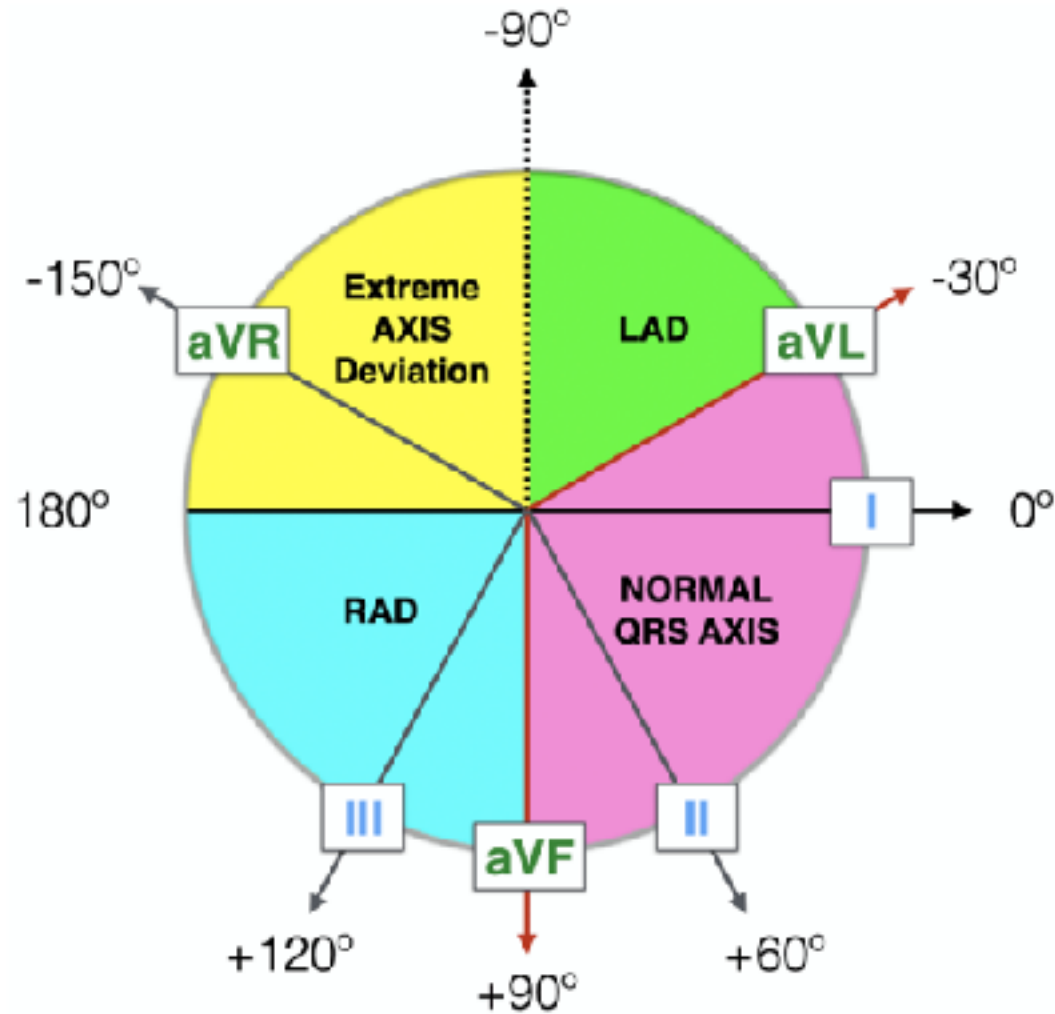
- **Step 2: What is the rhythm?**

- *What are the 3 questions we ask to determine rhythm?*

Step 3: Determining Axis



Normal vs Abnormal Axis



How do we determine axis?

+I & +avF

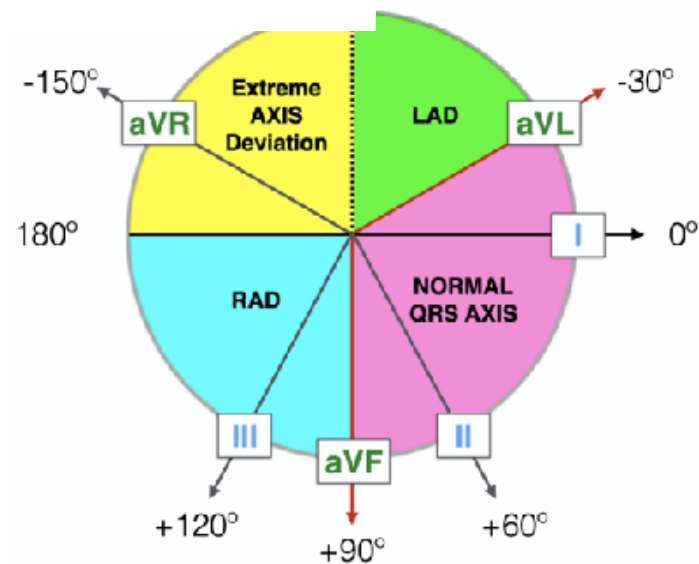
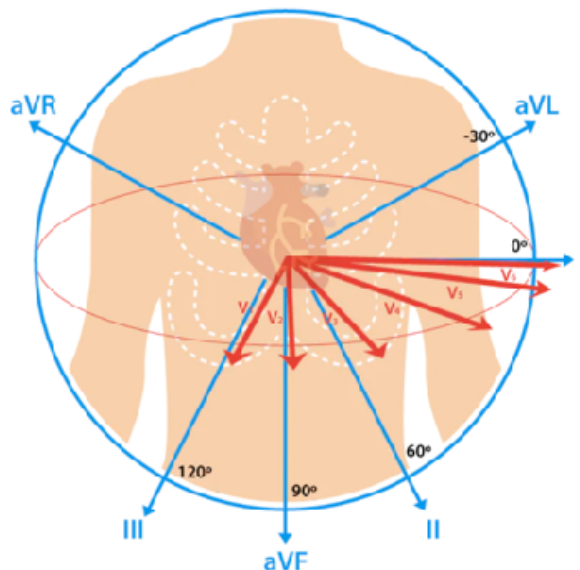
- Normal Axis
- “2 thumbs up”

+I & -avF

- Look at lead II
 - “Negative in II to be TRUE left axis deviation”
 - If +II, then normal axis

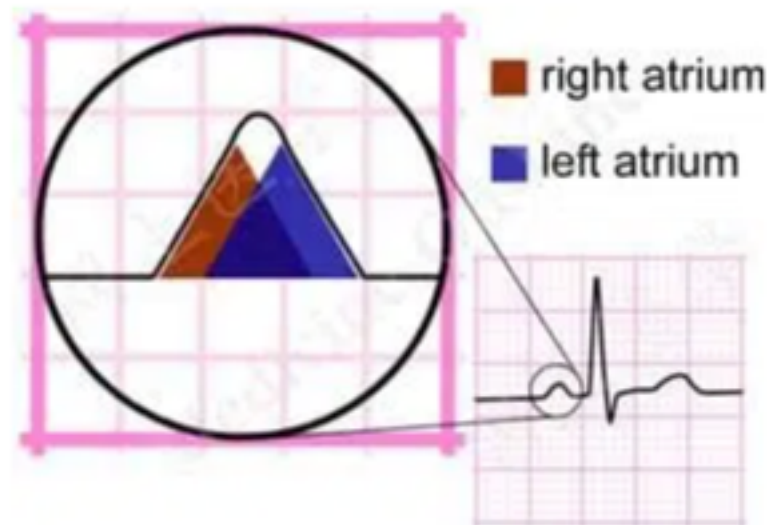
-I and +avF

- Right axis deviation



P-wave Morphology

- *Atria are small so voltage generated is also small*
- *Amplitude of p wave: usually $< 0.25\text{mV}$ or 2.5mm (aka 2.5 small boxes)*
- *Atria depolarize from Right to Left*











Leads for P-wave Morphology

Lead II

- *Nearly parallel to flow of current through atria so records largest positive deflection*
- *Very sensitive to perturbation in atrial depolarization*

Lead V1

- *To right of sternum*
- *Oriented perpendicularly to flow of current*
- *Biphasic and allows easy separation of right and left atrial components*

	II	V1
Normal		
RAE		
LAE		
RAE + LAE		

P-wave Morphology

Right Atrial Enlargement

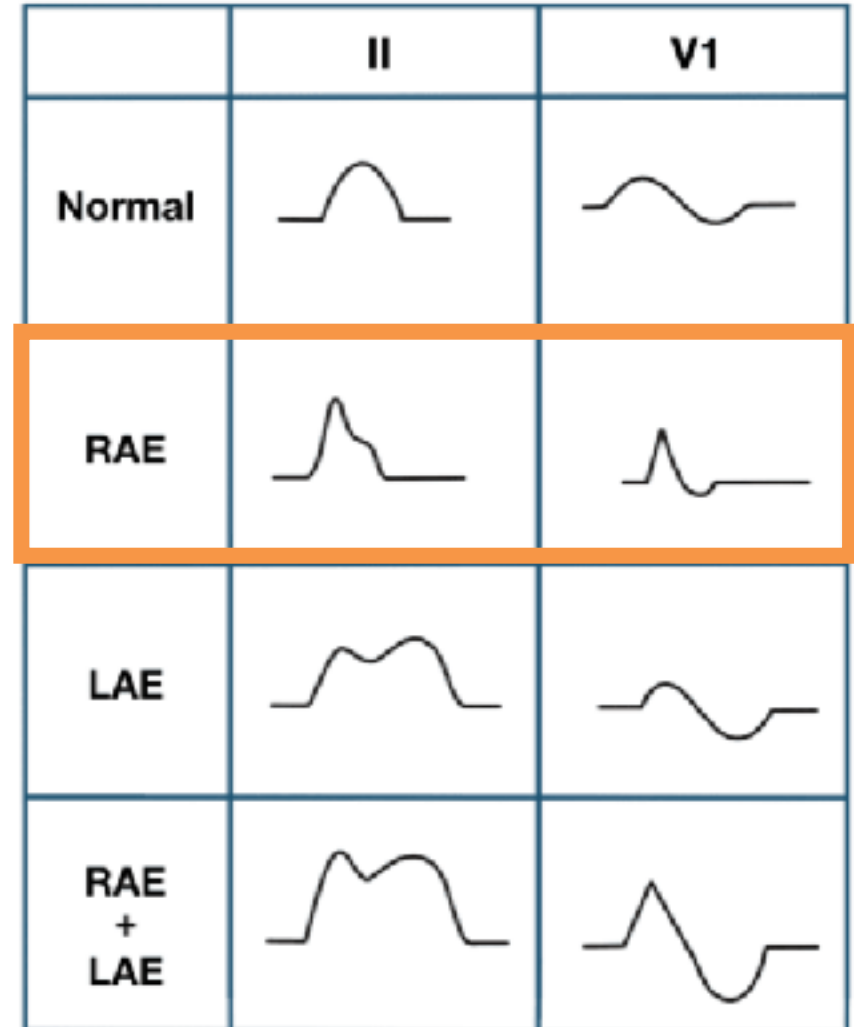
- Width doesn't change because terminal component of p wave is Left Atrial in origin
 - *Prolonged depolarization of RA hidden by LA portion of p wave (eg while RA taking longer to depolarize don't see as LA is depolarizing at that time)*

• Lead II

- P wave amplitude **TALLER** ($> 2.5\text{mm}$ /small boxes) as parallel to vector which is larger given larger Right Atrium

• Lead V1

- **Peaked initial portion** (reflects R-side of heart as R-side more anterior)



P-wave Morphology

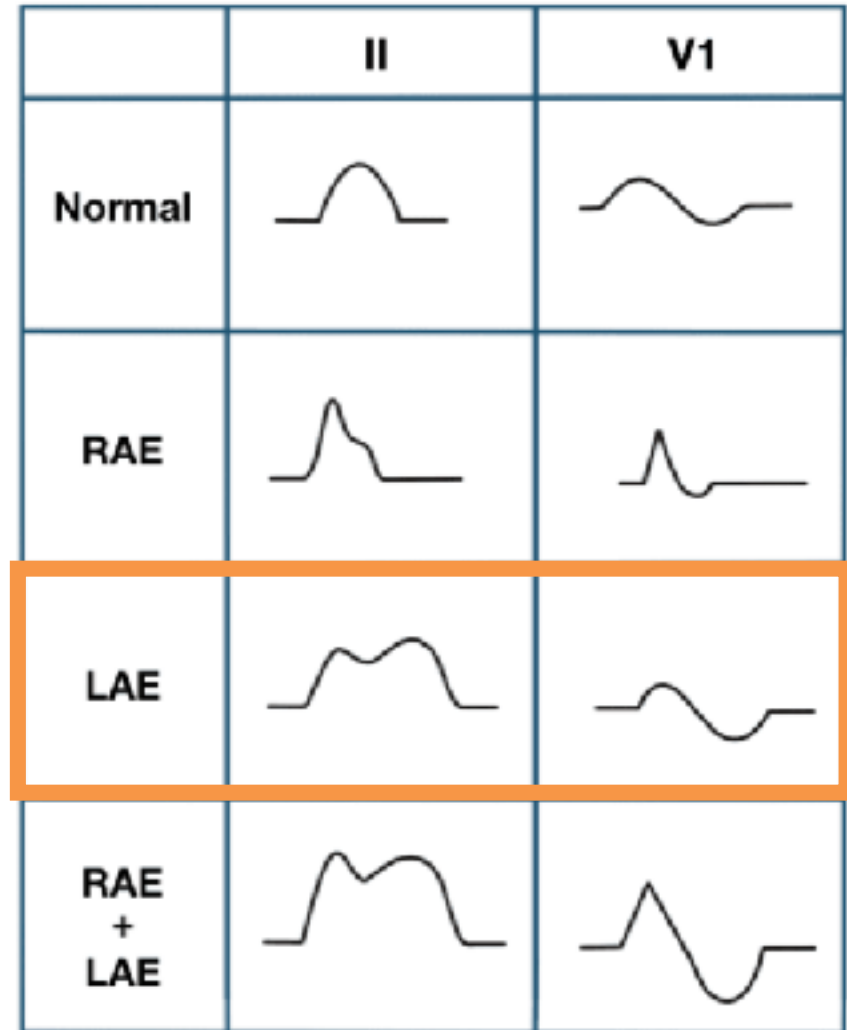
Left Atrial Enlargement

• Lead II

- Increased duration of p-wave (**>2.5 small boxes**) since terminal portion of p wave represents Left Atrial depolarization (which will take longer time-wise as Left Atrium larger) >2.5 small boxes

• Lead V1

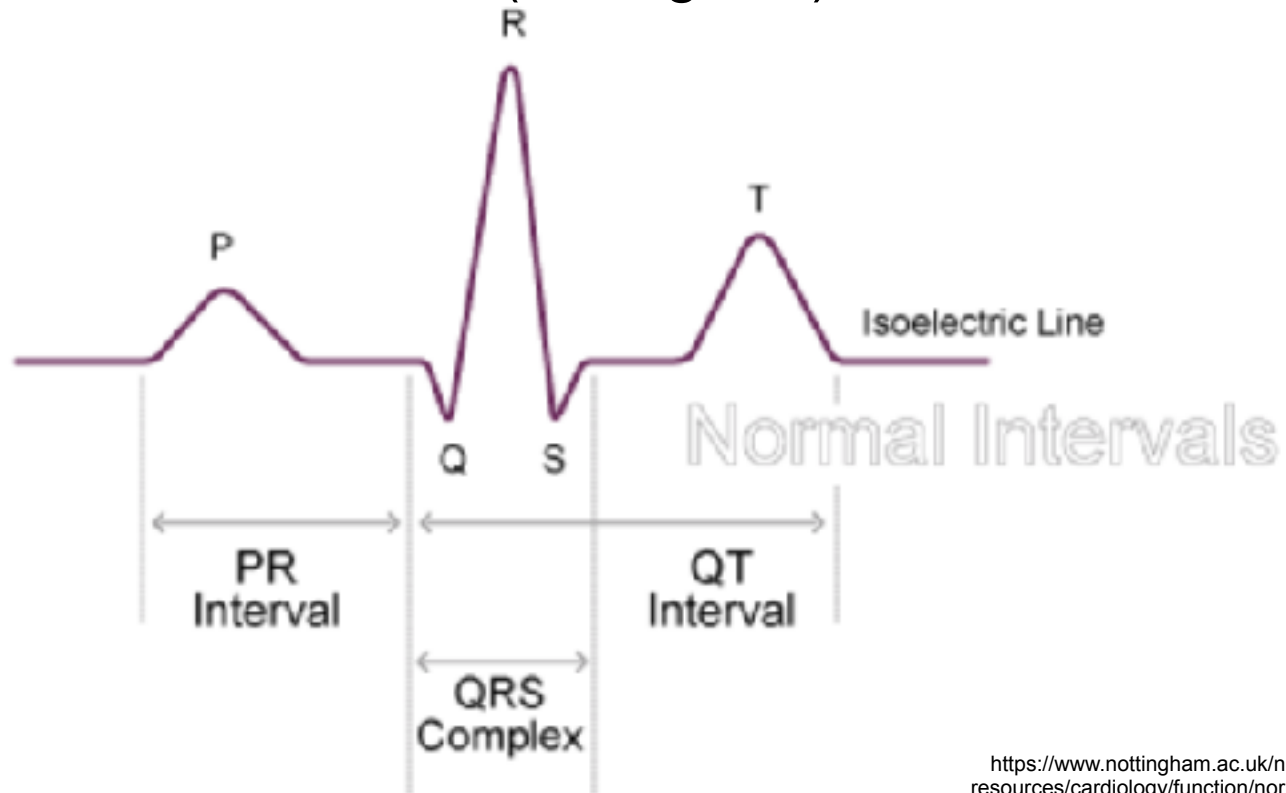
- Will see **drop >1mm (1 small box) below isoelectric line** since V1 overlies the R heart



PR Interval

Definition of PR Interval: Beginning of p-wave to beginning of QRS

Normal Duration: <0.2 seconds (< 1 big box)



https://www.nottingham.ac.uk/nursing/practice/resources/cardiology/function/normal_duration.php

What are the definitions of 1st, 2nd and 3rd degree AV blocks?

46 years

Female Caucasian

62in 144lbs

Vent. rate 88 bpm

PR interval 132 ms

QRS duration 82 ms

QT/QTc 346/419 ms

P-R-T axes 42 -76 57

Rate
Rhythm
Axis

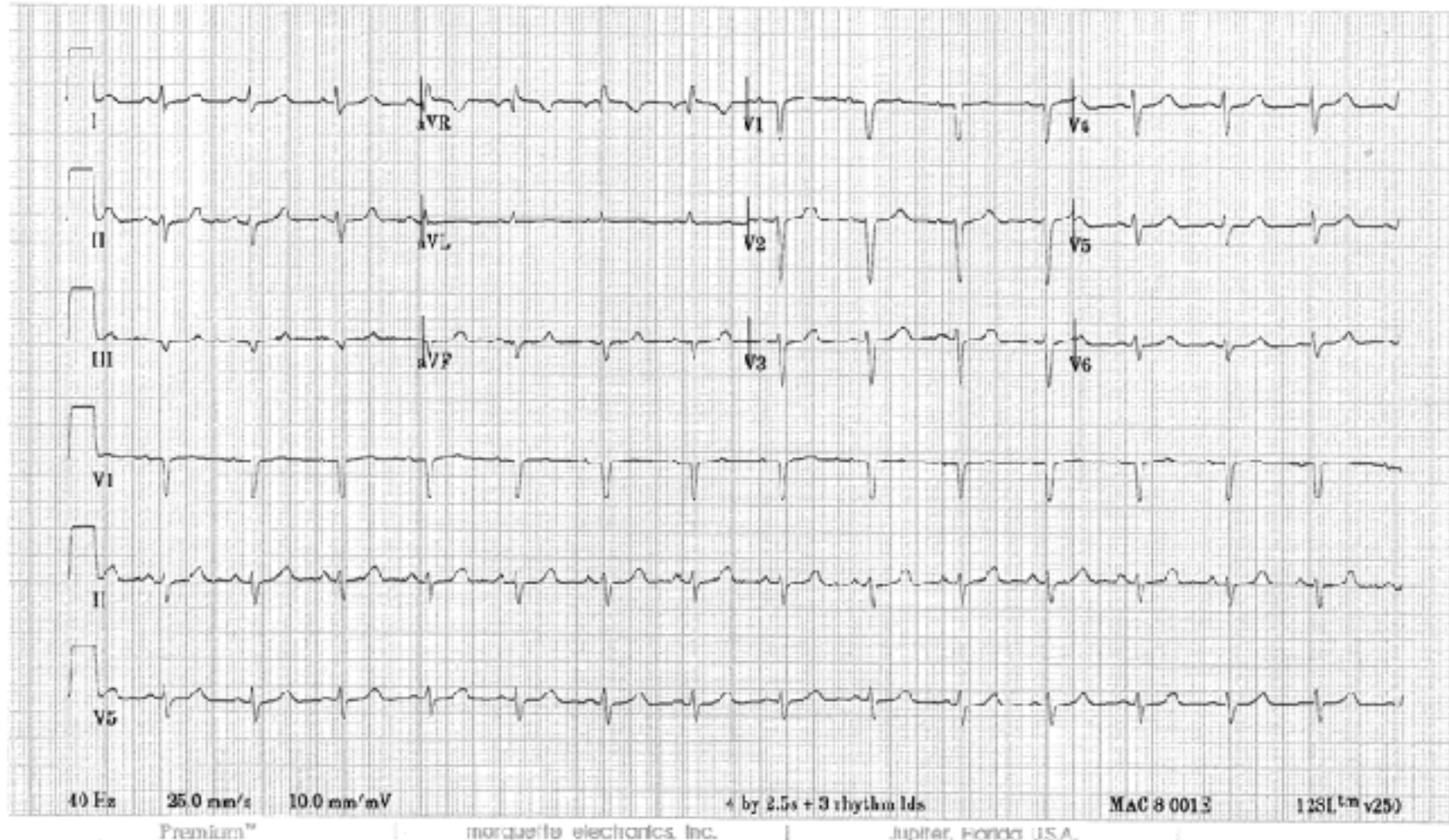
P wave morphology-?Atrial Enlargement
PR interval

Technician: SB

EKG #1

Referred by: Dr. Reinhert

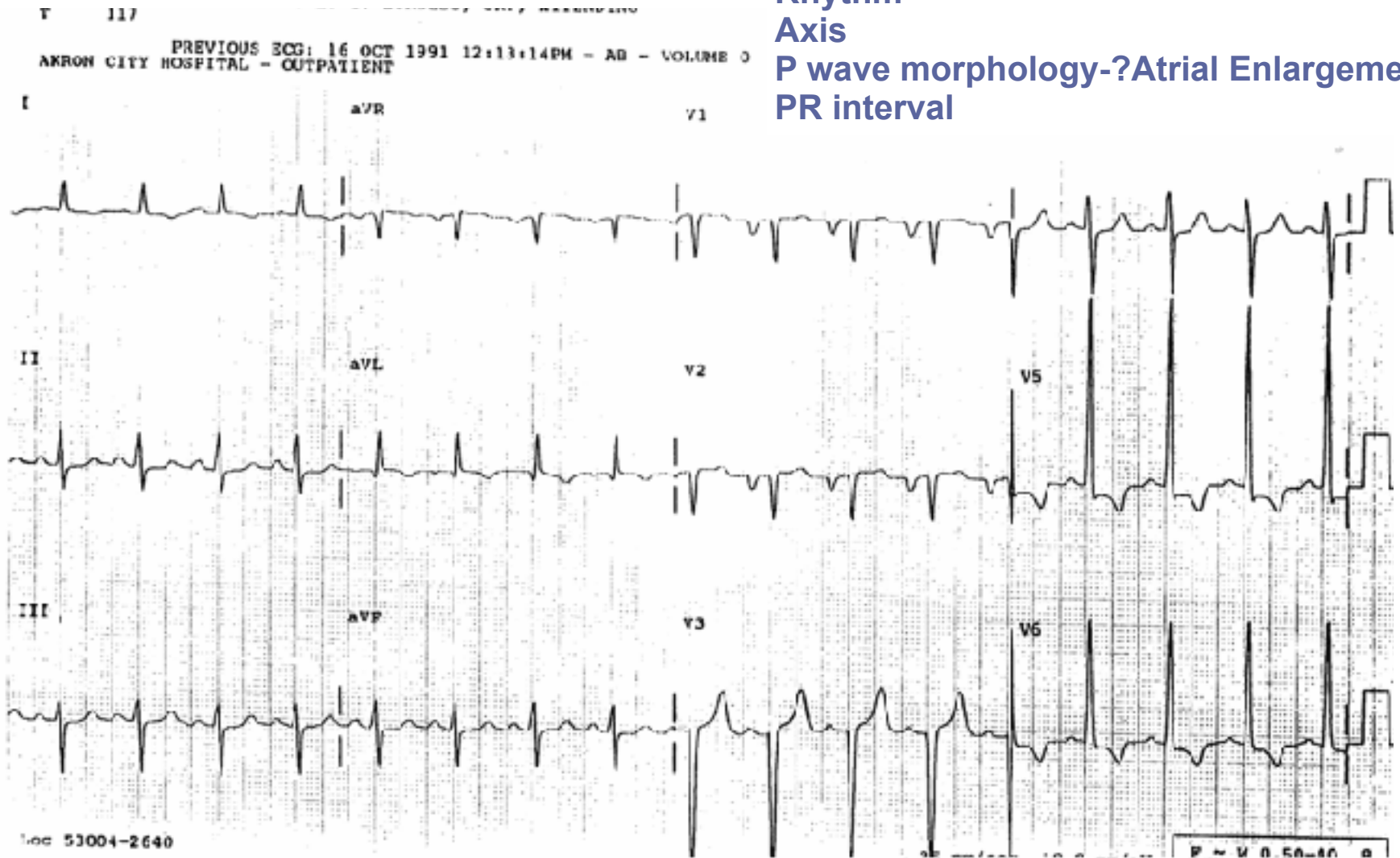
Unconfirmed



EKG #2

Rate
Rhythm
Axis

P wave morphology-?Atrial Enlargement
PR interval



QRS Complex

- If 1st deflection is downward

- **Q wave**

- The 1st deflection upward

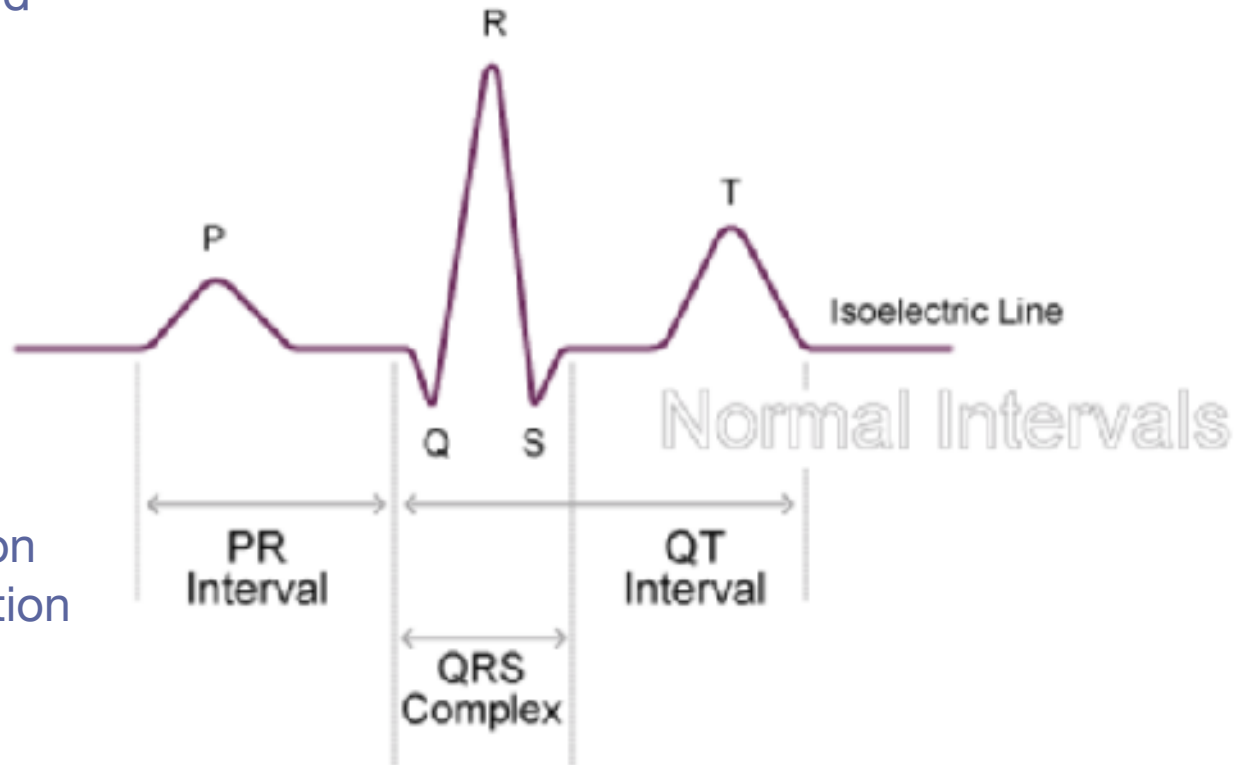
- **R wave**

- The 1st downward deflection following an upward deflection

- **S wave**

- If there is a 2nd upward deflection

- **R' wave**



QRS Complex

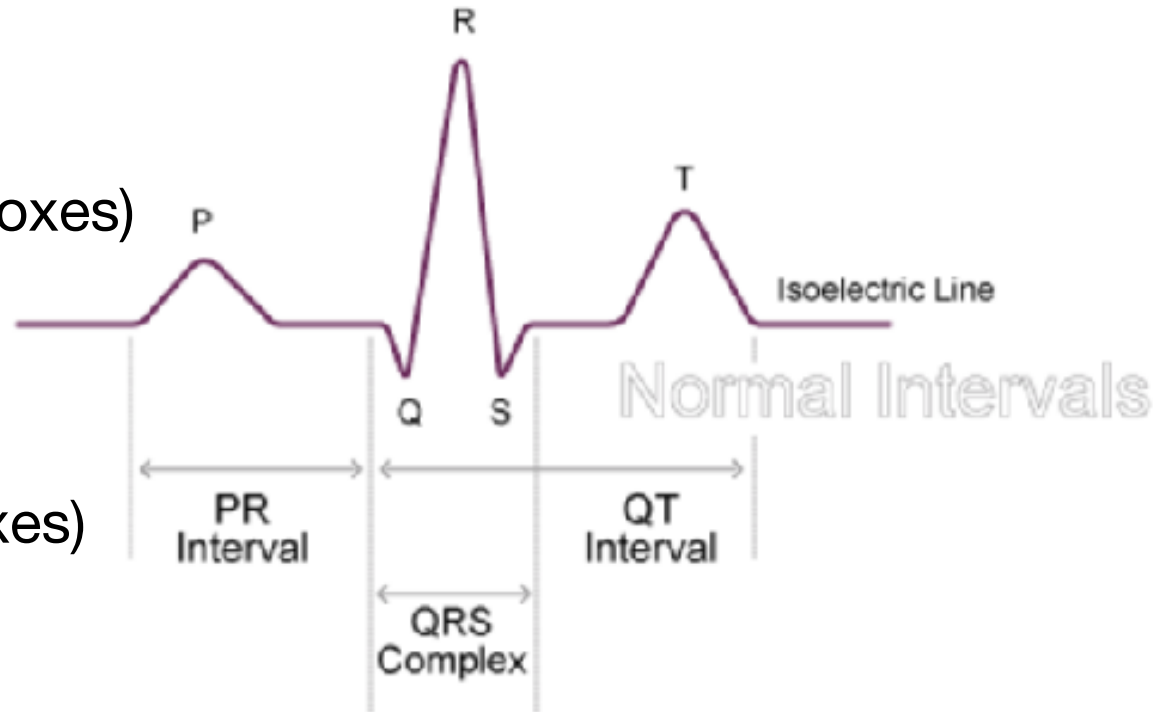
- **Most of what is seen on EKG represents Left Ventricle**
(since LV = 3x mass of RV)

- **Normal QRS**

- <0.10 sec (2.5 small boxes)

- **Wide QRS**

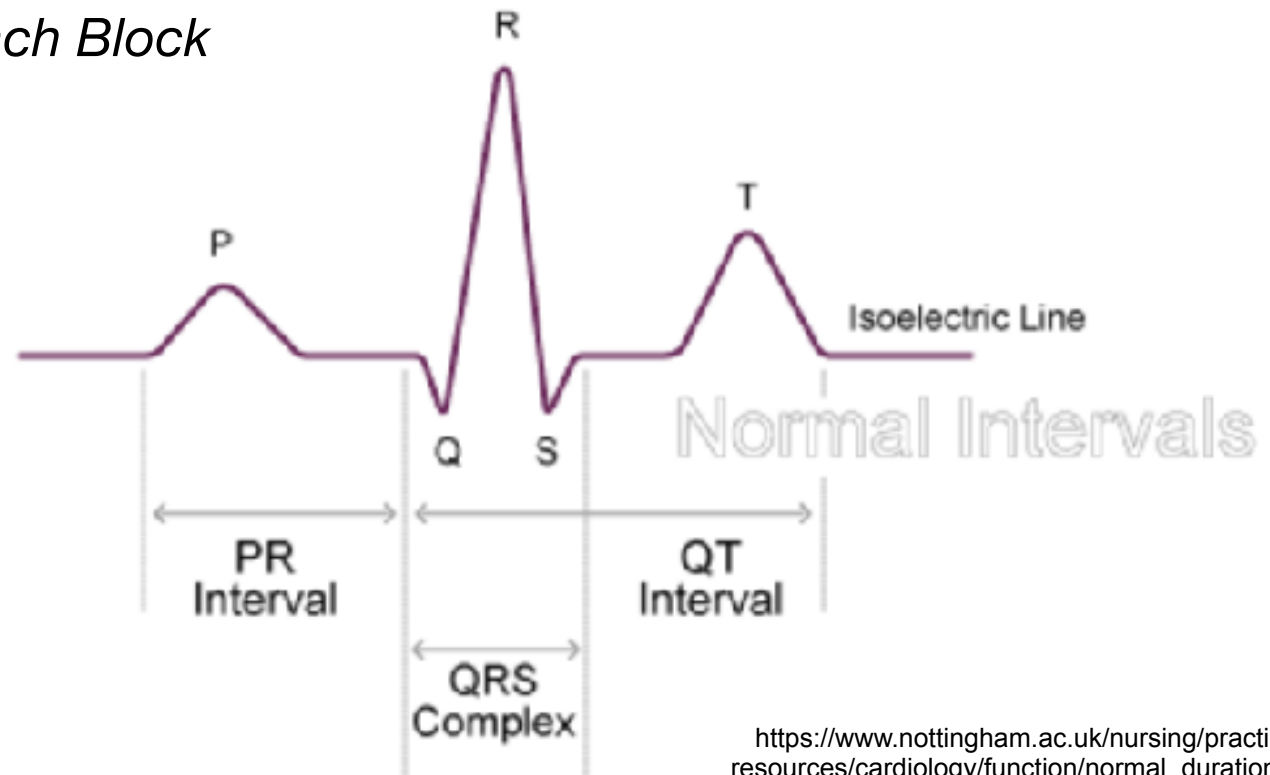
- >0.12 sec (3 small boxes)



QRS Complex

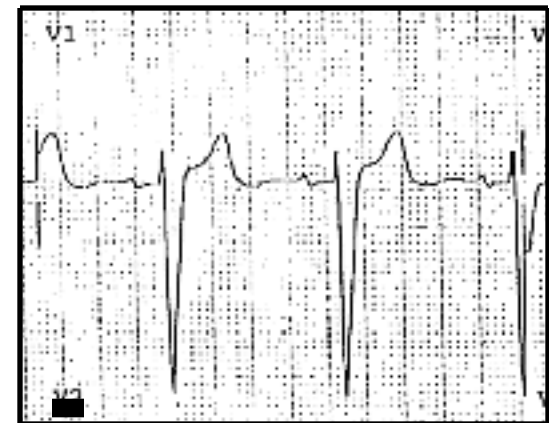
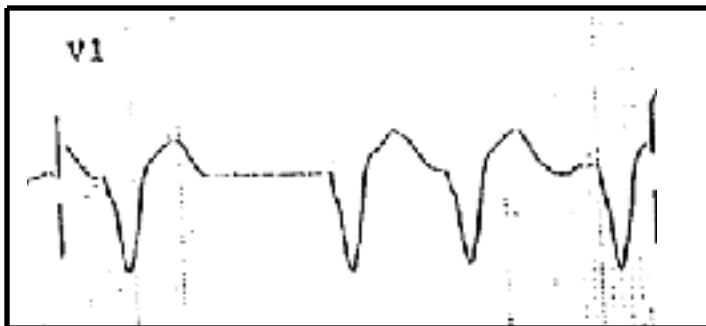
- Causes of wide QRS

- *Beat originating in ventricle*
- *Supra-ventricular beat conducted aberrantly*
 - *Bundle Branch Block*



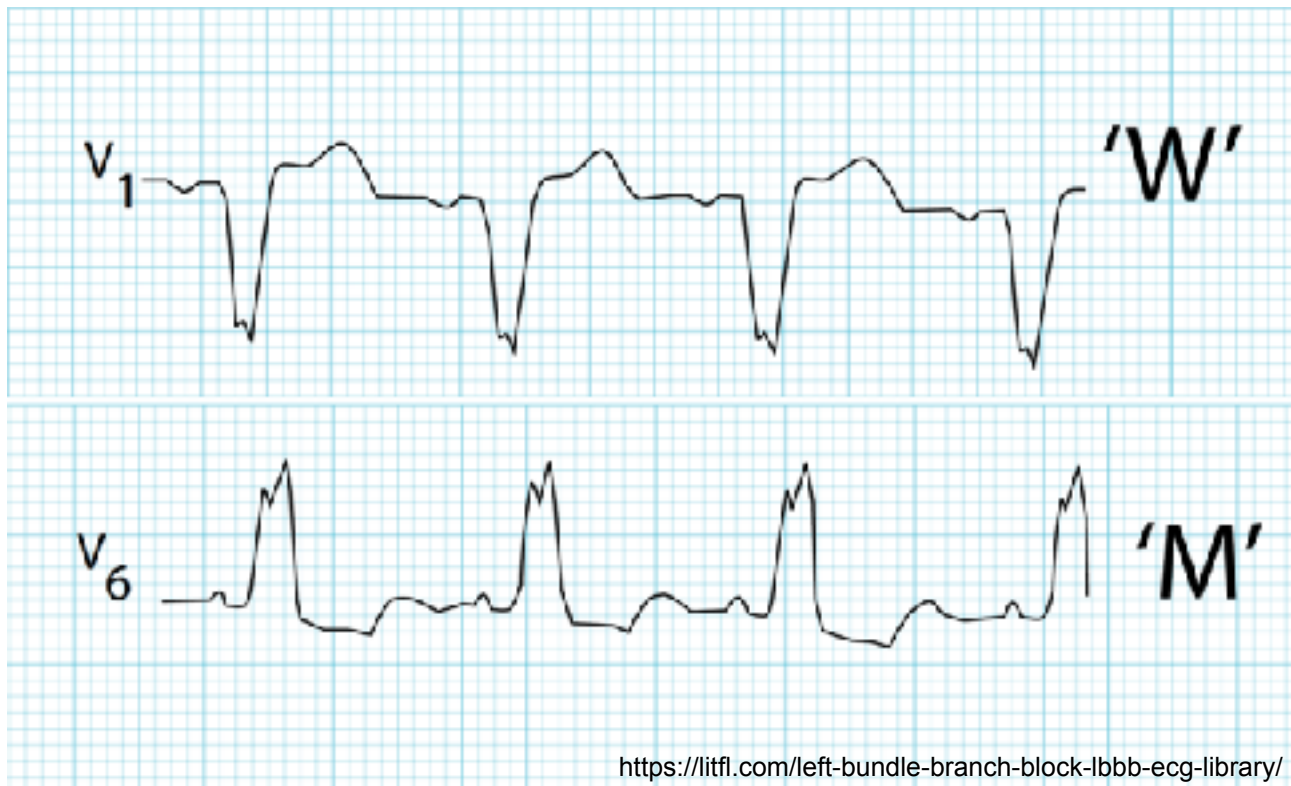
LBBB Criteria

- Wide QRS: $>0.12\text{sec}$ (3 small boxes)
- Lead V1: Deep S wave (qS or rS)
 - Why?
- *“Left behind in a hole”*



LBBB Criteria

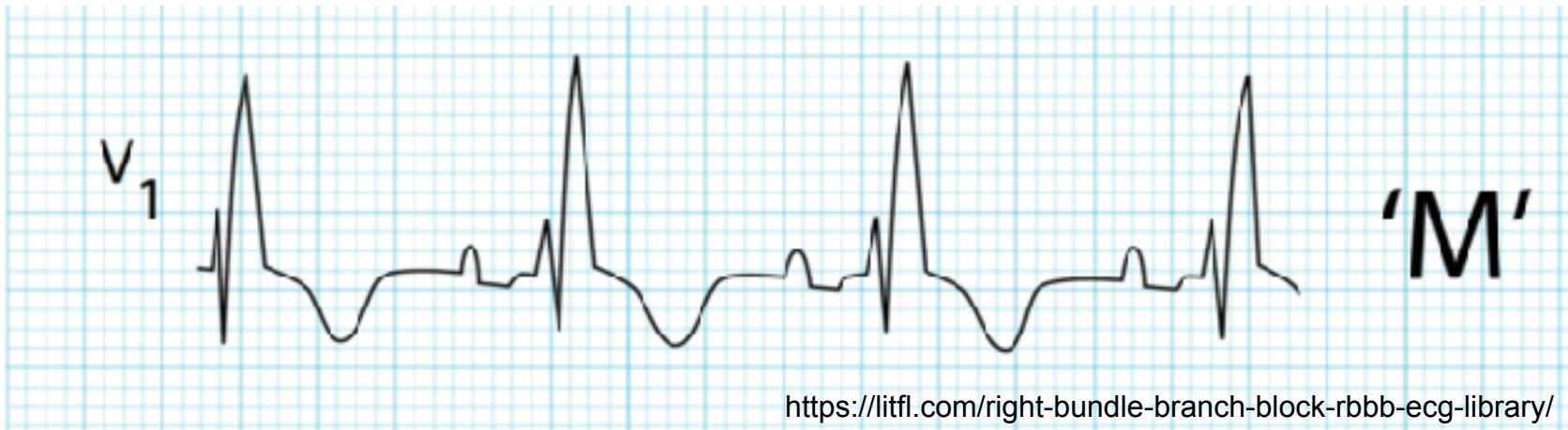
- Lead V6:
 - *Overlies the LV so wider R wave because LV taking longer to depolarize*



- **Difficult to assess/interpret ST elevations in LBBB** (*can interpret in RBBB*)

RBBB Criteria

- Wide QRS: $>0.12\text{sec}$ (3 small boxes)
- Lead V1: M shaped QRS (“bunny ears” / rSR’)
 - Second R’ represents RV finally depolarizing after LV has finished
 - *Positive wave because V1 overlies the RV*



Simple rule: if you see a wide QRS and a prominent R’ wave in V1 it is a RBBB

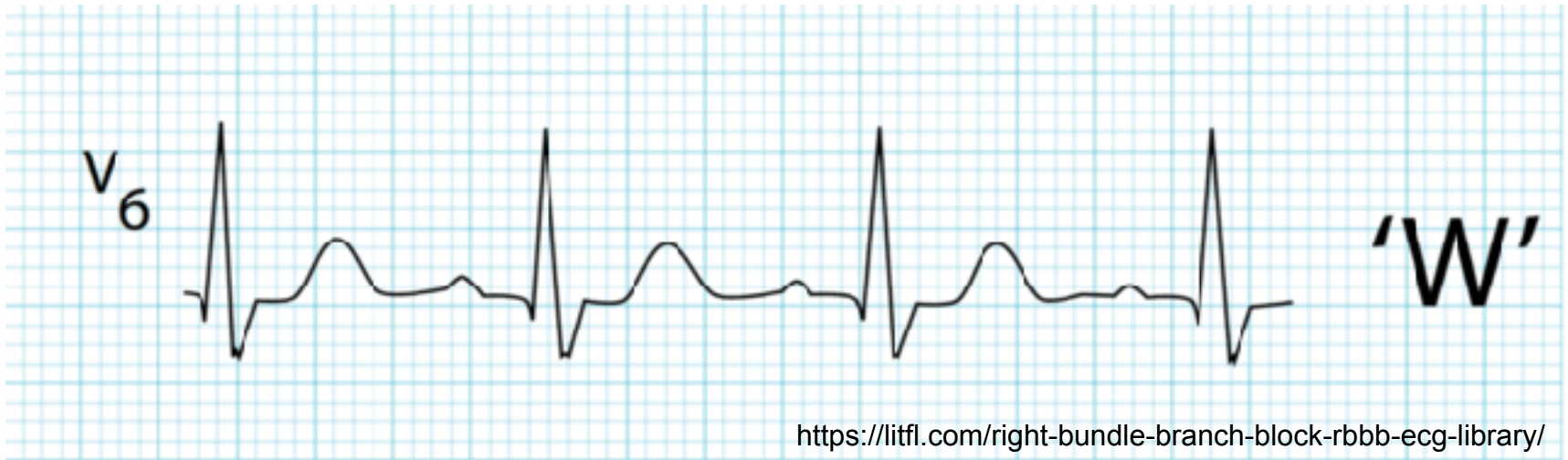
– *R is for Right Bundle Branch Block*

RBBB Criteria

- What would you expect to happen to “S” wave in lead V6 then?

RBBB Criteria

- Wide QRS: $>0.12\text{sec}$ (3 small boxes)
- Lead V6: Wide S at end of QRS
 - Late RV depolarization causes reciprocal late deep S waves
 - *V6 along midaxillary line and so RV depolarization opposite direction/negative*



RBBB Criteria



Left Ventricular Hypertrophy

- Determining LVH by EKG
 - **Useful** but **imperfect** tool for detecting LVH
 - **Inexpensive** and widely **available**
 - **Limitations**
 - **Moderate sensitivity**
 - *So if not meeting criteria, doesn't rule out LVH*
 - **Higher specificity**
 - *If evidence of LVH on EKG by certain criteria, then higher likelihood LVH is actually present*

EKG Findings of LVH

- *Increased QRS Voltage*
- *Increased QRS duration (“kinda wide” - not BBB)*
- *Leftward axis given larger LV mass*
- *Left atrial enlargement*
- *“Repolarization” abnormality in ST-T’s*

Left Ventricular Hypertrophy

- Two main voltage rules
 - **S wave in V1 plus R wave in V5 or V6 $\geq 35\text{mm}$**
(≥ 35 small boxes)
 - *More sensitive*
 - **R wave in aVL $\geq 11\text{mm}$** (≥ 11 small boxes)
 - *More specific*

Romhilt-Estes Point Score System

Criterion	Points
Any limb R wave or S wave ≥ 2.0 mV (20 mm)	3
OR S in V1 or S in V2 ≥ 3.0 mV (30 mm)	
OR R in V5 or R in V6 ≥ 3.0 mV (30 mm)	
ST-T wave changes typical of LVH	
Taking digitalis	1
Not taking digitalis	3
Left atrial abnormality	
P terminal force in V1 is 1 mm or more in depth with a duration 40 milliseconds (0.04 seconds)	3
Left axis deviation $\geq -30^\circ$	2
QRS duration ≥ 90 milliseconds	1
Intrinsicoid deflection in V5 or V6 ≥ 50 milliseconds (0.05 seconds)*	1

A score of 5 or more indicates "definite" LVH; a score of 4 indicates "probable" LVH.

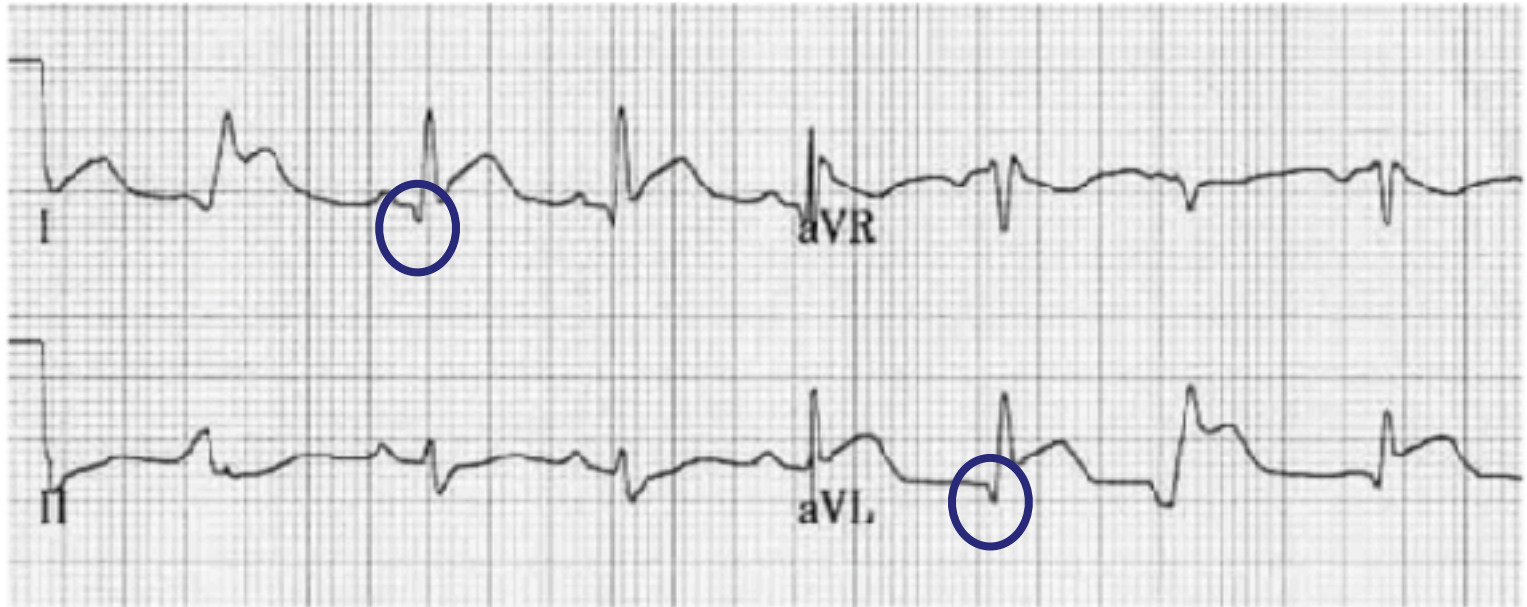
ECG: electrocardiogram; LVH: left ventricular hypertrophy.

* Intrinsicoid deflection is defined as interval between beginning of QRS interval and the peak of the R wave.

Q Waves

- **Definition:** *Considered Q wave if 1st deflection of QRS is downward*
- **Normal Q-waves**
 - *Ventricular septal depolarization moves L to R so left lateral leads record it as small initial negative deflection (Q wave) which can also be seen in inferior leads and can be normal*
- **Pathologic Q-waves**
 - *Indicate scar/infarct (develop within hours of MI)*
 - *>1mm (>1 small box) wide*
 - *>2mm (>2 small boxes) deep*
 - *>25% of depth of QRS*
 - *In contiguous leads*
 - *What are contiguous leads (lateral, inferior, anterior)?*

Q Waves



<https://litfl.com/q-wave-ecg-library/>

• Lateral Q waves (I, aVL) with ST elevation due to acute MI

ST Segment

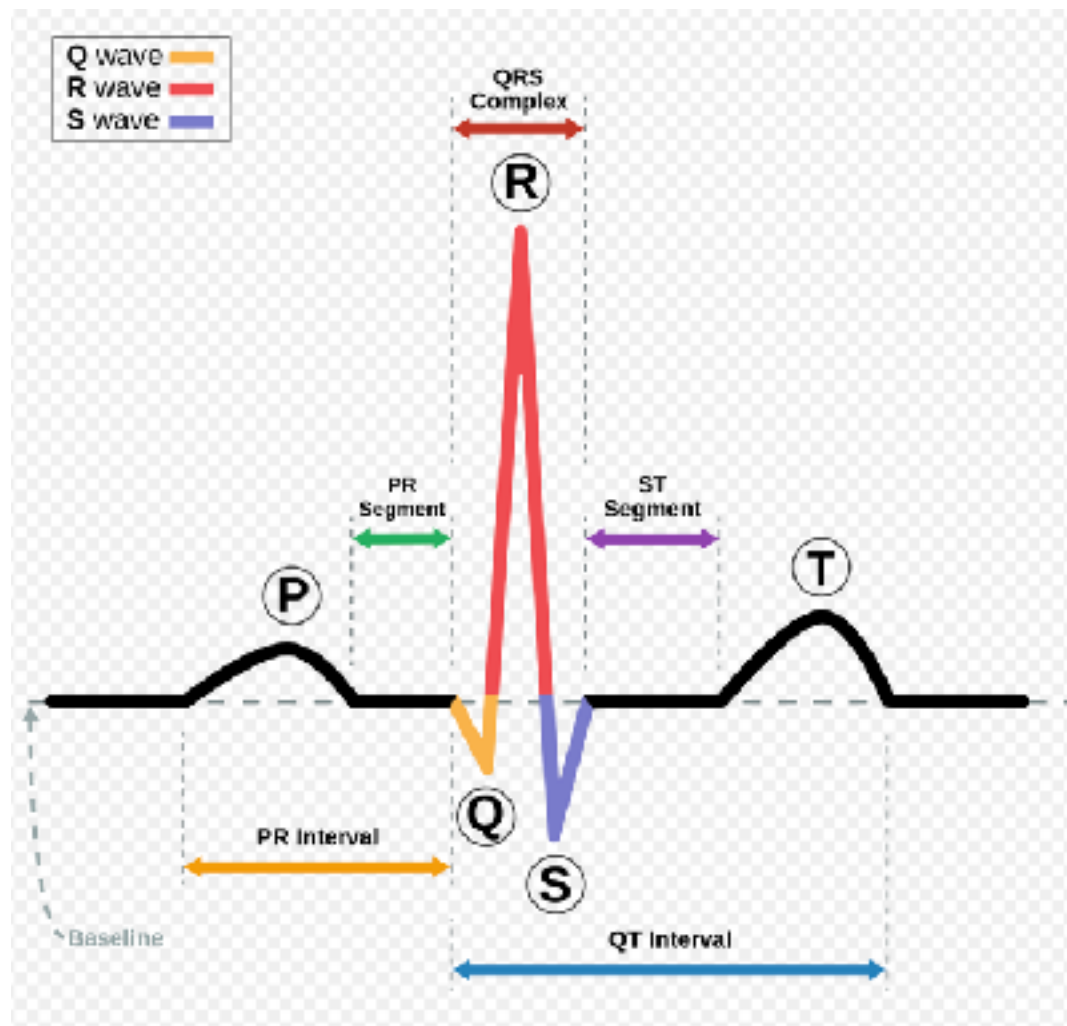
What are the reference points to determine if ST segment is elevated or depressed?

Causes of ST elevation

- *Myocardial injury (infarcting, transmural)*
- *Pericarditis (if diffuse/all leads)*

Causes of ST depression

- *Myocardial Ischemia*
- *“Strain” pattern in LVH*



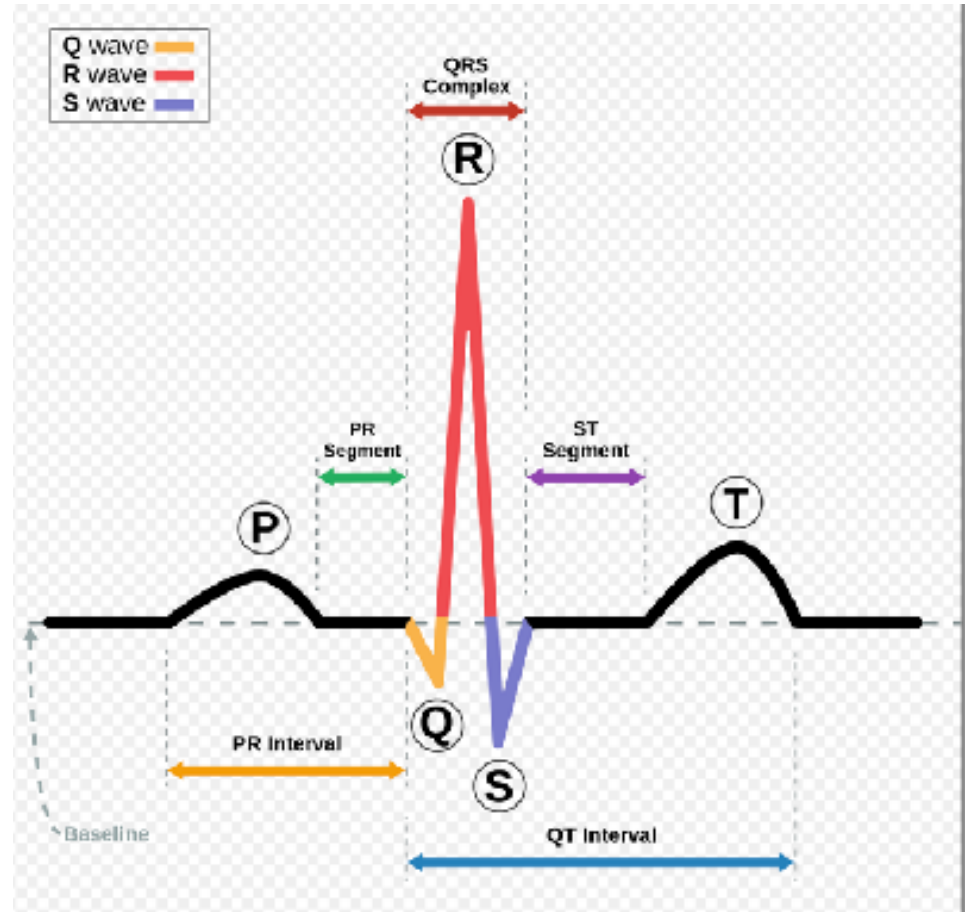
T Wave

- Peaked

- *Early ischemia (eg “hyper-acute T-waves”)*
- *Hyperkalemia*

- Inverted

- *Ischemia (also can see biphasic T-waves)*
- *“Strain” pattern (early repol) in LVH*



QTc Interval

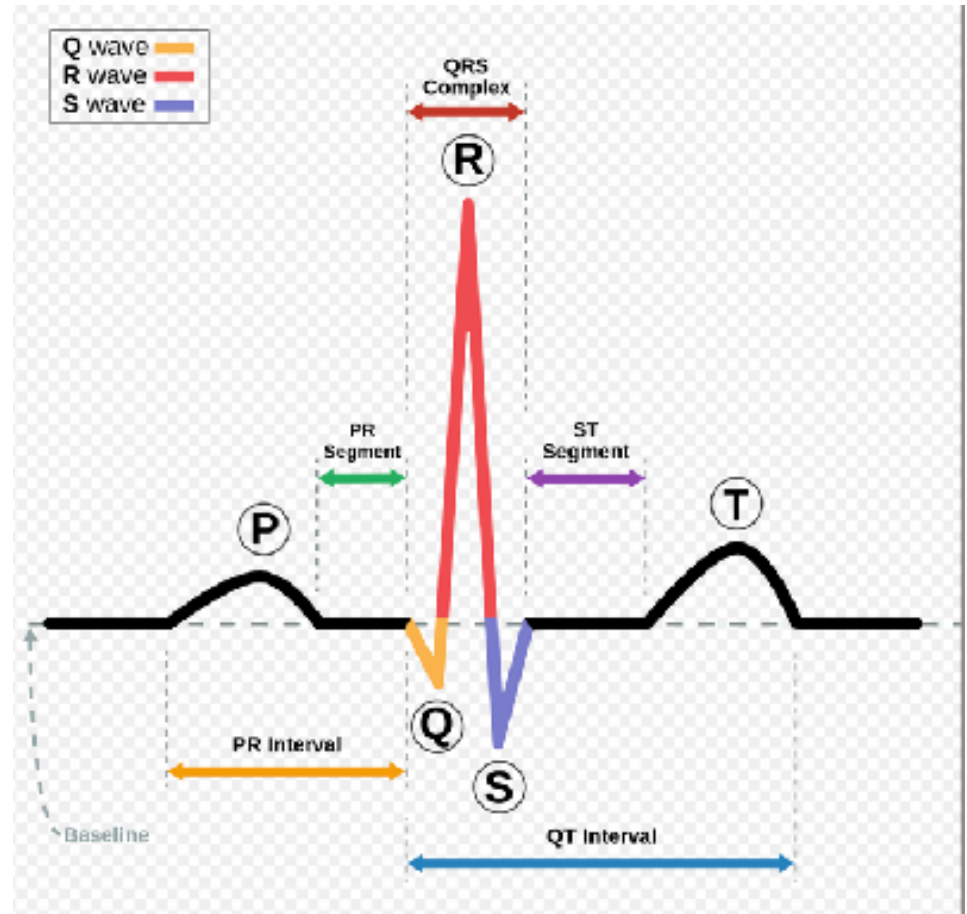
What is difference between QT-interval and QTc-interval?

Definition of prolonged QTc

- *>460 borderline/prolonged (some differences between genders)*

Causes of prolonged QTc

- *Meds*
 - *Avoid if QTc already >500*
- *Electrolyte derangements*
- *Congenital conditions*
- *Brady-arrhythmias*
 - *Sinus node dysfunction*
 - *2nd or 3rd degree AV block*



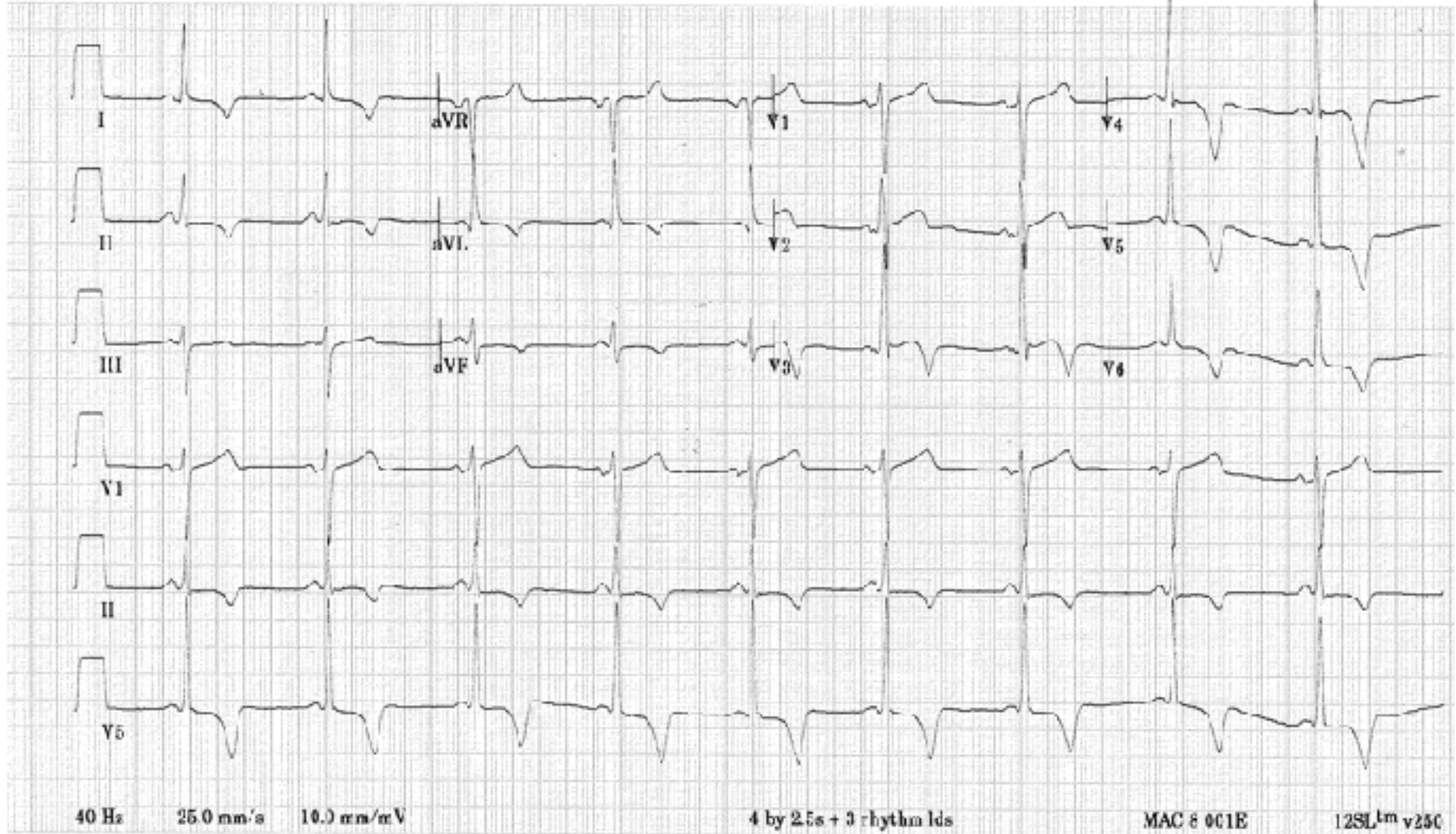
Is there a quick way to “eyeball” the QTc when looking at EKG without measuring/calculating?

EKG #3

Rate
Rhythm
Axis
P wave morphology
PR interval

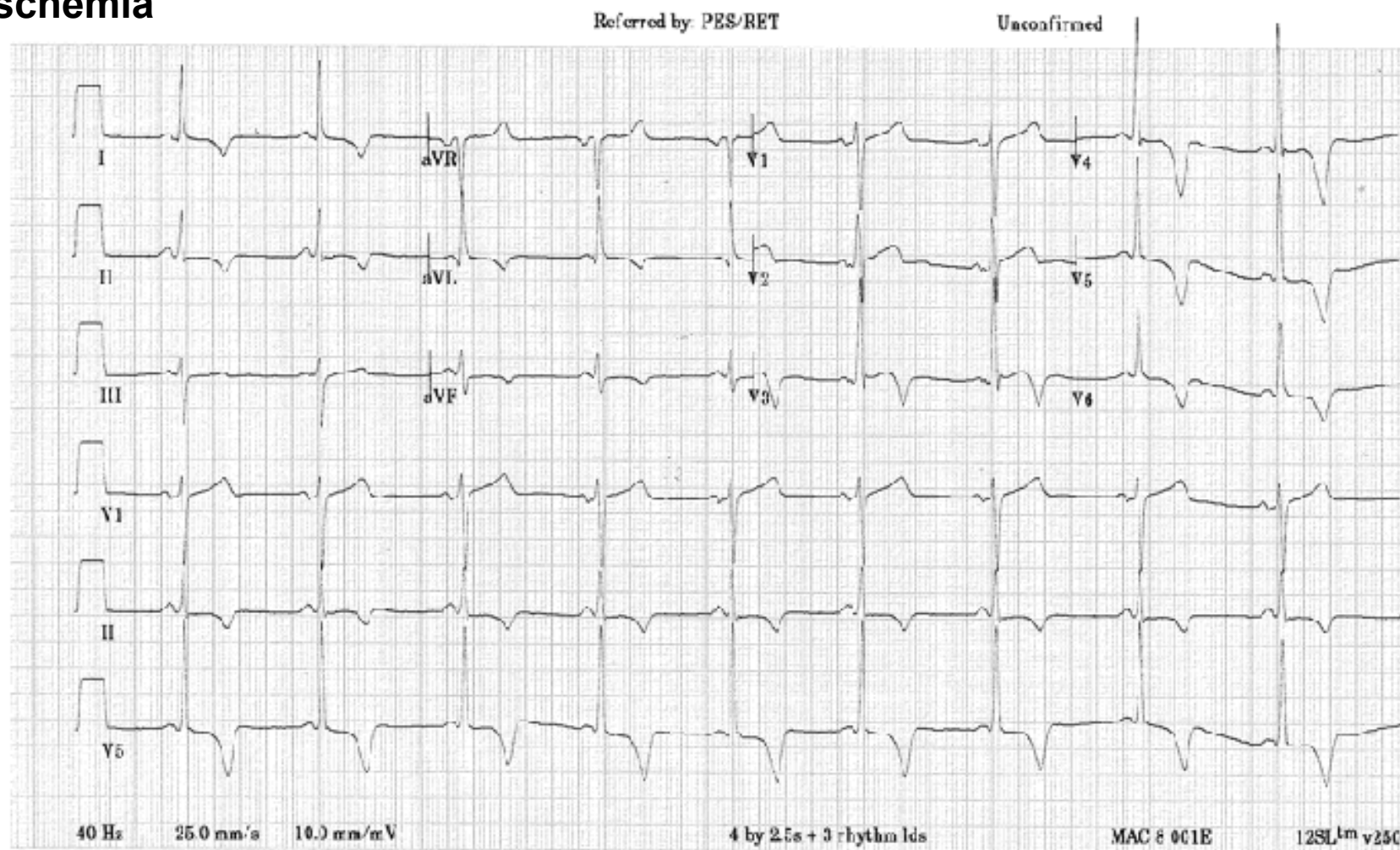
QRS- Wide or Narrow? BBB? LVH?
Q waves present/pathologic?
ST segment
T waves
QTc interval Unconfirmed

Referred by: PES/RET



EKG #3: Rate ~50's / Reg Rhythm / P causing QRS = yes / P waves upright in lead II = yes // NSR / Axis Normal / P morphology normal / PR interval normal / Narrow QRS/no BBB / Voltage? +LVH as $aVL > 11$ and S in $V1 + R$ in $V5 > 35$ / Q- ST – T wave = Diffuse changes including t-wave inversions/ STD's

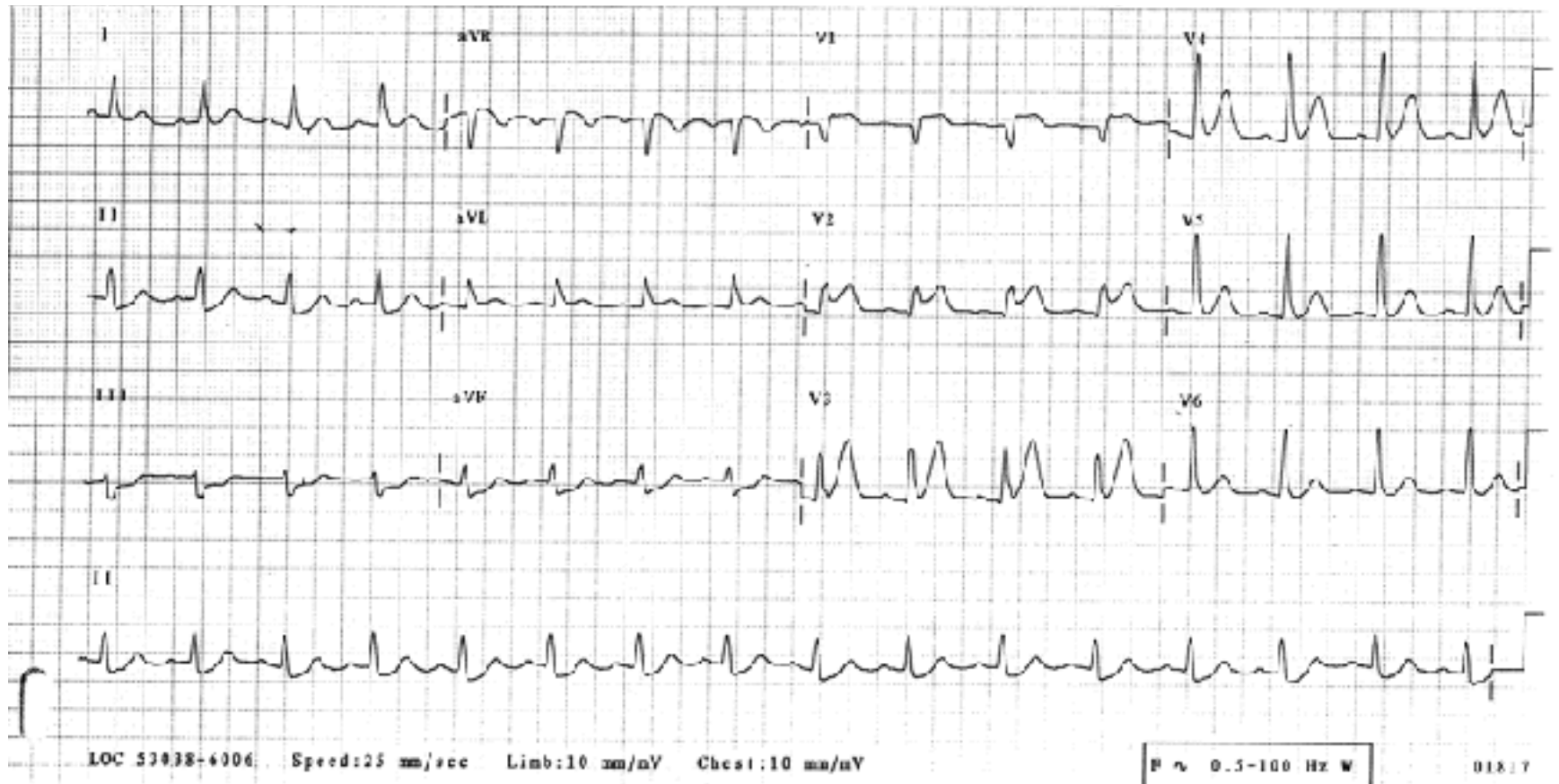
SUMMARY: Normal Sinus Rhythm, LVH with diffuse ST/T-wave changes consistent with “Strain/Repolarization Abnormalities” but can't rule out ischemia



EKG #4

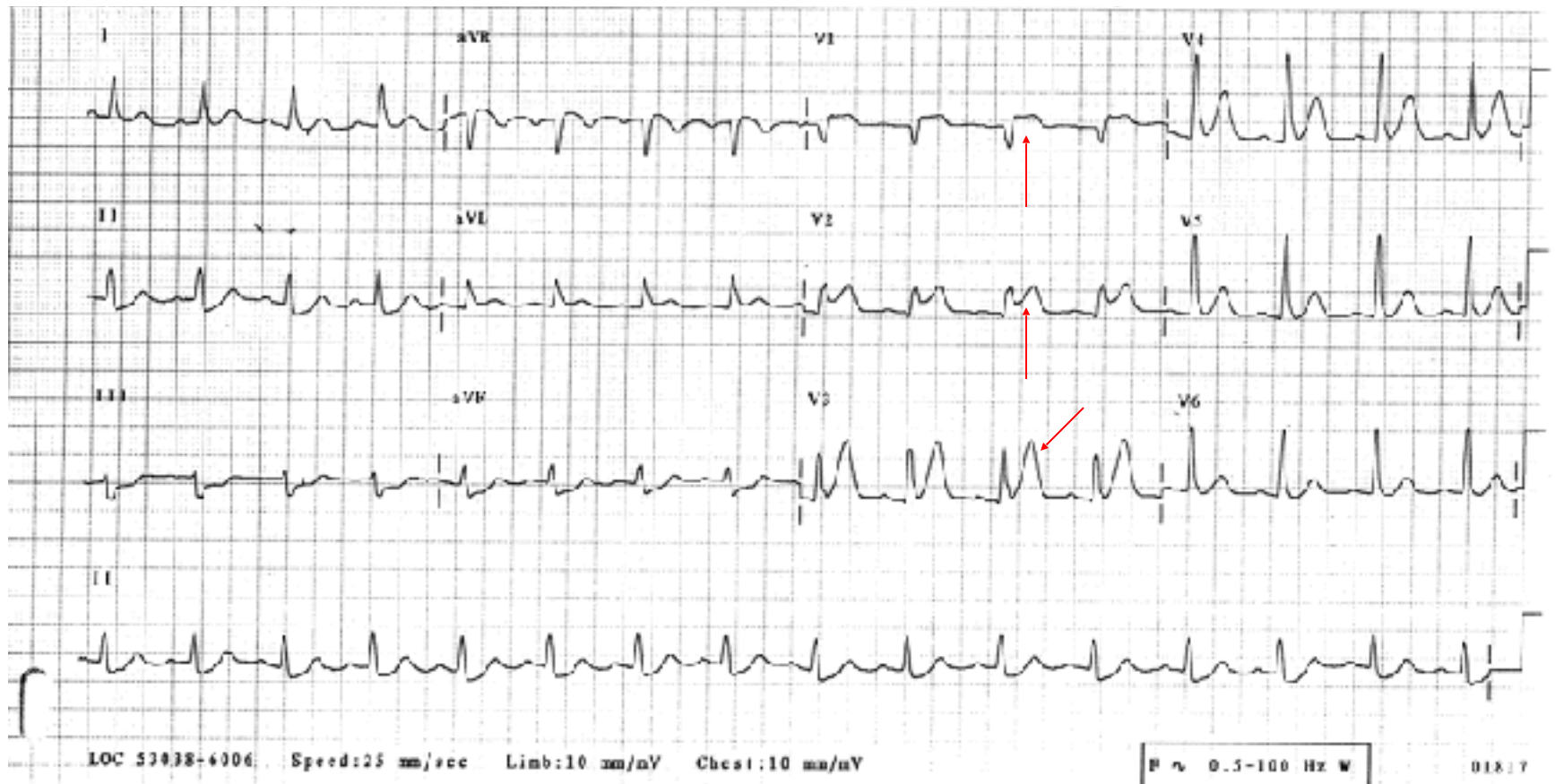
Rate
Rhythm
Axis
P wave morphology
PR interval

QRS- Wide or Narrow? BBB? LVH?
Q waves present/pathologic?
ST segment
T waves
QTc interval



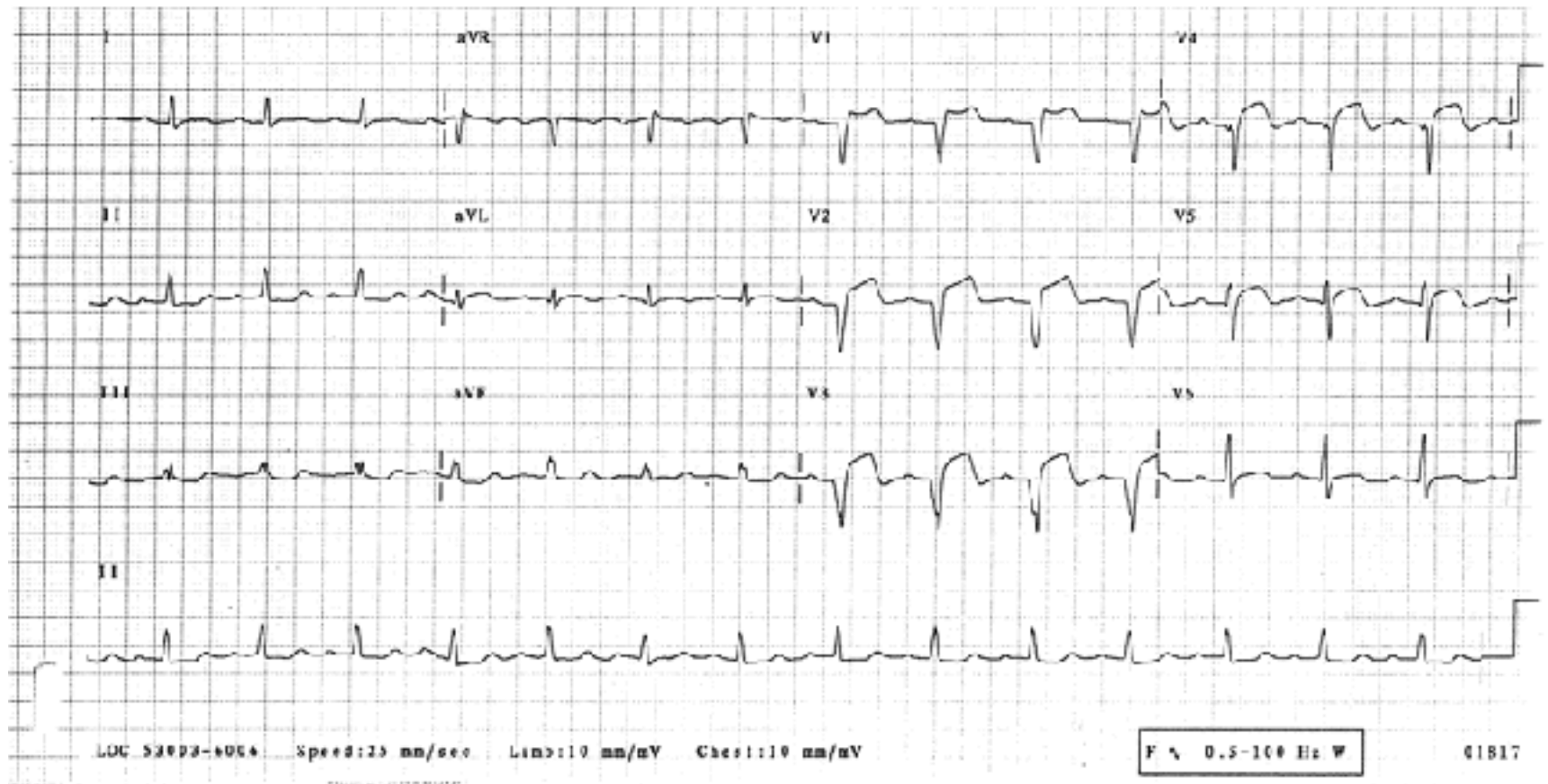
EKG #4: Rate 96 / Reg Rhythm / P causing QRS = yes / P waves upright in lead II = yes // NSR / Axis Normal / P morphology OK / PR interval normal / Narrow QRS/no BBB / Voltage? – No LVH / Q- ST – T wave = ST Depression inferior leads II, III, aVF, ST ELEVATION V1-V2 with Q's and HYPERACUTE T V3-V4

SUMMARY: Normal Sinus Rhythm, Acute Anterior wall MI (early) with reciprocal changes in inferior leads



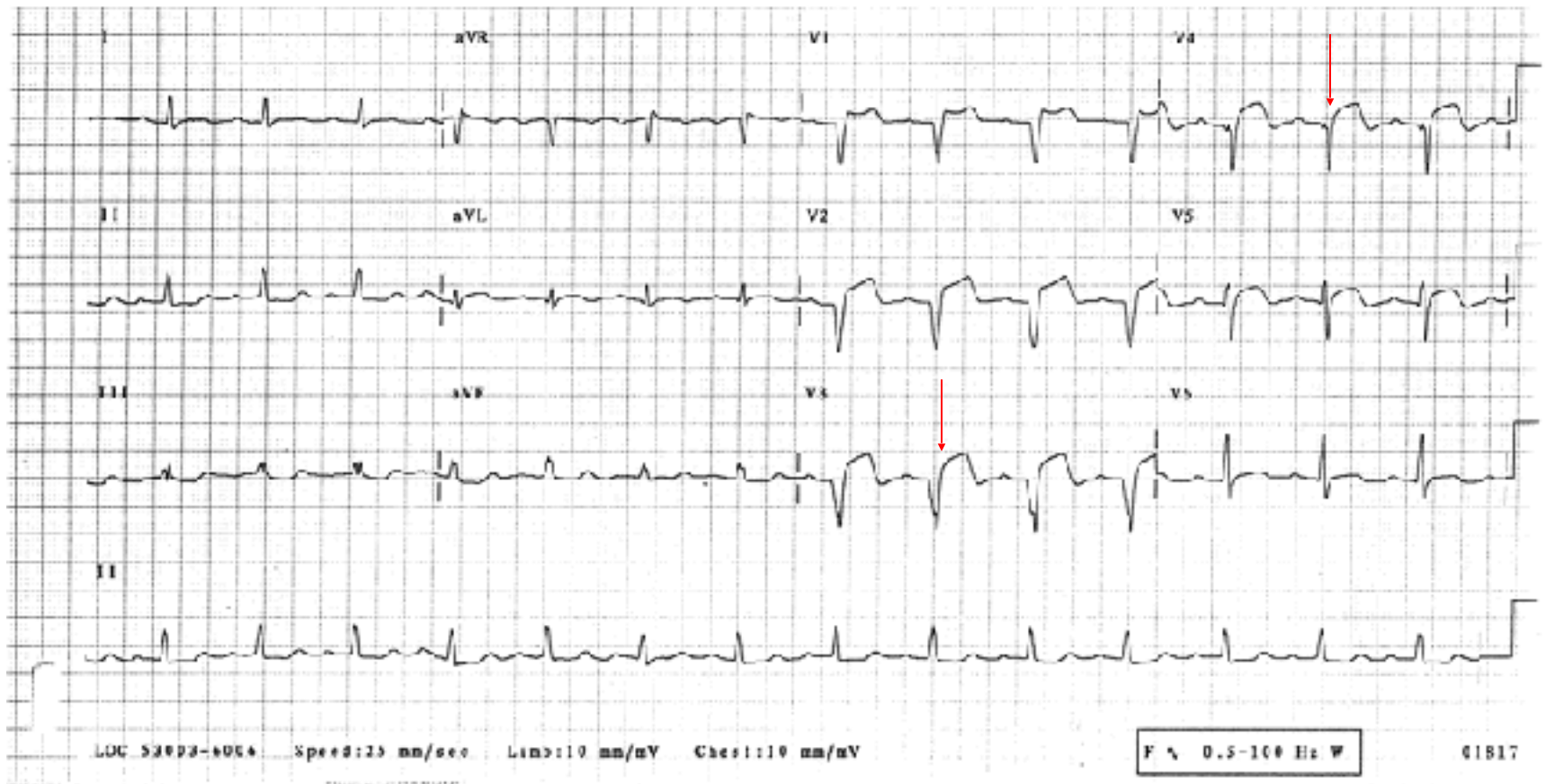
SAME PATIENT AS THE PRIOR EKG.

HOW HAS THE EKG CHANGED?



EKG #4 Second Version:

-Progression of the acute anterior MI with Q waves developing now in V3-V4 as well as ST elevation to replace the hyperacute T waves anteriorly



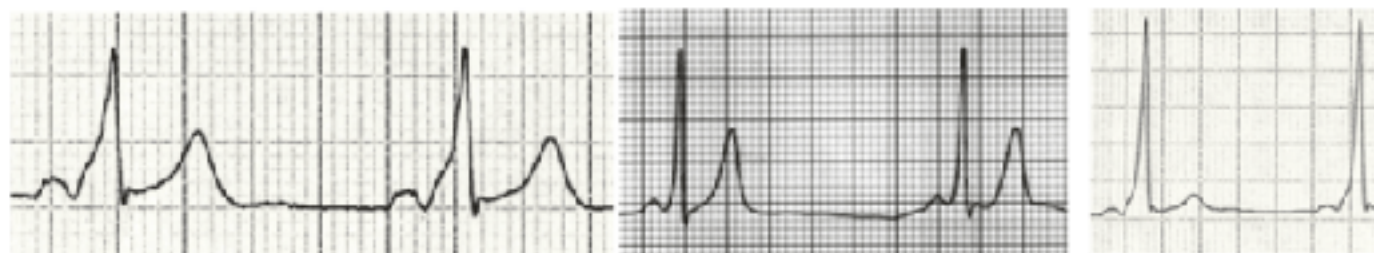
The characteristic ECG findings in **Wolff-Parkinson-White syndrome** are:

- Short PR interval ($< 120\text{ms}$)
- Broad QRS ($> 100\text{ms}$)
- A slurred upstroke to the QRS complex (the **delta wave**)



Delta wave: Premature excitation of the ventricles causes a slurred upstroke to the QRS

Delta wave



- Note that the remainder of the QRS remains normal — conduction still occurs through the AV node and this is the dominant pathway. On arrival to the ventricles, such conduction cancels out any pre-excitation that has occurred via an accessory pathway

EKG Assignment

- Be sure to do all the steps on the cards (show your work/write out your thought process)
 - Would add assessing for QTc prolongation to the steps at the end
- Write out your work for all the steps AND your summary statement/EKG interpretation on each individual EKG
- Useful website: [life in the fast lane](#)