Basic Electrocardiography

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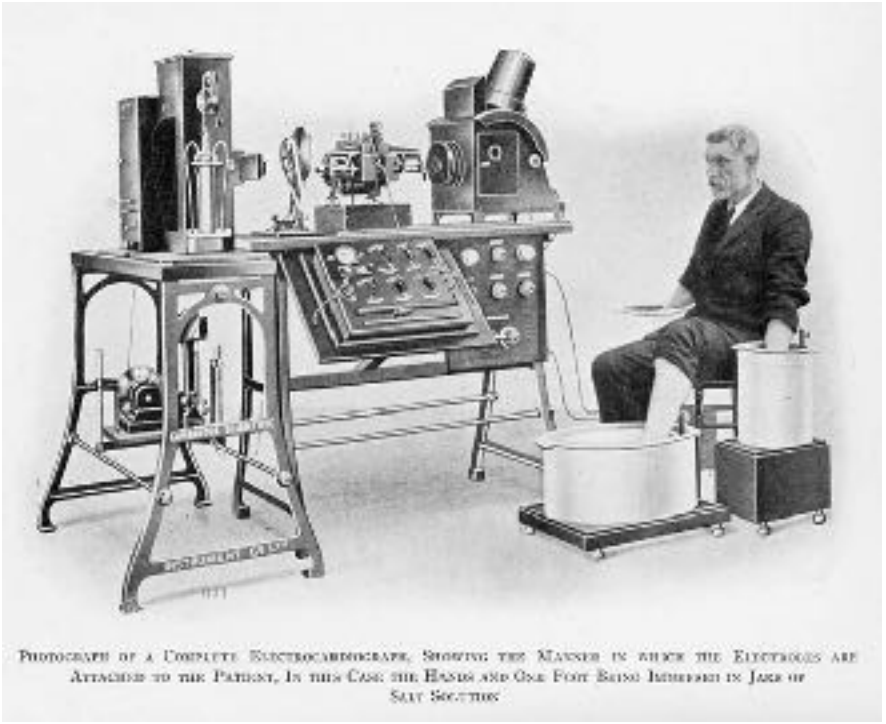
Adapted, with permission, from slides of N. Botkin and B. Gentile.

Learning Objectives

- What is an ECG and what is its function?
- What are P, QRS and T waves?
- What does a typical 12-lead ECG look like?
- What are PR, ST and QT?
- How does one determine heart rate on an ECG?
- How does one measure intervals?

History

- 1901 Willem Einthoven (Leiden, Netherlands)
  - String galvanometer
  - Elektrokardiogramm
- EKG: Elektrokardiogramm
- ECG: Electrocardiogram

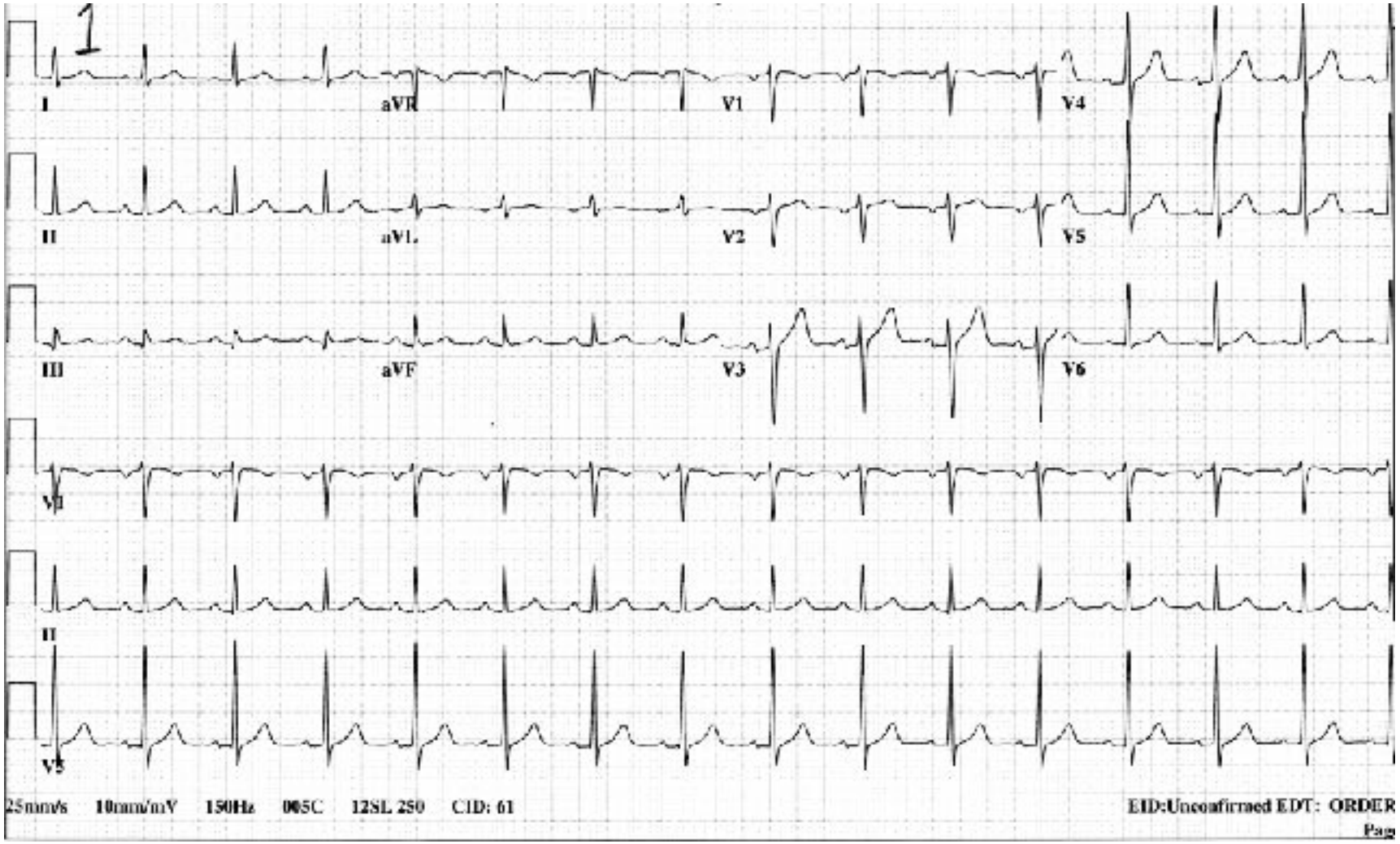


PHOTOGRAPH OF A COMPLETE ELECTROCARDIOGRAPH, SHOWING THE MANNER IN WHICH THE ELECTRODES ARE ATTACHED TO THE PATIENT, IN THIS CASE THE HANDS AND ONE FOOT BEING IMMERSED IN JARS OF SALT SOLUTION

Why are ECGs important?

- ECGs are a point of care test that are used across all fields of medicine
  - IM/Cardiology/Pediatrics/Emergency Medicine
  - Surgery/Orthopedics/OB/Anesthesia
  - Psychiatry, Radiology, Pathology
- Provide a wealth of information about a patient's cardiac status at low cost and low risk

ECGs summarize electrical activity in the heart from multiple “points of view”



What types of information can be obtained?

- Activity of the electrical conduction system
- Myocardial perfusion (ischemia, infarction)
- Structure (chamber size and thickness)

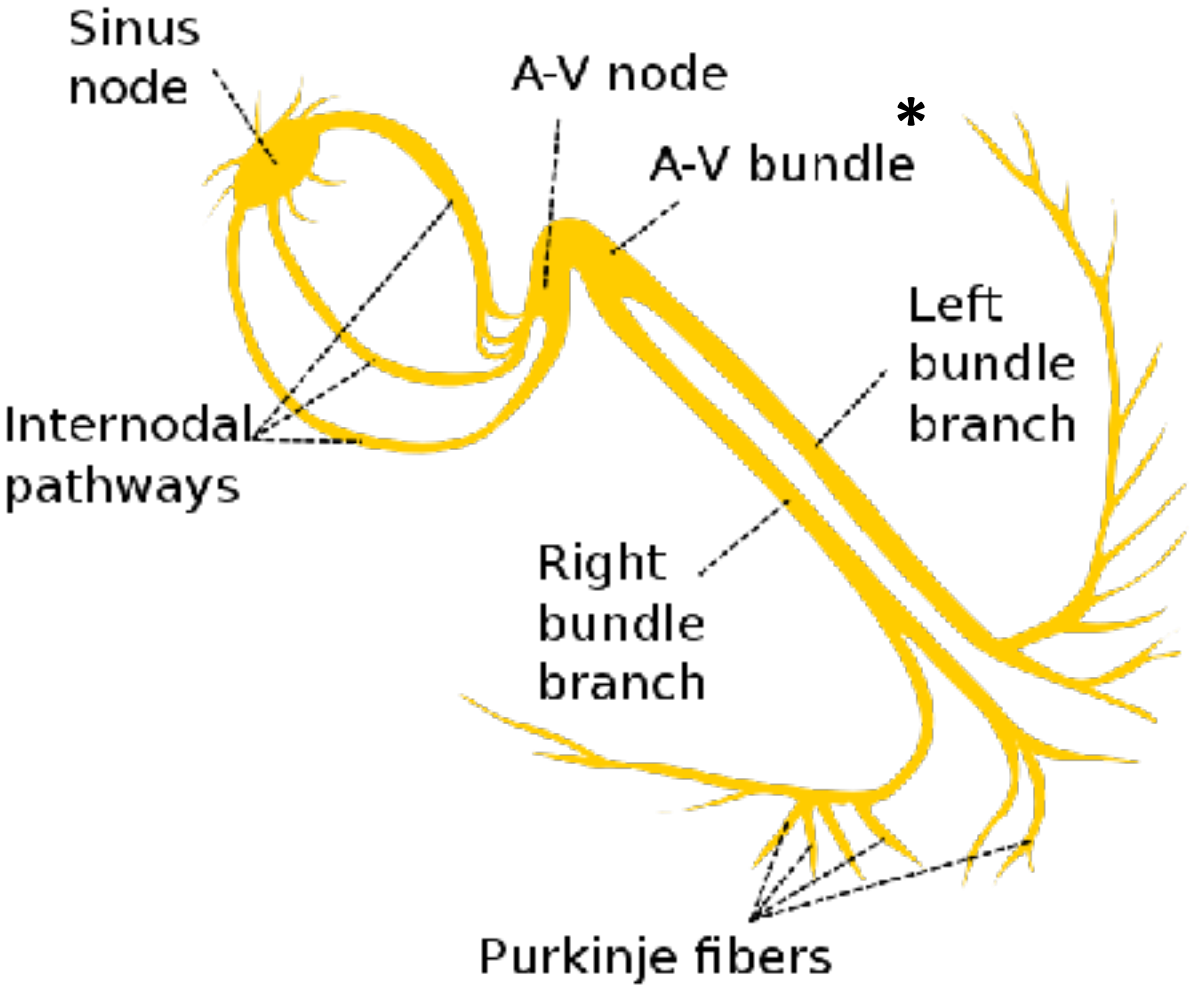
What is an ECG lead?

- Not to be confused with **electrode**
  - Electrode is a conductive pad that makes an electrical circuit with the electrocardiograph (machine)

- **Lead** = measurement of a vector between two electrodes, one positive and the other negative. AKA “dipole”.

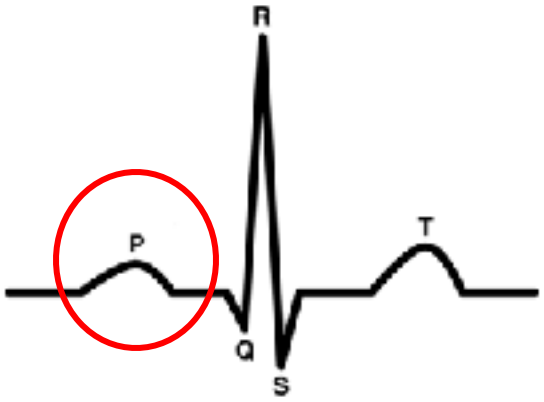
- ECG machine records the **difference in electrical potential** between the electrodes.

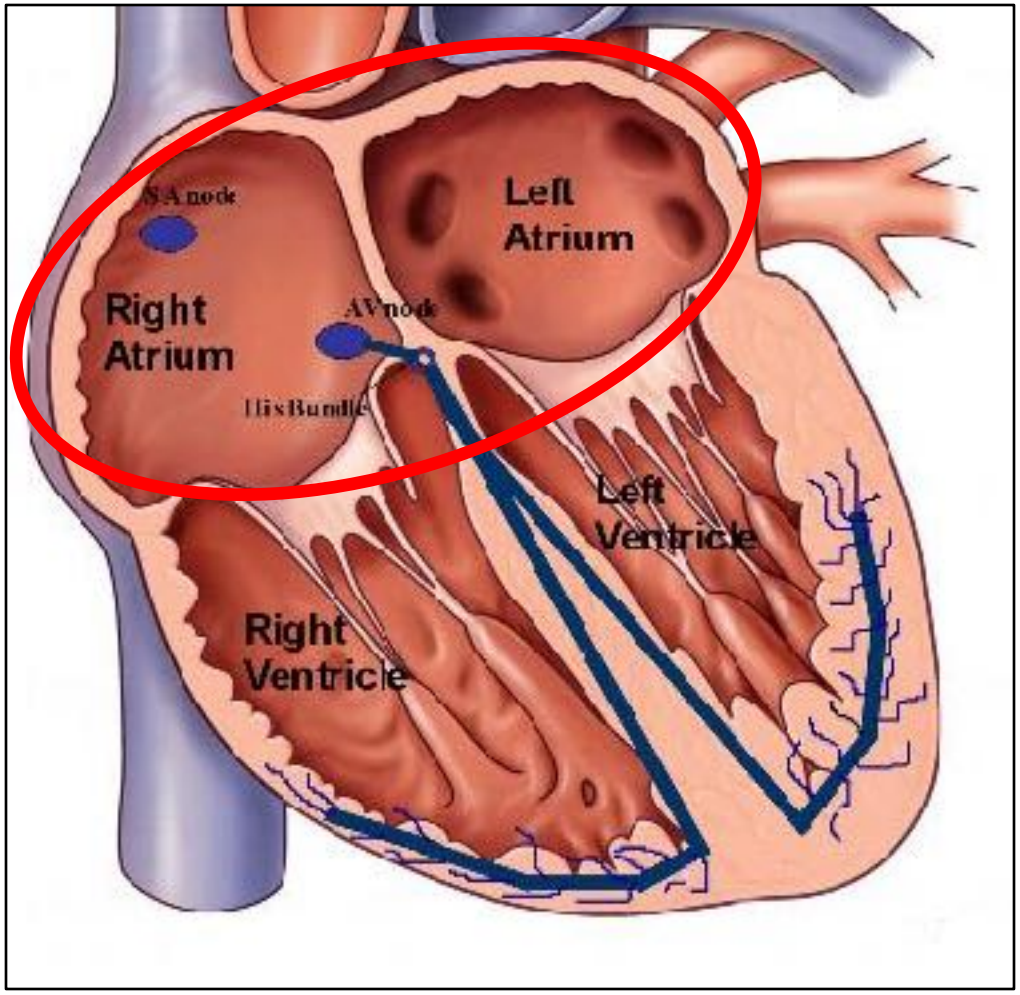
Review of conduction tissue



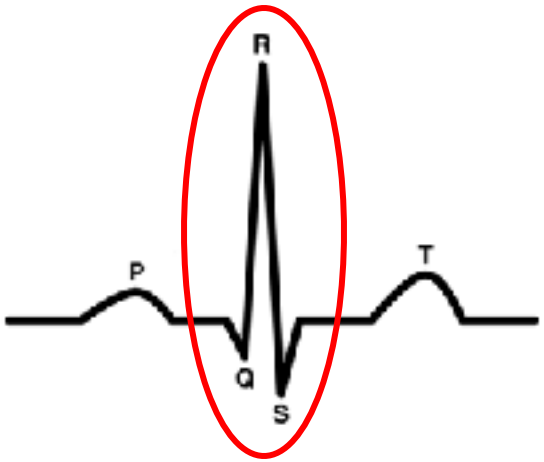
* Bundle of His

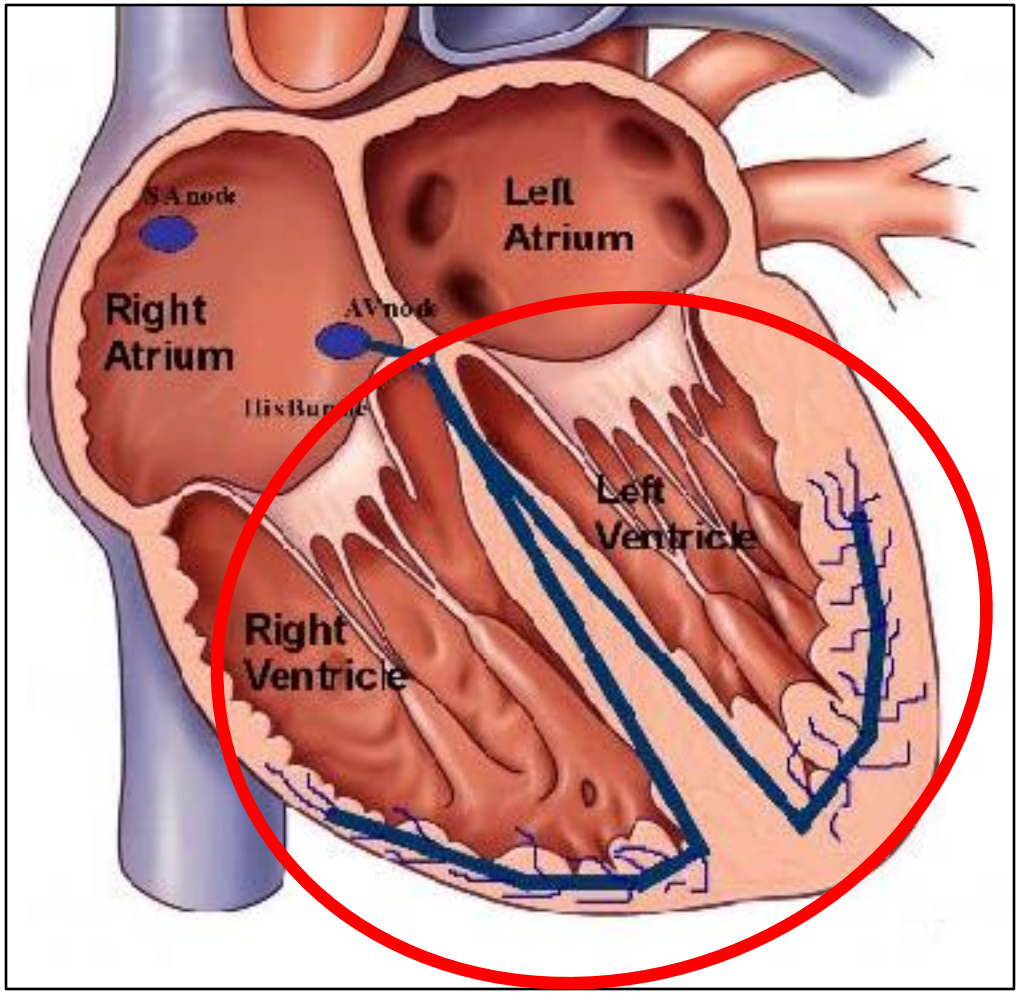
The P wave signifies atrial depolarization.



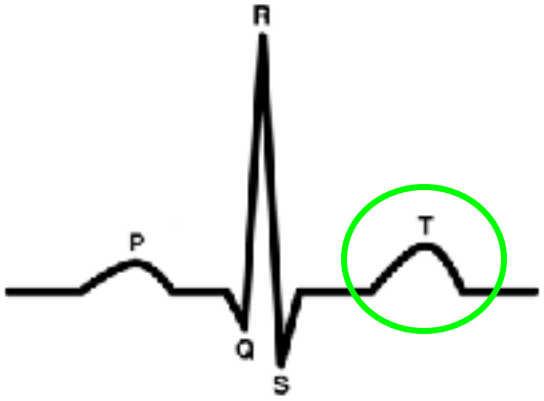


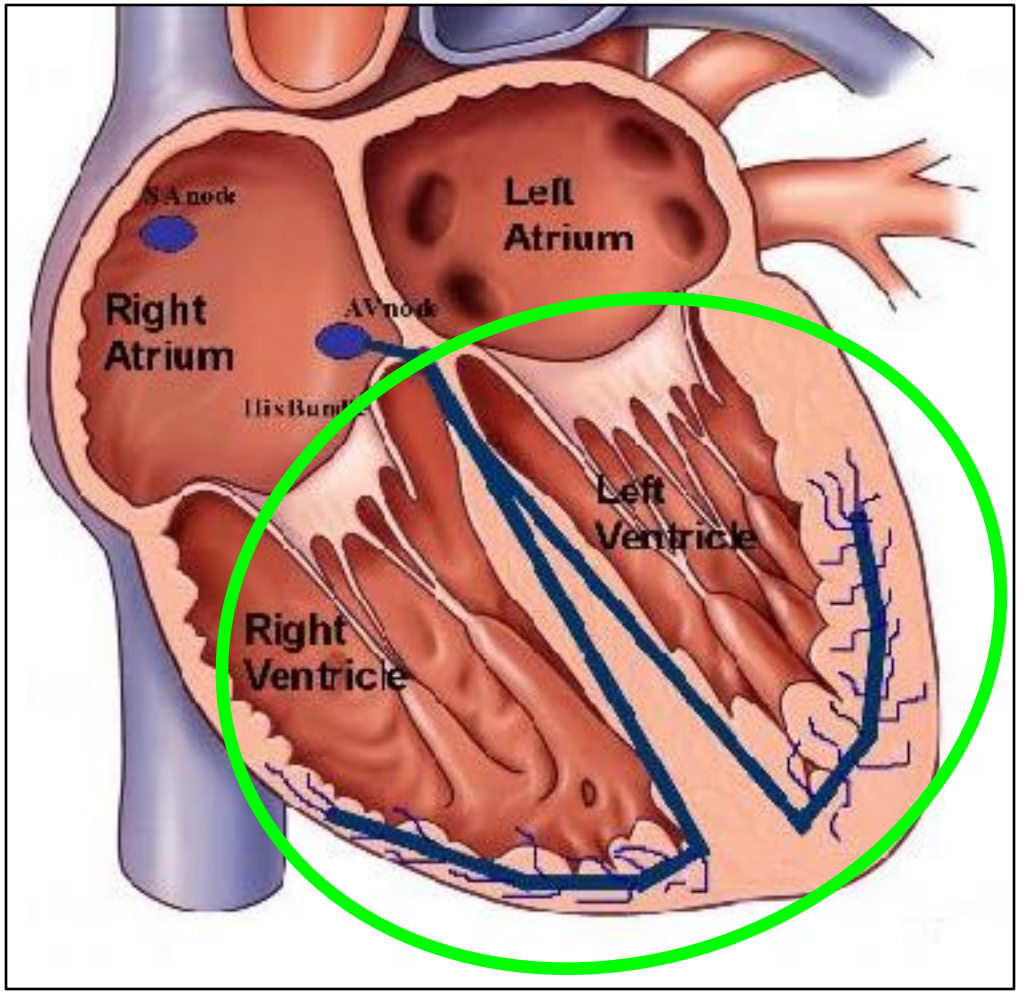
The QRS complex signifies ventricular depolarization.





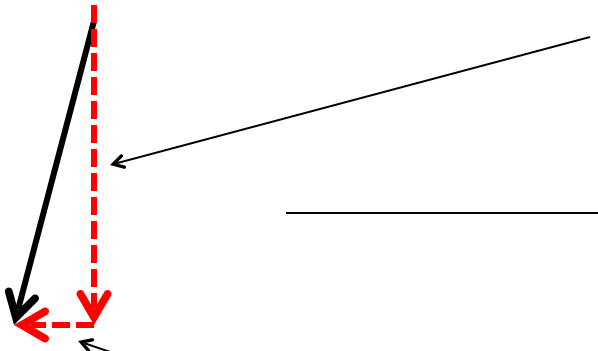
The T wave signifies ventricular repolarization.



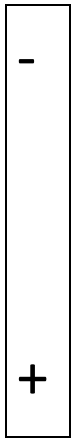


Different leads = different appearance of the same electrical event

Vector describing direction and amplitude of depolarization at a given time.



Lead aVF senses vertical axis activity

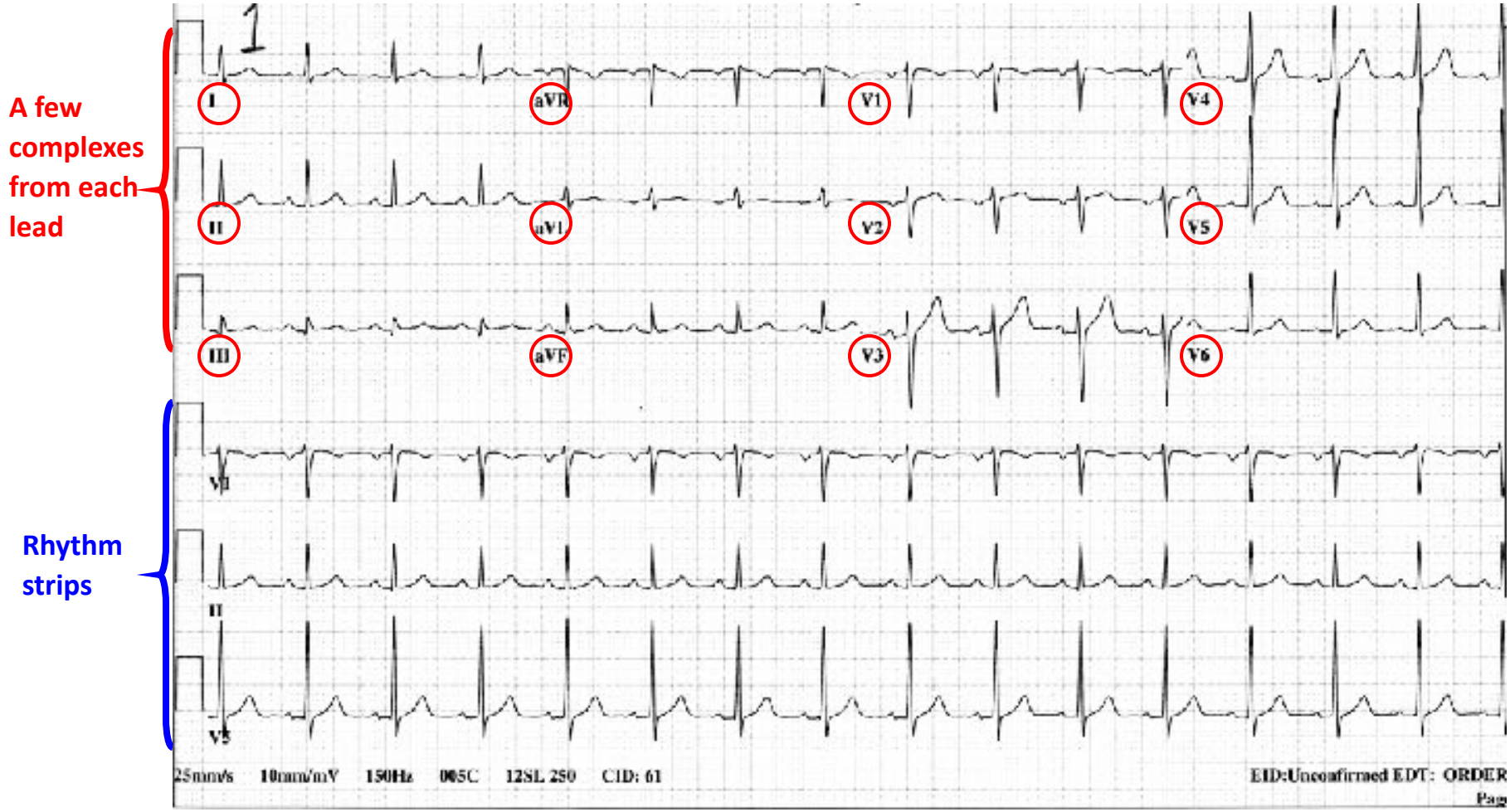


Activity towards positive pole appears as a tall positive deflection.

Lead I senses horizontal axis activity

Activity away from positive pole appears as a small negative deflection.

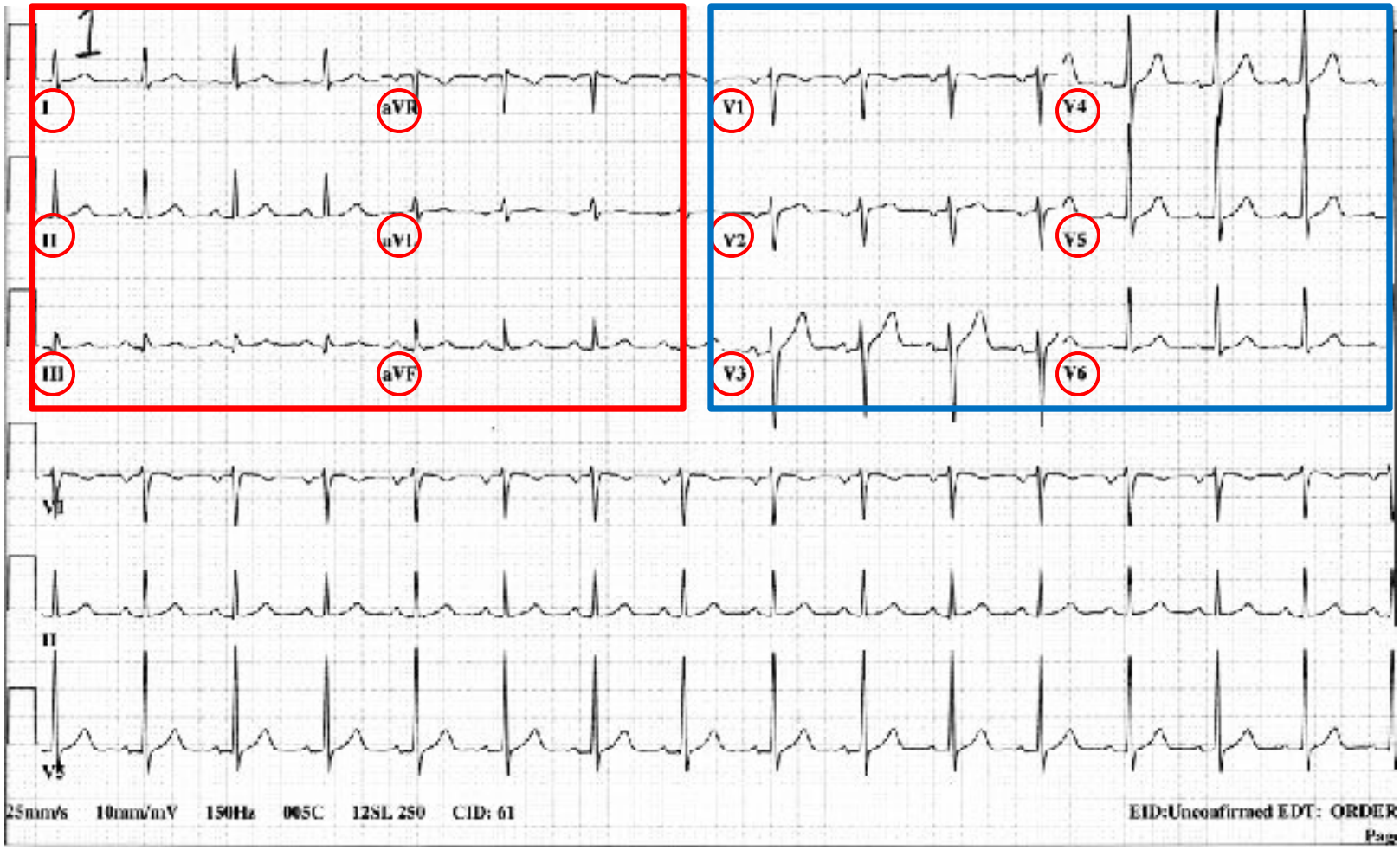
A 12-lead ECG


A few complexes from each lead
Rhythm strips
1
I
aVR
V1
V4
II
aV1
V2
V5
III
aVF
V3
V6
V1
II
V5
25mm/s 10mm/mV 150Hz 005C 12SL 250 CID: 61
EID:Unconfirmed EDT: ORDER

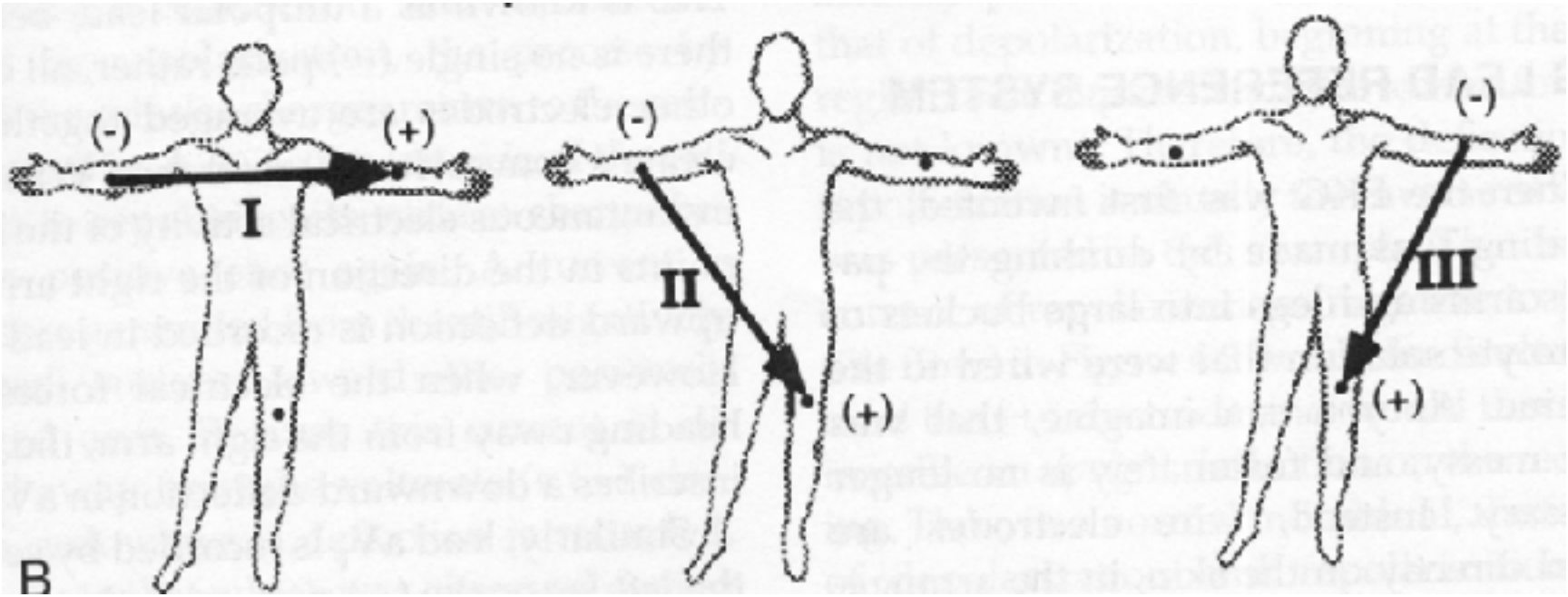
A 12-lead ECG

Limb Leads

Precordial Leads

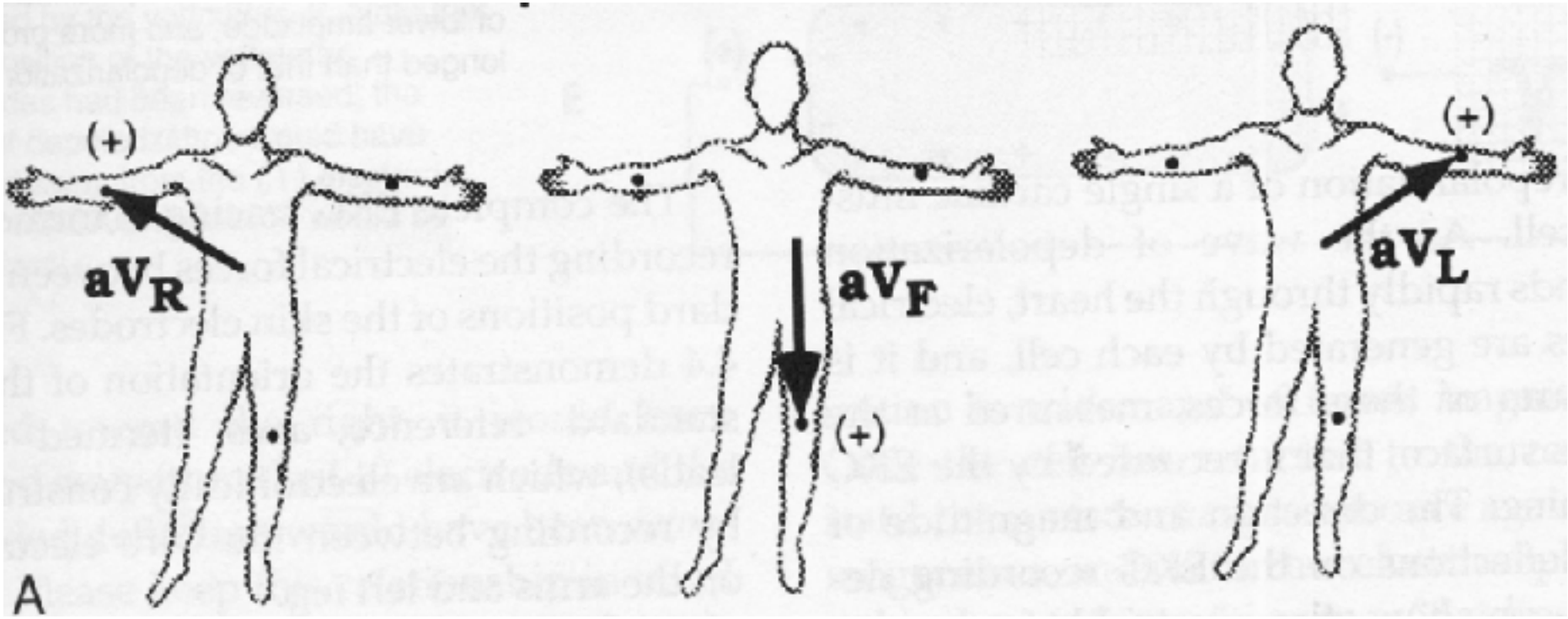


There are 3 bipolar limb leads.



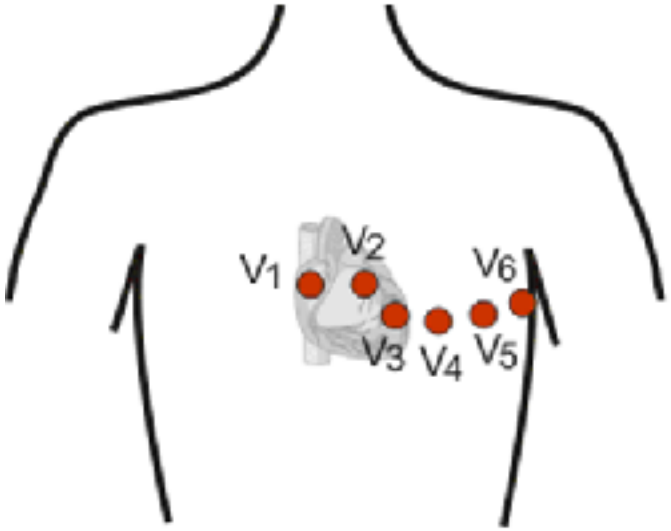
By convention, leads are drawn with the arrowhead at the positive pole.

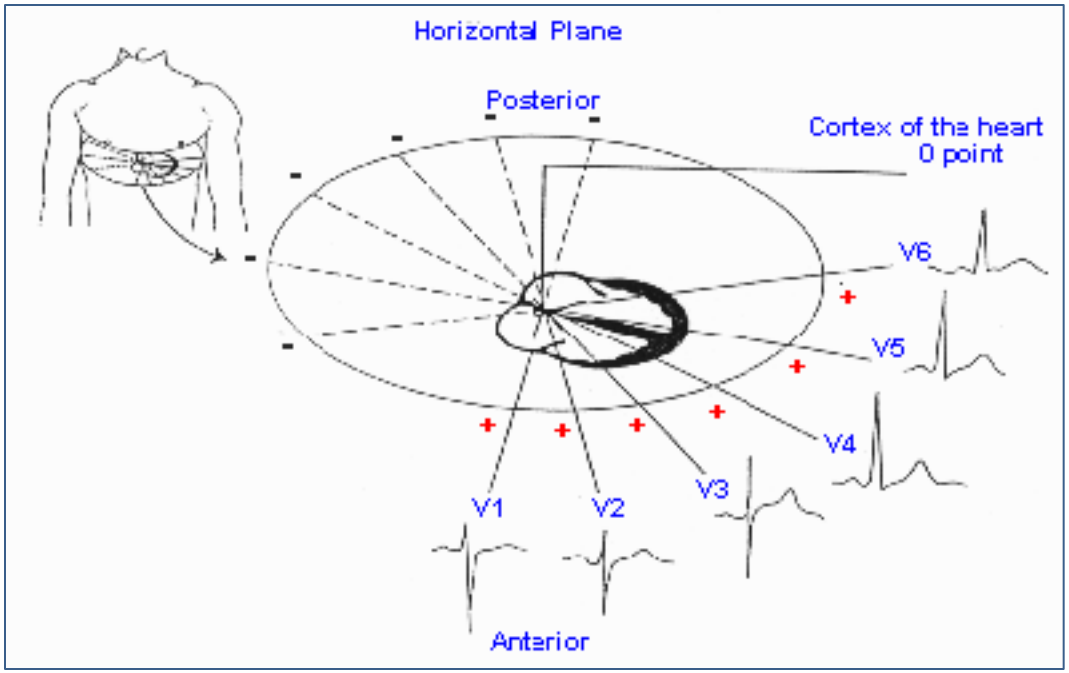
There are 3 unipolar limb leads.

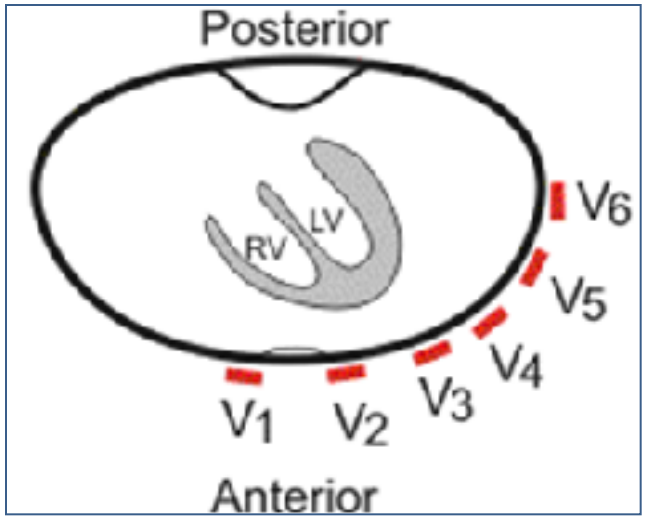


R = Right arm F = Foot L = Left arm

There are 6 precordial leads.

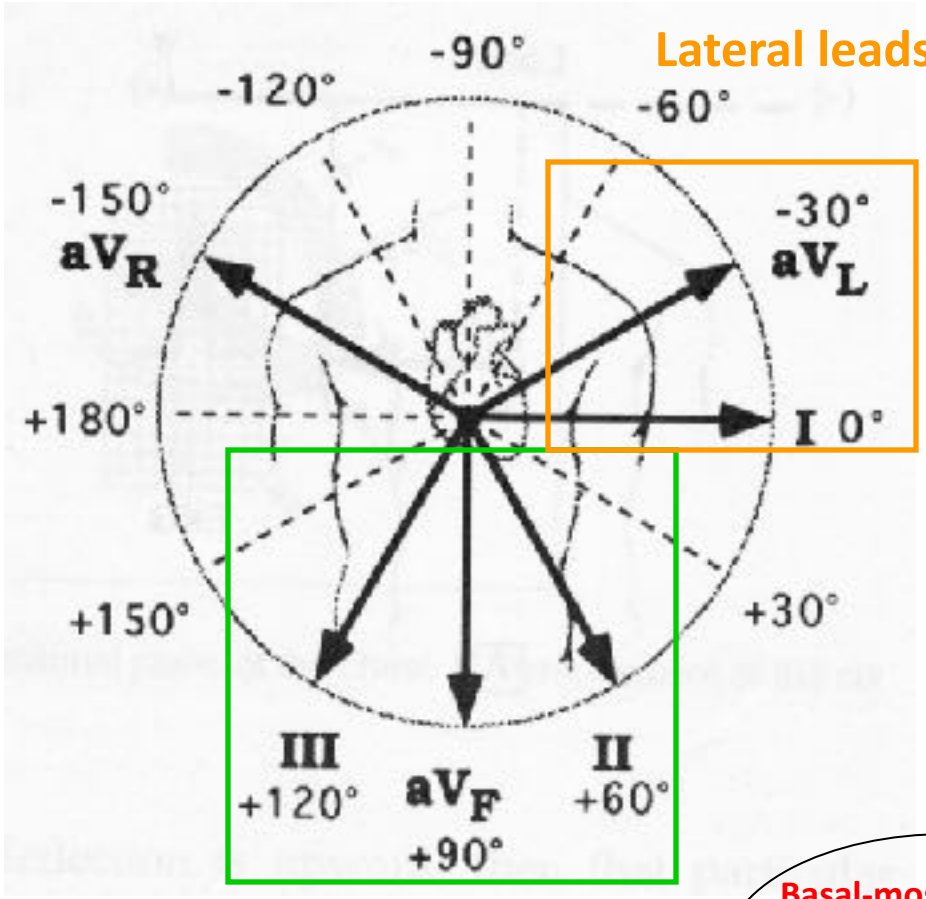




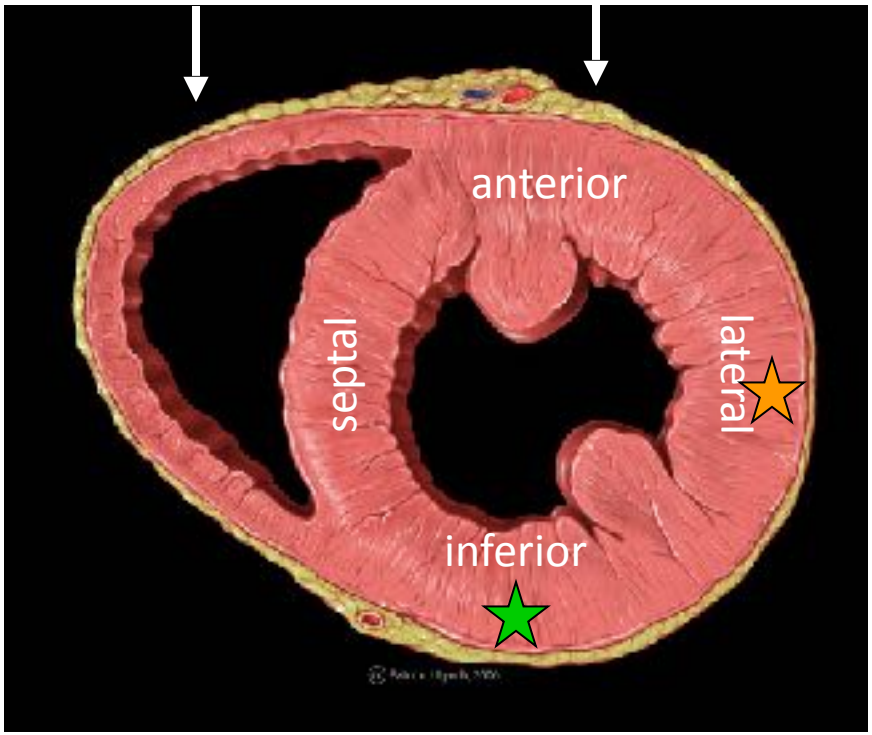


The LV has more myocardium than the RV, which explains the QRS progression from mainly negative in V1 to mainly positive in V6.

Leads are grouped according to the region of the LV that they "see" best. Here are the limb leads:

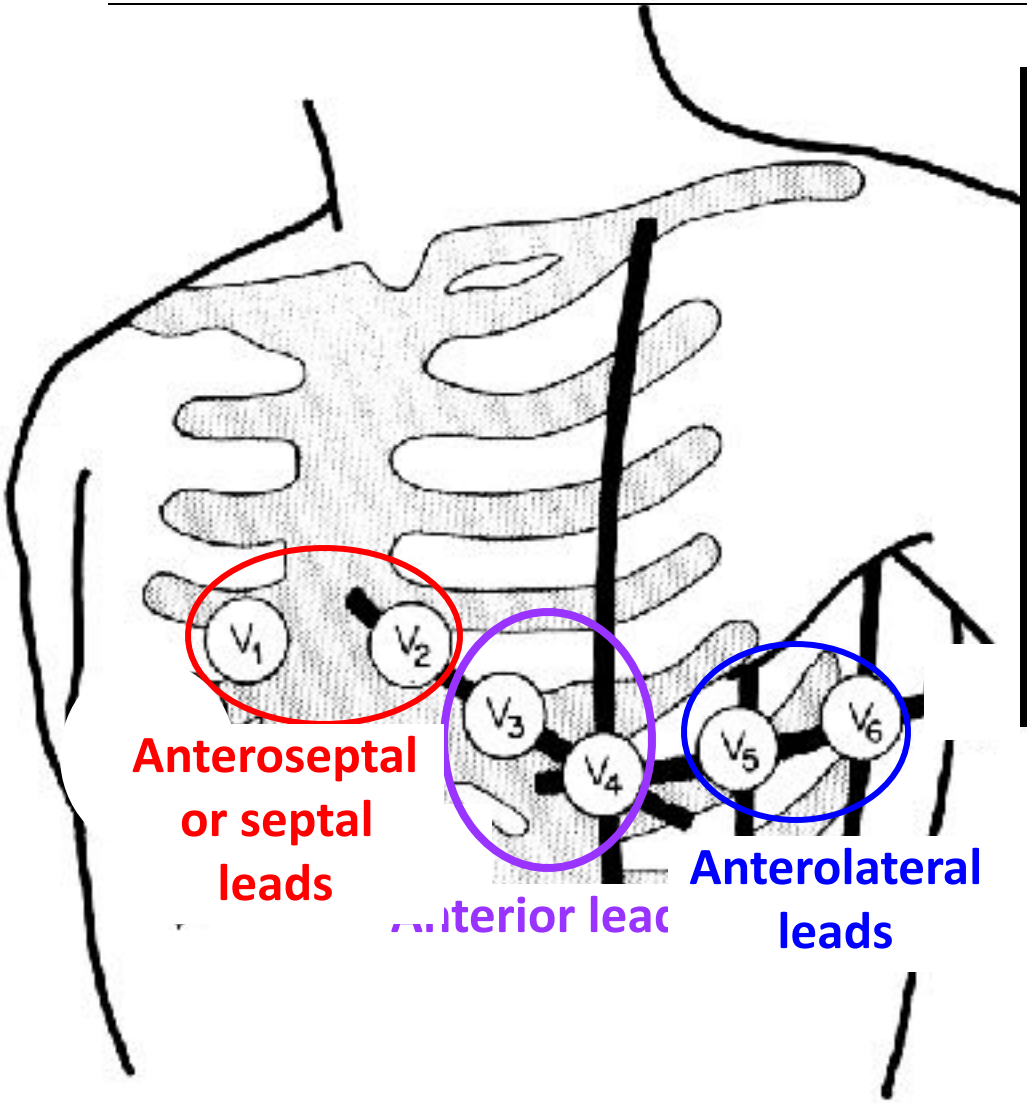


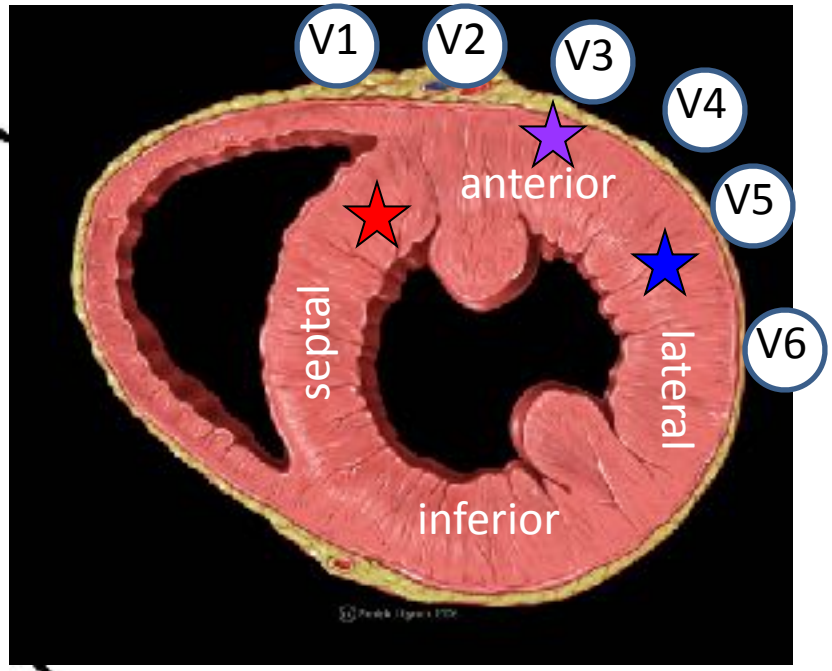
Cross section of ventricles



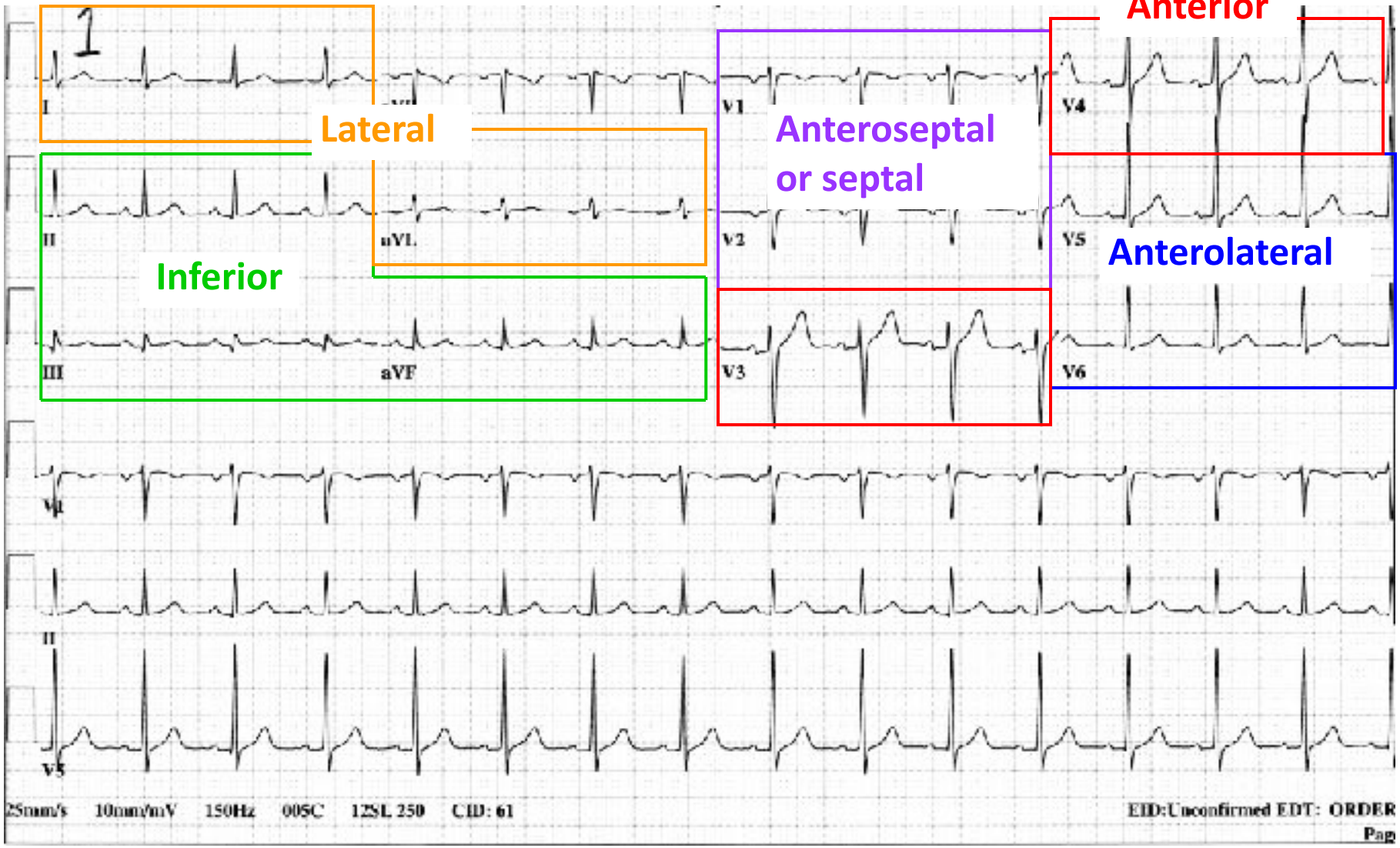
Basal-most portion of inferior wall is sometimes called the "posterior" wall.

Precordial leads detect septal and anterior activity.

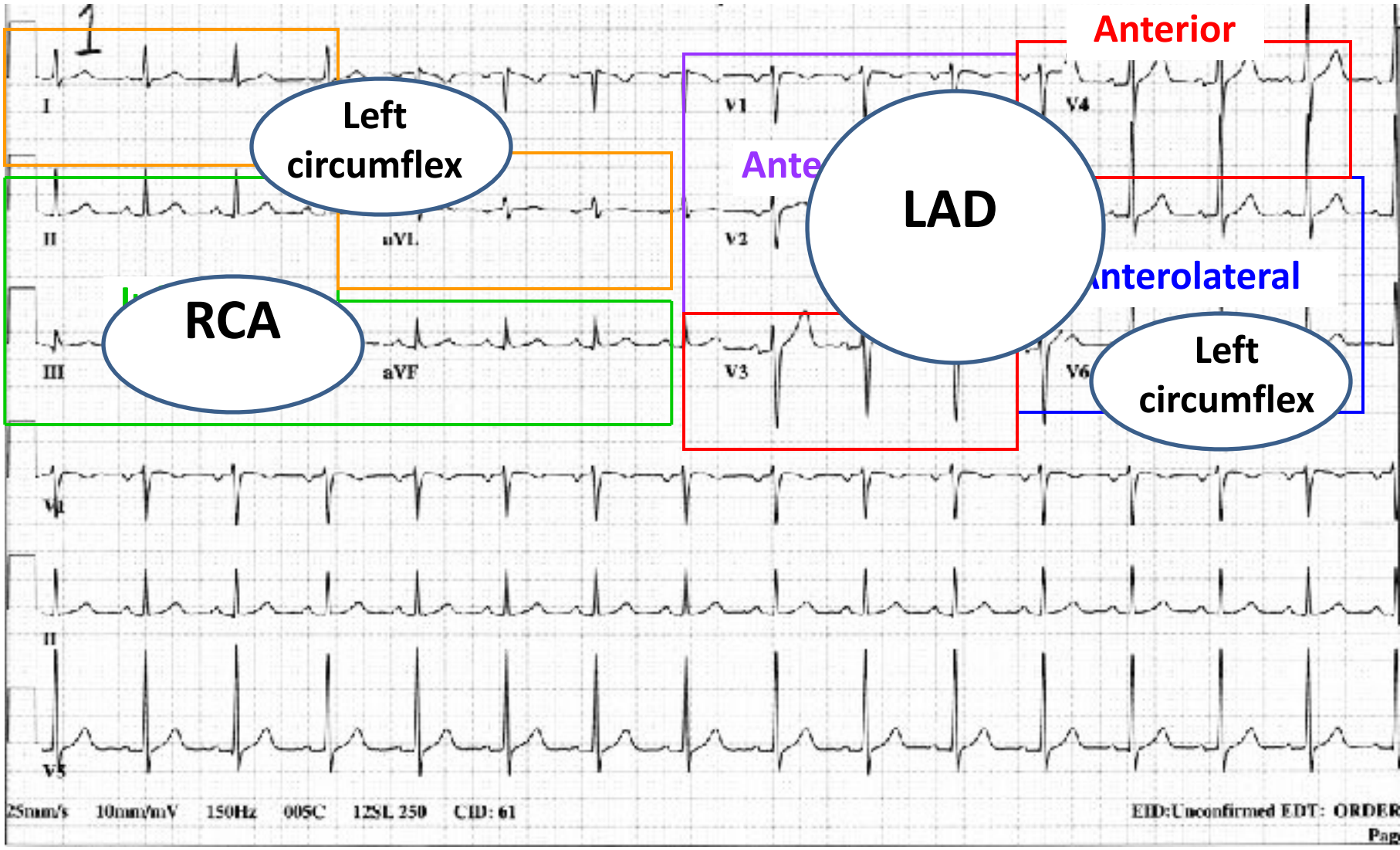




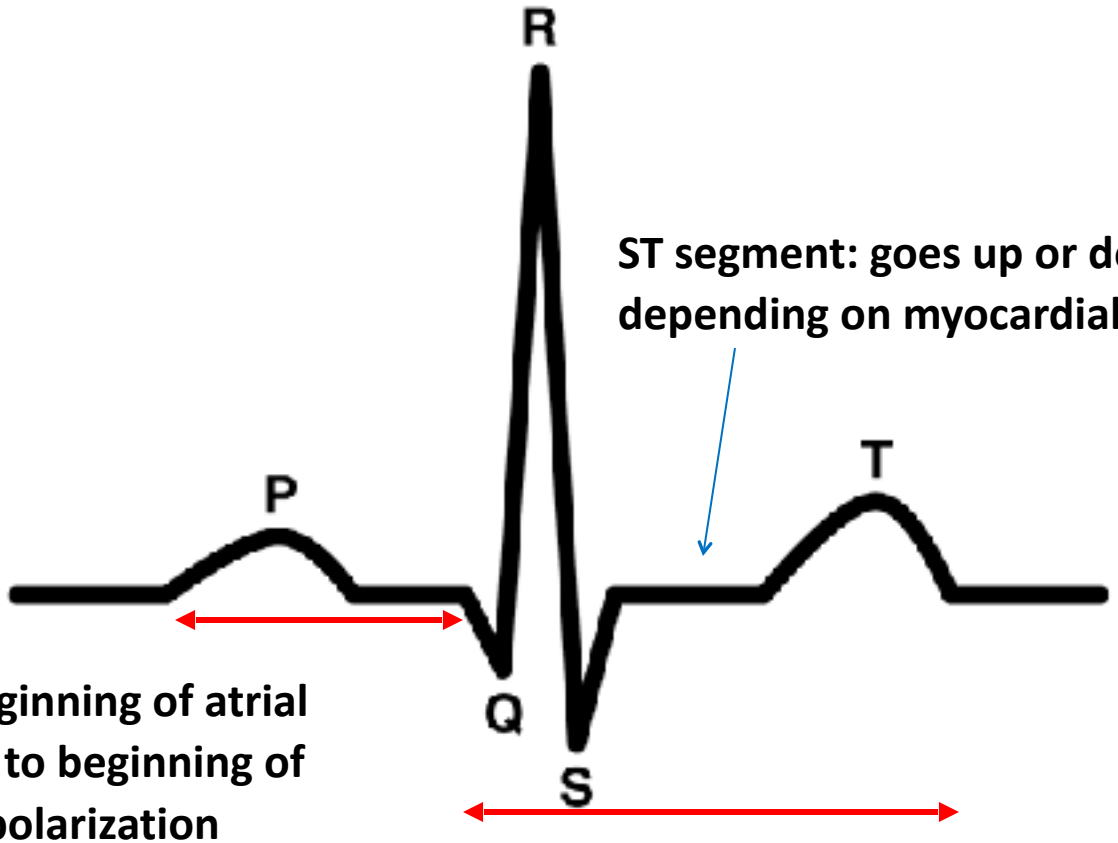
Typical Layout of Leads



Corresponding blood supply



Important ECG terms



ST segment: goes up or down depending on myocardial perfusion

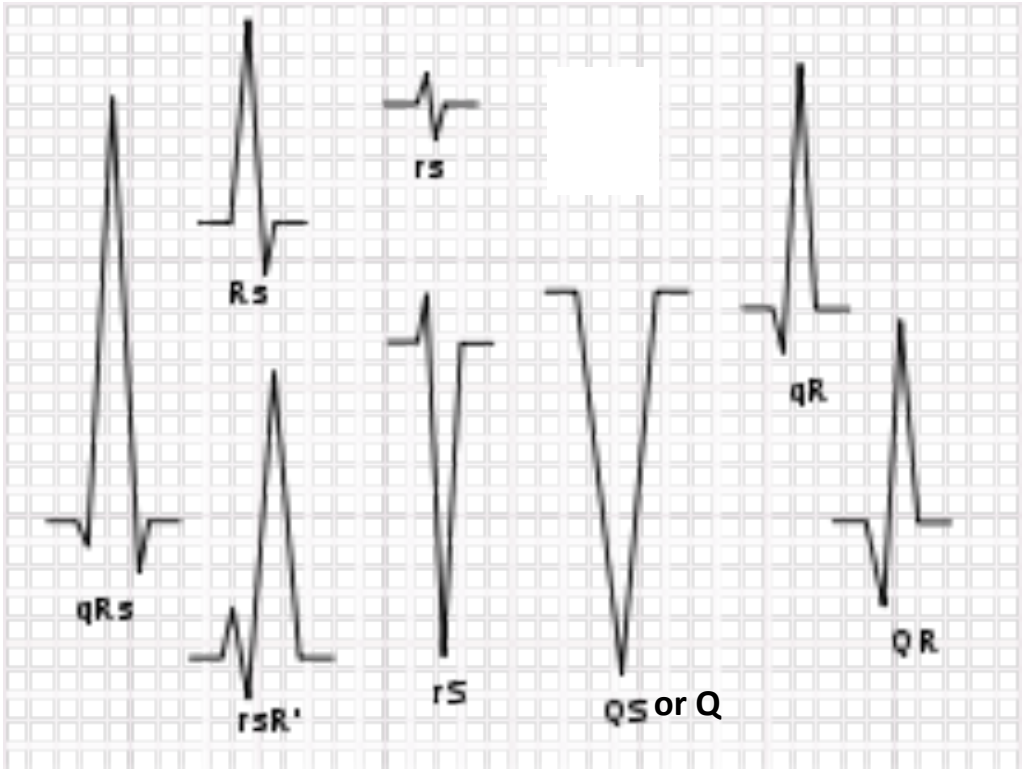
PR interval: beginning of atrial depolarization to beginning of ventricular depolarization

QT interval: beginning of ventricular depolarization to end of ventricular repolarization

QRS nomenclature looks complex, but is actually simple.

Q = 1st negative deflection
R = 1st positive deflection
S = 2nd negative deflection
R’ = 2nd positive deflection

(We don’t distinguish between upper and lower case letters.)



A systematic method of ECG interpretation

- Rate
- Rhythm
- Intervals
- Axis*
- P, QRS, ST, T abnormalities*

**Mostly covered in future years and not in OSD.*

A systematic method of ECG interpretation

- Rate
- Rhythm
- Intervals
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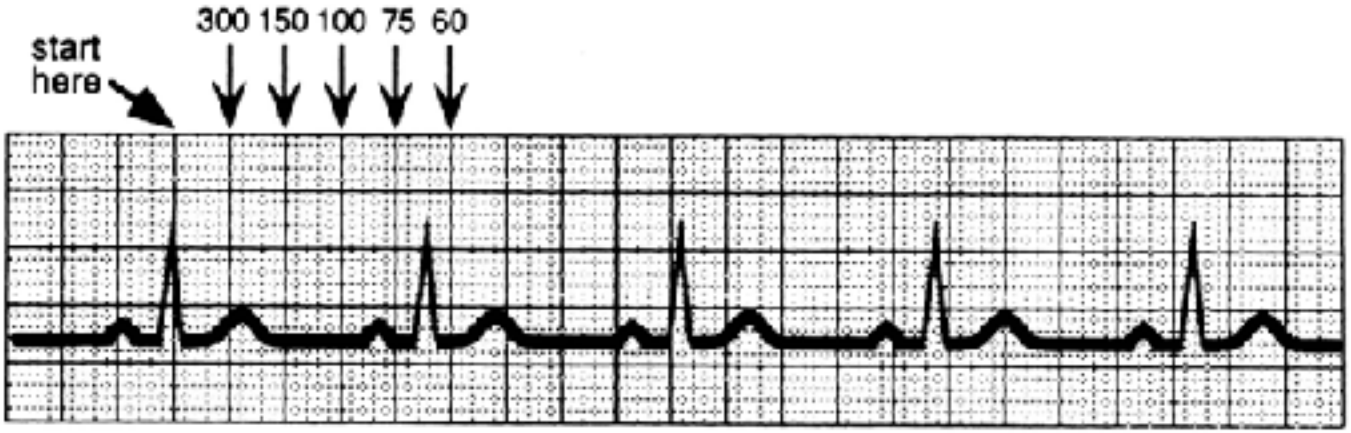
Determining the rate if the rhythm is regular

The "count-off" method requires memorizing the sequence:

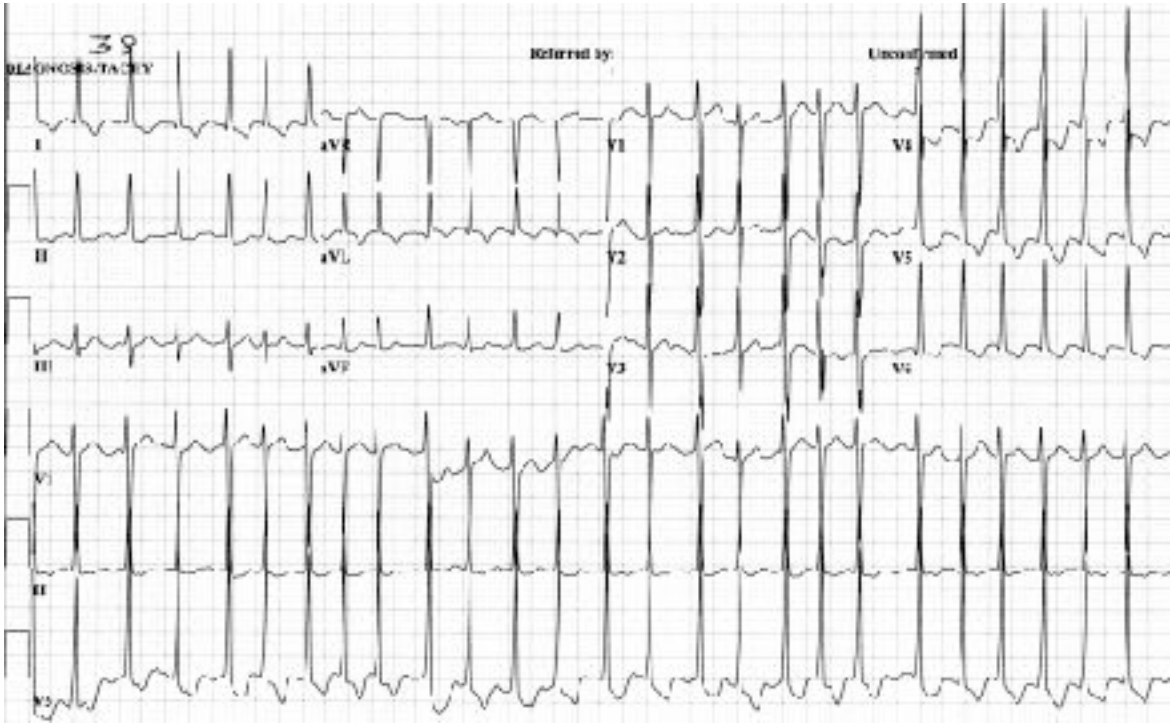
300 - 150 - 100 - 75 - 60 - 50

In the example, count-off the number of large boxes between two consecutive beats:



The second QRS falls between the "75" and "60" beats/min; therefore the heart rate is approximately mid-way between them, ≈ 67 beats/min. Knowing that the heart rate is *approximately* 60-70 beats/min is certainly close enough.

Determining the rate if the rhythm is irregular



Since an ECG is 10 seconds long, count the number of complexes and multiply by 6.

In this example, the rate is 26 x 6 = 156 bpm.

A systematic method of ECG interpretation

- Rate
- Rhythm
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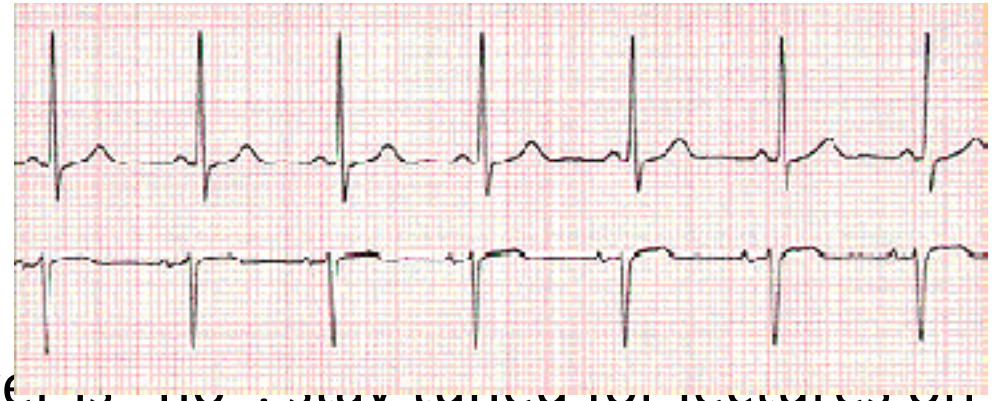
Determining the rhythm is not simple.

- Is it normal sinus rhythm?
  - Is there a P wave before every QRS complex and a QRS after every P wave?
  - Is the rate between 55-100 bpm in adults, 70-120 bpm in kids aged 1-10 or 100-160 bpm in newborns?



- If the answer is "no", stay tuned for lectures on arrhythmias.

A systematic method of ECG interpretation

- Rate
- Rhythm
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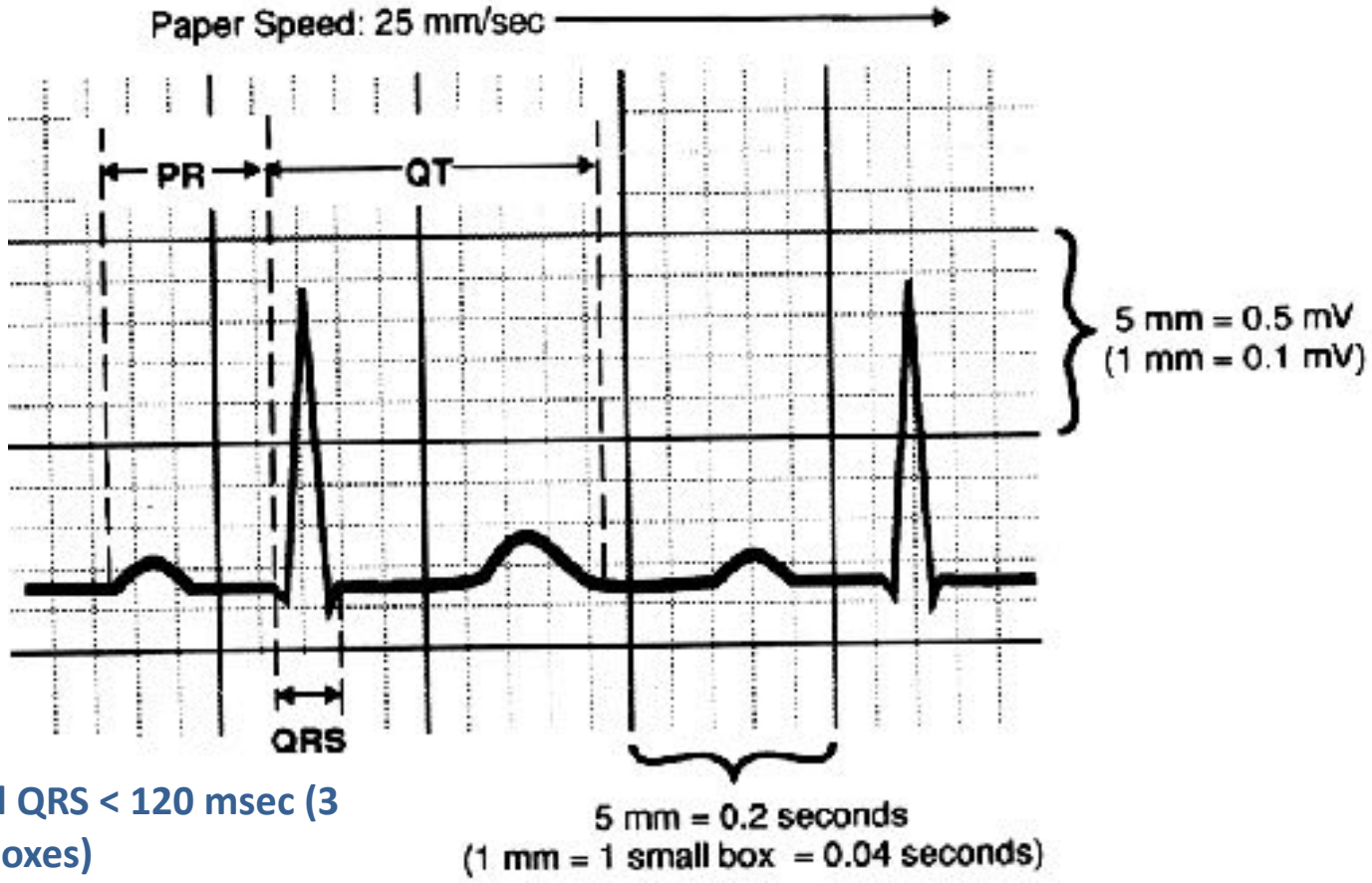
How to measure intervals

Normal PR = 120-200 msec (3-5 small boxes)



Normal QRS < 120 msec (3 small boxes)

Normal QT depends on heart rate and gender. To get the corrected QT (QTc), divide QT by square root of R-R interval (distance between QRS complexes). Normal QTc <450 msec for males, <460 msec for females.

How much of this will be on the exams?

-- You might be shown an ECG with ischemia or infarction on it and be asked to identify it.

-- You might be shown an ECG with an obvious arrhythmia and be asked to identify it.

-- You will NOT have to calculate heart rate or intervals.

Questions?