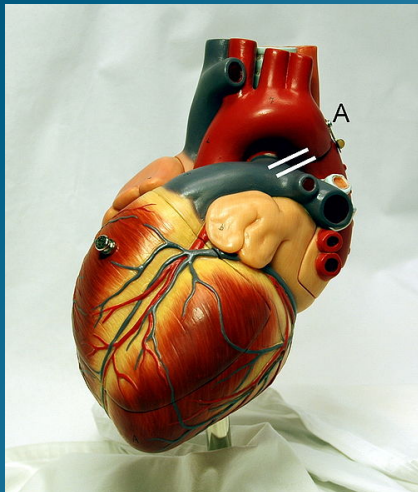


# Cardiovascular System Block The Electrocardiogram (ECG)



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## Lecture Objectives

1. Identify waves of the normal ECG and the physiological cause of each
2. Define the normal intervals in the ECG trace
3. Determine the bipolar, unipolar and chest leads

# The Normal Electrocardiogram (ECG)

The depolarization wave spread through the heart



electrical currents pass into the surrounding tissue

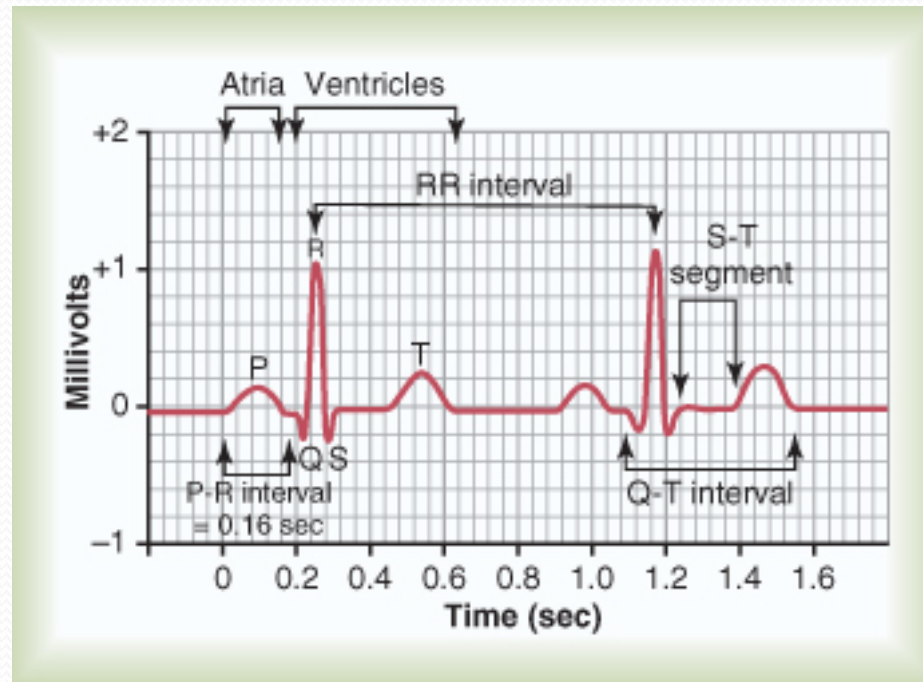


part of the current reaches the surface of the body

- **The electrical potentials generated by these currents can be recorded from electrodes placed on the skin opposite the heart**

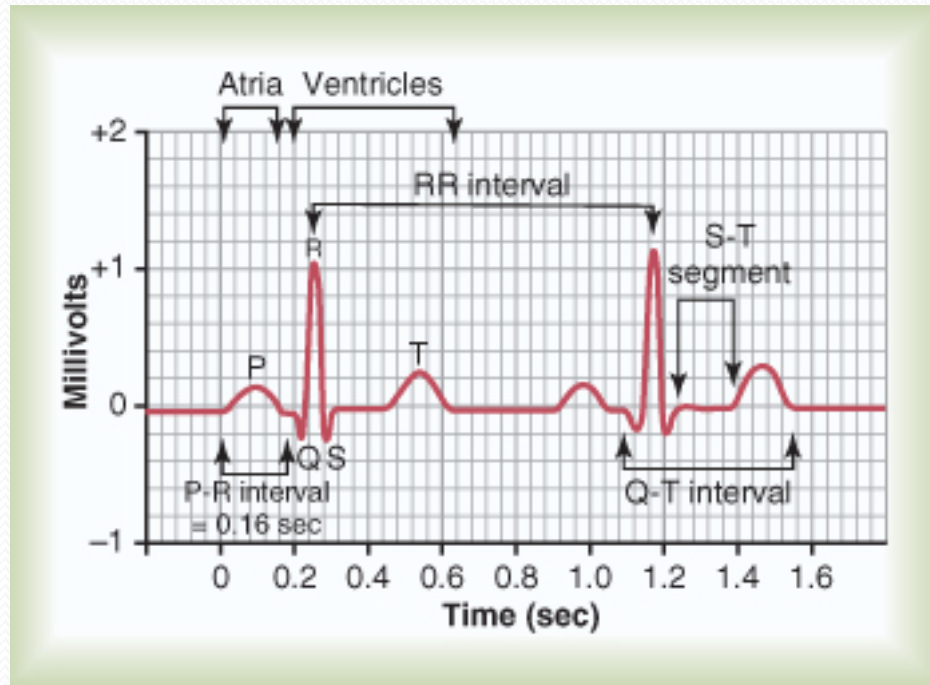
# The Normal Electrocardiogram (ECG)

- *The Electrocardiogram (ECG)* is a recording of the electrical activity of the heart



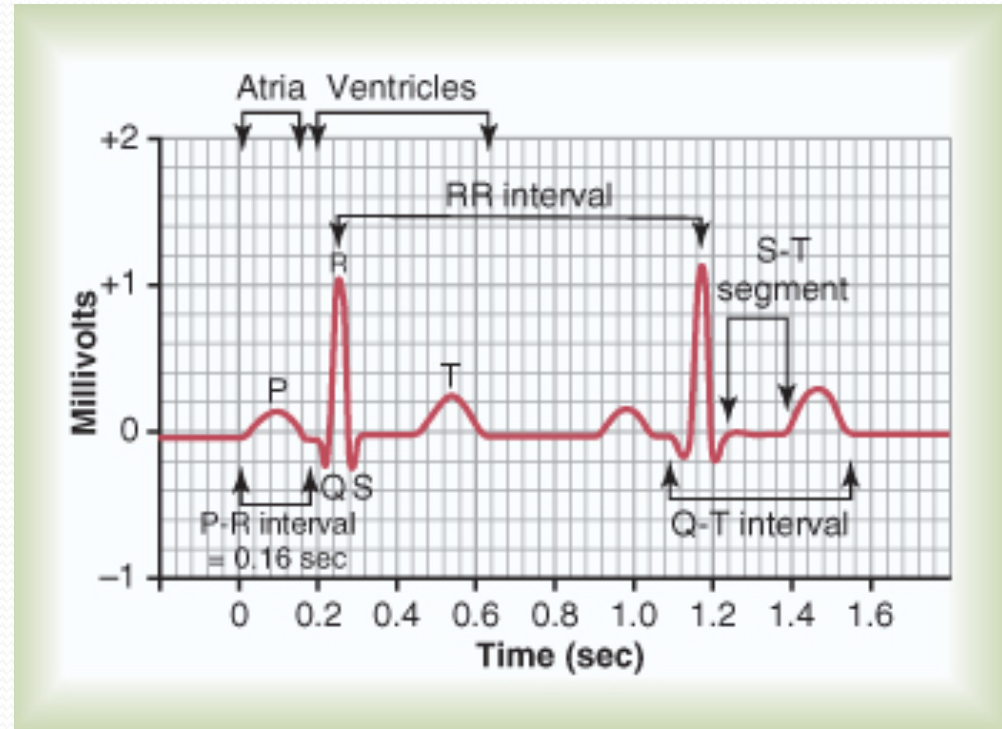
# The Normal Electrocardiogram (ECG)

- **P wave**: is caused by atrial depolarization
- **QRS complex**: is caused by depolarization of the ventricles
- **T wave**: repolarization of the ventricles



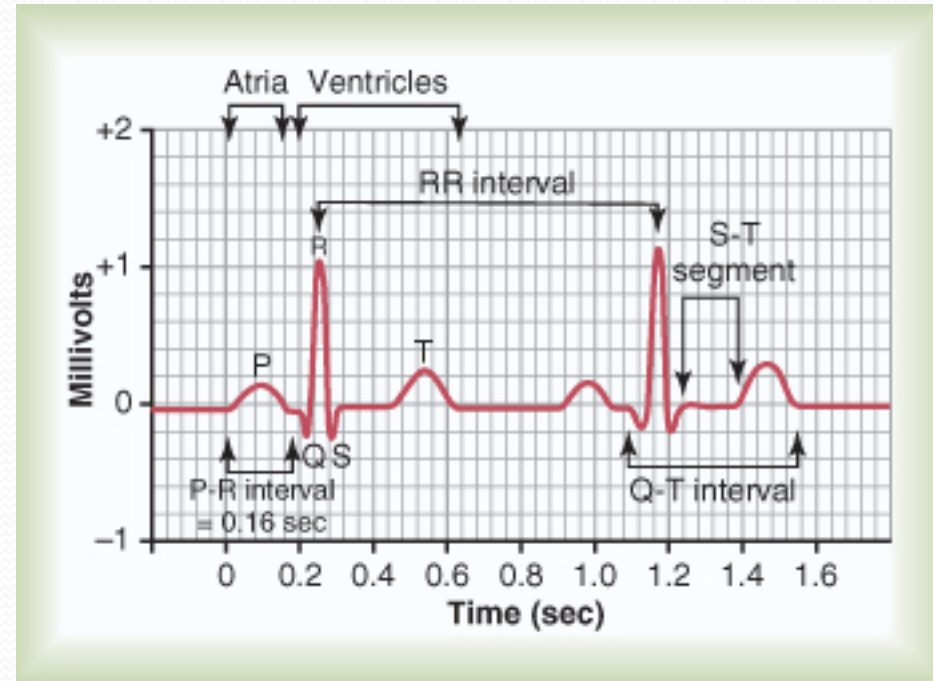
# Voltage and Calibration of the ECG

- The vertical calibration lines: Voltage(millivolt)
  - 5 small lines = 1 mV
- The horizontal calibration lines: Time (seconds)
  - 1 inch(25 small lines) = 1 second
  - Each inch is divided by 5 dark vertical lines
  - The interval between the dark lines= 0.2 second
  - thin line=0.04 second



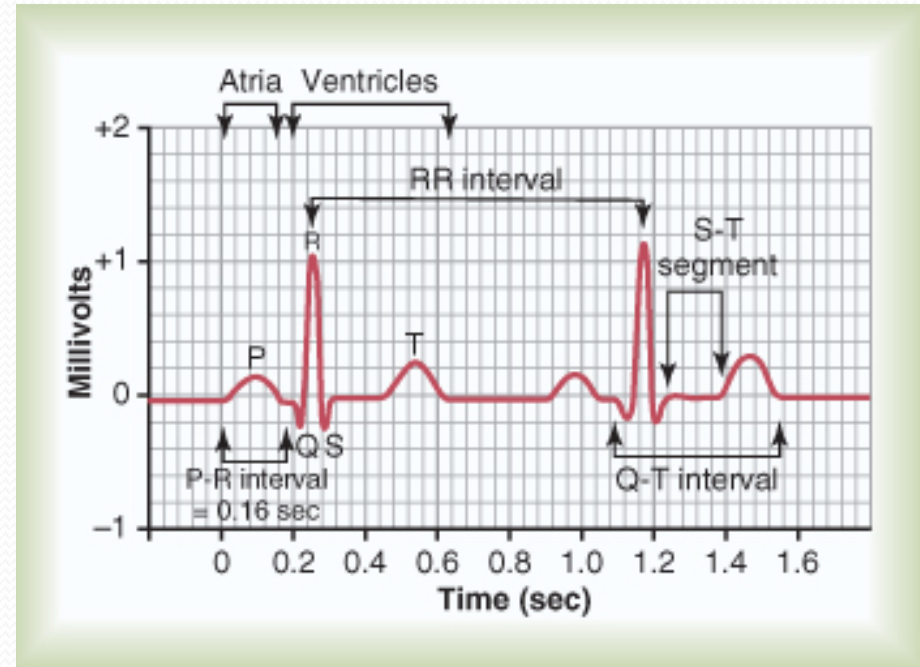
## P-R interval

- It is the time between the beginning of the P wave and the beginning of the QRS complex
- It is the interval between the beginning of electrical excitation of the atria and the beginning of excitation of the ventricles
- The P-R interval is about 0.16 second



# Q-T interval

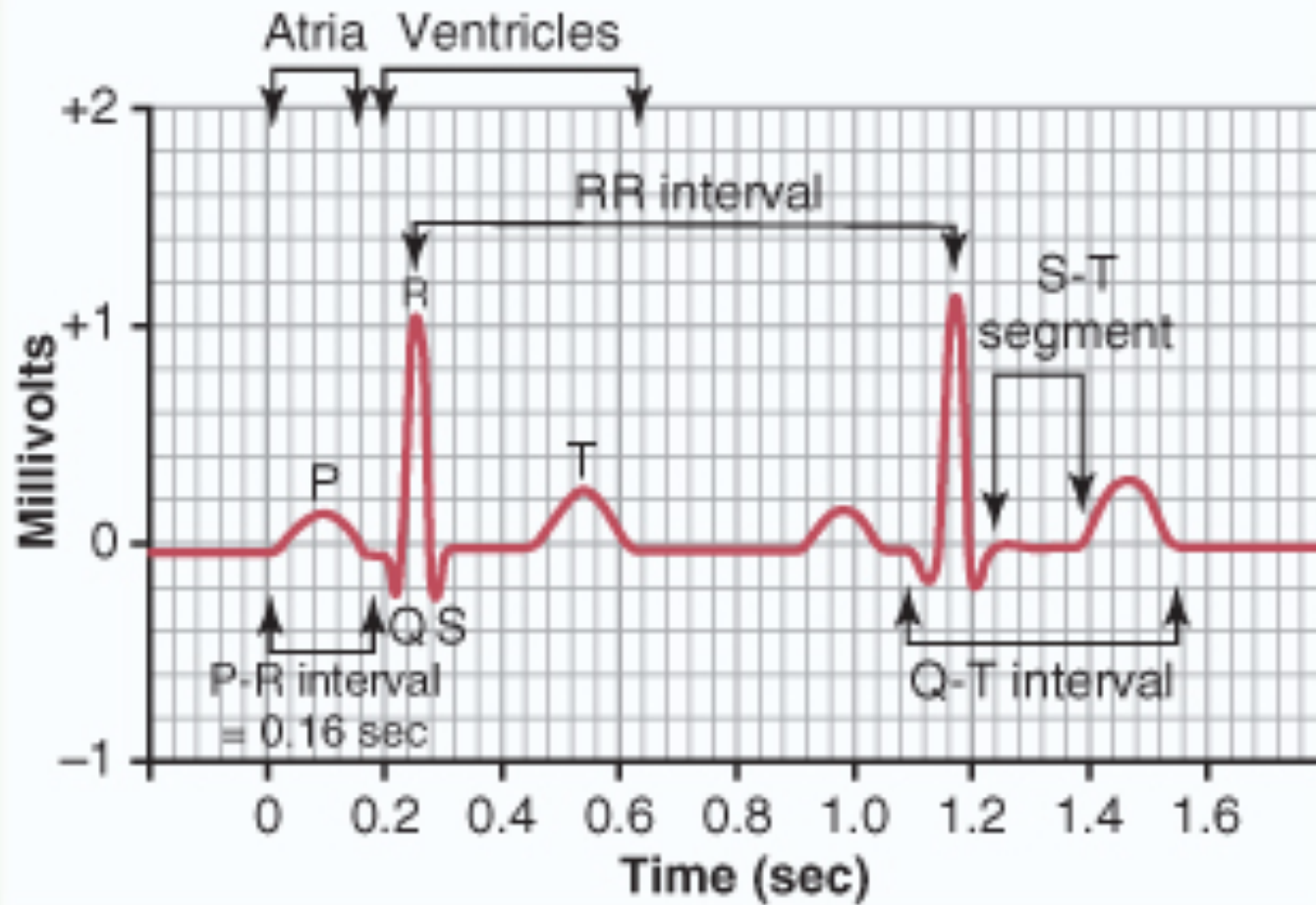
- The QT interval represents electrical depolarization and repolarization of the ventricles
- Q-T interval is the time from the beginning of the Q wave to the end of the T wave
- Q-T interval is about 0.35 second





## Heart Rate

- The heart rate is the repetition of the time interval between two successive heartbeats
- If the interval between 2 beats is 1 second, the heart rate is 60 beats per minute



# Methods for Recording Electrocardiograms

## Computer-based and electronic display

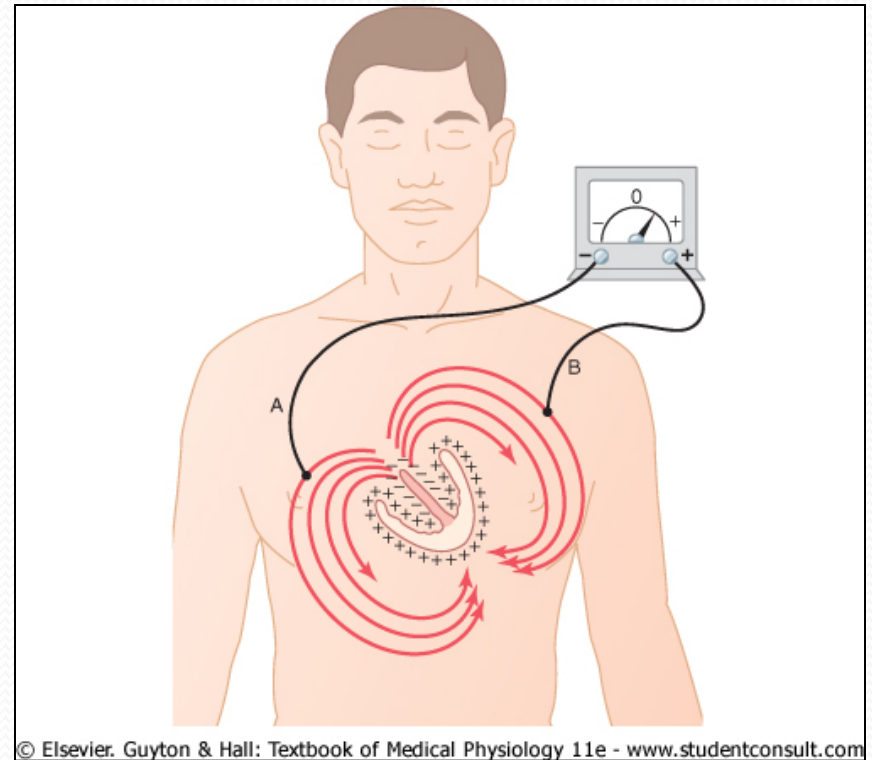


## Pen recorder and a moving sheet



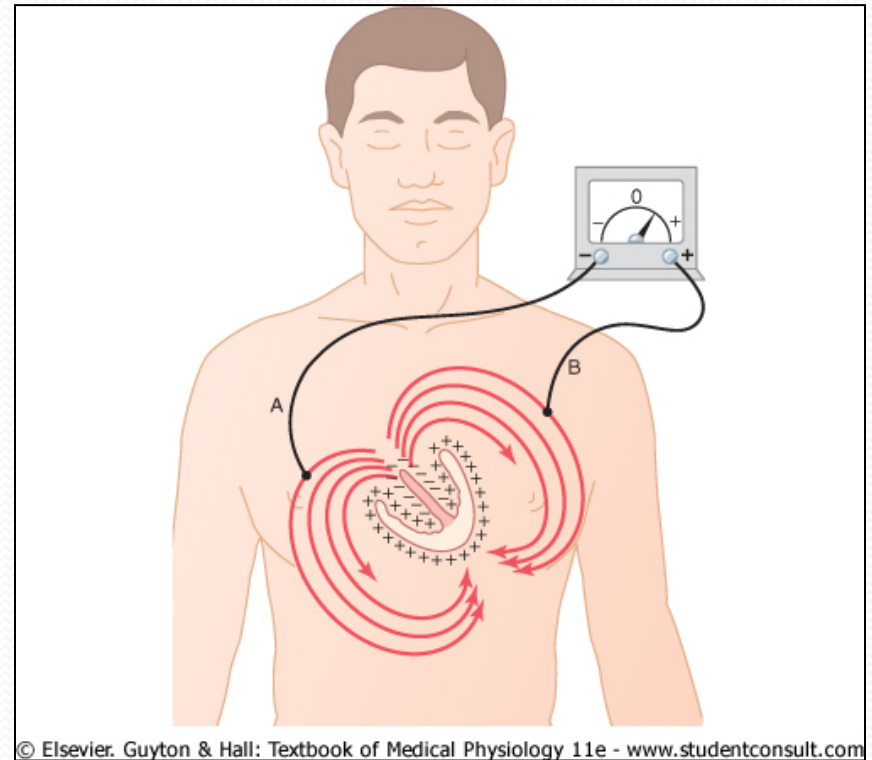
# Flow of Electrical current in the Heart

- In normal ventricles, current flows from negative to positive from the base of the heart toward the apex
- The first area that depolarizes is the ventricular septum



# Flow of Electrical current in the Heart

- Current flows from the electronegative inner surface of the heart to the electropositive outer surface (from the base of the heart to the apex)
- An electrode placed near the base of the heart is electronegative, and near the apex is electropositive

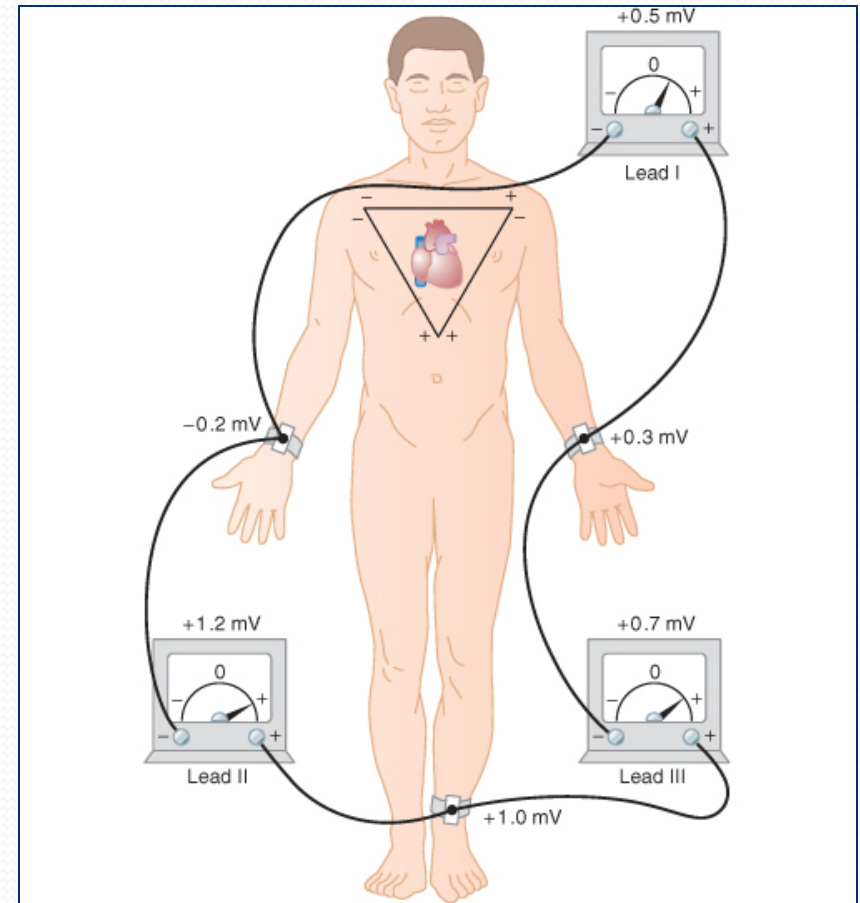


# The ECG Leads

- **Lead: two wires and their electrodes to make a complete circuit**
- **The Bipolar Limb Leads: (I, II, III)**
- **Chest Leads: (V<sub>1</sub>, V<sub>2</sub>, V<sub>3</sub>, V<sub>4</sub>, V<sub>5</sub>, V<sub>6</sub>)**
- **Augmented Unipolar Limb Leads (aVR, aVL, aVF)**

# The Bipolar Limb Leads

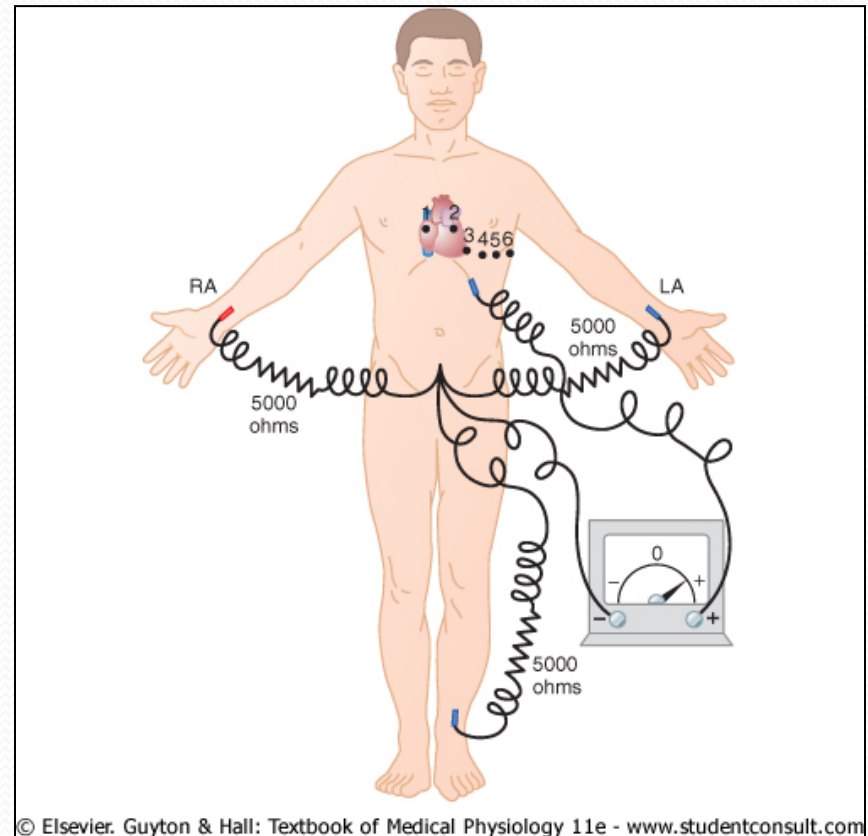
- Bipolar: means that the ECG is recorded from two electrodes
- Lead I:
  - *The right arm : -ve*
  - *The left arm: +ve*
- Lead II:
  - *The right arm: -ve*
  - *The left leg: +ve*
- Lead III:
  - *The left arm: -ve*
  - *The left leg: +ve*



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## Chest Leads

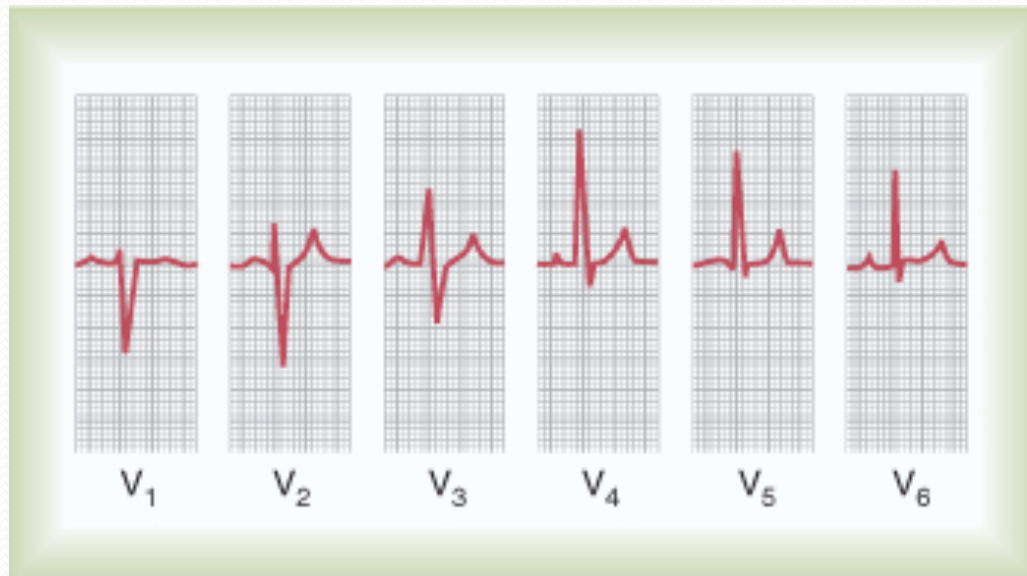
- Recorded from the anterior surface of the chest (V<sub>1</sub>, V<sub>2</sub>, V<sub>3</sub>, V<sub>4</sub>, V<sub>5</sub>, V<sub>6</sub>)
- Positive electrode on the chest
- The indifferent electrode is the negative electrode connected to the right arm, left arm, and left leg





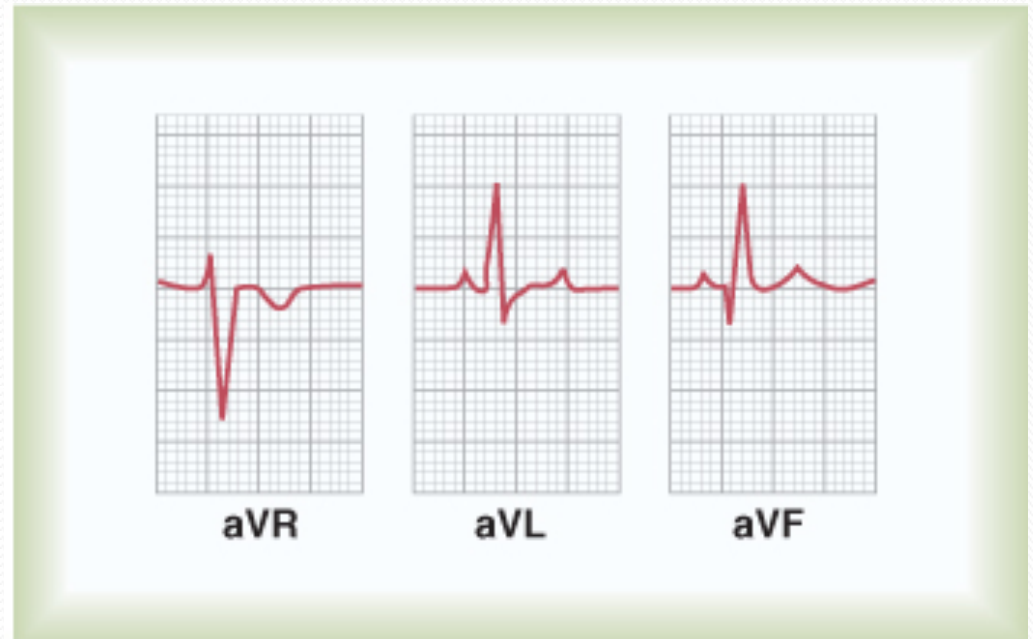
## Chest Leads

- V<sub>1</sub> and V<sub>2</sub>: QRS are mainly negative because the chest leads are nearer to the base of the heart
- V<sub>3</sub>, V<sub>4</sub> and V<sub>6</sub> are mainly positive because the chest electrode are nearer to the apex



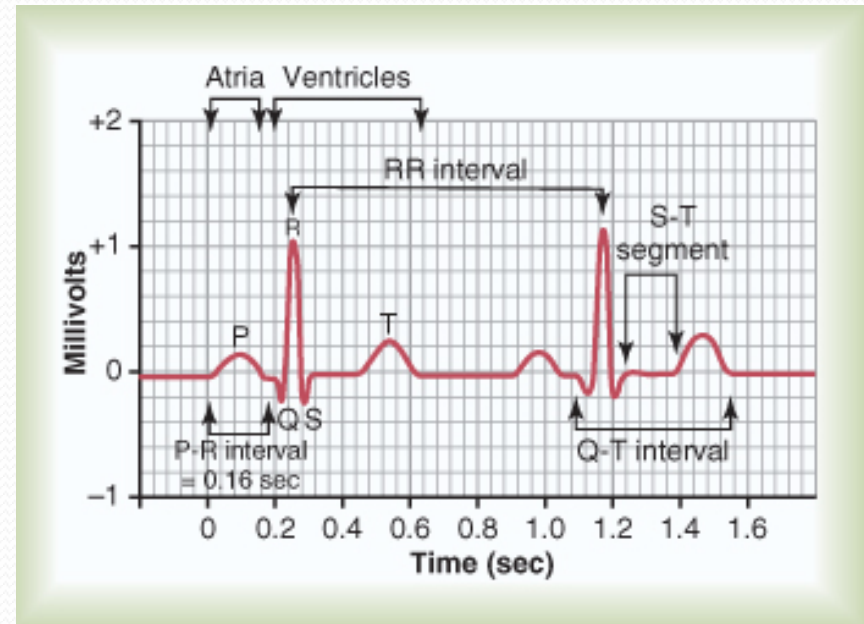
# Augmented Unipolar Leads

- The two limbs are connected to the negative terminal of the ECG, and the third limb is connected to the positive
- When the positive terminal is on:
  - The right arm (aVR)
  - The left arm (aVL)
  - The left leg (aVF)
- All are similar to the standard limb leads
- aVR lead is inverted



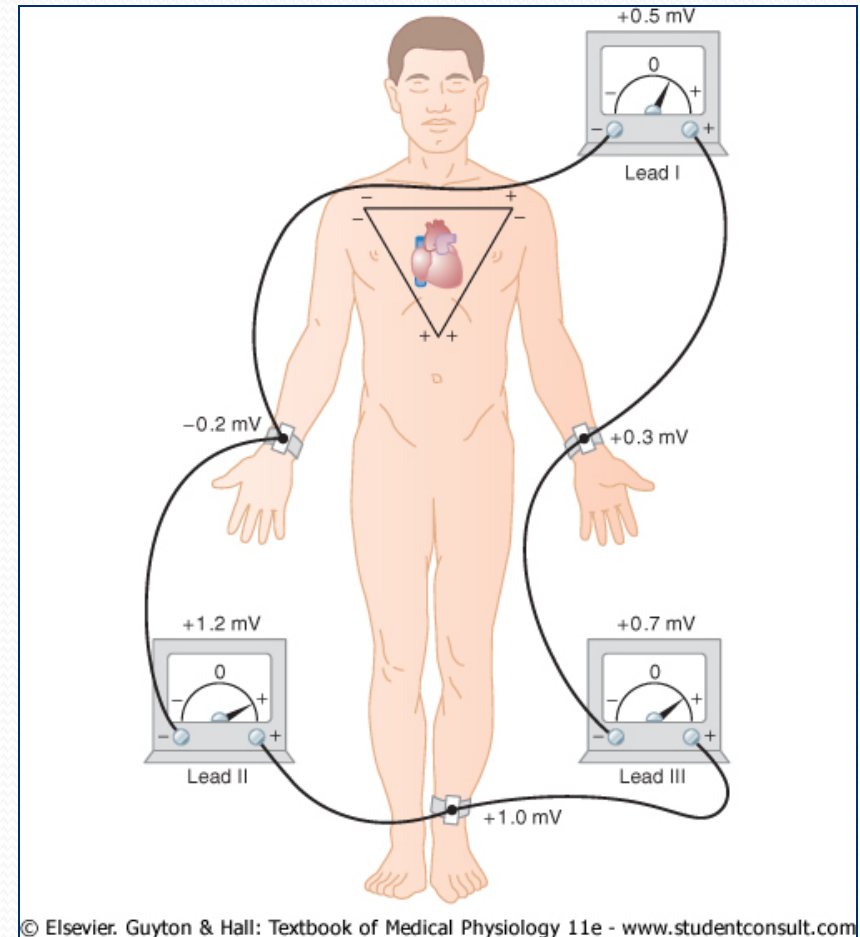
# Practical use of the ECG

- Heart rate
- Normal intervals
- Rhythm
  - Regular
  - Single p-wave precedes every QRS complex
  - P-R interval is constant and within normal range
- Cardiac axis Axis



# Einthoven's Triangle

- Einthoven's Triangle: is drawn around the area of the heart
- The two apices at the upper part of the triangle represent the points at which the two arms connect electrically
- The lower apex is the point at which the left leg connects



## Einthoven's Law

- Einthoven's Law: if the electrical potential of any two of the three bipolar limb leads are known, the third one can be determined mathematically by summing the first two (note the +ve and -ve signs)

- *The sum of the voltage in  
Lead I + Lead III = Lead II*

**Einthoven's law**

For further readings and diagrams:

**Textbook of Medical Physiology by Guyton & Hall**  
Chapter 11 (The Normal Electrocardiogram)