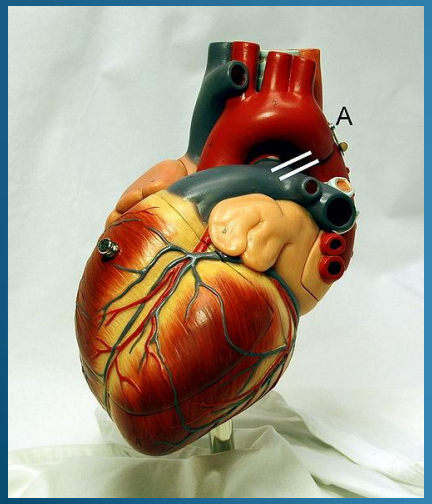
Cardiovascular System Block
The Electrocardiogram (ECG)



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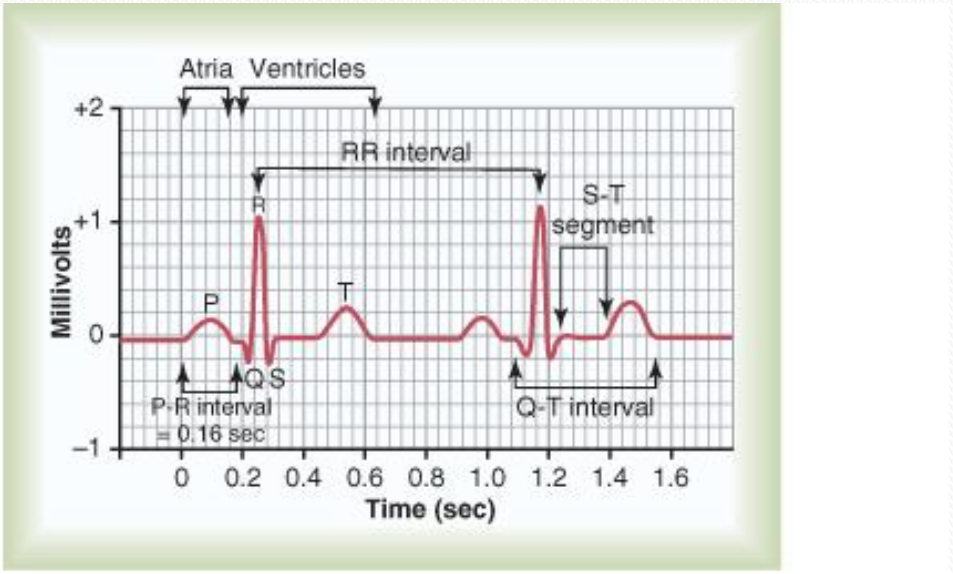
Lecture Objectives

1. Describe how the standard 12 lead ECG is recorded
2. Explain the physiological origin of the various elements of the ECG trace
3. Identify the normal values of the ECG
4. Define the normal intervals in the ECG trace

The Electrocardiogram (ECG)

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

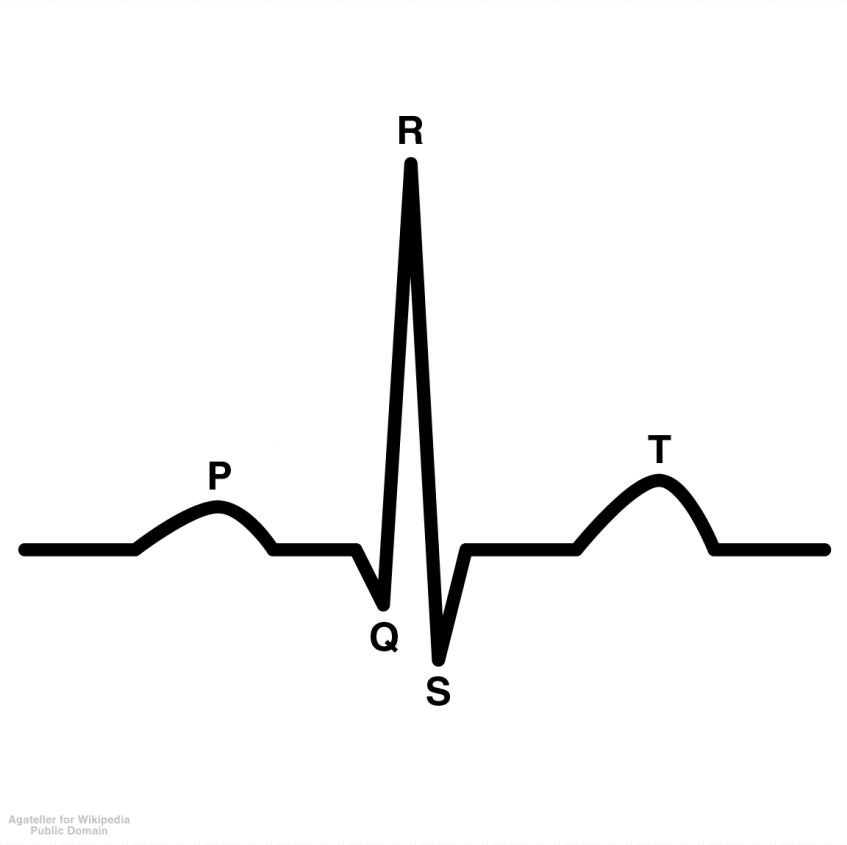


Interesting Fact

- *British physiologist Augustus D. Waller published the first human ECG in 1887*
- *Willem Einthoven made his first recording of the ECG in 1901 and was awarded the Nobel prize in 1924*

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**

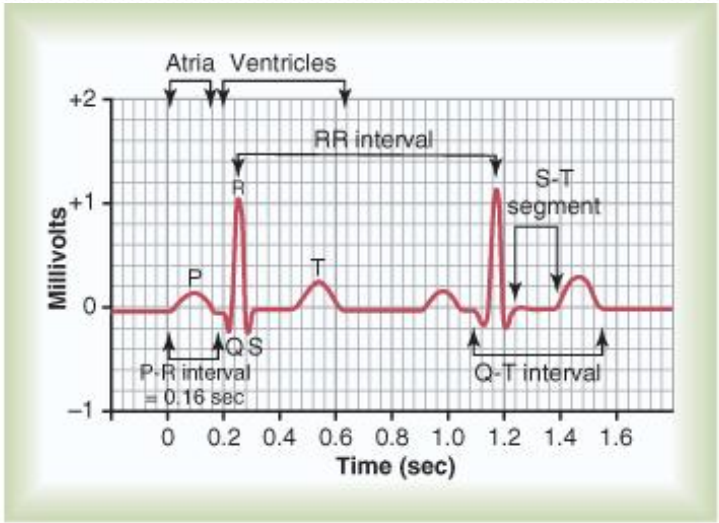


No atrial repolarization wave, why?

- Because atria repolarize during ventricular depolarization, so the wave is obscured by the large QRS complex

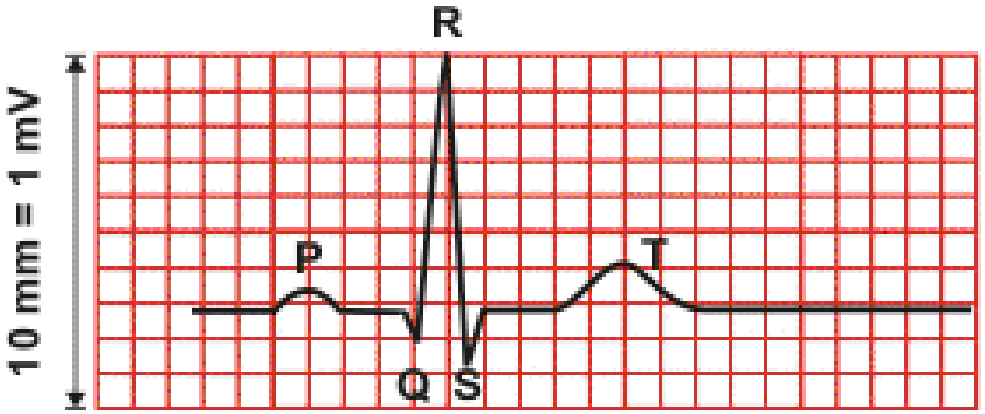
Voltage and Calibration of the ECG

- **Horizontal lines**:
  - 10 small lines = 1 mV
- Vertical lines:
  - thin line=0.04 second
  - 5 small thin lines= 0.2 second
  - 1 inch= 1 second



The Normal Electrocardiogram (ECG)

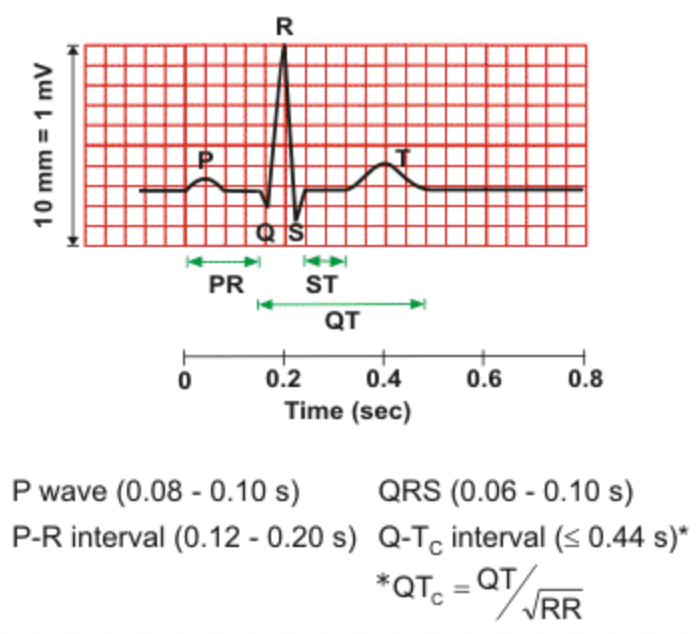
- The amplitude of the ECG deflection reflects the mass of tissue involved
  - Why P wave is always smaller than QRS?
- Compare Twave and QRS complex (voltage and duration)
- The T wave is a prolonged wave but the voltage is less than the QRS complex because the process of repolarization extend over a long period



Practical Use of the ECG
Normal Intervals on the ECG

P-R interval

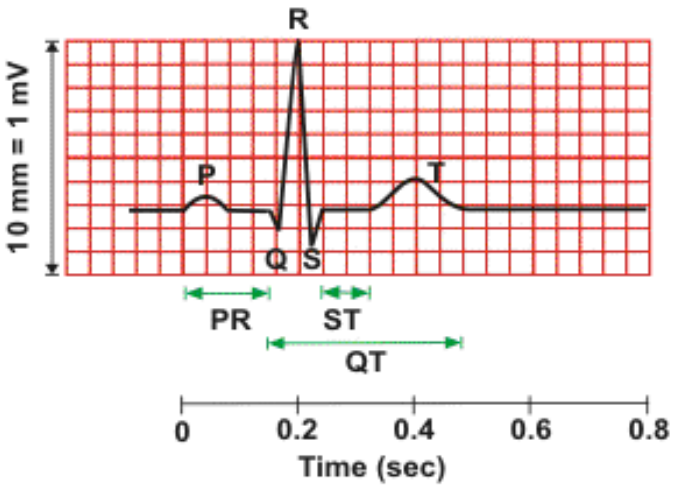
- **the time between the beginning of the P wave and the beginning of the QRS complex**
- **the time between the beginning of electrical excitation of the atria and the beginning of excitation of the ventricles**
- **Normal P-R interval = 0.12-0.2 second**



Practical Use of the ECG
Normal Intervals on the ECG

Q-T interval:

- the time from the beginning of the Q wave to the end of the T wave
- **Normal Q-T interval< 0.4 second**



P wave (0.08 - 0.10 s) QRS (0.06 - 0.10 s)

P-R interval (0.12 - 0.20 s) Q-T_C interval (≤ 0.44 s)*

*$QT_C = QT/\sqrt{RR}$

Practical Use of the ECG

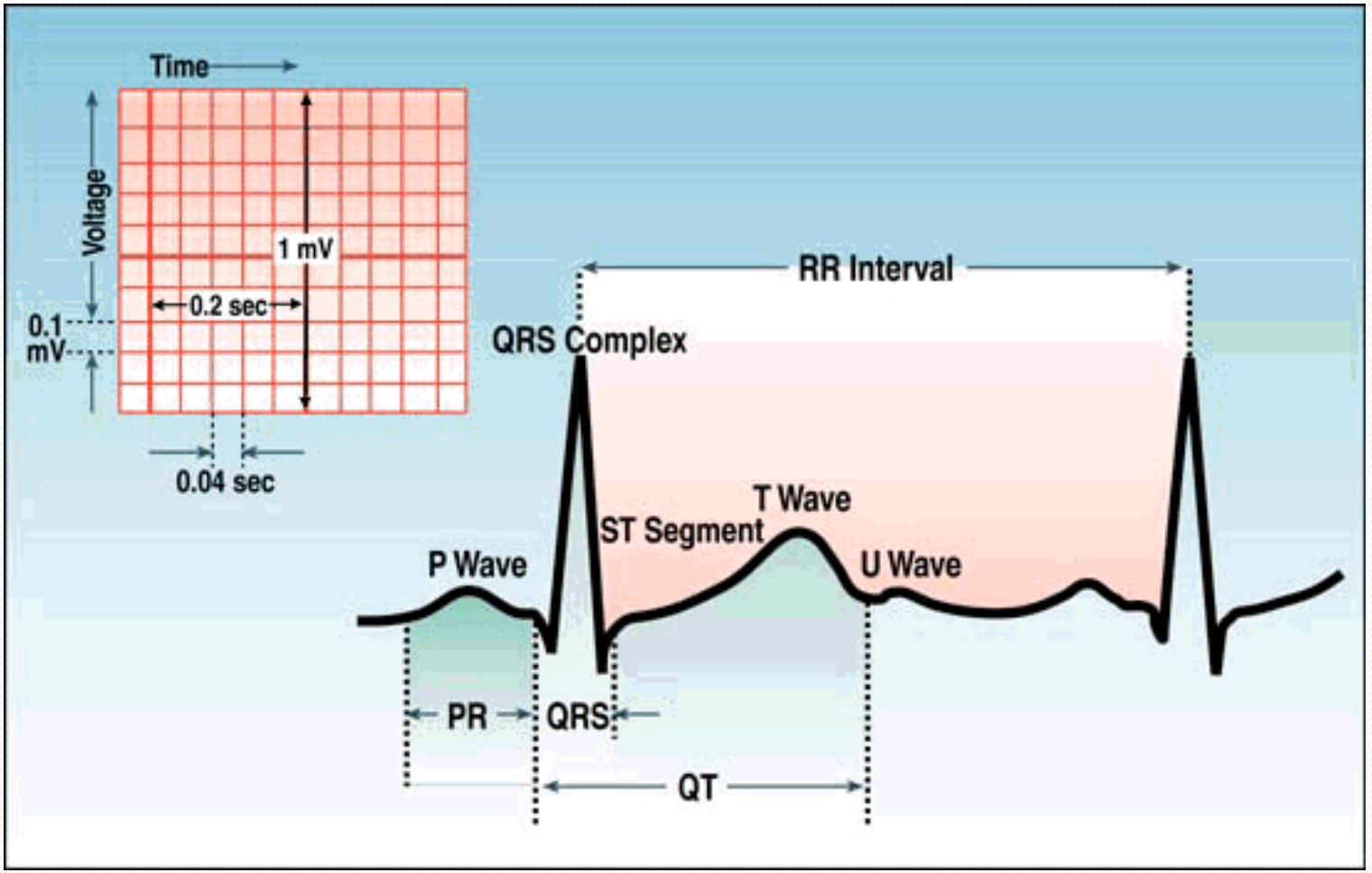
Heart Rate

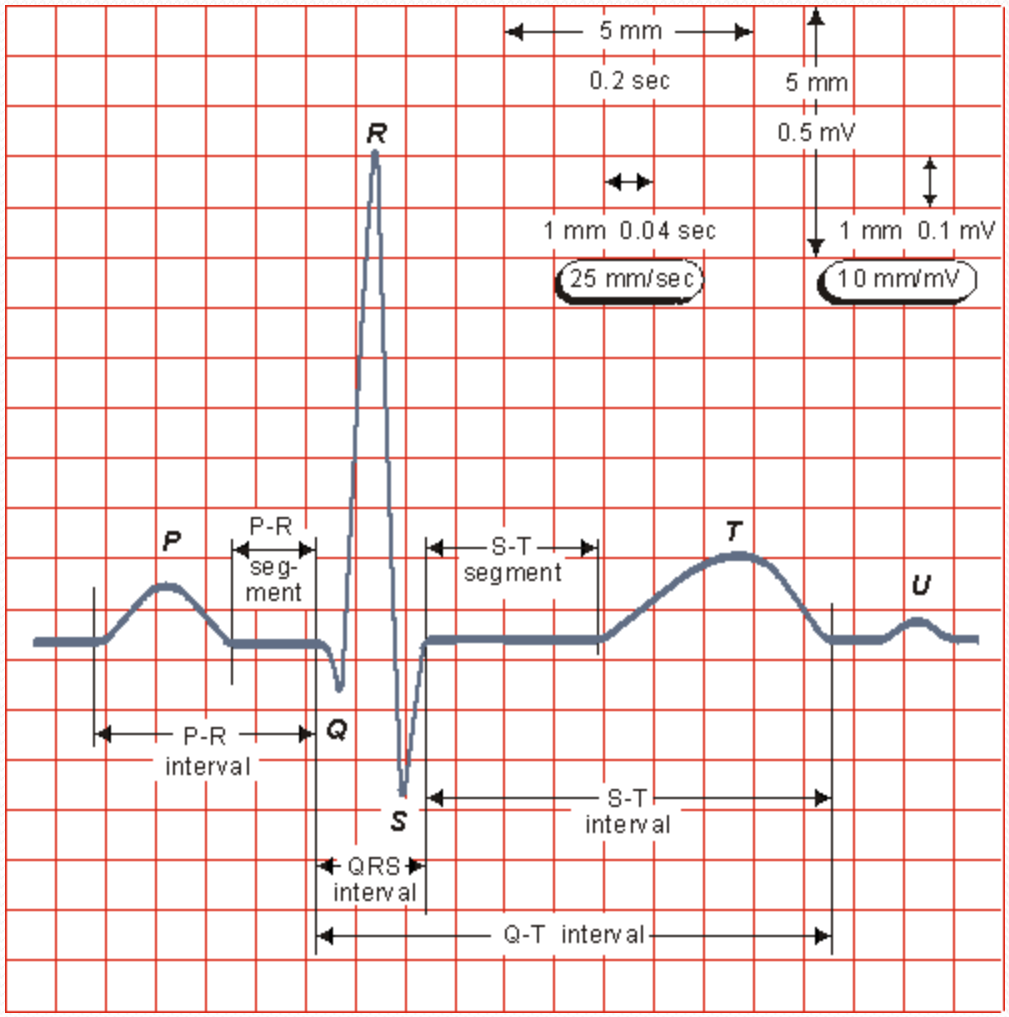
Example

- Large square = 0.2 s
- 5 large squares / s
- 300 large squares / min
- Heart Rate = 300 / number of large squares between R-R interval

Practical Use of the ECG

Heart Rate




5 mm
0.2 sec
5 mm
0.5 mV
R
1 mm 0.04 sec
1 mm 0.1 mV
25 mm/sec
10 mm/mV
P
P-R
seg-
ment
S-T
segment
T
U
P-R
interval
Q
S
S-T
interval
QRS
interval
Q-T interval

Practical Use of the ECG

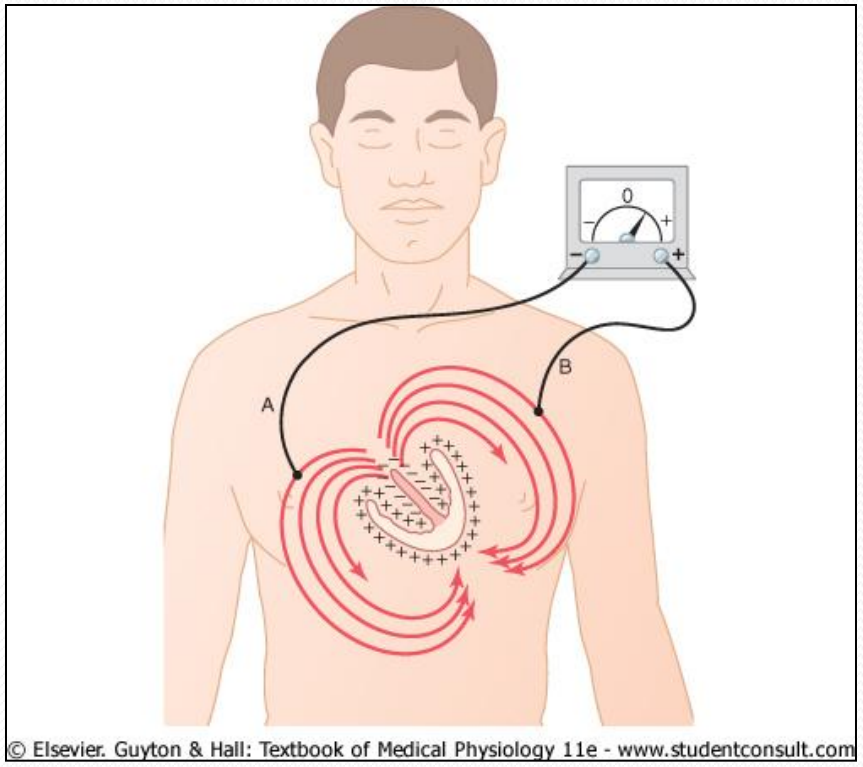
- Normal Intervals (P-R, Q-T intervals)
- Heart Rate
- Cardiac Axis
- Rhythm

Flow of Electrical current in the Heart

- **The first area that depolarizes is the ventricular septum then shortly spreads to the inside of the ventricles**
- ***During depolarization, the electrical current flows***

  from the base of the heart negative)

  toward the apex (positive)



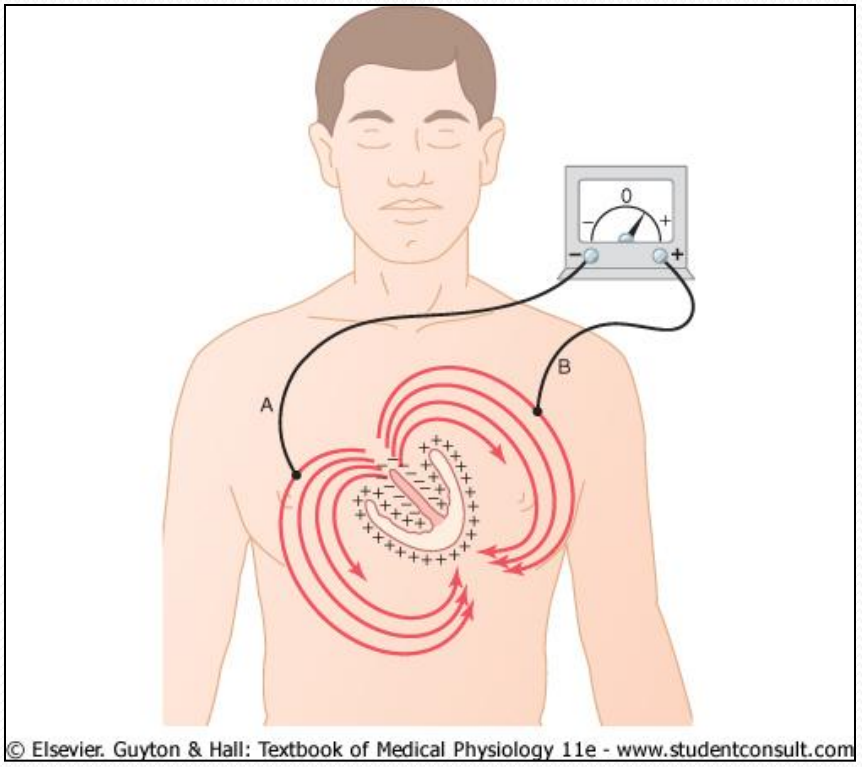
Flow of Electrical current in the Heart

The electrodes

Near the *base is -ve,*

and

near *the apex is +ve*



Methods for recording ECGs

Computer-based and electronic display

Pen recorder and a moving sheet

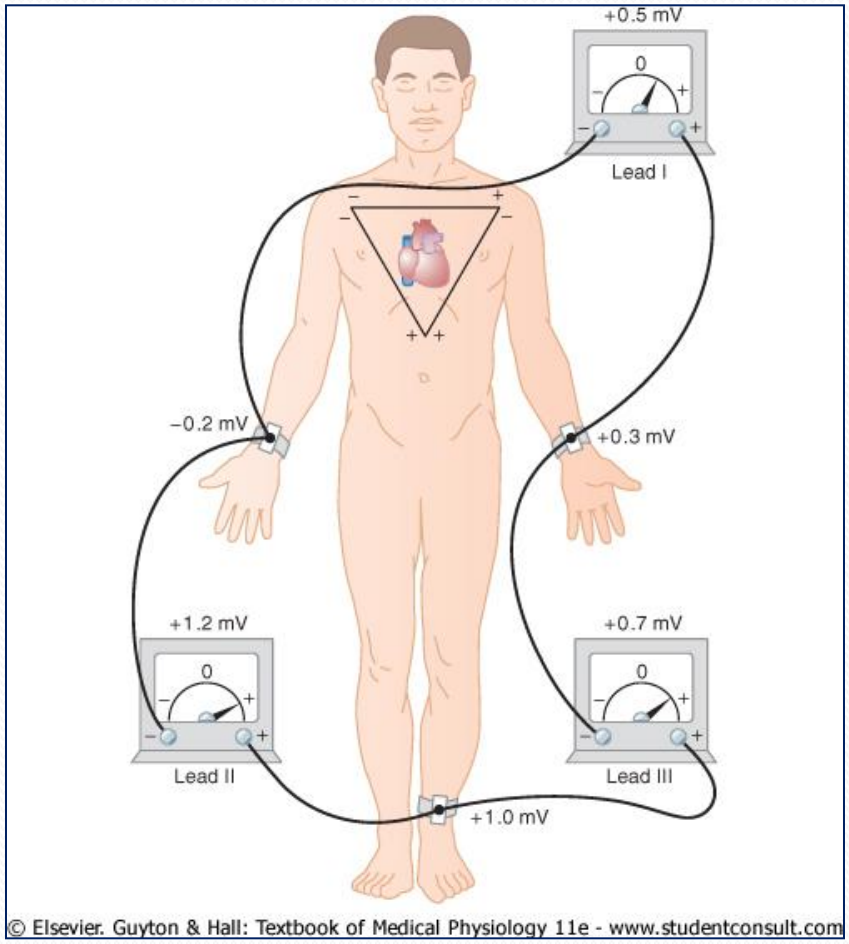
The ECG Leads

- **Lead: two wires and their electrodes to make a complete circuit**
- **3 types of ECG leads:**
  1. **The Bipolar Limb Leads (standard limb leads): (I, II, III)**
  2. **The unipolar augmented leads (aVR, aVL, aVF)**
  3. **Chest Leads: (V1, V2, V3, V4, V5, V6)**

The ECG Leads

The Standard Limb Leads

- **The Standard Limb Leads: Lead I, II & III**
  - **the electrocardiogram is recorded from two electrodes**
  - **the electrodes are on the right arm, left arm, left leg**
- ***Lead I: right and left arm***
- ***Lead II: right arm and left leg***
- ***Lead III: left arm and left leg***



The ECG Leads

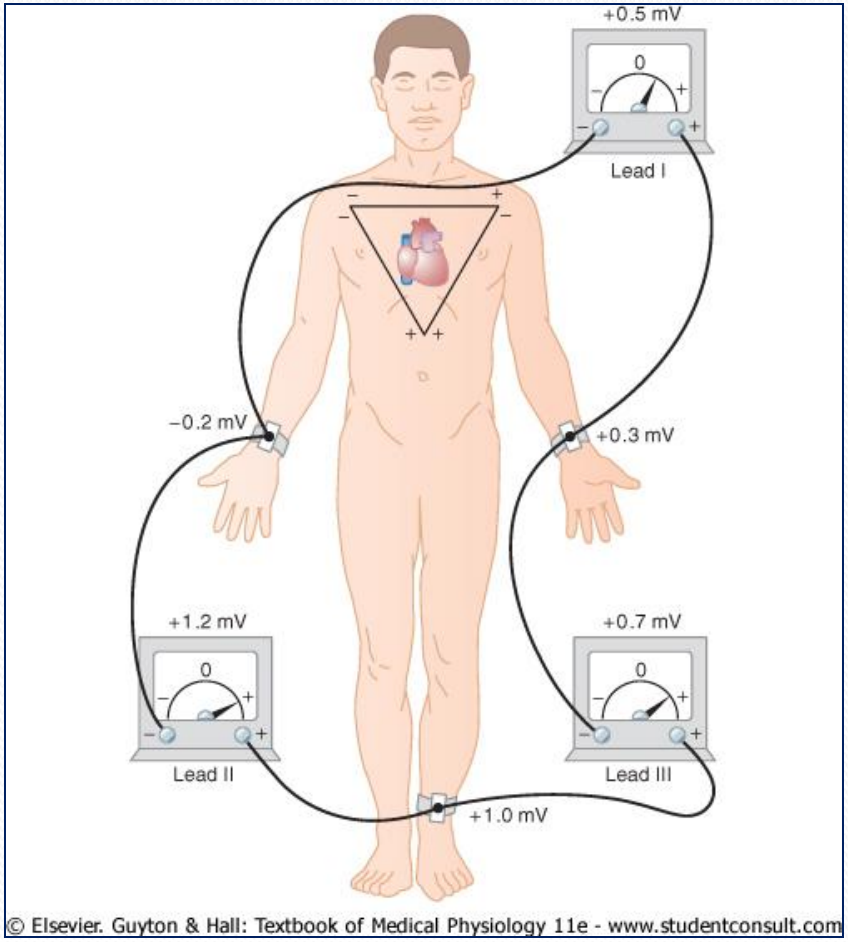
The Standard Limb Leads

- **The Standard Limb Leads: Lead I, II & III**

Enthoven's Triangle

- **Enthoven's Triangle**: is drawn around the area of the heart
- **Enthoven'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)
- Example: the sum of the potentials in lead I and III equals the potentials in lead II

I+III=II



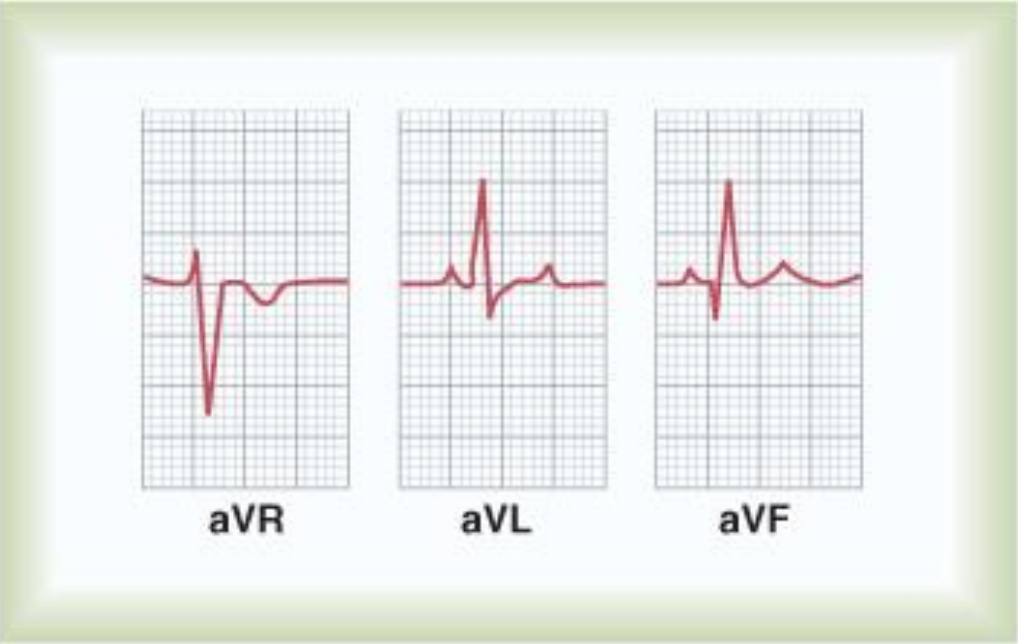
The ECG Leads

Augmented Unipolar Limb Leads

- **Augmented Unipolar Limb Leads (aVR, aVL, aVF)**
  - **right arm (aVR)**
  - **left arm (aVL)**
  - **left leg (aVF)**

The ECG Leads

Augmented Unipolar Limb Leads



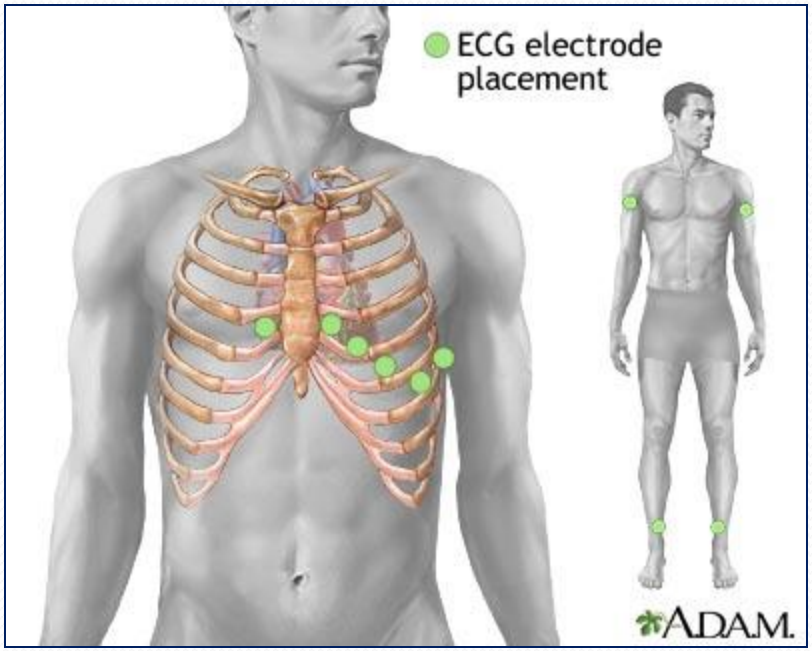
The ECG Leads

Chest Leads

- **Chest Leads: (V1, V2, V3, V4, V5, V6)**
- **one electrode is placed on the anterior surface of the chest on one of the points shown (positive)**
- **The *indifferent electrode* is the negative electrode connected to the right arm, left arm, and left leg**
- **V1 and V2: QRS are mainly negative because the chest leads are nearer to the base of the heart**
- **V3,V4 and V6 are mainly positive because the chest electrode are nearer to the apex**

The ECG Leads

Chest Leads: (V1, V2, V3, V4, V5, V6)



The ECG Leads

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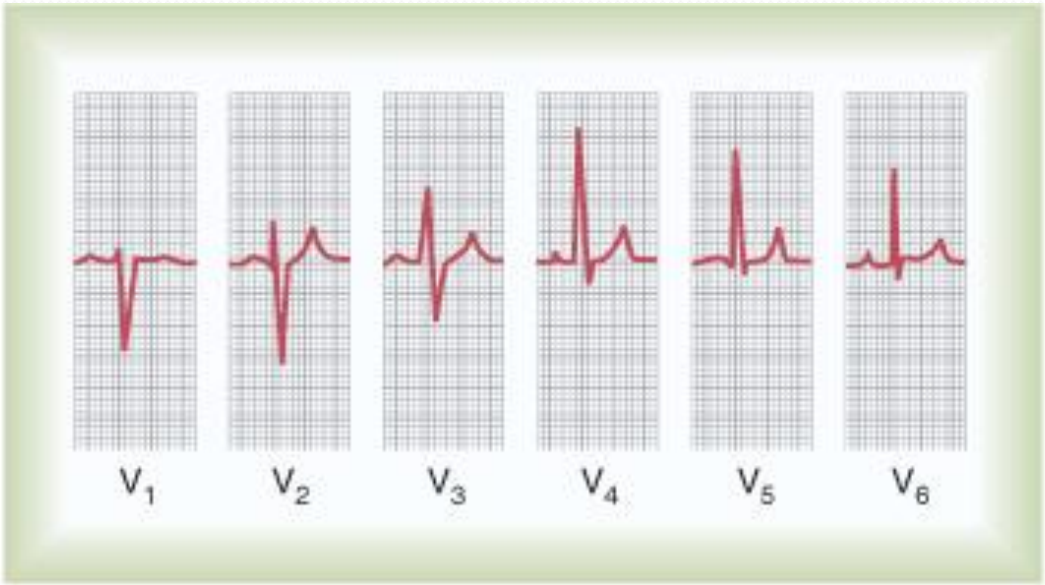


Cardiac Axis

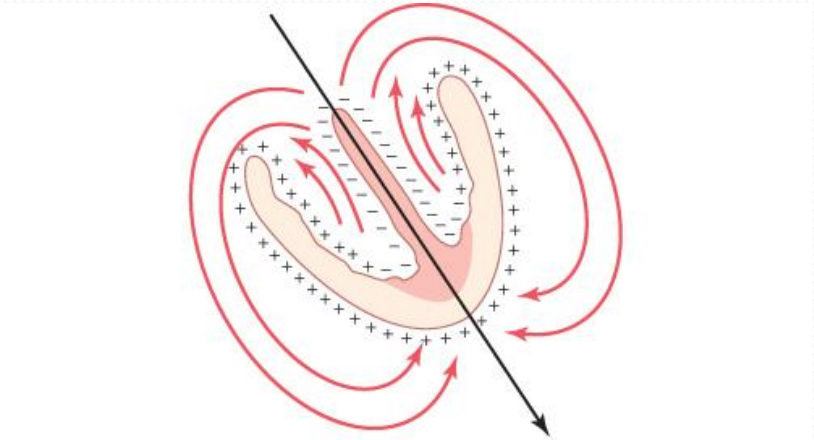
Practical Use of the ECG

Cardiac Axis

- **The ECG can be used to identify the direction of travel of the wave of depolarization through the heart**

Cardiac Axis

- **The electrical potential can be represented by a vector, with the *arrowhead pointing in the positive direction***
- **The *length* of the vector is *proportional to the voltage***



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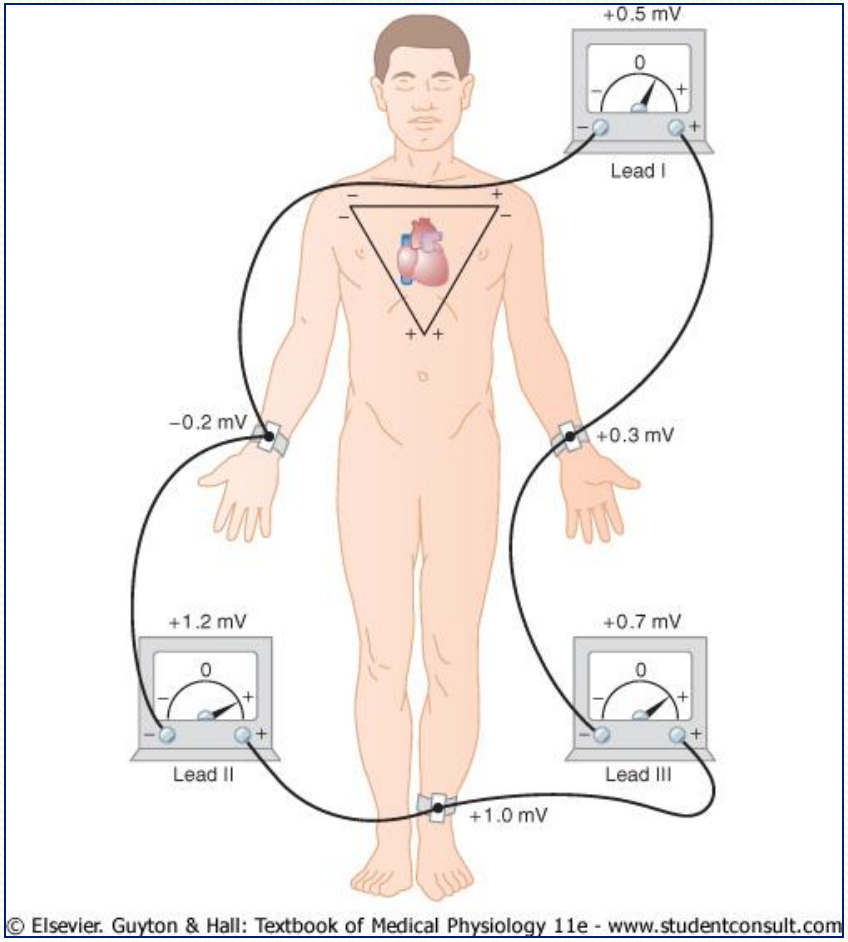
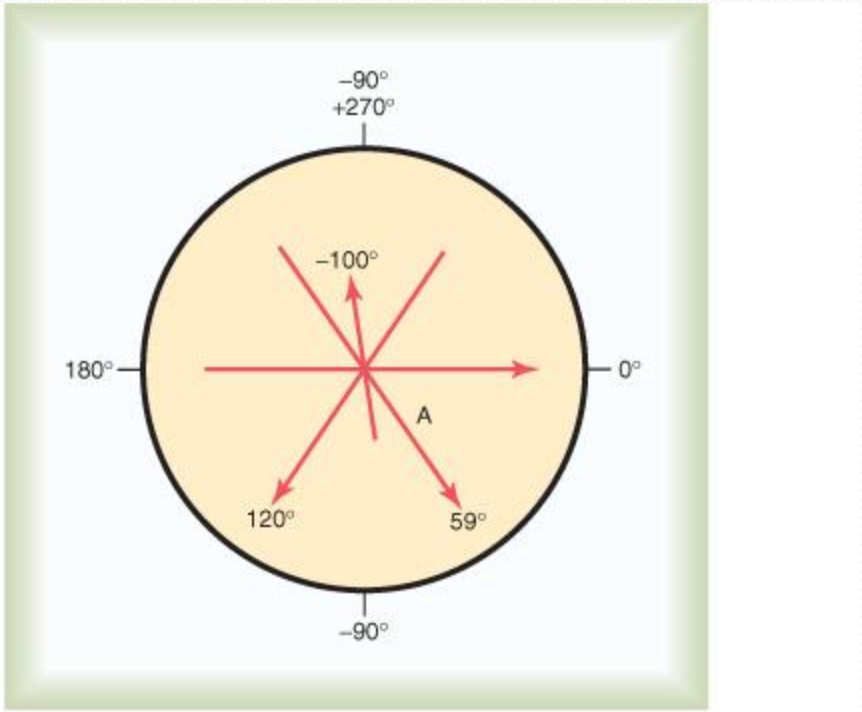


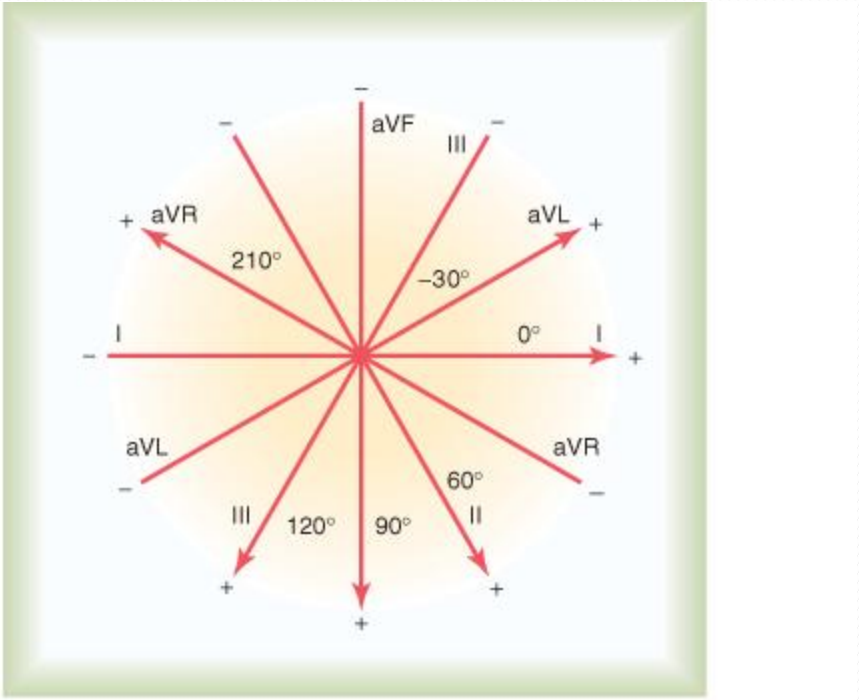
Cardiac Axis

- **When the vector is *horizontal* and points toward the *left side*, the axis is *zero***
- ***Downwards +90 (clockwise)***



Cardiac Axis

- ***Lead I*** ***zero***
- ***Lead II*** ***+60***
- ***Lead III*** ***+120***



Abnormal Ventricular Conditions that cause **Axis Deviation**

Left axis deviation (counterclockwise)

- ***Left bundle branch block block***
- ***Left ventricular hypertrophy (hypertention)***

Right axis deviation (clockwise)

- ***Right bundle branch block***

Right axis deviation (clockwise)

- ***Right bundle branch block***