

# **Electrocardiography – Normal 5**

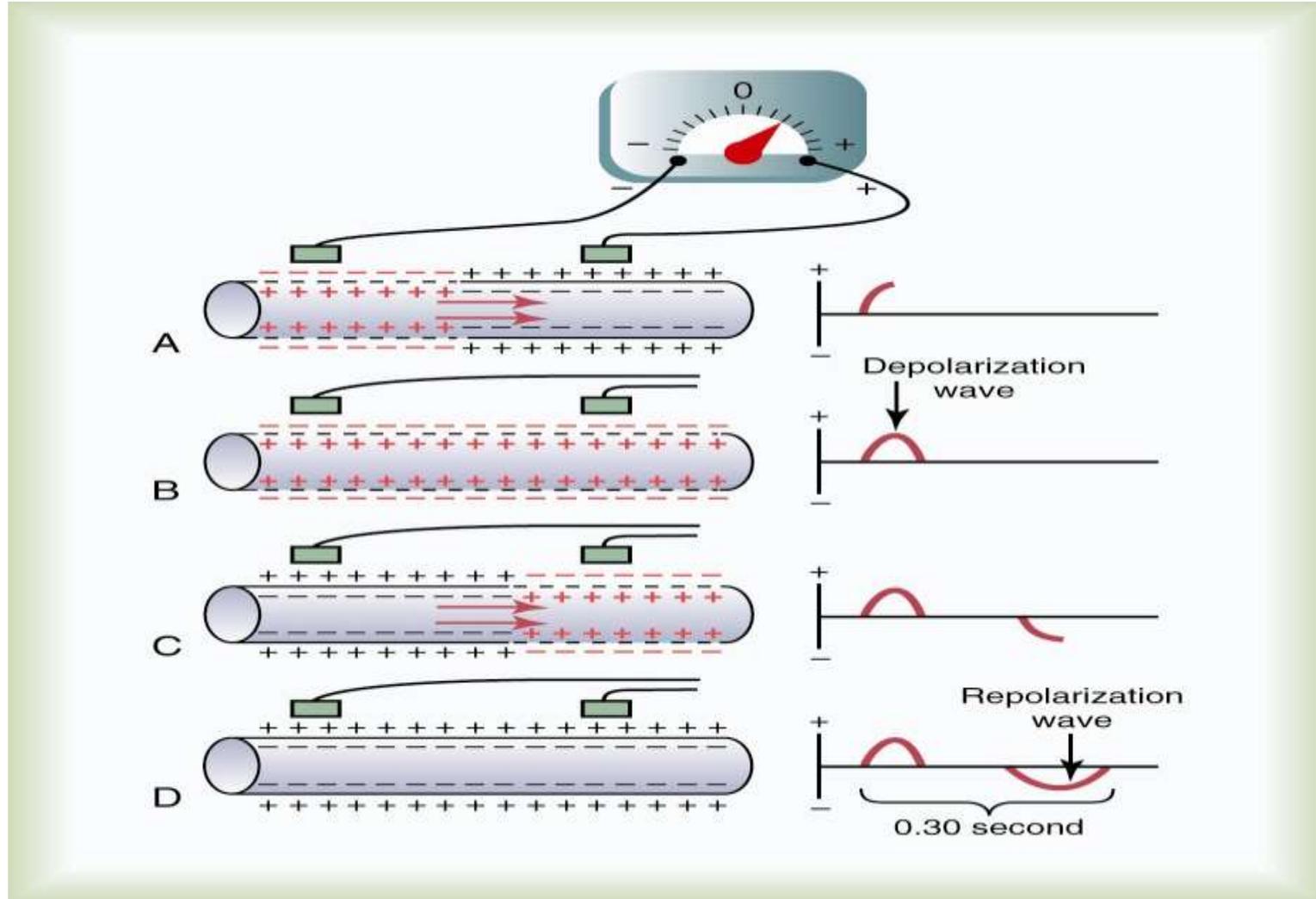
Faisal I. Mohammed, MD, PhD

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# Objectives

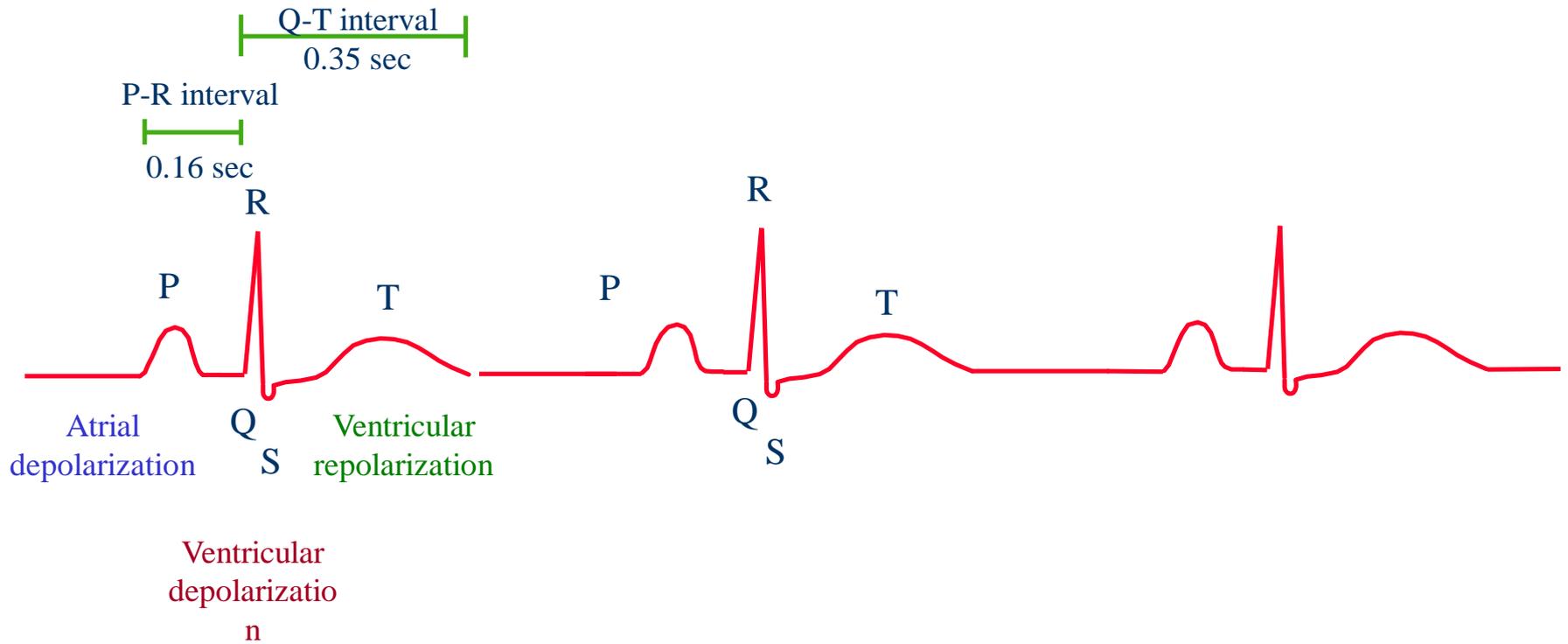
1. Describe the different “waves” in a normal electrocardiogram.
2. Recall the normal P-R and Q-T interval time of the QRS wave.
3. Distinguish the difference in depolarization and repolarization waves.
4. Recognize the voltage and time calibration of an electrocardiogram chart.
5. Point out the arrangement of electrodes in the bipolar limb leads, chest leads, and unipolar leads.
6. Describe Einthoven’s law.

# Depolarization and Repolarization Waves

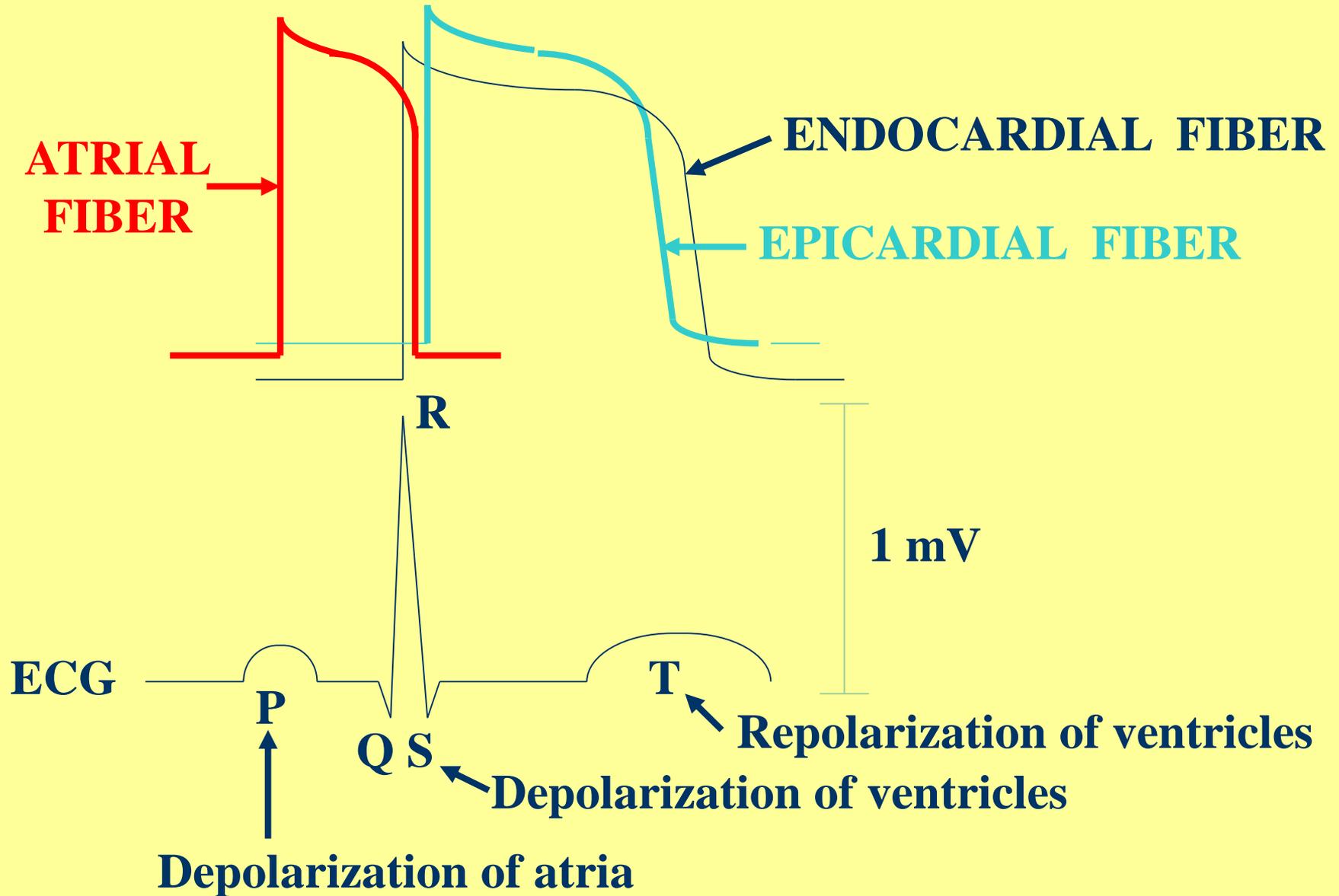


- Note that no potential is recorded when the ventricular muscle is either completely depolarized or repolarized.

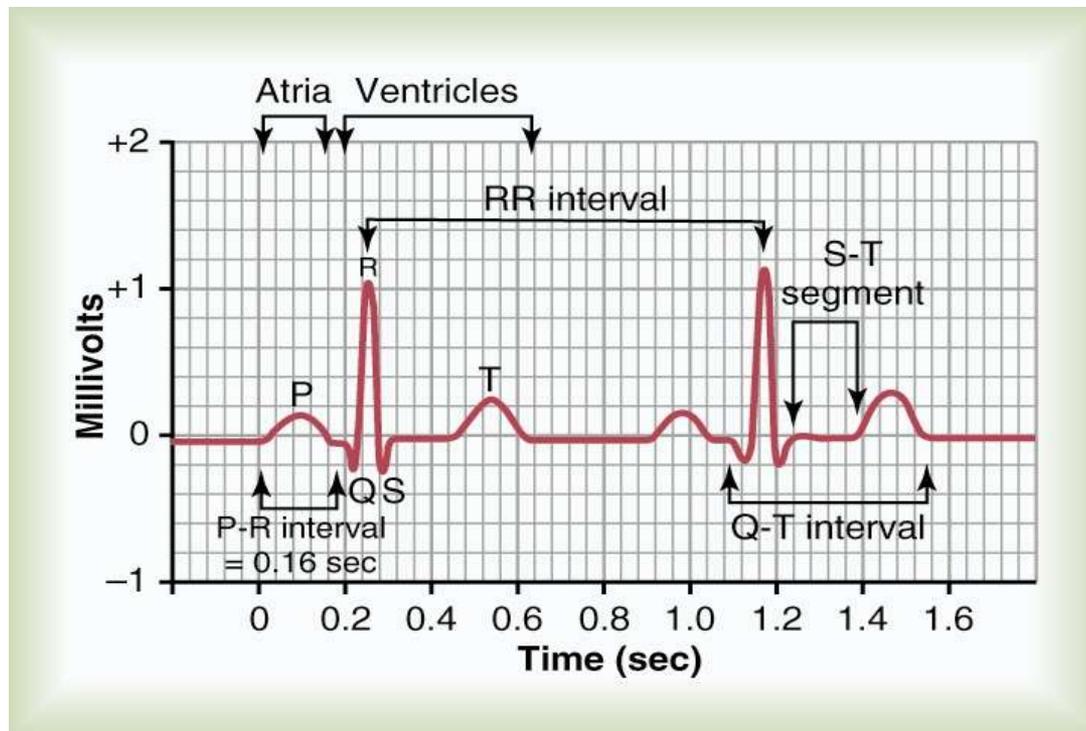
# Normal EKG



# SINGLE VENTRICULAR ACTION POTENTIAL



# Standardized EKG's

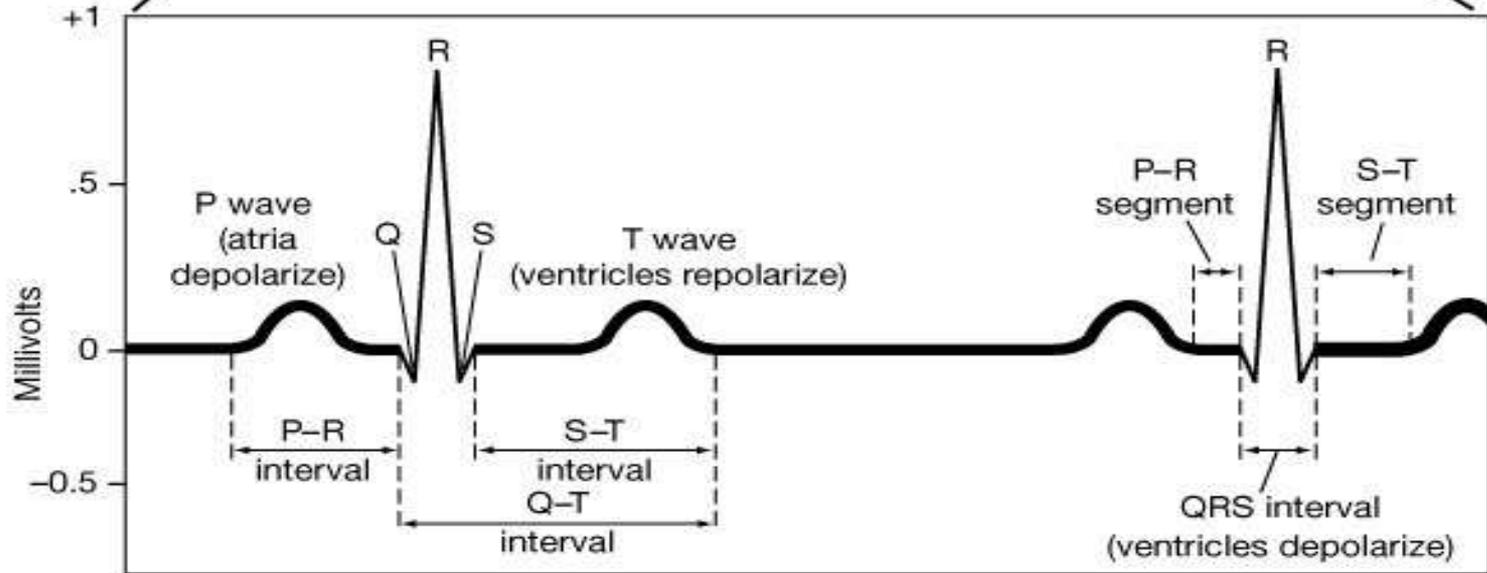


- Time and voltage calibrations are standardized

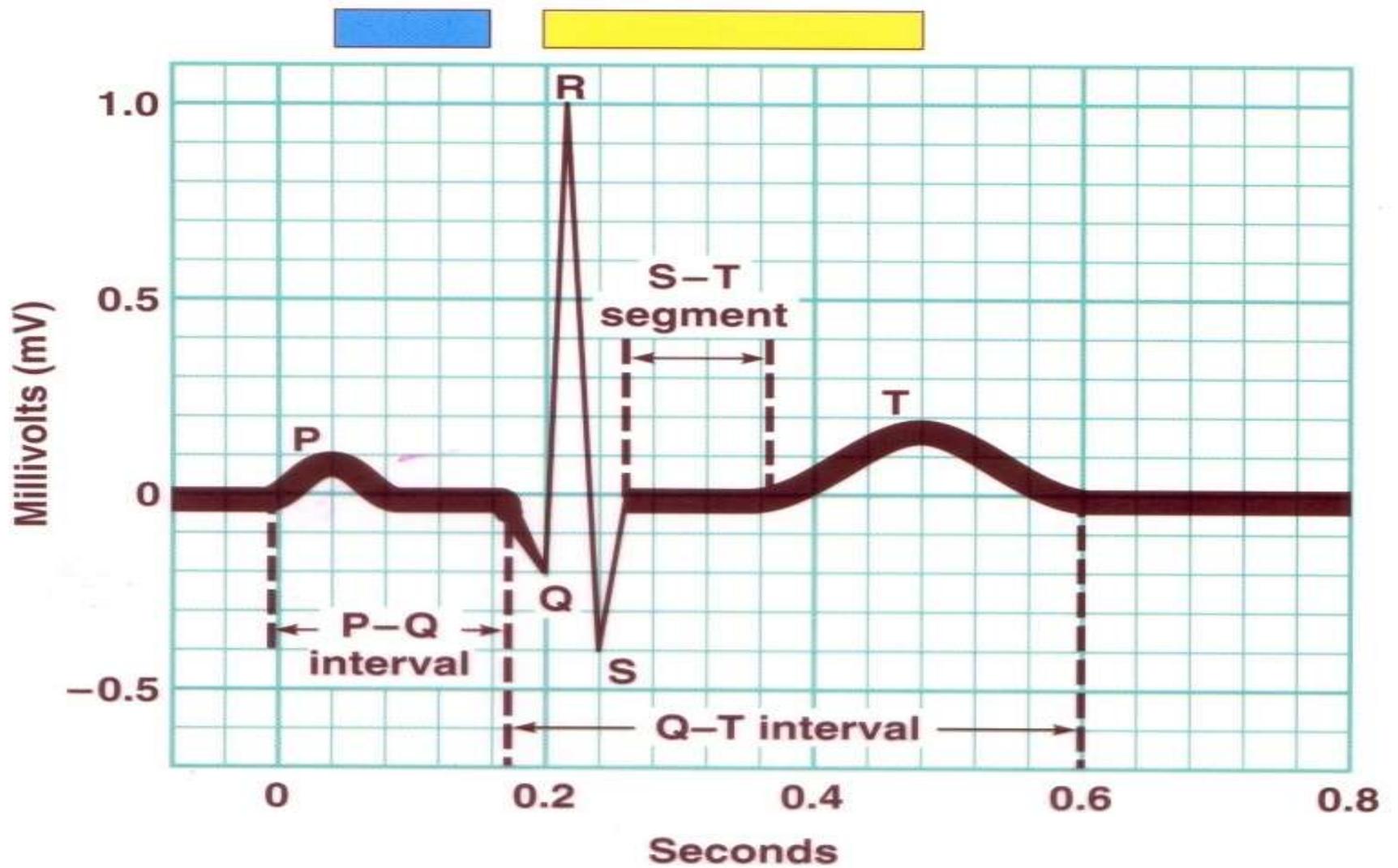
# Electrocardiogram

- Record of electrical events in the myocardium that can be correlated with mechanical events
- **P wave:** depolarization of atrial myocardium.
  - Signals onset of atrial contraction
- **QRS complex:** ventricular depolarization
  - Signals onset of ventricular contraction..
- **T wave:** repolarization of ventricles
- **PR interval** or PQ interval: 0.16 sec
  - Extends from start of atrial depolarization to start of ventricular depolarization (QRS complex) contract and begin to relax
  - Can indicate damage to conducting pathway or AV node if greater than 0.20 sec (200 msec)
- **Q-T interval:** time required for ventricles to undergo a single cycle of depolarization and repolarization
  - Can be lengthened by electrolyte disturbances, conduction problems, coronary ischemia, myocardial damage

# Electrocardiogram



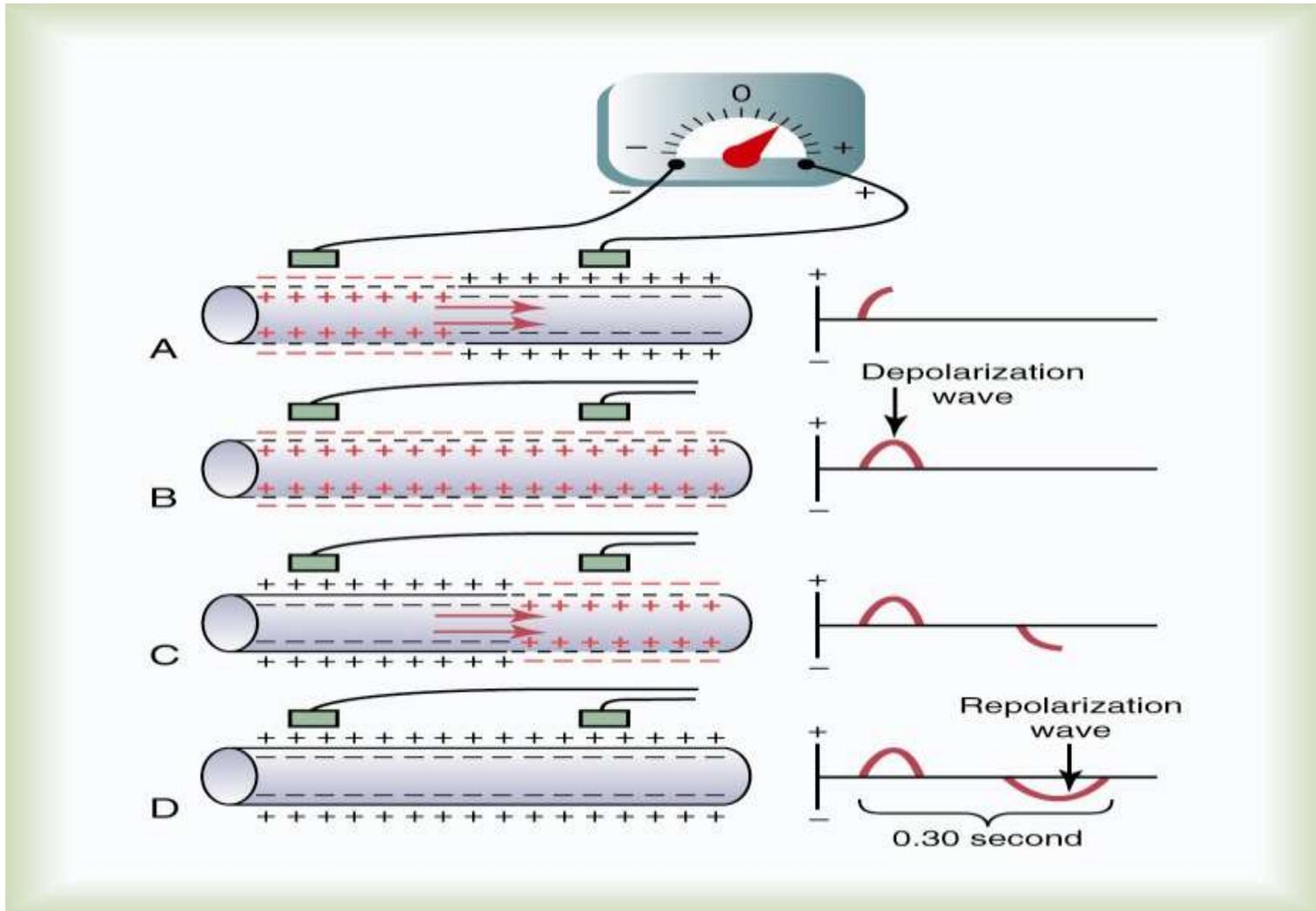
(b)



**Key:**

- Atrial contraction
- Ventricular contraction

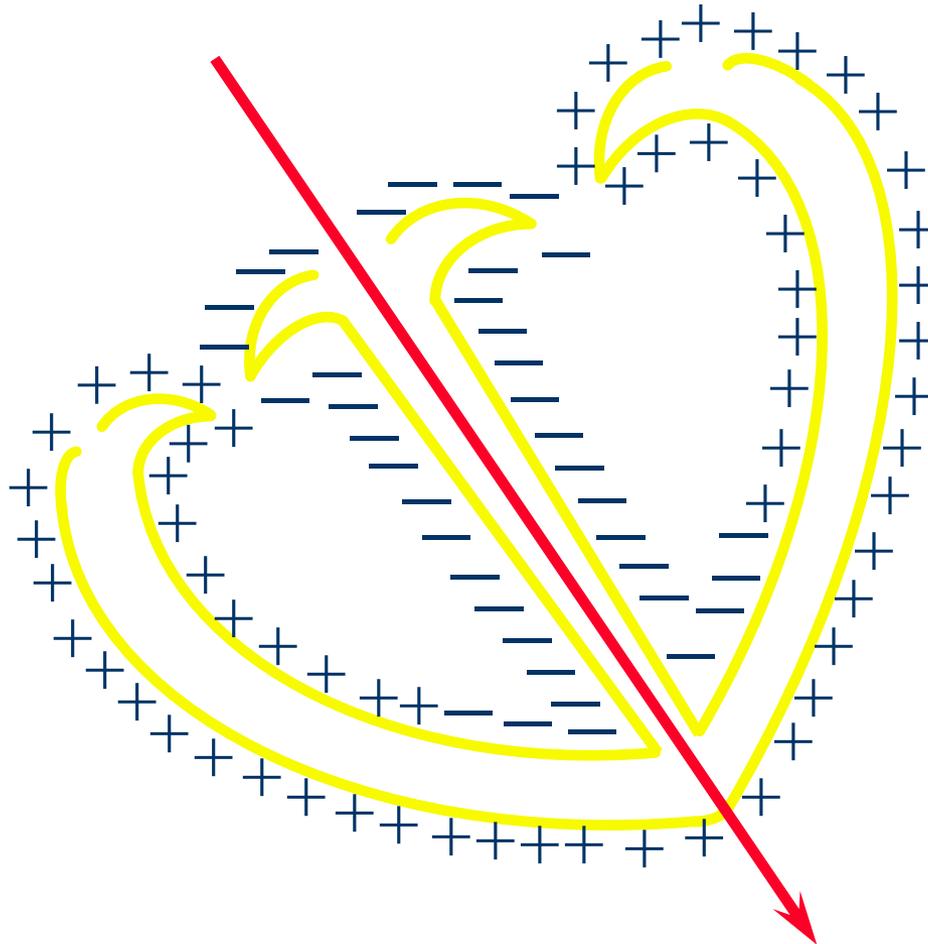
# Depolarization and Repolarization Waves



- Note that no potential is recorded when the ventricular muscle is either completely depolarized or repolarized.

# Flow of Electrical Currents in the Chest Around the Heart

Mean Vector Through the Partially Depolarized Heart



# Flow of Electrical Currents in the Chest Around the Heart (cont'd)

- Ventricular depolarization starts at the ventricular septum and the endocardial surfaces of the heart.
- The average current flows positively from the base of the heart to the apex.
- At the very end of depolarization the current reverses from 1/100 second and flows toward the outer walls of the ventricles near the base (S wave).

# EKG Concepts

- The P wave immediately precedes atrial contraction.
- The QRS complex immediately precedes ventricular contraction.
- The ventricles remain contracted until a few milliseconds after the end of the T repolarization wave.
- The atria remain contracted until the atria are repolarized, but an atrial repolarization wave cannot be seen on the electrocardiogram because it is masked by the QRS wave.

## EKG Concepts (cont'd)

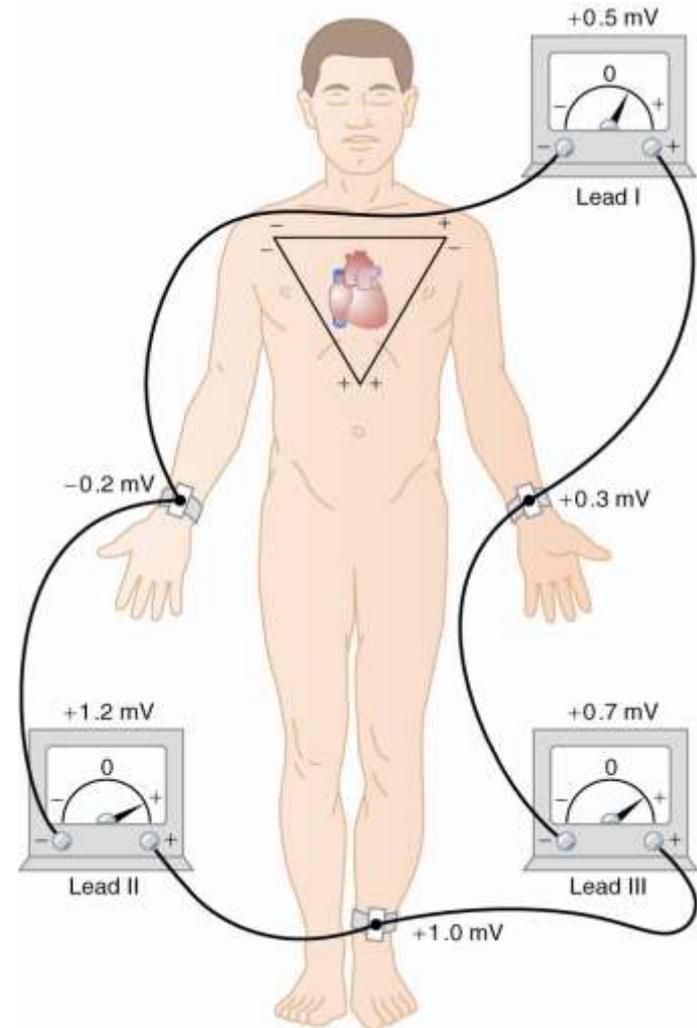
- The P-Q or P-R interval on the electrocardiogram has a normal value of 0.16 seconds and is the duration of time between the beginning of the P wave and the beginning of the QRS wave; this represents the time between the beginning of atrial contraction and the beginning of ventricular contraction.

## EKG Concepts (cont'd)

- The Q-T interval has a normal value of 0.35 seconds and is the duration of time from the beginning of the Q wave to the end of the T wave; this approximates the time of ventricular contraction.
- The heart rate can be determined with the reciprocal of the time interval between each heartbeat.

# Bipolar Limb Leads

- Bipolar means that the EKG is recorded from two electrodes on the body.



## Bipolar Limb Leads (cont'd)

- Lead I - The negative terminal of the electrocardiogram is connected to the right arm, and the positive terminal is connected to the left arm.
- Lead II - The negative terminal of the electrocardiogram is connected to the right arm, and the positive terminal is connected to the left leg.

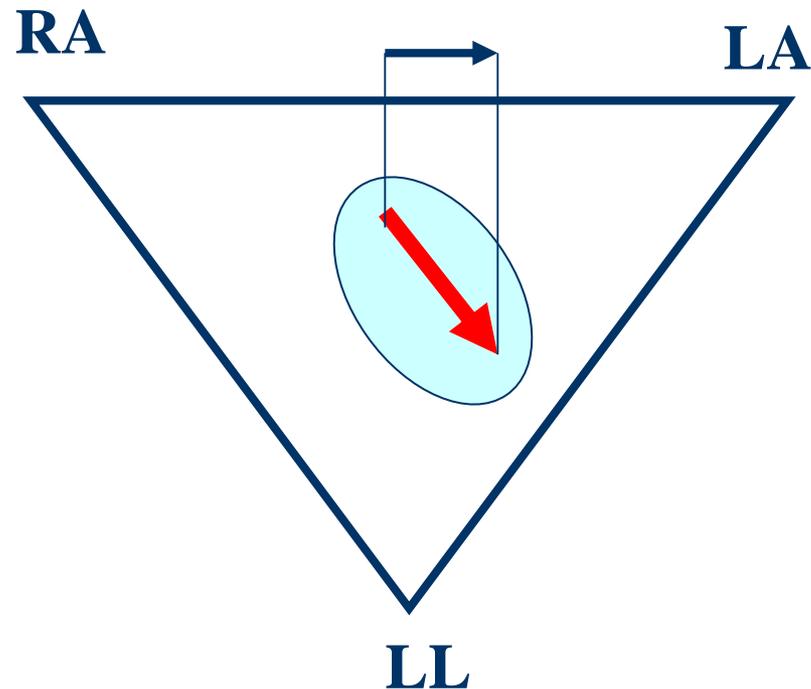
## Bipolar Limb Leads (cont'd)

- Lead III - The negative terminal of the electrocardiogram is connected to the left arm, and the positive terminal is connected to the left leg.
- Einthoven's Law states that the electrical potential of any limb equals the sum of the other two (+ and - signs of leads must be observed).  $L II = L I + L III$
- If lead I = 1.0 mV, Lead III = 0.5 mV, then Lead II = 1.0 + 0.5 = 1.5 mV
- Kirchoff's second law of electrical circuits  $L I + L II + L III = 0$

# ECG Recordings (QRS Vector pointing leftward, inferiorly & anteriorly)

## 3 Bipolar Limb Leads:

**I = RA vs. LA (+)**



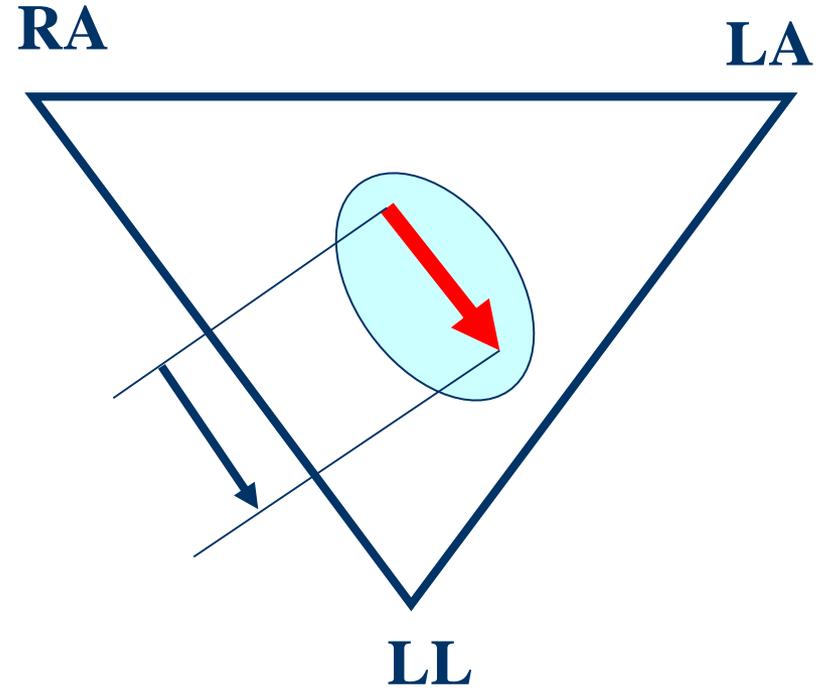
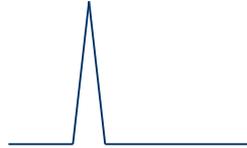
# ECG Recordings (QRS Vector pointing leftward, inferiorly & anteriorly)

## 3 Bipolar Limb Leads:

**I = RA vs. LA (+)**



**II = RA vs. LL (+)**



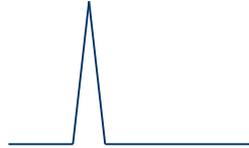
# ECG Recordings (QRS Vector pointing leftward, inferiorly & anteriorly)

## 3 Bipolar Limb Leads:

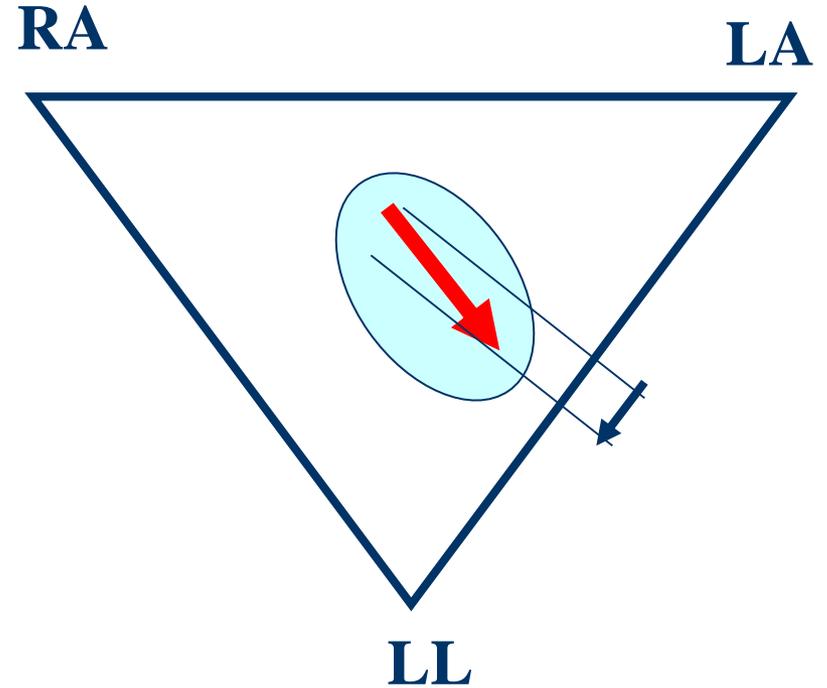
**I = RA vs. LA (+)**



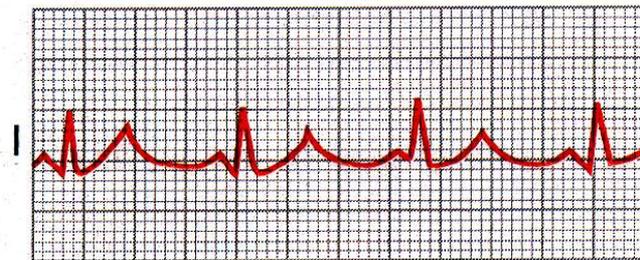
**II = RA vs. LL (+)**



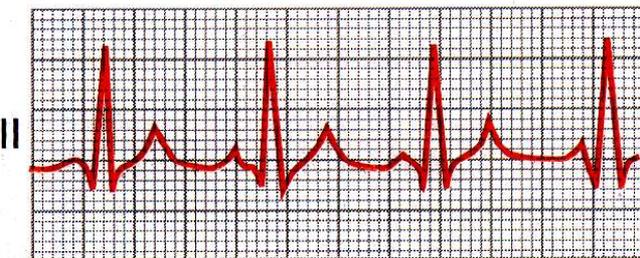
**III = LA vs. LL (+)**



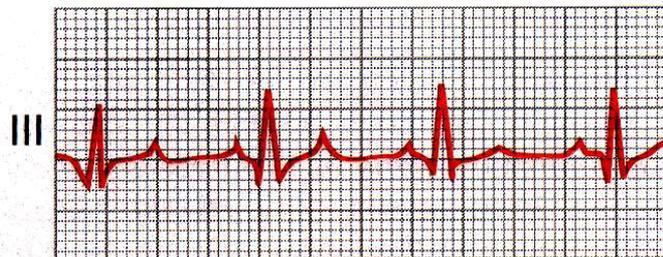
# Bipolar Limb Leads (cont'd)



0.5 mV

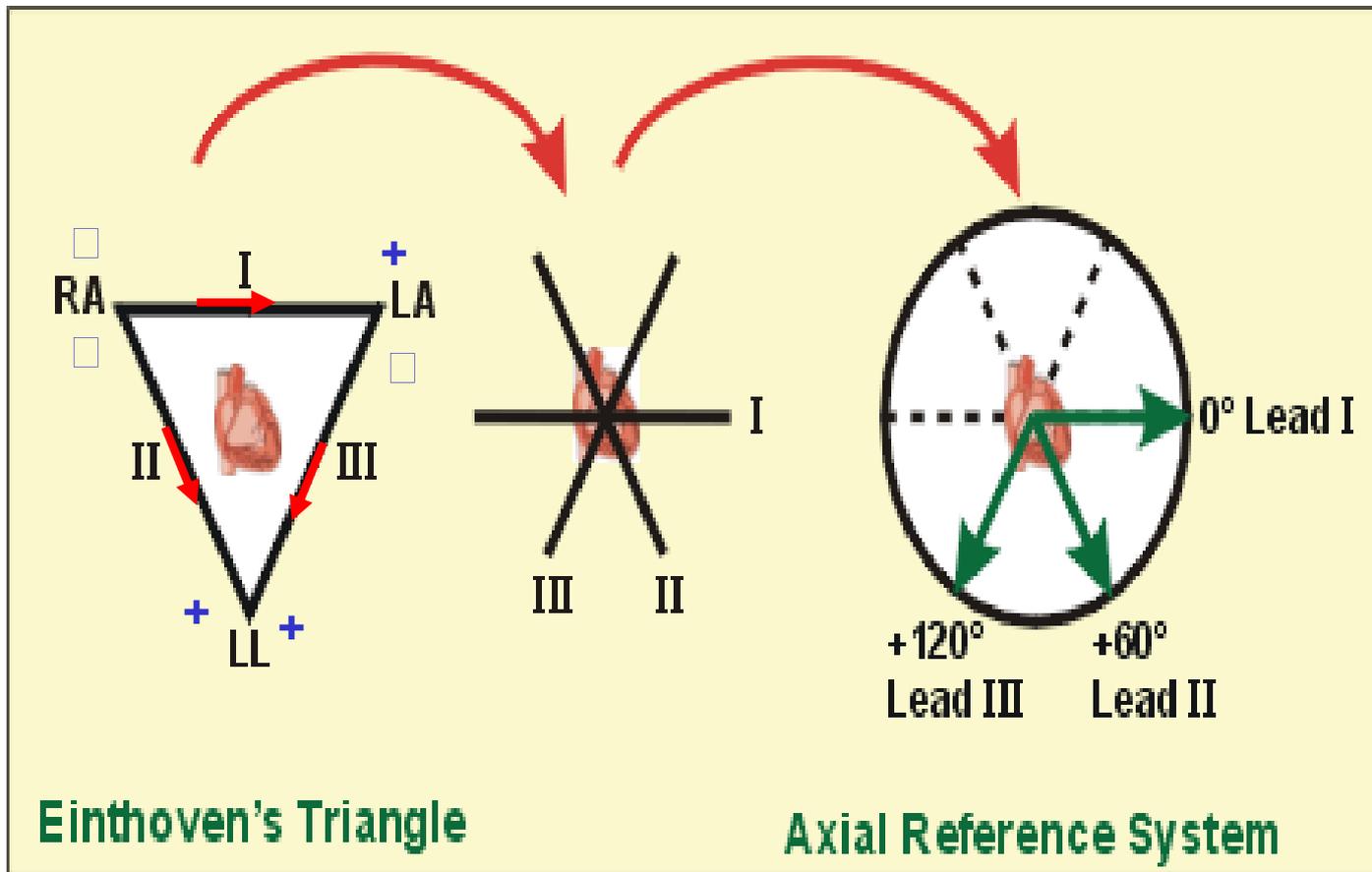


1.2 mV



0.7 mV

# Einthoven's triangle and law



## Other EKG Leads (cont'd)

- Augmented Unipolar Limb Leads aVR, aVL, and aVF are also in use. For aVR the + electrode is the right arm, and the - electrode is the left arm ⊕ left leg; aVL + electrode is left arm; aVF + electrode is left foot and the negative electrode is the other two limbs

# Unipolar Limb Leads

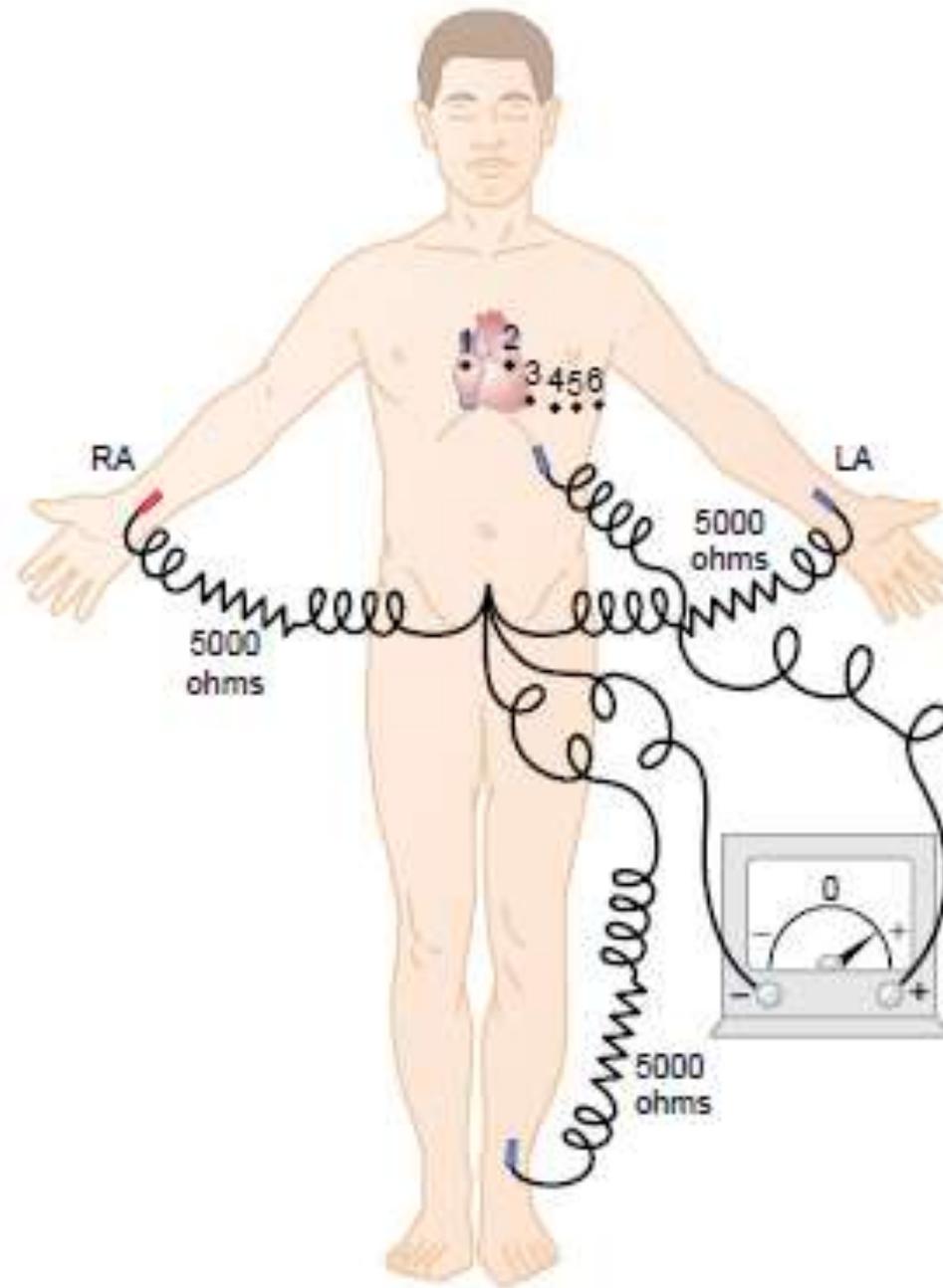


FIGURE 44-9

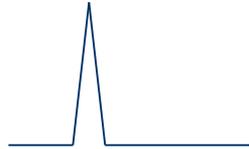
# ECG Recordings (QRS Vector pointing leftward, inferiorly & anteriorly)

## 3 Bipolar Limb Leads:

**I = RA vs. LA (+)**



**II = RA vs. LL (+)**

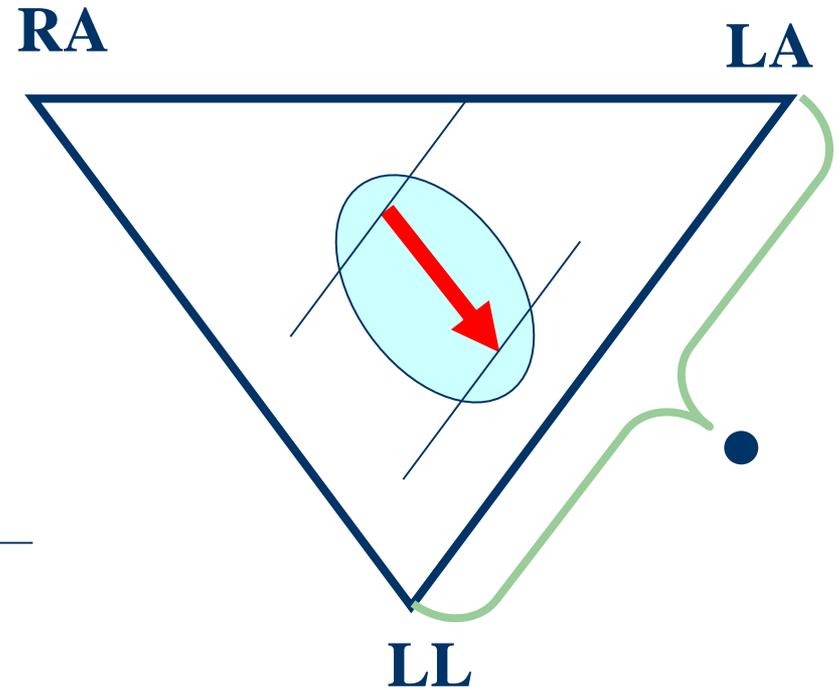
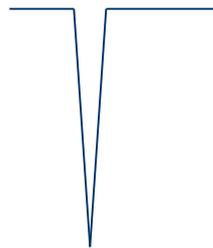


**III = LA vs. LL (+)**



## 3 Augmented Limb Leads:

**aVR = (LA-LL) vs. RA(+)**



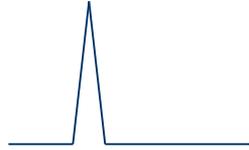
# ECG Recordings (QRS Vector pointing leftward, inferiorly & anteriorly)

## 3 Bipolar Limb Leads:

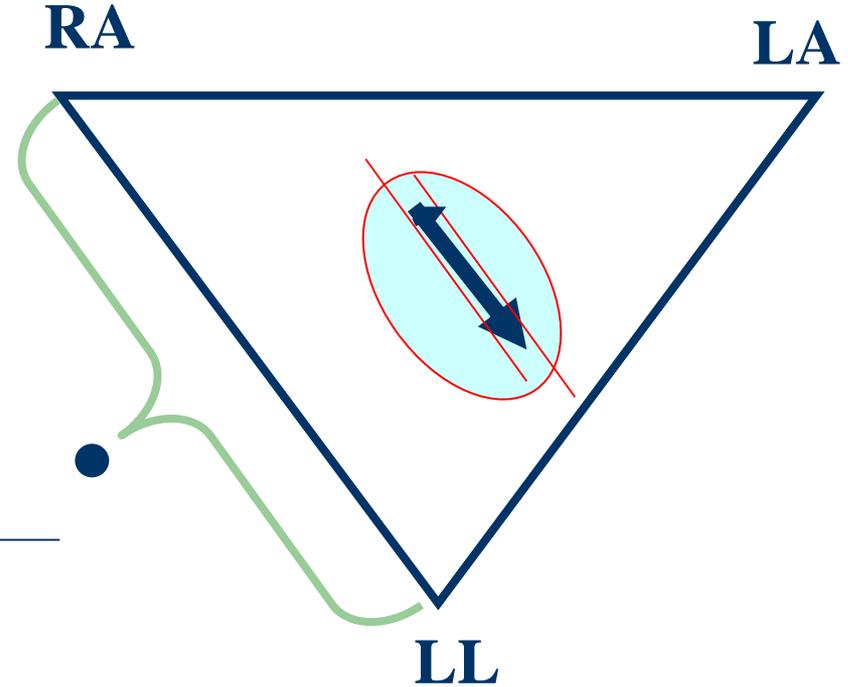
**I = RA vs. LA (+)**



**II = RA vs. LL (+)**

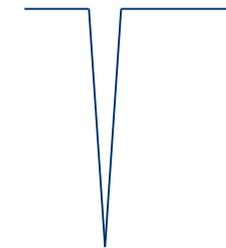


**III = LA vs. LL (+)**



## 3 Augmented Limb Leads:

**aVR = (LA-LL) vs. RA(+)**



**aVL = (RA-LL) vs. LA(+)**



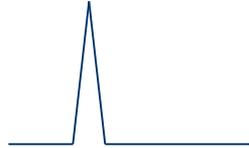
# ECG Recordings (QRS Vector pointing leftward, inferiorly & anteriorly)

## 3 Bipolar Limb Leads:

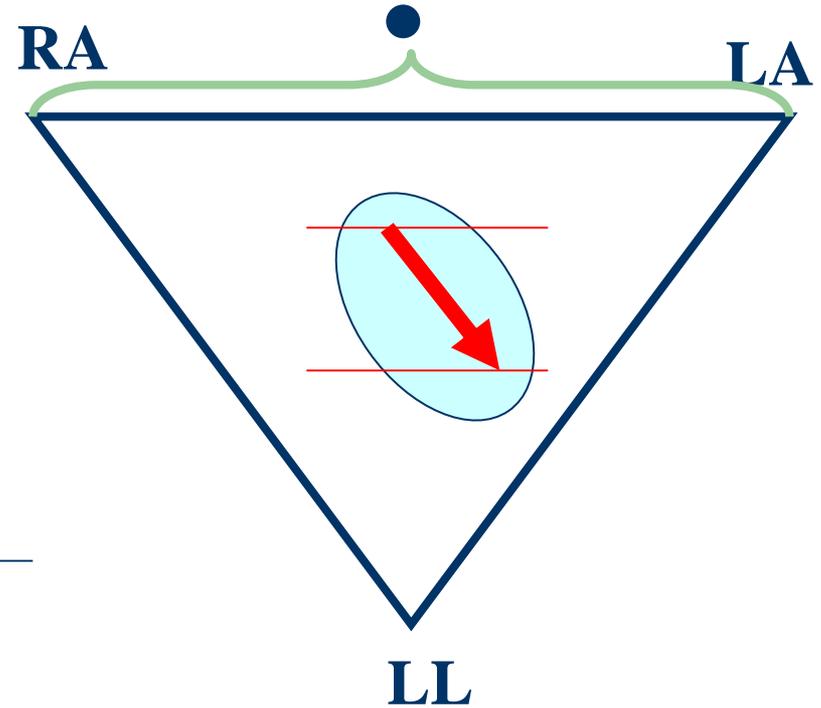
**I = RA vs. LA (+)**



**II = RA vs. LL (+)**

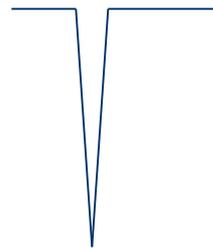


**III = LA vs. LL (+)**



## 3 Augmented Limb Leads:

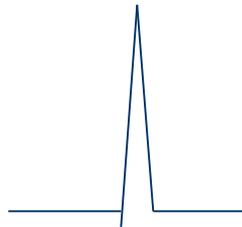
**aVR = (LA-LL) vs. RA(+)**



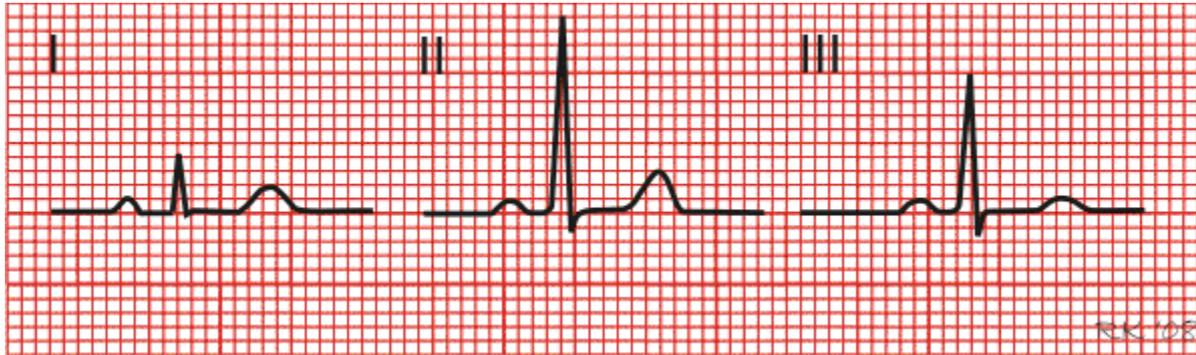
**aVL = (RA-LL) vs. LA(+)**



**aVF = (RA-LA) vs. LL(+)**

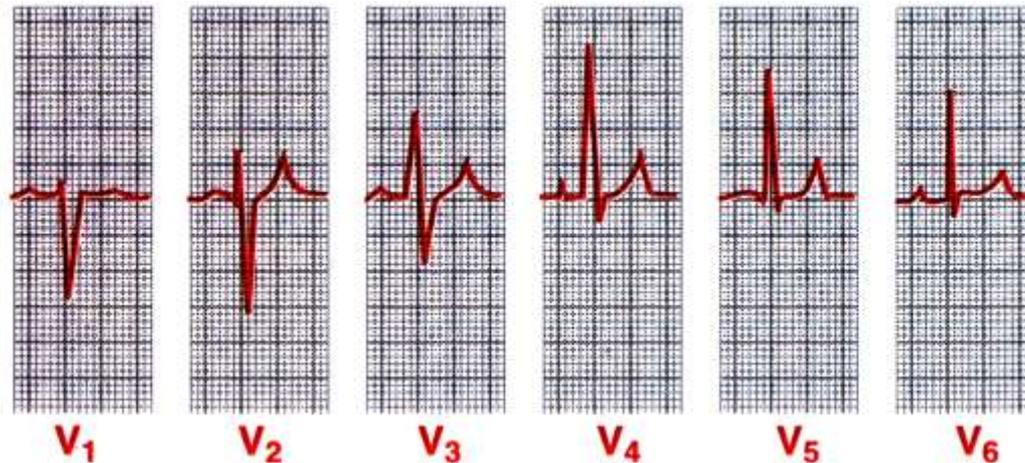


# Bipolar and Unipolar Limb Leads

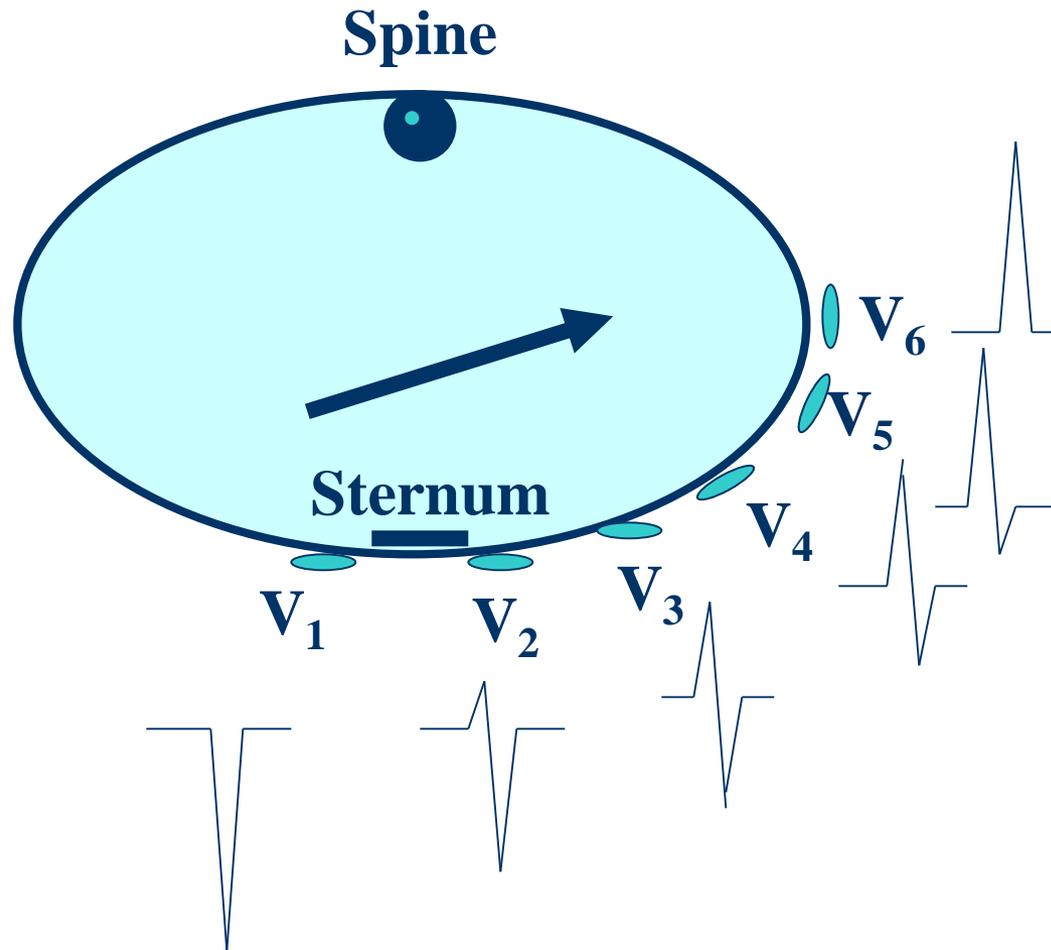


## Other EKG Leads

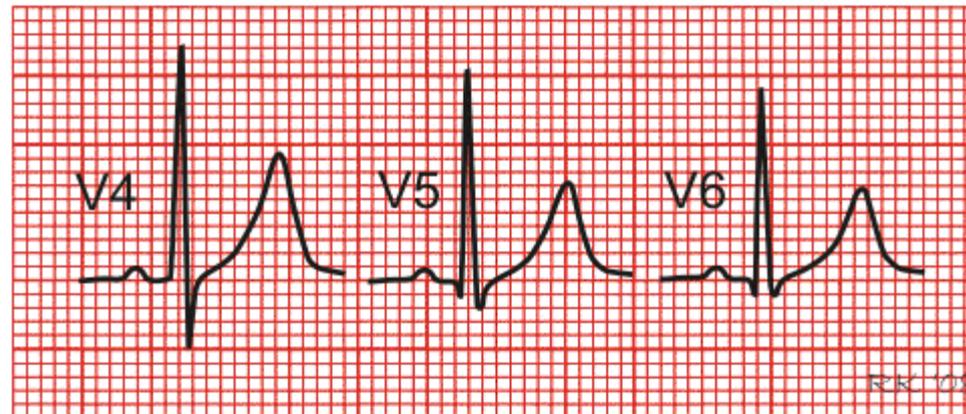
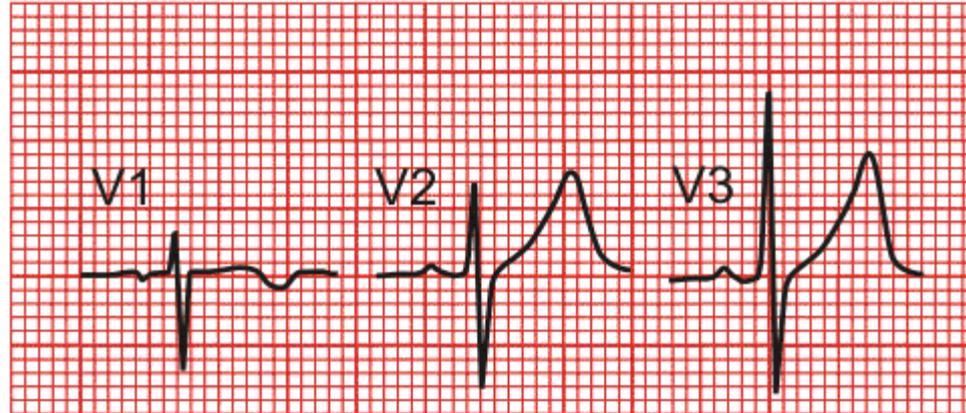
- Chest Leads (Precordial Leads) known as  $V_1$ - $V_6$  are very sensitive to electrical potential changes underneath the electrode.



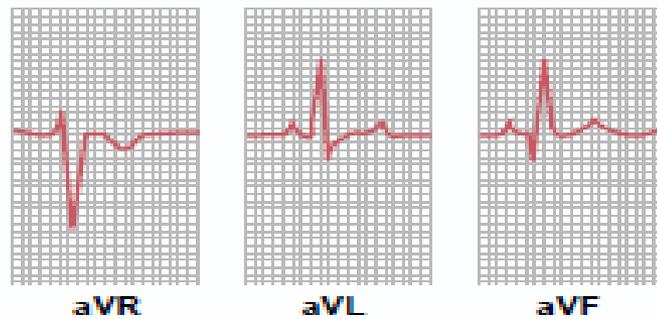
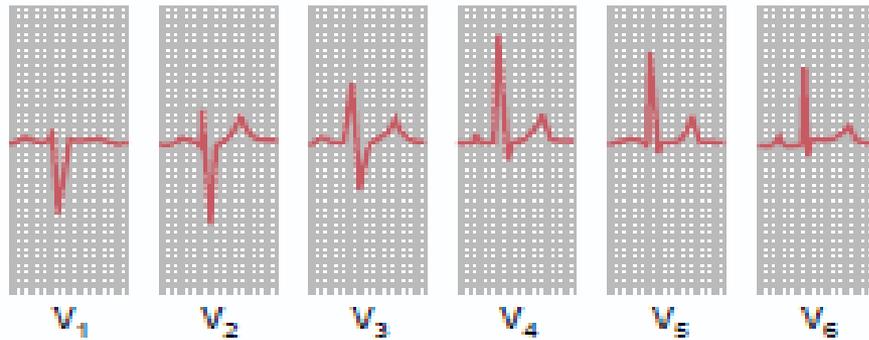
## 6 PRECORDIAL (CHEST) LEADS

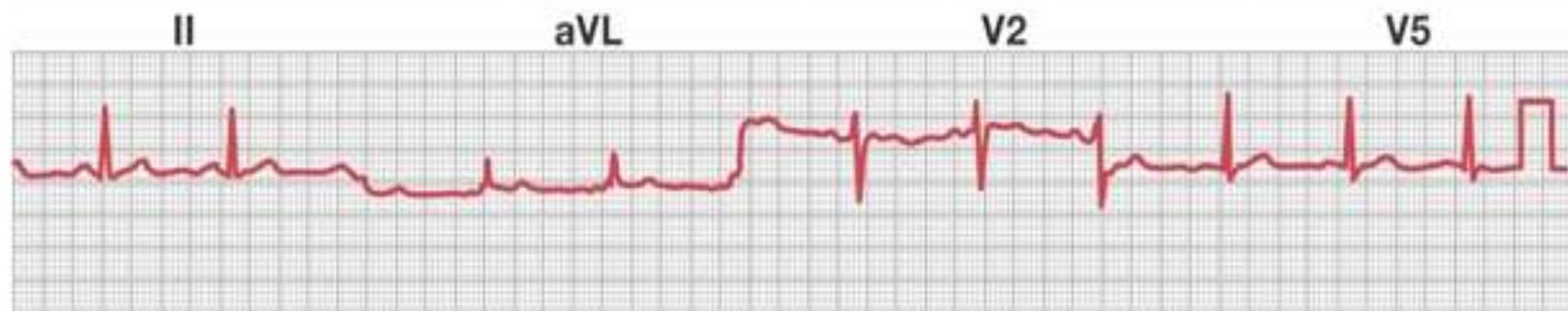


# Chest leads (Unipolar)



# Uniplolar Leads





# ECG Recordings: (QRS vector---leftward, inferiorly and anteriorly)

## 3 Bipolar Limb Leads

I = RA vs. LA(+)

II = RA vs. LL(+)

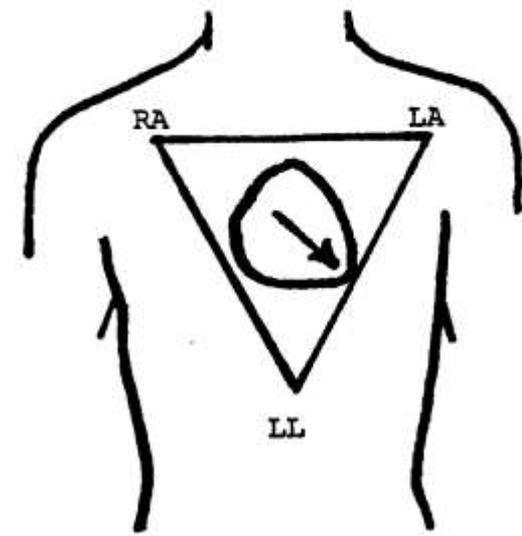
III = LA vs. LL(+)

## 3 Augmented Limb Leads

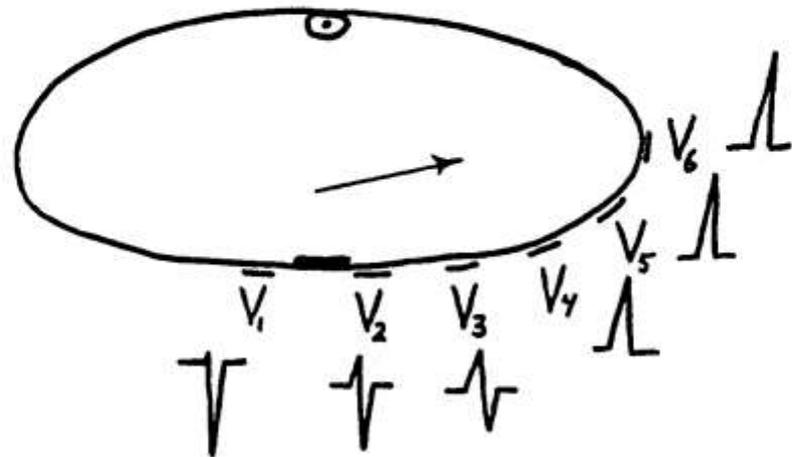
aVR = (LA-LL) vs. RA(+)

aVL = (RA-LL) vs. LA(+)

aVF = (RA-LA) vs. LL(+)

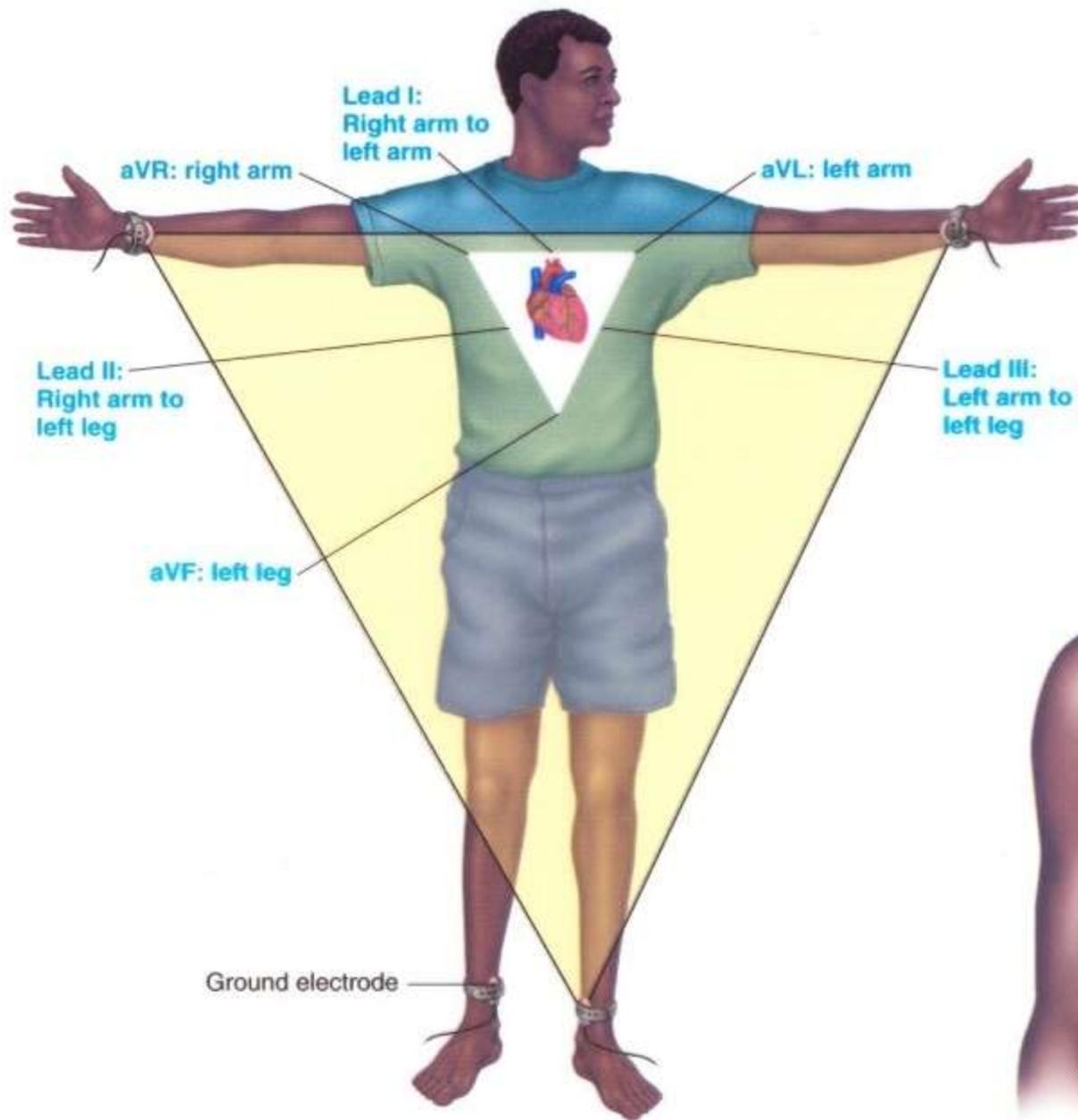


## 6 Precordial (Chest) Leads: Indifferent electrode (RA-LA-LL) vs. chest lead moved from position V<sub>1</sub> through position V<sub>6</sub>.



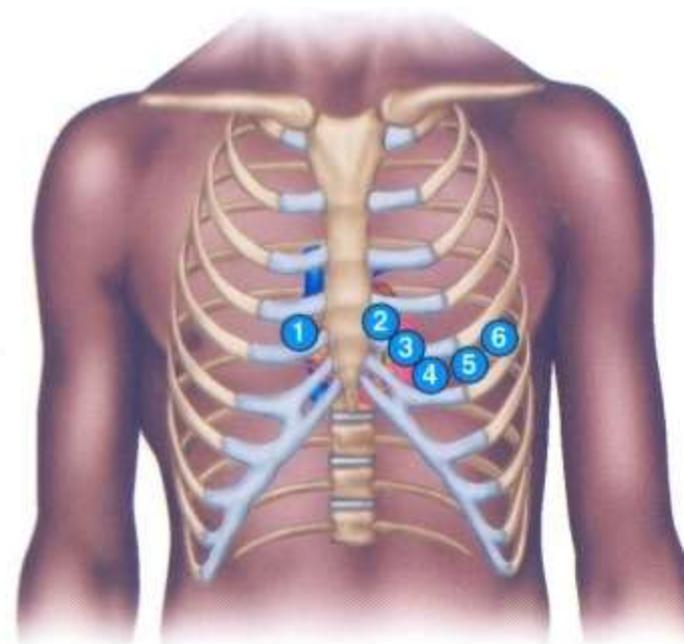
# Electrocardiogram leads

## Limb leads



(a)

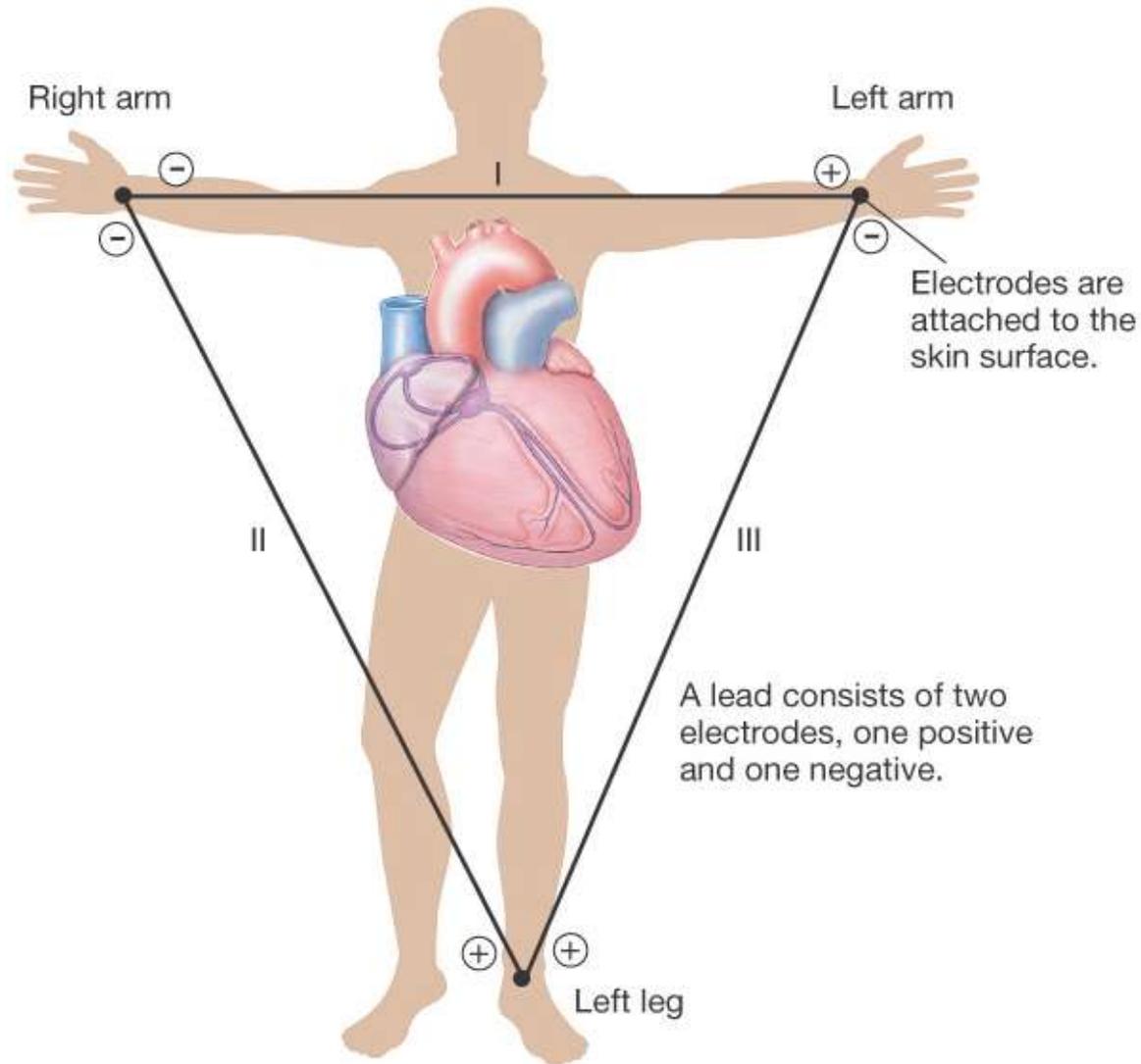
## Chest leads



(b)

# Electrocardiogram (ECG):Electrical Activity of the Heart

- Einthoven's triangle
- P-Wave – atria
- QRS- wave – ventricles
- T-wave – repolarization



# Thank You

