Al-Mustaqbal University
College of Engineering
Biomedical Engineering Department

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Lecture No.: - 2 -

Lecture Title: [EKG and Electrode Position]

EKG and Electrode Position

An electrocardiogram (ECG or EKG) records electrical events that occur within the heart. In a healthy heart, a natural pacemaker in the right atrium (the *sinoatrial node*) initiates an electrical sequence. This impulse passes down natural conduction pathways between the atria to the atrioventricular node and from there to both ventricles. The natural conduction pathways facilitate orderly spread of the impulse and coordinated contraction of first the atria, then the ventricles. The electrical journey creates unique deflections in the EKG that tell a story about heart function and health (see Figure 1).

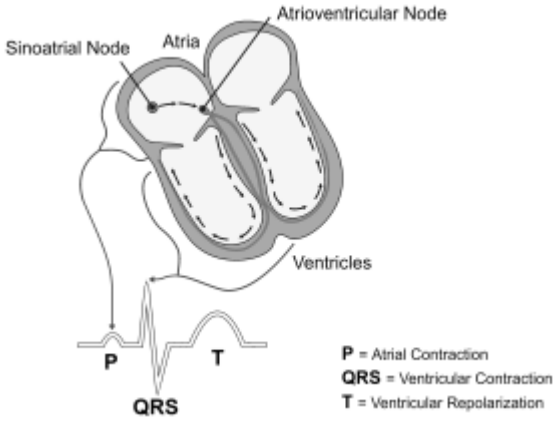

Figure 1

Even more information is obtained by looking at the story from different angles, which is accomplished by placing electrodes in different arrangements on the body. Each arrangement is called a *lead*. Each lead reveals unique information based on the lead's orientation relative to the axis of the heart.

The heart's axis tends to vary with general body shape, age, and other factors. In this experiment, you will use an EKG sensor to make graphical recordings of the heart's electrical activity using several different electrode positions to create three different leads. For each lead, you will connect the three EKG electrodes in a specific pattern.

Lead I

For Lead I, the electrodes are connected as follows:

- Green (negative) electrode: Right upper arm or wrist
- Red (positive) electrode: Left upper arm or wrist
- Black (reference) electrode: Inside of left ankle (reference point for the isoelectric line)

Drawing an imaginary line between the red and green electrodes shows that this lead measures the polarity changes across the chest, above the heart, and parallel to the shoulders.

Lead II

For Lead II, the electrodes are connected as follows:

- Green (negative) electrode: Right upper arm or wrist
- Red (positive) electrode: Left inner thigh or inside of left ankle
- Black (reference) electrode: Left upper arm or wrist (reference point for the isoelectric line)

Drawing an imaginary line between the red and green electrodes yields an oblique line from the right shoulder towards the left leg. Lead II generally gives the greatest variation of impulse and is the EKG usually shown in movies and text books.

Lead III

For Lead III, the electrodes are connected as follows:

- Green (negative) electrode: Left upper arm or wrist
- Red (positive) electrode: Left inner thigh or inside of left ankle
- Black (reference) electrode: Right upper arm or wrist (reference point for the isoelectric line)

This arrangement of the red and green electrodes yields an imaginary line from the left shoulder to the left leg.

Einthoven's Triangle

If you connect the three electrodes in a lead with imaginary lines, the lines would make a triangle. This triangle is called the Einthoven's triangle. The measured intensity of voltage on its three sides can be used to study heart functions and anatomy. You can make an approximation of the axis of your heart; that is, the orientation of the centerline of the mass of your heart.

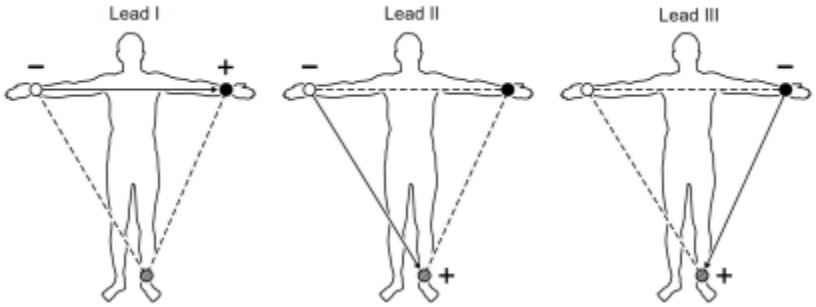

Figure 2

By comparing results from Lead I, Lead II, and Lead III recordings, you will determine which lead yields the maximum R wave amplitude. If the maximum R wave is with Lead I, then the axis of your heart is approximately at 0 degrees as measured from the horizontal and your left. If the maximum R wave is with Lead II, then the axis of the heart is approximately 60 degrees down from the horizontal and to the left.

If the maximum R wave is with Lead III, then the axis is approximately 120 degrees from the horizontal and your left. You can make a further refinement in your estimate by noting the relative proportion of R wave strength between the two leads with the largest R wave.

If the Lead II and the Lead III R waves are about equal, then the axis is about halfway between the 60 degree angle and the 120 degree angle. You could therefore estimate the axis of the heart to be nearly vertical.

Important: The equipment used in this experiment is for educational purposes only and should not be used to diagnose medical conditions.

OBJECTIVES

- Obtain graphical representation of the electrical activity of the heart using three different EKG lead placements.
- Compare waveforms generated by alternate EKG lead placements.
- Estimate the orientation of the heart axis for your subject based on the results.

MATERIALS

Chromebook, computer, **or** mobile device
Graphical Analysis 4 app
Go Direct EKG Sensor
electrode tabs
paper towels

PROCEDURE

Select one person from your group to be the subject.
Note: Save the file with the name (L3-ALB_HP2_05_GroupNO). Copy all the data file on a CD and give it to your colleagues in the group so that they can analyze the data.

Part I EKG with Lead I

1. Launch Graphical Analysis. Connect Go Direct EKG to your Chromebook, computer, or mobile device.

2. To remove any lotion or natural skin oil and moisture, use a paper towel to gently scrub the areas of the skin where the electrode patches will be placed.

3. Attach three electrode tabs to the subject's arms and ankle as follows: place a single patch on the right upper arm, the left upper arm (distal to the elbow), and the inner surface of the area behind the left ankle bone (medial malleolus).

4. Connect the EKG clips to the electrode tabs to create Lead I (see Figure 3):

   a. Green (negative) electrode: Right upper arm
   b. Red (positive) electrode: Left upper arm
   c. Black (reference) electrode: Inside of left ankle (reference point for the isoelectric line)

5. Instruct the subject to sit in a relaxed position in a chair, with forearms resting on the legs or on the arms of the chair. When the subject is properly positioned, click or tap Collect to start data collection. Data collection will stop after 3 seconds.

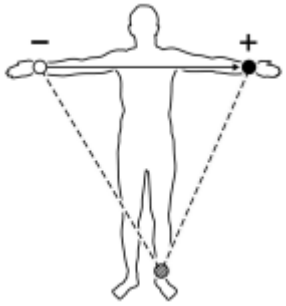

Figure 3 Lead I

6. When data collection is complete, you can remove the EKG clips, but leave the electrode tabs in place.

7. Determine the maximum amplitude of the R wave.

   a. To select the QRS complex in your graph, click or tap just after the P wave and drag across the entire complex.

   b. Select Graph Tools, , and choose View Statistics. Record the absolute value for Δy in Table 1 as the peak amplitude for the R wave.

Part II EKG with Lead II

8. Connect the EKG clips to the electrode tabs to create Lead II:

   a. Green (negative) electrode: Right upper arm

   b. Red (positive) electrode: Inside of left ankle

   c. Black (reference) electrode: Left upper arm (reference point for the isoelectric line)

9. Repeat Steps 5–7 to collect and record data for Lead II.

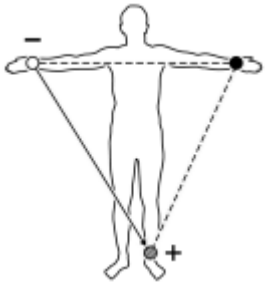

Figure 4 Lead II

Part III EKG with Lead III

10. Connect the EKG clips to the electrode tabs to create Lead III:

    a. Green (negative) electrode: Left upper arm

    b. Red (positive) electrode: Inside of left ankle

    c. Black (reference) electrode: Right upper arm (reference point for the isoelectric line)

11. Repeat Steps 5–7 to collect and record data for Lead III. **Note**: After data collection is complete, the subject can remove the EKG clips and the electrode tabs.

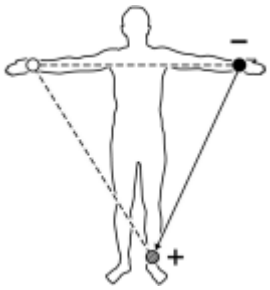

Figure 5 Lead III

DATA

Table 1	
Lead	R wave amplitude (mV)
Lead I	
Lead II	
Lead III	

DATA ANALYSIS

1. Which lead configuration produced the largest R wave in the subject you tested?

2. What was the estimated axis of the heart for the subject you tested?

3. Research the condition situs inversus (also known oppositus or situs transversus). This condition is found in approximately 0.01% of the population. Which lead configuration would produce the largest R wave in a subject with this condition? What would be the most likely axis of the heart for a subject with this condition?

EXTENSIONS

1. Using the data for the entire class, determine which lead configurations produce the largest R wave for the subjects tested.

2. Calculate the mean R wave amplitude and the standard deviation of the amplitude for the subjects tested. Do this for all three lead configurations. Using the data for the entire class, determine what the most common heart axis is for all the subjects tested.

3. The net deflection of the R wave is used to calculate the actual heart axis when performing a 12-lead ECG. Trigonometry can be used to calculate the net deflection of the R wave at an angle between the specific leads that are used. Using trigonometry, use the data you have collected to determine the heart axis of your subject.