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Lead systems

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Objectives

Understand the terminology and theory of the 12 views of the heart with reference to:

- Unipolar and Bipolar leads
- Precordial leads
- Eintovens triangle
- Goldberger augmented leads
- Wilsons central terminal

This will all make sense in the end!, basically all these buzz words are used to describe the limb and chest leads, how they record voltages from the heart and the scientists which invented them, along with their theories!
Why use so many leads to record an ECG?

- The heart is a 3-D organ, therefore, electrical activity must be understood in 3-D as well.
- The observers in the diagram each get a different impression of the elephant. One sees the trunk, the other the body and one the rear.
- For the best description you would need to ask all 3 people.
The 12 lead ECG

• The standard ECG consists of 12 leads.
• Each lead views the heart at a unique angle, enhancing its sensitivity to a particular region of the heart.
• The more views we have, the more information we have
• Using 12 leads is partly historical and reflects the development of leads systems in the past, however the more leads the more information. You Can do as many leads as the acusision module will allow!
Extremity limb leads

- Electrodes are attached to the wrists and ankles
- Right leg electrode functions as an electrical ground only. It prevents alternating current interference and can be ignored
- Electrical activity is conducted through the torso to the extremities
- Voltages detected at the left wrist or any were on the LA will be equivalent to those detected below the left shoulder
Bipolar Leads (Leads I, II, III)

- Named because they record the difference in voltage between 2 extremities
- Lead I-difference in voltage between the left arm and right arm
- Lead II-difference in voltage between the left leg and right arm
- Lead III-difference in voltage between the left leg and left arm
Einthoven’s triangle

- Leads I, II and III can be represented in terms of a triangle.
- It demonstrates the angle of orientation of the three bipolar leads (I, II, III).
- Each lead has a positive and negative pole which the machine automatically designates.
- Lead I-points horizontally. Its left pole is positive therefore = LA-RA
- Lead II-points diagonally downwards. Its lower pole is positive and upper negative therefore = LL-RA
- Lead III-points diagonally downwards. How is this formed?
Einthoven’s equation

- Relationship between the 3 leads, shown as an equation:
  - Lead I + Lead III = Lead II
- In other words if you add the voltage in lead I to the voltage in lead III you will get the voltage of Lead II
- Try this yourself by measuring the voltage of the R wave in leads I and III and add together.
- Measure the voltage in lead II
- What do you get?
The hexaxial diagram

The bipolar leads

Fig. 3-5. Einthoven’s triangle, A, has been converted to a triaxial diagram, B. This is done simply by shifting leads I, II, and III so they intersect at a common point.

• Einthoven triangle can be re-drawn so that leads I, II, and III slide across so that they intersect at a central point, that being the heart
Einthoven’s first ECG

- Originally the ECG consisted only of leads I, II and III
- Einthoven was a Dutch physician who introduced the limb leads
- Recorded his first ECG in 1902 by placing limbs in buckets of conducting solution!
Summary of Einthoven’s theory

• Illustrates how the bipolar leads are recorded

• Leads I, II and III are the bipolar extremity leads

• These leads record the difference in voltage between extremities

Remember that in electrocardiography 1 plus 3 equals 2!
The frontal plane and angle of orientation

- The limb leads view the heart in a vertical plane called the frontal plane.
- These leads view electrical activity moving up and down and left to right on the frontal plane.
- The vertical plane can be envisaged by drawing a circle superimposed on the body and marked off in 360 degrees.
- The angle of each lead can be determined by drawing a line from the negative electrode to the positive electrode on the circle above.
Angle of orientation

- To create the six leads, each of the electrodes is designated with a positive and negative pole (done by the machine).
- Lead I – LA is positive and the RA is negative (LA-RA). Angle of orientation is zero degrees.
- Lead II – legs are positive and RA negative (LL-RA). Angle of orientation is 60 degrees.
- Lead III – legs positive and LA negative (LL-LA). Angle of orientation is 120 degrees.
Views of the heart using the extremity leads

- Each lead perceives the heart from its own unique point
- II, III and aVF look at the inferior surface
- I, aVL look at the left lateral wall
Development of the Unipolar extremity leads

- After the invention of the bipolar leads, 9 additional leads were added.
- Introduced by Dr Frank Wilson and colleagues in the 1930’s.
- First-Unipolar chest leads (V1-V6)
- Shortly after-3 augmented Unipolar extremity (Limb) leads-aVr, aVL and aVF. Introduced by Emanuel Goldberger.
- Today, the bipolar leads plus the unipolar leads make up the 12-lead ECG.
Goldberger’s Augmented Leads  
aVR, aVL & aVF

• Invented by a man called Emanuel Goldberger
• The abbreviation ‘a’ refers to augmented. A definition of augmented is to increase in size which simply means that the ECG machine amplifies the signal to make it more readable. (the machine augments the reading by 50%)
• The ‘V’ refers to voltage
• R, L and F refer to right arm, left arm and left foot
Unipolar leads-aVR, aVL, aVF

- Records electrical voltages from 1 location, rather than between 2 extremities as in the bipolar leads.

- We can use Einthoven’s triangle to represent the unipolar leads by drawing lines from the bipolar leads so that the lines meet at a central point.

- The sum of the 3 voltages of RA, LA & LL always equals zero

- The zero potential is obtained inside the ECG machine by joining the 3 leads

- Refer back to the ECG and add all of the QRS voltages together in the bipolar leads

- What is your answer?
The triaxial diagram

The unipolar leads

- Useful way of representing the orientation of the unipolar leads (aVR, aVF, aVL)
- The leads are shown as lines (axis) which have positive and negative poles
- Since the diagram has 3 axis it is called a triaxial diagram
Wilson’s Central Terminal
The unipolar leads

- Wilson was an American physician that introduced a terminal which connects the RA, LA and LL together via a central terminal.
- The central terminal records an average of the 3 limb leads.
- Goldberger modified the Wilson's central terminal to augment the voltage of the unipolar leads by 50%.
Precordial (Chest) Leads

- Leads are placed in a horizontal plane
- They record voltages moving anteriorly and posteriorly
- Each of the leads has its own sight and a region of the heart it views best
Hexaxial reference system
The 12 views of the heart
The Extremity (limb) leads

- Named the 6 extremity (limb) leads. They include:
  - 3 augmented leads aVR, aVL, aVF. These are the unipolar leads
  - 3 standard leads I, II and III. Named the bipolar leads
Lead Systems Summary

• The 12 leads provide a 3-D view of the electrical activity of the heart
• 6 extremity leads record voltages from the frontal plane of the heart. These leads consist of the bipolar (I,II,III) and unipolar leads(AVR,AVL,AVF)
• Bipolar leads record the difference in voltage between 2 extremities
• Unipolar leads record voltages at one point relative to zero
• Einthoven’s triangle describes the relationship between the bipolar leads. Wilsons central terminal describes the orientation of the unipolar leads. This also is described using Einthoven’s triangle.
• The two triaxial diagrams can be combined to form a hexaxial diagram which illustrates the angle of orientation of the leads
• The unipolar precordial leads record voltages from the heart in the horizontal plane by placing electrodes in specific anatomical positions

• Diagrams taken from; The only EKG book you’ll need. Malcolm.S.Thaler
• The ECG explained. Macfarlan & Coleman SCST