

LEADS

in a 12-Lead ECG

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ECG Leads



A lead can be thought of an eye or pair of eyes watching the heart.

Leads: Definitions

- A lead is a recording electrode or a pair of recording electrodes at a specified location.
- A lead can also refer to an electrical tracing.



Donna Memory Koenig

Leads: Definitions

- A wire that is implanted in the heart and gives information to a pacemaker or implantable cardioverter defibrillator (ICD) is also a lead.
- Notice the positive and negative electrodes at the tip of the lead.



Direct, Semi-Direct and Indirect Leads

- If a lead is directly on heart tissue, it is a direct lead. Pacemaker and ICD leads are **direct leads**.
- If a lead is *more than two cardiac diameters* from the heart, it is an **indirect lead**.
- **Semi-direct leads** are in close proximity but not in direct contact with the heart.
- These terms related to ***distance***.



A permanently implanted pacemaker is connected by wires (or leads) into heart muscle. Above is a Medtronic pacemaker, which is a brand. There are several brands of pacemakers used.

Bipolar and Unipolar Leads

- A bipolar lead has a distinctly positive pole and a distinctly negative pole. These leads include the frontal leads in an ECG I, II, and III.
- Most modern pacemaker and ICD leads are bipolar. They have a negative and a positive electrode at the tip of the wire or wires.
- A unipolar lead has a pole with a distinct positive pole but does not have a distinct negative pole. These leads include aVL, aVR, and aVL. The chest leads are also unipolar: leads V1 through V6.
- These terms relate to *how the waveform is sensed* by the leads.



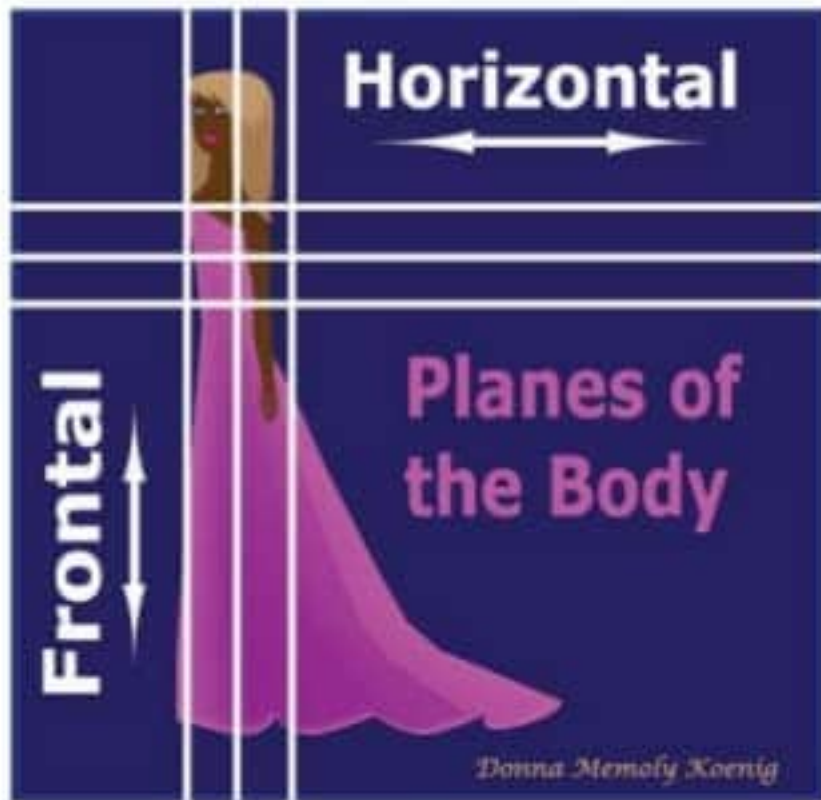
Durata lead from St. Jude Medical used in ICDs

Planes of the Body

Some 12-lead ECG leads are on the *frontal* plane and some are on the *horizontal* plane.

The **frontal** leads scan the top surface of the body.

The **horizontal** leads sense electrical forces from front to back of the body.



Frontal Plane Leads: Lead I

Lead I: RA (-) to LA (+) (Right Left, or lateral)

- Lead I has a positive electrode on the left arm and a negative electrode on the right arm.
- Lead I is a bipolar, indirect lead.
- Think of a frontal lead as a field of observation on the frontal plane of the body.
- Do not think of a frontal lead as a line between two points.



Frontal Plane Leads: Lead II

RA (-) to LF (+) (Superior Inferior)

- Lead II has a positive electrode on the right arm and a negative electrode on the left foot.
- Lead II is a bipolar, indirect lead.
- As a frontal leads, Lead II is a field of sensing on the frontal plane of the body.



Frontal Plane Leads: Lead III

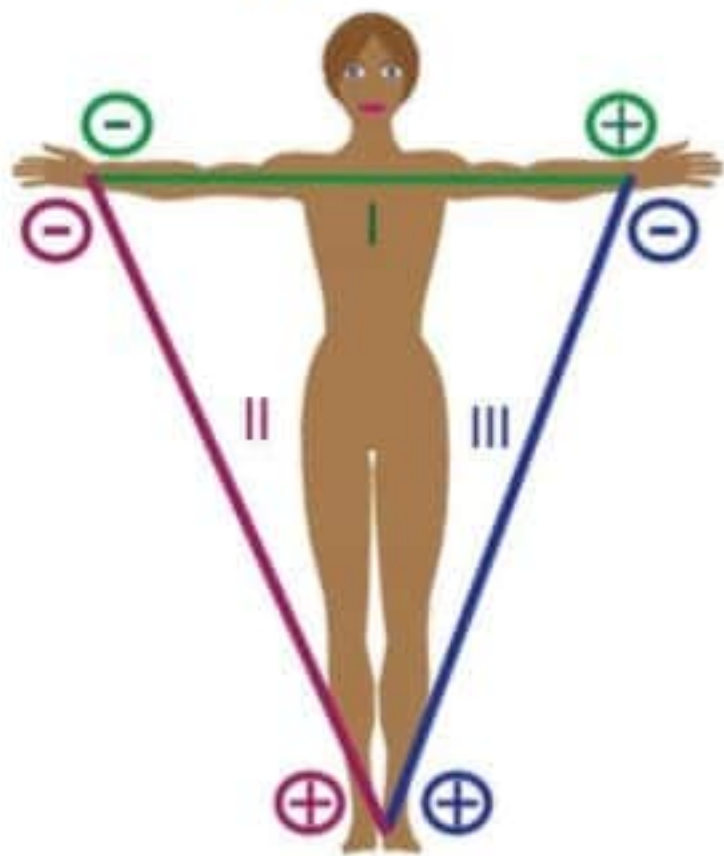
Lead III: LA (-) to LF (+) (Superior Inferior)

- Lead III has a *positive* pole on the left *foot* and a negative pole on the left *hand*.
- Lead III is a bipolar, indirect lead.
- As a frontal leads, Lead III is a field of sensing on the frontal plane of the body.



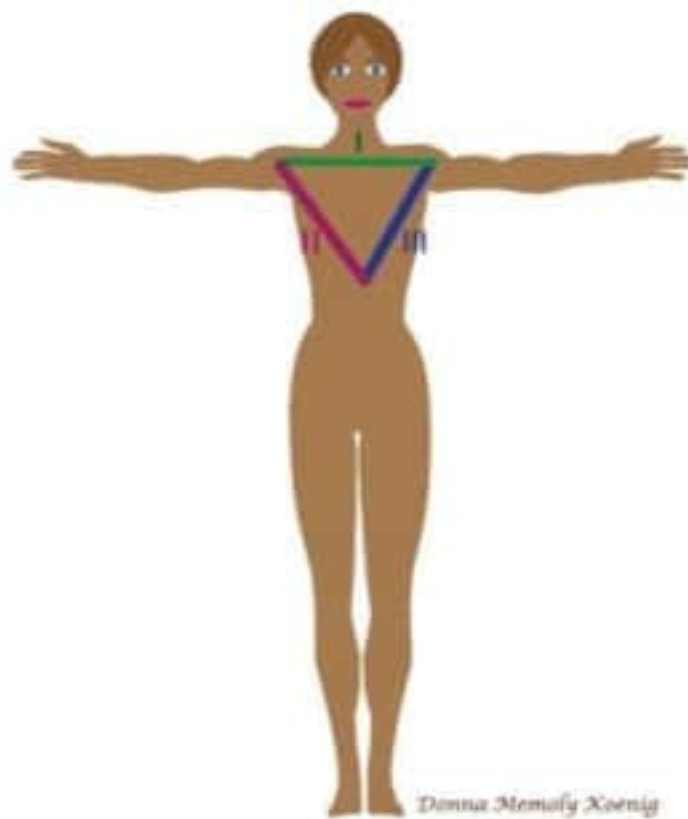
Leads I, II, and III: *Einthoven's Triangle*

- These three leads together compose *Einthoven's Triangle*.
- They are **bipolar leads**. Each lead has a positive and a negative pole.
- These leads are called **indirect** because they are more than two cardiac diameters from the heart.
- *Leads I, II, and III are indirect bipolar leads.*



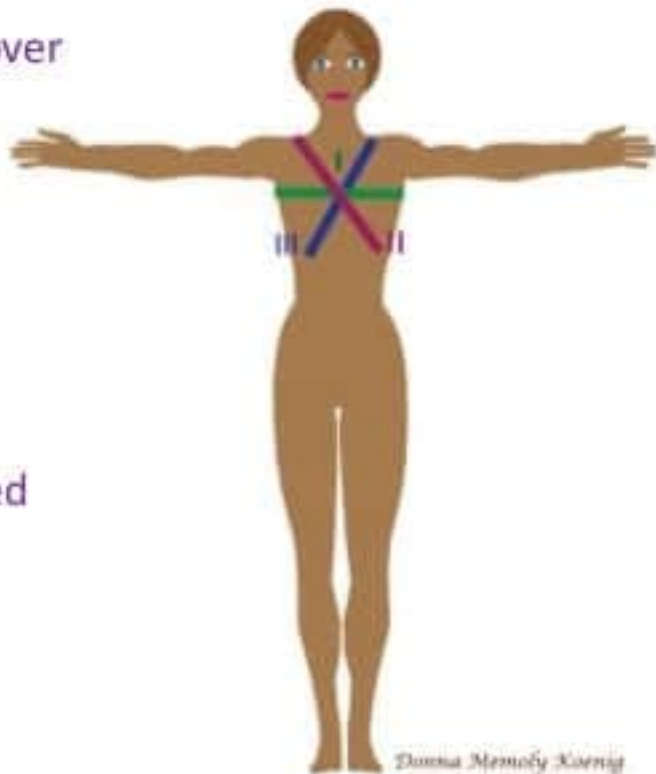
Einthoven's Triangle

- We can reduce the angles to the area over the chest and form a small triangle.



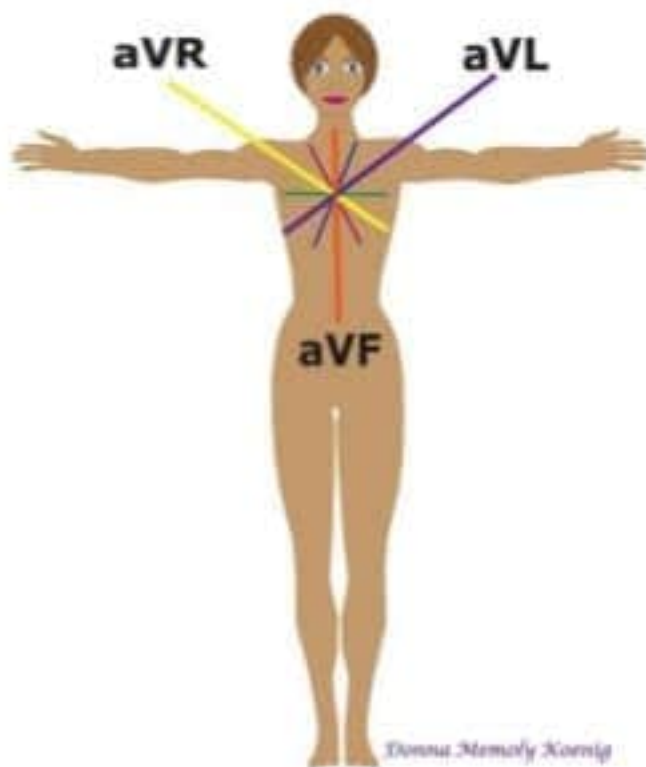
Einthoven's Triangle

- If leads I, II and III are then criss-crossed over the heart, we begin to build a system of leads that will cover the surface of the chest.
- At this point, we have a triaxial system.
- Note *Leads II and III* appear to have traded places.
- *We have room for more coverage* in the spaces between I, II, and III.



Augmented Limb Leads: aVL, aVF, and aVR

- Without adding any more physical leads on the body a number of physicians over time designed the *virtual* leads aVL, aVF, and aVR.
- These physicians included Dr. Wilson and Dr. Goldberger and their co-workers.
- These virtual leads use the existing limb leads, I, II, and III, and mathematical formulas to create three additional frontal-plane leads.



Augmented Limb Leads: aVL, aVF, and aVL

- aVL, aVF, and aVR are unipolar leads. They use a reference point reached through an algebraic formula as a positive pole on the surface of the body. The EKG machine calculates the equations.
- The equations use the heart as a negative reference point.
- The “a” stands for *augmented* because the signal is boosted for our vision by the ECG machine.
- The augmented limb leads are *unipolar, indirect, frontal limb leads*.



Teletronics 12-Lead EKG Machine. Printed with Permission from Teletronics Inc.

In Summary: Six Limb Leads

- Adding the leads aVL, aVR, and aVF between the open spaces completes the *frontal* leads of the 12-Lead ECG.
- We now have six limb leads
- Now we have an *hexaxial* system.

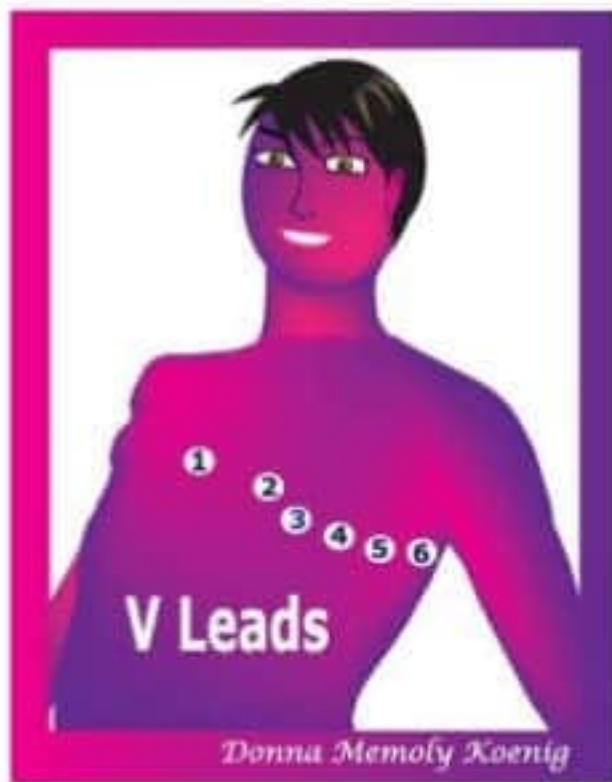


Precordial Leads

- The three standard limb leads (I, II, and III) and the three virtual leads (aVL, aVF and aVR) compose *six* of the twelve leads in a 12-lead ECG.
- **The other six leads are the precordial leads.**
- The precordial leads are *unipolar* leads. They have a positive electrode on the chest wall and use the heart as a general negative reference point.
- The precordial leads record the heart's electrical forces in a *transverse (or horizontal)* plane.
- The precordial leads are *semi-direct* leads because they are close to the heart but not directly on the muscle.

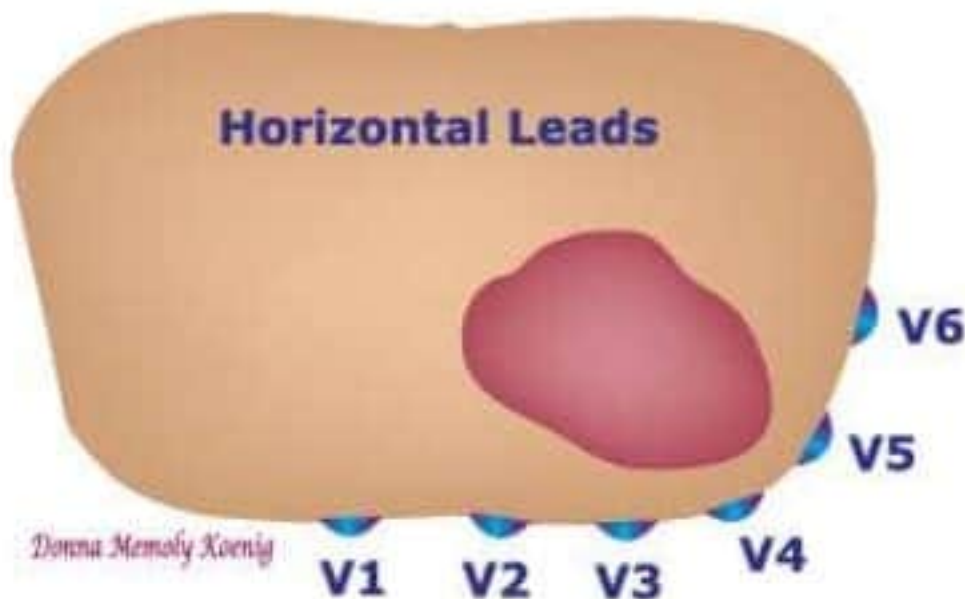
Precordial Leads

- Chest leads are placed in a circular pattern around the heart:
- V1: 4th intercostal space to the immediate *right* of the sternum.
- V2: 4th intercostal space to the immediate *left* of the sternum.
- V3: midway between V1 and V4.
- V4: in the midclavicular line, in the fifth intercostal space.
- V5: in the anterior axillary, at the same level as V4.
- V6: in the midaxillary line, at the same level as V4.



Precordial Leads

- **Why six anterior leads?**
 - V1 and V2 reflect the right side of the heart
 - V3 and V4 reflect the interventricular septum (location of His Bundle and Right and Left Bundle Branches)
 - V5 and V6 reflect the left side of the heart
 - The precordial leads are projected through AV node **through the heart.**



Summary of Leads

- There are six limb leads. They are indirect leads.
- Three of the limb leads are bipolar: I, II, and III. Three of the limb leads are unipolar: aVL, aVR and aVF.
- The limb leads are in the frontal plane.
- There are six precordial (chest) leads. The precordial leads lie in the horizontal plane. They are unipolar, semi-direct leads.
- Bipolar leads have a negative and positive pole. Unipolar leads have a positive pole and a negative frame of reference in the area of the heart.
- Indirect leads lie more than the distance of two heart widths from the heart.
- Semi-direct leads are in close proximity to the heart.
- Direct leads are in direct contact with the heart.