The Difference Between Leads

What is a lead?

An EKG lead consists of two surface electrodes of opposite polarity (one positive and one negative) or one positive surface electrode and a reference point. A lead composed of two electrodes of opposite polarity is called **bipolar** lead. A lead composed of a single positive electrode and a reference point is a **unipolar** lead.

12-lead ECG:

For a routine analysis of the heart's electrical activity an ECG recorded from 12 separate leads is used. A 12-lead ECG consists of three bipolar limb leads (I, II, and III), the unipolar limb leads (AVR, AVL, and AVF), and six unipolar chest leads, also called precordial or V leads, (V_1 ,V_2 ,V_3 ,V_4 ,V_5 , and V_6).

Limb leads: I, II, III, IV, V, and VI

Lead IV also called AVR

Lead V also called AVL

Lead VI also called AVF

Chest leads: V_i

The three types of ECG leads:

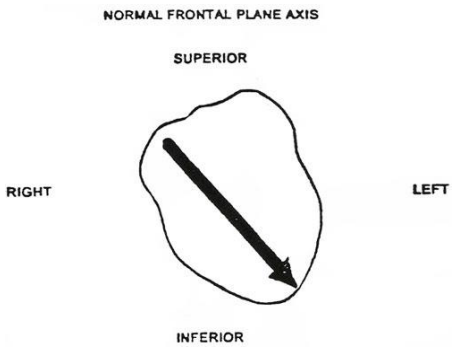
- Limb Leads (Bipolar)
- Augmented Limb Leads (Unipolar)
- Chest Leads (Unipolar)

frontal plane axis:

The frontal plane axis is the orientation of the heart's electrical activity in the frontal plane.

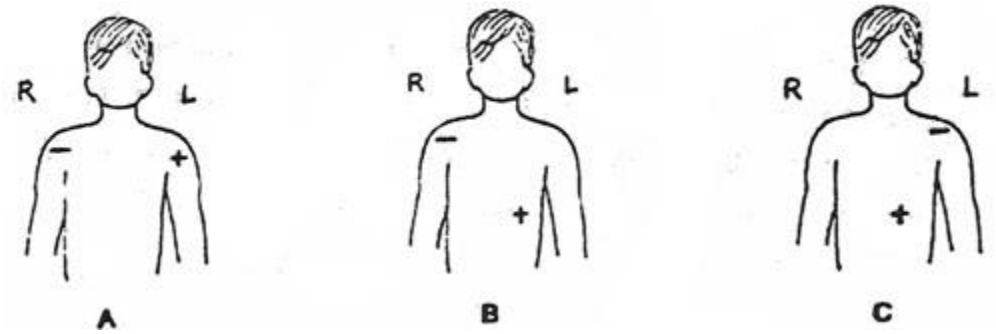
The fontal plane consists of:

Right-to-Left / Left-to-Right Directions AND:
Superior-to-Inferior / Inferior-to-Superior Directions



The Frontal Plane Leads:

The activity of the heart produces electrical potentials that can be measured on the surface of the skin. Using the galvanometer (EKG machine), differences between electrical potentials at different sites of the body can be recorded. See illustration below:



<u>Three different leads:</u>

Lead I: Right arm-negative, Left arm-positive

Records electrical differences between the left and right arm electrodes.

Lead II: Right arm-negative, Left leg-positive

Records electrical difference between the left leg and right arm electrodes.

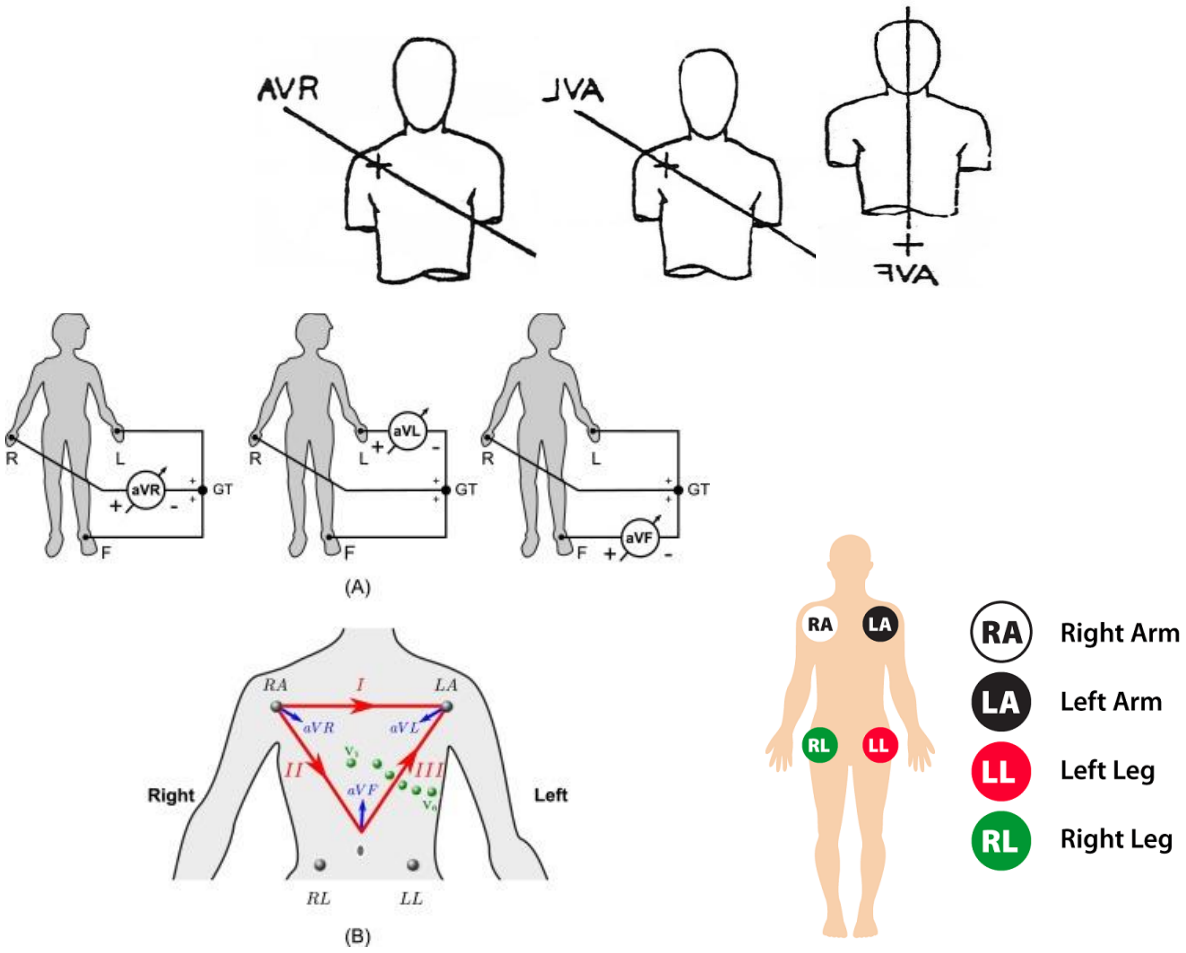
Lead III: Left arm-negative, Left leg-positive

Records electrical differences between the left leg and left arm electrodes.

Unipolar leads:

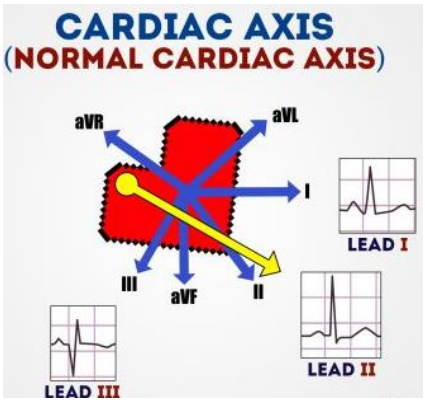
- Lead aVR Augmented Vector Right, positive electrode right shoulder.
- Lead aVL Augmented Vector Left, positive electrode left shoulder.

- Lead aVF Augmented Vector Foot, positive electrode on Foot.



Normal Cardiac Axis:

In healthy individuals, you would expect the cardiac axis to lie between -30°and +90º. The overall direction of electrical activity is therefore towards leads I, II and III (the yellow arrow below). As a result, you see a positive deflection in all these leads, with lead II showing the most positive deflection as it is the most closely aligned to the overall direction of electrical spread. You would expect to see the most negative deflection in aVR. This is due to aVR providing a viewpoint of the heart from the opposite direction.

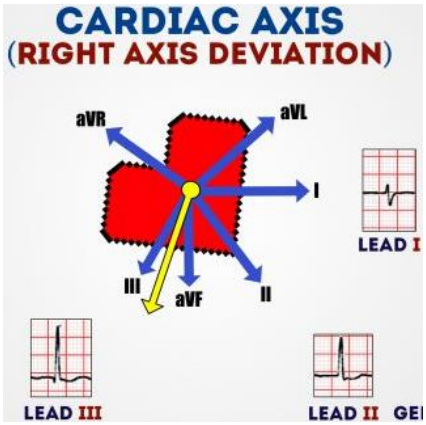


Right Axis Deviation:

Right axis deviation (RAD) involves the direction of depolarization being distorted to the right (between +90º and +180º).

The most common cause of RAD is right ventricular hypertrophy. Extra right ventricular tissue results in a stronger electrical signal being generated by the right side of the heart. This causes the deflection in lead I to become negative and the deflection in lead aVF/III to be more positive.

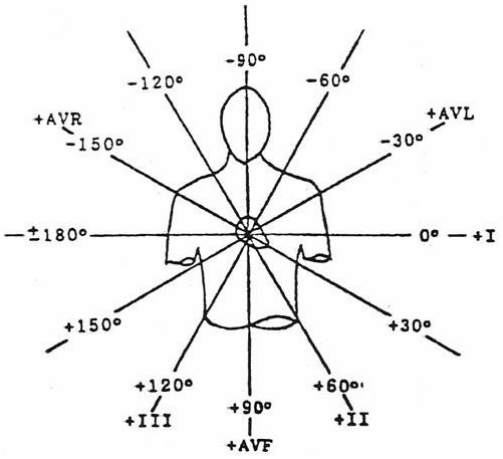
RAD is commonly associated with conditions such as pulmonary hypertension, as they cause right ventricular hypertrophy. RAD can, however, be a normal finding in very tall individuals.



Left Axis Deviation:

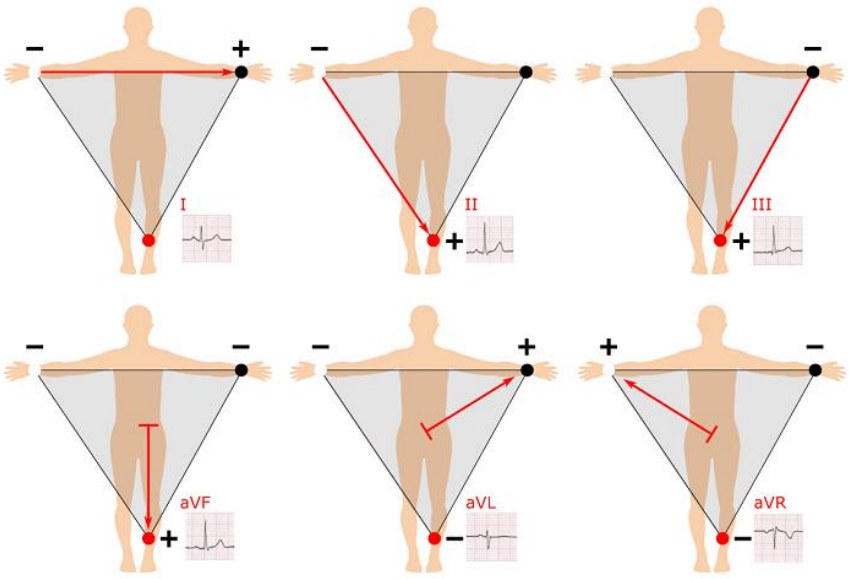
Left axis deviation (LAD) involves the direction of depolarization being distorted to the left (between -30° and -90°). This results in the deflection of lead III becoming negative (this is only considered significant if the deflection of lead II also becomes negative). LAD is usually caused by conduction abnormalities.

The six limb leads measure a copulate circle or 360 degrees around the heart. They measure the electrical activity of the heart from every possible angle. The reason for this is obvious. By measuring the heart from different angles, you will be able to pinpoint the location of any conduction left in the heart.



The angles are as follows:

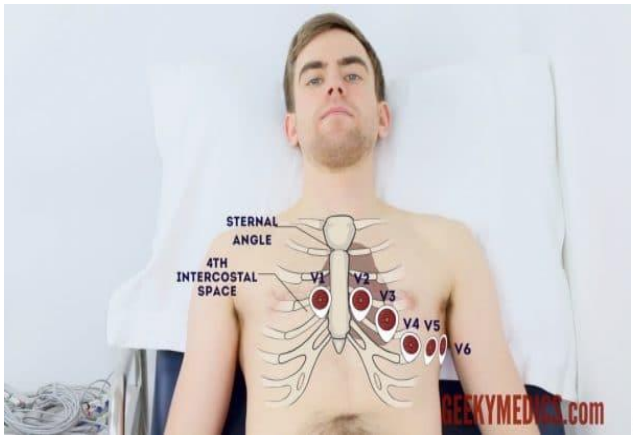
LEAD I	Is located at 0 degrees	And	(+) (-) 180 degrees
LEAD II	Is located at +60 degrees	And	-120 degrees
LEAD III	Is located at +120 degrees	And	-60 degrees
LEAD aVR	Is located at +30 degrees	And	-150 degrees
LEAD aVL	Is located at -30 degrees	And	+150 degrees
LEAD aVF	Is located at +90 degrees	And	-90 degrees

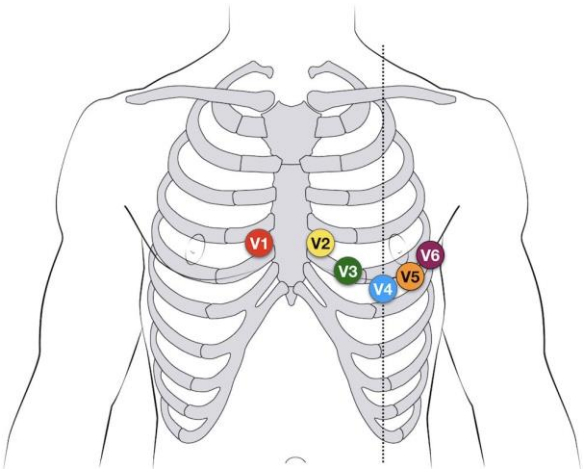


The Chest Leads (or Precordial Leads):

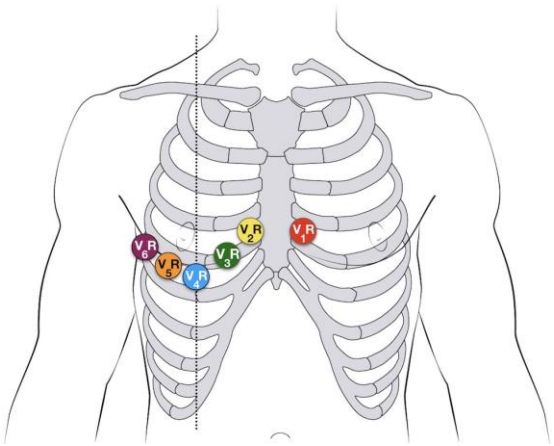
We will now discuss the remaining six leads of the 12-lead EKG. These next six leads are called the Chest leads or the Precordial leads. This part may also become confusing because these precordial leads are six additional leads that use the same V technique we used with the 3 limb leads. Therefore, do not confuse these Precordial V leads with the three V limb leads (aVR, aVL, aVF).

- V1: 4th intercostal space at the right sternal edge
- V2: 4th intercostal space at the left sternal edge
- V3: midway between the V2 and V4 electrodes
- V4: 5th intercostal space in the midclavicular line
- V5: left anterior axillary line at the same horizontal level as V4
- V6: left mid-axillary line at the same horizontal level as V4 and V5

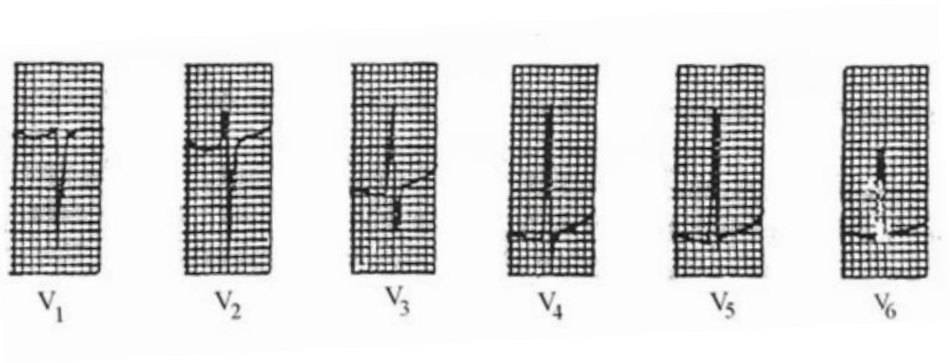




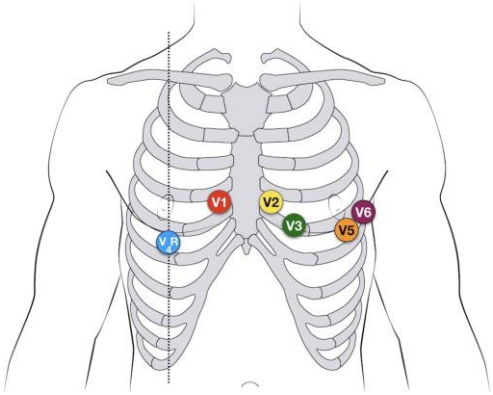
Right sided ECG electrode placement:



The normal ECG morphology of the complex in the V leads:



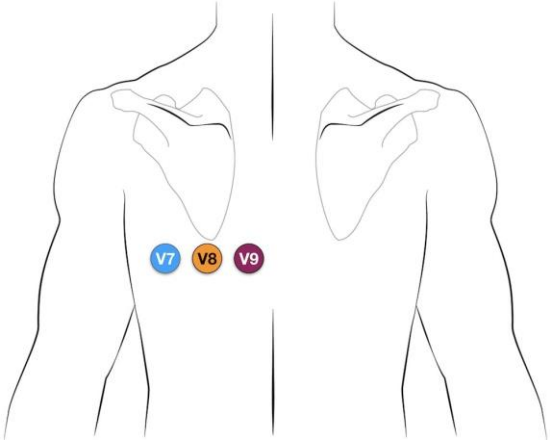
V4R ECG lead placement:



Posterior leads:

Leads V7-9 are placed on the posterior chest wall in the following positions:

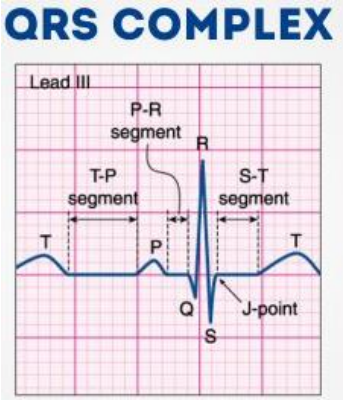
- V7 – Left posterior axillary line, in the same horizontal plane as V6.
- V8 – Tip of the left scapula, in the same horizontal plane as V6.
- V9 – Left paraspinal region, in the same horizontal plane as V6.



The shape of the ECG waveform:

Each individual lead's ECG recording is slightly different in shape. This is because each lead is recording the electrical activity of the heart from a different direction (a.k.a viewpoint). When the electrical activity within the heart travels towards a lead you get a positive deflection (انحراف مثبت). When the electrical activity within the heart travels towards a lead you get a positive deflection. When the electrical activity within the heart travels away from a lead you get a negative deflection. Each deflection (a.k.a. wave) on the ECG represents the average direction of electrical travel (which is calculated using mathematical formulae by the ECG machine). The height of the deflection represents the amount of electrical activity flowing in that direction (i.e. the higher the deflection, the greater the amount of electrical activity flowing towards the lead). In this case three states can be happened:

- If the R wave is greater than the S wave it suggests depolarization is moving towards that lead.
- If the S wave is greater than the R waves it suggests depolarization is moving away from that lead.
- If the R and S waves are of equal size it means depolarization is travelling at exactly 90° to that lead.

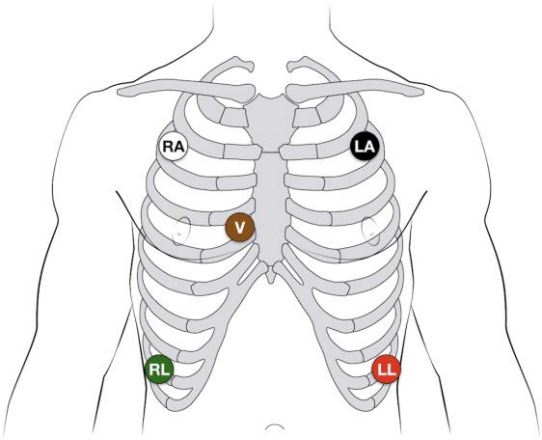


What is the difference between 5 lead and 12-lead ECG?

A 5-lead provides a lot of information, but if something concerning is noted, a 12-lead ECG is ordered to provide even more information. Think of each lead like a camera, taking a snapshot of the heart's electrical activity. Twelve cameras provide substantially more information than five.

- Uses **5** electrodes (RA, RL, LA, LL and Chest)

- Monitor displays the bipolar leads (I, II and III)
- **AND** a single unipolar lead (depending on position of the brown chest lead (positions V1–6))

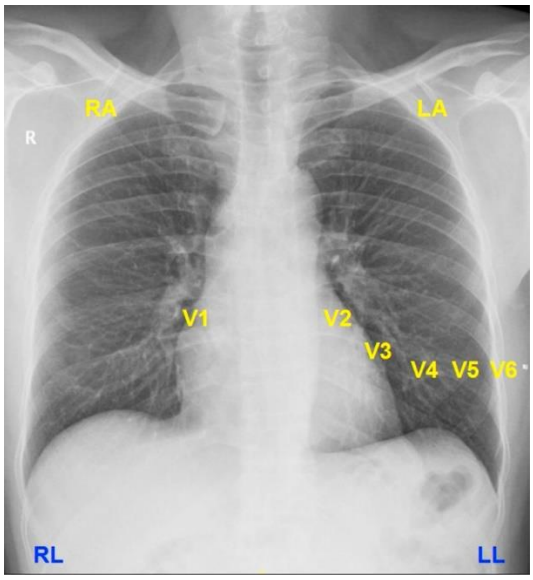


What is the difference between 6 lead and 12-lead ECG?

The mean difference between the HR as measured on the 6-lead and 12-lead ECGs was 5.5 beats per minute (bpm; 95% confidence interval [CI] 4.9–6.0 bpm).

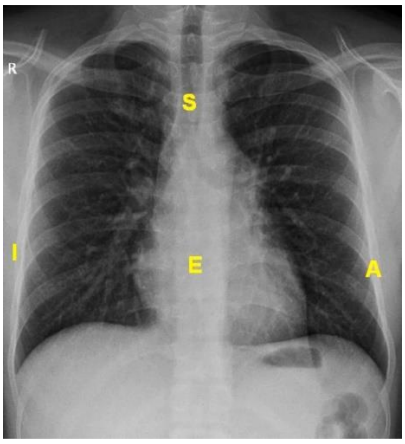
10 electrode 12 lead monitoring:

Although it is called a 12-lead ECG, it uses only 10 electrodes. Certain electrodes are part of two pairs and thus provide two leads. Electrodes typically are self-adhesive pads with a conducting gel in the center. The electrodes snap onto the cables connected to the electrocardiograph or heart monitor. Mason-Likar modification of standard 12 leads is quite popular for treadmill testing. In this system, chest electrodes are placed in the standard positions, but limb electrodes are transposed to the torso to reduce movement artefacts. Right and left arm electrodes are placed in the infraclavicular fossae, medial to the deltoid muscle, 2 cm below the lower border of the clavicle. Right and left leg electrodes are kept in the anterior axillary line, halfway between costal margin and iliac crest. Right lower electrode serves as the ground as in standard 12 lead ECG. There will be a total of ten electrodes from which all 12 leads can be obtained. This lead system is good for real time ST segment monitoring during thrombolytic therapy as well. But the diagnostic value of 12 lead electrocardiogram obtained using this lead system is altered by the change in the location of limb electrodes. Q waves in the inferior leads may be masked and there is mild right ward shift in the QRS axis.



EASI lead system:

EASI lead system uses five electrodes and derives 12 leads by a computer algorithm. In EASI lead system, A, E and I are same as that of Frank vectorcardiographic system. E is located at the lower end of body of sternum. A and I are located in left and right midaxillary lines in the same horizontal level as E. Electrode S is placed on the manubrium sternum. Ground electrode for the EASI system is on the torso in same location as in Mason-Likar system. Algebraic transfer coefficients are used to generate a derived 12 lead ECG using 5 electrode EASI system. When the EASI system is used for continuous monitoring, excessive artefacts while turning from supine position to right has been documented. This is due to artefacts picked up by the electrode in the right mid axillary line (I). But myoelectric noise in the limb leads during physical activity was lesser with EASI system than Mason-Likar system. It may be noted that derivation of 12 leads from EASI electrodes is an approximation and a 12/12 match with standard 12 lead ECG should not be expected.



Fontaine leads (Fontaine bipolar precordial lead ECG):

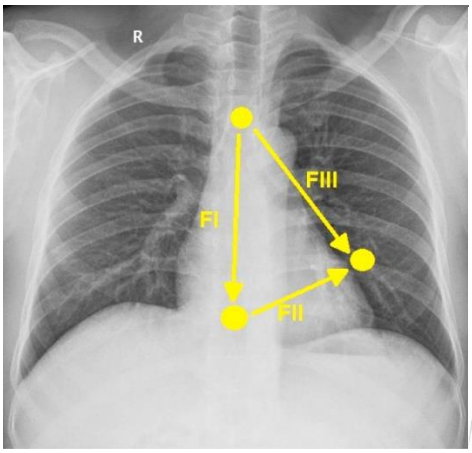
Fontaine bipolar precordial leads (F-ECG) are used to increase the sensitivity of epsilon wave detection. Named after French cardiologist and electrophysiolgist Guy Hugues Fontaine (1936-2018). Leads are placed as shown:

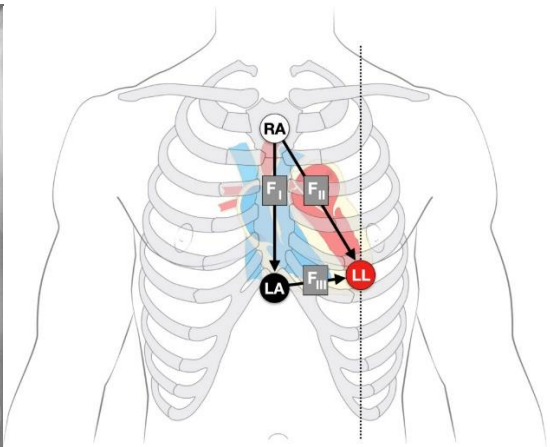
- ✓ Right Arm (RA) over the manubrium;
- ✓ Left Arm (LA) over the xiphoid process;
- ✓ and Left Leg (LL) in the standard V4 position (5th ICS MCL).

Instead of regular leads I, II, and III there are now three bipolar chest leads that are termed FI, FII, and FIII which record the potentials developed in the right ventricle, from the infundibulum to the diaphragm.

The vertical bipolar lead FI, (similar to aVF) magnifies the atrial potentials and can be used to record:

- ✓ epsilon waves;
- ✓ search for AV dissociation in ventricular tachycardia;
- ✓ and to study abnormal atrial rhythms when the P waves are too small on regular leads.





ECG Electrode Guide

Electrode	Colour	Position	System
RA	White (Snow)	Right Arm	3-Electrode 5-Electrode 12-Lead ECG
LA	Black (Smoke)	Left Arm	3-Electrode 5-Electrode 12-Lead ECG
LL	Red (Fire)	Left Leg	3-Electrode 5-Electrode 12-Lead ECG
RL	Green (Grass)	Right Leg	5-Electrode 12-Lead ECG
C	Brown	Central Chest Over Sternum	5-Electrode
V1	Red	Sternal Edge Right 4th ICS	12-Lead ECG
V2	Yellow	Sternal Edge Left 4th ICS	12-Lead ECG
V3	Green	Between V2 and V4	12-Lead ECG
V4	Blue	Mid-Clavicular line Left 5th ICS	12-Lead ECG
V5	Orange	Between V4 and V6 Left 5th ICS	12-Lead ECG
V6	Purple	Mid-Axillary Line Left 5th ICS	12-Lead ECG

	AHA (American Heart Association)		IEC (International Electrotechnical Commission)	
Location	Inscription	Colour	Inscription	Colour
	RA	White	R	Red
	LA	Black	L	Yellow
	RL	Green	N	Black
	LL	Red	F	Green
	V1	Brown/Red	C1	White/Red
	V2	Brown/Yellow	C2	White/Yellow
	V3	Brown/Green	C3	White/Green
	V4	Brown/Blue	C4	White/Brown
	V5	Brown/Orange	C5	White/Black
	V6	Brown/Purple	C6	White/Purple

6-lead ECG recordings:

The 6-lead ECGs were recorded with the AliveCor KardiaMobile 6L, a small device (9.0 × 3.0 × 0.72 cm) that has three stainless steel recording electrodes and can thus record the six standard and augmented limb leads. Two electrodes are on the top of the device, while the third is on the bottom (Figure 1a). A patient places the bottom of the device on the left leg (ankle or knee) and touches the top electrodes with fingers from the right and left hands (Figure 1b). This allows recording of standard ECG leads I and II, from which lead III and the augmented limb leads may be derived. ECGs can be recorded from 30s to 5 min in duration, with a sampling rate of 300 samples/second. The device is connected via Bluetooth to an application loaded into the patient's smartphone, which allows the ECG recordings to be uploaded to AliveCor's Internet cloud-based servers.

Conclusion:

Different lead systems have been proposed for different purposes, in addition to the standard 12 lead ECG. Though the most important aspect of ECG monitoring is detection of rhythm abnormalities, detection of ST shift is equally important. Detection of ST shift is important during a stress test, during and after a percutaneous coronary intervention. Special leads have been designed mostly for enhancement of atrial activity which can be of use in arrhythmia analysis as well as for assessment of atrial repolarization which is often ignored in surface ECG.

https://www.nurseslearning.com/courses/nrp/nrp1619/Section%205/index.htm

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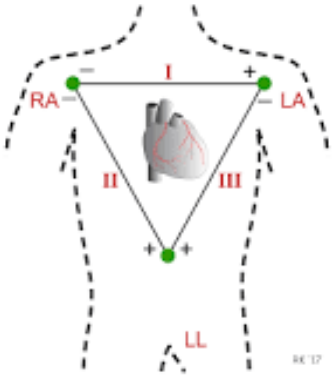
https://www.researchgate.net/publication/51567229_Unveiling_the_Biometric_Potential_of_Finger-Based_ECG_Signals

Information Extracted from Lead 1

Although 1-lead ECG (EKG) recorders are normally used primarily for basic heart monitoring, checking for various arrhythmias, or simple educational or research purposes, they can also be used for looking at the effects of exercise on the ECG.

Based upon universally accepted ECG rules, a wave a depolarization heading toward the left arm gives a positive deflection in lead I because the positive electrode is on the left arm.



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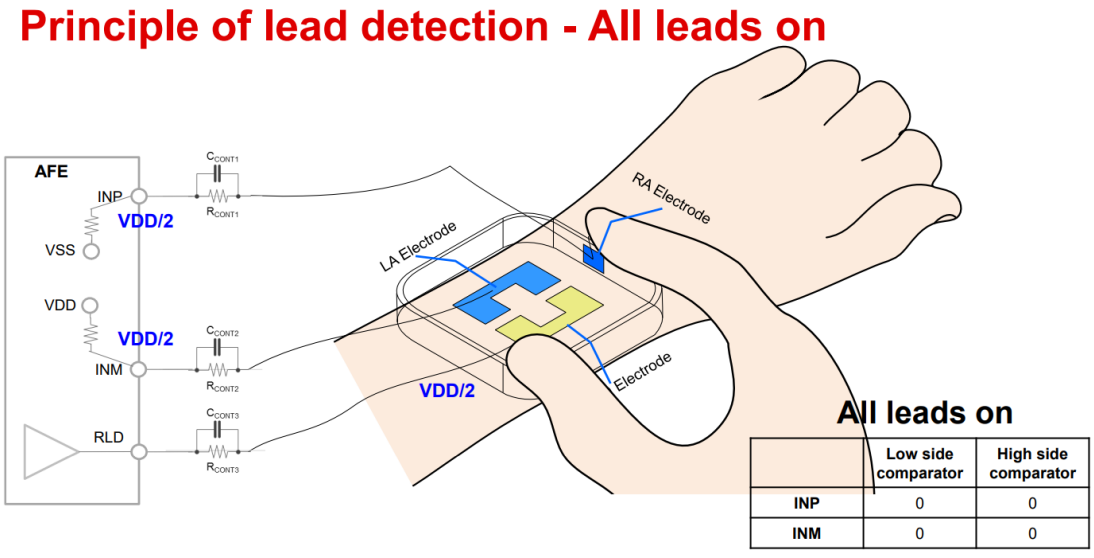

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