EKG Manual

June, 2012
What is an EKG?

An electrocardiogram, or EKG, is a recording of the heart’s electrical impulses as measured from various points on the surface of the body.

What's the difference between and “EKG” and an “ECG”?

No difference, they are one and the same. The EKG machine was invented by the Dutch physiologist Willem Einthoven in the early 1900’s. The traditional abbreviation “EKG” comes from the German word “elektrokardiogram.” The abbreviation “ECG” more closely reflects the English spelling of the word.

12-Lead EKG

The standard 12-lead EKG is comprised of:

- Three standard (bipolar) limb leads [I, II, III]
- Three unipolar augmented limb leads [aVR, aVL, aVF]
- Six unipolar chest (precordial) leads [V1, V2, V3, V4, V5, V6]

EKG Tracing

A typical EKG tracing is comprised of a series of waves that represent the sequence of “depolarization” and “repolarization” that occurs each time the heart makes a beat. The EKG waveform provides valuable information about the heart’s functioning.

The EKG also measures the heart’s rate and rhythm.
EKG Electrode Placement – PROPER ELECTRODE PLACEMENT IS EXTREMELY IMPORTANT!!!

Ten electrodes are used to create a standard 12-lead EKG. The electrodes usually consist of a conducting gel, embedded in the middle of a self-adhesive pad onto which the patient cables clip. Older units use a conducting gel along with metal electrodes attached to the arms and legs and suction cups attached to the chest.

Note that the limb electrodes can be far down on the limbs or close to the hips/shoulders, but they must be even (left vs. right).

<table>
<thead>
<tr>
<th>Electrode</th>
<th>Placement</th>
</tr>
</thead>
<tbody>
<tr>
<td>RA</td>
<td>Right arm (avoid bony prominences)</td>
</tr>
<tr>
<td>LA</td>
<td>Left arm (same location as RA, avoid bony prominences)</td>
</tr>
<tr>
<td>RL</td>
<td>Right leg, (avoid bony prominences)</td>
</tr>
<tr>
<td>LL</td>
<td>Left leg, (same location as RL, avoid bony prominences)</td>
</tr>
<tr>
<td>V1</td>
<td>In the fourth intercostal space (between ribs 4 &amp; 5), just to the right of the sternum (breastbone)</td>
</tr>
<tr>
<td>V2</td>
<td>In the fourth intercostal space (between ribs 4 &amp; 5), just to the left of the sternum</td>
</tr>
<tr>
<td>V3</td>
<td>Between leads V2 and V4</td>
</tr>
<tr>
<td>V4</td>
<td>In the fifth intercostal space (between ribs 5 &amp; 6) in the mid-clavicular line (imaginary line that extends down from the midpoint of the clavicle, or collarbone)</td>
</tr>
<tr>
<td>V5</td>
<td>Horizontally even with V4, in the anterior axillary line (imaginary line that extends down from the point midway between the midpoint and lateral end of the clavicle; the lateral end of the collarbone is the end closer to the arm.)</td>
</tr>
<tr>
<td>V6</td>
<td>Horizontally even with V4 and V5 in the mid-axillary line (imaginary line that extends down from the middle of the applicant’s armpit.)</td>
</tr>
</tbody>
</table>
Watch out for lead reversals...

A common error when performing EKGs is lead reversal – especially arm lead reversal.

You should always double check the labels on the leads as you attach them to the limbs! (Don’t forget to double check the labels on V1-V6 as you attach them, too!)

The appearance of the EKG tracing can provide an easy to identify “alerting sign” in Leads I and aVR.

A normal EKG generally has the following characteristics:

- **Lead I**: predominately positive P wave, QRS complex, and T wave  
  Lead I is normally up!
- **Lead aVR**: predominately negative P wave, QRS complex, and T wave

With arm lead reversal, a characteristic appearance will be seen on EKG that includes:

- **Lead I**: predominately negative P wave, QRS complex, and T wave
- **Lead aVR**: predominately positive P wave, QRS complex, and T wave

If you see this “alerting sign,” double check all the leads to be sure that they are properly placed.

**Side Note**: An EKG pattern similar to switched arm leads occurs in a rare condition known as “dextrocardia” where the heart is on the right side of the chest instead of the left. In dextrocardia, however, the precordial leads (V1-V6) are also affected. In the case of limb lead reversal, the precordial leads are not affected.
EKG Settings:
Unless specifically requested otherwise, EKGs should be run with the following standard settings:

- **Paper Speed:** 25 mm/sec
- **Calibration Standard:** 1mV = 10mm

**Isoelectric Line**

The “isolectric line” is the flat part of the EKG between complexes. This represents the period of time between heartbeats in which there is no electrical activity. In a properly performed EKG, this line should be completely horizontal (flat) and free from interference. In the example below, the isoelectric line is nice and flat. Minor “baseline interference” is apparent, but the “P waves” before the “QRS complexes” are clearly visible – so it is acceptable.
**Troubleshooting**

Artifacts that make an EKG uninterruptable may occur for a number of different reasons, including poor technique. It is extremely important that EKGs performed for Superior Mobile Medics are submitted without artifacts.

This may sometimes mean making multiple attempts (and wasting EKG paper) to obtain an acceptable EKG. Despite the extra time and effort required, this is much easier than the need for a return visit, at which time neither the ordering insurance company nor the applicant (nor SMM) will be happy.

Following are some common types of artifacts and tips to avoid them:

1. **Poor contact**

   ![Artifact – poor contact](image)

   Check each electrode for proper adhesion to skin. Electrodes which are loose have decreased conductivity and ability to transmit the heart’s signals.

   Poor contact may occur at a number of points between machine and applicant:
   - Machine to lead wire – Check to be sure that connection is firm and intact.
   - Lead wire to electrode – Check to be sure that connection is firm and intact. Unhook and reattach leads as needed to ensure proper attachment.
   - Electrode to patient – Cleansing the skin with an alcohol swab prior to applying the electrode can help to make better contact, especially with oily skin, lotion on skin*, or excessive body hair.

   *When scheduling appointments with applicants who require an EKG, it is best to advise the applicant to avoid the use of body lotion on the day of the exam.

   For very hairy individuals, the following techniques may be employed to ensure good contact and adhesion of the electrodes:
   - Clean the area (hair and underlying skin) with an alcohol swab to remove natural body oils or applied lotions.
   - Spread the hair between thumb and forefinger; firmly apply the sensor to the exposed skin.
   - Applicant’s body hair should NOT be shaved.

   Make sure electrodes are not expired and feel appropriately “sticky.” Electrodes can dry out if expired or if exposed to air for a long period of time. Never re-use disposable electrodes.
2. **Lead wire/patient movement or muscle tension**

Any movement or tension in the patient and/or lead wire can result in artifact.

Position the applicant comfortably on a cot, bed, couch, or examination table large enough to support both arms and legs and allow for complete relaxation. Avoid discomfort by protecting the applicant from cold, drafts, or other disturbing factors.

Encourage the applicant to lay back, relax and take nice easy breaths. Assure the applicant that there is no danger or pain involved in the procedure. Explain that his/her full cooperation will assist in the process.

Encourage the applicant to lie very still while the EKG is running.

3. **Electrical Interference (AC)**

Electrical interference can obscure much of an EKG recording by producing a wide baseline. Its amplitude depends on the strength of the AC source and the lead being recorded. The frequency of the interference signal corresponds to the supply line frequency (usually 60 Hz).

Tips to eliminate or minimize AC effects:

- Run EKG using rechargeable battery option, if available.
- Have applicant remove wristwatch, cell phone, pager, etc.
- Locate the EKG machine and applicant as far as possible from extraneous equipment cords, building electrical wiring, and any other likely source of electrical interference.
- Locate the EKG machine so that the line cord is well away from the patient and patient cable.
- Make sure that the machine and patient cable are both plugged in all the way.
- Be sure that machine in properly grounded by means of the wall outlet to which it is connected. Ground machine to metal bed frame or metal pipe via auxiliary ground lead, if available.
- Arrange patient cable leads as close together as possible and following the body contour. Avoid loopin excess lead wires.
- Turn off all nearby electrical equipment and lighting fixtures. Unplugging nearby electrical equipment may also help.
- Electrical wiring in walls and ceilings is also a source of possible AC interference. Simply moving the patient to a different location may alleviate the problem.
- Utilizing the EKG machine’s AC filter, if so equipped, may be necessary.

4. **No Signal in a Lead (flat line leads)**

No signal in a lead, or a “flat line” lead, may represent one of the following:

- Poor connection between electrode and applicant
- Switched leads (must be sure that the RA lead is connected to the Right Arm, etc.)
- An internal break in a lead wire
- Machine malfunction

A clue to pinpointing the problem may also come from knowing what an EKG is measuring. For example, Lead II measures the electrical difference between the Right Arm (RA) and the Left Leg (LL). So lack of a Lead II signal may have something to do with the RA and/or LL electrode connections.

The augmented leads (aVR, aVL, aVF) measure combinations of the limb electrodes. As a result, problems with these leads would also generally involve problems with the standard limb leads (I, II, III).

The chest leads (V1-V6) are unipolar leads directly measuring electrical activity. So, for example, lack of a V3 signal would indicate a likely problem with the V3 electrode.

Following is a simplified summary of which electrode connections on the patient are important with respect to generating a 12-lead EKG:

<table>
<thead>
<tr>
<th>Leads on the printed 12-lead EKG</th>
<th>Relevant electrode connections on the applicant</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>Right Arm (RA) and Left Arm (LA)</td>
</tr>
<tr>
<td>II</td>
<td>Right Arm (RA) and Left Leg (LL)</td>
</tr>
<tr>
<td>III</td>
<td>Left Arm (LA) and Left Leg (LL)</td>
</tr>
<tr>
<td>aVR, aVL, aVF</td>
<td>All limb electrodes (RA, LA, RL, LL)</td>
</tr>
<tr>
<td>V1, V2, V3, V4, V5, V6</td>
<td>Corresponding chest electrode (V1 – V6)</td>
</tr>
</tbody>
</table>
5. **Miscellaneous**

Not all EKG cardiac leads are interchangeable with other cardiac equipment. Be sure you have the correct leads for the machine you are using.

For older machines with reusable sensors, be sure that sensors are thoroughly cleaned after each use.

A broken internal wire in the patient lead may cause rapid, erratic tracing deflections, or lack of signal (flat line).

Be sure that connectors (e.g., alligator clips) are firmly attached to electrode wire pins.

**Caution**

Often times, the problem with EKG electrodes is getting them to stick. There are some electrodes, however, that have very strong adhesive. Please exercise extreme care when removing EKG electrodes because they can actually remove the skin from individuals who have delicate skin.

EKG electrodes should always be gently and smoothly peeled back from the skin in order to avoid injury.

**Maintenance**

Many EKG machines require no ongoing operator maintenance or adjustment procedures. Refer to your owner’s manual. Machines equipped with rechargeable battery packs generally need these replaced approximately every 2 years.

**Service**

In the event that your machine needs service, this should be performed by an authorized medical equipment distributor or service center.
Reminders from the Superior Mobile Medics Paramedical Examiner Training Manual...

- An EKG may be requested as part of the paramed exam.
- Male examiners should not perform EKGs on female applicants.
- The applicant should be instructed not to wear any lotions or body oils.
- Alcohol may be used to cleanse the skin if there is a problem making a good connection.
- Applicants should not be wearing panty hose. They can cause interference.
- Applicants should open or remove their upper body clothing. Female applicants should not remove their bras. Chest electrodes should be placed by working around the bra.
- The applicant should be lying on a flat or near flat surface such as a bed, couch, table or the floor. A recliner may be used.
- The tracing should include leads I, II, III, aVR, aVL, aVF, V1-V6.
- The applicant must sign and date the actual tracing.
- EKGs should be mounted unless otherwise instructed.
- EKGs must be signed by the applicant.
- All EKGs should be run at 25mm/sec.
- Tracings should include standardization at 1.0 cm.
- Most EKGs are labeled automatically. If yours is not, you must label each lead.