



Standard Operating Procedures Clinical and *Translational* *Research* Center

Title:	Electrocardiogram (ECG), 12-Lead		
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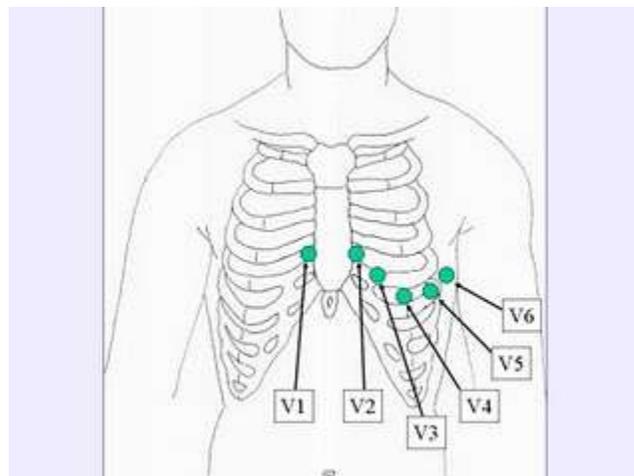
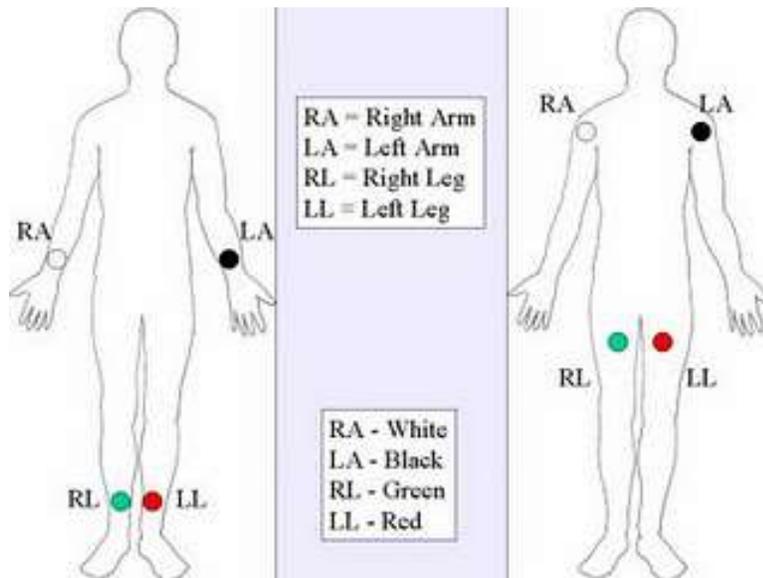
Purpose

A 12-lead electrocardiogram (ECG) is a non-invasive procedure that is used to ascertain information about the electrophysiology of the heart. The purpose of this SOP is to ensure that all clinical staff uses the same procedure to obtain a standard 12-lead ECG to ensure consistency and accuracy of the ECG tracing. It is the responsibility of the Principal Investigator to analyze, interpret, and arrange appropriate follow-up for all abnormalities found.

Procedure

1. The investigator or authorized personnel is responsible for ensuring that a 12-lead ECG is required by the study protocol and also to ensure that a specific machine is being utilized as stated in the protocol.
2. Wash hands and gather the following equipment and supplies:
 - 12-lead ECG Machine
 - ECG Electrodes
 - Alcohol swabs
 - Adhesive remover swabs
 - 2 x 2 gauze pads
 - Razor (optional)
3. Introduce yourself and verify the subject's name and date of birth. Subject identifiers must match the research chart.

4. Ask the subject to remove clothing from the waist up and don a hospital gown with the opening to the front. Ensure privacy by closing the curtain and door.
5. Explain the ECG procedures and answer questions, as appropriate, the subject may have regarding the ECG. Refer the subject to the investigator or study coordinator if you are not sure of the answer.
6. Ask the subject to lay flat on the exam table with legs uncrossed and arms to the side.
7. Wash your hands and stand on the left side of the subject. Prepare the skin, where the electrodes will be placed, by rubbing the lower legs, lower forearms, and chest area with alcohol swabs. Dry the areas with gauze pads.
8. Apply the electrodes starting with the lower legs, lower forearms, and chest area. See the diagram below.



Electrode placement

(RL) On the right leg, lateral calf muscle

(LL) In the same location that RL was placed, but on the left leg.

(RA) On the right arm, avoiding thick muscle.

(LA) In the same location that RA was placed, but on the left arm.

(V₁) In the *fourth* intercostal space (between ribs 4 & 5) just to the *right* of the sternum (breastbone).

(V₂) In the *fourth* intercostal space (between ribs 4 & 5) just to the *left* of the sternum.

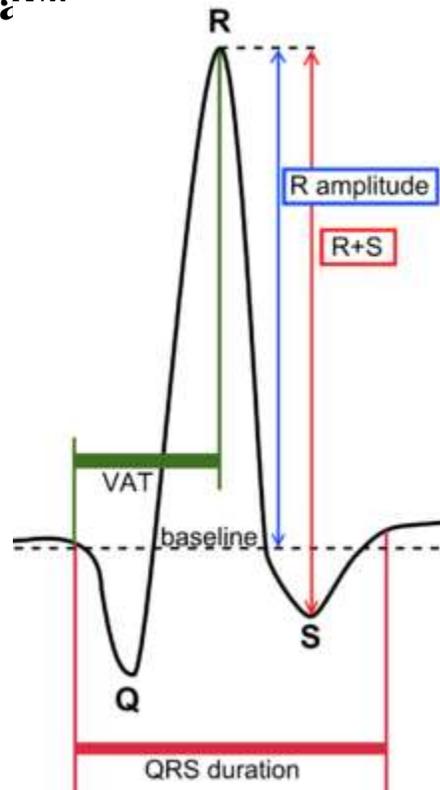
(V₃) Between leads V₂ and V₄. V₄ In the fifth intercostal space (between ribs 5 & 6) in the mid-clavicular line (the imaginary line that extends down from the midpoint of the clavicle).

(V₅) Horizontally even with V₄, but in the anterior axillary line. (The anterior axillary line is the imaginary line that runs down from the point midway between the middle of the clavicle and the lateral end of the clavicle; the lateral end of the collarbone is the end closer to the arm.)

(V₆) Horizontally even with V₄ and V₅ in the midaxillary line. (The midaxillary line is the imaginary line that extends down from the middle of the subject's armpit.)

9. Connect lead wires to the corresponding electrodes. Attach the limb lead wires first beginning with the right leg. Cover the subject with a sheet to keep warm.
10. Turn on the machine and enter the subject's name, date of birth, subject ID number or other protocol specific information. Verify information against the chart.
11. Ask the subject to breathe normally, relax, and remain still.
12. Acquire the ECG reading. Refer to the manufacturer's operational instructions for each specific machine.
13. When a satisfactory ECG is acquired, save, and print. Follow manufacturer's operational instructions if additional copies for the ECG tracing are needed.
14. Remove lead wires and electrodes from the subject. Adhesive swabs or a warm, moist wash cloth may be used to remove adhesive gel from the skin.
15. ECG tracings should be placed in the subject's chart. The investigator or authorized designee should read and determine the urgency of advising the subject and the subject's physician if the he requires urgent care.

A Normal ECG Waveform



Detail of the [QRS complex](#), showing [ventricular activation time](#) (VAT) and amplitude.

Waves and intervals

A typical ECG tracing of the cardiac cycle (heartbeat) consists of a P wave, a QRS complex, a T wave, and a U wave which is normally visible in 50 to 75% of ECGs.^[23] The baseline voltage of the electrocardiogram is known as the *isoelectric line*. Typically the isoelectric line is measured as the portion of the tracing following the T wave and preceding the next P wave.

Feature	Description	Duration
RR interval	The interval between an R wave and the next R wave . Normal resting heart rate is between 60 and 100 bpm	0.6 to 1.2s
P wave	During normal atrial depolarization, the main electrical vector is directed from the SA node towards the AV node, and spreads from the right atrium to the left atrium . This turns into the P wave on the ECG.	80ms
PR	The PR interval is measured from the beginning of the P wave to 120 to 200ms	

interval	the beginning of the QRS complex. The PR interval reflects the time the electrical impulse takes to travel from the sinus node through the AV node and entering the ventricles. The PR interval is therefore a good estimate of AV node function.	
PR segment	The PR segment connects the P wave and the QRS complex. This coincides with the electrical conduction from the AV node to the bundle of His to the bundle branches and then to the Purkinje Fibers. This electrical activity does not produce a contraction directly and is merely traveling down towards the ventricles and this shows up flat on the ECG. The PR interval is more clinically relevant.	50 to 120ms
QRS complex	The QRS complex reflects the rapid depolarization of the right and left ventricles. They have a large muscle mass compared to the atria and so the QRS complex usually has a much larger amplitude than the P-wave.	80 to 120ms
J-point	The point at which the QRS complex finishes and the ST segment begins. Used to measure the degree of ST elevation or depression present.	N/A
ST segment	The ST segment connects the QRS complex and the T wave. The ST segment represents the period when the ventricles are depolarized. It is isoelectric.	80 to 120ms
T wave	The T wave represents the repolarization (or recovery) of the ventricles. The interval from the beginning of the QRS complex to the apex of the T wave is referred to as the <i>absolute refractory period</i> . The last half of the T wave is referred to as the <i>relative refractory period</i> (or vulnerable period).	160ms
ST interval	The ST interval is measured from the J point to the end of the T wave.	320ms
QT interval	The QT interval is measured from the beginning of the QRS complex to the end of the T wave. A prolonged QT interval is a risk factor for ventricular tachyarrhythmias and sudden death. It varies with heart rate and for clinical relevance requires a correction for this, giving the QTc.	300 to 430ms ^[citation needed]
U wave	The U wave is hypothesized to be caused by the repolarization of the interventricular septum. They normally have a low amplitude, and even more often completely absent. They always follow the T wave and also follow the same direction in amplitude. If they are too prominent we suspect hypokalemia, hypercalcemia or hyperthyroidism usually. ^[24]	
J wave	The J wave, elevated J-Point or Osborn Wave appears as a late delta wave following the QRS or as a small secondary R wave . It is considered pathognomonic of hypothermia or hypocalcemia . ^[25]	

References

GE Medical Systems Information Technologies. (2001). *MAC 1200 resting ECG analysis system: Operator's manual*.

Cedar-Sinai Medical Center, Clinical and Translational Research Center. (2002). *12 Lead ECG*. Los Angeles, CA.