CHAPTER 49

Electrocardiography

Learning Objectives

After completing this chapter, you should be able to:

49.1 Define and spell the terms for this chapter.

49.2 Describe polarity as it relates to the cardiac cycle.

49.3 Explain what wave patterns represent on an ECG.

49.4 Compare methods for calculating a heart rate using an ECG.

49.5 List the components of an ECG machine.

49.6 Identify the location for proper lead placement.

49.7 Describe preparations that must be made before ECG testing.

49.8 Explain how to correct various artifacts that occur during ECG testing.

49.9 Describe how a normal ECG would appear.

49.10 List abnormalities commonly revealed through ECG testing.

49.11 Explain the importance of exercise tolerance testing.

49.12 Outline patient education related to wearing a 24-hour Holter monitor.

Case Study

Eliot Masterson, a 41-year-old business owner, was seen by Dr. Salpega for a routine physical. During the office visit, Eliot informed Dr. Salpega that he has had some episodes of chest pain over the past few months that have occurred after exercising. Dr. Salpega decides to have his medical assistant, David Dolan, perform an ECG on Mr. Masterson.

Terms to Learn

artifacts	hyperventilating	perfusion
coronary artery disease (CAD)	inspiration strip	polarity
depolarized	ischemic	repolarized
Einthoven's triangle	leads	rhythm strip
electrocardiogram (ECG)	maximum heart rate	stress test
electrocardiography	maximum target heart rate	telemetry
heart rate	multiple gated acquisition (MUGA) scan	thallium
heart rhythm	pacemakers	wave
Holter monitor		

Heart disease and disorders of the cardiovascular system are extremely prevalent in the United States. **Coronary artery disease (CAD)** is the leading cause of death among both men and women in the United States. Early detection of heart disease can be accomplished with specialized cardiac testing, discussed in this chapter.

Medical assistants play an important role in helping physicians with diagnostic assessments of cardiovascular disorders. Most medical offices require blood pressure readings and pulse rate measurement for adult patients during their office visits. Medical assistants accurately obtain these vital signs and alert the physician of any abnormalities.

When more specific cardiac information is needed, **electrocardiography** is performed. Electrocardiography is a procedure for recording electrical changes in the heart. The record that electrocardiography produces is called an **electrocardiogram (ECG)**. Keep in mind that the ECG represents only the heart's electrical activity, not its mechanical performance. The physician orders this painless, noninvasive test when the heart sounds are unusual, the rhythm is irregular, or the patient has any heart-related complaints or a condition that might affect the heart. An ECG may also be made as a reference that future recordings be compared with to detect changes over time. For that reason, the original recording may be called a baseline ECG. In most medical offices and clinics, ECG tests are performed by medical assistants.

ECG is the abbreviation for electrocardiogram that is most commonly used in the United States, but the abbreviation EKG is also often used. The Dutch doctor Willem Einthoven, who invented the first practical electrocardiogram in 1903, named it the electrokardiogram, or EKG, from *kardia*, the Greek word for heart. The abbreviation ECG derives from the English spelling, electrocardiogram. Both abbreviations, ECG and EKG, are correct and can be used interchangeably.

ELECTRICAL CARDIAC ACTIVITY

The electrical charges created by the heart's cardiac conduction system can be sensed throughout the body. Electrodes placed on specific areas of the skin are electrodes that can detect those cardiac electrical charges and transmit them to a computer for amplification of the signal and recording on paper (the ECG) for assessment by the physician.

When the ECG equipment senses an electrical charge, it is recorded on the readout as either an upward or a downward deflection from the horizontal baseline. Movement away from the baseline is called a deflection or **wave**. The waves or deflections that go up (positive) or down (negative) from the baseline represent amplitude or voltage. The strength or voltage of the electrical impulse determines the size of the deflection. Large voltages cause larger deflections; small voltages create smaller deflections. If no energy is sensed, the ECG equipment records a flat line, which is also called an isoelectric line.

Polarity and the Cardiac Cycle

The cells of the myocardium (heart muscle) produce electrical charges as a result of **polarity**. Defined simply, polarity means having two separate poles, one positive and one negative. When a myocardial cell is in a resting phase, it is termed *polarized* because it has a negative internal charge and a positive external charge.

The sinoatrial (SA) node, a small area of tissue at the top of the right atrium, is known as the heart's pacemaker because it controls myocardial polarity. When the SA node initiates electrical activity, the atrial cells become **depolarized** (the internal negative charge is reduced and the difference in charge inside and outside the cell is lost). As the electrical impulse travels from the atria and into the ventricles, cells in the ventricles also depolarize. As the cells depolarize, the atria and ventricles contract, and blood is pushed out of the heart and into the circulatory system. At the end of the contraction, the myocardium relaxes and rests. During this stage of relaxation, the cells become **repolarized**.

This cycle of electrical impulses—depolarization and repolarization, contraction and relaxation—represents one heartbeat.

PQRST Waves

A normal electrical cardiac cycle (one heartbeat) is traced on an electrocardiogram as one set of PQRST waves. The P represents atrial depolarization, the QRS complex represents ventricular depolarization, and the T is repolarization (a return to the resting electrical state). Figure 49-1 illustrates what is occurring in the heart and how it is represented on ECG tracing. The time that it takes for each component of the PQRST sequence to take place is discussed in the next section.

On an ECG, the horizontal axis (line) represents time; a slower heart rate will have more space between the PQRST complexes. For a patient with a faster heart rate, the cardiac cycles will be closer together. When the heart skips a beat, there is a long flat line between PQRSTs. The amount of space between the P wave and the QRS complex indicates the time required for the conduction system to carry the impulse from the SA node at the top of the atria to the Purkinje fibers that carry the impulse to the ventricles.

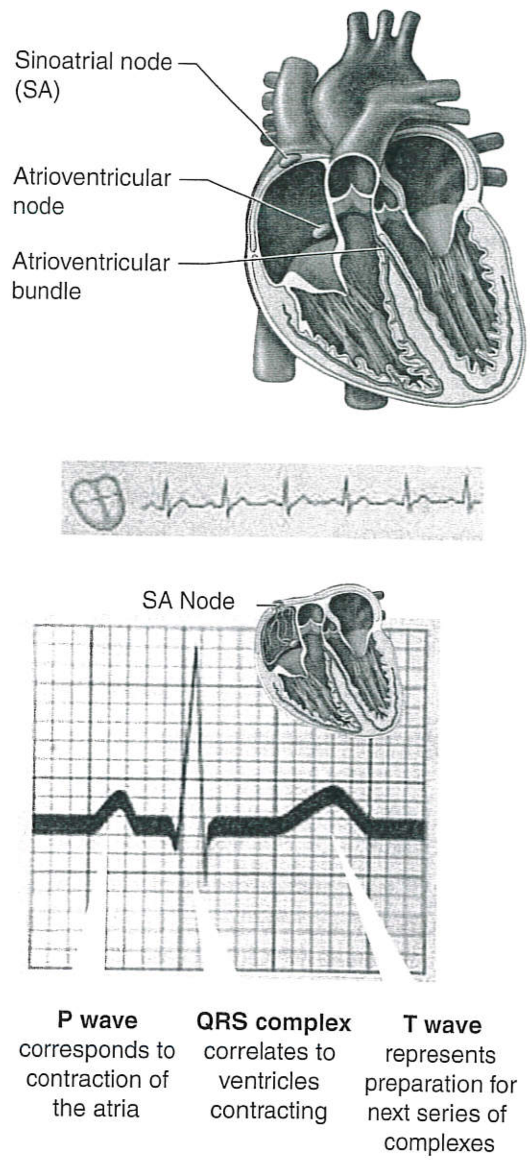


FIGURE 49-1 The cardiac cycle and an ECG tracing.

Recordings are made from a variety of perspectives or angles known as **leads**. Each lead will record from a specific combination of electrodes. When completed, the 12-lead ECG produces a three-dimensional record of cardiac impulses. The pattern of deflections will appear quite different on each lead. The pattern of deflections recorded, voltage or amplitude and time, assist the physician in evaluating the status of the patient's heart.

Time and the Cardiac Cycle

A P wave that is present in normal size and shape indicates the electrical stimulus causing the heart to beat that originated in the SA node (Figure 49-2). Normally, the P-R interval (time from the beginning of P to the middle of QRS) is between 0.12 and 0.20 seconds (three to five small boxes on the ECG graph paper). This interval represents the time it takes for the impulse to cross the atria and atrioventricular (AV) node and reach the ventricles.

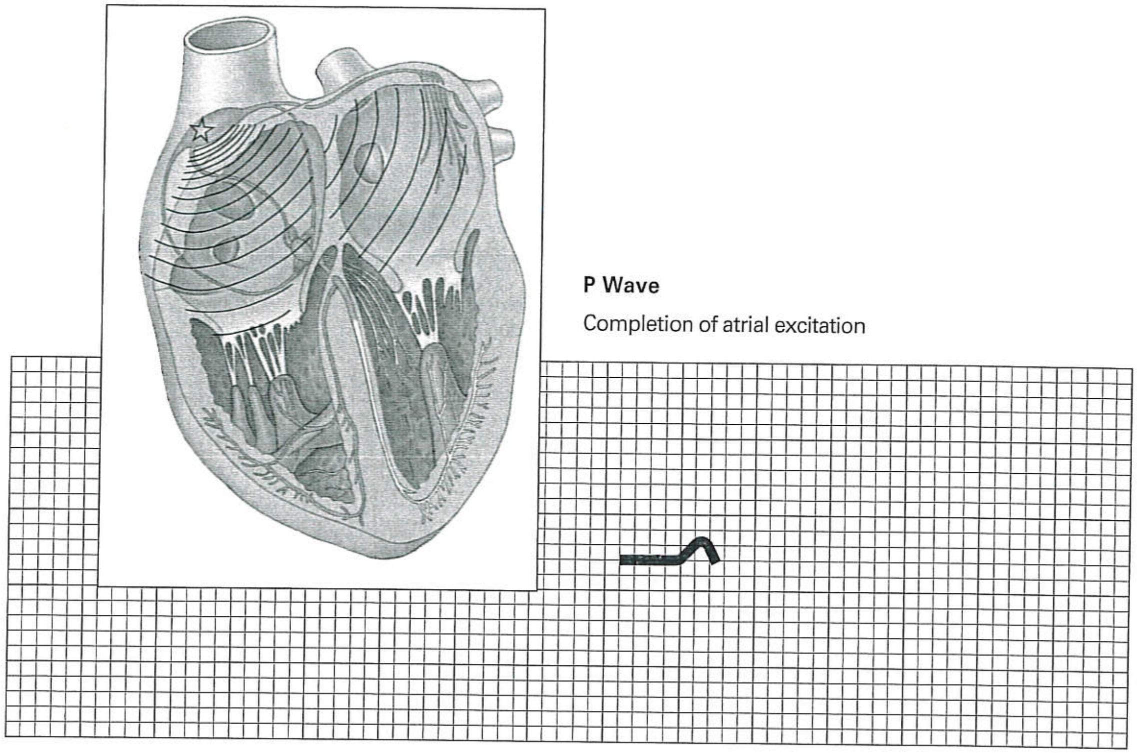


FIGURE 49-2 P wave (SA node initiates atrial depolarization).

A deviation from these times could represent an abnormality in either the electrical system of the heart or in a structure of the heart that impacts the electrical system. A P-R interval that is too short means the impulse has reached the ventricles through a shorter-than-normal pathway. If the interval is too long, a conduction delay in the AV node might be assumed.

The QRS complex represents the time necessary for the impulse to travel through the bundle of His, the bundle branches, and the Purkinje fibers (the structures that carry the electrical impulse to the ventricles) to complete ventricular contraction. This usually takes less than 0.06 to 0.12 second (three small ECG boxes). (See Figure 49-3.)

The ST segment and the T wave represent repolarization of the ventricles. (Repolarization of the atria is "hidden behind"—takes place at the same time as—the QRS complex so is not seen on the ECG.) The ST segment is normally flat (on the isoelectric line or baseline) or is only slightly elevated. The T wave represents a part of the recovery of the ventricles after contraction (Figure 49-4).

The QRS complex and the T wave typically point in the same direction, and T waves that are opposite in direction from the QRS may indicate a problem in the heart or its electrical system. Although the medical assistant should not try to interpret the ECG, understanding what is normal in the cardiac cycle is helpful. Table 49-1 provides a summary of ECG wave patterns.

TABLE 49-1 | **ECG Wave Patterns**

Wave Pattern	Corresponding Heart Activity	Electrical Activity
P Wave	Atrial contraction that is initiated by an electrical impulse from the SA node.	Atrial depolarization
QRS Complex	Ventricular contraction of the heart.	Ventricular depolarization
T Wave	Completion of ventricular contraction; here, the cells begin their resting phase before the process restarts.	Ventricular repolarization
U Wave	Sometimes present and represents further relaxation of the ventricles.	A continuation of ventricular repolarization

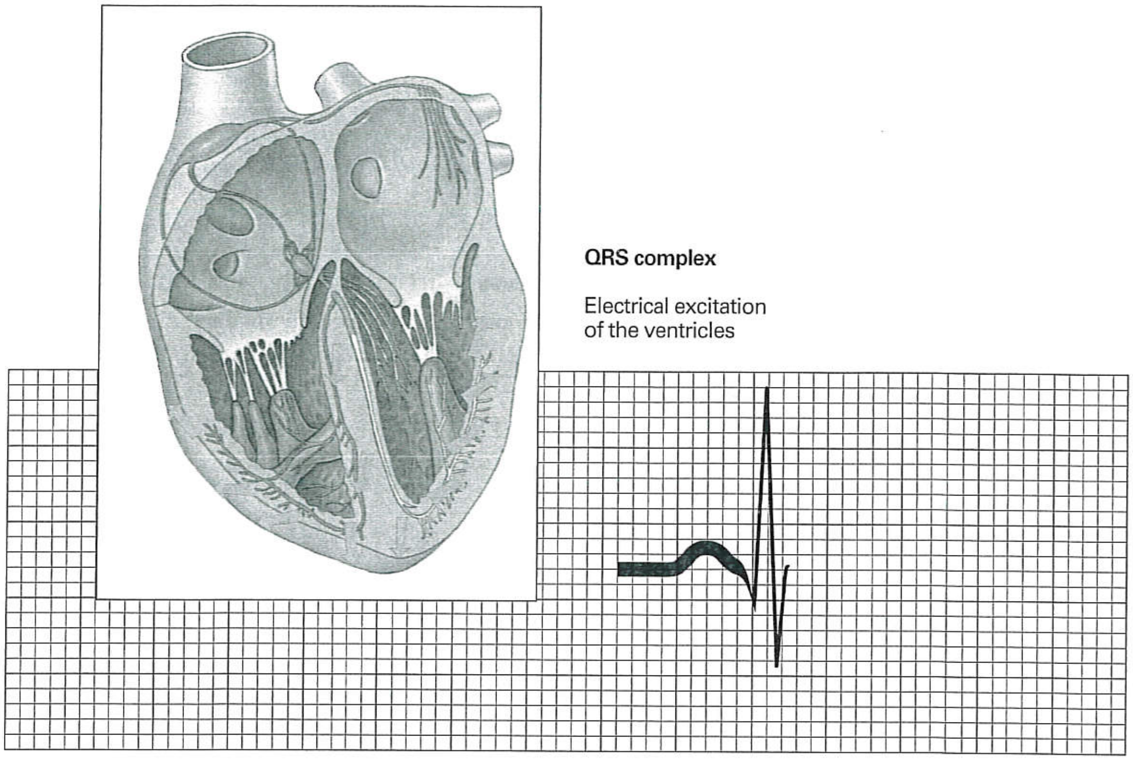


FIGURE 49-3 QRS complex (ventricular depolarization).

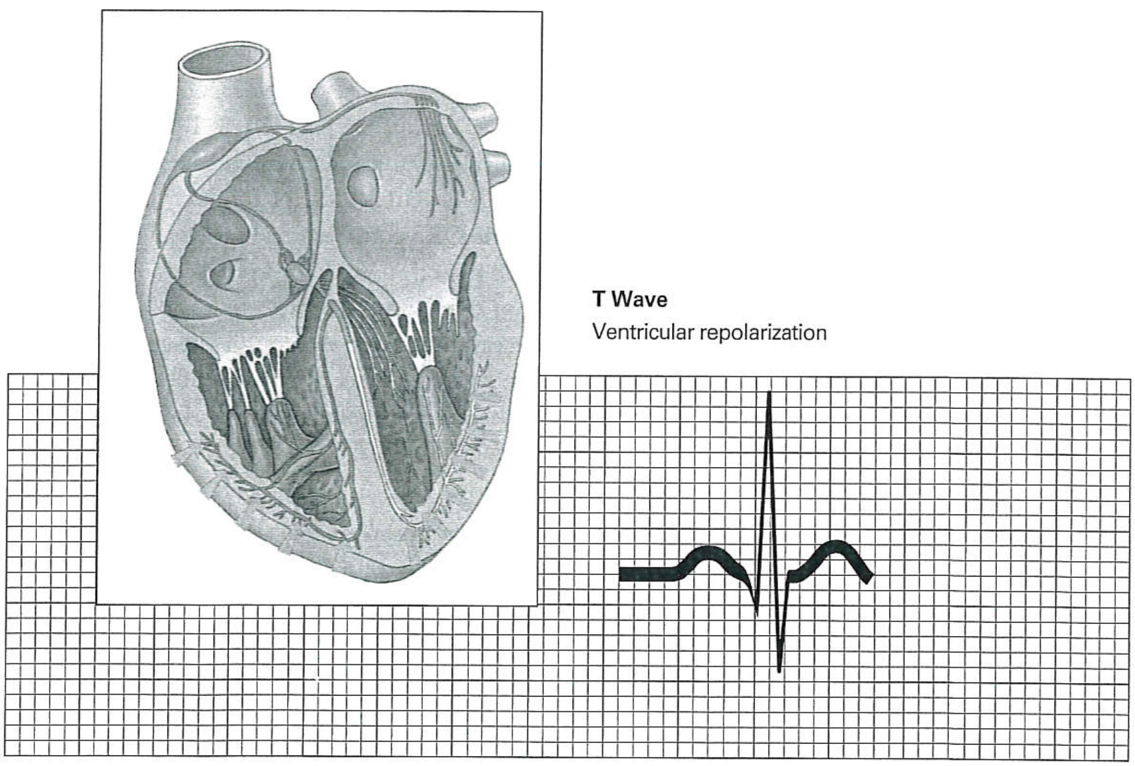


FIGURE 49-4 T wave (ventricular repolarization).

Calculating Heart Rate

Heart rate is expressed as beats per minute. It is possible to estimate the heart rate from an ECG. Some offices have a protocol that states you should record additional cycles if the heart rate is above or below certain numbers. Many cardiologists also expect you to perform an exact calculation of the heart rate before you place the recording in the patient record or on the doctor's desk for review. Two methods for heart rate estimation and one for exact calculation are discussed next.

Abnormal heart rates are identified as either bradycardia (a heart rate less than 60 beats per minute) or tachycardia (a heart rate greater than 100 beats per minute).

Estimation of Heart Rate. To obtain an estimated heart rate of either the ventricular or the atrial contractions, use the six-second method. Count the number of P waves across 30 large, darker squares (30 squares = 6 seconds). Once you have the correct number, multiply by 10 (or simply add a 0 to the end of the counted number). Counting P waves will give you the estimated atrial contraction rate. To estimate heart rate based on ventricular contractions, simply measure the number of complete QRS complexes across a span of 30 large squares and multiply by 10.

Exact Calculation of Heart Rate. To obtain an exact calculation of the heart rate, recall that the paper moves at a standard speed of 25 mm/second, so it will move at 1,500 mm/minute (25 mm/second × 60 seconds = 1,500 mm/ minute). An exact calculation of ventricular heart rate is achieved by counting the millimeter boxes (the smaller, lighter squares) between two QRS complexes and dividing that number into 1,500. For instance, if there is 20 mm between two QRS complexes, 1,500 divided by 20 equals 75 beats per minute. An exact calculation of atrial heart rate is achieved by counting the millimeter boxes between two P waves and by dividing that number into 1,500. These calculations are accurate only for the complexes that were examined.

Assessing Heart Rhythm

Heart rhythm is the regularity or irregularity of the occurrence of heartbeats. Ventricular rhythm is determined by measuring the distance between QRS complexes. There should be a fairly consistent space between complexes to qualify as a regular rhythm. Atrial rhythm is determined by measuring the distance between P waves. Again, for a regular rhythm, there should be a fairly consistent space between waves.

Train yourself to look at the rhythm while you are record- . Some offices have protocols about what extra tracings to record in the event the rhythm appears to you to be irregular.

THE ELECTROCARDIOGRAM MACHINE

Many types of ECG machines are in use, but all should be calibrated to align with the international standard. This means that the paper in all machines moves at the same speed of 25 mm/second and, given the same amount of electrical energy, the recording stylus will move the same distance (1 mV of electricity input will cause the stylus to deflect 10 mm), thus giving uniform recordings worldwide. Standardization is a means of verifying that each machine deflects 10 mm in response to 1 mV (millivolt) of electricity in sensitivity.

The majority of ECG machines used in the medical office are computerized. Computerized models have automatic features, so you may only need to push a button. All 10 electrodes are placed on the patient at the beginning of the procedure, and the computer switches from lead to lead in rapid succession. Before operating the machine, you will enter data directly into the ECG machine. Data usually includes the patient's name, date of birth, diagnoses, height, weight, age, blood pressure, medications taken, and information pertinent to the ECG. You may ask the patient these questions while entering the data in the computer, which helps the patient to relax a bit before beginning the procedure.

Two main types of ECG machines are used in the medical office: single channel and multichannel (Figure 49-5). When all leads have been recorded, the long strip must be cut apart at the specific leads and mounted onto an ECG mounting card. Mounting cards have adhesive areas to help in mounting

Professionalism The Life Span

The Child

ECGs are rarely performed on children except in cardiac offices, in cases of emergencies, or before some sports physicals. Lead placement is exactly the same as in an adult, but sometimes placing the leads can be a challenge because of the smaller available space for them. Because it is critically important to have cooperation for the ECG, parents may need to help persuade the child to cooperate. If the child is frightened, the test may not be accurate.

The Older Adult

The positioning of ECG leads on the older adult is the same as that for other adults. However, sometimes making the leads truly accurate can be a challenge because of a loss of elasticity in the skin. Older adults also have fragile skin. Be very careful not to rip the electrodes from the skin but, instead, hold traction on the skin and work the electrode off carefully. It may take a few minutes of being careful, but the patient will be grateful for the consideration.

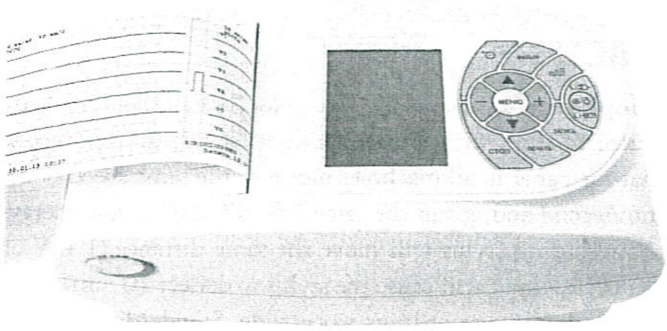


FIGURE 49-5 A multichannel ECG.

the strip sections. Figure 49-6 shows a properly mounted 12-lead, single channel ECG. A multichannel ECG records all 12 leads simultaneously. These ECGs have printouts on a much wider strip of paper, which is needed to show the multiple recordings. Multichannel ECGs are more commonly found in medical offices and require less time, because cutting and mounting aren't necessary.

It is possible to override automated machines if there is a need for manual controls. For example, the physician may have ordered just one rhythm strip of lead II, rather than a complete 12-lead ECG.

Many computerized models can record from more than one lead at once, which saves time and effort. Each is recorded in a separate channel or pathway for the signal and, typically, these machines record three channels at once. Other machines have a built-in interpretive feature and will print out a statement of the status of the heart. Some models can connect directly via fax with a regional office that will carry out the interpretation function and fax results to your office. As electronic health records (EHRs) become prevalent in medical offices, new ECG models will allow test results to be electronically transferred directly into the patient's medical

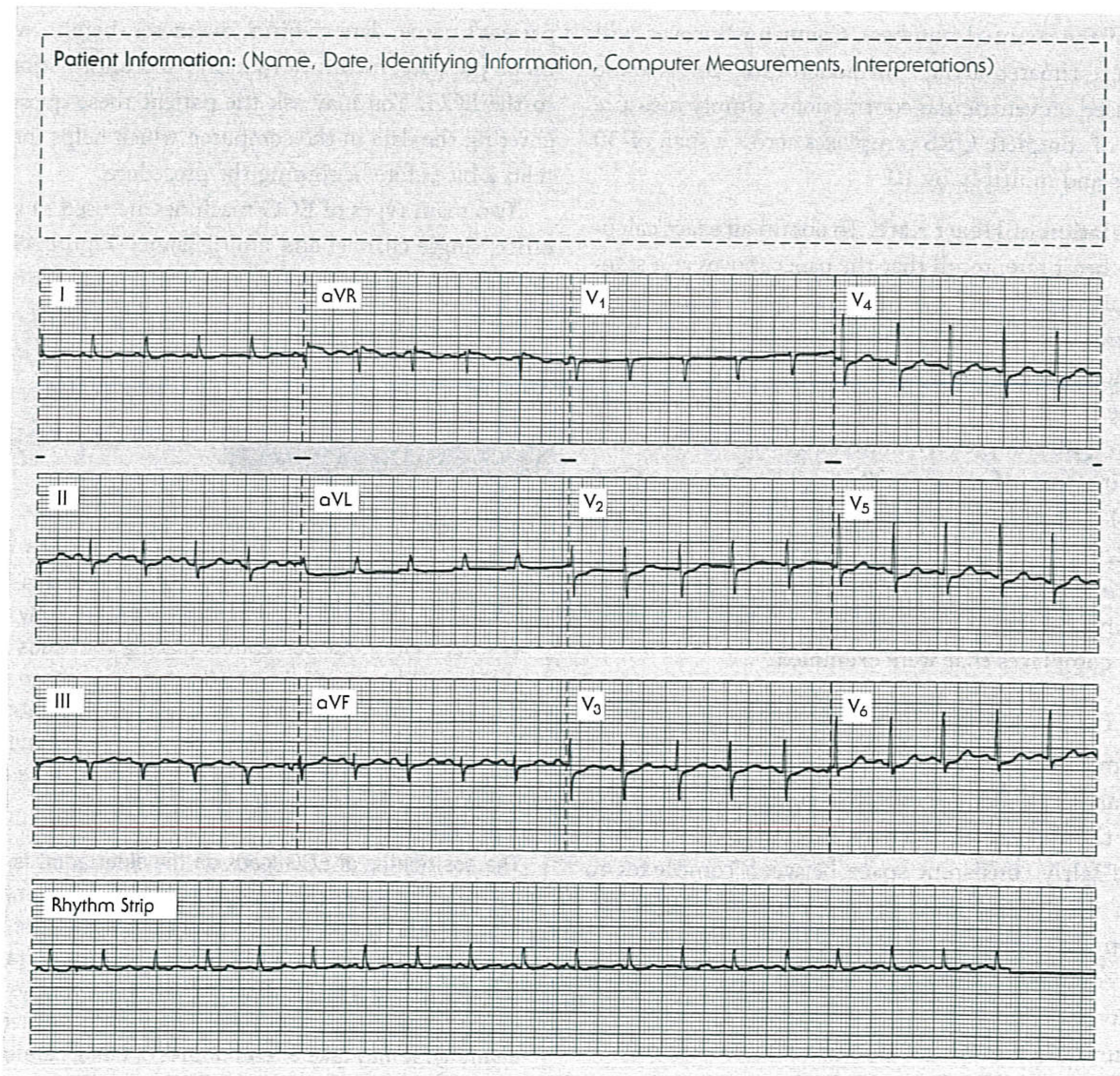


FIGURE 49-6 A properly mounted 12-lead, single channel ECG.

record. These models can also be configured to send the test electronically to a specialist for interpretation.

Although computerized electrocardiographs save considerable time in mounting ECGs, care should still be taken to ensure that a clear ECG is made before disconnecting the electrodes. Computerized electrocardiographs should also still be monitored for **artifacts** (errors). Common artifacts are discussed later in this chapter.

It is the medical assistant's responsibility to produce a clear and accurate tracing for each patient. Read the manufacturer's instructions for the machine in your office before using it. Knowledge of the control panel will help produce a tracing that is clear, accurate, and easy to read. A control panel usually includes the following features:

- Main power switch (off/on)—Allow for a warm-up time (as specified by the manufacturer) before using.
- Record switch—This switch moves the paper at the international standard "run 25" speed (25 mm/sec). Another option is "run 50" (50 mm/sec, or twice as fast). This is used when the heart rate is so rapid that interpretation requires that it be stretched out. This is used only for detailed interpretations because it tends to waste paper and can be more difficult to read.
- Lead selector—This determines from which electrodes the machine will record:
  - Standard (limb) leads: Record from two electrodes placed on all extremities.
  - Augmented leads: Record from the midpoint between two limb electrodes to a third limb electrode.
  - Chest leads (also called precordial leads): Record from various positions on the thorax.
- Sensitivity control—Allows the operator to increase or decrease the recording size to enlarge or shrink the deflections to fit on the paper. When changing from the international standard of sensitivity 1 to sensitivity ½ or sensitivity 2, the operator must include a standard for the interpreter information.
- Standard button—Allows verification of calibration to the international standard.
- Stylus control—Centers the recording in the middle of the page or the center of each channel by moving the stylus.
- Stylus heat control—Increases or decreases heat and adjusts for the sharpest tracing by the stylus. This control is seen on older models, but newer machines use an ink cartridge instead of a heat stylus.
- Marker—Indicates, by a code, which lead is being recorded.

Professionalism | The Workplace

Be aware that many patients have elevated blood pressure readings just from being in a medical environment. This phenomenon is referred to as "white coat" syndrome. When performing an ECG or monitoring a patient's cardiac rhythms, be alert for signs of instability or life-threatening emergencies such as shortness of breath, chest pain, rapid heart rate, dropping blood pressure, profuse sweating, or changes in mental alertness.

Electrocardiogram Paper

Electrocardiogram paper is pressure- and photo-sensitive and must be handled carefully. If this paper is exposed to light for long periods, the markings will fade. Many newer machines use an ink cartridge to supply the stylus and provide a longer-lasting printout. Be sure to read the manufacturer's instructions carefully when changing the ink cartridges.

"Time" markers, referred to as three-second markers, are printed on all ECG paper. Look for them at the top of single-channel paper and between channels in multichannel paper. The time markers are small squares with a light line and larger squares with a darker line. The small squares are 1 mm by 1 mm square and represent 0.1 mV of voltage in the height and 0.04 second time in the width. The larger squares are 5 mm by 5 mm square and represent 0.5 mV of voltage in the height and 0.20 second time in the width. Thus, the paper records both time (horizontally) and voltage (vertically). See Figure 49-7 for ECG paper and markings.

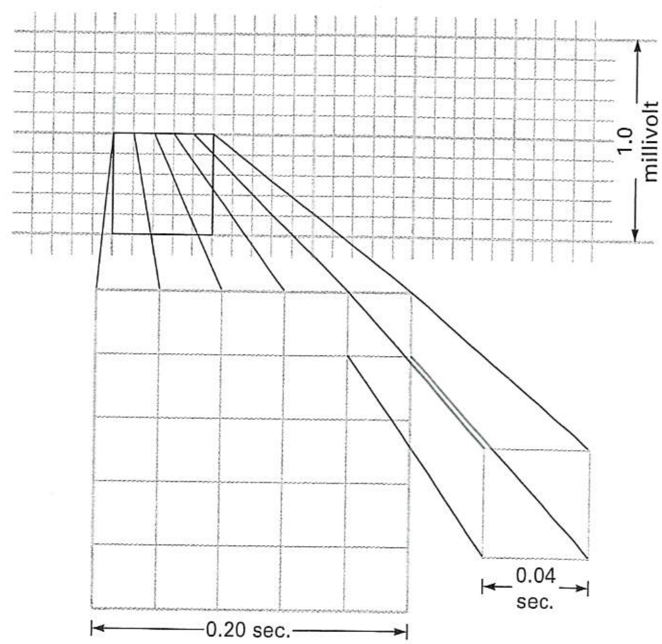


FIGURE 49-7 ECG paper and markings.

PERFORMING ELECTROCARDIOGRAPHY

The medical assistant may be asked to perform the procedure that records the electrical activity of the heart. As noted at the beginning of the chapter, the procedure is known as electrocardiography; the record produced is the electrocardiogram.

Electrocardiography does not introduce electricity into the heart; instead, it merely records the heart's own electrical activity. Whether the electrocardiogram is produced as a paper strip or a computerized record, that record is important to diagnosing the patient.

Electrode Placement

The ECG machine records the cardiac cycle through 10 electrodes (sensors) placed on the bare skin of the limbs (extremities) and the chest. After placement, long wires called leads will be attached to the electrodes. The term "lead" often refers to both electrode and wire.

Limb leads are placed over the fleshy part of the inner aspect of both lower legs and either both upper arms or both forearms, avoiding the bony prominences. These limb lead locations are abbreviated LA for left arm, RA for right arm, LL for left leg, and RL for right leg. The RL electrode serves as an electrical reference point and is not actually used in the recording. If you have a patient on whom you cannot place one of the limb leads as planned, you must place the electrodes on both extremities symmetrically. For example, a patient in a cast up to the knee requires that both electrodes be placed above the knee. If a hand and forearm are amputated, both arm electrodes must be placed on the upper arm.

Precordial leads are placed on the chest. The precordial leads, designated V, are placed on six locations on the chest and numbered V1, V2, V3, V4, V5, and V6. Placement of the precordial leads must be anatomically correct to ensure an accurate ECG. The precordial leads are placed in the following anatomical locations (Figure 49-8):

- V1—Fourth intercostal space, right sternal border
- V2—Fourth intercostal space, left sternal border
- V3—Midway between V2 and V4
- V4—Fifth intercostal space, left of the midclavicular line

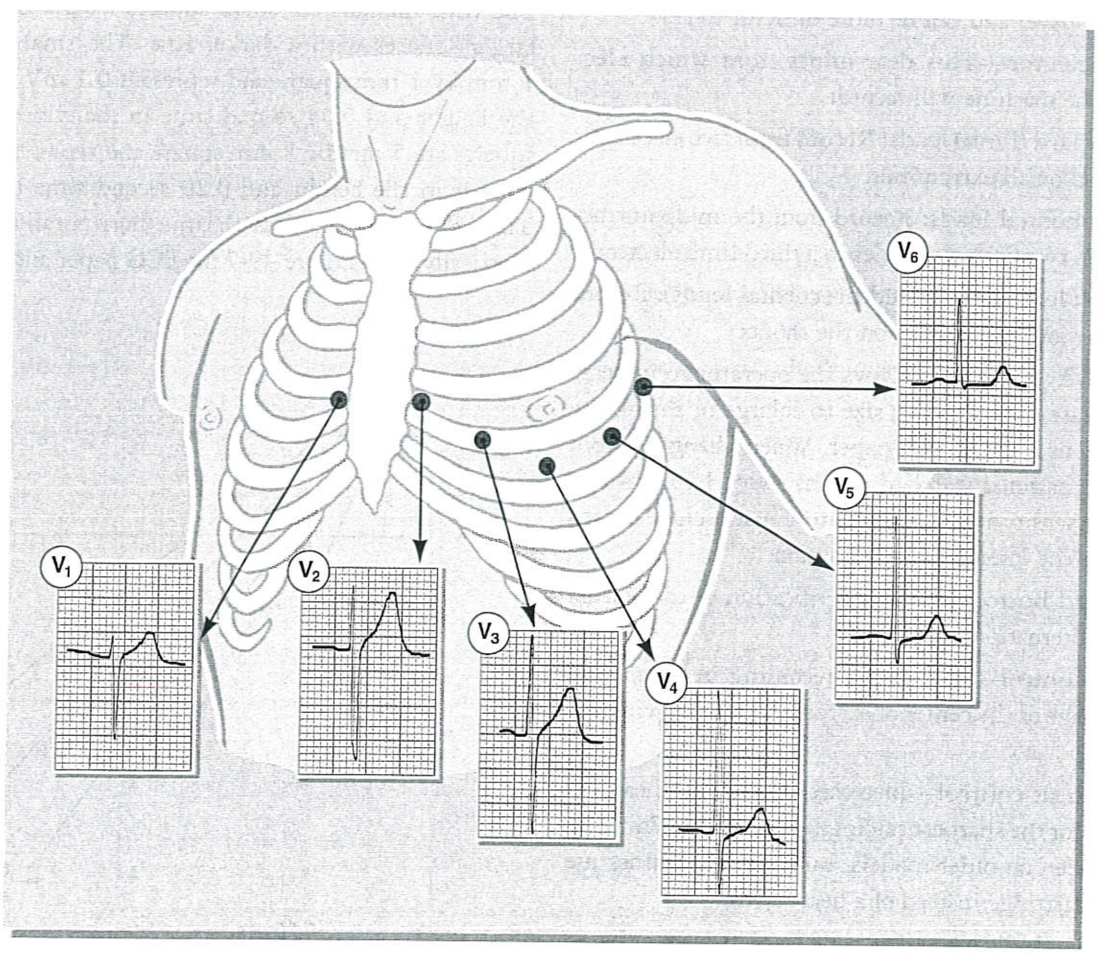


FIGURE 49-8 Electrode placement for chest leads V1–V6.

- V5—Left of the anterior axillary fold, in line with V4
- V6—Left of the midaxillary, in line with V4 and V5

An intercostal space is a space between ribs. The sternal border is the border of the sternum, or breastbone. The midclavicular line is an imaginary vertical line that runs through the middle of the clavicle, or collarbone. The anterior axillary fold is the fold at the front of the armpit. The midaxillary line is an imaginary vertical line that runs from the center of the armpit.

After the electrodes have been applied to the correct anatomical locations, the leads are attached. Leads are long wires that connect and transmit the electrical activity from the patient to the ECG machine. Each lead has a clip that attaches to the electrode. Leads are marked to correspond with the limb and chest electrode placements. The style of electrodes and clips varies with the manufacturer of the ECG machine. One single lead will record the electrical cardiac activity between where two electrodes are placed.

By recording from different combinations of directionality of electrodes, the electrical activity of the heart is seen from different angles. It is a bit like viewing a statue in a museum from multiple angles. Each view has different richness of information. A lead selector switch or lead indicator selects the combination of electrodes for that lead. One electrode is used for chest (unipolar) leads. A combination may two electrodes, as with standard limb (bipolar) leads, or three electrodes, as with augmented limb leads.

With many leads and many views possible, when you are performing manual tracing, you must indicate on the tracing from which lead you are recording. An international marking system has been devised using dashes and dots. Most machines automatically mark the code just above the cardiac tracing. Others require manual marking of the locations, to which the leads are attached using the international code. Table 49-2 lists limb, augmented, and chest leads and proper placement and marking codes.

It is helpful to memorize the positions of electrodes used in the limb and augmented leads. Then, if you have difficulty getting a clear recording from one lead, you do not have to look at all the electrodes, only those involved. Some find it easier to remember all the leads and the electrodes being recorded (see Table 49-2) or by picturing **Einthoven's triangle**, which is a pictorial guide to the leads (Figure 49-9).

Patient Preparation

Patient preparation begins with providing the patient information about the test. A well-informed patient is more cooperative and less anxious. Explain the equipment, the procedure, and what the patient will be expected to do. The ECG is often performed in an exam room with the patient supine (lying on the back) on the exam table.

The surroundings should be pleasant and clean. The exam table should be wide enough for comfort and adequate support. Patients must be bare to the waist, so privacy must be provided for disrobing. Offer female patients a gown to be worn with the opening at the front. In addition, you will need access to bare skin on the lower legs. Instruct patients to remove socks or stockings and roll long pants legs out of the way. Position the patient comfortably supine with a pillow under the head and another under the knees if needed to

TABLE 49-2 | **Electrode and Lead Placement and Marking Codes**

Leads	Placement	Abbreviation	Marking Code
Limb Leads Lead I	Right arm to left arm	RA-LA	•
Lead II	Right arm to left leg	RA-LL	••
Lead III	Left arm to left leg	LA-LL	•••
Augmented Leads AVR	RA-midpoint (LA-LL)	(LA-LL) RA	-
AVL	LA-midpoint (RA-LL)	(RA-LL) LA	--
AVF	LL-midpoint (RA-LA)	(RA-LA) LL	---
Chest Leads V1	Fourth intercostal space, right sternal border		—•
V2	Fourth intercostal space, left sternal border		—••
V3	Midway between V2 and V4		—•••
V4	Fifth intercostal space, midclavicular left		—••••
V5	Left anterior axillary fold, horizontal to V4		—•••••
6	Left midaxillary, horizontal to V4 and V5		—••••••

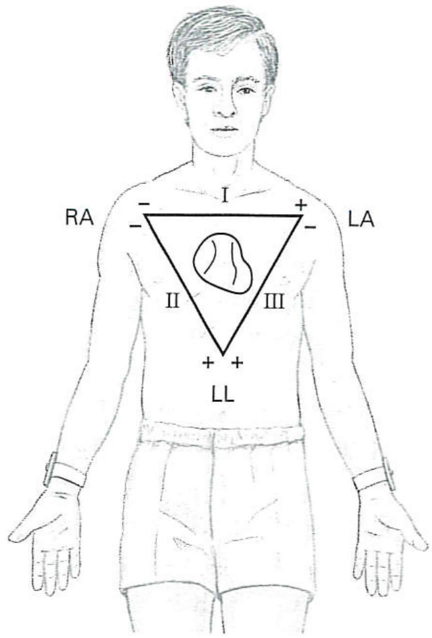


FIGURE 49-9 Einthoven's triangle.

eliminate back strain. If the patient cannot tolerate lying down, instead use the semi-Fowler's position (raising the back of the exam table so the patient is in a sitting position at about a 45-degree angle) and make a notation of the positional change in the patient's medical record.

Jewelry, particularly metal jewelry, must be removed so it does not interfere with the electrical current of the ECG. Prepare the skin where the electrodes will be applied. It is common for patients to use talcum powder, skin lotion, or shower gels that moisturize the skin. All of these products can leave residue on the skin that interferes with electrode contact. Such residue must be removed with alcohol before the electrolyte electrodes are applied. Additionally, some men have large amounts of chest hair, which can also interfere with electrode and skin contact. If so, you will need to shave small areas of the chest where electrodes will be placed.

Special Considerations

Sometimes special considerations are necessary for special patient issues. For example, if a patient has an amputated leg, then the electrode will be placed on the upper leg stump rather than the lower leg and the other electrode is placed directly across from the electrode on the stump. If the patient has a pacemaker or a dialysis catheter, notify the physician that leads were not in the usual position, because the pacemaker will probably be close to usual lead positioning. Patients with cognitive disabilities or small children may be unusually frightened of the procedure and may need to be reassured that no electricity is going into the body, but the machine is simply recording "sounds" inside the body. Body piercings near leads may need to be removed or documented if they force the medical assistant to adjust the usual positioning of the lead. Avoid placing leads on scars or tattoos if at all possible, and document if you must put an electrode on one.

If a patient complains of any dyspnea, pain, or syncope during the ECG, the test should be discontinued and the physician notified immediately.

Technical Preparation

Technical preparation begins with ensuring that you have adequate supplies and that the ECG machine is correctly calibrated and in working order. When checking the ECG machine, plug the machine into a properly grounded outlet on an interior exam room wall. Allow it to warm up while you make other preparations. Verify that the machine is operational and in compliance with the international standard. The manufacturer of the ECG machine may suggest a series of quality control measures. It is important to keep instructional manuals in preapproved locations so that they can be easily located if necessary. When storing equipment after use, make sure it is cleaned and stored according to manufacturer's recommendations. It is prudent to have extra batteries, electrodes, and papers in stock for future use.

Procedure 49-1 details the steps for recording a 12-lead electrocardiograph. It is important to note that proper placement of the electrodes is imperative for accuracy. Therefore, extra review of the anatomical landmarks for the precordial electrodes (those on the chest) is recommended.

Mounting and Uploading

If the electrocardiograph produces paper strips, you will need to mount them correctly into the patient chart, usually by scanning or cutting and pasting. If you are cutting and pasting into the chart, cut part of the rhythm strip that includes the indicated number of cycles desired; paste them into the chart making sure you align the correct strip with its correct section. If the equipment produces digital results, these can be scanned or electronically uploaded into the EHR. Notify the physician and document the procedure after the results are mounted, scanned, or uploaded.

ADJUSTMENTS AND TROUBLESHOOTING

Sometimes the procedure does not go according to plan, so you need to be able to make appropriate adjustments depending on patient needs and troubleshoot problems. Care should be taken to avoid artifacts that can affect results.

PROCEDURE 49-1

Performing a 12-Lead Electrocardiogram

Objective ◈ *Perform an ECG without assistance.*

EQUIPMENT AND SUPPLIES

ECG machine lead wires and patient cables, and power cord; ECG paper; electrodes; alcohol wipes; screwdriver, for adjustments, if needed; patient gown, if needed; razor, if needed.

METHOD

1. Assemble the necessary supplies and perform hand hygiene.
2. Greet and identify the patient; have the patient verify his full name and date of birth.
3. Introduce yourself and explain the procedure to the patient.
4. Begin technical preparation of the ECG machine by attaching the power cord and plugging in the machine to a grounded outlet.
5. Turn on the machine, allowing it time to warm up. Following office policy and manufacturer instructions, ensure that the machine is properly calibrated.
   a. Enter necessary patient data into the ECG machine.
6. Prepare the patient for the procedure.
   a. Offer female patients gowns to be worn with the opening down the front. Instruct female patients to remove the bra.
   b. Instruct male patients to remove the shirt so that the chest can be exposed.
   c. Both male and female patients should be instructed to remove shoes and socks or stockings.
   d. Instruct patients to roll up their pant legs to expose their lower legs.
   e. Instruct patients to remove any metal jewelry, because it can interfere with the electrical current of the ECG.
7. Position the patient in a supine position, flat on the examination table. Provide pillows for comfort, if necessary.
8. Prepare the patient's skin for electrodes by wiping the areas with alcohol wipes. Shave excessively hairy areas using a razor, if necessary.
9. Attach the electrodes to the appropriate anatomical landmarks (Figure A). Refer to Figure 49-8 on p. 1212 for additional placement guidance.
10. Connect all lead wires to the electrodes, making sure the wires remain untangled.

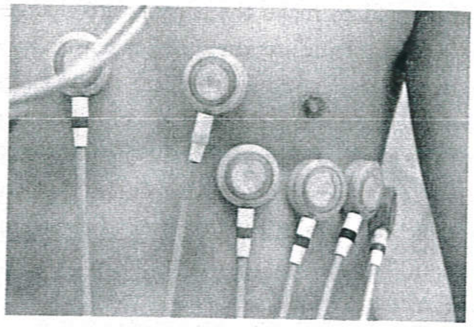


FIGURE A Chest or precordial leads in place.

11. Instruct the patient to relax, breathe normally, and refrain from speaking during the procedure.
12. For automatic machines, depress AUTO-RUN; for manual machines, select the leads in sequence and depress the correct button to run each individual lead. Use problem-solving skills if you encounter artifacts and repeat the recording if necessary so that the final tracing is clean and clear of artifacts.
13. Remove the lead wires from the electrodes and carefully put away the patient cable box with attached lead wires.
14. Carefully remove the electrodes from the patient's skin and wipe away any excess adhesive residue.
15. Perform hand hygiene.
16. Inform the patient that he may get dressed. Leave the room for privacy, taking the ECG machine and test with you.
17. In a quiet area, mount the ECG, if necessary, and transfer necessary patient information.
18. Chart the procedure in the patient's medical record.
19. Give the ECG to the physician for interpretation.
20. Clean the machine and accessories according to the manufacturer's instructions.

CHARTING EXAMPLE

3/11/YY 2:10 P.M. 12-lead ECG performed and given to Dr. Salpega to read. Patient appeared to tolerate procedure well and denies any discomfort.....................W. Short, CMA (AAMA)

Making Adjustments

A satisfactory tracing is one that is accurate, readable, and clear; travels across the center of the page; and has a baseline that is consistently horizontal. Deviations require adjustment of the machine and a new recording taken. If the baseline begins to drift upward or downward, use the position control knob to return it to the center of the page. Observe whether the tracing remains within the graph portion of the paper. If significant wave deflections occur, refer to the manufacturer's instruction manual to make the appropriate changes. Sometimes it is necessary to adjust the speed or sensitivity controls.

Normally the paper moves through the machine at the rate of 25 mm/second, but an option available in recording is to move the paper twice as fast, at 50 mm/second. This would only be necessary if the cardiac cycles were compacted by a very rapid heart rate. In this case, a better-quality cardiogram would be produced if the cycles were stretched out. If you have to change the speed or sensitivity, mark the tracing to indicate that you did so. In machines that mark the lead with an international code, the code marks are stretched out; the dots appear as dashes, and the dashes are long ones.

Multichannel machines produce an ECG very quickly on a single sheet of paper about 8 × 11 inches. You will have to center three baselines. A sensitivity or speed change affects all three channels.

Knowledge of the leads and their electrode locations will help you trace any irregular or erratic markings (artifacts) back to the source. You can also perform other troubleshooting techniques during the recording process. Failure to make the necessary corrections will result in an unsatisfactory tracing. The physician will not be able to read and interpret such a recording.

Artifacts

Occasionally, the electrodes will either not work properly, or they will detect electrical activity from a source other than the heart. These deflections, or artifacts, impair accurate interpretation of the tracing. You must find the cause of the artifact and correct it. Causes of artifacts and how to correct them include the following:

- Somatic tremor—This artifact is caused by a tense muscle or a muscle contraction, even one that you cannot see. This muscular activity causes unwanted stylus movement while the ECG is recording. It may result from patient discomfort, tension, chills, talking, or moving. Calm and reassure the patient. Suggest that the patient relax, breathe normally, and not talk. If necessary, place the patient's hands, palm side down, under the hips. This is especially helpful if the patient is not relaxed on the narrow table. This position is also best for patients with a tremor disorder. They will display the smallest number of artifacts in this position. Figure 49-10 illustrates somatic tremor artifacts.
- **Wandering baseline**—Baseline sway and baseline shift (Figure 49-11) are caused by poor electrode contact with the skin, such as when electrodes are dirty or applied too tightly or too loosely, when lotion or talcum prevents good contact with the skin, or when the patient cable slips toward the floor and pulls on the lead wires. You must readjust, reapply, or clean the electrodes and place the patient cable securely on the table. You may need to clean the skin with alcohol or shave chest hair to allow proper electrode skin contact.
- **60-cycle or AC (alternating current) interference**—Electrical current in wires and equipment may be picked up by the patient's body and the recording machine. This appears in the recording as small

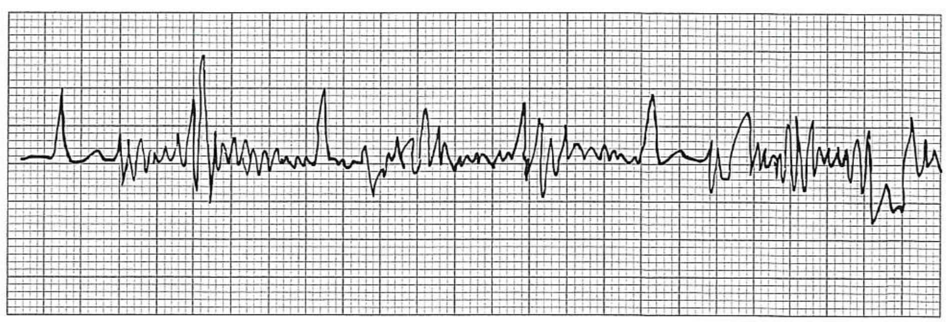


FIGURE 49-10 Somatic tremors artifact.

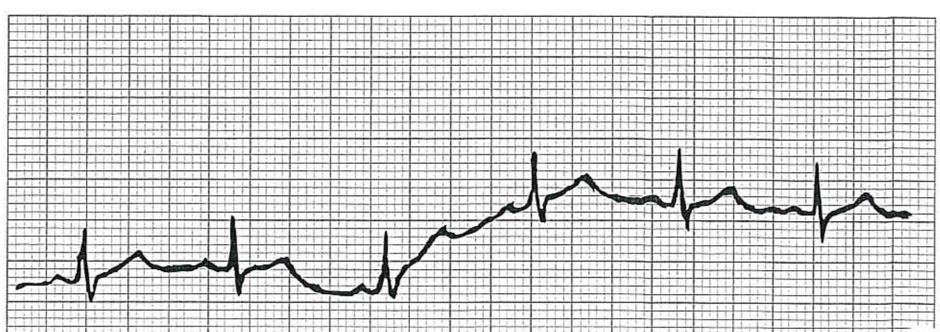


FIGURE 49-11 Wandering baseline.

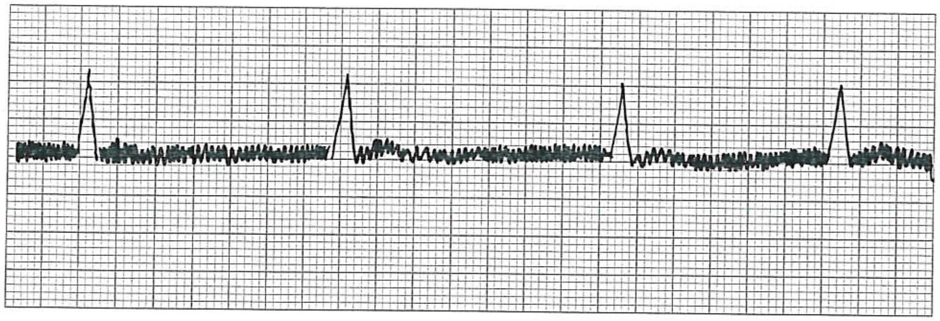


FIGURE 49-12 60-cycle interference.

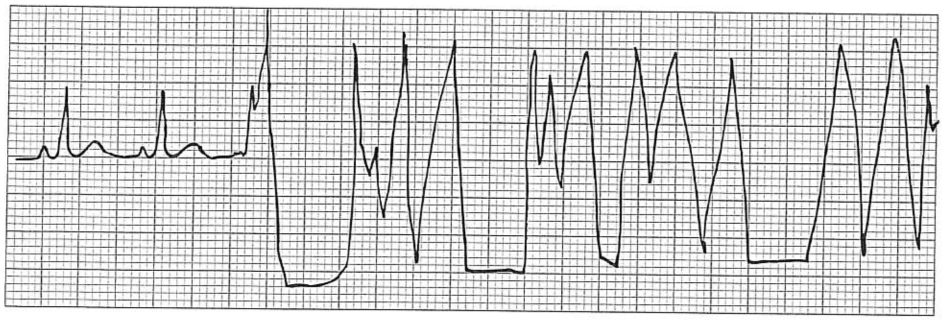


FIGURE 49-13 Broken recording.

regular spikes or static, and is caused by improper grounding, nearby electrical equipment in use, or twisted and coiled lead wires. Ground the machine properly. Unplug other electrical equipment in the area. Move the machine to an interior wall outlet away from outlets containing other cables. You may have to wait until a procedure in an adjacent room, such as an X-ray, is completed (Figure 49-12).

- **Broken recording**—Loose or broken lead wires cause the stylus to thrash erratically and to go off the page, leading to broken recording. Repair the wires, replace them, or call for service on the equipment (Figure 49-13).

Fortunately, most ECG machines today are so technologically advanced that they are able to detect and override artifacts.

Evaluating the Electrocardiogram

Interpreting an electrocardiogram is out of the medical assistant's scope of practice. However, you must be able to evaluate and assess the ECG to ensure that it is an acceptable tracing. As just discussed, if you detect an artifact, take measures to correct the issue and retest the patient.

Some offices may require you to calculate the patient's heart rate according to the ECG results. Finally, review the ECG to look for abnormalities in the patient's heart activity that you should immediately bring to the attention of the physician.

What Is Normal?

A normal sinus rhythm means that each heartbeat has three distinct waves: a P wave; a T wave; and—between the P and T—a QRS complex where the Q is a downward deflection, the R is an upward deflection, and the S is a downward deflection following an R. In a normal rhythm, the beats come at regular intervals, indicating that the impulse originates in the SA node. Within the lead being recorded, each cardiac cycle appears the same as previous cycles. To recognize abnormalities, you must first be able to recognize what is normal. Figure 49-14 illustrates and identifies features of a normal 12-lead ECG.

Most newer ECG machines used today will print out an interpretation and abnormalities will be identified. Interpretation of ECGs is outside the medical assistant's scope of practice, but you should be able to recognize what is normal and be able to perform an ECG in such a way that the results are accurate. The ECG machines themselves will help identify abnormalities and facilitate diagnosis.

Abnormalities

Occasionally, a tracing will reveal an abnormality caused by cardiac pathology in the patient. An observant medical assistant will recognize the more common abnormalities and draw them to the attention of the physician or will follow office protocol, which often calls for an additional recording of a

> **Professionalism**
>
> As a health care provider, you must maintain a healthy lifestyle and set an example for patients. Cardiac risk factors (age, gender, heredity, smoking, obesity, hyperlipidemia, hypertension, stress, and excessive drinking or use of drugs) can affect anyone. Be a living example of a healthy lifestyle by engaging in regular exercise, making healthy food choices, and avoiding use of recreational drugs and excessive alcohol consumption. Encourage patients to do the same.

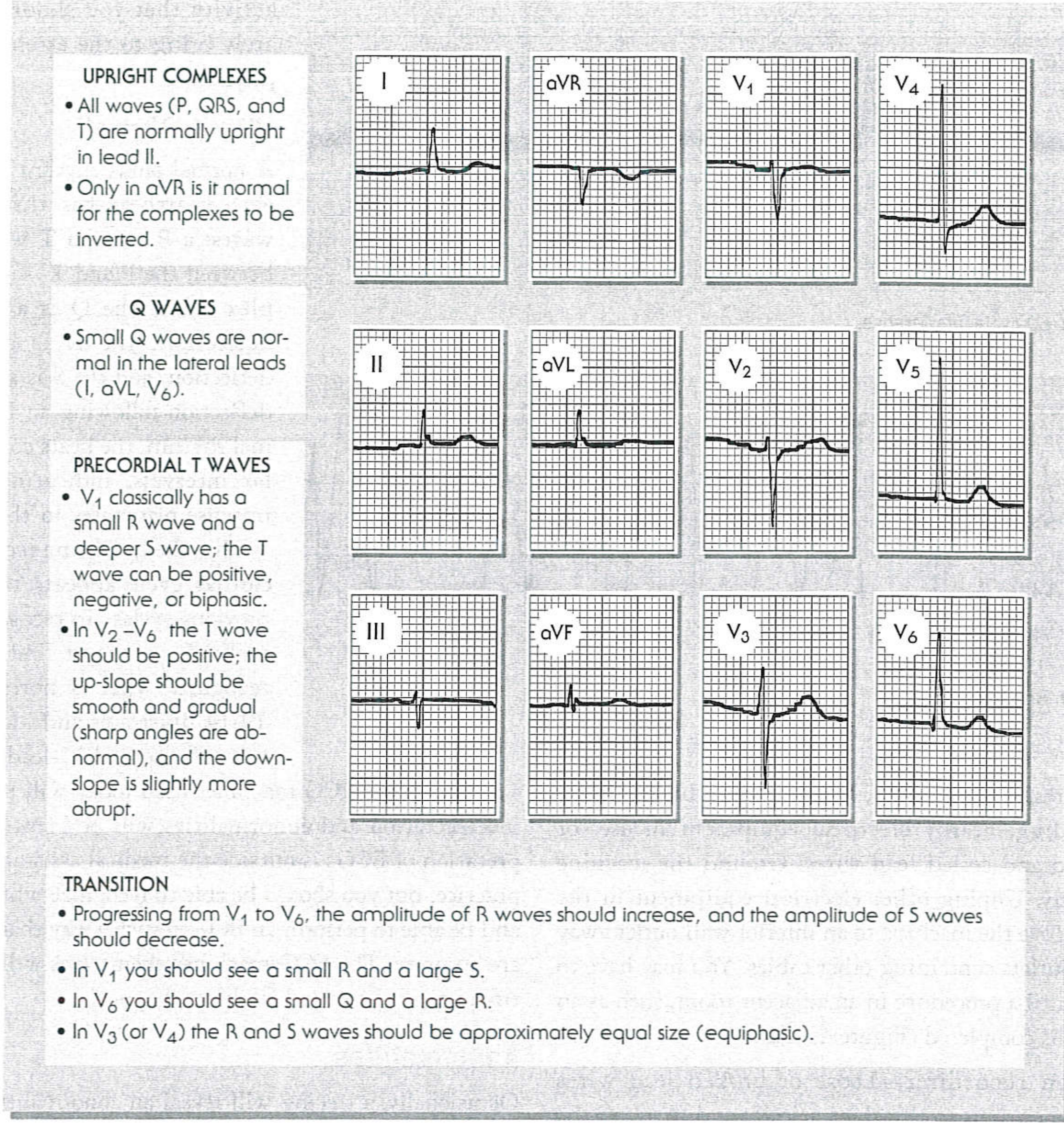


FIGURE 49-14 Features of a normal 12-lead ECG.

particular lead. Table 49-3, which includes Figures 49-15 to 49-22, lists some cardiac pathology that can be visualized by ECGs, including references to several examples of the abnormalities listed.

SPECIAL PROCEDURES

Additional Tracings

Some ECG-related diagnostic procedures are performed regularly in the primary care office or in cardiology. The following two procedures involve recording additional lengths of tracings and may be part of written office protocol for cardiograms.

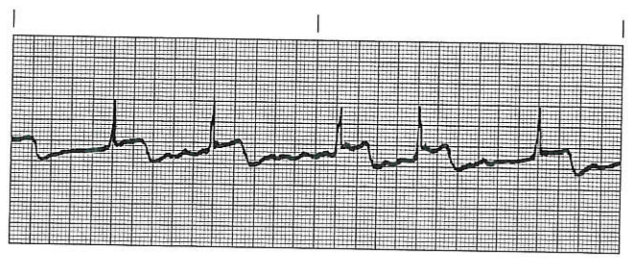
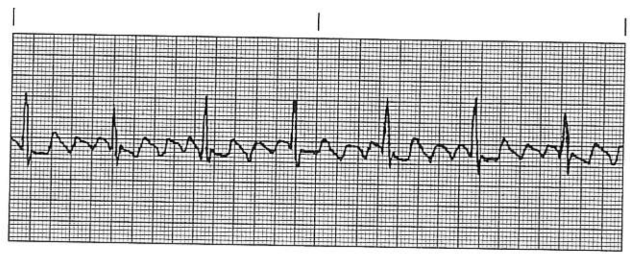
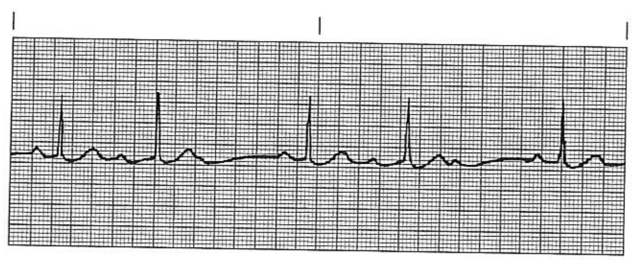
The first, a **rhythm strip**, is run on lead II for 20 seconds at the physician's request or if the medical assistant sees anything that appears abnormal on the tracing. This is not cut and mounted but carefully folded and given to the physician for interpretation.

The second procedure, an **inspiration strip**, is run on lead II for 10 seconds with the patient holding her breath. This is of greatest value when, as the patient breathes, your tracing shows a wandering baseline. This will eliminate any respiratory impact on the tracing.

Exercise Tolerance Testing

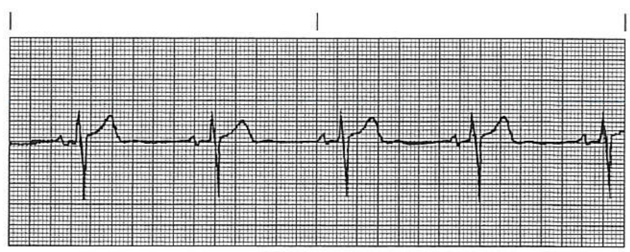
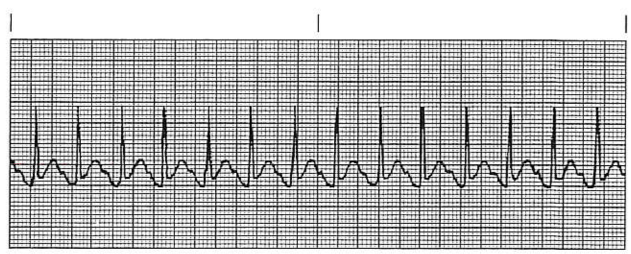
At times, patients will have symptoms that are not obvious on a resting ECG. A **stress test**, or treadmill test, involves an evaluation of the heart's response during moderate exercise while a 12-lead ECG is performed. It is a diagnostic procedure performed to determine the likelihood of coronary

TABLE 49-3 | **Abnormalities Caused by Cardiac Pathology**

Abnormality	Description
Atrial fibrillation	There are as many as 350 irregular P waves and 130–150 irregular QRS complexes per minute (Figure 49-15).  **FIGURE 49-15** Atrial fibrillation.
Atrial flutter	This rapid fluttering of the upper chambers looks on the ECG like the pattern of teeth on a saw. The atrial rate is 250–350 per minute. Not all the impulses are conducted through the AV node, because they are coming too fast. There is some "blockage" at the AV node. This is one type of heart block (Figure 49-16).  **FIGURE 49-16** Atrial flutter.
AV heart block	The node is diseased and does not conduct the impulse well. There are three types: first degree, in which the PR interval is prolonged; second degree, in which some waves do not pass through to the ventricles; and third degree or complete AV block, in which the atria and ventricles beat independently (Figure 49-17).  **FIGURE 49-17** Third-degree heart block.
Junctional arrhythmia	Cardiac rhythms arising from the atrioventricular (AV) junction that usually occur as an automatic tachycardia or as an escape mechanism during periods of significant bradycardia with rates slower than the intrinsic junctional pacemaker.
Myocardial infarction (MI)	There are broad and deep Q waves. *Old injury:* The ST segment is usually depressed below the baseline. A depressed wave below baseline can indicate an old MI or a current MI and is often indicated in patients with coronary artery disease. *New injury:* The ST segment is usually elevated above the baseline. Angina pectoris is the name for the syndrome of pain and oppression in the anterior chest caused by heart tissue being deprived of oxygen. If this pain lasts 20–30 minutes, suspect a myocardial infarction in which the heart tissue is actually dying.

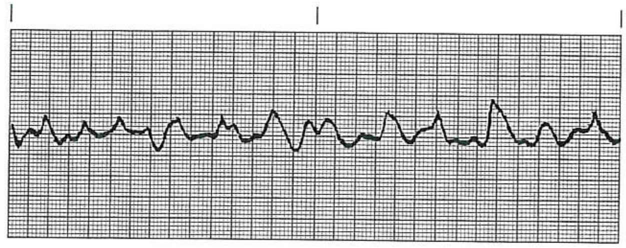
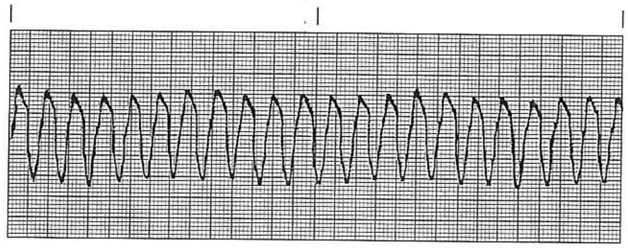
(*continued*)

TABLE 49-3 | **Abnormalities Caused by Cardiac Pathology (*continued*)**

Abnormality	Description
Paroxysmal atrial tachycardia (PAT)	There is a common arrhythmia, usually seen in young adults with normal hearts. There are no visible P waves, because they are hidden by the T wave of the previous cycle. The atrial rate is 140–250 per minute.
Premature atrial contractions (PACs)	A P wave occurs earlier than expected, usually from a source outside the sinus node. Therefore, P waves are distorted.
Premature ventricular contractions (PVCs)	The wide QRS complexes occur without preceding P waves. They may be caused by electrolyte imbalance, stress, smoking, alcohol, or toxic reactions to drugs and in a majority of patients who have had a heart attack (Figure 49-18).  **FIGURE 49-18** Multifocal premature ventricular contractions (PVCs).
Sinus arrhythmia	Normally seen in children and young adults; all aspects of the ECG are normal except the irregularity. The space between QRS complexes is not equal. The heart rate increases on inspiration and decreases on expiration.
Sinus bradycardia	There are fewer than 60 beats per minute; cycles are normal (Figure 49-19).  **FIGURE 49-19** Sinus bradycardia.
Sinus tachycardia	There are more than 100 beats per minute; cycles are normal (Figure 49-20).  **FIGURE 49-20** Sinus tachycardia.

(*continued*)

TABLE 49-3 | **Abnormalities Caused by Cardiac Pathology (*continued*)**

Abnormality	Description
Ventricular fibrillation	The waves are irregular and rounded, the contractions uncoordinated. Death may occur in as little as four minutes (Figure 49-21).  **FIGURE 49-21** Ventricular fibrillation.
Ventricular tachycardia	Three or more consecutive PVCs. Usually originating below the SA node, the complexes are wide and bizarre in appearance (Figure 49-22).  **FIGURE 49-22** Ventricular tachycardia.

artery disease (CAD), blockage of the arteries that supply the heart muscle. The patient is asked to exercise on a bicycle or treadmill, which stresses the heart and requires more oxygen for the heart muscle cells. A faster heart rate makes it easier to detect decreased blood flow.

Stress testing may be used to evaluate patients with a high risk for developing heart disease, known to have early heart disease, or about to begin a strenuous exercise program. This test is also done on patients who have cardiac complaints such as shortness of breath when exercising and as an evaluation of their rehabilitation following cardiac surgery. The treadmill test is noninvasive, and frequent blood pressure measurements are taken while exercise is in progress.

The stress test is continued until the **maximum target heart rate** is achieved or the patient becomes symptomatic. The maximum target heart rate is calculated by first establishing the **maximum heart rate**, determined by using the following formula: 220 minus the patient's age = the maximum heart rate for that person.

To determine the maximum target heart rate for the stress the procedure, which is 85 percent of the patient's maximum heart rate, multiply the maximum heart rate by 0.85. The complete formula to determine the maximum target heart rate is $220 -$ the patient's age $\times 0.85$. As an example, for a 60-year-old patient, $220 - 60 = 160 \times 0.85$ (85%) $=$ 136, or the maximum target heart rate for this patient.

For patients who have had a myocardial infarction (MI), the target heart rate is set lower, at 70 percent. This is known as a submaximal test.

The test concludes when the patient's symptoms of chest pain or fatigue or ECG changes indicate significant changes, especially to the ST segment. After the conclusion of the

Professionalism The Law

Stress tests or thallium scans require that a consent form be signed by the patient before the procedure, because these tests may lead to serious arrhythmias. Close monitoring by the assistant and the presence of a physician are also required for these procedures. If the medical assistant detects a potentially life-threatening arrhythmias, it is a professional duty to immediately notify the physician.

test, the patient rests while the monitoring of blood pressure and heart rate continue until both are within normal range. Complications may occur, and appropriately stocked emergency carts should be on hand.

Patient Preparation

Medical assistants are often in charge of scheduling stress tests and other outpatient procedures. In addition to simply providing the patient with the scheduled date and time, it is important to provide patient instruction and education about the procedure. The patient should be instructed to wear comfortable exercise or walking shoes and loose-fitting clothes on the day of the test. Female patients should be instructed to wear a bra to minimize artifacts on the ECG. Instruct all patients not to eat a large meal for at least four hours before the test to avoid nausea. Patients should take their normal medications unless otherwise instructed by the physician.

Inform the patient that baseline vital signs and a resting ECG are recorded first. Vital signs are measured with the patient in supine position and standing. Another ECG is taken with the patient standing and **hyperventilating** (breathing rapidly). This is done because rapid breathing can produce some changes in the ST segment and the T wave on the ECG recording. It is important to know this in advance so the interpretation of the stress test ECG is not compromised. Also, a thorough history is taken emphasizing any symptoms such as shortness of breath or chest pain. Explain to the patient that an ECG will be recorded as the patient walks or bikes at a carefully prescribed pace in the presence of the physician. Increases in rate or incline will be made, but the patient should not feel discomfort or shortness of breath.

Varieties of Stress Tests

The physician may order additional types of stress tests either based on the outcome of an exercise tolerance test or based on patient limitations. Medical assistants should be familiar with these tests so that they can be ready to answer questions that the patient might have.

Thallium (a radioisotope that emits gamma rays and is used in nuclear medicine) is sometimes injected into the patient's vein during a stress test for better understanding of **perfusion** (blood flow to the myocardium). Thallium is injected during the last minute of exercise. The patient lies on a special table, and a gamma camera takes pictures. If the heart muscle is **ischemic** (receiving less than the normal amount of blood flow), poor uptake of the thallium will occur. This is indicated as a "cold spot" on the pictures. Normal perfusion of the myocardium is indicated by "hot spots" on the pictures.

Another type of test, the **multiple gated acquisition (MUGA) scan**, can be done to check blood flow in the myocardium. This involves injection of an isotope and having a nuclear scan performed to detect myocardial perfusion. Pharmacological stress testing does not involve exercise. In this case, a medication is given to the patient that causes the heart rate to climb to the target heart rate. Continuous ECGs and vital sign evaluation are performed. This test procedure is useful on patients with physical limitations or those who cannot perform enough exercise to elevate the heart rate.

Holter Monitor

The **Holter monitor** records cardiac activity while the patient is ambulatory for at least a 24-hour period. Holter monitoring might be ordered if the results of an ECG are inconclusive or cardiac irregularity was not captured on the tracing. A small recording device and a patient diary are used to detect heart irregularities that are infrequent and not detected on the standard 12-lead cardiogram (Figure 49-23). Today, most Holter monitors are digital recorders. However, some offices may still use the older models that use cassette tape recorders. The monitor is often set to record continuously and/or to record when the patient presses an "event" button at the onset of symptoms. A medical assistant may instruct the patient and apply the chest electrodes.

During patient preparation, stress the importance of the diary. While wearing the monitor, patients will carry on all routine daily activities except showering or bathing. They must also avoid areas of high voltage, because it could interfere with the recording. Patients use the diary to record their activities during the day such as stair climbing, sexual activity, having bowel movements, sleeping, eating, exercising, and so forth. They also indicate in the diary or by depressing an "event button" when they experience any cardiac symptoms, such as chest pain, shortness of breath, or palpitations. Patients should record such events in the diary. The

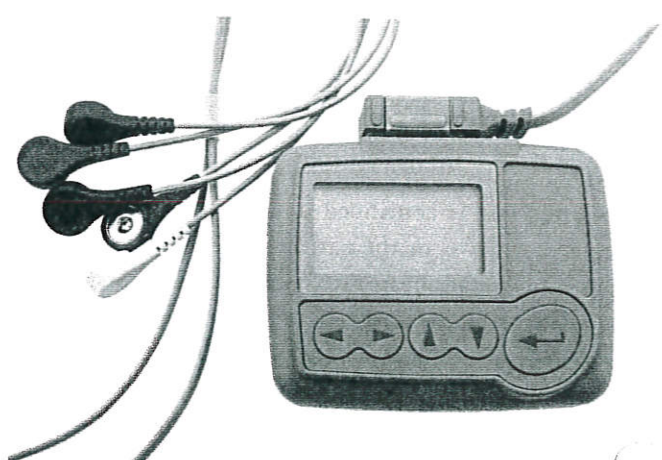


FIGURE 49-23 A digital Holter monitor.

physician will compare the tape with the activity log to determine which activities were stressing the patient.

The five special disposable chest electrodes are attached more securely than in the 12-lead ECG because they must remain in place during all activity. In addition to the usual skin preparation to remove oils, areas for attachment may have to be shaved and an abrasive skin cleaner used. Electrodes are placed in the following locations:

- Third intercostal space 2 or 3 inches to the right of the sternum
- Third intercostal space 2 or 3 inches to the left of the sternum
- Fifth intercostal space at the left sternum margin
- Sixth intercostal space at the right anterior axillary line
- Sixth intercostal space at the left anterior axillary line

Procedure 49-2 describes the procedure for applying a Holter monitor.

Cardiac Event Monitor

To capture a record of a cardiac event, a physician may provide the patient a cardiac event monitor to use for a period of time. The physician might ask the patient to use the monitor until one event occurs and is recorded or might ask the patient to use it during a certain time span. For patients who have infrequent events, the physician might ask the patient to use the monitor for up to 30 days to ensure that any events will be captured.

With a cardiac event monitor, electrodes are worn much as they would be for a Holter monitor. The patient presses a button on the monitor when perceiving a cardiac event such as a rapid or slow heartbeat or dizziness or feeling faint. The equipment records heart activity for five minutes after the depression of the button. Some monitors record the information; some permit sending the information by telephone to the physician or to a receiving center. The patient may also keep a diary to align the event with activity at the time. For example, the patient might note having events only when climbing stairs.

Mobile Cardiac Telemetry

Some patients can have their heart activity monitored and measured from far away through **telemetry**. Mobile cardiac telemetry (MCT) allows a device to send data continually to a facility that is staffed 24 hours per day. It is then interpreted by a qualified, cardiac-trained registered nurse. In contrast to the cardiac event monitor, MCT provides real-time monitoring and analysis. There are a wide variety of telemetry monitors—with 3, 5, and 12 leads. Leads are placed according to manufacturer's instructions. Figure 49-24 shows one type of telemetry monitor.

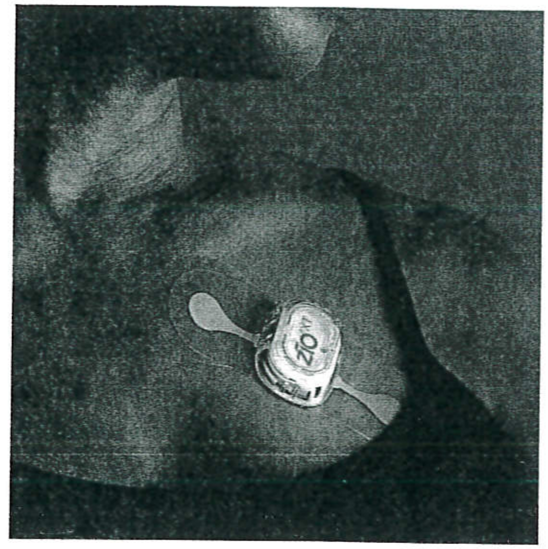


FIGURE 49-24 A ZIO Patch telemetry monitor.

To be successful, it is very important for the medical assistant to ensure that the patient understands how to use the telemetry monitor and is comfortable with using the technology for telemetry. Encourage the patient to call the help number that comes with the equipment to learn how to attach the leads and use the equipment correctly and to get help should any problems arise while the equipment is being used.

Pacemakers

Pacemakers are electronic devices that help the heart maintain normal rhythm. They may be used to increase heart rate in patients with bradycardia (slow heart rate), to decrease the heart rate in a patient with tachycardia (rapid heart rate), or to correct other dysrhythmias. Pacemakers may be temporarily or permanently installed in the patient. Temporary pacemakers

Professionalism — Cultural Considerations

Although many men may not have a problem with shaving chest hair if it is necessary for an ECG, many cultures and religions may consider this practice to be taboo. If a male patient protests the idea of having to shave chest hair based on religious or cultural beliefs, it is important not to argue with the patient. If this circumstance arises, it would be best to inform the physician of the patient's concern and continue with the ECG without shaving the chest. It would be necessary to document in the medical record that the ECG was performed but that the patient did not allow his chest to be shaved to ensure proper lead placement and connectivity.

PROCEDURE 49-2

Applying a Holter Monitor

Objective ◆ *Apply a Holter monitor and instruct the patient.*

EQUIPMENT AND SUPPLIES

Holter monitor with electrodes; patient cable; patient activity diary; fresh batteries or charging device; blank recording tape or digital flashcard or microchip; adhesive tape; razor, if needed; alcohol wipes; dry washcloth

METHOD

1. Assemble the necessary supplies.
2. Install new batteries; depending on the model, make sure the digital storage unit (flashcard or microchip) has the maximum amount of memory. For older models, insert a new blank cassette tape.
3. Verify that the machine is operational.
4. Introduce yourself and then identify, interview, and instruct the patient according to office protocol. Explain the importance of accurately recording in the diary as well as depressing the event button at the correct times.
5. Have the patient remove clothing to the waist (female patients may wear a gown open down the front) and sit on an examination table.
6. Perform hand hygiene.
7. Prepare the electrode sites by shaving small patches of chest hair where the electrodes will be placed (if necessary). Using alcohol wipes, wipe the skin to remove any residue that could interfere with electrode placement. Allow the skin to air dry.
8. Using a dry washcloth or other abrasive material, rub the skin where the electrodes will be placed. This will help the electrodes stick to the skin more effectively.
9. Attach the electrodes according to the manufacturer's instructions. The electrodes will be placed in these locations: third intercostal space 2 or 3 inches to the right of the sternum, third intercostal space 2 or 3 inches to the left of the sternum, fifth intercostal space at the left sternum margin, sixth intercostal space at the right anterior axillary line, and sixth intercostal space at the left anterior axillary line (Figure A).
10. Attach the wires so that they point toward the feet, and then connect the patient cable.
11. Secure each electrode with adhesive tape.
12. Assist the patient with replacing his shirt. Extend the cable between the buttons or under the hem.
13. Place the recorder in the carrying case, and either attach to the patient's belt or place the neck strap around the patient's neck. Check that there is no tension on the wires.

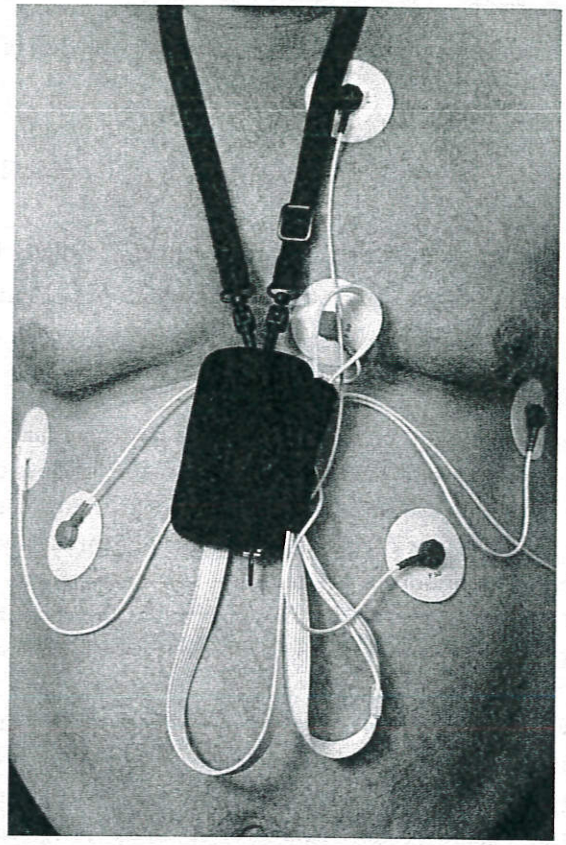


FIGURE A Correct electrode placement for a Holter monitor.

14. Plug the cable into the recorder.
15. Record the starting time in the diary.
16. Ensure that the patient understands what to do by having the patient repeat the instructions for pressing the event button as well as what to record in the diary.
17. Confirm the time for the patient to return to the clinic for removal of the Holter monitor.
18. Chart the procedure in the patient's record.

CHARTING EXAMPLE

3/11/YY 4:15 P.M. Holter monitor applied and instruction given. Patient to return in 24 hours with diary and monitor. Patient verbalized understanding and repeated back instructions.......... ....E. Blodgett, CMA (AAMA)

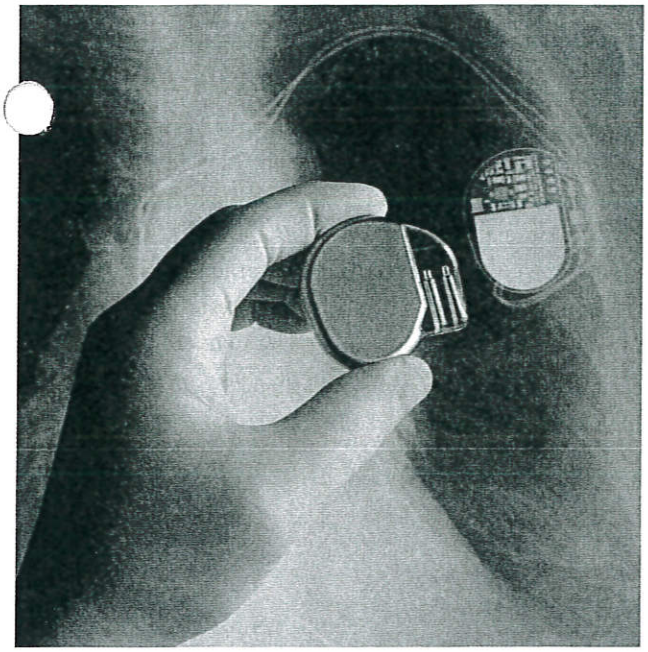


FIGURE 49-25 A surgeon holds a pacemaker next to an X-ray of a pacemaker implanted in a patient's chest.

are used in acute settings to stabilize and maintain the patient for shorter periods of time. Patients with temporary pacemakers must be hospitalized and continuously monitored. The pulse generator is located outside the body, and leads are threaded through specific veins (subclavian, femoral, brachial, or external jugular) to either the right atrium or the right ventricle. A temporary pacemaker may be attached during surgery to the outer surface of the heart. The wires then exit the chest and are attached to an external pulse generator.

The type of permanent pacemaker implanted depends on the patient's condition and the type of cardiac problem involved. These are long-term devices, and the pulse generator is implanted into the subcutaneous tissue of the upper chest (Figure 49-25). The leads are inserted into a major vein leading into the heart in the region of the myocardium that is impaired. The opposite ends of the leads are attached to the pulse generator. Figure 49-26 illustrates both temporary and permanent pacemakers.

Some pacemakers are fixed rate, or continuous. Some fire only when needed (on demand). Some are rate-responsive to physiological changes and respond to the body's demands

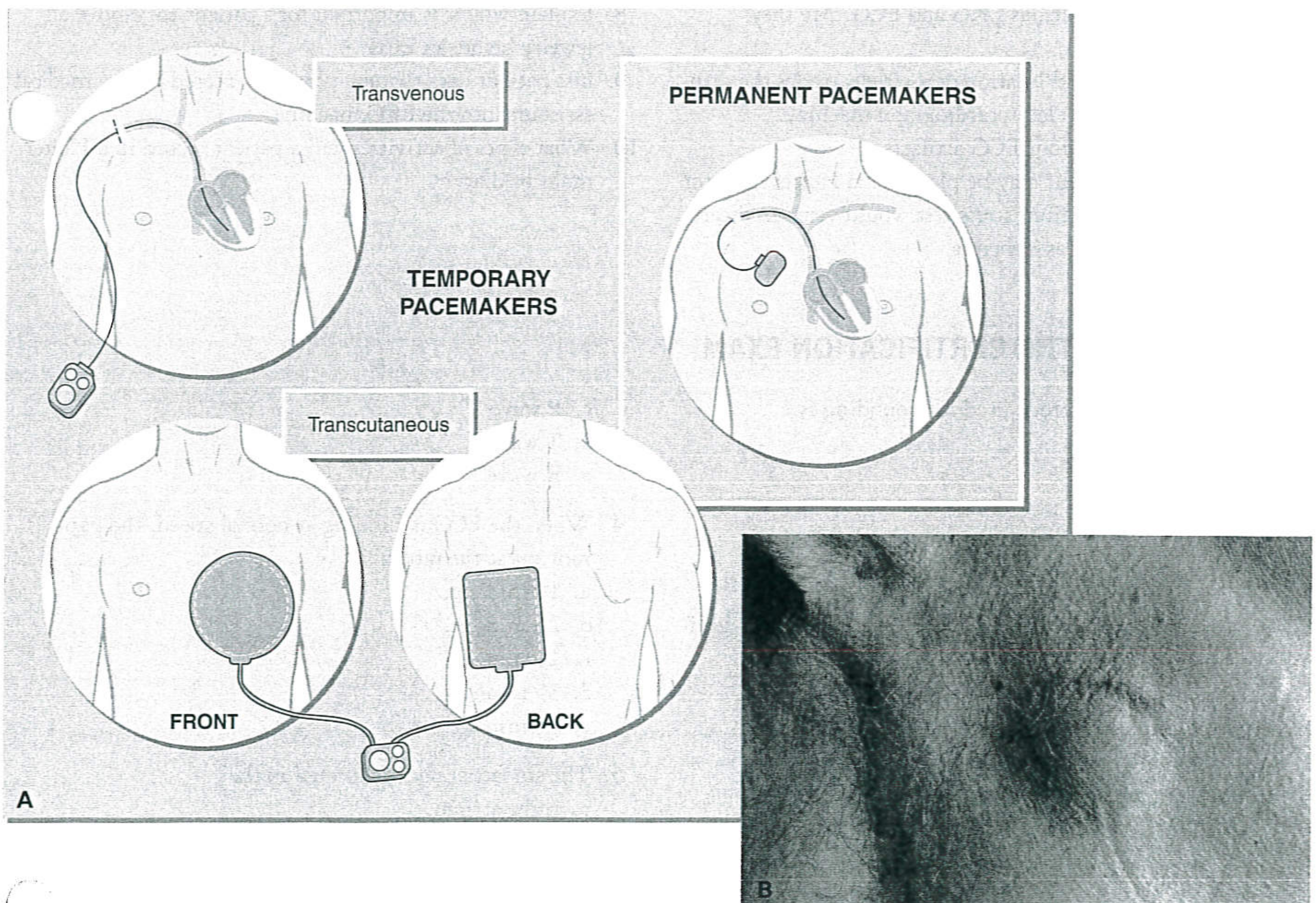


FIGURE 49-26 (A) Temporary and permanent pacemakers. (B) A pacemaker in a patient's chest.

according to changes in the patient's activities. The atrial-paced pacemaker will show a spike with the P wave. The pacemaker spike appears as a long vertical line, usually rhythmically paced before the P wave. Pacemakers that spike with the QRS wave are ventricular-paced.

Notify the physician if the implanted pacemaker is visible on the surface of the skin, because this would signify movement of the implanted device.

SUMMARY

The use of electrocardiography for the early diagnosis and treatment of heart disease has contributed to the lengthened life expectancy of many patients and has improved their quality of life. ECGs are usually performed while the patient is lying down. Sometimes ECGs are done in combination with stressful exercise to see the effect on the heart. If a patient experiences dyspnea, pain, or syncope during the stress test, the test is aborted and the physician notified immediately. The patient may be monitored for 24 hours with a Holter monitor to see which activities stress the heart. Accuracy in carrying out your duties during these tests will provide the physician with the best possible data to make that diagnosis and institute the correct treatment.

49 CHAPTER REVIEW

COMPETENCY REVIEW

1. Define and spell the terms for this chapter.
2. Explain the abbreviations EKG and ECG. Are they interchangeable?
3. Identify by name and location of their electrodes the standard 12 leads on an electrocardiograph machine.
4. Name and describe four ECG artifacts.
5. Explain why a patient may be placed on a Holter monitor.
6. Describe how a thallium stress test would visualize heart abnormalities, such as ischemia.
7. Name the components of a cardiac wave pattern.
8. Explain why it is important for a patient to remove all jewelry before an ECG.
9. List patient data that are typically entered by the medical assistant into the ECG machine.
10. What types of activities will a patient record in a Holter monitor diary?

PREPARING FOR THE CERTIFICATION EXAM

1. In an ECG, the electrode used in grounding is
   a. LA.
   b. LL.
   c. RA.
   d. RL.
   e. V1.
2. When taking an ECG, the position of the first chest lead V1 is
   a. third intercostal space, left sternal margin.
   b. third intercostal space, right sternal margin.
   c. fourth intercostal space, left sternal margin.
   d. fourth intercostal space, right sternal margin.
   e. fifth intercostal space, midclavicular line.
3. The second wave of the ECG is the
   a. S wave.
   b. Q wave.
   c. P wave.
   d. T wave.
   e. R wave.
4. When the ECG is running at normal speed, the paper is moving at the rate of
   a. 10 mm/sec.
   b. 20 mm/sec.
   c. 25 mm/sec.
   d. 35 mm/sec.
   e. 50 mm/sec.
5. The sinoatrial node is located in the
   a. right atrium.
   b. left atrium.
   c. apex.
   d. ventricles.
   e. septum between the atria.