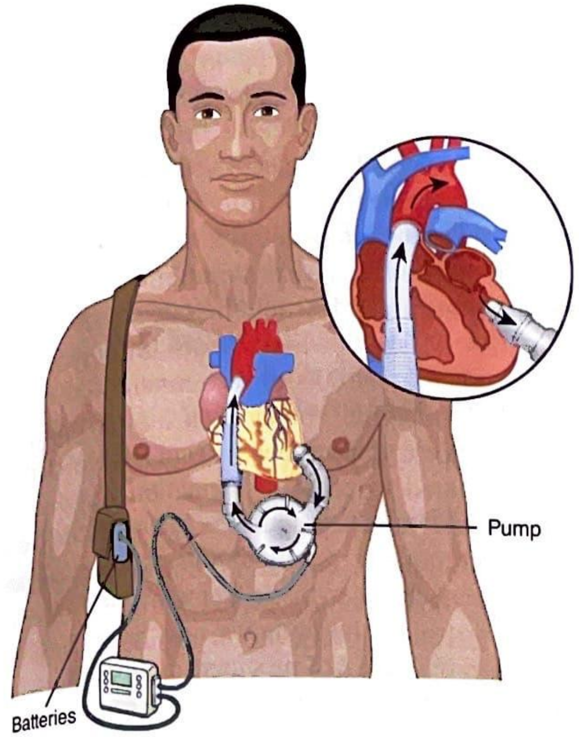
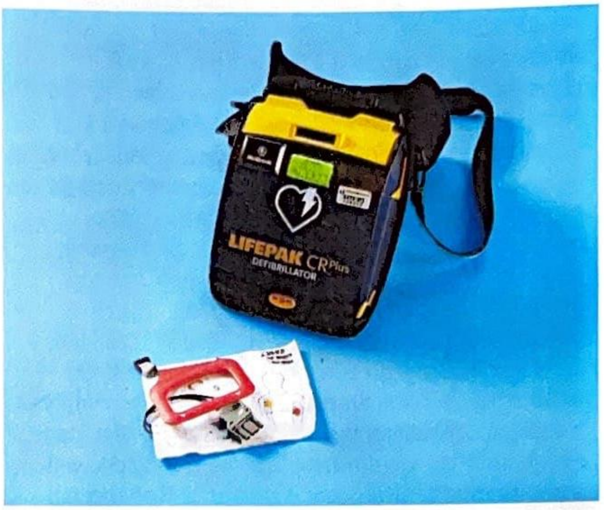


FIGURE 17-14 Left ventricular assist device.

A



B

FIGURE 17-15 Automated external defibrillators vary in their design, features, and operation. Two types (**A**) and (**B**) of defibrillators.

Cardiac Arrest

Cardiac arrest is the complete cessation of cardiac activity. It is indicated in the field by the absence of a carotid pulse. Until the advent of CPR and external defibrillation in the 1960s, cardiac arrest was almost always a terminal event. With good initial CPR, early defibrillation, and access to advanced care, it is now possible for some patients to survive a cardiac arrest without neurologic damage.

When you arrive to find a patient who appears to be in cardiac arrest, you should automatically follow your CPR training. CPR is covered in Chapter 14, *BLS Resuscitation*.

Automated External Defibrillation

In the late 1970s and early 1980s, scientists developed a small computer that could analyze electrical signals from the heart and determine when VF was taking place. This development, along with improved battery technology, made the automated portable defibrillator—a device that can automatically administer an electrical shock to the heart when needed—possible.

AED machines come in different models with different features (**FIGURE 17-15**). All of them require a certain degree of operator interaction, beginning with turning on the machine and applying the pads. The operator also has to push a button to deliver an electrical shock, regardless of the model. Many AEDs use a computer voice synthesizer to advise the operator which steps to take on the basis of the AED's analysis. Some have a button that tells the computer to analyze the heart's electrical rhythm; other models start doing this as soon as they are turned on. Even though most defibrillators are now semiautomated, we still use the term AED to describe all of these machines. There are few fully automatic AEDs (which would deliver a shock without the operator pressing a button) left. All manufacturers are now producing only semiautomated external defibrillators.

AEDs deliver electrical energy from one pad to the other (and then back to the first pad) to electrically stun the heart and allow it to resume normal function. The amount of electricity delivered by the machine varies among the manufacturers, but each one has shown that the energy delivered is adequate to defibrillate the heart. The factors involved in the defibrillation include voltage, current, and impedance. Most AEDs are set up to adjust the voltage based on the impedance (or resistance of the body to the flow of electricity) to deliver the proper amount of current, which is what causes the cells to defibrillate.

The computer inside the AED is specifically programmed to recognize rhythms that require defibrillation to correct, most commonly VF. AEDs are extremely accurate. It would be rare for an AED to recommend a shock when a shock is not required, and an AED rarely fails to recommend one when it would be helpful. Therefore, if the AED recommends a shock, you can believe that it is indicated.

Automated external defibrillation has several advantages. First, the machine is fast, and it delivers the most important treatment for a patient in VF: an electrical shock. It can be delivered within 1 minute of your arrival at the patient's side. Second, AEDs are easy to operate. ALS providers do not have to be on the scene to provide this definitive care.

Current AEDs offer two other advantages. The shock can be given through remote, adhesive defibrillator pads, which are safe to use. Also, the pad area is larger than manual paddles, which means that the transmission of electricity is more efficient. Usually, there are pictures on the pads to remind you where they go on the patient's chest. As a safety measure, make sure the patient is not lying on wet ground or touching metal objects when he or she is being shocked.

Special Populations

A pediatric patient with chest pain is not a common call. It is usually associated with a noncardiac condition or with a child who has a preexisting heart condition, which is usually congenital (present since birth). In pediatric situations, it is vital to see family members or caregivers as a valuable source of information.

Cardiac arrest in infants and children is usually the result of respiratory failure and not a primary cardiac event. However, the American Heart Association has determined that AEDs are safe to use in infants and children. If the patient is 8 years old or younger, pediatric-size pads and a dose-attenuating system (energy reducer) are preferred. However, if these are unavailable, a regular adult AED can be used. If the child is between 1 month and 1 year of age (an infant), a manual defibrillator is preferred to an AED. If a manual defibrillator is not available, an AED equipped with a pediatric dose attenuator is preferred. If neither is available, an AED without a pediatric dose attenuator may be used.

YOU are the Provider

After completing the remainder of your assessment and initial treatment, you place the patient onto the stretcher, load her into the ambulance, and proceed to a hospital located 20 miles away. You ask your partner to notify the hospital to alert the staff as you reassess the patient.

Recording Time: 10 Minutes	
Level of consciousness	Conscious and alert; still anxious
Respirations	18 breaths/min; adequate depth
Pulse	84 beats/min; strong and irregular
Skin	Pale and cool; less diaphoretic
Blood pressure	136/84 mm Hg
Spo_2	96% (on oxygen)

9. Why is early notification of the receiving facility so important for patients with an acute coronary event?

10. Should you apply the AED to determine if this patient is experiencing a cardiac dysrhythmia? Why or why not?

Not all patients in cardiac arrest require an electrical shock. Although the cardiac rhythm of all patients in cardiac arrest should be analyzed with an AED, some do not have shockable rhythms (eg, pulseless electrical activity and asystole). Asystole (flatline) indicates that no electrical activity remains and therefore defibrillation will not help. Pulseless electrical activity refers to a state of cardiac arrest that exists despite an organized electrical complex; defibrillation could possibly make this situation worse. In both cases, CPR should be initiated as soon as possible, beginning with chest compressions.

Rationale for Early Defibrillation

Few patients who experience sudden cardiac arrest outside a hospital survive unless a rapid sequence of events takes place. The chain of survival is a way of describing the ideal sequence of events that can take place when such an arrest occurs.

The six links in the chain of survival are as follows (**FIGURE 17-16**):

- Recognition of early warning signs and immediate activation of EMS
- Immediate CPR with emphasis on high-quality chest compressions
- Rapid defibrillation
- Basic and advanced EMS
- ALS and postarrest care
- Recovery

If any one of the links in the chain is absent, the patient is less likely to be resuscitated. For example, few patients benefit from defibrillation when more than 10 minutes elapses before administration of the first shock or if CPR is not started within the first 2 to 3 minutes. If all links in the chain are strong, the patient has the best possible chance of survival. The link that is the most common determinant for survival is the third link: rapid defibrillation. This link and those for immediate high-quality CPR and basic and advanced EMS are where EMTs are most involved.

CPR helps patients in cardiac arrest because it prolongs the period during which defibrillation can be effective. Rapid defibrillation has successfully resuscitated many patients with cardiac arrest due to VF. However, defibrillation works best if it takes place within 2 minutes of the onset of the cardiac arrest. Remember, seconds really matter when a patient is in cardiac arrest. The fourth link in the chain of survival is basic and advanced emergency medical services.

The fifth link in the chain of survival is ALS and post–cardiac arrest care. This refers to continuing ventilation at 10 breaths/min; maintaining oxygen saturation between 94% and 99%; ensuring systolic blood pressure is above 90 mm Hg; and using targeted temperature management when the patient arrives at the hospital. It also includes cardiopulmonary and neurologic support at the hospital as well as other advanced assessment techniques and interventions when indicated. The final step in the chain of survival, recovery can take a year or longer for many of the 10% of victims of out-of-hospital cardiac arrest who are fortunate enough to survive.

Integrating the AED and CPR

Because most cardiac arrests occur in the home, a bystander at the scene may already have started CPR before you arrive. For this reason, you must know how to work the AED into the CPR sequence. Remember that the AED is not very complex, but

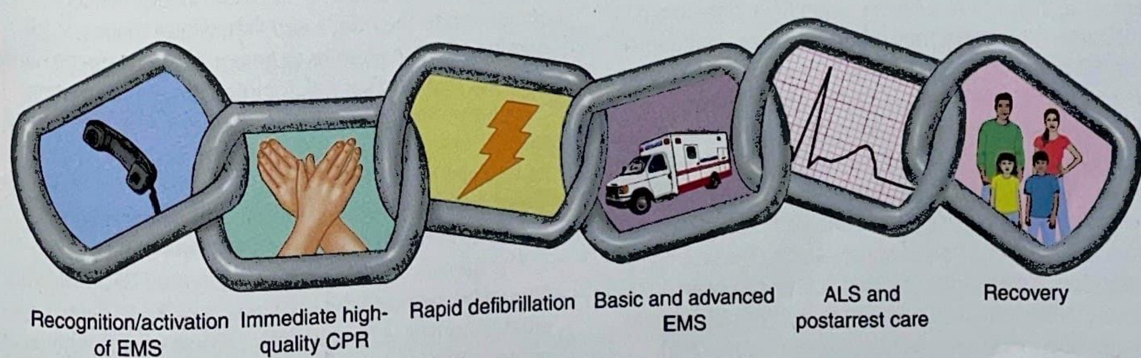


FIGURE 17-16 The six links of the chain of survival.

Data from American Heart Association.

it may not be able to distinguish other movements from VF. To avoid this problem, apply the AED only to pulseless, unresponsive patients and stay clear of the patient (do not touch the patient) while the AED is analyzing the heart rhythm and delivering shocks. You may perform chest compressions after the "shock advised" message while the AED is charging. Just remember to stop compressions and stay clear of the patient before pressing the button to deliver the shock.

AED Maintenance

One of your primary missions as an EMT is to deliver an electrical shock to a patient in VF. To accomplish this mission, you need to have a functioning AED. You must become familiar with the maintenance procedures required for the brand of AED your system uses. Read the operator's manual. If your defibrillator does not work on the scene, someone will want to know what went wrong. That person may be your system's administrator, your medical director, the local newspaper reporter, or the family's attorney. You will be asked to show proof that you maintained the defibrillator properly and attended any mandatory in-service sessions.

The main legal risk in using the AED is failing to deliver a shock when one was needed. The three most common errors in using certain AEDs are failure of the machine to shock fine VF; applying the AED to a patient who is moving, squirming, or being transported; and turning off the AED before analysis or shock is complete. Operator errors include failing to apply the AED to a patient in cardiac arrest, not pushing the analyze or shock buttons when the machine advises you to do so, or pushing the power button instead of pushing the shock button when a shock is advised. Like any other manufactured item, the AED can fail, although this is rare. Ideally, you will encounter any such failure while doing routine maintenance, not while caring for a patient in cardiac arrest.

Another risk is failure to deliver a shock due to a battery that did not work, usually because it was not properly maintained. Check your equipment, including your AED, daily at the beginning of each shift and maintain the battery as often as the manufacturer recommends. Ask the manufacturer for a checklist of items that should be checked daily, weekly, or less often (**FIGURE 17-17**).

An error can also occur when the AED is applied to a responsive patient with a rapid heart rate. Most

Special Populations

Like the other body systems, the cardiovascular system undergoes changes during the aging process. The heart, like other major organs, will show the effects of aging. As the heart's muscle mass and tone decrease, the amount of blood pumped out of the heart per beat decreases. The residual (reserve) capacity of the heart is also reduced; therefore, when the vital organs of the body need additional blood flow, the heart cannot meet the need. When blood flow to the tissues is decreased, the organs suffer. If blood flow to the brain is inadequate, the patient may report weakness, fatigue, or dizziness and may experience syncope (fainting).

The heart muscle is stimulated by electricity and has its own electrical system. Under normal conditions, electrical impulses travel throughout the heart, resulting in the contraction of the heart muscle and the pumping of blood from the heart's chambers. With aging, the electrical system can deteriorate, causing the heart's contraction to weaken or, if blood flow to the heart muscle is affected, extra beats to form. With decreased strength of contraction, the heartbeat is weaker and blood flow to the tissues is reduced. If extra beats are produced, the patient's heart rhythm will be irregular. Although some irregular heart rhythms are not harmful, others can be lethal.

The arteries are also affected by aging. Arteriosclerosis (hardening of the arteries) can develop, reducing perfusion of the tissues. There is an increased chance of heart attack or stroke due to decreased blood flow or plaque formation (atherosclerosis) in the narrowed arteries.

Patients with diabetes can experience reduced circulation to the hands and feet, which makes peripheral pulses harder to detect. It also puts the hands and feet at particular risk for infection and ulceration.

In some older patients with angina or AMI, particularly people with diabetes, chest pain is absent, and the clinical picture can be confused with other, noncardiac conditions. These patients may present with a chief complaint of syncope (fainting), fatigue, or shortness of breath.

The cardiovascular system is affected by aging. You should be aware of the changes, seeking to determine what is normal versus what is chronic versus what is an acute condition for the individual patient.

AUTOMATED EXTERNAL DEFIBRILLATOR
Inspection Checklist

Serial # ____________ **Date** ____________ **Time** ____________

Model # ____________ **Inspected by** ____________

Item	Pass	Fail
Exterior/Cables		
Nothing stored on top of unit		
Carry case intact and clean		
Exterior/LCD/cables connectors clean and undamaged		
Cables securely attached to unit		
Batteries		
All chargers plugged in and operational (if applicable)		
All batteries fully charged (battery in unit, spare battery)		
Valid expiration date on both batteries		
Supplies		
Two sets of electrodes in sealed packages with valid expiration dates		
Razor		
Hand towel		
Alcohol wipes		
Memory/voice recording device—module, card, microcassette		
Manual override—module, key (if applicable)		
Printer paper (if applicable)		
Operation		
Unit self-test per manufacturer's recommendation/instructions		
Display (if applicable)		
Visual indicators		
Verbal prompts		
Printer (if applicable)		
Attach AED to simulator/tester		
Recognizes shockable rhythm		
Charges to correct energy level within manufacturer's specifications		
Delivers charge		
Recognizes nonshockable rhythm		
Manual override system in working order (if applicable)		

Signature:

FIGURE 17-17 A sample checklist for the automated external defibrillator (AED).

AEDs identify a regular rhythm faster than 150 or 180 beats/min as VT, which should be shocked if the patient is pulseless. However, shocking VT in a patient with a pulse may result in the patient losing his or her pulse and going into cardiac arrest. To avoid this problem, you should apply the AED only to unresponsive *pulseless* patients.

If the AED fails while you are caring for a patient, you must report the problem to the manufacturer and the US Food and Drug Administration. Be sure to follow the appropriate EMS procedures for notifying these organizations.

Medical Direction

Defibrillation of the heart is a medical procedure. Although AEDs have made the process of delivering electricity much simpler, there is still a benefit in having a physician's involvement. The medical director of your service should approve the written protocol that you will follow in caring for patients in cardiac arrest.

There should be a review of each incident in which the AED is used. After returning from the hospital or the scene, discuss with the rest of the team what happened. This discussion will help all members of the team learn from the incident. Review such events by using the written report and the device's recordings, if applicable.

There should also be a review of the incident by your service's medical director or quality improvement officer. Quality improvement involves meetings between EMTs using AEDs and their EMS system managers or supervisors. This review should focus on speed of defibrillation—that is, the time from the first contact with the patient to the time that the first shock is delivered and, when the monitor can record it, the quality of CPR (to include timing of pauses). Few systems will achieve the ultimate goal: shocking 100% of patients within 1 minute of initial patient contact. However, all systems continuously work on improving patient care. Mandatory continuing education with skill competency review should be required for all EMS providers.

Emergency Medical Care for Cardiac Arrest

Preparation

When dispatch reports an unresponsive patient with CPR being performed, the AED is probably one of the first pieces of equipment you will obtain from the ambulance. As the operator of the AED, you are responsible for making sure the electricity does not injure anyone, including yourself. Remote defibrillation using pads allows you to distance yourself safely from the patient. As long as you place the pads in the correct position and make sure no one is touching the patient, you should be safe. Do not defibrillate a patient who is in pooled water. Although there is some danger to you if you are also in the water, there is another problem. Electricity follows the path of least resistance; instead of traveling between the pads and through the patient's heart, it will flow into the water. Therefore, the heart will not receive enough electricity to cause defibrillation. You can defibrillate a soaking wet patient but try first to dry the patient's chest. Do not defibrillate someone who is touching metal that others are touching, and carefully remove a nitroglycerin

Street Smarts

Very few things we do in EMS have the potential to be as chaotic as treating a patients in cardiac arrest. Adapting the American Heart Association focus on team dynamics, many EMS systems have developed a "pit crew" strategy for handling these scenes. The term derives from the pit crew in Formula One automobile racing, which services a racecar in the middle of a race by changing tires and adding fuel. On a pit crew, each person has a specific job to do, so one person changes the rear tires while another changes the front tires. In the pit crew concept of managing a cardiac arrest, each person also has a specific assignment, which is determined prior to or at the beginning of the scene.

For example, one person will be assigned to start chest compressions and another will perform ventilations with the bag-mask device. Another person should be running the code, or "calling the shots," and another is keeping a record of all that is being done, and still another can be applying and operating the AED. When each person has a specific job to do and can focus on that job, the chaos that often accompanies this type of call can be greatly reduced.

The pit crew concept is also driven by improvement. In many pit crew protocols, many aspects of the cardiac arrest, such as compression depth, rate, and pre- and post-shock pauses, are measured and analyzed to try to meet certain benchmarks. Many systems that have implemented the pit crew approach have significantly improved cardiac arrest survival rates.