FEATURE

Automated external defibrillators: The CHO's role

Cardiovascular disease is the leading cause of death among adults in the United States. More than 250,000 people suffer sudden cardiac arrest before reaching a hospital. Automated external defibrillators (AEDs) are a proved method of reducing morbidity and mortality from acute myocardial infarction (heart attack). The most common lethal arrhythmia in adult cardiac arrest, ventricular fibrillation (VF) can be cured by electricity; early defibrillation is a nationally recognized standard of care. To provide a realistic chance of survival, defibrillation must be available soon after cardiac arrest: For every minute between onset of VF and administration of an electrical shock (defibrillation) survival chances decrease by approximately 10%. AED technology has advanced to highly reliable machines requiring minimal training and maintenance, allowing nonmedical personnel to provide rapid, potentially life-saving response. The steadily expanding role of chemical hygiene officers should include AEDs to augment emergency response capabilities and provide greater protection for employees and visitors.

By Jeff Rubin

The relative value of early defibrillation in reducing the interval between adult sudden cardiac arrest and first defibrillatory shock by one to two minutes does more to improve the probability of survival for an individual patient than all the medications, airway interventions, and newly designed defibrillation waveforms combined.

—American Heart Association[1]

Cardiovascular disease is the leading cause of death among adults in the United States, with 1.1 million heart attacks per year and 500,000 deaths due to coronary heart disease (occlusion of the arteries that supply blood to the heart). More than 250,000 people suffer sudden cardiac arrest—cessation of spontaneous pulse and breathing—before reaching a hospital.[2] Most of these cases happen at home, but many occur in the workplace or in public assembly areas such as airports, shopping malls, and sports or performing arts venues. Automated External Defibrillators (AEDs) are a proved method of reducing morbidity and mortality from acute myocardial infarction (heart attack). The most common initial cardiac electrical activity in adult victims of sudden, nontraumatic (i.e., not caused by catastrophic injury) cardiac arrest is ventricular fibrillation (VF, or "V-fib"), an uncoordinated quivering of the heart that does not pump blood or generate a pulse and is uniformly fatal if not treated. A metered electrical shock through the heart (defibrillation) is the treatment of choice for VF. More important, ready availability of AEDs—accessible to nonmedical personnel—is both a consensus standard of care and a national goal.[1,3] To provide a realistic chance of survival, defibrillation must be available soon after cardiac arrest: For every minute between onset of VF and defibrillation survival chances decrease by approximately 10%. AED technology has advanced to highly reliable machines requiring minimal training and maintenance, allowing AEDs to become standard emergency response equipment.

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MANAGING SUDDEN CARDIAC ARREST

Participants in cardiopulmonary resuscitation (CPR) courses learn about the four chain of survival techniques for managing sudden cardiac arrest: early access, early CPR, early defibrillation, and early advanced care.[2] In the past, non-EMS providers (e.g., police/security personnel, EHS staff, ordinary employees) were expected to provide at least the first and preferably the first two links; AEDs allow non-EMS providers to provide the first three.

Early Access

The first and most crucial link in the chain of survival is recognizing the problem as soon as possible. Bystanders (family members, coworkers, and safety and emergency response personnel) should be able to recognize signs and symptoms of heart attack, airway obstruction (choking), respiratory arrest, and cardiac arrest. Having recognized a life-threatening emergency, an individual must make a decision to act, specifically:

- Calling 9-1-1 or internal emergency number to request response from

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trained emergency medical personnel [local emergency medical services (EMS), internal emergency response team (ERT), or both].
- The person or agency receiving the call should be trained to take information on location and nature of the emergency, dispatch appropriate resources, and, ideally, provide pre-arrival instructions (e.g., CPR, rescue breathing) to possibly untrained people on the scene.
- Properly trained and equipped first responders who can arrive before local EMS and initiate at least basic life support procedures; first responders include firefighters, ERT members, or police/security officers, and possibly ordinary employees.

Early CPR

Cardiopulmonary resuscitation rarely saves adult victims of cardiac arrest by itself, but it can buy time until more definitive treatment arrives. The brain and the heart itself are particularly sensitive to interruption of circulation. Once the heart stops circulating blood, irreversible brain damage can occur in <5 min. Effective CPR can only equal 25–33% of the circulatory capacity of a healthy heart, but that is enough to extend the window of both cerebral viability and cardiac receptivity to defibrillation for a limited amount of time. In the case of pediatric patients, early and effective CPR may be directly lifesaving.

Early Defibrillation

Defibrillation is the definitive treatment for the most common initial type of sudden cardiac arrest. Simply put, the earlier the shock, the better the potential outcome. Survival rates drop by approximately 10% for each minute between arrest and defibrillation. The American Heart Association (AHA) strongly supports EMS providers being able to provide early defibrillation, defined as delivery of first shock within 5 min of EMS receipt of emergency call. Even in facilities where local EMS or fire department response can provide this, recognition of the problem and the initial call to EMS may add minutes to the overall response time. It is thus essential for onsite personnel to be able to provide at least early CPR. If onsite personnel are equipped with AEDs, they can shave minutes off the arrest-to-shock interval and potentially make a life-saving difference far greater than with CPR alone. A reduction of even a single minute in the interval between sudden cardiac arrest and delivery of the first shock is significant.[1]

Early Advanced Care

Advanced cardiac life support (ACLS) is generally provided by EMS paramedics or emergency department personnel. Although the advanced airway procedures and medications of ACLS may not save many lives by themselves, they are essential components in the escalating sequence of care in the chain of survival. If the combination of early recognition, early CPR, and early defibrillation has succeeded in restoring spontaneous pulse and respiration, ACLS can maintain that circulating cardiac activity and prevent rearrest. If the patient is still in cardiac arrest upon the arrival of advanced personnel, ACLS can make cardiac tissue more receptive to defibrillation. If there has been no treatment provided before arrival of ACLS-trained local EMS, survival chances tend to be marginal.

HOW AEDs WORK

Unlike manual defibrillators (those carried by paramedics or used in hospitals), AEDs do not require human interpretation of the presenting cardiac electrical activity, or rhythm. Potential responders who receive AED training must learn to recognize three indications in a potential defibrillation candidate: unconsciousness, apnea (no breathing), and pulselessness—the same indications for CPR. After an AED is attached to someone meeting these criteria, it analyzes the rhythm and makes an unequivocal determination: to shock or not to shock. An AED cannot determine presence or absence of pulse, breathing, or consciousness; it can only determine whether the current cardiac rhythm requires defibrillation. By comparing the actual rhythm (measured through two large electrode pads applied to the upper right and lower left of the patient's chest and connected to the machine) to a series of parameters stored in the AED's computer chip "brain," the AED will indicate that a shock (defibrillation attempt) is either recommended or not recommended. If the latter, the AED will advise the user to attend to the patient as necessary (i.e., CPR or related activity). If a shock is indicated, the AED will so advise, charge its capacitor, and direct the user to press a button to administer the shock (after visually ensuring that no one is in physical contact with the patient). Most AED protocols advise up to three sequential shocks at a time, separated by 1 min of CPR.

Public-access AEDs should be semi-automated, biphasic, and easy to use, with clear verbal and visual prompts. They should be easy to store and easy to carry, and be as maintenance-free as possible. A low-energy (≤200 J) biphasic waveform is the only type of defibrillation to receive an AHA Class IIa designation (highly recommended; good to very good evidence). Although early defibrillation itself has an AHA Class I designation (definitely recommended; excellent evidence), no other indication of waveform or energy level preference has received that designation relative to any other. Most current AED models offer a variety of settings; there is only one exclusively low-energy biphasic machine currently on the market. All modern AEDs have excellent specificity and sensitivity, better than minimum requirements for both lab and field results.[4]

ROLE OF THE CHO

The role of the CHO continues to expand. Implementation of a chemical hygiene plan includes ensuring that appropriate first aid and emergency medical care is available to employees. Basic treatment for injuries and chemical exposure is specifically mentioned in the OSHA lab standard, as is onsite availability of CPR.[5] Significant advances in technology and engineering have made AEDs safe, effective, and reliable to the point that they have been likened to fire extinguishers in their utility, ease of use, and necessity.[5–7]

A CHO may not need to directly

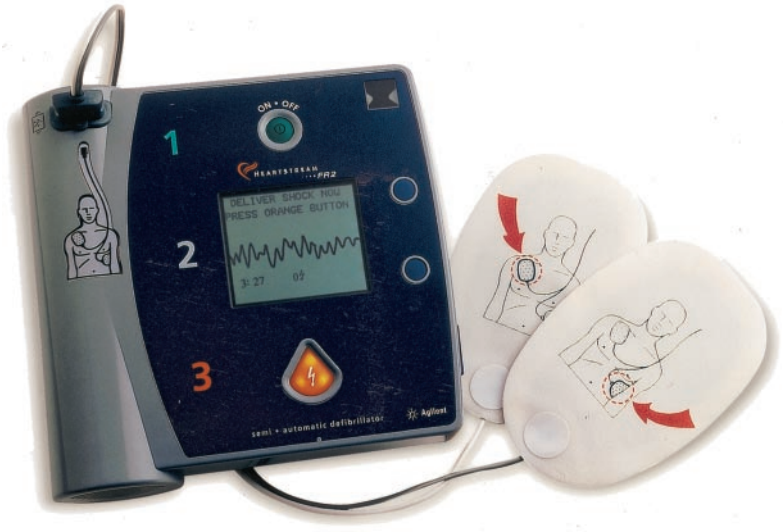

Figure 1. Portable Automatic External Defribillator.

supervise all aspects of an AED program, but AED training and availability should be seriously considered for all facilities, both for medical problems directly related to lab activities and those independent of occupation or location. In determining whether an AED program is called for, the CHO should consider the following items: needs assessment, medical direction, financial restrictions, legal concerns, training requirements, equipment maintenance, record keeping, AED placement, and quality assurance/quality improvement (QA/QI).

Needs Assessment

Recently released guidelines[1] state that public-access defibrillation capability is appropriate anywhere it is reasonable to expect one incidence of adult sudden cardiac arrest per 1000 person-years; this averages out to approximately one incident per 5 years. Basic AED needs assessment includes:

- nature of work done on premises, job-related hazards, number of employees
- local EMS, first response capability (including internal response), including effective average response time to facility
- CPR statistics (facility and community): incidence and outcomes
- scope: single facility/institution versus multiple sites.

Medical Direction

Many states require physician-approved training, formal medical standing orders approved by a physician, notification and approval of a physician or local EMS provider, or a combination of all three.[8] Medical direction can be internal [e.g., director of student health center at educational institution, corporate medical director, corporate (single- or multiple-facility) occupational medicine physician] or external (e.g., local EMS medical director, contract physician). The AHA has developed a set of guidelines for medical directors of AED programs; the publication should be available in March 2001. A recent draft of that document listed five key areas of responsibility for medical directors of Public Access Defibrillation (PAD) programs:

- Assume responsibility for all medical control aspects of the program.
- Assume responsibility for program planning and operation.
- Ensure rescuers are properly trained and their skills are maintained.
- Assist the PAD site in establishing and reviewing procedures for AED use.
- Assist the PAD site in establishing a quality improvement plan.

These general areas can be divided into two program phases, initiation and maintenance.

Program Initiation

- equipment specification
- medical protocols for AED use
- training requirements for individual providers

Program Maintenance

- assurance of appropriate equipment maintenance
- assurance of appropriate training maintenance for AED responders
- assurance of appropriate training and maintenance record keeping
- QA/QI

Financial

Costs for an AED program are almost entirely on the front end: program development, equipment purchase, and employee training. Maintenance costs (almost entirely equipment maintenance and refresher training) are considerably less. Large programs should be able to obtain purchasing contracts or at least a sizeable discount. Employee training may cost more than equipment if employee time is factored in and large numbers of employees are trained. Expendable equipment costs are minimal (generally ≤$100/year per machine). Even for a large program, one true "save" (defined as a person who was in cardiac arrest being discharged from the hospital without significant disability) over 5 years can justify the expense, even if viewed in purely financial terms. This one-save-in-5-years calculation fits in with one of the needs criteria suggested by AHA.[1] The University of Texas at Austin program[9] involving purchase of 20 AEDs and training 120 employees cost approximately $70,000. Avoiding the expense of even a brief stay in an intensive care unit and (or) payout of death benefits would more than compensate for that amount.

There is ample opportunity for cost savings, especially if the applicable

state law allows a training program other than a nationally standardized one. Either way, employers developing a training program may want to use internal instructors (employees who either already were, or are paid to become CPR/AED instructors). Internal instructors tend to pay for themselves in 1–3 years of initial and refresher training (payback interval depends on size of program; more trainees tends to mean quicker payback).

Legal Considerations

Although technology had outpaced tort laws for several years, 49 states (all but Maine) have enacted laws that specifically address liability issues related to AED use.[8] An increasingly common view[6,10] is that potential liability for lack of AED availability will soon exceed that for having and using AEDs. Although laws vary from state to state, most afford Good Samaritan protection to AED providers (both individually and institutionally), whether public-safety responders or laypeople trained in CPR and AED use but without other medical certification or license. State laws tend to address some combination of the following: medical direction and medical protocols, approved training for laypeople, liability protection for manufacturers as well as providers, and maintenance and record-keeping standards. In general, a specific agency—commonly the state health department—is designated to establish specific rules and guidelines, which vary from state to state.

Training

Depending on state law, training may require physician approval. Nationally standardized CPR and AED courses such as those offered by the AHA[7] and the American Red Cross[11] are acceptable in all 49 states with AED laws. Some states allow physician discretion in developing internal training programs.[12] Regardless of the training provider, training considerations include:

- recognition and assessment skills
- scenario-based decision-making evaluation; "no-shock" scenarios are essential (including pediatric patients where appropriate to the location)
- acceptable minimum trainee numbers, to be determined in advance
- appropriate staff identified by function, location, and work hours
- tiered training that may be best for large workforces or large workspaces. An effective response is possible if numerous employees are trained in CPR and fewer in CPR and AED use, especially if an AED and trained user can reach the patient in 2–3 min.
- *all* staff should know general emergency procedures and AED location(s).

Maintenance

Most modern AEDs require little actual maintenance, but they are still FDA-approved medical equipment and thus require regular checks. Daily or weekly checks can be instituted consisting of battery status, presence and expiration dates of ancillary equipment, and equipment self-tests (the last of which is performed automatically by the Heartstream AED recommended in this proposal). Equipment checks provide a useful way to maintain staff familiarity with the equipment and its location, as well as upkeep with perishable and expendable supplies. Currently implemented battery technology obviates the need for (re)charging and even annual battery changes in some models.

Record Keeping

What would a safety program be without records? FDA regulations mandate that regular checks be performed and documented. Maintenance records should include equipment checks, any problems, and actual use. Training records should include dates and evidence of successful completion of initial and refresher training. These records can serve as prompts for refresher training as well. Maintenance records should include equipment checks, any problems, and actual use. Internal audits may be desirable to assess record keeping and employee preparedness.

AED Placement

One of the most important decisions is where AEDs will go. Funds may be limited, but unless there is a preexisting determination of total number of AEDs to be deployed (not a recommended method), location and response profile should determine total AED count. Although every facility is different, there are some generally desirable locations, including health centers and/or first aid stations, and security/reception desks. Locations that are high risk owing to either employee and/or visitor profile (e.g., visitor centers, meeting/conference facilities) or activity profile (e.g., electrical utilities, machine shops, gyms) may also be appropriate. On-site police/security personnel may be tasked with carrying AEDs in vehicles and responding with them throughout a facility or campus; this provides an excellent umbrella and may be all that some sites require for effective coverage. Occupational health staff, safety personnel, internal police/security, emergency response teams, and others with an existing duty to respond are logical, even preferable[1] choices for AED trainees, but ordinary facility staff, research, administrative, or supervisory, are appropriate as well.

QA/QI

Modern AEDs are equipped with cassette tapes, personal computer memory (i.e., PCMCIA) cards, or flash cards that record machine readings, shocks delivered, and verbal input from rescuers and bystanders. Software provided by manufacturers (generally free and Internet based) allows for any user to download and interpret machine readings, but this is best left to the medical director or a medical designee. An active QA/QI program is essential for an effective AED program: updating training, protocols, and ultimate outcomes depend on meaningful evaluation of response data.

RECOMMENDATIONS

Chemical hygiene officers should consider implementing AED response programs in their facilities. Aside from the obvious benefits of enhanced em-

ployee protection and potential positive public relations, AED programs can be justified medically, financially, and incur little if any additional liability. Desirable AED features include: semiautomated format, biphasic waveform, low-energy output, ease of use, transport, and storage, low maintenance, and compatibility with preexisting equipment and (or) that of local EMS provider(s). The process should be initiated by consultations with: local EMS provider(s), internal medical personnel, internal security personnel, internal EHS personnel, and executive officers and corporate legal authorities. Such consultation is not only necessary to establish a successful program, but it establishes and strengthens liaisons that are crucial for an AED program and effective safety and emergency response.

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12. Austin/Travis County Emergency Medical Services. AED training program, 2000.

AED RESOURCES

Policies and Information

National Center for Early Defibrillation (University of Pittsburgh Medical Center). http://www.early-defib.org. 2000.

Public Access Defibrillation League. http://www.padl.org/index.html. 2000.

AED Manufacturer Web Sites

Agilent Technologies (Heartstream Division): http://www.healthcare.agilent.com/mpgcpd/heartstream/index.html

Chain of Survival home page (Agilent Technologies and Laerdal Medical Corporation): http://www.chainofsurvival.com/

Laerdal Medical Corporation: http://www.laerdal.com

Medical Research Laboratories, Inc.: http://www.mrlinc.com

Medtronic Physio Control: http://www.physiocontrol.com/home.html

Survivalink: http://www.survivalink.com/home.html

Zoll Corporation: http://www.zoll.com/products.htm