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Review

The introduction of public access defibrillation to a university community: The University of Virginia Public Access Defibrillation Program

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Abstract The use of the automatic external defibrillator (AED) can significantly reduce the time to defibrillation in patients with sudden cardiac death. This early defibrillation via the AED can also improve patient outcome, including survival and neurologic status among survivors. We undertook the addition of a public access defibrillation program at a large mid-Atlantic university. In our design of the system, we found little useful information to guide us in the development and construction our system. This article is a review of the process of public access defibrillation AED system development such that other medical and academic leaders at similar institutions can more easily develop such systems.

1. Introduction

Despite decades of research, education, and the flourishing of a vast array of treatment options, cardiovascular disease (CVD) in its many variations continues to be the most common cause of death in the United States. It accounts for 1 of every 2.8 deaths in the United States, with an average of 1 death occurring every 37 seconds. More lives are claimed each year by CVD than cancer, accidental trauma, respiratory disease, and diabetes mellitus combined [1]. One particularly troubling aspect of CVD is sudden death resulting from cardiovascular events.

Sudden death may occur for a range of reasons, including medical and traumatic. Of the medical events, cardiac etiologies represent the most frequently encountered cause (Fig. 1); in fact, 75% of sudden death events are related to cardiac etiologies [2]. In this setting, acute dysrhythmias are common, whether they represent the primary event (eg, sudden ventricular fibrillation [VF]) or a secondary process related to the primary event (eg, acute pulmonary edema with progressive hypoxemia and resultant cardiac arrest). In those patients with sudden, unexpected death involving a dysrhythmia, the presentation is most appropriately termed *sudden cardiac death*. The term *cardiac arrest* can be applied to this population as well as to patients with cardiorespiratory arrest occurring because of traumatic injury, metabolic disorder, massive ingestion, etc.

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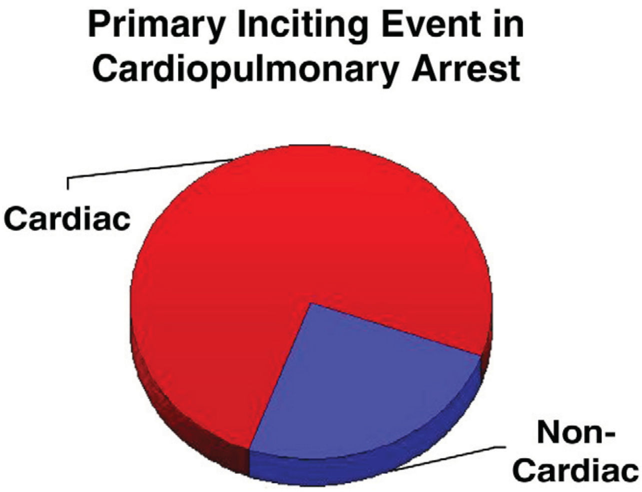

Fig. 1 Sudden death may occur for a range of reasons, including medical and traumatic. Of the medical events, cardiac etiologies represent the most frequently encountered cause, with 75% of sudden death events related to cardiac etiologies.

2. The approach to out-of-hospital cardiac arrest

In the out-of-hospital setting, therapeutic interventions in cardiac arrest range from the simple to the complex (Table 1), involving a range of providers, abilities, and equipment. The initial and subsequent personnel involved in the resuscitation can include any combination of the lay public, security officials, law enforcement officers, emergency medical systems (EMS) technicians, and health care providers. The medical abilities of these various persons range from minimal to maximal, and the available equipment also ranges from none to a full resuscitation kit. In simple interventions, "basic life support" includes the call for help (activating the emergency system, most often by calling 911), bystander cardiopulmonary resuscitation (CPR; either compression only or traditional CPR), and use of the automatic external defibrillator (AED)—these interventions are usually performed by the event bystander and/or early trained responders. More complex interventions ("advanced cardiac life support" measures) include medical care provided by adequately trained prehospital personnel. Such therapies frequently involve intravenous fluids and medications, invasive airway management, and additional electrical therapies (defibrillation of unstable cardiac arrhythmias and cardiac pacing).

The dominant paradigm for management of sudden cardiac death over the past 4 decades, starting with the original 1974 American Heart Association (AHA) guidelines for CPR [3], posited that the greatest chance of survival in cardiac arrest lay with more complex therapeutic interventions—involving not only the lay public but also medical personnel. As so often happens in science and medicine, however, this paradigm proved to be flawed. For instance, the Ontario Pre-hospital Advanced Life Support investigators set out to determine whether the advanced cardiac life support paradigm provided a survival benefit in out-of-hospital cardiac arrest patients [4]. Surprisingly, the study found that basic maneuvers (emergency system activation, CPR, and early defibrillation) had a greater positive impact on survival than more advanced maneuvers (parenteral access, administration of cardioactive medications, and placement of invasive airways). For instance, early activation of the public emergency response system (ie, calling 911) was associated with an adjusted odds ratio favoring survival of 4.4 (confidence interval [CI], 3.1-6.4); additional basic interventions demonstrated similar favorable odds ratios, including the performance of bystander CPR (3.7 [CI, 2.5-5.4]) and early defibrillation (3.4 [CI, 1.4-8.4]). Conversely, more complex interventions, such as advanced life support, demonstrated a markedly less impressive impact on survival—in fact, the adjusted odds ratio for survival with respect to advanced life support therapy was 1.1 (CI, 0.8-1.5; Fig. 2) [4]. In a more basic analysis, Mitchell and colleagues

Table 1 Therapeutic interventions in cardiac arrest range from the simple to the complex

Basic—potentially provided by both lay & trained rescuers (nonmedical & EMS personnel)
- Activation of the emergency response team (ie, local internal team and/or public safety with police, fire, & EMS)
- Some form of CPR
- Application & appropriate use of the AED

Complex—provided by trained rescuers (EMS personnel)
- Intravenous/intraosseous access
- Cardioactive medication administration
- Airway management (noninvasive & invasive)
- Advanced electrical therapies (defibrillation & cardiac pacing)

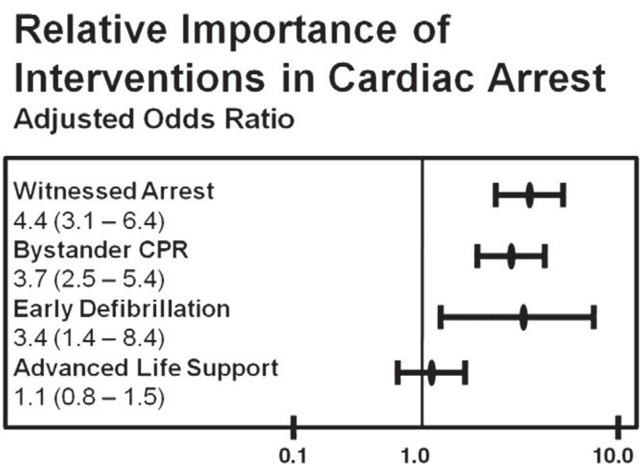

Fig. 2 Relative importance of interventions in out-of-hospital cardiac arrest. Note that odds ratios greater than 1.0 suggest that the intervention is associated with a greater chance of survival, whereas odds ratios less than 1.0 suggest that the intervention is associated with a lower chance of survival; an odds ratio of 1.0 suggests that the intervention does not impact outcome.

[5] compared the outcome of out-of-hospital cardiac arrest between 2 EMS systems: Milwaukee in the United States and Edinburgh in Scotland. In this evaluation, the authors found that survival to discharge was higher in the Scottish system using a "more basic" approach—CPR, electrical defibrillation, and airway management—compared with the "more complex" interventions in the North American model—the above intervention plus parenteral medications. These 2 studies suggest that basic therapies rather than advanced intervention are associated with a significantly improved cardiac arrest survival. The AHA, in fact, has placed just such an emphasis on out-of-hospital cardiac arrest—the optimization of early system activation coupled with bystander CPR and early defibrillation via an AED [6].

3. Portable, external cardiac defibrillators

The dysrhythmias seen initially in the out-of-hospital cardiac arrest presentation include 3 basic groups (Fig. 3) and involve a range of ultimate causes. One category involves rhythms that are not initially managed with electrical defibrillation: *asystole* and *pulseless electrical activity*. These rhythms are frequently encountered in cardiac arrest scenarios and are associated with extremely poor ultimate outcomes. The other categories include *pulseless ventricular tachycardia* and *VF,* which represent forms of malignant ventricular dysrhythmias that are most appropriately managed with some form of CPR and early defibrillation; note that the use of the external defibrillator is the primary therapy in this latter cardiac arrest rhythm setting.

The development of the portable, external defibrillator in 1979 by Diack and colleagues [7] introduced a new and very valuable therapy to the care of victims of cardiac arrest. Diack and colleagues recognized the potential for this lifesaving therapy, which could enable a significant time reduction in bringing defibrillation to the patient before hospital

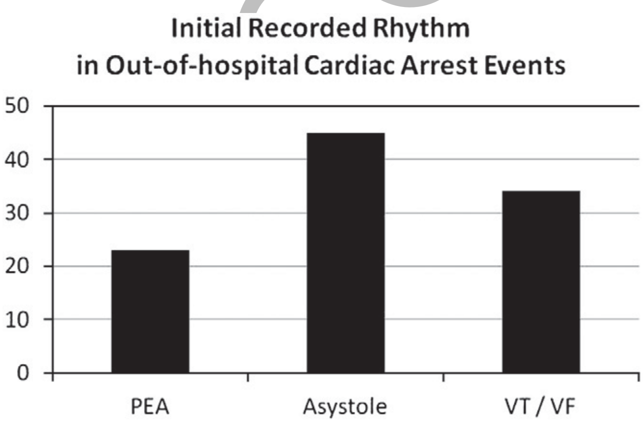

Fig. 3 The dysrhythmias seen initially in the out-of-hospital cardiac arrest presentation include 3 basic groups: pulseless electrical activity (PEA), asystole, and pulseless ventricular tachycardia (VT)/VF.

arrival. Since then, additional refinements in defibrillator technology have produced a unit that is compact, lightweight, easily applied, and very safe. And yet, nearly 30 years later, external defibrillation is infrequently used in out-of-hospital cardiac arrest. In fact, a 2002 study demonstrated that only 2.05% of lay responders used a defibrillator after witnessing an out-of-hospital cardiac arrest [8].

The AHA defines an *automatic external defibrillator* as a computerized medical device that can efficiently analyze the heart rhythm of an individual and advise the provider if an electrical defibrillation is required. The device uses clear voice prompts to direct the rescuer's actions, with the rescuer having to make the final action to deliver the shock by pressing a button. These devices are extremely accurate in rhythm recognition and quite simple to use. Furthermore, they have demonstrated that anyone can learn to operate an AED and thus provide lifesaving treatment to a sudden cardiac arrest victim in the time-critical minutes before local public safety units (eg, police, fire, and EMS) arrive. Indeed, Valenzuela and colleagues [9] demonstrated improved survival in witnessed cardiac arrest in a study done in the Las Vegas gaming casinos. The authors reported that security officers were trained to operate AEDs and the devices were strategically placed at approximately 3-minute walking distance intervals within the casino. These non-medical personnel responded to 105 VF arrests, with 54% surviving to discharge. The average time from witnessed collapse to defibrillation was 4.4 minutes, whereas the EMS required on average 9.8 minutes to arrive at the scene. The authors concluded that successful use of AEDs by non-medical personnel in response to VF is possible but that the time between collapse and defibrillation is the key to survival. Similarly, Caffrey et al [10] were able to demonstrate that effective placement of AEDs in the Chicago airport system (O'Hare and Midway airports) led to effective resuscitation of patients with witnessed VF arrest by untrained lay bystanders. Other investigators have found similar results [11].

Increased effort should be expended in this area, focusing not only on the widespread placement of AEDs in public access fashion but also on educational programs stressing the importance of CPR and early defibrillation using the AED. The placement of AEDs in public locations, ranging from early adopters such as airports and gambling casinos to more recent additions including schools, health clubs, hotels, and office buildings, has increased access to rapid defibrillation by lay providers with an associated improvement in survival.

4. Public access defibrillation programs using the AED

Public access defibrillation (PAD) is defined as AED availability to the individual in cardiac arrest in a non–

patient care area. This PAD application of the AED is made by a provider who is trained in CPR and AED use; this rescuer can be a health care provider or a member of the lay public. It is important to note that numerous reports are found in the lay and medical press detailing untrained, lay provider use of the PAD AED in successful resuscitations with ultimately favorable outcomes. As a result of this simple yet effective device, lay providers are of significant importance in the "chain of survival" [12] concept during out-of-hospital cardiac arrest. Automatic external defibrillators broaden the range of responders who can use a defibrillator and thereby markedly reduce the time between a witnessed collapse and electrical defibrillation that is associated with higher rates of survival [4]. Consequently, the AHA now recommends that these devices be placed in high-density areas such as airports, casinos, shopping malls, and major sporting venues, among many other venues and locales [13]. The AED should not be considered an alternative to first responder care. It is, however, an adjunct device that can increase the patient's survival odds through the timely intervention of lay bystanders. Automatic external defibrillators have become an integral component of basic life support to be used in concert with CPR and early EMS response systems.

Public access to defibrillation involves lay rescuers and has the best potential to impact survival from sudden cardiac death. Public access defibrillation programs are likely to increase the number of cardiac arrest victims who receive CPR from witnesses and will also likely reduce time to defibrillation. Since 1995, the AHA has recommended that these programs be encouraged and expanded, with emphasis being placed on training, planning, CPR practice and AED use, and ongoing program improvement [14]. The main objective of these programs is to decrease the time between cardiac arrest and the initiation of CPR with AED shock delivery. Success for these programs involves maximizing the impact of AEDs through strategic placement in public areas and continued coordination with the EMS system [15]. In addition, for PAD programs to be the most efficient, frequent awareness campaigns, refresher courses, and practice sessions are encouraged.

A closely related system of response for the AED is the targeted first responder method. In this application of the AED, targeted first responders include the police and fire personnel who have less medical training but are often the first to arrive during emergencies. For instances, a recent report describes the significant clinical utility of the targeted first responder AED application. White et al [16] report that, over a 13-year period, firefighters and police officers in Rochester, MN, were trained and given AEDs to use in the field. During that time, 41% of patients who presented in VF were eventually discharged from the hospital with intact central nervous system function. Such demonstrated success could be translated to other communities nationwide through similar initiatives, and so the AHA recommends the use of AEDs by all targeted first responders.

The medical literature supporting the use of the AED is robust; furthermore, it is both very supportive and quite convincing of the AED concept in the public arena, used by both lay providers as well as trained responders. Multiple studies have been conducted to illustrate the effectiveness of not only the AED itself, but also the various systems of response. One early application of the PAD model was the use of AEDs on airlines and in airports. In a study published by O'Rourke et al [17] in 1997, cardiac arrests occurring on international flights and in airport terminals were evaluated. Over a 5-year period, there were 109 AED applications with 46 victims receiving defibrillatory shocks. On the flights, 59% of events were witnessed; but 78% had non-VF rhythms. In the terminals, 100% of cardiac arrests were witnessed, with 89% in VF. Defibrillation was initially successful in 91% of cases, with long-term survival of 26%. Several years later, AED programs were established at the Chicago-area airports with 33 AEDs placed at O'Hare and 7 at Midway. Over the course of the study, 16 arrests occurred, 13 presented in VF, and 69% survived. As a result of the success in Chicago, the program was replicated in other airports, with Boston Logan having a 21% survival and Los Angeles a 26% survival [10]. As noted above, other early adopters of the PAD use of the AED were the Las Vegas gaming casinos who demonstrated very impressive results with regards resuscitation of cardiac arrest.

In 2003, Nichol and colleagues [11] conducted an important investigation into the cost impact of lay AED use as compared with EMS application of the AED. These researchers concluded that the public application of AEDs, that is, the PAD model, was cost-effective when cardiac arrests were frequent in a particular locale and likely to be discovered by a lay bystander. This study assisted greatly with the practical question of AED placement location. Another study evaluating the cost-effectiveness of PAD AED, the Ontario Prehospital Advanced Life Support Study, defined the cost-effectiveness of PAD AED programs. In this study, they found that patients receiving early defibrillation by PAD lay providers increased from 76.7% to 92.5%, whereas survival to discharge improved from 3.9% to 5.2%. The subsequent impact was easily apparent with 21 additional lives being saved each year as a result of the PAD AED use. The cost of establishing a PAD program in the communities involved was $46 900 per life saved with a cost of $2400 per life saved to maintain the program [18].

The Public Access Defibrillation Trial Investigators conducted a prospective, community-based, multicenter clinical trial that was published in 2004. The study involved randomly assigned community units with lay volunteers trained in either CPR or CPR/AED. Of the victims attended by rescuers using CPR only, 15 of 107 survived to discharge. In comparison, 30 of 128 victims who received both AED and CPR survived to discharge. Victims who survived to discharge showed no difference in functional status, and the victims received no inappropriate shocks by the AED [19]. It has thus become apparent through various studies involving both targeted first responders and PAD programs in communities, airlines, and casinos that AEDs are an effective and efficient resource that should rightfully be integrated more thoroughly into public areas nationwide.

5. Establishing PAD programs in a university setting

5.1. Institutional leadership approval and support

In establishing a PAD program, the single most important factor in determining the success or failure of such an initiative is the early endorsement of institutional leadership (Table 2). Enlisting the assistance of senior leaders is of vital importance not only with respect to program funding but also concerning acceptance by the members of the university community. The University of Virginia (UVa) itself is a very large educational facility with respect to geography; it also allows significant functional autonomy among the various schools and programs. Senior leadership endorsement makes any new program seem less optional because there is underlying pressure to agree to be involved. To that end, the vast majority of schools, centers, and areas of the university opted to be included in the program. Therefore, having a foundation of institutional leadership approval and support provides an excellent, and truly necessary, springboard for developing PAD programs.

5.2. Personnel

To properly initiate and develop a PAD program, a particular organizational leadership structure is advised. The necessary positions include medical director, program coordinator, local site AED coordinators, and CPR/AED training facilitator. The medical director is a physician responsible for medical oversight and quality control. Medical direction increases the likelihood of proper AED deployment, decreases institutional liability, assists in the standardization of devices, improves quality assurance in materials and training, increases confidence in equipment function, and reinforces adherence to procurement guidelines. In addition, having a program supported and directed by a medical professional will inspire confidence in the program, as he or she will serve as an advocate and possibly a spokesperson for the program. The program coordinator is responsible for the daily activities of the program and serves as a communication link among key decision-makers, those involved in the PAD program, and the public. The local site AED coordinators are university faculty and/or staff who have been assigned to locally manage specific AEDs in the program; this person should be someone who works in an adjacent area to an individual AED site. The training facilitator is responsible for the training and education of the required number of volunteers per AED.

Table 2 Considerations in the development of a university-based PAD program

- University leadership involvement with active support
- Program funding
- Availability of appropriate personnel (coordinator, medical director, trainer, local site coordinator)
- Centralized program management
- Medical coordination and oversight
- Strategic placement of AED units with consistent methodology
- Awareness of local site issues (daily building function, artistic and historical considerations)
- Consistent AED type throughout system
- Quality assurance and debriefing
- Awareness of local and regional public safety agencies

5.3. Phases of development

The implementation of a PAD program at a large university is a complicated process that is best served being subdivided into multiple phases. At UVa, 3 major phases were developed to best serve the community in a timely and orderly fashion.

Phase 1: introduction of the AED to the university police force with a targeted first responder application.
Phase 2: determination of preexisting AEDs at the UVa with development of a centralized program coordination and medical oversight.
Phase 3: placement of AEDs in priority areas that were not covered by the preexisting units as noted in phase 2.

The initial phase developed a core of targeted first responders involving the use of AEDs by the University Police Department. This group was chosen to roll out AED implementation because officers are already trained in AED use and for their breadth of university grounds' coverage with the potential for an extremely rapid response in all instances.

The second phase of the PAD program focused on the determination of preexisting AEDs at the UVa with development of a centralized program coordination and medical oversight. This phase included information gathering and organizational development of AEDs already placed throughout the university grounds before the development of the UVa PAD program. In any large entity, it is certainly possible that there are often ongoing, uncoordinated smaller AED programs; thus, it was important to determine where these devices were already in place. In August 2006, a survey was conducted throughout the university via e-mail to determine where AEDs were located on university grounds. The survey focused on not only the location of preexisting units, but also the unit models, types of training provided for their use, and monitoring frequency. One hundred twentyseven responses were received; and subsequent analysis of survey data revealed potential areas of improvement with regards existing AED placement, practice, coverage, and training, including the following:

1. Varied AED types: Independent procurement of AEDs led to a variety of makes and models throughout the university. As a result, an individual who is trained to use an AED in one location might not be familiar with another model.
2. Nonstrategic placement of AEDs: The survey also brought to attention that devices were not located in some of the most highly trafficked and highest-risk buildings.
3. Lack of medical oversight and central coordination of the system: Of the buildings in which AEDs were present, most lacked a central coordinator, medical oversight, or training program.

In phase 2, we determined that the university required a single, coordinated program for these devices, including central coordination with medical oversight, standardized AED unit type, planned strategic placement of the AEDs at various sites, unit monitoring, and quality reviews.

Once the AEDs already present on university grounds were successfully integrated into a single program, the third phase of the PAD program was begun. The implementation phase involved prioritizing university buildings and the strategic placement of additional AEDs. Criteria used to determine AED placement included (1) local site interest in the program, (2) increased proportion of at-risk population in the immediate area, and (3) limited or difficult access to public safety responders. The implementation phase, phase 3, remains an ongoing process of expansion, while also maintaining and replacing AEDs already in service. Furthermore, offices that desire to purchase AED units in the future (apart from primary locations in which the university chose to place a unit) now have guidelines and assistance for locating and positioning the unit within their building.

5.4. Site selection

Selecting specific university buildings for the placement of AEDs during the final phase of the PAD program involved 3 main criteria and multiple additional considerations (Table 3). Priority consideration was given to areas with high foot traffic volume, areas with larger numbers of at-risk individuals, and areas with difficult emergency responder access. Once the buildings themselves were selected, the process of identifying specific sites within the building to place the AEDs began. Site visits were conducted to determine the best location and number of AEDs for placement within each building. Building functionality played a large role in specific site selection. Working with individual people experienced with the specific building dynamic (ie, workers, facility coordinators, etc) assisted significantly in determining where people congregate and identifying high-traffic areas. We felt that AEDs should be placed in public areas that are accessible at all times of building operation; importantly, we felt that AEDs should not be placed in offices or parts of the building that will be locked and inaccessible at certain periods of building operation (eg, night and/or weekends). Finally, the AEDs should be placed in a highly visible location that is not obstructive and does not interrupt building flow. Ideally, the AED should be placed where the local workers and the public will regularly see it; think about it; and, as a result, know where to get it if the need arises. Some buildings may need more than one AED. This should be checked by physically testing whether a rescuer can go from the victim to the AED and back within 3 minutes. If this is found to be impossible, an additional AED was considered for that area of the building.

Table 3 Methodology and considerations for AED site placement—strategic site placement

Overall site considerations
■ High volume of persons.
■ Significant presence of at-risk individuals.
■ Potentially difficult or delayed access of public safety responders.
Site-specific considerations
■ Located within an approximate 3-min "foot response" area
■ Artistic and historical concerns
■ Nonobstructive to building function
■ Clearly visible to all patrons of building
■ Easily accessed by all patrons of building
■ Located adjacent to other "emergency equipment" (ie, fire extinguisher and fire pull alarms)

The process of determining where to place purchased AEDs, while seemingly straightforward, can require some persuasion and often negotiation, as unit placement may effect historical preservation and/or have a negative artistic impact. Coordinated considerations of AED placement addressed these important concerns. In fact, historical preservation was a major concern in some of the oldest university buildings; however, a willingness to work with architects and other building leaders prevented difficulties. In other buildings, there were concerns about the potential negative artistic impact of the AED unit. Concerns included the fear that the AED would be a distraction, worries about the size and color of the device, and general anxiety for making the building unattractive. Aesthetic concerns should not be underestimated. The use of model AEDs and cabinets, demonstrated to the building leaders, addressed most such concerns. In addition, building coordinators could often be further persuaded by using public relations arguments and explaining how the AED is a lifesaving device and a genuine service to their patrons. Fig. 4 illustrates the typical appearance of the AED cabinet and the unit itself.

Fig. 4 University of Virginia AED cabinet and AED unit. Photograph courtesy of William J Brady, IV.

5.5. Local site responsibilities

The local site AED coordinator is responsible for the regular checking and maintenance of each AED. The coordinator's responsibilities include a daily determination of the AED's continued presence, weekly checks regarding functional status, and monthly checks of the battery and pads. The overall appearance of each unit should also be monitored for vandalism. Each site coordinator is also accountable for monitoring training needs for building personnel and also serves as a liaison to the medical director and program coordinator. The local site AED coordinator is vital to the success of the PAD program, as his or her responsibilities ensure the proper functioning and readiness of the devices for emergencies.

5.6. Integration with local public safety agencies

Local public safety agencies, including police, fire, and EMS entities, were made aware of all phases of the plan. Furthermore, they were informed of the various AED locations and the specific type of unit such that equipment compatibility could be addressed prospectively.

6. Medicolegal issues

Medicolegal issues are a very important portion of PAD consideration for all parties involved. In fact, concern for liability is the most frequent stated reason for both individual rescuers as well as various owner-leaders to avoid involvement in such events and programs. Such concerns must be considered from several different perspectives, including the individual rescuer, the "owner" of the AED and location of the unit, the AED coordinator/trainer, and the medical director. All states in the United States have some form of "Good Samaritan" legislative protection. The reader is referred to the AHA's resource entitled *American Heart Association: AED Legislation—Good Samaritan* [20]. Medicolegal specifics vary from state to state, yet the common theme is protection from legal liability for a rescuer who uses an AED in attempted appropriate fashion without "gross negligence or willful and wanton misconduct." Furthermore, the National Cardiac Arrest Survival Act provides legal protection for the rescuer; this act was initially intended to offer immunity from liability for individuals in states without Good Samaritan legislation. Now, with all states offering such protection, it is unclear what additional protection, if any, is offered by this act; any additional protection is dependent on court interpretation. Nonetheless, Good Samaritan protection is now present in all 50 states of the United States, removing medicolegal concerns for personal liability as a reason to avoid lay provider resuscitation assistance in the critical early minutes of cardiac arrest [20,21].

Legal concerns certainly impact owner-leader decision-making with regard to implementation of a PAD program. Appropriate concerns range from proper AED use and lay provider training to lack or improper application in an event. Again, these concerns are all appropriate. Unfortunately, Good Samaritan legislation is less robust in this form of legal protection for the "acquirer and enabler" of a program. In fact, the AHA reports that 39 of the 50 states offer some form of liability protection to the acquirer and enabler of an AED program with respect to acts of commission (ie, alleged negative events resulting from a provided AED unit during a resuscitation attempt) [20]. Many such owner-leaders consider only liability concerns from acts of commission. This rather short-sighted view does not regard the lack of AED presence as a potential source of civil liability exposure. For instance, the owner-leader may, in fact, place the entity in more legal jeopardy by not providing an AED for use by staff and visitors.

Automatic external defibrillator program coordinators and medical directors, similar to the "acquirer and enabler of a PAD project," experience variable protection from civil prosecution from state to state [20].

In this and other legal considerations, the involved person (the individual rescuer, owner-leader, program coordinator, and medical director) should consult his or her legal counsel for advice and guidance in this important area of PAD implementation and operation.

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