Invited Review

Public access defibrillation: improving accessibility and outcomes

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Abstract

Background: Worldwide, out-of-hospital cardiac arrest (OHCA) remains a serious problem. Public access defibrillation (PAD) has been shown to be effective in improving survival in OHCA with good neurological outcome.

Sources of data: Original articles, reviews and national/international guidelines.

Areas of agreement: Limitations to how much we can improve ambulance response times mean that the public have an essential role to play in OHCA survival. Training of laypersons in the use of automated external defibrillators (AEDs) has been shown to improve outcomes. Placement of AEDs should be related to underlying population demographics.

Areas of controversy: Placements of AEDs face cost constraints. PAD programs also face challenges in the upkeep of AEDs. Concerns about legal liability for lay rescuers to act remain.

Growing Points: Systematic programs should be in place to train the public in PAD. All AEDs should be listed in national registries and available for usage in an emergency.

Areas timely for developing research: ‘Smart’ technology is being developed to improve accessibility of AEDs.

Key words: public access defibrillation, automated external defibrillator, placement, out-of-hospital cardiac arrest
Introduction/Background

Out-of-hospital cardiac arrests (OHCAs) affect up to 700,000 individuals in Europe each year and >300,000 people in the USA each year. Yet survival rates vary drastically between communities. The difference in survival rates has been attributed to a variety of reasons including but not limited to differences in CPR rates by first responders, defibrillation times, Emergency Medical Services (EMS) response times and cardiac interventions in hospital.

Following cardiac arrest, brain death is known to be time dependent. The effectiveness of defibrillation diminishes with each passing minute (Fig. 1). The public have an important role to play in increasing survival rates. Early CPR and early defibrillation prior to the arrival of EMS have been shown to be effective in improving survival in OHCAs with good neurological outcome. The American Heart Association (AHA) explains what public access defibrillation (PAD) means: ‘Public access to defibrillation means making AEDs available in public and/or private places where large numbers of people gather or where people who are high risk for heart attacks live’.

This article will focus on the topic of PAD and how we can make it work better for witnessed OHCAs.

Current evidence for the effectiveness of public access defibrillation

Limitation in improvement of EMS response times

Every minute of delay until defibrillation causes 9% decrease in neurologically intact survival. This is an indication of how important prompt implementation of defibrillation is, rather than who performs the defibrillation. There have been real difficulties in reducing the time from patient collapse to defibrillation by EMS. Furthermore, a study funded by the Department of Health of the United Kingdom (UK) found that reducing ambulance times across the board to save lives did not represent a cost-effective policy. The UK also has reported a steady decline in achieving their target of 8 min mean EMS response time for life-threatening emergencies (69% in July 14 compared with 77% in July 11). This was partly attributed to increased demand on ambulance services. Ong et al. showed that the mean EMS response time in Singapore was 9.6 min, making bystander PAD an essential link to be developed in the chain of survival. Numerous studies have found that early defibrillation, irrespective of the defibrillation provider, was associated with neurologically favorable outcomes. Ringh et al. showed that public automated external defibrillator (AED) defibrillation had higher survival rates compared with defibrillation by EMS; this was most likely attributable to a much shorter time to defibrillation.

The need for willing laypersons at scene

The success of the actions of rescuers at the scene of an OHCA is time critical, and victims have a higher chance of survival if the first shock is delivered by a bystander using an AED before the arrival of EMS. For this to occur, large numbers of laypersons need to be trained in CPR and the use of an AED. Studies have shown that solely installing public access AEDs without an emphasis on CPR does not improve the rate of
survival after OHCAs.\textsuperscript{16,17} Without available trained laypersons, the heavy investment into public AEDs may go without returns with a distinct risk these AEDs turn into ‘white elephants’.

**Difficulties encountered by public responders**

Using an AED and performing CPR can be a challenge for laypersons.\textsuperscript{18} During an intensive intervention PAD trial by Hazinski \textit{et al.} where 20,000 volunteers underwent frequent re-training and refresher drills, CPR rates were only 50\% and frequency of shock administered by PAD was only 7\%. The caveat is that most trials\textsuperscript{7,18} do not document the times when an AED was applied or used. It has been postulated that familiarity with the use of an AED, along with increased dissemination of public access AEDs, might promote a willingness to use an AED and a positive attitude toward CPR.\textsuperscript{19}

**Statewide and nation-wide training of laypersons can succeed**

Following statewide and nation-wide educational interventions in resuscitation training, the proportion of patients receiving bystander CPR and defibrillation increased substantially in both North Carolina\textsuperscript{20} and Japan\textsuperscript{21} with a corresponding increased odds of neurologically intact survival. There is a need to simplify and focus public training on CPR with AEDs to increase penetration. Simplified training programs have been shown to reach a larger audience and are more likely to succeed.\textsuperscript{22} The British Heart Foundation ‘Nation of Lifesavers – Call, Push, Rescue’ program, the PUSH project from Osaka and the DARE program from Singapore are three such examples of simplified training programs focusing on teaching of compression-only CPR and AED.

**AEDs can be used safely by trained laypersons**

AEDs can be used safely and effectively by trained laypersons.\textsuperscript{4} The Hallstrom trial also demonstrated that survival doubled when events occurred in communities equipped and trained with CPR and AEDs compared with CPR alone. In the study by Hazinski \textit{et al.}\textsuperscript{18} involving lay rescuers, no inappropriate shocks were given out of 239 OHCAs with attempted resuscitation. The reported adverse events includes stolen AEDs and transient psychological stress among rescuers. In a recently published trial, Ringh \textit{et al.}\textsuperscript{9} demonstrated similar findings: PADs increased the survival rate in Stockholm significantly more compared with CPR alone. The patients who survived following defibrillation achieved very good neurological outcomes—at the 1-month mark, 93\% of them were classified in cerebral performance Categories 1 or 2. These findings echo those of Kitamura \textit{et al.}\textsuperscript{7} 84.5\% of patients in Japan who had a first shock from public access AEDs followed by a return of spontaneous circulation (ROSC) achieved good neurological outcome at the 1-month mark. PAD has a clear role to play in saving lives.

**Shortcomings of available evidence**

Many of the studies quoted\textsuperscript{7,9,14,20–22} examine temporal trends and are subject to confounding factors. Currently, there is a lack of comparative studies showing a statistically significant effect of the provision of static AED programs versus no intervention.

**Placement strategies in the urban setting**

**The cost of AEDs**

Cost is known to be a barrier to dissemination of AEDs.\textsuperscript{23} AEDs are not inexpensive with each unit estimated to cost USD $2000\textsuperscript{16} and having an estimated shelf-life of 10 years. Maintenance and usage costs, such as battery and pad replacement, also add to the total cost of an AED. Partly due to a lack of AEDs in public areas, PAD is successfully deployed in <2\% of OHCAs.\textsuperscript{24}

**The evolution of guidelines**

Historically, placement of AEDs has been a subject of debate. The European Resuscitation Council (ERC) used to recommend placing an AED in sites with an
expectation of a cardiac arrest every 2 years while the AHA guidelines state that AEDs should be placed where the frequency of cardiac arrest events is such that there is a reasonable probability of one AED use in 5 years (estimated event rate of one sudden cardiac arrest per 1000 person-years). In a study utilizing a geographic information system marked on a digital map in Copenhagen, Folke et al. estimated that the ERC recommendations provided coverage for 19.5% of OHCAs and would require 125 AEDs. If AHA recommendations were to be applied, this coverage increased to 67% of arrests and 1104 AEDs would be required. The estimated cost per quality-adjusted life year (QALY) gained based on ERC guidelines was USD $33 100 and AHA guidelines was USD $40 900. Folke et al. recommended adopting the AHA recommendations for better coverage.

With the recent release of the latest ILCOR guidelines, ERC has reviewed their stance to be in line with AHA’s recommendations to place AEDs in areas where one cardiac arrest is expected to occur every 5 years.

Difference in type of location

It is known that OHCAs occurring in public places are more likely to be witnessed by laypersons compared with nonpublic places and have a higher survival rate.

OHCAs are in a way predictable events and have a definite geographical distribution which is related to underlying population demographics and day/night movement of populations. Placing AEDs in certain locations have shown to improve survival—sports facilities, airports and casinos, with caveat that there are responders onsite. In the context of a casino, using nonmedical personnel such as security officers, Valenzuela et al. was able to demonstrate improved survival rates for OHCAs due to ventricular fibrillation. Likewise, using security officers, Gianotto-Oliveira et al. was able to show improved survival rates with good neurological outcomes for patients who suffered from cardiac arrest on the Sao Paulo metro. On the other hand, a prospective randomized control trial involving 7001 patients with previous anterior wall myocardial infarction that were not candidates for the implantation of a cardioverter-defibrillator, Bardy et al. showed that access to a home AED did not significantly improve overall survival.

Regardless of location, it is clear that cost-effectiveness cannot be the only consideration in placement of AEDs. This has been echoed by several authors. For example, schools may not be cost-effective, but the unexpected death of a child has a profound effect on the community, and the desire to protect this population may outweigh conventional financial considerations. In a study of National Collegiate Athletic Association programs, it was found that most AEDs had been purchased on concerns of liability rather than cost-effectiveness.

Public versus private-driven initiatives

In the last decade, many communities have seen a large increase in publicly accessible AEDs. Placement of privately owned AEDs is usually determined by the owners of the AEDs and hence is asymmetrical. In an open, retrospective observational study conducted in Stockholm, Ringh et al. found that regulated programs for AED placement were more effective than unregulated AED placement. Despite only comprising 2.6% of the total number of public access AEDs, 28% of AEDs placed by the structured placement program were used over a 6-year period. This does not mean that private-driven initiatives in purchasing AEDs should be discouraged. South Korea adopted an innovative method to disseminate AEDs. They chose to embed AEDs in digital signage that was used for commercial advertising (Fig. 2). The digital signage could be changed to display medical information regarding CPR and AED, thereby contributing to public education. This concept enabled AEDs to be disseminated rapidly and widely due to its cost-effectiveness and the fulfillment of both public and providers’ needs.

Government bodies should provide leadership in harnessing both public and private resources in statewide placement of AEDs utilizing geographic information systems. In addition, government bodies can take the lead in registering both public and privately owned AEDs. It is recommended that this information be made available to the public and to the dispatch center; so that it can be assessed during emergencies.
Limitations of current strategies

Re-looking at accessibility

Accessibility continues to be an important issue to address. In assessing a network of AEDs accessible to laypersons and dispatch centers, Hansen et al.\textsuperscript{20} found that the majority of AEDs were deployed in areas with few or no cardiac arrests. Secondly, most AEDs remained inaccessible to more than half of OHCA cases in public locations after office hours.

A recently published observational study by Agerskov et al.\textsuperscript{33} found that only 3.8% of all OHCA cases from 2011 to 2013 in Copenhagen had an AED applied prior to ambulance arrival when 15.1% of all OHCA cases occurred within 100 m of an accessible AED. Reasons postulated included a lack of linkage between the Emergency Medicine Dispatch Centre and the AED network, a mismatch between the time of cardiac arrest and the accessibility of the AEDs, and the challenge of identification of OHCA by the dispatcher. Several solutions have emerged to tackle these problems which will be elaborated on later.

The need for continued emphasis

An effective PAD program requires continued supervision, maintenance and training.\textsuperscript{26} Over a period of time, the supervision and maintenance of a PAD site may falter. This is especially true if the site is maintained by volunteers. A small study from Iowa was particularly revealing. Two years after placement of AED by a voluntary task force, none of the sites had successfully maintained the program as judged by AHA recommendations. Issues included problems with inaccessible location of AEDs and inoperative equipment such as expired pads or batteries.\textsuperscript{34} Regarding training, as CPR and AEDs are infrequently used by laypersons, timely refresher courses are necessary to maintain familiarity.

Concerns about legal liability

Many studies have shown that AEDs can be used safely by laypersons.\textsuperscript{35} In spite of this fact, there has still been reluctance in using AEDs. It has been suggested that medico-legal issues, and the fear of being sued, could discourage bystanders from performing CPR and using AEDs.\textsuperscript{36} Good Samaritan laws offer legal protection to people who give reasonable assistance to those who are, or who they believe to be, injured, ill, in peril, or otherwise incapacitated. These laws vary across countries and jurisdictions. Implementation of a law to mitigate legal liability may be useful in reducing bystanders’ hesitation in rendering assistance utilizing PAD and encourage more AED owners to make their AEDs available for public use.

New developments that are game-changers

Locating AEDs

Leung et al.\textsuperscript{37} showed that locating an AED was very time-consuming. In recent years, local government bodies in several countries have shown maps of locations of installed AEDs on their websites.\textsuperscript{22} Building a national registry of locations of AEDs and making it known to the public is a first crucial step in promoting PAD.

A further step to increase PAD should target public awareness of this AED network\textsuperscript{33} and encourage the public to learn the exact location of AEDs in their vicinity.
Smartphone technology

In a blinded, randomized, control trial involving nearly 10,000 volunteers, Ringh et al.38 demonstrated using mobile phone positioning to alert volunteers significantly increased rates of bystander-initiated CPR for OHCA. Smartphone-enabled geolocation can help pinpoint the exact spot of the patient and nearest public-accessed AED. In a world where smartphones become increasingly ubiquitous, utilizing smartphone technology can decrease time of collapse to application of the AED.

Role of dispatchers

Besides diagnosing cardiac arrest and the dispatch of a high-priority EMS response, the emergency medical dispatcher plays an important role in improving rates of bystander CPR, locating and dispatching nearby AEDs.1 Through direct instructions, the dispatcher may help by increasing confidence for bystanders to use AEDs, thereby increasing defibrillation rates and decreasing time to first defibrillation (Fig. 3).

Smarter AEDs

New technology like web-enabled AEDs that can signal where they are would be useful in rapid location of AEDs. For ease of maintenance, these web-enabled AEDs are able to indicate remotely when their batteries need to be changed. There is currently research into using AED drones that may become more commonplace in the future.

Role of the medical community

First responders

Lay rescuers have been found to have considerable variation in their ability to operate AEDs and commence CPR.39 Our familiarity in handling emergencies and sick patients makes it intuitive for the medical community to play a key role in being first responders in PAD. Smartphone Apps, like the one mentioned above, would enable medically trained first responders to extend the circumference of our reach in reacting to emergencies in our vicinity.

Installation of AEDs

A Swedish study conducted in Göteborg, Engdahl et al.40 found that the offices of general practitioners (GPs) were the sites of considerable numbers of OHCA. GPs can take the lead in purchasing, installing, and maintaining AEDs. It is recommended that GPs who own AEDs allow their AEDs to be accessed publicly and share information about their AEDs with relevant AED registries.22

Community champions in education

The medical community is in a unique position to educate the public in CPR and usage of AEDs. In the UK, the British Heart Foundation has taken the lead in rallying medical professionals to support education of the public. Zakaria et al.11 recommended an integrated program at PAD sites to educate people working in the vicinity. This included teaching the method of activating the emergency system; informing them about the exact location of AEDs and how to use AEDs; as well as training them to be CPR proficient. These activities can be facilitated by members of the medical community working near PAD sites.
Recommendations and conclusion
PAD has been shown to be effective in achieving good neurological outcome following OHCA from ventricular fibrillation. With considerable planning, ongoing supervision and maintenance of AEDs, and appropriate placement in high-risk sites, the obstacles to achieving success with PADs can be overcome. In an effort to improve outcomes further, new developments, such as using smartphone technology, are currently underway that may change the way PAD is done.

Conflict of interest statement
The authors have no potential conflicts of interest.

References


