ORIGINAL RESEARCH

Mobile Versus Fixed Deployment of Automated External Defibrillators in Rural EMS

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Abbreviations:
AHA: American Heart Association
AED: automated external defibrillator
CPR: cardiopulmonary resuscitation
EMS: Emergency Medical Service
FF: firefighter
FR: first responder
PAD: public access defibrillator
POV: private-owned-vehicle
SCA: sudden cardiac arrest

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Abstract

Introduction: There is no consensus on where automated external defibrillators (AEDs) should be placed in rural communities to maximize impact on survival from cardiac arrest. In the community of Stokes County, North Carolina (USA) the Emergency Medical Services (EMS) system promotes cardiopulmonary resuscitation (CPR) public education and AED use with public access defibrillators (PADs) placed mainly in public schools, churches, and government buildings.

Hypothesis/Problem: This study tested the utilization of AEDs assigned to first responders (FRs) in their private-owned-vehicle (POV) compared to AEDs in fixed locations.

Methods: The authors performed a prospective, observational study measuring utilization of AEDs carried by FRs in their POV compared to utilization of AEDs in fixed locations. Automated external defibrillator utilization is activation with pads placed on the patient and analysis of heart rhythm to determine if shock/no-shock is indicated. The Institutional Review Board of Wake Forest University Baptist Health System approved the study and written informed consent was waived. The study began on December 01, 2012 at midnight and ended on December 01, 2013 at midnight.

Results: During the 12-month study period, 81 community AEDs were in place, 66 in fixed locations and 15 assigned to FRs in their POVs. No utilizations of the 66 fixed location AEDs were reported (0.0 utilizations/AED/year) while 19 utilizations occurred in the FR POV AED study group (1.27 utilizations/AED/year; $P < .0001$). Odds ratio of using a FR POV located AED was 172 times more likely than using a community fixed-location AED in this rural community.

Discussion: Placing AEDs in a rural community poses many challenges for optimal utilization in terms of cardiac arrest occurrences. Few studies exist to direct rural community efforts in placing AEDs where they can be most effective, and it has been postulated that placing them directly with FRs may be advantageous.

Conclusions: In this rural community, the authors found that placing AED devices with FRs in their POVs resulted in a statistically significant increase in utilizations over AED fixed locations.

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Introduction

Beginning in 1995, the American Heart Association (AHA; Dallas, Texas USA) recommended the development of lay rescuer automated external defibrillator (AED) programs to shorten the time from onset of sudden cardiac arrest (SCA) until cardiopulmonary resuscitation (CPR) and defibrillation occur.[1] Initially, four levels of response programs were defined: Level 1 refers to traditional first responder (FR) defibrillation where a duty to respond exists; Level 2 includes non-traditional responders, such as lifeguards, security, or airline personnel; Level 3 refers to lay persons who receive CPR and AED training; and Level 4 refers to community programs where non- or minimally-trained citizens respond to a cardiac arrest.[2]

Lay rescuer AED programs within airports, casinos, and of police FRs equipped with AEDs demonstrate survival rates of 41%-74% with witnessed ventricular fibrillation SCA when immediate bystander CPR is provided and defibrillation occurs within five minutes

of collapse. In programs where no decrease in time to defibrillation is observed, high survival rates are not demonstrated.[1]

Where should AEDs be placed in the rural community so as to maximize their impact on survival? Most rural communities do not have industries or complexes where a large number of people gather or work, so many seek out local churches and schools to place AEDs. In 2004, Portner et al found no single location in a rural community was related to cardiac arrest and theorized that a FR with an AED would likely have the greatest impact.[3] In the community of Stokes County, North Carolina (USA), the Emergency Medical Service (EMS) promotes CPR public education and public use of an AED. Over the past 10 years, numerous citizens have undergone CPR training, and 66 public access defibrillators (PADs) have been placed, mainly in public schools, churches, and government buildings. This study hypothesized that AEDs assigned to FRs in their private-owned-vehicle (POV) would be utilized more often than AEDs in a fixed community location in this rural community.

Methods

Study Design

The authors performed a prospective, observational study to measure utilization/defibrillation of AEDs carried by FRs in their POVs compared to utilization/defibrillation of AEDs placed in fixed locations throughout a rural community. Automated external defibrillator utilization involves the AED being activated with pads placed on the patient and analysis of heart rhythm to determine if shock/no-shock is indicated. The Institutional Review Board of Wake Forest University Baptist Health System (Winston-Salem, North Carolina USA) approved the study and written informed consent was waived. The study began on December 01, 2012 at midnight and ended on December 01, 2013 at midnight.

Population and Setting

The study was performed in rural Stokes County, located in the Piedmont area of North Carolina. The county's land area is 449 miles. The 2011 United States Census Bureau (Washington DC, USA) estimated a population of 47,242 people. Of this population, 93.8% is white, 4.4% is black, and American Indian and Asians represent 0.4% and 0.3%, respectively. A total of 16.6 % of the population is 65 years and older. The county has a county-wide EMS that is supplemented by FRs at nine volunteer fire-rescue agencies and one career-volunteer fire-rescue agency. Community fixed AED locations are listed in Table 1.

Research Protocol

Participation was voluntary and open to all FRs currently a member at any of 10 different fire-rescue agencies in Stokes County. Automated external defibrillator devices were assigned based on willingness to participate, agency, agency officer recommendation, and geographical location in an effort to distribute the AEDs over the county response districts. At least one FR participated in the study from all fire-rescue departments. First responders with AEDs responded to 911-calls using their POV per their standard operating guidelines and provided care, including AED use, under county-wide EMS protocols. First responders reacted within their district according to availability, and outside their district when they were proximate to a dispatched call as mutual aid, then completed a standardized CPR run-report.

Southeastern Emergency Equipment of Youngsville, North Carolina (USA) provided AEDs for use in this study. Fifteen Philips HeartStart FR2+ AEDs (Philips HealthCare 3000; Andover, Massachusetts USA) were provided for the study period. A 3-hour training program in AED use was provided to all FRs having an AED assigned to them. Where community AEDs were placed, initial CPR and AED training was provided by the EMS training officer to all who volunteered.

Fixed Location	Number of Locations	Total AEDs Deployed
Business	1	1
Churches	22	22
Government Buildings	11	13
Public Schools	22	30
Totals	56	66

Table 1. Locations of AEDs Stationed Within the County and the Total Number of AEDs Deployed
Abbreviation: AED, automated external defibrillator.

Cardiac Arrest Locations	Percentage
Residence	71%
Skilled Nursing Facility	14%
Business (Public or Private)	7%
Roadside/Street	4%
Hemodialysis Center	3%
Health Care Facility	1%

Table 2. Shows Cardiac Arrest Locations and Their Respective Percentages

Data Collection and Statistical Analysis

First responders who used AED devices located in their POVs completed a standardized CPR run-report from which a study team member transferred information to a standardized data collection form. The number of community fixed-location AEDs and their utilizations were compared to the number of mobile POV-located AEDs and their utilizations using Fisher's exact test to calculate a two-tailed *P* value (GraphPad InStat version 3.10 for Windows, GraphPad Software; San Diego, California USA).

Results

The EMS system responded to 70 cardiac arrest incidents during the study period, consistent with the expected 1.5 cardiac arrests per 1,000 people. Locations of the cardiac arrests are shown in Table 2. Return of spontaneous circulation occurred in 57%, and 43% were terminated on-scene after resuscitation efforts. Eleven of 70 were of non-cardiac etiology, with an overall survival of 12% and an Utstein survival of 18%, and discharged alive with a good neurological outcome.

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Five First Responder AED Utilizations	
Witnessed Arrest	80%
Terminated Resuscitation On Scene	40%
Terminated Resuscitation in Emergency Department	40%
Discharged Alive	20%

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Table 3. Characteristics and Outcomes of First Responder AED Utilizations Where Defibrillation is Delivered
Abbreviation: AED, automated external defibrillator.

During the 12-month study period, 81 community AEDs were in place. Sixty-six of those were in fixed locations while 15 were assigned to FRs in their POVs. No utilizations of the 66 community-placed, fixed-location AEDs were reported (0.0 utilizations/AED/year) while 19 utilizations occurred in the FR POV AED study group (1.27 utilizations/AED/year; $P < .0001$). In this group, 14 utilizations advised no-shock indicated while five utilizations advised shock was indicated and delivered therapy before arrival of fire-rescue apparatus or EMS. Odds ratio of using a mobile POV-located AED was 172.35 times more likely than using a community fixed-location AED in this rural community (95 % CI, 11.44–29.67; Table 3).

Discussion

Placement of a public access AED in a rural community is difficult in terms of optimal utilization due to variability in cardiac arrest locations as well as lack of public locations where a large number of people gather on a recurring basis. In this rural community, a large number of AEDs are located in government buildings, churches, and schools; however, De Maio et al estimated that a school-placed AED would be used once every 357 years for an adult and once every 4,000 years for a child.[4-6]

Placing an AED in low-risk locations leads to under or no utilization of the device and increased cost in quality-adjusted life years. Folk et al evaluated the effectiveness of unguided AED placement in Copenhagen (Denmark) where AEDs were placed in municipal buildings, schools, community centers, and public swimming pools. The year following placement, no utilizations occurred.[7] Compliance with AHA recommendations for maintenance of a PAD site is also variable. Haskell et al published survey results which evaluated PAD AHA compliance and found site visits revealed expired batteries and pads, obscure locations, and general lack of knowledge concerning the AED, or even its presence.[8]

An AED located on a fire-rescue apparatus in a rural volunteer agency poses utilization issues as well, in that a FR needs to respond to a fixed location to retrieve the apparatus and respond to the scene with an AED. This study demonstrated increased utilization of an AED when assigned to a FR and maintained in their POV, which enables a FR to respond directly to a scene with an AED.

Lay rescuer AED programs have the greatest impact on survival from SCA where it is more likely to occur; for example, the AHA recommends placement where cardiac arrest can be expected every five years.[2] In the Public Access Defibrillation Trial Programs, AEDs are placed at sites with a history of at least one cardiac arrest every two years, or in sites where more than 250 adults over the age of 50 are present more than 16 hours per day,[1] yet these locations are few in a rural setting.

Cardiopulmonary resuscitation and AED use by public-safety FRs (traditional and nontraditional) is recommended to increase survival rates for SCA (Class 1, Level of Evidence B). In Seattle, Washington (USA), when AEDs were placed with FR firefighters (FF), 30% of cardiac arrest victims survived to hospital discharge, where only 19% survived when FF performed CPR and awaited EMS arrival with a defibrillator.[9] Establishment of AED programs in public locations where there is a reasonable likelihood of witnessed cardiac arrest (airports, casinos, and sports complexes) is recommended.[1]

Limitations

The study is limited in a number of ways. The small rural community had a relatively low number of cardiac arrest per year, which limits the power of this study. There were a small number of utilizations of AEDs as well. This rural EMS system may not be generalizable to other rural communities in terms of resources.

The deployment of AEDs with FRs was random, based on willingness to participate, and not based on a structured deployment taking into account where a cardiac arrest was most likely to occur. The system lacked software to perform system status management. The system also lacked time synchronization, not allowing the authors to measure variations in time to defibrillation

First responders assigned an AED may be more likely to respond to a cardiac arrest event based on their willingness to participate in this study, introducing some bias compared to randomly assigning an AED to a FR based solely on membership in an agency.

Conclusion

Placing an AED in a rural community poses many challenges for optimal utilization in terms of cardiac arrest occurrences, industry or complexes where a large number of people gather or work, and development of lay rescuer programs. In the rural community of Stokes County, North Carolina, the authors found that placing an AED device with a trained FR in their POV resulted in a statistically significant increase in utilizations over fixed locations where AEDs had been placed.

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