Bystander Performance Using Automated External Defibrillators During Simulated Cardiac Arrest

Richard N Bradley, The University of Texas Health Science Center at Houston
Lynda M Schoenstein, The University of Texas Health Science Center at Houston
Wesley H Hamilton, The University of Texas Health Science Center at Houston
Mark R Boyle, The University of Texas Health Science Center at Houston

Available at: https://works.bepress.com/richard_bradley1/36/
Bystander Performance Using Automated External Defibrillators
During Simulated Cardiac Arrest

Richard N. Bradley, MD
Lynda M. Schoenstein, MD
Wesley H. Hamilton, BS
Mark R. Boyle, BS

From the University of Texas Medical School at Houston Department of Emergency Medicine.

Author Affiliations: University of Texas Medical School at Houston (RNB, LMS, WHR, MRB) and Baylor College of Medicine (RNB). Dr. Schoenstein is currently at Memorial Hermann Hospital.

Address for reprints and author correspondence: University of Texas Medical School at Houston, 6431 Fannin St., Ste. J JL 429, Houston, Texas, 77030-1503

Phone: +1-713-704-5841. Fax: +1-713-704-5189

E-mail: Richard.N.Bradley@uth.tmc.edu

Running Title: Bystander Defibrillation
ACKNOWLEDGEMENT PAGE

The authors would like to thank David E. Persse for assistance in the design of the study, and the Houston Airport System for allowing the use of their facility for data collection. They would also like to thank the Houston Fire Department for the loan of the automated external defibrillator training devices.

The authors received no financial support for the investigation or manuscript development. The authors deny having potential conflicts of interest due to any financial arrangements.

The authors were responsible for the analysis of the data.
ABSTRACT

Objective: Automated external defibrillators (AEDs) are becoming widely available to the public. This study examined the hypothesis that less than 75% of the general population can defibrillate using an AED in less than three minutes.

Methods: This was a survey of the behavior of individuals over age 12 in a major airport on Jan. 2–3, 2003. After obtaining consent, an investigator told the subject that he/she was walking down the concourse and saw a person collapse. The subject demonstrated his/her response, using only a telephone and an AED simulating ventricular fibrillation. Data were analyzed using a one-sample test of proportions.

Results: 30 subjects participated in the study; one was excluded. Only 8 subjects (28%) (95% CI 13–47%) were able to defibrillate within 3 minutes. The primary reasons for inability to shock were placing the electrodes over the patient’s clothes (45%) or failure to remove the protective backing from the electrodes (48%).

Conclusions: This study supports the hypothesis. Visual and aural instructions from the AED are not adequate to facilitate its use by an untrained individual. As authorities make AEDs more accessible to the public, they must ensure an effective educational program is also in place. Primary limitations to this study are that the use of a training AED on a manikin may not represent results of using a functioning AED on a human in cardiac arrest, and the participants may not reflect the bystanders most likely to provide initial care.
Key words: cardiopulmonary resuscitation; electric countershock; emergency treatment; equipment failure; heart arrest; human; public facilities; sudden cardiac death
INTRODUCTION

Background

Cardiovascular disease has been the leading cause of death in the United States for the past century. There are about 340,000 deaths per year in the United States due to ventricular fibrillation.¹

Importance

Reducing the interval from onset of ventricular tachycardia or fibrillation to delivery of electrical countershock will improve survival.¹² There is not yet sufficient evidence to determine whether placing an AED in the hands of an untrained bystander will improve outcomes.

Goals of This Investigation

The primary hypothesis of this study was that using only instructions from the AED, less than 75% of the general population could operate an AED and deliver a shock in less than 3 minutes. The secondary hypothesis of the study is was that less than 25% of the public could perform all of the steps of basic life support (BLS) including delivering a countershock and starting CPR in less than 5 minutes.
METHODS

Theoretical model of the problem

Successful bystander defibrillation requires several components. Bystanders must recognize that a person may require medical assistance. They must be aware that an AED is available. They must access the AED and bring it to the patient. They need to apply the AED correctly. The AED must function. Applying the AED correctly involves turning the device on, connecting the pads to the patients bare skin, and pressing the analyze and shock buttons when appropriate.

Study Design.
This study was a survey of the behavior of a convenience sample of passers-by at a large commercial airport in the United States. It was approved by the Committees for the Protection of Human Subjects (CPHS) at the University of Texas Health Science Center at Houston.

Setting
Selection of participants
This project was conducted on passers-by in Terminal C at George Bush Intercontinental Airport in Houston, Texas (IAH) on January 2 and 3, 2003. Subjects were included if their age was greater than or equal to thirteen years, and were excluded if they had ever taken an advanced cardiac life support class. IAH is located in Harris County, Texas, which, in 2001, had an estimated population of 3,460,589 people. More people experienced sudden cardiac death at IAH

3

4
than any other out-of-hospital location in Houston (unpublished data). This is consistent with the reported information from other areas.\textsuperscript{5}

\textit{Interventions}

The investigators set up a study area in a central concourse in the airport that had a high pedestrian volume. Passers-by who expressed an interest in the manikin lying on the floor were asked to participate in a 7 minute scientific research project. The investigator gave them an CPHS-approved informed consent document to read and sign.

Subjects were then taken to an area where there was a CPR manikin, a telephone, and a Lifepak\textregistered{} 500 AED simulator (Medtronic Physio-Control, Bellingham, Washington). The telephone had a sign attached that read, “Pick up phone and dial 9-1-1 for all emergencies.” The AED had a sign above it that read, “Automated External Defibrillator—For Emergency Use Only.”

The investigator then read the following instructions to the subject:

“This is a research project designed to see if untrained members of the public can operate this device, an automated external defibrillator, to save someone’s life. This device is very easy to use and will give you all the information you need to know to use it. It is completely safe and can not harm you. I want you to pretend that you were walking here and found this person lying unmoving on the ground. You notice that this device, an automated external defibrillator, is available under a sign that says “Automated External Defibrillator—For Emergency Use Only.” You remember reading that these devices are now available for public use and can start someone’s heart when it has stopped. There is no one else around to help. Please actually
demonstrate what you would do, using the items that you see here. Nothing here can hurt you. I will only count the things that you actually do, not things that you only say that you would do. If you have any questions, I will answer them now. Once you start, I will not be able to answer any questions. Do you have any questions now?”

The investigator attempted to answer any questions without answering any specifics about how the AED operated, how to do CPR, or how to call for help.

**Methods of measurement**

The investigators used explicit criteria to determine if the subject successfully completed each step of a standard basic life support and automated external defibrillator (BLS/AED) protocol.

**Data collection and processing**

A one-sample test of proportions based on the binomial distribution was used to test whether the observed proportion of subjects who accomplished defibrillated in three minutes or less was significantly different from the hypothesized value (0.75).

A pilot study led to an expectation of a 50% success rate. Based on this, and desiring a study with 80% power to detect a difference with a 95% confidence level, the desired sample size was 23 subjects.
RESULTS

Main results

A total of thirty subjects were included in the study; one of these met exclusion criteria. The success rates for each of the variables are summarized in Table 3. This table includes the numbers of subjects who successfully completed the primary outcome measure. It also reports the number of individuals who were able to complete all of the steps in the BLS/AED protocol in less than five minutes and the success rate for each individual step in the BLS/AED protocol.

The pilot study demonstrated a recurring pattern of errors that prevented successful defibrillation among the subjects. We prospectively collected the rates at which two specific errors occurred. The first error was applying the electrodes on top of the simulated patient’s clothing. On a real patient, this would prevent the device from detecting the ECG rhythm. The AED would continue to prompt the rescuer to “Connect Electrodes.” We simulated this prompt by surreptitiously disconnecting the electrode cable from the monitor until both electrodes were attached to the manikin’s bare skin. This caused the defibrillator to prompt “Connect Electrodes,” and prevented the subject from analyzing the rhythm. Only 16 of the subjects (55%, 95% CI 36 – 74%) attempted to place the electrodes on the simulated patient’s bare skin; the others attempted to attach the electrodes over the manikin’s sweater.

The other recurrent error was the subject’s failure to remove the paper backing from the electrodes. The backing covers the patient side of the electrode prior to use. Under the backing is both the adhesive portion of the electrode and the conductive medium.
The subjects who committed this error tried to hold the electrodes directly on the simulated patient – they held the electrodes (with the backing in place) against the manikin with their hands. Only 15 subjects (52%, 95% CI 33 – 71%) removed the backing prior to attempting to apply the electrodes to the simulated patient.
DISCUSSION

Sudden cardiac death is a significant health problem in the world today. In the year 2000, there were 250,000 cases of out-of-hospital sudden cardiac death in the United States. Many of these patients had an initial rhythm of ventricular fibrillation.\textsuperscript{7} The interval from collapse to defibrillation is critical; for each minute that defibrillation is delayed, the chance of survival drops approximately 10%.\textsuperscript{1,2} Because of the importance of rapid defibrillation, defibrillator use was introduced in the pre-hospital care setting. Automated external defibrillators (AEDs) were introduced to further reduce delays.\textsuperscript{8} The first AEDs were used by traditional responders, specifically, Emergency Medical Technicians who responded to medical emergencies in the course of their normal duties. More recently, AED’s have been placed in the hands of non-traditional responders, with varying degrees of success. The most recent push to reduce the interval from collapse to shock has been to implement “Public Access Defibrillation,” where AEDs are installed in locations accessible to the general public. Public access defibrillation programs have been developed based on consensus, without scientific data providing any evidence as to how beneficial they may be.

This study attempted to fill some of the gaps in the evidence, and suggests that slightly more than half of all bystanders, using only the visual and auditory instructions from an AED, are able to deliver a shock in three minutes or less. When they do deliver a shock, they rarely complete all of the essential steps of AED use.

An important point of this study is a determination of the barriers to delivering a shock within three minutes. In almost every case, it was due to one of two problems. One
occurred when the subject did not bare the patient’s chest and stuck the electrodes on top of the manikin’s sweater. In this case, the AED never stopped giving the “connect electrodes” prompt. The other problem occurred when subjects did not remove the paper backing from the electrodes. Often it appeared that the subjects were trying to use the hands-free electrodes as manual defibrillator paddles, as they tried to hold the paddles on the SP’s chest.

Published reports suggest that AEDs are so simple that untrained children can operate them. One study reported the ability of sixth graders to successfully defibrillate a manikin. However this article also reports the same barriers to successful defibrillation and, in fact, the authors found it necessary to instruct the children how to remove the backing and stick the pads to the patient. Another study reported the ability of third graders to operate the AED, however in this study the manikin’s shirt was removed before the study began, and again, the subjects were shown how to peel the backing from the electrodes.

The results of this study differ from a recently published study that retrospectively reported the performance of an actual public access defibrillation program in a major airport system. That study reported findings from a two-year period where resuscitation was attempted on twenty-two patients who had a witnessed ventricular fibrillation event of presumed cardiac etiology. Publicly-accessible AED’s were used for 18 (82%) of these cardiac arrests. In all of these cases, the defibrillator was operated correctly. The key element of this study is that the AEDs were installed as part of a comprehensive training and public education program. It is very likely that is the primary reason why that study shows public access defibrillation to be successful while
this study suggests results should not be as good. Public access defibrillation programs must include a comprehensive educational plan.

It is likely that once trained, individuals retain their ability to successfully operate the AED and deliver a shock.\textsuperscript{13,14} A major, multi-center trial is underway and expected to be completed in September, 2003. This trial should give additional information about expected bystander performance.\textsuperscript{15} It is likely that best results will continue to be seen in systems where there are trained individuals who have response to cardiac arrest as an additional job duty (e.g. security guards).\textsuperscript{16,17}
LIMITATIONS

One of the important limitations of this study is that it may have experienced selection bias in the recruitment of the subjects. Subjects enrolled in the study if they were curious about the manikin and AED on the floor of the terminal. In the pilot study the authors attempted to systematically recruit subjects but found that potential subjects – people walking through an airport concourse – tend to ignore anyone who approaches them to try to solicit their participation. In fact, the only individuals that were recruited in the pilot study were those who walked up and expressed an interest in the research project. The authors observed that the subjects were generally individuals who were not otherwise occupied. They tended to be passengers on layovers or airport or airline personnel on breaks from work. The majority of potential subjects who did not stop at the site appeared to be rapidly walking by as if to reach a flight or to collect baggage. Thus, the subjects in this study may not be representative of the individuals likely to stop and render assistance to a person experiencing an actual medical emergency.

In this study, only one subject was able to complete all of the required steps in the BLS/AED protocol in five minutes. The importance of completing all of these steps for improved patient outcome is unknown. The investigators understand that there is no consensus on the optimal protocol for BLS and AED use.\textsuperscript{18}

Another potential limitation is that the study was conducted with one particular model of AED. Each AED has different schemes for packaging and labeling the electrodes. Each AED also has differing aural and visual prompts as well as different panel configurations. Some AEDs, such as the one in this study, have three buttons on the
panel; others have only two. It is possible that the outcomes of the study would be different if a different model of AED was used. The authors did use the Lifepak 500 as well as the Forerunner I and Forerunner II during the pilot study. While there was some difference between the three models, there were still significant failure rates with all three.

Some AED manufacturers have begun to modify their products to address these limitations. Improved aural and visual prompts may improve the rate of successful defibrillation. New electrode packaging techniques may also make a difference. For example, one manufacturer now places both electrodes on either side of the same sheet of protective backing. This makes it impossible for the rescuer to try to hold the two electrodes on to the patient’s chest.
CONCLUSIONS

The results of this study support both the primary and secondary hypothesis. The data support rejection of the null hypothesis that at least 75% of bystanders can deliver a shock to a patient using an AED in less than 3 minutes. The data also support rejection of the null hypothesis that at least 25% of bystanders can complete all the steps in the BLS/AED protocol in less than 5 minutes.

While public access defibrillation programs may be cost effective, the most successful systems will include strong public education and training programs. To successfully use an AED, a bystander probably does not need to have extensive training, but he or she should have some exposure to the AED. The important elements seem to be that the rescuer must know to remove the backing from the electrodes and to stick the electrodes on the patient’s bare skin.
REFERENCES


## TABLE 1. Demographics

<table>
<thead>
<tr>
<th></th>
<th>Study Group</th>
<th>City of Houston$^6$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age—mean (±SD)</td>
<td>33 (± 16) yr</td>
<td>31 yrs</td>
</tr>
<tr>
<td>Gender—female</td>
<td>18 (60%)</td>
<td>50%</td>
</tr>
<tr>
<td>Race</td>
<td></td>
<td></td>
</tr>
<tr>
<td>White</td>
<td>11 (37%)</td>
<td>38%</td>
</tr>
<tr>
<td>African American</td>
<td>10 (33%)</td>
<td>26%</td>
</tr>
<tr>
<td>Hispanic</td>
<td>3 (10%)</td>
<td>32%</td>
</tr>
<tr>
<td>Other</td>
<td>6 (20%)</td>
<td>4%</td>
</tr>
</tbody>
</table>
**TABLE 2. BLS/AED Protocol**

1. Confirm unresponsiveness
2. Check for breathing for at least 5 seconds
3. Deliver 2 slow full rescue breaths
4. Check for a pulse
5. Turn on AED
6. Attach electrodes correctly
   a. Sternum electrode on upper right chest
   b. Apex electrode lateral to left midclavicular line
   c. Electrodes plugged in to AED
   d. Electrodes stuck to bare skin
7. Say “clear” and visually clear the patient prior to countershock
8. Ensure someone calls 9-1-1 to activate the EMS system
9. Start CPR when prompted by AED
### TABLE 3. Successful Performance on Outcome Measures

<table>
<thead>
<tr>
<th>Outcome Measure</th>
<th>n</th>
<th>Percent</th>
<th>95% Confidence Interval</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Countershock &lt; 3 minutes</td>
<td>8</td>
<td>28</td>
<td>(13, 47)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Protocol complete in &lt; 5 min.</td>
<td>1</td>
<td>3</td>
<td>(0, 18)</td>
<td>0.003</td>
</tr>
<tr>
<td>Establish unresponsiveness</td>
<td>7</td>
<td>24</td>
<td>(10, 44)</td>
<td>0.008</td>
</tr>
<tr>
<td>Check breathing</td>
<td>15</td>
<td>52</td>
<td>(33, 71)</td>
<td>&gt;0.999</td>
</tr>
<tr>
<td>Give 2 breaths</td>
<td>5</td>
<td>17</td>
<td>(6, 36)</td>
<td>0.001</td>
</tr>
<tr>
<td>Check pulse</td>
<td>12</td>
<td>41</td>
<td>(24, 61)</td>
<td>0.458</td>
</tr>
<tr>
<td>Apply electrodes correctly</td>
<td>4</td>
<td>14</td>
<td>(4, 32)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Clear patient</td>
<td>6</td>
<td>21</td>
<td>(8, 40)</td>
<td>0.002</td>
</tr>
<tr>
<td>Activate EMS</td>
<td>27</td>
<td>93</td>
<td>(77, 99)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Start CPR</td>
<td>17</td>
<td>59</td>
<td>(39, 76)</td>
<td>0.458</td>
</tr>
</tbody>
</table>

P values for the time intervals are based on the study hypothesis; p values for the subgroups are based on the probability of success ≠ 0.5.