A 2-Tiered Approach to In-Hospital Defibrillation
Nurses Respond to a Trial of Using Automated External Defibrillators as Part of a Code-Team Protocol

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Background and Significance

**The Importance of Early Defibrillation**

Early defibrillation is critical to the outcomes of adults in cardiac arrest. Cardiac arrest has a high mortality rate unless defibrillation occurs quickly, usually within 10 minutes of the onset of cardiac arrest. Survival decreases 7% to 10% with each minute that passes; therefore, rapid defibrillation is an essential goal in any protocol for treating patients with life-threatening ventricular arrhythmias. The latest guidelines from the American Heart Association (AHA) suggest that defibrillation be administered to patients in the hospital within 3 minutes of the onset of sudden cardiac arrest. A small body of evidence exists on the use of AEDs in hospitals and the out-

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comes of patients treated with AEDs. Introducing AEDs to hospital teams who respond to codes is a relatively new idea.

Traditional responses to hospitalized patients who are experiencing cardiac arrest vary according to where in the hospital the event occurs. Critical care nurses on code teams often respond from their units to distant inpatient units. At Boston Medical Center, we have many patient floors in many different buildings. This wide distribution of patients may cause delays when a traditional response by a code team is used because the nurses outside the critical care areas do only cardiopulmonary resuscitation (CPR) until a team arrives that can administer defibrillation and perform other advanced measures.4,5

Hospital areas where patients are monitored (eg, intensive care, cardiac care, telemetry, and cardiac rehabilitation units) have excellent response times, and survival rates of these patients can be almost 90%.6,7 In contrast to those rates, survival rates after sudden cardiac arrest in non–critical care areas or areas where patients are not monitored can be as low as 11% to 15%.8,9

Outcomes from sudden cardiac arrest in the community have improved remarkably with the institution of initiatives for public access to defibrillators. With recent increased public training in the use of AEDs and CPR, survival rates of 70% and higher have been reported.10,11 These types of statistics have even prompted USA Today to print an article titled “Hospitals A Bad Bet For Heart Jump-Start.”12

Effects and Use of AEDs

AEDs initially were developed for providers of emergency medical services; subsequently the general public has gained access to AEDs and the training to use the devices. The experiences of these users have led to improvements in design that make AEDs more efficient and easy to use. Even sixth-grade students have been successful in using an AED.13 Use of AEDs in public is becoming more common, especially in places such as airports, casinos, and golf courses. Similarly, AEDs are beginning to appear in more healthcare facilities, including hospitals.

Resuscitation or code committees must evaluate current hospital protocols and validate response and defibrillation times in all areas, but especially in the non–critical care areas. The addition of AEDs in these areas has proved beneficial in hospitals.14-16 Understanding and integrating AEDs into current protocols were parts of the process we went through at Boston Medical Center for both critical care nurses and non–critical care nurses. Critical care nurses will continue to encounter AEDs both in their communities and when they respond to sudden cardiac arrest in the hospital. The American Association of Critical-Care Nurses supports funding for public defibrillation programs, as outlined in an action alert on their Web site (http://www.aacn.org).

Operation of AEDs

As previously mentioned, the design of AEDs has been improved so that the devices are very easy to use. At the same time, AEDs have undergone complex technological advances that have improved their efficiency.17-20 Our devices have “Smart Biphasic” technology that uses advanced algorithms to identify cardiac rhythms and can adjust to a patient’s impedance or resistance to the flow of current through the chest. Such adjustments mean that lower energy settings can be used and that the potential for skin burns or myocardial damage is reduced.21,22 Our older manual defibrillators use monophasic waveform energy and deliver current from one paddle to another in a single direction, whereas these newer biphasic units deliver energy in 2 directions between the pads or paddles. Studies indicate that biphasic energy is more successful than monophasic energy in terminating arrhythmias.23 We are moving away from using paddles and instead are using pads as our primary mode for defibrillation. The AHA recommends placement of
pads on the right side of a patient’s chest to the right of the sternum just below the clavicle and on the left side, laterally at the midaxillary line at a level just below the nipple. When pads are initially used with an AED, our code team can easily unplug the pad cable and insert the cable into the manual defibrillator without changing the pads that are attached to the patient. Not only is this process quick and easy, but then the pads can be used immediately for monitoring, pacing, cardioversion, or defibrillation as determined by the critical care nurse on the team. An adapter connector may be needed to connect these pads to a manual defibrillator, as was the case for us during the study period. Our new devices do not need an adapter, though, because both the AED and the manual devices have the same connection; thus, disconnection and reconnection can be done quickly without adapters.

Single-Team Versus 2-Tiered Approach

Our code committee discussed the use of AEDs in our non–critical care areas and because it was a new approach, asked us to design a trial to obtain feedback from nurses before implementing the program campuswide. A 2-tiered system was proposed. Hands-free pads would be used as well as standard paddles. The trial would provide information to decide how and if such a system would be instituted. Specific questions related to the new device and the change in protocol would be examined.

We thought that the benefits of adding AEDs and changing to a 2-tiered approach could be significant. Any patient with sudden cardiac arrest would be treated by using the AED with pads, and the initial defibrillation would be delivered by the non–critical care nurse at the bedside. Rapid replacement of the AED by the manual defibrillator would be done by the critical care nurse when the code team arrived. This process was a significant improvement from our previous system. Quicker defibrillation with a smoother, rapid transition of care to the code team would be possible with this 2-tiered system.

Moving to this new technology had other potential benefits. Documentation and data collection could be easier and more reliable because the AEDs contain a data card that can be used to save data automatically, including electrocardiographic tracings and information on events. These data can be downloaded into a computer and printed for later review and use (Figures 2A and 2B). Cardiologists, electrophysiologists, and the code team could use these data to treat patients further and to improve quality of care.

Our past practice had been to place manual defibrillators in every inpatient area, even though many nurses in those areas were not trained to use defibrillators. Often, the devices were used only as monitors. Another potential benefit of a 2-tiered approach is cost savings, because the cost of a manual defibrillator is 2 to 5 times more than the cost of an AED. Prices listed range from $2000 to $3000 for
AEDs and from $7000 to $12 000 for manual units. If personnel in non–critical care areas use more AEDs and fewer manual units, considerable cost savings might be realized for the medical center.

**Methods**

In response to our code committee’s request, an in-hospital AED study was designed to use a 2-tiered protocol (Figure 3) based on the AHA algorithm and guidelines for defibrillation. The study design was submitted to our institution’s investigational review board and was approved. A survey questionnaire was developed with a series of questions for the nurses to answer (Figure 4). Our aim was to survey 20 or 30 nurses who used AEDs throughout the 1-year study and report back to the committee about ease of use and the nurses’ attitudes toward AEDs and the 2-tiered response. Support for our project was requested and was granted by the Ross Committee for Nursing at Boston Medical Center. We obtained 5 AEDs and selected 2 care units that had large populations of cardiac patients. We hoped to enroll enough patients to use the protocol and the devices and obtain nurses’ feedback. We thought that 5 AEDs could be dispersed for quick access by the nursing staff. The devices that we used were Philips Forerunner (FR2) AEDs (Andover, Mass). Each of these units has a screen that displays electrocardiographic rhythms and is visible to all responders. This feature is not available on all AEDs; the advanced practitioners wanted to have a visible indication of a patient’s heart rhythm when they arrived. The AEDs were strategically located in 2 non–critical care areas in hallway locations that offered easy access to the devices and proximity to any patient’s room. The units were mounted in wall boxes that were custom-made with a clear front panel and a plastic snap lock (Figure 5). The AEDs were secured in this manner to discourage removal except when needed. Our hospital electricians and carpenters agreed to make the boxes for the AEDs. A small battery-powered buzzer was activated when the wall box was opened to alert the staff that the AED had been removed. We also hoped that the noise of the buzzer would be a deterrent to theft. Each AED also included an adapter to connect the AED pads to the manual defibrillators (HP Code Master, Philips Medical, Andover, Mass, and Physio Control Life Pack, Medtronic, Palo Alto, Calif).

**Figure 3** Two-tiered protocol.
Abbreviation: CPR, cardiopulmonary resuscitation.
Courtesy of Boston Medical Center, Boston, Mass.
We used the protocol we had developed for defibrillation to provide in-service education by performing mock codes with the AED and a manual defibrillator (Figure 6). Device-specific training on the AEDs was also given to both the non–critical care nurses and the code team nurses by the AED vendor and the study coordinators.

**Results**

At the conclusion of our trial, we reviewed the nurses’ survey responses about their experience with the AED and the 2-tiered system. Overall, the nurses recommended the use of AEDs in non–critical care areas. The data from the surveys collected are contained in the Table.

Twenty-six patients in our study areas had the code team activated for an event during the 1-year duration of our trial. Seventeen nurses who used or observed the AED being used responded to our questionnaire. The hands-off pads were placed on the patient initially with the AED, and 8 patients had the pads connected to the manual defibrillator when the code team arrived. The first nurses to switch the pads from an AED to manual defibrillators said that doing so was not easy. An adapter was used to allow the pads to remain on patients while a nurse connected the pads to the manual device, but some respondents found that switching from an AED to a manual defibrillator was difficult. After the nurses were retrained, it was easier for them to use the adapter and switch from the AED to the manual device.

Our initial training included only nurses because they would be the pri-
AED was analyzing the patient’s rhythm (that process takes up to 10 seconds). At the end of the study, the responding nurses concluded that the AEDs were easily accessible, simple to use, and allowed patients to receive defibrillation more quickly than before.

Discussion

Only 3 of the 26 patients who had an AED applied had ventricular tachycardia or ventricular fibrillation that required defibrillation. Upon reviewing other studies of cardiac arrests that occurred in hospitals but outside critical care units, we found that the low incidence of ventricular tachycardia or fibrillation that we noted is consistent with the incidence reported for similar studies.\textsuperscript{4,14} We were encouraged, however, that 3 patients received defibrillation, and 2 of them had return of spontaneous circulation before the code team arrived. The third patient died despite a lengthy resuscitation attempt. Seven patients in the group died, consistent with the high mortality rate associated with in-hospital cardiac arrests in non–critical care areas. The patients who died did not have ventricular tachycardia or fibrillation as an initial rhythm.

Limitations

Our survey was developed and designed as a simple means to evaluate nurses’ responses to the use of AEDs and a change in practice. We did not measure outcome data, our sample size was small, and the number of patients with ventricular fibrillation was low. Our code committee used the responses on our questionnaire to further pursue a new approach in our hospital. Actual times from cardiac arrest to defibrillation were not noted, but patients who needed defibrillation received it before the code team arrived.

Nursing Implications and Recommendations

Sudden cardiac arrest is not an everyday event, and in most nursing units, it occurs unexpectedly. Delayed defibrillation occurs infrequently in patients who are monitored and in patients in critical care units, but it occurs in non–critical care hospital units and in outpatient and diagnostic facilities, which hundreds of patients enter and leave each day. In areas such as these, centralized response teams can take many minutes to arrive with a defibrillator, attach it, and administer defibrillation.\textsuperscript{14}

We think that in-hospital practice, like out-of-hospital care, must shift from a focus on CPR as the sole form of BLS to include both CPR and defibrillation. Outside the critical care areas, staff nurses trained in BLS are usually the first to discover that a patient is having a cardiac arrest. They provide CPR until the resuscitation team arrives.

The use of an AED is a BLS skill; in fact, BLS courses now include the use of AEDs for healthcare providers. We think that AED training should

Survey results, based on 26 calls for code team and 17 survey respondents who used the automated external defibrillator (AED)

| 17 respondents used an AED |
| 17 respondents observed an AED being used |
| Only nurses used the AED |
| 8 “hands-off” pads were used with the manual defibrillator |
| The manual defibrillator was used 3 times |
| 3 patients received defibrillation before the code team arrived |
| 7 respondents stated that switching from the AED to the manual device was easy; 7 respondents stated that it was not easy (before retraining) |
| 19 respondents stated they would consider using AEDs in non–critical care areas |
| 20 respondents considered the AED easily accessible |
| 18 respondents thought that the AED was simple to use |
| 10 respondents thought that defibrillation would be delivered sooner if the AED was used |
| 1 respondent stated that it was difficult to synchronize and pace with the AED |

Other data

At least 3 additional patients did not have an AED applied or it was removed because of the house staff’s discomfort with the device

3 of 26 patients for whom a code was called had a rhythm that warranted defibrillation (ventricular fibrillation) and received defibrillation

2 of 3 patients who received defibrillation were revived before the code team arrived

The initial switchover from the AED to the manual defibrillator was difficult and retraining was required

7 deaths occurred in the study group
be incorporated into all BLS training programs for hospital personnel expected to respond to patients who are experiencing a cardiac arrest, and rapid defibrillation should be a priority along with immediate CPR. Because the algorithms used by the AEDs to detect arrhythmias are sensitive and specific for recognizing abnormal heart rhythms that can be treated by defibrillation, the operators of AEDs do not require ACLS training or training to recognize arrhythmias. Critical care nurses responding to a patient in cardiac arrest must also be comfortable interacting with and using the AEDs so that the transition to advanced life support is smooth.

In moving from a single-tier structure to a 2-tiered response, our nurses and physicians needed to understand not only how the 2 tiers interact but also what each type of defibrillator can and cannot do (ie, monitoring, defibrillation, synchronization, cardioversion, or pacing). Reinforcement and reeducation of our teams were necessary and beneficial in our 2-tiered approach. Early in our experience with the AED program, some physicians responding to a cardiac arrest in which an AED was being used were eager to remove the device and use conventional manual defibrillation. “Get that thing off!” and “Bring the real defibrillator!” were heard occasionally. Our initial exclusion (inadvertent) of physicians from the AED training was a mistake that we corrected. Now that physicians, including critical care staff. The goal set by the AHA to administer defibrillation within 3 minutes of the onset of cardiac arrest (in-hospital standard) is what we are striving to achieve.

The Joint Commission on Accreditation of Healthcare Organizations has recently required stricter resuscitation documentation, and with new defibrillators that can not only record but also download data, documentation should be easier and more accurate.

Many successful community programs use nonlicensed personnel to operate AEDs. Might hospitals be able to do the same? One might envision a secretary, security guard, or patient care assistant using an AED so that the nurse can assist the code team and coordinate the patient’s overall care.

Conclusion

AEDs have a useful role in patients with cardiac arrest who are in non–critical care areas of the hospital. The comfort level of all healthcare professionals is critical to the success of AED protocols. Whenever a new program is starting or a new device is being evaluated, difficulties may be encountered and must be addressed. Comprehensive training and practice with all levels of respondents, including physicians, code team nurses, and unit nurses will help create this comfort level. A 2-tiered approach to defibrillation can provide rapid defibrillation and allow better integration between personnel with different levels of training (ie, basic and advanced) who respond to patients who are having cardiac arrest. This approach could also allow hospitals to decrease costs without decreasing (and perhaps even increasing) the quality of patients’ care. Costs could be reduced by using the less-expensive AEDs instead of manual defibrillators in some areas. The nurses who used the AEDs and responded to the survey reported a high level of satisfaction and thought that AEDs should be considered for use in non–critical care areas of the hospital. Ventricular fibrillation is infrequent during codes called in the hospital, as it was during our study, despite the high morbidity and mortality in the patients on whom the AED was used. Those patients who did have ventricular fibrillation had a high revival rate and received defibrillation before the code team arrived. The prehospital community at large has expanded use of AEDs and improved response times. At times defibrillation may occur as fast or faster in the prehospital community than in the hospital’s non–critical care areas. Our goal is to make response times for defibrillation in non–critical care areas of the hospital as short as or shorter than defibrillation times in the community.

We encourage and support the use of AEDs in hospitals. Our study reemphasized to our code committee that a 2-tiered response to codes in the hospital setting can be effective. When AEDs are deployed in carefully selected areas of a hospital, the potential benefits of rapid defibrillation and improved survival of patients can be realized.

More study is needed to look at specific outcomes for patients according to accurate response times and time to first defibrillation. Our nurses had a positive attitude toward use of AEDs as part of a 2-tiered code-response system in the hospital. Critical care nurses will continue to
see AEDs and must be aware of how the devices work and how they fit into hospital response protocols.

References


12. Sternberg S. Hospitals a bad bet for heart jump-start. USA Today. November 9, 1999:8 D.


Learning objectives: 1. Discuss the initiation of a 2-tiered defibrillation response system in one hospital  2. Discuss the importance of early defibrillation in cardiac arrest  3. Describe the limitations of the study

1. According to the latest guidelines from the American Heart Association, the initial defibrillation for a cardiac arrest in a hospital should be administered within what time frame?
   a. 3 minutes
   b. 2 minutes
   c. 4 minutes
   d. 5 minutes

2. Survival of cardiac arrest in nonmonitored areas of the hospital can be as low as what percentage?
   a. 7% to 11%
   b. 11% to 15%
   c. 15% to 23%
   d. 25% to 30%

3. The American Heart Association recommends that defibrillation paddles or pads be placed where on the patient?
   a. Just below the left clavicle and at the level of the nipple, left midaxillary line
   b. Just below the left clavicle and at the level of the nipple, left anterior axillary line
   c. Just below the right clavicle and at the level of the nipple, left anterior midaxillary line
   d. Just below the right clavicle and at the level of the nipple, left midaxillary line

4. In the initial study, automated external defibrillators (AEDs) were placed in which non–critical care area?
   a. Nurses’ station
   b. Hallway
   c. Elevators
   d. Medication rooms

5. What would occur when wall box containing the AED was opened?
   a. Hospital engineering was notified.
   b. The hospital operator was notified.
   c. A small buzzer attached to the box was activated.
   d. A light attached to the box was activated.

6. During the study period of 1 year, how many patients actually received defibrillation from an AED before the code team arrived?
   a. 10 patients
   b. 8 patients
   c. 7 patients
   d. 3 patients

7. Which of the following difficulties was an initial complaint that nurses had regarding the AED, which was dealt with by retraining?
   a. Switching from the AED to the manual defibrillator
   b. Applying the AED pads correctly
   c. Remembering the correct AED sequence
   d. Doing cardiopulmonary resuscitation around the AED

8. How many patients who received defibrillation with an AED had a spontaneous return of circulation before the code team arrived?
   a. 0 patients
   b. 2 patients
   c. 5 patients
   d. 7 patients

9. What were 2 limitations of the study?
   a. No statistical analysis of the gathered data and the initial exclusion of physician house staff from the study
   b. Initial exclusion of physician house staff from the study and a small sample
   c. Initial exclusion of physician house staff from the study and a low number of patients with ventricular fibrillation
   d. A small sample and a low number of patients with ventricular fibrillation

10. What were 2 recommendations for further study by the authors?
    a. Incorporating AED use in all units and teaching AED use to all levels of providers
    b. Teaching AED use to all levels of providers and identifying accurate response times
    c. Teaching AED use to all levels of providers and identifying time to first defibrillation
    d. Identifying accurate response times and time to first defibrillation

11. Survival of a cardiac arrest requiring defibrillation will be affected by how fast defibrillation can be accomplished, and will decrease how much for each minute that passes?
    a. 5% to 7%
    b. 7% to 10%
    c. 10% to 13%
    d. 13% to 16%

12. The price differential between AEDs and manual defibrillators can be how large?
    a. $10 000
    b. $5 000
    c. $8 000
    d. $2 000

Test answers: Mark only one box for your answer to each question. You may photocopy this form.

1. a ❑ b ❑ c ❑ d ❑
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5. a ❑ b ❑ c ❑ d ❑
6. a ❑ b ❑ c ❑ d ❑
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12. a ❑ b ❑ c ❑ d ❑

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