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Clinical paper

Automated external defibrillators and in-hospital cardiac arrest: Patient survival and device performance at an Australian teaching hospital☆

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ABSTRACT

Aims: To evaluate the effect of automated external defibrillators (AEDs) on patient survival and to describe the performance of AEDs after in-hospital cardiac arrest.
Methods: Prospectively collected data were analysed for cardiac arrests in the general patient care areas of a teaching hospital during the 3 years before and the 3 years after the deployment of AEDs. The association between availability of an AED and survival to hospital discharge was assessed using multivariate logistic regression. AED performance during automated management of the initial rhythms was assessed using information captured by the AEDs.
Results: There were 84 cardiac arrests in the AED period and 82 in the pre-AED period. Patient and event characteristics were similar in each period. The initial rhythm was shockable in 16% of cases. Return of spontaneous circulation was higher in the AED period (54% vs. 35%, $P=0.02$) but the proportion of hospital survivors in each period was similar (22% vs. 19%, $P=0.56$). The adjusted odds ratio for hospital survival when an AED was available was 1.22 (95% CI 0.53–2.84, $P=0.64$). An AED was applied in 77/84 (92%) possible cases. Median interruption to chest compressions was 12 s (inter-quartile range 12–13). An automated shock was delivered in 8/13 (62%) possible cases.
Conclusions: Availability of AEDs was not independently associated with hospital survival. Shockable presenting rhythms were not common and, in keeping with the manufacturer's specifications, the AEDs did not shock all potentially shockable rhythms. The hands-off time associated with automated rhythm management was considerable.

1. Introduction

Automated external defibrillators (AEDs) can analyse the cardiac rhythm, charge automatically if a shockable rhythm (i.e. ventricular fibrillation [VF] or ventricular tachycardia [VT]) is recognised and provide the operator with audible and/or visual prompts for the safe delivery of an electrical shock.[1] According to the recently updated guidelines of the Australian Resuscitation Council, the use of AEDs as a component of managing in-hospital cardiac arrest is acceptable.[2–6]

The benefits to patients of using AEDs during cardiac arrests in certain out-of-hospital settings have been demonstrated.[7,8] However, there has never been a randomised controlled trial of AEDs for in-hospital cardiac arrest and recent observational studies have cast doubt on the effectiveness of AEDs in hospitals. A single-centre study found that replacing manual defibrillators with AEDs made no difference to survival to hospital discharge after in-hospital cardiac arrest when the initial rhythm was shockable (31% vs. 29%, $P=0.80$), and survival to hospital discharge was significantly reduced if the rhythm was not shockable (15% vs. 23%, $P=0.04$).[9] A study of almost 12,000 patients from over 200 hospitals found AED use during in-hospital cardiac arrest was independently associated with a reduction in survival to hospital discharge (16.3% vs. 19.3%; adjusted rate ratio 0.85, $P<0.001$).[10] The accompanying editorial advocated a cautious approach to introducing AEDs into the hospital setting.[11]

There are factors that may count against the use of AEDs for in-hospital cardiac arrest. Automated rhythm management is associated with longer interruptions to chest compressions compared to non-automated management[12,13] and, in out-of-hospital settings where AEDs have improved patient outcomes, the initial cardiac arrest rhythm was shockable in more than half the cases and the response times of advanced life support providers were relatively long,[7,8] but in the hospital setting the initial rhythm is shockable in only about one out of five cases and the

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response times of advanced life support providers are relatively fast.[9,10,14,15]

We have previously reported that there was no change in survival to hospital discharge after in-hospital cardiac arrest in the first year following the deployment of AEDs to the general patient care areas of our hospital.[15] We now present cardiac arrest data for the 3 years before and the 3 years after the AED deployment. The use and performance of AEDs and the effect on patient outcomes is assessed.

2. Methods

Following Human Research Ethics Committee approval, the study was conducted at St Vincent's Hospital Melbourne, Australia, a university-affiliated hospital which had approximately 300 acute and 80 subacute inpatient beds for adults. Each year at the hospital there were over 40,000 admitted patient episodes and over 30,000 emergency department presentations.

There were two types of medical emergency response at the hospital: a 'Respond MET' was available for inpatients that were displaying serious (but non-arrest) signs and symptoms and a 'Respond Blue' was available to assist patients suffering cardiac arrest, respiratory arrest or a threatened airway. The Medical Emergency Team (MET) consisted of a medical registrar, intensive care registrar and a senior intensive care nurse. The Respond Blue team consisted of the MET personnel, an anaesthetic registrar and, for subacute patient areas, an emergency registrar. Australian Resuscitation Council algorithms for basic life support and advanced life support were followed.

In May 2007, 18 AEDs (*Heartstart FR2+*, model M3860A, Philips Medical Systems, Seattle, Washington, USA) were purchased. These were stand-alone devices, not manual defibrillators with AED capability. The AEDs permitted biphasic waveform defibrillation at a fixed energy level of 150 J, had an ECG display that allowed basic rhythm interpretation and had manual override capability to permit manual defibrillation. The AEDs had a reported sensitivity (proportion of shockable rhythms correctly identified) of ≥67% for VT and ≥87% for VF and a reported specificity (proportion of non-shockable rhythms correctly identified) of ≥97% for sinus rhythm, ≥92% for asystole and ≥88% for other rhythms.[16]

The AEDs were programmed to perform automated rhythm analysis when first applied to a patient and thereafter at 2-min intervals. For shockable rhythms, the AEDs gave a single automated shock (i.e. not 'stacked' shocks) for each attempt at defibrillation. The AEDs were also programmed so that, for the first automated rhythm analysis, if a shockable rhythm was detected an automated shock would not be given if the device determined the rhythm characteristics were such that Return of Spontaneous Circulation (ROSC) after an attempt at defibrillation was unlikely, a feature the manufacturer called 'Smart CPR'. [16]

Software was used that enabled collection of electrocardiographic (ECG) and event data (e.g. the time of application of electrode pads and shock advice) stored by the AEDs (*Event Review Pro 3.5.1*, Philips Medical Systems, Seattle, Washington, USA).

On 8 November 2007, the AEDs were deployed to the general patient care areas of the hospital including dialysis, medical imaging, the rehabilitation ward and the acute inpatient wards. AEDs completely replaced manual defibrillators in these areas. Little continuous cardiac monitoring was available in these areas and most first responders could not perform manual defibrillation. Manual defibrillators were retained in the emergency department, operating theatres, intensive care, coronary care, the cardiology and cardiothoracic wards and the cardiac catheterisation laboratories. In the 3 months before the AED deployment, a staff education programme was undertaken and this provided over 80% of clinical staff with instruction in the use of AEDs. The use of AEDs was then incorporated into the hospital's usual resuscitation training programmes.

Prospective, Utstein-style[17] data were gathered by intensive care staff in relation to all cardiac arrests that occurred at the hospital and were associated with a medical emergency call. Data were checked against a log of medical emergency calls from the hospital paging system to ensure that all cases of cardiac arrest associated with an emergency call were captured. Data collection was overseen by the medical director of intensive care (JDS). Cardiac arrest was deemed to have occurred when a patient was treated with chest compressions or electrical defibrillation. We analysed the data for cardiac arrests that occurred in areas where AEDs were deployed, for the 3 years before and the 3 years after the deployment, i.e. the 6-year period from 8 November 2004 to 7 November 2010.

The patient's primary treating unit at the time of arrest was classified as either medical or surgical. Medical units included general medicine, gastroenterology, haematology, neurology, renal and stroke. Surgical units included breast and endocrine, colorectal, hepatobiliary, orthopaedics, neurosurgery and vascular. Predicted hospital mortality for acute inpatients was calculated using a validated technique called the Hospital Outcome Prediction Equation, which is based on age, gender, hospital admission source, hospital admission urgency and hospital admission diagnosis.[18] The 'hands-off' time with initial use of the AEDs was calculated from the time the device recorded that electrode pads were connected until the device began timing the 2-min period for delivery of chest compressions and rescue breathing. This incorporates the time taken for automated rhythm analysis and, when necessary, charging the AED and discharging a shock.

Statistical analysis was performed using the statistical software programme *Stata*, *Version 11.0* (StataCorp, College Station, Texas, USA). Categorical variables were reported as counts and proportions. Normally distributed continuous variables were presented as mean and standard deviation, while non-normal variables were presented as median and inter-quartile range. Differences in ROSC and survival to hospital discharge between the pre-AED and AED periods were compared using Pearson's chi-squared. Reported *P*-values were two-sided and values <0.05 were taken to signify statistical significance.

Multivariate logistic regression was used to determine the adjusted odds ratio of survival to hospital discharge after cardiac arrest when an AED was available. A stepwise backward elimination procedure was used to select variables.[19] The following pre-specified variables that were considered to be potential confounders were included and then, beginning with the least important explanatory variable, omitted in a stepwise fashion if their *P*-value was greater than 0.20: age, gender, predicted mortality, primary treating unit (medical or surgical) at the time of arrest, the shock eligibility of the initial rhythm (shockable or not shockable), and whether the onset of arrest was witnessed or not witnessed. A second regression model, using the same methodology, was constructed that tested the association between *use* (rather than *availability*) of an AED and hospital survival.

3. Results

3.1. Numbers of cardiac arrests and patients

There were 166 cardiac arrests in the AED areas, 82 during the 3 years before the AED deployment (pre-AED period) and 84 during the 3 years after the deployment (AED period). The 166 cardiac arrests involved 162 different patients: during their hospital stay 158 patients had 1 arrest and; 4 patients had 2 arrests.