Title: In-hospital cardiac arrests: effect of amended Australian Resuscitation Council 2006 guidelines

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Abstract

Objective: To evaluate cardiac arrest outcomes following the introduction of the Australian Resuscitation Council (ARC) 2006 amended guidelines for basic and advanced life support.

Methods: A retrospective study of all consecutive cardiac arrests during a 3-year phase pre-implementation (2004-2006) and a 3-year phase post-Implementation (2007-2009) implementation of the ARC 2006 guidelines was conducted at a tertiary referral hospital in Brisbane, Australia.

Results: Over the 6 year study phase 690 cardiac arrests were reported. Resuscitation was attempted in 248 patients pre-implementation and 271 patients post-implementation of the ARC 2006 guidelines. After adjusting for significant prognostic factors we found no significant change in return of spontaneous circulation (ROSC) (OR 1.21; 95% CI 0.80-1.85, p=0.37) or survival to discharge (OR1.49; 95% CI 0.94-2.37, p=0.09) after the implementation of the ARC 2006 guidelines. Factors that remained significant in the final model for both outcomes included having an initial shockable rhythm, a shorter length of time from collapse to arrival of cardiac arrest team (CAT), location of the patient in a critical care area, shorter length of resuscitation, and a day time arrest (0700-2259) In addition the arrest being witnessed was significant for ROSC, while younger age was significant for survival to discharge.

Conclusions There are multiple factors that influence clinical outcomes following an in-hospital cardiac arrest and further research to refine these significant variables will assist in the future management of cardiac arrests

What is known about this topic?

The evaluation of outcomes from in-hospital cardiac arrests focuses on immediate survival expressed as ROSC and survival to hospital discharge. These clinical outcomes have not improved substantially over the last two decades.

What does this paper add?

This paper identifies the factors that are related to ROSC and survival to discharge following the implementation of the ARC 2006 guidelines which included a refocus on providing quality CPR with minimal interruptions.

What are the implications for practitioners?

Given that multiple factors can influence clinical outcomes following an in-hospital cardiac arrest, focusing on maximising a range of factors surrounding CPR is essential to improve outcomes.

Introduction

Survival rates from in-hospital cardiac arrests have remained poor with no substantial change over the last two decades despite advances in resuscitation training and the introduction of automatic external defibrillators .[1,2] Concerns that poor performance of CPR impairs haemodynamic status and affects survival rates led to an extensive evaluation of adult basic and advanced life support guidelines by the International Liaison Committee on Resuscitation at the International Consensus Conference on Cardiopulmonary Resuscitation and Emergency Cardiovascular Care Science in 2005.[3] The Australian Resuscitation Council (ARC) followed this with the release of the ARC 2006 guidelines [4] as summarise in Table 1.

Previous guidelines resulted in too much ‘hands-off time’ and contributed to poor-quality CPR,[3] with suboptimal chest compression and ventilation rates[5] correlated with poor pos-resuscitation survival rates. [6] ARC Cardiopulmonary Resuscitation Guideline 7 was amended to increase the number and rate of compressions, minimise interruptions to compressions, and prevent excess ventilation. The ARC ALS guidelines 11.1- 11.11 were also amended.[7] The major changes included refocusing on providing quality CPR with minimal interruptions, minimising the potential harm associated with hyperventilation, initiating a one shock strategy replacing the sequence of three stacked shocks and setting a default energy level of 200J for biphasic defibrillators.[8] The change from the three stacked shock sequence to one shock aimed to decrease inappropriate delays to recommencement of compressions.

These amended guidelines with fewer pauses and increased chest compressions aimed to improve the effectiveness of circulation to essential organs during CPR and led to the development of this study. The aim of our study was to evaluate clinical outcomes (return of spontaneous circulation [ROSC] and survival to discharge) from in-hospital cardiac arrests after hospital wide implementation of the ARC 2006 guidelines in a large tertiary referral hospital in Australia. ROSC is defined as restoration of spontaneous circulation which is sustained for 20 minutes or longer [9]

Methods

Setting

This study was undertaken at a 740-bed adult tertiary referral hospital providing all specialty services with the exception of gynaecology and obstetrics in Brisbane, Australia.

Cardiac Arrest Management

Within this hospital setting first responders to cardiac arrests are medical and nursing staff who commence basic life support (BLS) including defibrillation with a semi-automatic defibrillator (SAED) for patients in a shockable rhythm. A designated cardiac arrest team (CAT) attends each cardiac arrest to provide advanced life support (ALS). The CAT comprises ALS- trained staff including a medical registrar, an intensive care registrar, a medical resident and a registered nurse from a critical care area (Coronary Care Unit, Intensive Care Unit or the Emergency Department). A designated Resuscitation Co-ordinator and Resuscitation Committee are responsible for overseeing all resuscitation policies, procedures and resuscitation training throughout the hospital.

Data collection and sample

A retrospective study of all consecutive adult in-hospital cardiac arrests during a 3-year phase before implementation (PRE), and a 3-year phase after implementation (POST), of the ARC 2006 Guidelines was conducted. Power analysis showed that 330 patients were required in each group to detect a 10% difference in survival to discharge with an alpha of 0.5 and with 80% power calculated using the pre survival to discharge rate of 25%.

During November and December 2006 an intensive training program based on these amended guidelines was implemented throughout the hospital to ensure all appropriate staff were trained prior to the implementation date of 1 January 2007. The updated hospital policy and procedures for BLS and ALS were implemented in January 2007; they remained unchanged throughout the 3-year POST data collection phase.

A resuscitation form adapted from the Utstein guidelines[10], implemented previously at this hospital, was utilised to record all resuscitation details and was completed by the registered nurse member of the CAT. Utstein-style reporting templates have been used extensively in published studies to standardise research reports of cardiac arrests. [9] The following definition of a cardiac arrest was used:

> *'the cessation of cardiac mechanical activity as confirmed by the absence of signs of circulation'* (p236). [9]

All patients who had a documented cardiac arrest during the study period were included. Respiratory only arrests (cardiac arrest call where a cardiac output was present with no respiratory effort), and patients documented as 'Not for Resuscitation' (NFR), were excluded from this study. The Resuscitation Co-ordinator audited the patient's chart to ensure data validity, collated the completed resuscitation forms, and maintained the data base to generate subsequent reports.

Statistical analysis

This study investigated the outcomes of ROSC and survival to discharge with the variables:-

- witnessed and/or monitored arrest, which includes patients who may have been monitored only, had witnessed arrests only, or been monitored and had witnessed arrests
- location of the patient in a critical care (Intensive Care Unit, Coronary Care Unit or Emergency Department) or a ward area,
- the starting time of the arrest commencing when the patient was found was categorised into two groups to represent day shift (07:00-22:59 hours) and night shift (23:00-06:59 hours),
- length of the resuscitation from the start time to ROSC or death,
- time to arrival of the CAT, and
- initial rhythm .

Descriptive statistics are reported as medians with interquartile range (IQR). Categorical data were analysed using Chi-square tests and Wilcoxon rank-sum test for continuous variables. Variables were investigated for association with survival to discharge and ROSC using a univariate logistic regression. Variables significant at the 0.10 level were entered stepwise into a multiple logistic regression model. All variables were assessed for interaction and transformation. A dummy variable for PRE and POST was utilised and maintained in the model. The results from the multivariate logistic regression analysis were reported as adjusted odds ratios (OR) with 95% confidence intervals (CI) and P-values. Likelihood ratio and Wald tests were used to assess the prognostic values in the multivariate models. The predictive ability of the models were assessed using Receiver Operating Characteristic (ROC) curve. The ROC curve measures the ability of the model to correctly classify those surviving to discharge or ROSC compared to those that did not. All analyses were reported at the alpha 0.05 level. All analyses were conducted using Stata version 11(Stata Corporation, College Station, Tx).

Results

There were 690 events reported with resuscitation being attempted in 519 cardiac arrests (Figure 1). Prior to the guideline change (01/01/2004 to 10/12/2006), 248 cardiac arrests occurred (PRE) and after the guideline change (1/1/2007 to 31/12/2009), 271 cardiac arrests occurred (POST). The median age was 68 years in the PRE group and 70 years in the POST group. Two characteristics were significantly different between the PRE and POST groups: male gender ($p < 0.001$) and witnessed arrests ($p=0.02$) (Table 2).

During the PRE phase 124 (50%) patients had a ROSC compared to 157 (58%) during the POST phase. In addition 61(25%) of patients in the PRE phase survived to hospital discharge, compared to 97(36%) patients in the POST phase (Figure 1).

All variables were significantly associated with the outcome variable on univariate analysis at the 0.10 level, consequently they were entered into a multivariate model. Gender and age did not remain significant in the multivariate model to predict ROSC, while gender and whether the arrest was witnessed or monitored did not remain significant in the survival to discharge model so these variables were removed from the respective models. There was no significant interaction between the variables.

In the multivariate model patients were more likely to have a ROSC post guidelines implementation however this was not statistically significant (OR 1.21; 95% CI 0.80-1.85, p=0.37) (Table 3.) Initial survival, reported as ROSC, increased if the cardiac arrest was witnessed, if the presenting rhythm was shockable, if the patient was located in a critical care area and if the arrest occurred during the day (Table 3). The chances of initial survival decreased with increasing length of resuscitation and with increasing time for arrival of the CAT (Table 3).

Implementation of the 2006 ARC guidelines was not significantly associated with survival to discharge (OR1.49; 95% CI 0.94-2.37, p=0.09) (Table 4). Similar patterns were seen in relation to survival to hospital discharge as those identified with ROSC. Specifically, daytime events, an initial shockable rhythm and location of the patient in critical care areas increased the chance of survival to discharge, while increasing age, length of resuscitation and time to arrival of the CAT reduced survival to discharge (Table 4).

The ROC curve analysis showed good predictive ability for ROSC and survival to discharge with values of 0.81 and 0.84 respectively.

Discussion

This present study demonstrated no significant change for ROSC or survival to discharge , following implementation of the ARC 2006 guidelines however outcomes were influenced by a range of factors. In-hospital cardiac arrests are a leading cause of morbidity and mortality and continue to have poor survival rates.[11] Changes to resuscitation guidelines have sought to focus on CPR performance while integrating the performance of ALS into the continuous chest compression-ventilation sequence.[12]

The ARC 2006 guidelines introduced a uniform compression-to-ventilation rate of 30:2 to decrease pausing of compressions to give ventilations following observations that rescue breaths cause long interruptions during chest compressions which decrease myocardial blood flow and 24-hour survival.[13,14] The ARC 2006 guidelines also introduced one single shock for shockable rhythms replacing the previous guideline of a three-shock sequence. While there is no definitive evidence that one shock is better than three shocks there are associated time delays using stacked shocks and the associated analysing by the semi-automatic defibrillator.[13,14] Rea and colleagues[15] reported increased survival to hospital discharge following out-of-hospital cardiac arrests with the introduction of a resuscitation protocol which eliminated post shock rhythm analysis, stacked shocks and post defibrillation pulse checks as well as an extension of the phase of CPR between rhythm analysis from 1 to 2 minutes. Our results have demonstrated a similar trend for increased survival to discharge although the result was not statistically significant following implementation of the ARC 2006 guidelines.

In our study initial survival, or ROSC, which mainly represents the success of the cardiopulmonary resuscitation procedure, has improved from 50% to 58%, following implementation of the ARC 2006 guidelines. Short term survival has been shown to improve with good quality CPR of an adequate depth and compression rate.[16] Higher chest compression rates are significantly correlated with initial ROSC while suboptimal rates correlate with poor ROSC.[5] Following implementation of the ARC 2006 guidelines there was a significantly larger number of witnessed/monitored arrests in our cohort.

Witnessed/monitored arrests have better outcomes[17] and the current study has confirmed this relationship.

After implementation of the ARC 2006 guidelines our results demonstrated a 36% survival to discharge rate, a trend upwards from 25% in the PRE phase, and a higher percentage than commonly reported rates of 15 to 20%.[18] Possible contributing factors for our survival rates include the strong focus on the process of CPR and the increased compression to ventilation rates resulting in less interruption during chest compressions. The changes to the process for delivering shocks from a series of three stacked shocks to one shock may also have decreased inappropriate delays in compressions.

In our study variables significantly associated with ROSC included having an initial shockable rhythm, a shorter length of time from collapse to arrival of CAT, location of the patient in a critical care area, day time arrest (0700-2259), shorter length of resuscitation and a witnessed or monitored arrest. For survival to discharge the significant variables were similar, however additionally age was a significant variable, while a witnessed or monitored arrest was not significant. Outcomes from cardiac arrests are better when the first documented rhythm is shockable compared to non-shockable.[17-22] Shorter duration of arrest has also been found to increase 24 hour survival and survival to discharge[17,18,20] while patients who are located in a critical care area when they arrest have an improved survival to hospital discharge rate.[17] Although our study identified age as a significant variable for survival to discharge it is considered a controversial prognostic factor.[18]

Similar to our study previous research has shown that patients who arrest at night time have worse outcomes[20,23,24] and this is thought to be multi-factorial including differences in patients as well as health care staff, hospital staffing and operational factors.[24] We found a significant difference between initial rhythms for day and night time arrests with night time arrests having a higher number of initial non-shockable rhythms documented reflecting findings from other studies.[24]

Our study has demonstrated that implementation of the ARC 2006 guidelines with an increased focus on minimally interrupted chest compressions has contributed to a trend towards improvement in survival to hospital discharge. Our results reflect other studies that examined the effect of implementing the amended guidelines. In out-of-hospital cardiac arrests Olasveengen et al's[16] research found a trend towards improved survival to hospital discharge with rates changing from 11% to 13% after implementation of the modified 2005 guidelines, and Hinchley et al's[25] study reported significantly improved survival to discharge rates from 4.2% to 11.5% after implementation of the amended American Heart Association's 2005 guidelines. Thigpen et al's study[11] of in-hospital cardiac arrests reported an improvement from 17.5% survival to discharge rate to 28%. Although there have been more recent changes the fundamental changes implemented in 2006 have been maintained in the 2010 ARC revisions.[26]

This study has several limitations. First this is a single centre study with a small sample. Second we cannot discard that a Hawthorne effect may have contributed to our improved results. With the introduction of the ARC 2006 guidelines there was an intensive training program for all staff and an increased focus on cardiac arrest management so it is difficult to confirm whether it was the specific guideline changes or the general improvement in attention to arrest processes that contributed to improvements. Third our study relies on retrospectively documented data that specify time points and difficulties arise in collecting and verifying the accuracy of these data. Last, our study only collected data until hospital discharge. While it has been demonstrated that survival after discharge has a relatively small decline it is still important to have follow-up data for at least 12 months post discharge and our study would have been enhanced with data to demonstrate long term survival as well as neurological outcomes. We aim to collect follow-up data in future studies.

Conclusion

Our study adds to the currently available data supporting favourable outcomes following the implementation of the amended ARC 2006 guidelines. Our data has demonstrated that there are multiple factors that influence clinical outcomes following an in-hospital cardiac arrest and further research to refine these significant variables will assist in the future management of cardiac arrests.

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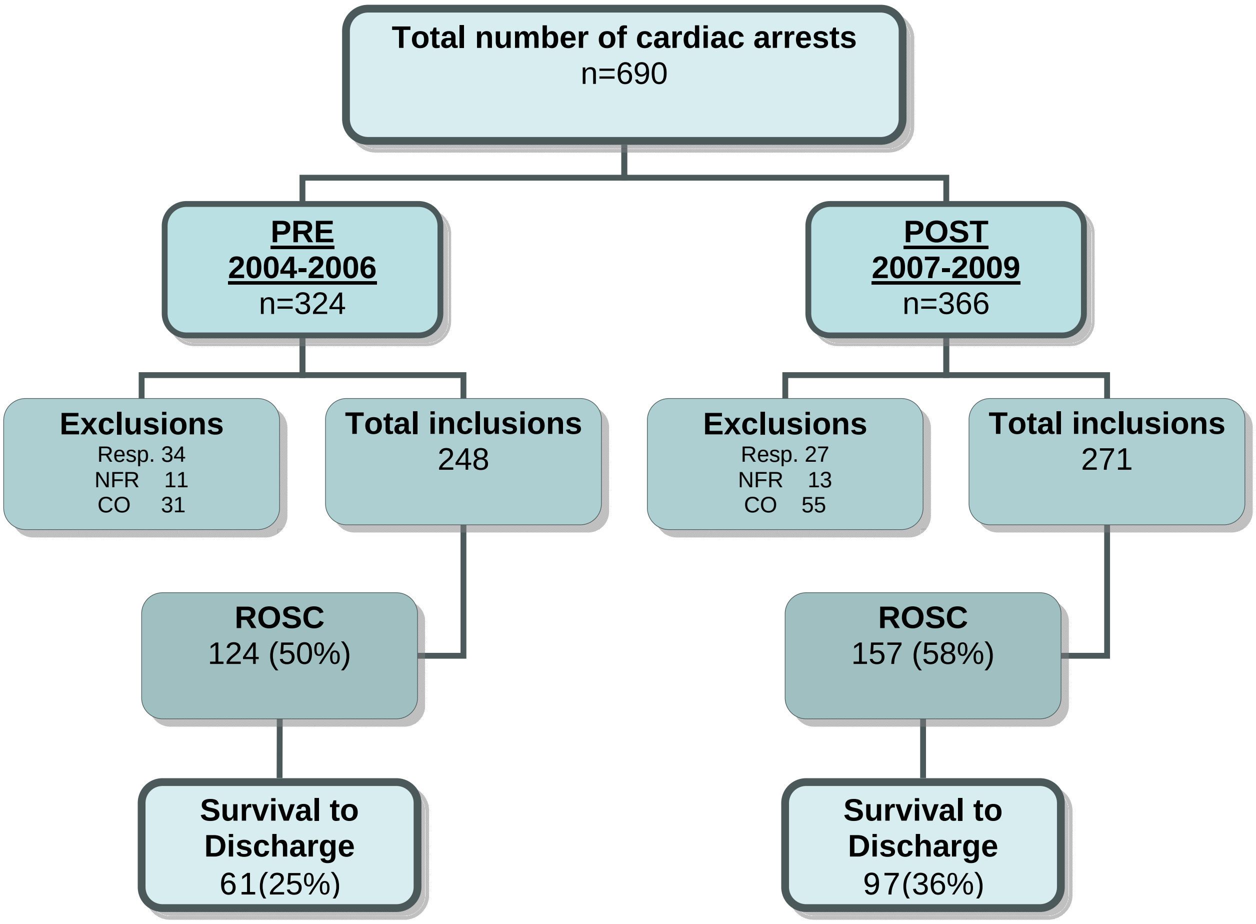
Figure 1: Outcomes for all cardiac arrests



All variables given in numbers (percentages in parenthesis).
Exclusions: Resp: respiratory arrests; NFR: documented 'Not For Resuscitation'; CO: cardiac output present.

Table 1: Summary of the changes to the Australian Resuscitation Council guidelines

	ARC[1] 2000 Guidelines (PRE)	ARC[1] 2006 Guidelines (POST)
Initial breaths	2 quick breaths	2 quick breaths
Ventilation rate	10-12/min	10-12/min
Compression-to-ventilation rate	1 rescuers 15:2 2 rescuers 5:1	30:2
Compression rate	100/min	100/min
Sequence of defibrillation	3 stacked shocks	1 shock except for witnessed/monitored arrests 3 stacked shocks
Check for pulse	After each shock	After 5 cycles of CPR

[1]*ARC =Australian Resuscitation Council*

Table 2: Demographic and clinical characteristics of cardiac arrests

	PRE (n= 248)	POST (n=271)	p value
	n(%)	n(%)	
Gender			< 0.001
Male	140(56)	188(69)	
Witnessed/ monitored cardiac arrest[1]	172(69)	211(78)	0.02
Initial pulse-less rhythm			0.07
Non-shockable	180(73)	177(65)	
Shockable	68(27)	94(35)	
Location of the patient			0.70
Ward	170(68.5)	190(70)	
Critical care area	78(31)	81(30)	
Time of cardiac arrest			0.48
2300-0659	70(28)	69(25)	
0700-2259	178(72)	202(75)	
	median (IQR)	**median (IQR)**	
Age, years	68(56-78)	70(59-78)	0.52
Length of resuscitation, minutes	12(6-22)	12(4-26)	0.76
Collapse to arrival of cardiac arrest team, minutes	2(0-3)	2(0-3)	0.46
Time to first CPR attempt, minutes	0(0-1)	0(0-1)	0.95

[1]Patients may have been monitored only, had witnessed arrests only or been monitored and had witnessed arrests

p values calculated with chi^2 for categorical variables and Wilcoxon rank-sum test for medians

Table 3: Variables associated with Return of Spontaneous Circulation (ROSC)

Variables	ROSC Yes (n=281)	ROSC No (n=238)	OR	(95% CI)	*p*-value
Implementation of ARC[1] 2006 guidelines					
Pre guideline change *01/01/04-10/12/06*	124	124	-		
Post guideline change *01/01/07-31/12/09*	157	114	1.21	(0.80-1.85)	0.37
Time of cardiac arrest					
23:00- 07:00	57	82	-		
07:00- 22:59	224	156	1.64	(1.01-2.66)	0.04
Initial rhythm					
Non shockable	149	208	-		
Shockable	132	30	2.23	(1.73-2.88)	<0.001
Witnessed/monitored					
No	39	143	-		
Yes	242	95	2.85	(1.72-4.71)	<0.001
Location of patient					
Ward	161	199	-		
Critical care area	120	39	2.11	(1.24-3.64)	0.01
Length of resusciation			0.97	(0.95-0.98)	<0.001
Collapse to arrival of CAT[2] (per additional minute)			0.87	(0.78-0.97)	0.02

[1]ARC= Australian Resuscitation Council, [2]CAT = Cardiac Arrest team. ROC curve for ROSC 0.81. OR, CI and p-values were determined through multivariate analysis.

Table 4: Variables associated with Survival to Discharge

Variables	Survival to discharge Yes (n=158)	Survival to discharge No (n=361)	OR	(95% CI)	p-value
Implementation of ARC[1] 2006 guidelines					
Pre guideline change *01/01/04-10/12/06*	61	187	-		
Post guideline change *01/01/07-31/12/09*	97	174	1.49	(0.94-2.37)	0.09
Time of cardiac arrest					
23:00- 07:00	27	112	-		
07:00- 22:59	131	249	1.97	(1.10- 3.52)	0.02
Initial rhythm					
Non shockable	65	292			
Shockable	93	69	2.20	(1.74-2.79)	<0.001
Location of patient					
Ward	83	277	-		
Critical care area	75	84	1.90	(1.12- 3.22)	0.02
Age (per additional year)			0.98	(0.97- 0.99)	0.02
Length of resuscitation (per additional minute)			0.95	(0.93- 0.96)	<0.001
Collapse to arrival of CAT[2] (per additional minute)			0.83	(0.72- 0.96)	0.01

[1]ARC= Australian Resuscitation Council, [2]CAT = Cardiac Arrest team. ROC curve for discharge 0.84.
OR, CI and p-values were determined through multivariate analysis.
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