Is Ward Experience in Resuscitation Effort Related to the Prognosis of Unexpected Cardiac Arrest?

Sen-Kuang Hou[1,2], Chii-Hwa Chern[1,3], Chorng-Kuang How[1,2]*, Lee-Min Wang[1,3], Chun-I Huang[1,3], Chen-Hsen Lee[1,2]

[1]Emergency Department, Taipei Veterans General Hospital, [2]Institute of Emergency and Critical Care Medicine, and [3]Department of Emergency Medicine, National Yang-Ming University School of Medicine, Taipei, Taiwan, R.O.C.

Background: The aim of this study was to investigate the outcome of patients of unexpected cardiac arrest initially resuscitated by first responders with dissimilar experiences under the support of cardiac arrest team (CAT).

Methods: All unexpected cardiac arrest patients receiving in-hospital resuscitation with the activation of CAT in a tertiary-care teaching hospital over a 12-month period were recorded according to the Utstein criteria. We prospectively recorded various factors at resuscitation and retrospectively evaluated the outcome. Outcome measures included return of spontaneous circulation (ROSC), survival longer than 24 hours, and survival to discharge.

Results: Altogether, 76 emergency calls were registered, and among these, 44 calls (58%) were cardiac arrests, including 8 ventricular tachycardia/fibrillation, 15 pulseless electrical activity, and 21 asystole. The rate of ROSC was 61%, the rate of survival longer than 24 hours was 37%, and the rate of survival to discharge was 18%. The response time of our CAT was 271 seconds (4 minutes and 31 seconds) on average. The patients who collapsed in the wards experienced in resuscitation effort received higher rates of appropriate basic and advanced cardiac life support interventions before CAT arrival (79% *vs.* 44%; $p = 0.019$), had an increased chance of ROSC (75% *vs.* 38%; $p = 0.014$), survival longer than 24 hours (54% *vs.* 13%; $p = 0.007$), and survival to discharge (29% *vs.* 0%; $p = 0.036$).

Conclusion: Hospital wards with more than 5 cardiac arrests per year have a better patient survival rate than those with fewer arrests. This is despite all ward staff receiving the same level of training. [*J Chin Med Assoc* 2007;70(9):385–391]

Key Words: cardiac arrest, cardiopulmonary resuscitation, in-hospital resuscitation, return of spontaneous circulation

Introduction

Cardiopulmonary arrest is a complication that can occur anywhere in a hospital. The majority of the inpatients who die are those who are expected to do so, and only 14% of all hospital cardiac arrests were unexpected and the resuscitation team alerted.[1] The reported survival rate from in-hospital cardiac arrest varies from 5% to 37%, but in the majority of hospitals, it is around 15%.[2] Many factors, including arrival time, initial rhythm and insufficient staff/equipment, show strong correlations with it.[3,4] The establishment of a cardiac arrest team (CAT), widespread basic life support (BLS) and advanced cardiac life support (ACLS) training, and improvement in resuscitation equipment have been adopted in many hospitals to improve the in-hospital cardiac arrest survival. Unfortunately, the survival rates have remained unchanged, despite continuous improvements in training methods and equipment.[2] There are still some systematic failures occurring during unexpected in-hospital resuscitation. Current knowledge indicates that survival of in-hospital cardiac arrests depends more on first responders than on CATs.[5] Cardiopulmonary resuscitation (CPR) is a team endeavor. Apart from medical knowledge and technical skills, human factors are likely to be relevant in the quality

*Correspondence to: Dr Chorng-Kuang How, Emergency Department, Taipei Veterans General Hospital, 201, Section 2, Shih-Pai Road, Taipei 112, Taiwan, R.O.C.
E-mail: ckhow@vghtpe.gov.tw • Received: January 14, 2007 • Accepted: May 23, 2007

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of CPR. Surprisingly, there are only limited data on the significance of behavioral issues in CPR.[6,7] In a scenario of simulated witnessed cardiac arrest, almost 2-thirds of teams composed of qualified health care workers failed to provide BLS and/or defibrillation within an appropriate time window.[7]

The aim of this study was to investigate the outcomes of patients of unexpected cardiac arrest initially resuscitated by first responders with dissimilar experiences under the support of CAT.

Table 1. Definitions of inappropriate basic life support and advanced life support

Delay to defibrillate in patients with ventricular fibrillation/ ventricular tachycardia
Incorrect use of defibrillator
Delay to deliver basic life support
Inadequate airway or ventilatory management
Suboptimal quality of chest compression
Improper medication administration
Absence of leadership behavior

Methods

Setting

Taipei Veterans General Hospital is an academic tertiary care center with 2,700 patient beds in Taipei, Taiwan. The hospital has all types of specialties, and the number of admissions in 2003 was 60,000. The total number of in-hospital deaths in 2003 was 2,513. General ward areas accounted for 1,412 (56.2%) of the total. Excluding 986 patients with do-not-attempt-resuscitation orders, 426 received in-hospital resuscitation when they collapsed on the general wards. BLS training was available to all hospital staff. In addition to BLS training, doctors and nurses undergo mandatory training to be ACLS providers. ACLS-trained nurses are authorized to implement all interventions, except intubation, contained in the appropriate algorithm. In addition to the doctors and nurses on duty in the ward, there is a CAT in assistance whenever an unexpected cardiac arrest occurs in the hospital. When an inpatient collapses in the absence of the duty doctor or first responders are unpracticed in resuscitation effort, the CAT will be activated by a special telephone number dialed by nearby hospital staff, who alert the hospital switchboard to activate the radio pagers carried by each member of the team. Since critical care units and the emergency department have immediate 24-hour advanced life support (ALS) available, patients in such areas were excluded. The CAT is made up of an anesthetist and a senior physician with emergency medicine, cardiology or chest medicine background. All members of the CAT are ACLS-certified. In each department and ward, there is an emergency kit including manual defibrillator, oxygen, endotracheal intubation equipment, bag-valve mask and intravenous medications.

Data collection

All CAT calls received by the hospital telephone switchboard between January 1, 2003 and December 31, 2003 were evaluated prospectively. We divided the nature of the events into 3 groups: cardiac arrests, airway interventions only or false arrests. A false arrest is defined as one for which no BLS or ALS action is needed. For patients with a cardiac arrest, the record of each event was begun immediately and reviewed later for completeness and accuracy by the emergency medicine registrar. The data were then entered into a computerized form based on the Utstein criteria for analysis, including demographics, date, time, location, interval between collapse and resuscitation, initial cardiac rhythm, treatment, return of spontaneous circulation (ROSC), survival longer than 24 hours, survival to hospital discharge, survival at 1 year, and the causes of patient collapse.[8] The members of the CAT also assessed, when possible, cardiac arrest patients as to whether or not they had received appropriate BLS and ALS intervention before CAT arrival. Inadequate airway or ventilatory management, delayed defibrillation in shockable rhythm, or improper medications was considered inappropriate (Table 1). Further clinical data were collected retrospectively, based on information from medical records.

Grouping

The study compared the outcome of unexpected cardiac arrests resuscitated by the CAT in the wards where first responders were experienced in resuscitation procedure (experienced group) to those less experienced (inexperienced group). We defined resuscitation-inexperienced wards as those places where the total number of cardiopulmonary resuscitation efforts occurred in the past 1 year was below 5 and the CAT was usually required; the inexperienced wards included the diagnostic department, outpatient department, dermatology department, dentistry department, ophthalmology department and rehabilitation center.

Outcome measures and statistical analysis

Outcome measures included ROSC, survival longer than 24 hours, and survival to discharge. SPSS version 10.0 (SPSS Inc., Chicago, IL, USA) for Windows was

used for statistical analysis on an IBM-compatible computer. Student's *t* test was used for continuous data, and Fisher's exact test for categorical data. The factors of statistical significance in univariate analysis using the Hosmer-Lemeshow goodness-of-fit test were further incorporated in a multiple regression analysis with forward selection to determine independent predictors of ROSC and survival longer than 24 hours. Statistical significance was accepted as $p<0.05$.

Results

During the 12-month study period from January 1, 2003 to December 31, 2003, 76 emergency calls were registered, and among these, 60 calls (79%) were attempted in-hospital resuscitations, including 44 (58%) cardiac arrests and 16 (21%) airway interventions only. The other 16 calls (21%) were classified as false arrests. These conditions included seizure ($n=3$), contrast anaphylaxis ($n=3$), fainting spell ($n=2$), postoperative bleeding ($n=2$), severe epistaxis ($n=1$), bronchial asthma with acute exacerbation ($n=1$), and rescinded calls ($n=4$), defined as a call received by the hospital telephone switchboard that was subsequently cancelled by the ward. The mortality for cardiac arrests, airway intervention only, and false calls were 82%, 56%, and 0%, respectively. A total of 44 patients with cardiac arrests were analyzed for the event variables and resuscitation results. The mean age was 72.7 years, and 55% were men. Initial rhythm was available for all patients: 8 had ventricular tachycardia (VT)/fibrillation (VF), 15 had pulseless electrical activity (PEA) and 21 had asystole. The rate of successful ROSC was 61%, the rate of survival longer than 24 hours was 37%, and the rate of survival to discharge was 18% (Figure 1). The response time of our CAT was 271 seconds (4 minute and 31 seconds) on average.

Twenty-eight patients with unexpected cardiac arrests collapsed in a resuscitation experienced area (experienced group) and 16 patients in a resuscitation inexperienced area (inexperienced group) (Table 2). Table 3 shows that the demographic data, underlying diseases, initial rhythm and time period were similar in both groups. The comparison of clinical factors regarding resuscitation between the experienced group and inexperienced group is summarized in Table 4. Notably, although all patients had already received some BLS in place at the time of collapse, the experienced group had received a higher rate of appropriate BLS and ALS interventions before CAT arrival (79% *vs.* 44%; $p=0.019$). The time between collapse and CAT arrival was similar in both subsets of patients. The experienced

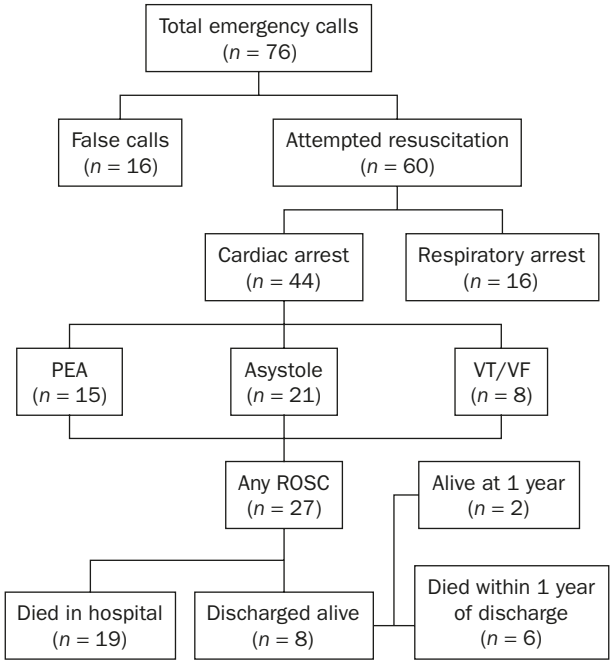

Figure 1. Utstein style template for in-hospital resuscitation. PEA = pulseless electrical activity; VT = ventricular tachycardia; VF = ventricular fibrillation; ROSC = return of spontaneous circulation.

group had increased chances of ROSC (75% *vs.* 38%; $p=0.014$), survival longer than 24 hours (54% *vs.* 13%; $p=0.007$), and survival to discharge (29% *vs.* 0%, $p=0.036$). Two patients (7%) in the experienced group survived at 1 year in this study, compared to none in the inexperienced group, but the number of those was inadequate for the outcome analysis.

We used multiple regression analysis to clarify the possible confounding effect of other clinical factors on resuscitation experience. We found that collapse in an experienced area was an independent factor associated with ROSC and survival longer than 24 hours (Table 5).

Discussion

In our study, the rate of successful ROSC, the rate of survival longer than 24 hours, and the rate of survival to discharge were similar with previous studies. Despite continuous improvements in training methods and equipment, the survival rates have remained unchanged.[2] This result is partly related to the high morbidity of intrahospital patients, with some of them having irreversible disease. However, another important reason may be systematic failure such as delayed resuscitation or lack of comprehensive knowledge/skills of clinicians.[4] In a multivariate study, Cooper et al demonstrated that duration of arrest, primary rhythm,

Table 2. Locations and incidence of cardiac arrests in both resuscitation-experienced and resuscitation-inexperienced groups

Locations	Number of total cardiac arrests with the need for in-hospital resuscitation	Number of unexpected cardiac arrests with CAT activation
Experienced groups		
Medical department	165	11
Surgery department	62	6
Obstetrics and gynecology department	20	2
Pediatrics department	12	0
Neurological institute	42	4
Chest department	75	2
Orthopedics department	11	1
Family medicine department	13	1
Otorhinolaryngology department	10	1
Inexperienced groups		
Diagnostic department	4	4
Outpatient department	3	3
Dermatology department	3	3
Dentistry department	2	2
Ophthalmology department	2	2
Rehabilitation center	2	2
Total	426	44

CAT = cardiac arrest team.

Table 3. Demographic data, underlying diseases, and time periods of patients

	Total ($N = 44$)	Experienced group ($n = 28$)	Inexperienced group ($n = 16$)	*p*
Age (yr)	73	74	70	NS
Male, *n* (%)	24 (55)	16 (57)	8 (50)	NS
Underlying disease, *n* (%)				
DM	9 (20)	6 (21)	3 (19)	NS
IHD	10 (23)	6 (21)	4 (25)	NS
Cancer	15 (34)	10 (36)	5 (31)	NS
Old CVA	10 (23)	6 (21)	4 (25)	NS
Rhythm, *n* (%)				
VF/VT	8 (18)	6 (21)	2 (13)	NS
PEA	15 (34)	10 (36)	5 (31)	NS
Asystole	21 (48)	12 (43)	9 (56)	NS
Time of day, *n* (%)				
00:00–08:00	12 (27)	6 (21)	6 (38)	NS
08:00–17:30	26 (59)	18 (64)	8 (50)	NS
17:30–24:00	6 (14)	4 (14)	2 (13)	NS

DM = diabetes mellitus; IHD = ischemic heart disease; CVA = cerebral vascular disease; VF = ventricular fibrillation; VT = ventricular tachycardia; PEA = pulseless electrical activity; NS = non-significant.

resuscitation within 3 minutes of an arrest, age less than 70 years, the primary mode of arrest (respiratory or cardiac), and difficulties with equipment and staff skills were the key factors influencing the survival rate of in-hospital arrest.[3] The response to cardiac arrest for unmonitored patients in general wards is expected to be less efficient, because of delayed diagnosis and the lack of equipment and trained personnel.[4] Arrest discovered by nurses trained in ACLS is significantly and dramatically associated with higher survival-to-discharge

Table 4. Comparison of clinical factors regarding resuscitation between experienced and inexperienced groups*

	Experienced group ($n=28$)	Inexperienced group ($n=16$)	*p*
Witness	12 (43)	8 (50)	NS
Appropriate BLS and ACLS	22 (79)	7 (44)	0.019
Col-Arr (s)	274 ± 50	266 ± 35	NS
ROSC	21 (75)	6 (38)	0.014
Survival > 24 hr	15 (54)	2 (13)	0.007
Survival to discharge	8 (29)	0	0.036

**Data are presented as n (%) or mean ± standard deviation. BLS = basic life support; ACLS = advanced cardiac life support; Col-Arr = time interval from patient collapse to EMT team arrival; ROSC = return of spontaneous circulation; NS = non-significant.*

Table 5. Outcome predictors using logistic regression analysis

	ROSC				Survival > 24 hr			
	Yes ($n=27$)	No ($n=17$)	*p*	OR (95% CI)	Yes ($n=17$)	No ($n=27$)	*p*	OR (95% CI)
Witnessed arrest								
Yes	13	7	0.651	1.33 (0.39–4.52)	8	12	0.865	1.11 (0.33–3.76)
No	14	10			9	15		
Initial rhythm								
VF/VT	7	1	0.124	5.60 (0.62–50.34)	6	2	0.032	6.82 (1.18–39.25)
Non VF/VT	20	16			11	25		
Cardiac arrest during office hours								
Yes	16	10	0.977	1.02 (0.30–3.50)	11	15	0.549	1.47 (0.42–5.13)
No	11	7			6	12		
Time CAT arrives								
≤ 3 min	11	5	0.449	1.65 (0.45–6.03)	8	8	0.245	2.11 (0.60–7.45)
> 3 min	16	12			9	19		
Location of arrest								
Experienced ward	21	7	0.017	5.00 (1.33–18.81)	15	13	0.013	8.08 (1.54–42.37)
Inexperienced ward	6	10			2	14		

ROSC = return of spontaneous circulation; OR = odds ratio; CI = confidence interval; VF = ventricular fibrillation; VT = ventricular tachycardia; CAT = cardiac arrest team.

rates.[9] Andreasson et al described the hospital as "a self-contained EMS system" and the efficiency depended on the same steps as in the chain of survival: early activation of the EMS, early CPR, early defibrillation and early ACLS.[1] Some quality improvements, such as establishment of a CAT, widespread BLS and ACLS training, and improvement in resuscitation equipment have been adopted in our hospital to improve the in-hospital cardiac arrest survival. However, our results did not show an amazing improvement in survival to discharge, especially among the inexperienced group. There were some noteworthy points during this study.

First, hospital structure significantly affects the CAT response time. Our hospital is composed of multiple separated buildings, like many tertiary hospitals. The response time of our CAT was 271 seconds (4 minutes and 31 seconds) on average. The collapse-to-treatment interval is a major prognostic factor in cardiac arrest, both inside and outside hospital.[3,4] Although the CAT was well trained and more experienced in resuscitation procedure, the arrival time of the CAT is often longer than 3 minutes in a large hospital with separate buildings.[4] Till now, there are not enough studies to discuss the appropriate numbers and disposition of CATs in coverage of a large hospital with multiple buildings. First-responder resuscitation is essential, especially when a long time for CAT arrival is expected.[10,11] Soar et al suggested a revised role for the CAT because all the

survivors to hospital discharge had first responder-assisted ROSC.[5]

Secondly, in addition to BLS and ACLS training, hospital staff need more real-life practice. It has been documented that well-trained hospital staff play an important role in early detection and early CPR/defibrillation. CAT efficiency may be impaired by lack of staff, equipment and coordination with the ward personnel.[4] An ACLS training program of hospital staff can contribute to increased overall survival of in-hospital cardiac arrest.[9,10] Our hospital resuscitation policy mandates all doctors and nurses be trained as ACLS providers. However, our study showed the experienced group had increased chances of ROSC, survival longer than 24 hours, and survival to discharge compared with the inexperienced group. Survival seems to be closely related to the relative effectiveness of the resuscitation organization in different parts of the hospital.[1] Although the staff in the inexperienced group had completed the ACLS training course, they may still be unskilled or hesitant due to lack of practice and the increasing specialization. There is evidence that even when staff have been trained, they are often not confident to attempt defibrillation.[12,13] The little experience physicians gain in treating cardiac arrests was the major reason for poor performance in a simulated sudden cardiac arrest study.[14] Marsch et al reported that a substantial portion of potential first responders may fail to react in a timely fashion and translate theoretical knowledge into effective team activity.[7]

In this series, the false arrest call rate of 21% was relatively high compared to other studies.[1,5,15] Delayed emergency call is another major problem encountered during in-hospital resuscitation.[4] Early recognition of patients at risk by the ward staff is extremely important to prevent further deterioration in cardiac arrest. On the other hand, careless activation of the CAT may cause the overuse of resuscitation resources. Patients who are the subject of a false arrest call should be considered to be at risk.[15] Indeed, the 1-year survival from a false cardiac arrest call (30%) was similar to that following a VF/VT arrest.[15] Despite a higher rate of false arrests in our study, early activation of CAT whenever an inpatient was at risk of cardiopulmonary arrest is acceptable.

This study had some limitations. First, the number of patients investigated was limited. Also, the use of CAT is not popular in the hospital (76/426). The validity of the study could be questioned. The study design was to evaluate the different wards' responses to unexpected cardiac arrests under the support of CAT. We only included unexpected cardiac arrests with the activation of CAT. Cardiac arrests with the available experienced first responders and no requirement of CAT were excluded. However, there was no difference in ROSC and survival rates between cardiac arrests with or without CAT activation in experienced wards during the study period. In addition, we used objective CAT members to judge the appropriateness of first-responder resuscitation in this study design. Second, the long-term results in these cases were important, however, the incidence of ROSC and survival to discharge were also important indicators for identifying patients who did or did not benefit from resuscitation. So we included both of them as outcome factors for analysis.

In conclusion, in our large hospital with multiple separate buildings, first-responder resuscitation was essential because the arrival time of the CAT was often longer than 3 minutes. Hospital wards with more than 5 cardiac arrests per year had a better patient survival rate than those with fewer arrests. This is despite all ward staff receiving the same level of training. In addition to BLS and ACLS training, hospital staff need more real-life practice.

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