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Original Article

Prognostic factors for survival outcome after in-hospital cardiac arrest: An observational study of the oriental population in Taiwan

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Abstract

Background: In-hospital cardiac arrest (IHCA) is a catastrophic complication for patients while admitted in a medical institution. The outcome of IHCA remains poor, and understanding of the prognostic factors for survival outcome after IHCA is lacking, specifically in an oriental population.
Methods: A retrospective observational cohort study of 382 patients with IHCA who required resuscitation was conducted in an urban tertiary hospital in Taiwan. Return of spontaneous circulation (ROSC) and survival to hospital discharge were the primary outcome measures.
Results: The incidence of IHCA was 3.25 per 1000 admissions. These patients had a mean age of 67.2 ± 21.7 years and were mostly men (66.5%). The rate of successful ROSC was 66%, and the rate of survival to hospital discharge was 11.8%. A stepwise decrease in ROSC was observed with additional resuscitation efforts. Independent predictors for survival to hospital discharge were being female, a resuscitation duration of <20 minutes, and no use of epinephrine during resuscitation. A 68% ROSC success rate and an 84% survival to discharge rate was recorded in patients receiving resuscitation for <30 minutes. Young patients seemed the most likely to benefit from longer resuscitation attempts (>30 minutes), as observed in survival to hospital discharge.
Conclusion: Based on data from a single hospital registry in East Asia, a shorter duration of resuscitation was demonstrated to be a predictor of immediate survival with ROSC and survival to hospital discharge.
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Keywords: Asia; cardiopulmonary resuscitation; in-hospital cardiac arrest; resuscitation; survival

1. Introduction

In-hospital cardiac arrest (IHCA) is a catastrophic complication for patients while admitted in a medical institution. There have been approximately 200,000 hospitalized patients per year treated for cardiac arrest in the United States, with a reported survival to hospital discharge rate of 7−26%.[1−3] IHCA patients tend to be sicker, with increased comorbidities, as well as demonstrating a higher rate of non-shockable rhythms [pulseless electrical activity (PEA) or asystole].[2,4] Therefore, it is crucial for clinicians to have a thorough understanding of the factors affecting the outcome of inpatient cardiopulmonary resuscitation (CPR).

Several factors, including the initial rhythm, resuscitation duration, underlying comorbidities, time of day, and initial resuscitation effort, may be related to the resuscitation outcome.[1,2,5−7] The majority of the IHCA literature includes participants from Western countries. There is a paucity of IHCA data in the Asian population,[8] which currently ranks as the world's second highest population, behind only

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Caucasians. Patient outcomes following IHCA are influenced by several variables, including ethnicity, socioeconomic status, health status, and utilization of healthcare resources.[9] Compared with white patients, survival after IHCA has been shown to be reduced in black patients.[9,10] The exiting validated risk model for IHCA from North America may not be suitable to different healthcare systems in an oriental society.[11] Therefore, we conducted this investigation to determine the independent predictors for resuscitation outcomes after IHCA focusing on an oriental population.

2. Methods

2.1. Hospital setting

A retrospective observational study at Taipei Veterans General Hospital (VGH), a 2700-bed, tertiary care medical center in Taipei, Taiwan, was performed. The VGH offers a variety of specialties, while serving an average of 250 emergency department visits and 320 admissions daily. All physicians and nurses are required to receive Advance Cardiac Life Support training, as well as obtain recertification every 3 years, to ensure their ability to resuscitate patients.

2.2. Study population and data collection

Data were recorded from a web-based IHCA registry system, implemented and directed since 2011 by the Center for Medical Quality Management of Taipei VGH. Following an IHCA, the nurse on duty records the applicable data to the web-based IHCA registry system. The database contains variables and outcome following the standardized Utstein-style definitions.[12] From January 1, 2012 to December 31, 2012, all adult (≥18 years) and pediatric (<18 years) patients who received an in-hospital resuscitation attempt after cardiac arrest were eligible for study inclusion. The exclusion criteria were cardiac arrests from out of hospital, patients with a do-not-resuscitate (DNR) order, and IHCAs occurring in visitors, outpatients, or hospital employees. The institutional review board of Taipei VGH approved the study and waived the requirement for informed consent.

Patient demographic data, event date and time, and patient outcomes were retrospectively extracted from the registry database and hospital records. These data were subsequently verified by two different attending physicians. The Charlson comorbidity index score was used to calculate and estimate the severity of comorbid disease.[13] IHCA time was documented as daytime (08:00−19:59) or nighttime (20:00−07:59). In the case of multiple IHCAs in the same patient within 48 hours, only data from the first episode was included to avoid the confounding effects between events. The duration of resuscitation was defined as the time from the onset of cardiac arrest to the termination of resuscitation efforts, or patient death. Primary outcome measures were immediate survival with return of spontaneous circulation (ROSC) and survival to hospital discharge. The secondary outcome was patient evaluation using the cerebral performance category scale at hospital discharge. A favorable neurological status was defined as a score of 1 or 2.

2.3. Statistical analysis

Results are expressed as *n* (%) for categorical variables. Descriptive statistics were reported as mean ± standard deviation, or median [interquartile range (IQR)] for continuous variables. Continuous variables were assessed using the Mann−Whitney *U* test for independent samples. Analysis of categorical variables was performed using Pearson's chi-square test or Fisher's exact test, as appropriate. A multivariable logistic regression model with conditional backward selection was performed to identify independent variables associated with resuscitation outcomes. Statistical analyses were performed using the Statistics Package for Social Sciences software (SPSS) 19.0 version. Odds ratios (ORs) and 95% confidence interval were reported to determine the prognostic factors that were independently associated with survival. A two-tailed $p < 0.05$ was considered significant.

3. Results

We identified a total of 382 patients with IHCA who received resuscitation attempts during the study period. The total number of hospital admissions during this period was 117,529, which translates to an incidence of 3.25 IHCAs per 1000 hospital admissions. The mean age of patients with an IHCA was 67.2 ± 21.7 years. Overall, 66.5% of patients were men. The most common comorbid diseases were hypertension (44.5%) and cardiovascular diseases (42.7%). The initial rhythm for patients identified with IHCA was as follows: ventricular fibrillation ($n = 11$; 3.7%), pulseless ventricular tachycardia ($n = 45$; 11.8%), PEA ($n = 190$; 49.7%), and asystole ($n = 133$; 34.8%). Intensive care units (ICUs) accounted for 188 (49.2%) of the total. A greater number of events occurred during the daytime (57.1%) and weekdays (64.4%). The median duration of resuscitation was 28 minutes (IQR 10−50 minutes). Extracorporeal membrane oxygenation (ECMO) was applied on 36 patients with suspected cardiac origin (9.4%) in whom duration of ischemia (collapse to ECMO) was 70.5 ± 32.5 minutes. The overall rate of successful ROSC was 66%, and the rate of survival to hospital discharge was 11.8%. Among the patients who survived to hospital discharge, 21 (46.7%) had favorable neurologic status. Patient demographic data and survival data are shown in Table 1.

The clinical variables associated with resuscitation outcome are summarized in Tables 2 and 3. Patients with initial shockable rhythms, shorter resuscitation duration, and incidence of cardiac arrest in the ICU or emergency department had increased chances of ROSC. However, female sex, initial shockable rhythm, and shorter resuscitation duration were the factors that significantly influenced survival to hospital discharge rates. Epinephrine use had a negative impact on immediate survival with ROSC and survival to hospital discharge. ECMO-assisted CPR resulted in a 91.7% (33 out of

Table 1
Patient characteristics.

Characteristics	(n = 382)
Age, mean (SD)	67.2 (21.7)
Male, *n* (%)	254 (66.5)
Pediatric patients, *n* (%)	24 (6.3)
Major comorbidity, *n* (%)	
Hypertension	170 (44.5)
Cardiovascular disease	163 (42.7)
Diabetes mellitus	124 (32.5)
Renal insufficiency	98 (25.7)
Malignancy	93 (24.3)
Initial rhythm, *n* (%)	
Vf	14 (3.7)
Pulseless VT	45 (11.8)
PEA	190 (49.7)
Asystole	133 (34.8)
Location, *n* (%)	
Intensive care unit	188 (49.2)
Ordinary ward	134 (35.1)
Emergency department	52 (13.6)
Hemodialysis room	6 (1.6)
Operation room	2 (0.5)
Time of day, *n* (%)	
08:00−19:59	218 (57.1)
20:00−07:59	164 (42.9)
Time of week, *n* (%)	
Weekday	274 (71.7)
Weekend	108 (28.3)
Time of resuscitation duration, median (IQR)	28 (10−50)
ECMO use, *n* (%)	36 (9.4)
ROSC, *n* (%)	252 (66.0)
Survival to discharge, *n* (%)	45 (11.8)
Neurological outcome at discharge, *n*	
CPC 1−2	21 (46.7)
CPC 3−5	24 (53.3)

CPC = cerebral performance category; ECMO = extracorporeal membrane oxygenation; IQR = interquartile range; PEA = pulseless electrical activity; Pediatric patient = age less than 20 years; ROSC = return of spontaneous circulation; SD = standard deviation; Vf = ventricular fibrillation; VT = ventricular tachycardia.

Table 2
Variables associated with return of spontaneous circulation.

	Yes (n = 252)	No (n = 130)	p
Age, mean (SD)	67.8 (20.5)	65.9 (23.9)	0.984
Pediatric patients, *n* (%)	12 (4.8)	12 (9.2)	0.088
Sex, *n* (%)			0.588
Male	165 (65.5)	89 (68.5)	
Female	87 (34.5)	41 (31.5)	
Charlson Comorbidity Index scores, mean (SD)	3.04 (2.34)	3.25 (2.47)	0.463
Initial rhythm, *n* (%)			0.004*
Vf	11 (4.4)	3 (2.3)	
Pulseless VT	37 (14.7)	8 (6.2)	
PEA	130 (51.5)	60 (46.1)	
Asystole	74 (29.4)	59 (45.4)	
Resuscitation duration			
Minutes, median (IQR)	15 (6−35)	42 (30−62)	<0.001*
Location, *n* (%)			0.005*
Intensive care unit	133 (52.7)	55 (42.3)	
Ordinary ward	73 (29.0)	61 (42.9)	
Emergency department	40 (15.9)	12 (9.2)	
Hemodialysis room	5 (2.0)	1 (0.8)	
Operation room	1 (0.4)	1 (0.8)	

Table 2 (*continued*)

	Yes (n = 252)	No (n = 130)	p
Medication, *n* (%)			
Epinephrine	235 (93.3)	128 (98.5)	0.027*
Amiodarone	41 (16.3)	14 (10.8)	0.147
Lidocaine	22 (8.7)	4 (3.1)	0.083
Weekend, *n* (%)	70 (27.8)	38 (29.2)	0.765
Daytime, *n* (%)	147 (58.3)	71 (54.6)	0.871
Existing intubation, *n* (%)	103 (40.9)	42 (32.3)	0.102
History of cardiovascular disease, *n* (%)	117 (46.4)	46 (35.4)	0.039*

*$p < 0.05$.
IQR = interquartile range; Pediatric patient = age less than 20 years; PEA = pulseless electrical activity; SD = standard deviation; Vf = ventricular fibrillation; VT = ventricular tachycardia.

36) return of spontaneous ventricular beating and a borderline advantage in 14-day survival ($p = 0.059$, data not shown) but failed to demonstrate a benefit in survival to hospital discharge ($p = 0.168$).

Using multiple regression analysis to identify the predictors of resuscitation outcome (Tables 4 and 5), the only factor to predict ROCS was resuscitation within 30 minutes. The likelihood of ROCS was reduced in a stepwise manner for every 10 minutes resuscitation duration extended. By contrast, female sex, resuscitation duration less than 20 minutes, and no

Table 3
Variables associated with survival to hospital discharge.

	Yes (n = 45)	No (n = 337)	p
Age, mean (SD)	63.4 (25.1)	67.7 (21.2)	0.369
Pediatric patients, *n* (%)	4 (8.9)	20 (5.9)	0.443
Sex, *n* (%)			0.008*
Male	22 (48.9)	232 (68.8)	
Female	23 (51.1)	105 (31.2)	
Charlson Comorbidity Index scores, mean (SD)	3.02 (2.40)	3.12 (2.38)	0.775
Initial rhythm, *n* (%)			0.001*
Vf	5 (11.1)	9 (2.7)	
Pulseless VT	11 (24.4)	34 (10.1)	
PEA	14 (31.1)	176 (52.2)	
Asystole	15 (33.3)	118 (35.0)	
Resuscitation duration			
Minutes, median (IQR)	9 (3−18)	30 (11−55)	<0.001*
Location, *n* (%)			0.323
Intensive care unit	24 (53.4)	164 (48.6)	
Ordinary ward	11 (24.4)	123 (36.5)	
Emergency department	9 (20.0)	43 (12.8)	
Hemodialysis room	1 (2.2)	2 (0.6)	
Operation room	0 (0.0)	2 (0.6)	
Medication, *n* (%)			
Epinephrine	36 (80.0)	327 (97.0)	<0.001*
Amiodarone	8 (17.8)	47 (13.9)	0.492
Lidocaine	6 (13.3)	20 (5.9)	0.104
Weekend, *n* (%)	14 (31.1)	94 (27.8)	0.653
Daytime, *n* (%)	21 (46.7)	197 (58.8)	0.133
Existing intubation, *n* (%)	14 (31.1)	131 (38.9)	0.314
ECMO use, *n* (%)	7 (15.6)	29 (8.6)	0.168

*$p < 0.05$.
ECMO = extracorporeal membrane oxygenation; IQR = interquartile range; Pediatric patient = age less than 20 year; PEA = pulseless electrical activity; SD = standard deviation; Vf = ventricular fibrillation; VT = ventricular tachycardia.

Table 4
Prognostic factors in the return of spontaneous circulation after IHCA using logistic regression analysis.

	Yes ($n = 252$)	No ($n = 130$)	p	OR (95% CI)
Initial rhythm, n (%)				
Shockable	48 (19.0)	11 (8.5)	0.257	1.28 (0.72–3.48)
Nonshockable	204 (81.0)	119 (91.5)	—	
Resuscitation duration, n (%)				
<10 min	86 (34.1)	7 (5.4)	<0.001*	12.29 (5.02–30.07)
10–19 min	59 (23.4)	10 (7.7)	<0.001*	5.90 (2.62–13.27)
20–29 min	27 (10.7)	4 (3.1)	0.001*	6.75 (2.15–21.21)
30–59 min	43 (17.1)	72 (55.4)	0.088	0.60 (0.33–1.08)
≥60 min	37 (14.7)	37 (28.5)	—	
Events in the ED, n (%)	40 (15.9)	12 (9.2)	0.229	1.63 (0.74–3.60)
Events in the ICU, n (%)	133 (52.8)	55 (42.3)	0.310	1.33 (0.77–2.28)
Medication, n (%)				
Epinephrine	235 (93.3)	128 (98.5)	0.423	0.49 (0.09–2.78)
History of cardiovascular disease, n (%)	117 (46.4)	46 (35.4)	0.644	1.13 (0.67–1.92)

*$p < 0.05$.
CI = confidence interval; ECMO = extracorporeal membrane oxygenation; ED = emergency department; ICU = intensive care unit; OR = odds ratio; Pediatric patient = age less than 20 years.

Table 5
Prognostic factors in survival to hospital discharge after IHCA using logistic regression analysis.

	Yes ($n = 45$)	No ($n = 337$)	p	OR (95% CI)
Age, mean (SD)	63.4 (25.1)	67.7 (21.2)	0.257	0.99 (0.98–1.01)
Sex, n (%)				
Male	22 (48.9)	232 (68.8)	0.002*	0.33 (0.16–0.66)
Female	23 (51.1)	105 (31.2)	—	
Initial rhythm, n (%)				
Shockable	16 (35.6)	43 (12.8)	0.097	1.98 (0.89–4.44)
Nonshockable	29 (64.4)	294 (87.2)	—	
Resuscitation duration, n (%)				
<10 min	25 (55.6)	68 (20.2)	<0.001*	7.01 (3.05–16.15)
10–19 min	10 (22.2)	59 (17.5)	0.011*	3.39 (1.32–8.69)
20–29 min	3 (6.7)	28 (8.3)	0.246	3.35 (0.56–9.91)
30–59 min	3 (6.7)	112 (33.2)	0.513	0.59 (0.12–2.84)
≥60 min	4 (8.9)	70 (20.8)	—	
Medication, n (%)				
Epinephrine	36 (80.0)	327 (97.0)	0.004*	0.20 (0.07–0.59)
ECMO use, n (%)	7 (15.6)	29 (8.6)	0.572	1.36 (0.47–3.89)

*$p < 0.05$.
CI = confidence interval; ECMO = extracorporeal membrane oxygenation; OR = odds ratio; SD = standard deviation.

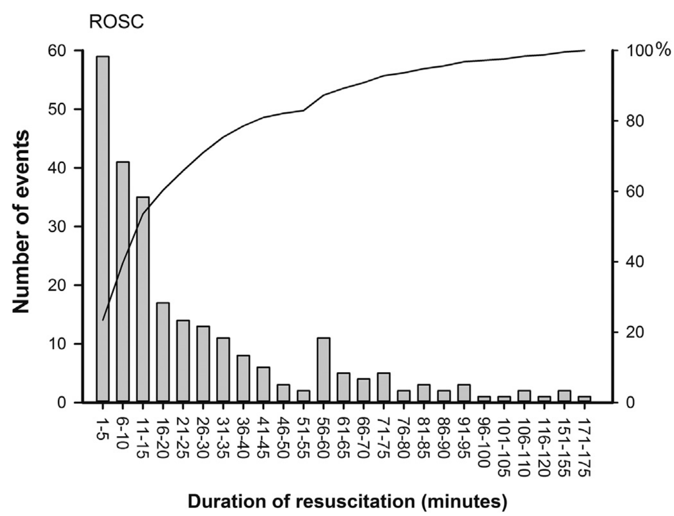

Fig. 1. Number and proportion of patients achieving return of spontaneous circulation relative to resuscitation duration.

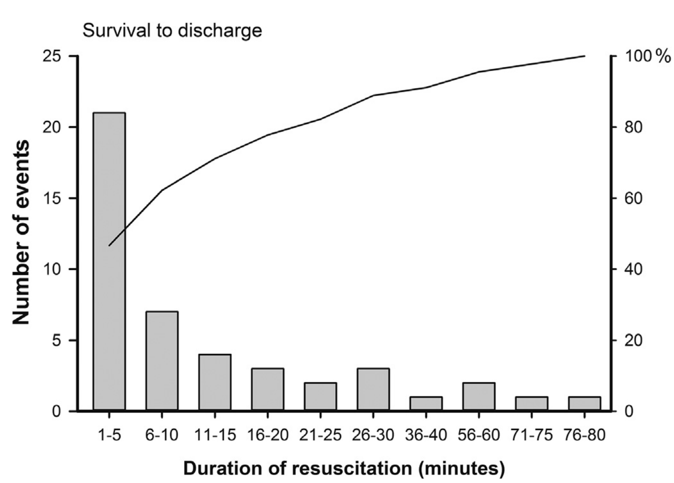

Fig. 2. Number and proportion of patients achieving survival to hospital discharge relative to resuscitation duration.

use of epinephrine during resuscitation were independent outcome predictors for survival to hospital discharge. Regarding immediate and short-term survival, a 68% success rate of ROSC and an 84% survival rate at discharge were recorded in patients who received resuscitation for less than 30 minutes (Figs. 1 and 2). With regard to resuscitation duration, only young patients benefited from prolonged resuscitation attempts (>30 minutes) to increase the chance of survival to hospital discharge (Table 6).

4. Discussion

Despite several advances in resuscitation care, survival after IHCA has not changed markedly in recent decades.[1–3] In

Table 6
Variables in patients with hospital discharge regarding resuscitation duration.

Resuscitation duration (min)	>30 ($n = 7$)	≤30 ($n = 38$)	p
Age, mean (SD)	43.1 (30.0)	67.2 (22.6)	0.042*
Sex, n (%)			> 0.99
Male	3 (42.9)	19 (50.0)	
Female	4 (57.1)	19 (50.0)	
Initial rhythm, n (%)			0.603
Shockable	1 (14.3)	16 (42.1)	
Nonshockable	6 (85.7)	22 (57.9)	
Location, n (%)			0.155
Intensive care unit	3 (42.9)	21 (55.3)	
Ordinary ward	4 (57.1)	7 (18.4)	
Emergency department	0 (0.0)	9 (23.7)	
Hemodialysis room	0 (0.0)	1 (2.6)	
Operation room	0 (0.0)	0 (0.0)	
Major comorbidity, n (%)			
Hypertension	3 (42.9)	23 (60.5)	0.433
Cardiovascular disease	4 (57.1)	19 (50.0)	> 0.99
Diabetes mellitus	4 (57.1)	12 (31.6)	0.225
Renal insufficiency	2 (28.6)	10 (26.3)	> 0.99
Malignancy	0 (0.0)	8 (21.1)	0.321
Existing intubation, n (%)	2 (28.6)	12 (31.6)	> 0.99

*$p < 0.05$.
SD = standard deviation.

the present study, the rate of ROSC in a hospital setting is similar to those of other reports.[7] However, survival to hospital discharge rate and neurological outcomes at discharge were suboptimal.[1] In the current study, patients admitted to this hospital were older and had more major comorbidities. In addition, a higher proportion of initial nonshockable cardiac rhythm was observed in the current study population.[1,8,14] Outcomes from witnessed ventricular fibrillation are often excellent in contrast to poor outcomes in asystole and PEA, generally.[1] An increased incidence of nonshockable IHCA rhythm, as well as out-of-hospital cardiac arrest, has been observed over the past decades.[1,15] This suggests that patients of greater age and with significant comorbidities will be encountered in the future. The univariate analysis demonstrated that cardiac arrests in the ICU or emergency department had increased the likelihood of ROSC in our study population. Survival was closely related to the relative effectiveness of the resuscitation efforts, which was also affected by the location of the resuscitation within the hospital.[16] Despite all hospital staff being required to be trained in resuscitation protocol, there is evidence that overall experience is related to patient prognosis.[17]

Our study showed that the incidence of IHCA requiring resuscitation was 3.25 per 1000 admissions, which is lower than those of previous reports from Taiwan. Lin et al[18] had demonstrated that the cumulative incidence of in-hospital CPR was 10.8 per 1000 admissions using Taiwan National Health Insurance data from 1997 to 2004. In the American Heart Association's Get With the Guidelines—Resuscitation registry, the median IHCA incidence rate was 4.02 per 1000 admissions (IQR, 2.95−5.65 per 1000 admission).[19] The reduction in CPR during hospitalization is reflective of the persistent and effective implementation of a national DNR policy in Taiwan.[18]

Our study included both adults and children. Someone may question that our population enrolled both adults and children with distinct characteristics and presumed difference in the etiology and pathophysiology of cardiac arrests.[20,21] Actually, both children and adults express typically analogous initial cardiac rhythm as asystole or PEA during IHCA, according to a previous survey.[2]

Other studies have demonstrated that ECMO provides additional benefits in pediatric and adult patients with IHCA of cardiac origin when compared to conventional CPR.[22,23] Our study failed to demonstrate a survival-to-discharge benefit of ECMO-assisted CPR. This may be attributable to a relatively longer duration of ischemia (collapse to ECMO) in our patients. The elapsed time from cardiac arrest to ECMO flow is a critical determinant of outcome, with previously reported survival rates of 50% when resuscitation was initiated within 30 minutes of IHCA, 30% when initiated between 30 and 60 minutes of IHCA, and 18% when initiated after 60 minutes of IHCA.[24]

Earlier administration of epinephrine has been reported to be associated with a higher probability of ROSC in IHCA with nonshockable rhythm.[25] However, our study demonstrated that the use of epinephrine had no benefit in ROSC, and may have possibly had a harmful impact on the rate of survival to hospital discharge. A possible explanation for this observed paradox, considering the vasodilatory effects of epinephrine,[26] is that a vasopressor secures the coronary perfusion pressure with slightly positive effect on the immediate survival. This is a result of reduced peripheral organ perfusion, which simultaneously leads to negative long-term outcomes.[27,28]

Female sex was an independent predictor for survival to hospital discharge. Our results were consistent with those of previous reports.[29] The current study also demonstrated that shorter resuscitation duration was predictive of immediate survival with ROSC and survival to hospital discharge. Previous reports also showed that patients with a shorter duration of cardiac arrest have better outcomes.[2,6,30] Longer resuscitation times suggest generalized tissue hypoperfusion and hypoxic damage; however, little evidence is available to guide clinicians regarding the appropriate length of resuscitation attempts before efforts should be terminated. It has been previously reported that only 2% of those in whom resuscitation attempts lasted longer than 10 minutes achieved ROSC.[31] Our study showed that more than 30% of patients who achieved ROSC did so only after 30 minutes of resuscitation, and only 10% of survivors with hospital discharge were resuscitated for longer than 30 minutes. Young patients seemed the most likely to benefit from longer resuscitation attempts.

This study has several limitations. First, data were collected via retrospective chart review. Some clinical presentations or records may not have been documented completely. Second, we did not recognize the exact response time, chest compression rate, and depth owing to the difficulty of obtaining accurate information. The effects of a prompt response in each case of CPR may interfere with the outcome of the resuscitation, possibly resulting in individualized bias.[32]

Fewer pauses between chest compressions and optimal chest compression quality are thought to improve overall survival following cardiac arrest.[33] Third, it is likely that unmeasured confounding factors remain despite multiple regression modeling on the basis of this retrospective evaluation.

In conclusion, in a single hospital registry in Taiwan, shorter resuscitation duration was the predictor of immediate survival with ROSC and survival to hospital discharge. Female sex and no use of epinephrine during resuscitation were also independent outcome predictors for survival to hospital discharge. Only young patients benefited from prolonged resuscitation duration, as observed in the rates of survival to hospital discharge.

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