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ORIGINAL RESEARCH

Prognostic factors for adults with cardiac arrest in the emergency department: a retrospective cohort study

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Abstract

Cardiac arrest in the emergency department is associated with the following three scenarios: out-of-hospital cardiac arrest, primary emergency department cardiac arrest (EDCA), and patients transferred from other hospitals after the return of spontaneous circulation from cardiac arrest. Among them, the primary cardiac arrest episode in the emergency department has been less studied. This aim of this study was to explore patient characteristics and the relationship between causes of EDCA and survival outcomes according to different patient management strategies. The main finding of this study was that EDCA with Cardiogenic etiology was associated with higher survival to discharge (OR: 2.31; 95% CI: 1.59–3.91) and discharged neurological outcome (OR: 2.84; 95% CI: 1.57–5.97). More favorable discharged neurological outcome were also found in EDCA patients with initial shockable rhythm (OR: 4.83; 95% CI: 2.33–10.01) and shorter resuscitation time (≤11.5 min, OR: 3.62; 95% CI: 1.57–8.32). EDCA patients under sedative medication (OR: 0.24; 95% CI: 0.10–0.59) and ventilator support by intubation before EDCA episode (OR: 0.26; 95% CI: 0.09–0.75) had poor neurological outcome. We conclude that EDCA patients with cardiogenic etiology have more favorable survival to discharge and discharged neurological outcomes. Prolonged CPR time during EDCA, post-intubation status and sedative medication use were prognostic factors of negative survival and neurological outcomes.

Keywords

Cardiac arrest; Emergency department; Cardiopulmonary resuscitation; Cerebral performance category

1. Introduction

Patients experiencing cardiac arrest in the emergency department (ED) require immediate intervention. Cardiac arrest is associated with three scenarios: out-of-hospital cardiac arrest (OHCA), primary emergency department cardiac arrest (EDCA), and patients transferred from other hospital after the return of spontaneous circulation (ROSC) from OHCA or in-hospital cardiac arrest (IHCA) episode [1–3].

OHCA has been explored in terms of the steps involved in treatment: from EMS dispatch, dispatcher-assisted or bystander cardiopulmonary resuscitation (CPR) [4], public access defibrillation, and prehospital management by emergency medical services (EMSs) to survival analysis [5]. In contrast to OHCA, primary EDCA is a critical situation, but it has yet to be fully understood. To the best of our knowledge, most studies have explored the association between the incidence of EDCA and ED overcrowding [6, 7]. A previous study proved the higher incidence of EDCA to be related to different parameters of overcrowding, including ED occupancy rate (EDOR) [8], ED bed occupancy rate (EDBOR) [6], total ED volume, and patient-to-nurse ratio [3]. Few studies have analyzed the cause of EDCA and have reported the survival outcomes of primary EDCA [1, 2, 9, 10].

Further studies are required to analyze the patients' characteristics and survival outcomes, including neurological prognosis, in the ED. Therefore, this study explored the relationship between patients' characteristics and variables in the resuscitation process, the causes of EDCA, and the survival outcomes of adult patients who experienced a primary cardiac arrest episode in the ED.

2. Material and methods

2.1 Study design and setting

This retrospective cohort study collected data from January 1, 2016, to November 30, 2018, through an electronic medical chart review at Chang-Gung Memorial Hospital, Linkou (LCGMH), Taiwan. LCGMH is an urban, academic, tertiary medical center in northern Taiwan, and it has a capacity of 3500 beds; its ED contains 190 beds, with approximately 170,000 visits every year. The inclusion criteria were adult ED patients

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aged over 18 years, and the exclusion criteria were trauma, do-not-resuscitate (DNR) initially, and OHCA (Fig. 1).

2.2 Data collection

Each primary cardiac arrest episode in the ED was reported and discussed in the monthly meeting regarding ED cardiac arrest. For each EDCA patient, one resident and an attending physician collected all data using the same template, including age, sex, Taiwan triage and acuity scale (TTAS) level [11–13], initial cardiac rhythm (the definition of initial cardiac rhythm in our study was the initial rhythm recorded when cardiac arrest occurred), location of cardiac arrest, time of cardiac arrest, patient management strategies (only observation, wait for ward, or intensive care unit (ICU)), possible cause of cardiac arrest, record of the entire resuscitation process (the definition of sedation use in our study was patients under sedation before EDCA occurred; cardiac arrest occurred during or post-intubation (within 30 minutes) was defined as "intubation under process" and the definition of "intubation done" was cardiac arrest occurred in ED patients have already been intubated before EDCA), whether extracorporeal cardiopulmonary resuscitation (ECPR) is activated, and survival condition of EDCA patients.

In the resuscitation process, the total time of resuscitation and the number of re-arrest times were recorded. If re-arrest occurred, the sum of each time of resuscitation course (cardiac arrest to ROSC) was also calculated. Data on survival outcomes were collected and analyzed, including whether ROSC was achieved, survival to admission, survival to discharge and cerebral performance category (CPC) score at discharge.

We divided the cause of cardiac arrest into four types according to the classification of the American Heart Association [14]: respiratory (hypoxia), metabolic (hydrogen or hyper/hypokalemia), acute coronary syndrome (cardiovascular thrombosis), and others (hypotension, hypothermia, pulmonary thrombosis, cardiac tamponade, tension pneumothorax, intoxication, and others). In addition to the analysis of the management strategies of each patient, we analyzed the cause of EDCA in different subgroups (under observation, wait for ward, wait for ICU including EDCA patients under resuscitation at the scene without a final management strategy).

There were no missing variables in our study due to all EDCA cases enrolled in our study had already been reported and reviewed in the EDCA meeting monthly.

2.3 Outcome measure

For the analysis of EDCA, the primary outcomes were survival to discharge and a favorable CPC score at discharge. The CPC was evaluated by the attending physician at discharge. The secondary outcomes were ever ROSC and survival to admission.

2.4 Statistical analysis

Categorical data, such as sex, triage, and cause of cardiac arrest, are reported as numbers with percentages and were analyzed using χ^2 tests. Continuous variables, including age, triage vital sign, and CPR time, are reported as mean and standard deviation or median and interquartile range, as appropriate. The Student t test and Mann–Whitney test were used accordingly. We used a bar chart to illustrate the relationship between the cause of ED cardiac arrest and the management strategy in the ED.

Logistic regression analysis was used to identify the variables associated with the primary and secondary outcomes. Further, multivariable logistic regression, adjusted for the cause of cardiac arrest as well as age, sex, triage, GCS (Glasgow Coma Scale), initial cardiac rhythm, intubation status, under sedation or not, inform critical condition before cardiac episode, witness or not, Charlson's comorbidity index and CPR Time were used to estimate the odds ratios (both crude and adjusted ORs) for the prognostic outcomes. The cubic spline approach was used to determine the optimal cutoff of CPR time. We think the EDCA patients would have poor survival and neurological outcome if they got ROSC after longer CPR time. Hence, we use the cubic spline approach to find the optimal cutoff in nonlinear correlations (here, we applied it to the CPR time 11.5 minutes) (Fig. 3).

Statistical analyses were performed using SPSS Statistics (IBM SPSS Statistics for Windows, version 26.0; IBM Corp, NY, USA) and Stata software for the restricted cubic spline function (version 16.0; StataCorp, College Station, TX, USA). $p < 0.05$ was considered statistically significant.

3. Results

Among 314,730 adults with non-trauma ED visits, 172,115 patients were discharged from the ED, and 137,002 patients were admitted to the ED for observation, waiting for admission (ward or ICU), or on scene. Totally, 589 EDCA episodes occurred, and the families of 80 patients signed DNR forms. This study enrolled 509 EDCA patients. Among them, 49 patients (9.60%) had initial shockable rhythm (pulseless ventricular tachycardia or ventricular fibrillation); cardiac arrest occurred in 204 (40.08%) patients during or post-intubation (within 30 minutes); ECPR was activated in 25 patients (4.9%); and percutaneous coronary intervention (PCI) was conducted by a cardiologist in 35 patients (6.9%). The median (IQR) of the CPR time of all EDCA cases was 13 (6–33), and 44 (8.64%) EDCA patients had discharge CPC scores of 1 and 2 (Table 1).

Different causes of cardiac arrest were reported (Table 1) and compared among the subgroups with different management strategies (Fig. 2). The most common cause of cardiac arrest in patients who were waiting for the ward was respiratory problems (33.7%), followed by metabolic causes (30.2%). The proportion of cardiogenic, metabolic, and respiratory problems in patients who would be transferred to ICU was lower than the proportion of other problems (43.6%). The most common etiologies of cardiac arrest occurred in patients under observation in the ED were due to metabolic reasons as well as other reasons (29.4%). Fig. 3 shows the CPR time value for which there was an average of probability of survival to discharge (104/509 = 20.4%) in EDCA patients was 11.5 minutes of the CPR time as a cutoff point of survival.

Table 2 shows that among EDCA patients with cardiogenic causes showed more favorable outcome of survival to discharge and CPC 1/2 at discharge. Respiratory etiology was

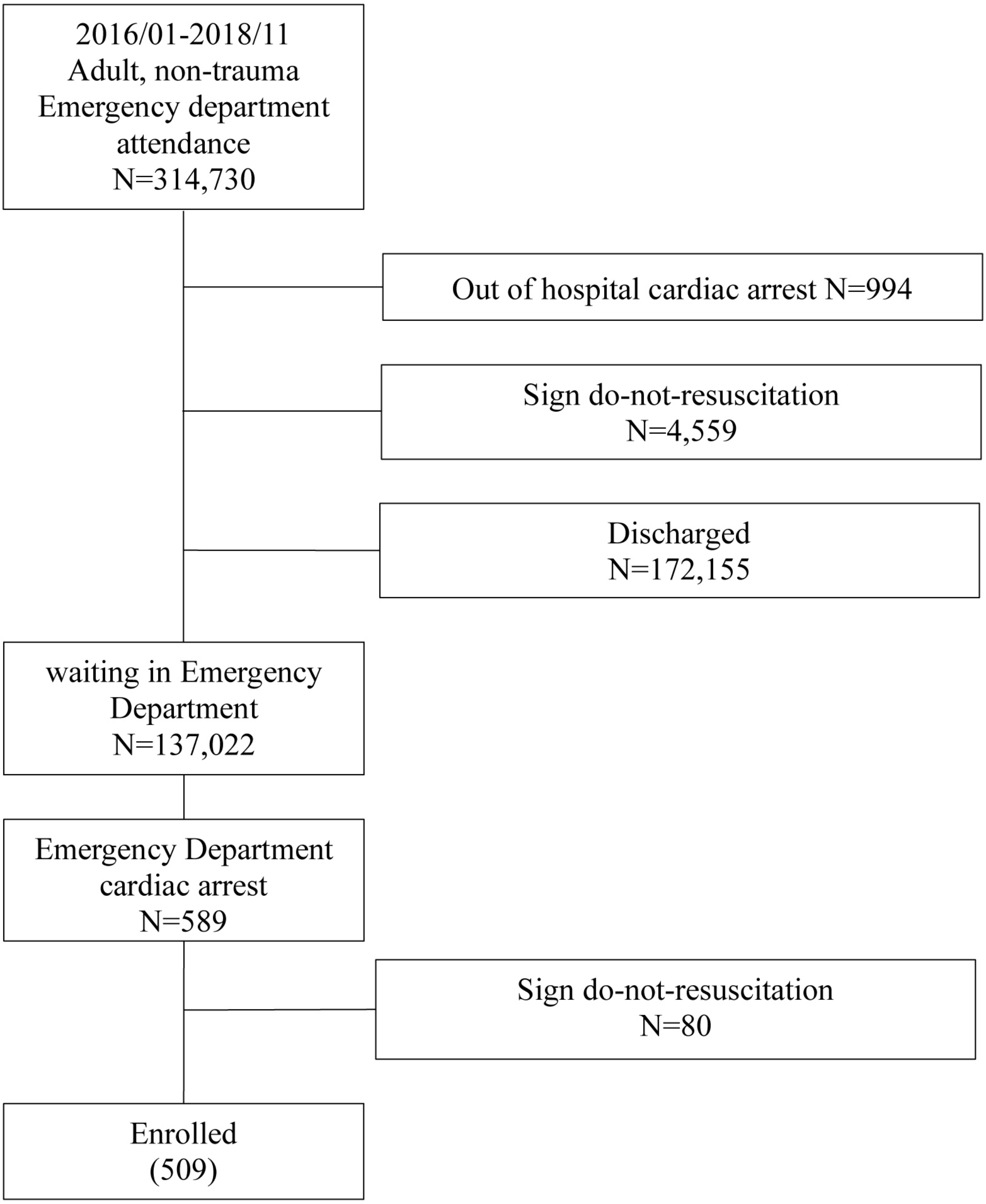

FIGURE 1. Flow diagram of patient enrollment.

associated with higher survival to discharge rate; however, not with favorable discharged neurological outcome. Besides, metabolic causes showed no correlation with survival outcome.

EDCA patients with an initial shockable rhythm and CPR time ≤11.5 minutes showed more favorable survival to discharge (3.41, 1.84–6.29; 4.74, 2.58–8.71, respectively) and good CPC at discharge (4.83, 2.33–10.01; 3.62, 1.57–8.32, respectively) (Table 3).

Poor survival to discharge and lower rates of CPC scores of 1 and 2 at discharge was found in EDCA patients with older age, under intubation (0.27, 0.14–0.55; 0.26, 0.09–0.75, respectively), and sedative medication use (0.45, 0.28–0.75; 0.24, 0.10–0.59, respectively). No significant statistical difference in survival outcomes was found for EDCA that occurred during and post-intubation (≤30 min).

4. Discussion

This study assessed the relationship among the characteristics, cause of EDCA, and survival outcome. Overall, we found that those factors (prolonged CPR time, post-intubation status, and the use sedation medication) indicated poor survival to discharge and neurological outcomes.

Nolan *et al*. [15] reported that in UK hospitals, the incidence of IHCA was 1.6 per 1000 hospital admissions, and

TABLE 1. Baseline characteristics of the study population.

Characteristics	All patients	Survival to discharge	non-survival to discharge	*p* value
	n = 509	n = 104	n = 405	
Age (yrs) , mean ± SD	62.42 ± 17.46	58.95 ± 16.75	63.31 ± 17.55	0.023
Sex = Male, n (%)	338 (66.4%)	68 (65.4%)	270 (66.7%)	0.805
Triage (TTAS), n (%)				0.907
1	241 (47.3%)	47 (45.2%)	194 (47.9%)	
2	207 (40.7%)	44 (42.3%)	163 (40.2%)	
3	60 (11.8%)	13 (12.5%)	47 (11.6%)	
4	1 (0.2%)	0 (0.0%)	1 (0.2%)	
5	0 (0.0%)	0 (0.0%)	0 (0.0%)	
Vital signs at triage				
SBP (mmHg), mean ± SD	118.18 ± 37.75	119.46 ± 43.39	117.86 ± 36.27	0.708
DBP	72.68 ± 23.98	72.24 ± 24.62	72.79 ± 23.84	0.841
Temperature (C), mean ± SD	36.47 ± 1.55	36.42 ± 1.37	36.48 ± 1.59	0.741
Pulse, mean ± SD	102.64 ± 30.96	101.62 ± 35.72	102.90 ± 29.68	0.708
Respiratory, mean ± SD	22.62 ± 5.78	22.05 ± 5.15	22.77 ± 5.93	0.255
GCS, n (%)				0.053
15	275 (54.0%)	67 (64.4%)	208 (51.4%)	
9∼14	97 (19.1%)	14 (13.5%)	83 (20.5%)	
3∼8	137 (26.9%)	23 (22.1%)	114 (28.1%)	
Cause of cardiac arrest, n (%)				<0.001
Cardiogenic	97 (19.1%)	28 (26.9%)	69 (17.0%)	
Metabolic	117 (23.0%)	15 (14.4%)	102 (25.2%)	
Respiratory	122 (24.0%)	37 (35.6%)	85 (21.0%)	
Others	173 (34.0%)	24 (23.1%)	149 (36.8%)	
Initial rhythm, n (%)				<0.001
Shockable rhythm	49 (9.6%)	21 (20.2%)	28 (6.9%)	
Non-shockable	460 (90.4%)	83 (79.8%)	377 (93.1%)	
Intubation, n (%)				0.001
Intubation Done	119 (23.4%)	10 (9.6%)	109 (26.9%)	
Intubation under process	85 (16.7%)	17 (16.3%)	68 (16.8%)	
Critical, n (%)	375 (73.7%)	74 (71.2%)	301 (74.3%)	0.813
Witness, n (%)	472 (92.7%)	97 (93.3%)	375 (92.6%)	0.185
Charlson's comorbidity index, median (IQR)	3 (2–5)	3 (1–4.5)	4 (2–5)	0.070

TABLE 1. Continued.

Characteristics	All patients	Survival to discharge	non-survival to discharge	*p* value
	n = 509	n = 104	n = 405	
Numbers of Comorbidity, n (%)				0.072
0~1	270 (53.0%)	59 (56.7%)	211 (52.1%)	
2~3	196 (38.5%)	33 (31.7%)	163 (40.2%)	
4 and above	43 (8.4%)	12 (11.5%)	31 (7.7%)	
Length of stay (days), median (IQR)	0 (0–12)	31 (14–52)	0 (0–1)	<0.001
ED Disposition, n (%)				0.141
Ward	199 (39.1%)	38 (36.5%)	161 (39.8%)	
ICU	94 (18.5%)	12 (11.5%)	82 (20.2%)	
Resuscitation	199 (39.1%)	51 (49.0%)	148 (36.5%)	
Observation	17 (3.3%)	3 (2.9%)	14 (3.5%)	
CPR time, median (IQR)	13 (6–33)	6 (2–11)	18.5 (6–37.5)	<0.001
ED arrival to CPR initiation interval (minutes), median (IQR)	215 (57.5–744.5)	147 (31.25–511.5)	247 (64.5–826.5)	0.009
ECMO, n (%)	25 (4.9%)	8 (7.7%)	17 (4.2%)	<0.001
PCI, n (%)	35 (6.9%)	19 (18.3%)	16 (4.0%)	<0.001
CPC at discharge, n (%)				0.070
1	24 (4.7%)	24 (23.1%)	0 (0.0%)	
2	20 (3.9%)	20 (19.2%)	0 (0.0%)	
3	39 (7.7%)	39 (37.5%)	0 (0.0%)	
4	21 (4.1%)	21 (20.2%)	0 (0.0%)	
5	405 (79.6%)	0 (0.0%)	405 (100.0%)	

Abbreviation: TTAS, Taiwan triage and acuity scale; SBP, Systolic Blood Pressure; DBP, Diastolic Blood Pressure; GCS, Glasgow Coma Scale; ECMO, Extracorporeal Membrane Oxygenation; ED, Emergency Department; PCI, Percutaneous coronary intervention; CPC, cerebral performance categories; CPR, Cardiopulmonary Resuscitation; ICU, intensive care unit; SD, Standard Deviation.

the survival to hospital discharge was 18.4%. Chen *et al*. [16] reported the incidence of EDCA to be 4.02 per 1000 admissions and the survival rate to be 18.8%. The incidence of EDCA is not low, but EDCA has a higher survival rate than OHCA [17, 18]. The quality of patient care in the ED can be improved by preventing the occurrence of EDCA. Tsai *et al*. [3] reported that a higher patient-to-nursing staff ratio had a significant positive correlation with the incidence of EDCA compared with patient-to-physician ratio.

No previous study has discussed the survival outcome by comparing causes of EDCA according to different patient management strategies. In this study, we found differences in the common causes of cardiac arrest among three subgroups (under observation, waiting for ward, waiting for ICU, or under resuscitation). The most common causes of cardiac arrest for a patient waiting for the ward were metabolic (30.2%) and respiratory (33.7%) causes. The potential explanation of this phenomenon is that not all ED patients waiting for the ward were monitored and followed up frequently. Once cardiac arrest occurred among them, most of the time, no vital sign or recent blood test was recorded before the cardiac arrest episode. This result suggests that clinicians and nursing staff should monitor these patients' respiratory pattern and the possibility of acidosis or hyper/hypokalemia. Among patients waiting for ICU, respiratory (9.6%) causes were the least common cause of cardiac arrest. The possible reason for this result is that airway and respiratory problems are always the first priority and are managed in the ED before cardiac arrest occurs. However, other causes (43.6%) and cardiogenic causes (25.5%) were the most common causes

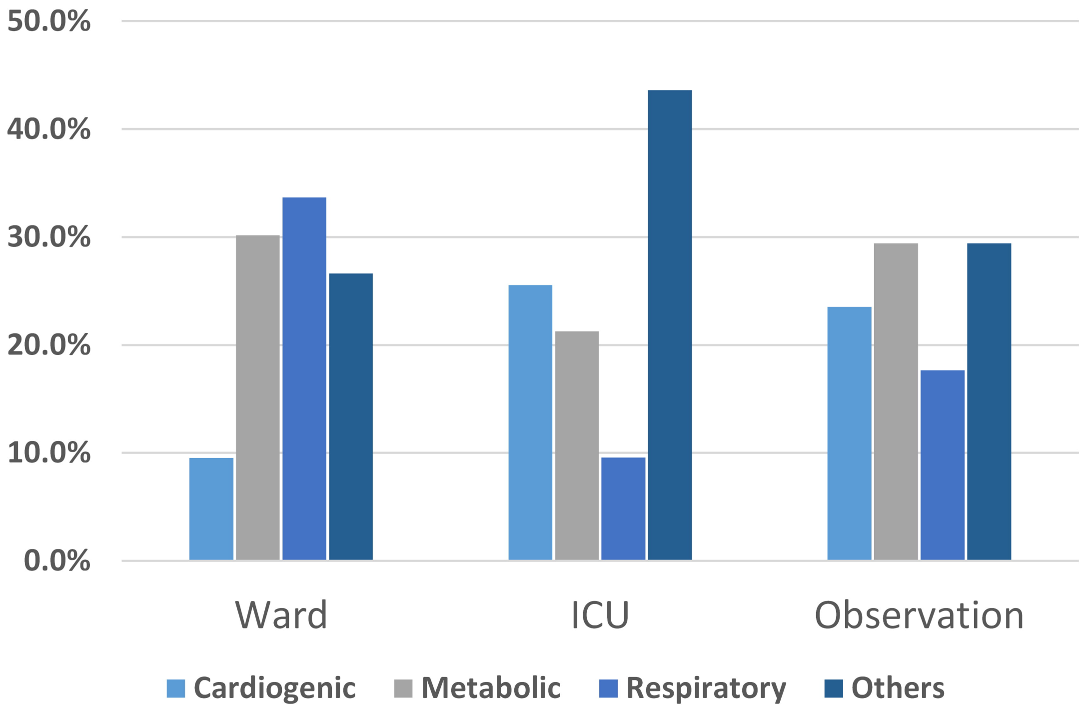

FIGURE 2. The distribution of causes of cardiac arrest. Abbreviations: ICU, Intensive Care Unit.

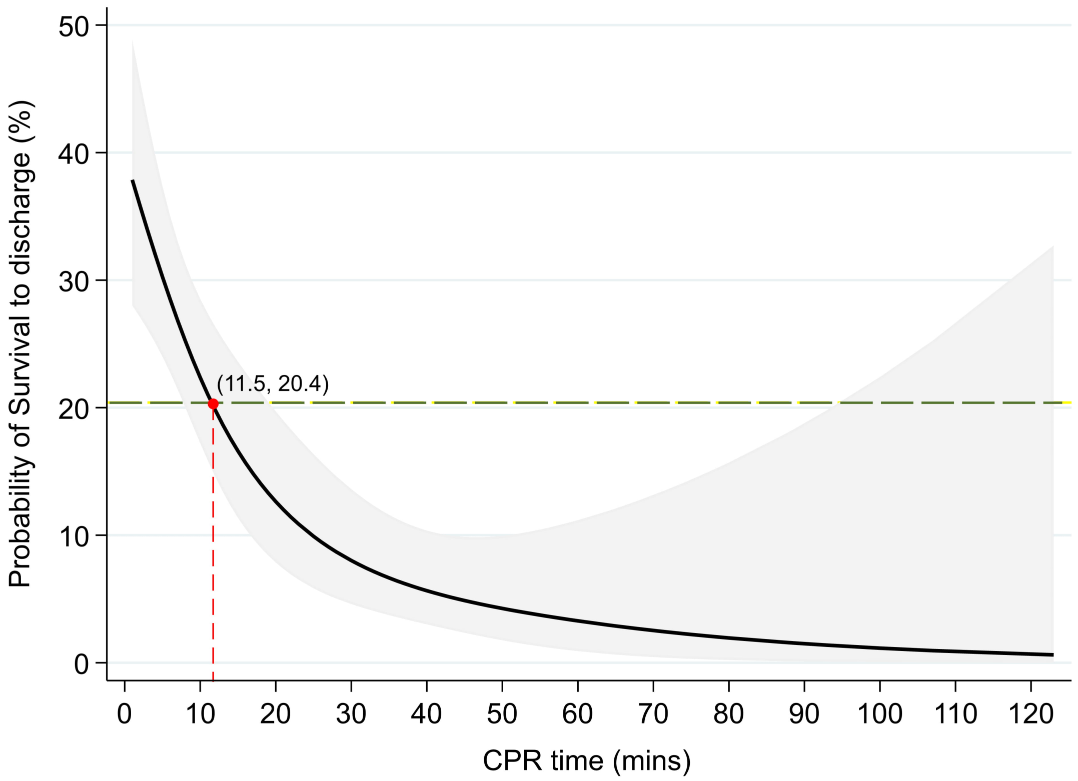

FIGURE 3. Probability of survival to discharge vs CPR time from a restricted cubic spline model. Abbreviations: CPR, Cardiopulmonary Resuscitation.

among EDCA patients with the management strategies of ICU admission or still under resuscitation on scene. The result indicates that frequent hemodynamic monitoring and more aggressive hemodynamic support (e.g., blood transfusion, broad-spectrum antibiotic treatment [19], intra-aortic balloon pump, extracorporeal membrane oxygenation [20, 21], and primary PCI) should be activated in advance among patients waiting for ICU.

A previous study [16] reported that the incidence of IHCA was 4.02 per 1000 admissions (hospitals with IHCA case numbers <50 during 1 year were excluded), and a significant negative correlation was found between a hospital's case

TABLE 2. Result of Multivariable Logistic Regression Analysis in cause of cardiac arrest.

Cause of cardiac arrest	Outcome Assessment, OR (95% CI)^{sig}			
	Ever ROSC	Survival to admission	Survival to discharge	Good CPC at discharge
Cardiogenic	1.43 (0.80–2.57) [c]	1.36 (0.83–2.24) [c]	2.52 (1.36–4.66)**[c]	3.22 (1.40–7.41)**[c]
	1.72 (0.87–3.41) [a]	1.23 (0.68–2.22) [a]	2.31 (1.59–3.91)*[a]	2.84 (1.57–5.97)*[a]
Metabolic	1.05 (0.62–1.77) [c]	0.84 (0.52–1.34) [c]	0.91 (0.46–1.82) [c]	0.73 (0.24–2.19) [c]
	1.18 (0.69–2.04) [a]	0.91 (0.56–1.49) [a]	0.92 (0.46–1.90) [a]	0.96 (0.30–3.10) [a]
Respiratory	1.90 (1.07–3.38)*[c]	1.86 (1.16–2.98)*[c]	2.70 (1.52–4.82)**[c]	2.11 (0.91–4.93) [c]
	2.28 (1.25–4.18)*[a]	1.94 (1.18–3.20)**[a]	2.62 (1.44–4.76)**[a]	2.23 (0.89–5.62) [a]
Others	*1 (ref. group)*	*1 (ref. group)*	*1 (ref. group)*	*1 (ref. group)*
Cause of cardiac arrest	Crude survival rate			
	Ever ROSC	Survival to admission	Survival to discharge	Good CPC at discharge
Cardiogenic	76/97 (78.35%)	54/97 (55.67%)	28/97 (28.87%)	16/97 (16.49%)
Metabolic	85/117 (72.65%)	51/117 (43.59%)	15/117 (12.82%)	5/117 (4.27%)
Respiratory	101/122 (82.79%)	77/122 (63.11%)	37/122 (30.33%)	14/122 (11.48%)
Others	124/173 (71.68%)	83/173 (47.98%)	24/173 (13.87%)	9/173 (5.20%)

*sig. mark: *$p < 0.05$/**$p < 0.01$.*
[c] Crude Odds Ratio; [a] Adjusted Odds Ratio, adjusted by Age, Sex, Triage, GCS, initial rhythm, Intubation, Sedation, Critical, Witness, Charlson's comorbidity index, CPR Time.

survival rate and incidence rate. Hospitals with low case survival rates had higher cardiac arrest incidence rates. Chang *et al.* [6] reported that the incidence of EDCA was 0.11% in another tertiary medical center in central Taiwan compared with the EDCA incidence of 0.16% in this study, but no survival outcome of EDCA was reported in in Chang's study.

Kim *et al.* [7] reported the incidence of EDCA with an initial shockable rhythm as 10.2% and the ECPR rate among all EDCAs as 13.4% in a university affiliated teaching hospital in Seoul, Korea. Our study showed that the incidence of the initial shockable rhythm was 9.80%, and that the ECPR rate among all EDCAs was 4.45%. Moreover, our study showed lower survival to discharge (20.43%) and lower CPC 1/2 (8.64%) ratios at discharge for EDCA. This lower ECPR rate [20–24] and lower initial shockable rhythm ratio might contribute to this result. Kim *et al.* [7] reported that the proportion of survival to discharge was 24.60% and that the rate of favorable neurological outcomes at discharge was 20.32%. The incidence of endotracheal intubation (ETI)-related CA in the ED varied significantly from 1.7% to 23.3% [25, 26]. EDCA episodes occurring during or post-intubation was the common reason in the ED. However, our study showed that the incidence of ETI-related CA was 16.7%, and only a trend was found between survival to discharge and discharge neurological outcomes because of low power related problem.

A previous study demonstrated a higher survival rate and more favorable discharge neurological outcomes of EDCA patients with the initial shockable rhythm [7, 10]. Our study also showed a higher survival-to-discharge rate and higher ratio of discharged CPC 1/2 in EDCA patients with cardiogenic causes or the initial shockable rhythm. This result can be explained using more aggressive management, which would be performed in this subgroup, including defibrillation, primary PCI, extracorporeal membrane oxygenation (ECMO), and intra-aorta balloon pump (IABP). The survival-to-discharge rate observed in EDCA patients with respiratory causes (e.g., airway obstruction and abnormal respiratory pattern) was higher than the rate in patients with other causes (e.g., metabolic and hypotension causes). This phenomenon may be because patients' clinical presentation of respiratory problems raised alarms among emergency medical staff, who manage these problems immediately.

Kayser *et al.* [1] reported that primary EDCA patients have a better chance of survival to discharge than those with recurrent events. Our study showed EDCA patients' probability of survival to discharge was 20.4% in the total resuscitation time (11.5 min). This finding provides ED physicians with insights into the management of such cases as well as an evidence-based explanation of the resuscitation process to patients' family.

5. Limitation

The study findings should be interpreted in the context of the following limitations. First, this study was conducted in a single tertiary medical center within a limited period, which might restrict the generalizability of our findings. Severe

TABLE 3. Result of multivariable logistic regression analysis in different outcome.

Variables	Outcome assessment, aOR (95% CI)^{sig}			
	Ever ROSC	Survival to admission	Survival to discharge	Good CPC at discharge
Age	0.99 (0.97–1.00)*	0.98 (0.97–0.99)***	0.99 (0.97–1.00)*	0.97 (0.96–0.99)***
Sex (M vs. F)	1.25 (0.82–1.90)	1.38 (0.95–1.99)	0.94 (0.60–1.49)	1.13 (0.59–2.19)
Triage (1,2 vs. 3,4)	0.74 (0.38–1.45)	0.67 (0.39–1.16)	0.94 (0.49–1.81)	1.10 (0.42–2.90)
GCS				
GCS (9∼14 vs. 15)	1.35 (0.84–2.18)	1.56 (1.04–2.36)*	1.60 (0.94–2.70)	2.12 (0.95–4.74)
GCS (3∼8 vs. 15)	0.96 (0.54–1.72)	0.87 (0.52–1.47)	0.84 (0.41–1.72)	0.88 (0.28–2.76)
Initial rhythm (Shockable vs. Non-shockable)	1.11 (0.55–2.25)	1.66 (0.90–3.06)	3.41 (1.84–6.29)***	4.83 (2.33–10.01)***
Intubation				
Intubation (Y vs. N)	1.14 (0.70–1.86)	0.70 (0.46–1.08)	0.27 (0.14–0.55)***	0.26 (0.09–0.75)*
Intubation (under process vs. N)	2.24 (1.16–4.33)*	1.50 (0.92–2.46)	0.74 (0.41–1.34)	0.47 (0.18–1.23)
Sedation use (Y vs. N)	1.38 (0.89–2.12)	0.86 (0.60–1.24)	0.45 (0.28–0.75)**	0.24 (0.10–0.59)**
Critical (Y vs. N)	1.66 (1.07–2.57)*	1.07 (0.72–1.59)	0.85 (0.53–1.38)	0.87 (0.44–1.71)
Witness (Y vs. N)	1.78 (0.88–3.62)	1.47 (0.75–2.88)	1.11 (0.47–2.60)	1.75 (0.41–7.55)
Charlson's comorbidity index	0.99 (0.90–1.09)	0.94 (0.87–1.02)	0.93 (0.84–1.02)	0.79 (0.67–0.92)**
CPR Time (≤11.5 mins vs. >11.5 mins)	2.53 (1.54–4.16)***	5.80 (3.69–9.13)***	4.74 (2.58–8.71)***	3.62 (1.57–8.32)**

*sig. mark: *p < 0.05/**p < 0.01/***p < 0.001.*
Abbreviation: ROSC, Return of Spontaneous Circulation; aOR, adjusted odds ratio; GCS, Glasgow Coma Scale; CPR, Cardiopulmonary Resuscitation.

patients are typically transferred to a tertiary hospital; thus, we should be careful when applying our findings to a basic hospital. Second, information on the length of stay (LOS) after cardiac arrest in the ED was not collected. Whether longer LOS in the ED after EDCA is associated with poor survival outcome should be further explored. Third, patients' baseline consciousness level and frailty were not recorded; this might cause poor neurological outcomes compared with those in other studies. Fourth, the low percentage of ECPR also might influence the neurological status at discharge because the criteria of ECPR were rigorous. Fifth, consider this is a retrospective study essentially, the associations should be interpreted with caution regarding causal relationships.

6. Conclusions

Prolonged CPR time, post-intubation status, and sedative medication use were associated with poor survival to discharge and neurological outcomes. EDCA patients with cardiogenic etiology have more favorable survival and neurological outcomes.

AUTHOR CONTRIBUTIONS

PCC and JHC conceived and designed the study. CCY, CHC, CCL collected the data. CJN and CJS managed the data, including quality control. LHT and CYC analyzed the data. PCC and JHC drafted the manuscript. LHT and CYC contributed substantially to its revision. LHT and CYC takes responsibility for the paper as a whole. PCC and JHC contributed equally to this work (both are first author). LHT and CYC both are corresponding author.

ETHICS APPROVAL AND CONSENT TO PARTICIPATE

This study was approved by the Chang Gung Medical Foundation's Hospital Ethics Committee on Human Research (IRB: 201900275B0). The study protocol was reviewed, and the study was exempted from the requirement of obtaining informed consent.

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CONFLICT OF INTEREST

The authors declare no conflict of interest. Cheng-Yu Chien is serving as one of the Guest editors of this journal. We declare that Cheng-Yu Chien had no involvement in the peer review of this article and has no access to information regarding its peer review. Full responsibility for the editorial process for this article was delegated to KJS.

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