ORIGINAL ARTICLE

Relationship Between the Duration of Cardiopulmonary Resuscitation in Emergency Department and Outcomes for Patients with Non-Traumatic Cardiac Arrest

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Objective: The optimal duration of cardiopulmonary resuscitation (CPR) in emergency department cardiac arrest (EDCA) patients remains uncertain. This study aimed to determine the association between CPR duration and survival outcomes among EDCA patients.

Materials and Methods: This retrospective observational study included adult patients with non-traumatic cardiac arrest in the ED between January 2012 and December 2024. Patients were categorized based on whether they achieved sustained return of spontaneous circulation (ROSC). Multivariable logistic regression analyses were performed to identify associations between CPR duration and 1) survival to hospital discharge and 2) survival with a favorable neurological outcome, adjusting for demographic, prehospital, and resuscitation-related variables.

Results: Among 1,711 EDCA patients, 931 (54.4%) achieved sustained ROSC. The median total CPR duration was 11 minutes (IQR 5 to 27) among patients with sustained ROSC and 33 minutes (IQR 30 to 45) among those without. Survival to hospital discharge occurred in 16.3%, and a favorable neurological outcome in 7.8%. Each 1-minute increase in CPR duration was associated with decreased odds of survival to hospital discharge (adjusted OR 0.93, 95% CI 0.92 to 0.95, p<0.001) and favorable neurological outcome (adjusted OR 0.91, 95% CI 0.88 to 0.95, p<0.001). Compared with CPR of 10 minutes or less, the adjusted ORs for survival to discharge were 0.67, 0.16, 0.08, and 0.06 for durations of 11 to 20, 21 to 30, 31 to 40, and more than 40 minutes, respectively. For a favorable neurological outcome, the corresponding adjusted ORs were 0.32, 0.11, 0.04, and 0.04. The 50th, 75th, 90th, 95th, and 99th percentiles of CPR duration for patients without survival to hospital discharge were 7, 14, 30, 41, and 89 minutes, respectively; and 6, 12, 28, 42, and 61 minutes for patients without a favorable neurological outcome.

Conclusions: The patients requiring prolonged CPR duration in the ED were strongly associated with reduced survival and poorer neurological outcomes. The likelihood of meaningful survival declined after 30 minutes of resuscitation.

Keywords: Emergency department cardiac arrest; Cardiopulmonary resuscitation duration; Survival outcome; Neurological outcome; Prognostication

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Cardiac arrest is a major global health problem due to its high incidence and mortality. In the United States, approximately 330,000 cases occur annually[1], and European countries report about 275,000 cases each year[1]. Although Thailand has no national registry, data from the Emergency Department (ED) of Thammasat University Hospital between 2012 and 2016 indicated an average of 140 cardiac arrest cases per year, including both out-of-hospital cardiac arrest (OHCA) and in-ED cardiac arrest.

Despite advances in resuscitation science, the overall survival rate remains low (10% to 20%), and many survivors suffer from neurological impairment, ranging from brain death to mild cognitive deficits[1-5]. Such disabilities create significant emotional and financial burdens and require substantial healthcare resources for long-term care and rehabilitation.

A major unresolved challenge in cardiac arrest management is determining how long resuscitation should continue. The 2020 American Heart Association (AHA) Guidelines provide no clear recommendation on the optimal duration of advanced cardiopulmonary resuscitation (CPR), leaving decisions to the physician's discretion[6]. Previous studies attempting to identify appropriate

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CPR duration have yielded inconsistent results due to variations in healthcare systems and patient populations[3-5].

In EDs, where time, staff, and critical care capacity are limited, accurate prognostication during resuscitation is crucial for guiding clinical decisions and resource allocation. Understanding the likelihood of meaningful survival based on CPR duration can help clinicians balance continuation versus termination of efforts, prioritize intensive care resources, and communicate effectively with families.

To date, no study has systematically investigated this issue in the Thai population, where differences in emergency systems and hospital settings may influence outcomes. This study aimed to evaluate the association between CPR duration and survival outcomes, including survival to hospital discharge and survival with a favorable neurological outcome, among emergency department cardiac arrest (EDCA) patients. The findings may support the development of context-specific prognostication tools and promote rational, resource-conscious resuscitation strategies in emergency care.

Materials and Methods

Study design and setting

This retrospective observational study was conducted in the ED of Thammasat University Hospital (TUH), a tertiary-care teaching hospital in Pathum Thani, Thailand. The study period spanned from January 2012 to December 2024. The ED operates 24 hours a day and receives approximately 18,000 emergency visits annually. The hospital's cardiac arrest registry prospectively collects standardized data from all resuscitation events occurring in the ED, including both OHCA patients presenting to the ED and in-hospital cardiac arrest (IHCA) occurring during ED care.

Study population

This study collected data from adult patients (aged 15 years and older) who experienced EDCA and received CPR in the ED during the study period. EDCA included 1) OHCA patients who arrived in ongoing cardiac arrest, regardless of whether prehospital CPR was initiated, and 2) patients whose first cardiac arrest occurred in the ED[7,8]. Cardiac arrest was defined as the absence of a palpable pulse and unresponsiveness requiring chest compressions. Patients were excluded if they had do-not-resuscitate (DNR) orders, traumatic cardiac arrest, signs of irreversible death, or missing CPR duration data.

Ethical approval

The study protocol was reviewed and approved by the Human Research Ethics Committee of Thammasat University (approved number MTU-EC-EM-6-122/60). The requirement for informed consent was waived due to the retrospective nature of the study and anonymized data collection.

Data collection

Data were extracted from the institutional cardiac arrest registry and verified through review of medical records. The following information was collected, included demographic characteristics: age and sex; clinical variables: presumed etiology of cardiac arrest, initial cardiac rhythm, witnessed status, initial location of cardiac arrest (out-of-hospital versus in-ED), and method of transport to the ED; resuscitation variables: total CPR duration (minutes), time to first chest compression, time to first epinephrine dose, time to advanced airway placement, defibrillation events, and use of intravenous medications (amiodarone, calcium, sodium bicarbonate, and insulin); outcomes: sustained return of spontaneous circulation (ROSC), survival to hospital discharge, and favorable neurological outcome [Cerebral Performance Category (CPC) 1 or 2 at day 30][9,10].

The primary exposure was total CPR duration, defined as the time from the initiation of chest compressions to the termination of resuscitation efforts or achievement of sustained ROSC. Each patient was included only once. In patients who experienced recurrent cardiac arrest after achieving sustained ROSC, no additional CPR duration data were collected for subsequent resuscitation episodes.

Outcome measures

The primary outcome was survival to hospital discharge, and the secondary outcome was survival with a favorable neurological outcome, defined as a CPC score of 1 or 2 at 30 days after cardiac arrest. Percentile analyses were performed to describe the distribution of CPR duration among survivors. The 50th, 75th, 90th, 95th, and 99th percentiles of total CPR duration were calculated separately for patients who survived to hospital discharge and those who survived with a favorable neurological outcome.

Statistical analysis

To enhance the reliability of the study findings, all patients who met the inclusion criteria during the study period were included in the analysis. The analyses were conducted as a complete-case analysis, and no data imputation was performed. Continuous variables were summarized as mean with standard deviation (SD) or median with interquartile range (IQR), depending on distribution. Categorical variables were expressed as frequencies and percentages. Group comparisons were performed using the Student's t-test or Mann-Whitney U test for continuous variables and the chi-square test or Fisher's exact test for categorical variables.

To examine the association between CPR duration and outcomes, multivariable logistic regression analyses were performed with adjustment for potential confounders, including sex, age, initial location of cardiac arrest (OHCA versus in-ED), presumed etiology, witness status, transfer method, collapse-to-CPR time, initial rhythm, time to first adrenaline, time to advanced airway placement, refractory shockable rhythm, and administration of amiodarone, calcium, sodium bicarbonate, and insulin. Adjusted odds ratios (aORs) with 95% confidence intervals (CIs) were reported. A two-sided p-value of less than 0.05 was considered statistically significant. All analyses were conducted using Stata Statistical Software, version 17 (StataCorp LLC, College Station, TX, USA).

Results

Two thousand two hundred forty-one patients with cardiac arrest were identified in the ED during the study period. After applying the exclusion criteria, the following patients were excluded: 100 patients aged 15 years or younger, 98 patients with DNR orders, 209 patients with trauma-related cardiac arrest, five patients showing signs of irreversible death, and 118 patients with missing time data. After these exclusions, 1,711 patients remained eligible for analysis. Of these, 931 patients (54.4%) achieved ROSC, while 780 patients (45.6%) did not (Figure 1).

Baseline characteristics of patients with and without sustained ROSC are summarized in Table 1. The mean age was comparable between groups (61.7±17.6 versus 61.3±18.6 years), and 59.4% of patients with sustained ROSC were male. A presumed cardiac etiology was more common in the sustained ROSC group (40.6%), while hypoxia and other medical causes were more frequent among those without ROSC. Witnessed arrests occurred more often in patients with sustained ROSC (84.2% versus 69.2%), whereas OHCA were more frequent in those without (81.0% versus 62.4%). Shockable rhythms were observed more frequently in patients with sustained ROSC, and the median time from

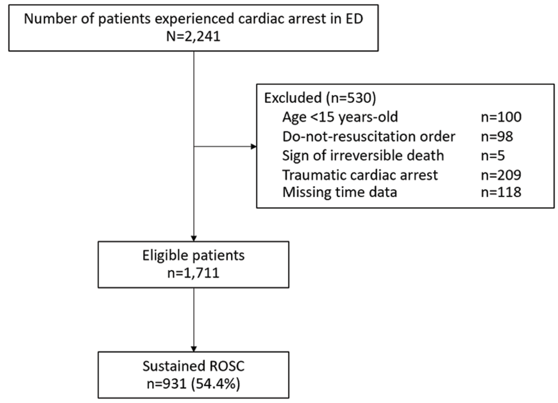

Figure 1. Flow diagram patient selection.

collapse to first chest compression was shorter [5 (0, 20) minutes versus 20 (2, 38) minutes]. Intravenous calcium, sodium bicarbonate, and amiodarone were administered more often in patients without sustained ROSC. Among those who achieved sustained ROSC, 279 (30%) survived to hospital discharge, and 133 (14.3%) had a favorable neurological outcome (CPC 1 or 2) at 30 days. The median total CPR duration was 11 minutes (IQR 5, 27) in patients with sustained ROSC and 33 minutes (IQR 30, 45) in those without.

In the multivariable logistic regression analysis adjusted for sex, age, initial location of arrest, etiology, witnessed status, transfer method, collapse-to-CPR interval, initial rhythm, time to first epinephrine, time to advanced airway, refractory shockable rhythm, and use of intravenous amiodarone, calcium, sodium bicarbonate, and insulin, each additional minute of CPR was associated with a 7% reduction in the odds of survival to hospital discharge (adjusted OR 0.93, 95% CI 0.92 to 0.95, p<0.001). When CPR duration was categorized, compared with CPR lasting 1 to 10 minutes, the adjusted odds ratios for survival to hospital discharge were 0.67 (95% CI 0.37 to 1.23, p=0.199) for 11 to 20 minutes, 0.16 (95% CI 0.07 to 0.34, p<0.001) for 21 to 30 minutes, 0.08 (95% CI 0.03 to 0.19, p<0.001) for 31 to 40 minutes, and 0.06 (95% CI 0.02 to 0.16, p<0.001) (Table 2).

For survival with a favorable neurological outcome, each additional minute of CPR was associated with a 9% decrease in the odds of good neurological recovery (adjusted OR 0.91, 95% CI 0.88 to 0.95, p<0.001). Compared with patients who received CPR for 10 minutes or less, the adjusted ORs were 0.32 (95% CI 0.12 to 0.89, p=0.029) for 11 to 20 minutes, 0.11 (95% CI 0.03 to 0.42, p=0.001) for 21 to 30 minutes, 0.04 (95% CI 0.01 to 0.19, p<0.001) for 31 to 40 minutes, and 0.04 (95% CI 0.01 to 0.16,

Table 1. Characteristics of emergency department cardiac arrest patients with sustained return of spontaneous circulation (ROSC) and no sustained ROSC

Characteristic	All emergency department cardiac arrest (n=1,711)	
	Sustained ROSC (n=931)	Without sustained ROSC (n=780)
Sex; n (%)		
Male	553 (59.4)	488 (62.6)
Female	378 (40.6)	292 (37.4)
Age (years); mean±SD	61.7±17.6	61.3±18.6
Etiology of cardiac arrest; n (%)		
Presume cardiac cause	377 (40.6)	463 (59.4)
Hypoxia	284 (30.6)	74 (9.5)
Non-traumatic massive bleeding	48 (5.2)	43 (5.5)
Other medical	219 (23.6)	200 (25.6)
Witness cardiac arrest; n (%)	783 (84.2)	540 (69.2)
Initial location of cardiac arrest; n (%)		
Out-of-hospital	581 (62.4)	632 (81.0)
In-emergency department	350 (37.6)	148 (19.0)
Transfer methods; n (%)		
Emergency medical service	209 (27.2)	190 (26.9)
First responder	29 (3.8)	46 (6.5)
Self-transport	512 (66.7)	416 (59.0)
Other method	18 (2.3)	53 (7.6)
Time from collapse to 1st chest compression (minutes); median (IQR)	5 (0, 20)	20 (2, 38)
Time from collapse to 1st chest compression classification; n (%)		
0 to 8 minutes	515 (55.3)	243 (31.4)
9 to 20 minutes	197 (21.2)	179 (23.1)
Over 20 minutes	219 (23.5)	353 (45.5)
Initial cardiac rhythm; n (%)		
Ventricular fibrillation	103 (11.1)	64 (8.2)
Pulseless ventricular tachycardia	17 (1.8)	15 (1.9)
Asystole	369 (39.7)	443 (56.9)
Pulseless electrical activity	440 (47.4)	257 (32.9)
Hypoglycemia; n (%)	122 (13.6)	121 (16.1)
Time to 1st dose of epinephrine (minutes); median (IQR)	1 (0, 2)	1 (0, 3)
Time to advanced airway (minutes); median (IQR)	2 (1, 4)	2 (1, 4)
Defibrillation during resuscitation; n (%)	260 (27.9)	327 (41.9)
Refractory shockable rhythm; n (%)	71 (8.1)	107 (14.4)
Intravenous amiodarone used during resuscitation; n (%)	109 (11.7)	191 (24.5)
Intravenous calcium used during resuscitation; n (%)	198 (21.3)	319 (40.9)
Intravenous sodium bicarbonate used during resuscitation; n (%)	234 (25.2)	363 (46.5)
Intravenous insulin used during resuscitation; n (%)	145 (15.6)	217 (27.8)
Survived to hospital discharge; n (%)	279 (30.0)	0 (0.0)
Cerebral performance categories (CPC) at day 30; n (%)		
Died in hospital	649 (69.7)	780 (100)
CPC 1	88 (9.5)	0 (0.0)
CPC 2	45 (4.8)	0 (0.0)
CPC 3	29 (3.1)	0 (0.0)
CPC 4	45 (4.8)	0 (0.0)
CPC 5	6 (0.6)	0 (0.0)
Unknown	69 (7.4)	0 (0.0)
Total CPR duration (minutes); median (IQR)	11 (5, 27)	33 (30, 45)
Total CPR duration classification; n (%)		
1-10 minutes	446 (47.9)	15 (1.9)
11-20 minutes	181 (19.4)	36 (4.6)
21-30 minutes	109 (11.7)	223 (28.6)
31-40 minutes	75 (8.1)	261 (33.5)
>40 minutes	120 (12.9)	245 (31.4)

CPR=cardiopulmonary resuscitation; SD=standard deviation; IQR=interquartile range

Table 2. Result from multivariable logistic regression analysis of survival to hospital discharge in term of cardiopulmonary resuscitation (CPR) duration

CPR duration*	Adjusted OR	95% CI	p-value
Total CPR duration (minutes)	0.93	0.92 to 0.95	<0.001
Total CPR duration classification			
1-10 minutes	Reference	Reference	Reference
11-20 minutes	0.67	0.37 to 1.23	0.199
21-30 minutes	0.16	0.07 to 0.34	<0.001
31-40 minutes	0.08	0.03 to 0.19	<0.001
>40 minutes	0.06	0.02 to 0.16	<0.001

OR=odds ratio; CI=confidence interval

* Adjusted with sex, age, initial location of cardiac arrest, etiology, witness status, transfer method, collapse to CPR time, initial rhythm, time to 1st adrenaline, time to advance airway, refractory shockable rhythm, use of amiodarone, calcium, sodium bicarbonate, insulin

Table 3. Result from multivariable logistic regression analysis of survival to hospital discharge with favorable neurological outcome in term of cardiopulmonary resuscitation (CPR) duration

CPR duration*	Adjusted OR	95% CI	p-value
Total CPR duration (minute)	0.91	0.88 to 0.95	<0.001
Total CPR duration classification			
1-10 minutes	Reference	Reference	Reference
11-20 minutes	0.32	0.12 to 0.89	0.029
21-30 minutes	0.11	0.03 to 0.42	0.001
31-40 minutes	0.04	0.01 to 0.19	<0.001
>40 minutes	0.04	0.01 to 0.16	<0.001

OR=odds ratio; CI=confidence interval

* Adjusted with sex, age, initial location of cardiac arrest, etiology, witness status, transfer method, collapse to CPR time, initial rhythm, time to 1st adrenaline, time to advance airway, refractory shockable rhythm, used of amiodarone, calcium, sodium bicarbonate, insulin

Table 4. Percentiles of CPR duration among patients without survival to hospital discharge and without survival with favorable neurological outcome

	Percentile CPR duration (minutes) (95% confidence interval)				
	50th	75th	90th	95th	99th
Without survival to hospital discharge (n=1,432)	7 (6 to 8)	14 (13 to 20)	30 (27 to 34)	41 (33 to 51)	89 (52 to 125)
Without survival with favorable neurological outcome (n=1,578)	6 (4 to 7)	12 (9 to 15)	28 (21 to 37)	42 (29 to 55)	61 (46 to 62)

CPR=cardiopulmonary resuscitation

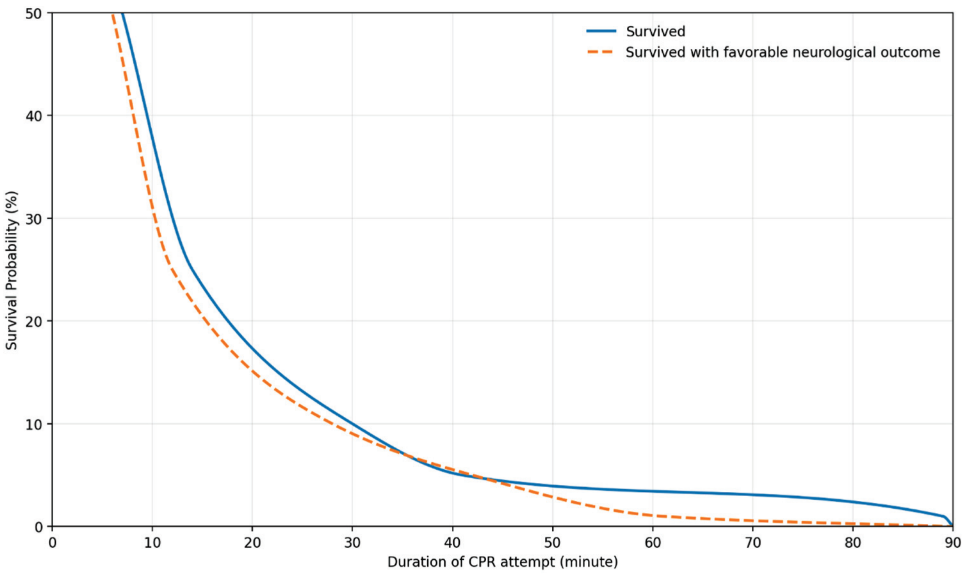

Figure 2. Prognostic value of CPR duration for survival to hospital discharge and favorable neurological outcome in emergency department cardiac arrest patients.

$p<0.001$) for more than 40 minutes (Table 3).

The relationship between CPR duration and survival outcomes is illustrated in Figure 2 and Table 4. Both survival to hospital discharge and a favorable neurological outcome declined steadily as CPR duration increased. For patients who did not survive to hospital discharge, the 50th, 75th, 90th, 95th, and 99th percentiles of CPR duration were 7 (95% CI 6 to 8), 14 (13 to 20), 30 (27 to 34), 41 (33 to 51), and 89 (52 to 125) minutes, respectively, indicating that non-survival became progressively more common as CPR duration increased. For patients who did not survive with a favorable neurological outcome, the corresponding percentiles were 6 (4 to 7), 12 (9 to

15), 28 (21 to 37), 42 (29 to 55), and 61 (46 to 62) minutes, respectively, showing a similar pattern.

Discussion

This study demonstrated a strong inverse relationship between the duration of CPR in the ED and survival outcomes among patients with cardiac arrest. Patients who achieved ROSC after shorter resuscitation efforts had higher survival and better neurological recovery compared with those who required prolonged CPR. Specifically, each additional minute of CPR was associated with a 7% decrease in the odds of survival to hospital discharge and a 9% decrease in the odds of a favorable neurological outcome. Among survivors, 50% achieved ROSC within seven minutes of CPR, and 90% within 31 minutes. These findings highlight the critical influence of resuscitation duration on clinical outcomes and underscore the prognostic value of CPR time in EDCA management.

The results of this study are consistent with previous international investigations. Reynolds et al.[3], Adnet et al.[4], Goto et al.[11], and Kashiura et al.[12] all reported that CPR lasting longer than 30 minutes was strongly associated with poor survival to hospital discharge. Similarly, in the study's analysis, the adjusted odds of survival decreased dramatically beyond the 30-minute threshold (aOR 0.08 for 31 to 40 minutes and 0.06 for more than 40 minutes). Moreover, the duration of CPR also affected neurological recovery, echoing findings from studies by Matsuyama et al.[5], Reynolds et al.[3], Goto et al.[11], and Kashiura et al.[12], which demonstrated a continuous decline in the likelihood of favorable neurological outcomes as resuscitation time increased. Together, these results reinforce the importance of early and effective resuscitation and support the use of CPR duration as an easily obtainable, real-time indicator for clinical decision-making.

Taken together, this study's findings and prior evidence consistently indicate that patients requiring prolonged CPR duration have diminished survival and neurological recovery. Clinically, these results emphasize that when circulation has not been restored within 30 minutes of conventional CPR, the probability of meaningful survival becomes exceedingly low. Beyond this point, continuation of standard resuscitation may provide little benefit, particularly in the absence of reversible causes. This observation supports the early consideration of advanced resuscitation strategies, such as extracorporeal cardiopulmonary resuscitation (ECPR). Although ECPR is not yet recommended as a first-line intervention, accumulating evidence suggests that it can improve survival and neurological outcomes in selected patients when initiated promptly after failed conventional CPR[13-15]. Based on the survival percentiles observed in this study, the optimal window for considering transition from conventional CPR to ECPR may lie between 15 and 20 minutes of ongoing resuscitation, before the likelihood of a favorable outcome declines sharply.

This study has limitations. First, its retrospective design may have introduced missing or incomplete data, although the use of a prospectively maintained registry minimized this concern. Second, a subset of patients experienced recurrent cardiac arrest within a short period (less than 20 minutes) after initial ROSC and required additional resuscitation, which potentially inflated the apparent duration of CPR. Third, survival outcomes were not adjusted for several missing or incomplete variables across patients, such as prehospital and ED assessments, ED overcrowding or bed occupancy rate, and treatments that might have affected the outcomes[16-20], the duration of on-scene resuscitation in OHCA cases[21], and differences in post-cardiac arrest care among patients who achieved sustained ROSC, which may have influenced patient survival[22,23].

A further limitation is that this study did not perform subgroup analyses by initial cardiac rhythm to determine whether the associations between CPR duration and outcomes differ between patients with shockable versus non-shockable rhythms. This remains an important knowledge gap that warrants future investigation. In addition, this study may be susceptible to survivorship bias or a self-fulfilling prophecy. For example, clinicians often terminate resuscitation at around 30 minutes, which could influence the observed outcomes. However, this finding regarding favorable neurological outcomes, showing that 90% of patients who received CPR for at least 28 minutes had poor neurological outcomes, may help support the robustness and credibility of the study's conclusions. Finally, because this study included only adult patients, the findings cannot be directly applied to pediatric cardiac arrest, which differs in both etiology and resuscitation dynamics.

Despite these limitations, the present study provides robust evidence from a large Thai ED population, demonstrating that CPR duration is a powerful and clinically useful prognostic indicator for survival and neurological recovery after cardiac arrest. The findings highlight the importance of early ROSC, timely decision-making regarding continuation or termination of CPR, and potential transition to advanced circulatory support when appropriate. Incorporating CPR duration into structured prognostication frameworks could help optimize resource utilization, guide family communication, and improve the overall quality and ethical integrity of emergency resuscitation care.

Conclusion

This study showed that longer CPR duration in the ED was strongly associated with lower survival and poorer neurological outcomes. Each additional minute of CPR reduced the odds of survival to hospital discharge and favorable neurological recovery. Half of all survivors achieved ROSC within seven minutes, and survival declined markedly beyond 30 minutes of CPR. These findings highlight the importance of early restoration of circulation. Incorporating CPR duration into prognostication may help guide timely clinical decisions, consideration of E-CPR, and efficient use of emergency care resources.

What is already known about this topic?

- Cardiac arrest in the ED is common and deadly. Neurological disability among survivors is frequent.
- No guideline-defined optimal duration for advanced CPR; decisions rely on clinician judgment.
- Longer CPR, especially beyond 30 minutes, sharply reduces survival and favorable neurological outcomes.
- Evidence is largely non-Thai and out-of-hospital. Thai ED-specific data are scarce, making time-based prognostication (e.g., CPR duration) crucial for decisions and selective ECPR in resource-limited settings.

What does this study add?

- Provides large, single-center Thai ED evidence with 1,711 patients on the association between CPR duration of EDCA and key outcomes.
- Demonstrates an independent, minute-by-minute inverse association. Each additional minute of CPR was associated with lower odds of survival to discharge and a favorable neurological outcome after multivariable adjustment.
- Reports clinically usable CPR-duration categories (10 minutes or less, 11 to 20 minutes, 21 to 30 minutes, 31 to 40 minutes, more than 40 minutes) with adjusted odds ratios showing a marked decline in outcomes as duration increases.
- Provides percentile estimates of CPR duration among patients without survival to discharge and without a favorable neurological outcome, supporting time-based prognostication during ED resuscitation.

Acknowledgement

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Authors' contributions

Conceptualization: WS and TU. Protocol development: WS and TU. Data collection: WS and TU. Data analysis: WS and TU. Writing and editing manuscript: WS and TU. All authors read and approved of the final manuscript.

Data availability

The datasets used or analyzed during the current study are available from the corresponding author on reasonable request.

Ethics approval and consent to participate

The study protocol was reviewed and approved by the Human Research Ethics Committee of Thammasat University (approved number MTU-EC-EM-6-122/60). The requirement for informed consent was waived due to the retrospective nature of the study and anonymized data collection.

Clinical trial registration

Not applicable.

Use of artificial intelligence

The authors did not use any artificial intelligence tools in the writing, analysis, or preparation of this manuscript.

Conflicts of interest

The authors declare no conflict of interest.

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