

ORIGINAL ARTICLE

What are the predictors of survival among patients who suffer cardiac arrest in the ED? A single-center chart review

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ABSTRACT

Background: Cardiac arrest in the emergency department (ED) has not been well studied; however, the existing literature shows that there are better survival and neurological outcomes with cardiac arrest in the ED than out-of-hospital cardiac arrest (OHCA) and in-hospital cardiac arrests. The aim of this study was to examine the cardiac arrests managed in a tertiary care center ED and identify the characteristics of patients who had good outcomes.

Methods: This was a retrospective chart review of patients who had cardiac arrest in ED from January 2018 to June 2019

Results: There were 209 cardiac arrests reported in the ED. A total of 189 patients were excluded because they presented with OHCA. Twenty patients had cardiac arrests in the ED. The survival to discharge from the hospital for the total patients analyzed was 40% (8/20). 60% (12/20) of patients were male with a median age of 60.5 years. Altered mental status or drowsiness was the presenting complaints of nearly 40% (8/20) of the patients, followed by dyspnea in 20% (4/20). Only 10% (2/20) reported having chest pain at presentation. 45% (9/20) of the patients had peri-intubation arrest. The most common initial rhythm was pulseless electrical activity (PEA) (70%, 14/20), followed by asystole (25%, 5/20) and ventricular fibrillation (VF), which was only 5% (1/20). 95% (19/20) of the patients had a return of spontaneous circulation with an average duration of cardiopulmonary resuscitation (CPR) of only 5 minutes. CPR duration and heart rate (HR) on arrival were the potential predictors of survival as per the classification and regression trees method. Age, gender, HR as a continuous variable, systolic blood pressure, diastolic blood pressure, mean arterial blood pressure >70 mm hg, the Modified Early Warning Score, or National Early Warning Score 2 were not statistically significant by Cox regression analysis as predictors of survival.

Conclusion: Cardiac arrests occurring in ED are associated with better outcomes than OHCA. CPR duration of less than 5 minutes coupled with presenting HR of > 110 b/min might be a predictor of survival. Larger database analyses of cardiac arrest in EDs are needed to validate this finding.

Keywords: Out-of-hospital cardiac arrests, emergency department cardiac arrests, peri-intubation arrests, MEWS, NEWS2, pseudo-PEA.

Introduction

According to the American Heart Association, the incidence of emergency medical services assessed out-of-hospital cardiac arrest (OHCA) in people of any age is approximately 100 individuals per 100,000 population (0.1%) [1]. The survival of patients presenting to the emergency department (ED) in cardiopulmonary arrest has significantly improved in the past few years because of recent advances in cardiac arrest care [2].

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Out-of-hospital cardiac arrest (OHCA) is a common presentation in EDs worldwide. Survival rates are variable across the world, with increased survival benefits in the west compared to the Middle East and Asia. The literature indicates that the variation in outcomes between developed countries and developing countries is likely due to immediate prehospital care, bystander cardiopulmonary resuscitation (CPR), and rapid access to defibrillators [1,3].

The survival rate of cardiorespiratory arrest differs between OHCA, ED cardiac arrests, and in-hospital cardiac arrests. A study performed in the Northern Emirates of the United Arab Emirates (UAE) on OHCA had a 5.4% rate of return of spontaneous circulation (ROSC) [4]. Another study performed across seven countries in Asia showed a survival to discharge rate of OHCA in the emirate of Dubai to be 3%, with a range of 0.5%-8.5% in the rest of the Asian countries [5]. On the contrary, in-hospital cardiac arrest showed an increased survival compared to OHCA [6]. A study performed in a tertiary hospital in the Emirate of Abu Dhabi on in-hospital cardiac arrests showed a survival to discharge rate of 7.7% [7]. Other studies that examined in-hospital cardiac arrest survival showed similar improved results compared to OHCA [6,8].

Little is known about cardiopulmonary arrest occurring while the patient is in the ED. In previous studies performed to assess cardiac arrest in EDs, it was noted that survival and neurologic outcomes in ED cardiac arrest are better compared to cardiac arrest occurring elsewhere in the hospital [9]. Some of the identified survival factors were initial shockable rhythm and time to ROSC of less than 10 minutes, which may be used to guide decision-making during resuscitation [6].

The aim of this study was to examine the cardiac arrests managed in a tertiary care center ED and identify the characteristics of patients who had good outcomes. The findings may help to identify gaps in the healthcare system and guide us to implement strategies that will improve the delivery of care.

Materials and Methods

A chart review of all the patients presenting to the ED alive and sustained cardiac arrest within the department between January 2018 and June 2019 was carried out.

Mafraq Hospital is a tertiary care academic hospital with 380 beds with an ED that attends to nearly 100,000 patients annually. The ED is staffed with trained emergency physicians (EP), 24 hours a day, and all ED nurses are certified in advanced cardiac life support. On arrival at the ED, the patients are triaged according to the emergency severity index. The hospital uses the Cerner application for electronic medical records.

We included all age groups who sustained cardiac arrest in the ED. We excluded all patients who sustained OHCA whether they arrived post-ROSC, had ongoing CPR on arrival, or were dead on arrival.

We used Excel to collect data, and the statistical analysis was performed using IBM SPSS® version 26.0. The univariate proportional Cox regression was used to determine the predictors of survival. The associated risk of mortality was quantified using hazard ratios (HRs) and the corresponding 95% confidence intervals (CIs). The classification and regression trees (CART) procedure was used to group patients according to survival status as it helps to determine the optimal cutoff values for continuous variables with the minimal loss of information. All the predictors were entered into the CART model.

Results

There were a total of 209 cardiac arrests reported during the audit period; 189 were excluded as per the predetermined exclusion criteria, and 20 patients who experienced cardiac arrests in the ED were included for analysis. The survival to discharge from the hospital of the total patients analyzed was 40% (8/20). 90% (18/20) of the cardiac arrests in the ED had a nontraumatic etiology. 60% (12/20) of patients were male with a median age of 60.5 years. Altered mental status or drowsiness was the presenting complaint of nearly 40% (8/20) of the patients, followed by dyspnea in 20% (4/20). Only 10% (2/20) reported having chest pain at presentation. 45% (9/20) of the patients had peri-intubation arrest. The most common initial rhythm was pulseless electrical activity (PEA) (70%, 14/20), followed by asystole (25%, 5/20) and ventricular fibrillation (VF), which was only 5% (1/20). 95% (19/20) of the patients had ROSC with an average duration of CPR of only 5 minutes.

Only 20% (4/20) of the study patients were transferred to the catheterization laboratory for percutaneous intervention (PCI); three of them had post-ROSC ST-elevation myocardial infarction (STEMI) electrocardiogram (ECG) changes, and one had pre-arrest non-STEMI (NSTEMI) ECG changes. The survival rate of those who went for PCI was 75% (3/4). 40% of the study patients had brain imaging in the ED, and none of them showed acute infarct or intracranial hemorrhage as an etiology.

Regarding factors predicting survival, the following variables were not statistically significant by Cox regression analysis: age, gender, heart rate (HR) as a continuous variable, systolic blood pressure (SBP), diastolic blood pressure (DBP), mean arterial blood pressure > 70 mm Hg, Modified Early Warning Score (MEWS), or National Early Warning Score 2 (NEWS2) (Table 1). However, CPR duration and HR on arrival were the potential predictors of survival as per the CART method, and the patients were divided into three groups as follows (Figure 1).

Group 1: Patients with prolonged CPR (>5 minutes) ($n = 4$)

Group 2: Patients with short CPR (≤ 5 minutes) and HR of ≤ 110 b/minute ($n = 8$)

Group 3: Patients with short CPR (≤ 5 minutes) and HR of >110 b/minute ($n = 8$)

The worst survival status was observed in the first group (patients with CPR duration >5 min) with a mortality rate of 100% (4/4), followed by the second group with a mortality rate of 75% (6/8). Group 3 patients had the best survival rate, with a mortality rate of 25% (2/8) (Table 2). Statistically significant results were observed between Groups 1 and 3 ($p = 0.002$) and between Groups 2 and 3 ($p = 0.011$), and the hazard ratio of longer CPR (>5 minutes) was 12 ($p = 0.027$).

The average length of stay in the ED for all patients with cardiac arrest was 2 hours and 28 minutes. The average length of time before cardiac arrest was 31 minutes among survivors versus 66 minutes among nonsurvivors. The average MEWS in all patients was 7, and the NEWS2 score was 9.

Discussion

Cardiac arrest in the ED has a higher survival rate than cardiac arrest occurring in other hospital areas and OHCA, with a survival rate ranging from 22.2% to 48.1% [6,9–11]. Although not thoroughly studied, there are many reasons that these differences could be attributed to, such as early access to the chain of survival in the ED [2]. A study conducted by Kayser [6] compared cardiac arrests in the ED with arrests occurring elsewhere in the hospital, and the better outcomes seen with cardiac arrests in the ED were attributed to the high prevalence of VF, shorter time to defibrillation, and shorter time to invasive airway. In addition, on the contrary to inpatient

staff, ED staff perform resuscitation more often and have an Emergency Physician (EP) available all the time [6]. A study performed in Singapore collected data retrospectively on the cardiac arrests occurring in the ED for 32 consecutive months. They had a total of 106 patients, 43.4% had a presumed cardiac diagnosis, 48.1% of the patients survived to hospital discharge, and there were no preventable causes identified in the study [1]. Another study performed in the United States examined more than 60 thousand patients who had cardiac arrest in

Table 1. Predictors of survival among cardiac arrest patients.

Predictors of survival	HR	95% CI	p-value
Age	1.00	(0.97, 1.02)	(0.687)
Male	0.73	(0.23, 2.28)	(0.583)
HR			
SBP	0.99	(0.98, 1.01)	(0.380)
DBP	0.99	(0.97, 1.01)	(0.368)
Continuous	0.99	(0.97, 1.01)	(0.364)
≥ 70	0.51	(0.16, 1.6)	(0.245)
O2			
Continuous	1.03	(0.97, 1.1)	(0.354)
≥ 90	1.81	(0.4, 8.26)	(0.445)
MEWS	1.01	(0.84, 1.21)	(0.949)
NEWS2	1.01	(0.87, 1.18)	(0.855)
Duration of CPR			
>5 minutes	2.96	(0.86, 10.18)	(0.086)
HR			
Continuous	1.00	(0.98, 1.01)	(0.525)
≤ 110 b/minute	2.82	(0.82, 9.72)	(0.100)
CART groups			
< 5 minutes and >110 b/minute	Ref		
>5 minutes	12.00	(1.33, 108.33)	(0.027)
< 5 minutes and ≤ 110 b/minute	8.00	(0.96, 66.73)	(0.055)

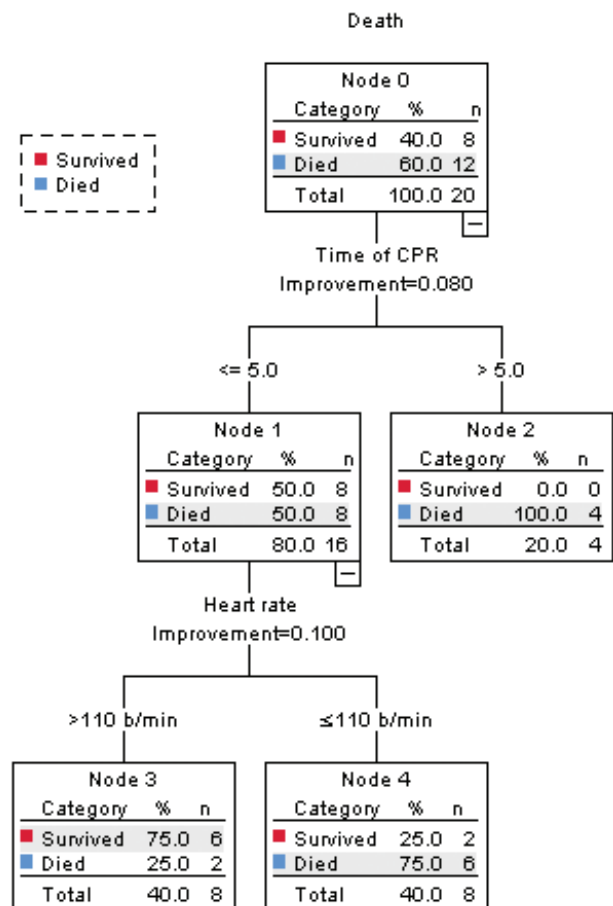


Figure 1. Classification and regression trees (CART) algorithm grouped cardiac arrest patients into three groups according to their survival status.

Table 2. Mortality rates and survival time among the CART-created groups.

CART-created groups	Estimate	95% CI
Mortality rate (%)		
>5 minutes	100%	(40%, 100%)
<5 minutes and ≤ 110 b/minute	75%	(35%, 97%)
<5 minutes and >110 b/minute	25%	(3%, 65%)
Whole sample	60%	(36%, 81%)
Survival time (days)		
>5 minutes	0.5	(<1, 1.1)
≤ 5 minutes and ≤ 110 b/minute	15.4	(<1, 33.2)
≤ 5 minutes and >110 b/minute	449.3	(293, 605.6)
Whole sample	231.3	(107.5, 355.1)

the hospital and compared survival outcomes between ED, intensive care unit (ICU), telemetry, and general floors [6]. ED cardiac arrests had higher survival to discharge rates (22.2%) compared to ICU (15.5%), telemetry (19.8%), and general floors (10.8%) [6]. In this study, the survival rate was 40%, which is concordant with the best reported survival outcome from previous studies.

The most common presenting symptom in the patient sample was altered mental status in 40% (8/20) of the patients, and the most common likely etiology of arrest was cardiac etiology in 35% (7/20) of the patients, which is consistent with previous studies that reported cardiac-related causes such as myocardial infarction and heart failure as their most common etiology of arrest [6,9]. Another cardiac arrest etiology in the sample was septic shock in 30% (6/20), trauma-related and pulmonary embolism, each at 10% (2/20), and intoxication in 5% (1/20) of the patients. In the ED, we have a sepsis triage recognition tool that identifies potential sepsis that then triggers detailed sepsis assessment and management. Perhaps, community education about sepsis signs and symptoms and when to seek care is needed to prevent patients from presenting late.

In studies examining cardiac arrest in EDs, an initial shockable rhythm has been associated with better survival outcome [8,9,11]. We had only one patient with an initial shockable rhythm; hence, we cannot draw any conclusions in this regard. Reflecting on the fact that we have a 40% survival rate in the non-shockable rhythm population raises the possibility of patients having pseudo-PEA rather than true PEA, which could be detected by point-of-care ultrasound (POCUS) and not by pulse check [12]. This is a state of profound shock, where there is no palpable pulse with echocardiographic motion [13]. These patients may benefit from push dose vasopressors and direct interventions to manage shock rather than CPR [13,14]. Most of the physicians are trained to perform POCUS; however, not all of them have integrated POCUS shock assessment into their practice.

We noted that we had a high peri-intubation arrest rate at 45% (9/20) of the patients, whereas previous studies of peri-intubation cardiac arrest in EDs reported the rates of 4%-31% (3) [15]. Peri-intubation arrest is defined as cardiac arrest that occurs within 60 minutes of airway management [16–18]. In this study, only one-third (3/9) of those with peri-intubation arrest survived to hospital discharge. These findings highlight the risks associated with emergency airway management in general and the need to analyze the root cause of peri-intubation arrests in the ED and develop strategies to reduce it.

It has been well reported in the literature that a lower duration of CPR contributes to a better survival rate [9,19]. In this study, the patients with short CPR (≤ 5 min) and HR of >110 b/min had a survival rate of 75% (6/8). None of the previous studies that examined cardiac arrests in EDs commented on the HR at triage and its association with survival if the patient developed

cardiac arrest in the ED. However, we can hypothesize that patients with a higher HR at triage had a better physiologic response to their illness or were in early compensated shock and, therefore, had a more favorable survival outcome.

The length of stay in the ED of 12 hours or more has been associated with increased mortality [20]. In this study, the average length of stay in the ED for all patients with cardiac arrest was 2 hours and 28 minutes. The average length of time between arrival to ED and cardiac arrest was 31 minutes among survivors versus 66 minutes among nonsurvivors. One hypothesis can be that those who spent more time in the ED pre-arrest had already received extensive resuscitation and arrested despite resuscitation efforts; hence, their post-arrest outcome was poor, whereas those arresting shortly after arrival still had room for resuscitation or were at the organ reversibility stage.

The Modified Early Warning Score (MEWS) is used as a tool for the early recognition of subtle changes in the patient's condition, and a high MEWS is believed to be associated with clinically relevant events and may lead to a decrease in the number of cardiac arrests if instability is recognized and intervention is performed early [21]. The patients' average MEWS was 7, and hence, the level where the EPs will be alerted to reassess the patient. On the contrary, the patients' average NEWS2 score was 9, which is considered a high score (more than 7) and requires immediate clinical assessment by the EP [22]. When looking at whether MEWS or NEWS2 scores in the patient population predicted survival, we found no significant difference.

Limitations

A key limitation of this study is the small sample size. The studies performed on cardiac arrests in the ED are limited worldwide, and this is the first one in the United Arab Emirates. Therefore, the results are of value to the center, other EDs in the UAE, and the region. Another limitation is that 10% (2/20) of the study patient population had traumatic cardiac arrests. The etiology and management of traumatic cardiac arrest are different from medical cardiac arrest; however, since they are only two cases, with one survival, it likely did not affect the total result analysis.

Conclusion

Cardiac arrests occurring in the ED are associated with better outcomes than OHCA. A CPR duration of less than 5 minutes coupled with a presenting HR of >110 b/minute might be a predictor of survival. Larger database analyses of cardiac arrest in EDs are needed to validate this finding.

List of Abbreviations

CPR	Cardiopulmonary resuscitation
DBP	Diastolic blood pressure
ECG	Electrocardiogram
ED	Emergency department
MEWS	Modified Early Warning Score

NEWS2	National Early Warning Score 2
OHCA	Out-of-hospital cardiac arrest
PEA	Pulseless electrical activity
POCUS	Point-of-care ultrasound
ROSC	Return of spontaneous circulation
SBP	Systolic blood pressure
STEMI	ST-elevation myocardial infarction
VF	Ventricular fibrillation

Conflicts of interest

The authors declare that there is no conflict of interest regarding the publication of this article.

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Consent for publication

Not applicable.

Ethical approval

Given the retrospective/observational design of the study, ethics approval is not required in the institution.

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