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Out of hospital cardiac arrest - new insights and a call for a worldwide registry and guidelines

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Abstract

Introduction Out of hospital cardiac arrest (OHCA) is a major public health problem with substantial mortality rates worldwide. Genetic diseases and primary electrical disorders are the most common etiologies at younger ages, while ischemic heart disease and cardiomyopathies are common causes at older ages. Despite improvement in prevention and treatment in recent years, OHCA is still a major cause of cardiovascular death.

Method We report prospective data regarding etiology, characteristics, clinical course, and outcomes of patients with OHCA who were admitted to a tertiary care center intensive cardiac care unit (ICCU) between 2020–2023.

Results A total of 92 patients admitted after OHCA were included in the cohort. Mean age was 63.8 ± 13.8 years and 75 (82%) were males. The most common etiology of OHCA was acute coronary syndrome (ACS) in 54 (59%) patients, of whom 46 (85%) patients had ST elevation myocardial infarction and 8 (15%) had non-ST elevation myocardial infarction. During hospitalization, 42 (46%) patients underwent targeted temperature management and 13 (14%) received mechanical circulatory support. Interestingly, 77 (84%) patients underwent coronary angiography, while only 51 (55%) received percutaneous coronary intervention (PCI). Neurologic status was favorable in 49 (53%) patients with Cerebral Performance Category score of 1–2. Overall, mortality rates were relatively low, with 15 (16%) in-hospital deaths and 24 (26%) deaths at 30-day follow-up.

Conclusion Although ACS was the most common etiology for OHCA, only 55% of patients underwent PCI. Most OHCA patients admitted to the ICCU survived hospitalization and were discharged. Increased awareness, public education, worldwide registries, and specific evidence-based guidelines for the treatment of OHCA patients may lead to improved outcomes for these patients who often carry poor prognoses.

Keywords Cardiac arrest, Acute coronary syndrome, Cardiac intensive care unit, Outcomes

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Introduction

Out of hospital cardiac arrest (OHCA) is a major public health problem accounting for a substantial number of deaths worldwide [1, 2]. Patients who survive cardiac arrest with return of spontaneous circulation (ROSC), have high rates of death and neurological impairment during hospitalization [3]. The survival rate after OHCA remains low, ranging between 8–10% in the United States [4] and Europe [5], with lower rates in the Middle East, ranging between 2–10% [6–8].

The etiology of cardiac arrest historically was classified as medical (cardiac, respiratory, anaphylaxis, GI bleed, unknown) versus non-medical (traumatic, drug overdose, asphyxia, drowning etc.) [9]. Interestingly, a recent study investigating the etiology of cardiac arrest demonstrated that only 26% of total cardiac arrest cases were secondary to cardiac causes, and only around half of those cases were secondary to acute coronary syndrome (ACS) [10].

Despite a variety of advanced management strategies, the survival rates following OHCA have not changed substantially in the last three decades [2]. Studies looking at early versus late coronary angiography in cardiac arrest survivors without ST segment elevation on initial ECG did not show any benefit for the early angiography approach [11–13]. Similarly, targeting a higher mean arterial pressure (MAP) goal (85–100 mmHg) during the first 36 h in patients after OHCA did not show any improvement in the extent of anoxic brain damage or neurological outcome [14]. In contrary to previous practice, a recent study investigating a more selected population of cardiac arrest patients with presumed cardiac causes, targeted hypothermia strategy (33 °C) compared with targeted normothermia strategy (≤ 37.8 °C) did not show any benefit for neurologic outcomes [15].

Several markers of shock, including hypotension, elevated blood lactate levels, and vasopressor dependence, are observed in majority of patients after OHCA and are consistently associated with adverse outcomes and increased mortality [16, 17].

The aim of the current study was to describe the etiology, characteristics, clinical course, and outcomes of a current era population with OHCA admitted to a contemporary tertiary care center cardiac intensive care unit (ICCU).

Methods

We prospectively collected data of patients admitted with a diagnosis of OHCA during January 1, 2020—April 30, 2023. Shaare Zedek Medical Center (SZMC) is a large university hospital located in Jerusalem, Israel. SZMC has approximately 1000 hospital beds providing medical care to a population of more than 1 million residents of Jerusalem and its surroundings that include a wide variety of ethnicities and socioeconomic backgrounds.

Data collection

Demographic data, presenting symptoms, comorbid conditions, and physical examination were systematically recorded, as well as laboratory and imaging data. Chronic cardiomyopathy was identified according to previous diagnoses reported in medical records of each patient.

Study outcomes

Primary outcomes were in-hospital and 30-day mortality rates. Secondary outcomes were Cerebral Performance Category (CPC), that was assessed at the time of patient discharge from ICCU or death. The CPC is a 5-point scale ranging from 1 (good cerebral performance) to 5 (dead), it is commonly dichotomized into "good" (CPC 1–2) versus "poor" (CPC 3–5) neurological outcome [9]. The etiology of cardiac arrest was finalized by the ICCU director in each case after collecting and incorporating all the diagnostic data available. OHCA patients in our ICCU were treated and managed by expert critical care cardiologists according to the most recent critical care management recommendations, including temperature management, vasopressor and inotrope use, mechanical ventilation, mechanical circulatory support, etc.

The local Institutional Review Board (IRB) approved the study based on strict maintenance of participants' anonymity by de-identification during database analysis. Informed consent was waived by the IRB. The IRB approval number: 0315–19-SZMC. The authors had no relevant conflicts of interest to declare. No Funding was applied for the study and all methods were performed in accordance with relevant guidelines and regulations.

Statistical analyses

Characteristics were described as numbers and percentages for categorical variables and by means ± standard deviations or median with interquartile ranges for continuous variables. Relations between categorical variables were evaluated by chi-square and Fisher's exact tests. The effect of categorical variables on continuous measurements was tested by student-T and Mann–Whitney tests. The choice of a parametric or nonparametric test depended on the distribution of the continuous variable. All tests were two-sided with $p < 0.05$ considered as statistically significant. Analyses were performed using SPSS Statistics for Windows, Version 25.0. (IBM Corp, Armonk, NY, USA).

Results

Baseline characteristics

During the study period a total of 3871 patients were admitted to the ICCU, 92 (2.4%) of whom were OHCA survivors that were included in the study. Mean age was 63.8 (±13.8) years, and 75 (82%) patients were male. The most common comorbidities were hypertension (57%), hyperlipidemia (45%), active smoking (37%), and diabetes mellitus (26%) (Table 1). Admission rates of OHCA patients out of total ICCU admissions has been increasing annually, with 1.4%, 2%, 2.6% and 5.7% in 2020, 2021, 2022 and 2023 respectively (Fig. 1). The left ventricular ejection fraction (LVEF) on admission was 42%, and mean length of hospitalization was 5.9 days (Table 1). Patients with arrest etiology of ACS had lower LVEF compared to non-ACS patients (41% vs. 45%, $P=0.02$).

Cardiac arrest etiology

The etiologies for OHCA are presented in Fig. 2. The most common etiology was acute coronary syndrome (ACS), found in 54 (59%) patients, with ST elevation myocardial infarction (STEMI) representing 85% of the ACS cases. The second most common admission diagnosis was cardiomyopathy, found in 22 (24%) patients. The majority (91%) of these patients had chronic cardiomyopathy, which included ischemic, non-ischemic, and hypertrophic etiologies (Table 1). An additional 15 (16%) patients had an unclear etiology of their cardiac arrest, of whom 8 had a cardiac arrest without a shockable rhythm, 5 patients had presumed infectious or respiratory etiology, and 3 patients died soon after admission to the ICCU without a clear etiology for their death. Of the remaining 7 patients who had cardiac arrest with a shockable rhythm, one patient was suspected to have Brugada syndrome, (his family did not consent for additional testing due to his anoxic brain injury), 5 patients died soon after admission to the ICCU without a clear etiology for the arrest, and the last patient had a non-specific finding of late gadolinium enhancement of both papillary muscles on a cardiac MRI. Patients with arrest etiology of ACS had lower rates of cardiomyopathy, atrial fibrillation or flutter, chronic kidney disease and ICD implantation compared to non-ACS group (Table 2).

A shockable rhythm was identified by the emergency medical services (EMS) in 73 (79%) patients, which subsequently required one or more electrical shocks to obtain ROSC. 65 (71%) patients in our study had cardiogenic shock on admission. There were no significant differences in baseline characteristics and comorbidities comparing shockable vs. non-shockable arrest rhythm (Table 3).

Table 1 Baseline characteristics of study population. Data displayed as n (%) for categorical variables and mean ± SD for continuous variables

Demographics	OHCA patients $n=92$ (%)
Age (mean ± SD)	63.8 ± 13.8
Male sex	75 (82%)
BMI (mean ± SD)	27 ± 5.7
Comorbidities	
Hypertension	52 (57%)
Diabetes mellitus	24 (26%)
Hyperlipidemia	41 (45%)
Smoking	34 (37%)
Family history of coronary artery disease	8 (9%)
Coronary artery disease	26 (28%)
Coronary artery bypass grafting	6 (7%)
Stroke/ TIA	12 (13%)
Peripheral artery disease	5 (5%)
Cardiomyopathy	13 (14%)
Pacemaker/ICD	4 (4%)
Atrial fibrillation/Flutter	18 (20%)
Malignancy	10 (11%)
Chronic kidney disease	9 (10%)
Hemodialysis	2 (2%)
COVID	4 (4%)
Admission diagnosis	
ACS	54 (59%)
• STEMI	46 (85%)
• NSTEMI	8 (15%)
Cardiomyopathy	22 (24%)
• Acute (non-ischemic)	
o Myocarditis	1 (4%)
o Stress-induced (Takotsubo)	1 (4%)
• Chronic	
o Ischemic	11 (50%)
o Non-ischemic	7 (32%)
o Hypertrophic	2 (9%)
Cardiogenic shock	65 (71%)
Distributive shock	3 (3%)
Shockable rhythm by EMS	73 (79%)
Admission left ventricular ejection fraction % (mean ± SD)	42.38 ± 10.3

BMI Body mass index, *TIA* Transient ischemic attack, *ICD* Implantable cardioverter defibrillator, *ACS* Acute coronary syndrome, *STEMI* ST segment elevation myocardial infarction, *NSTEMI* Non ST segment elevation myocardial infarction, *EMS* Emergency medical service

Interventions during admission

Coronary angiography was performed in 77 (84%) patients, of whom 44 (57%) underwent primary percutaneous intervention (PCI) (Table 4). The majority of patients required supportive mechanical ventilation

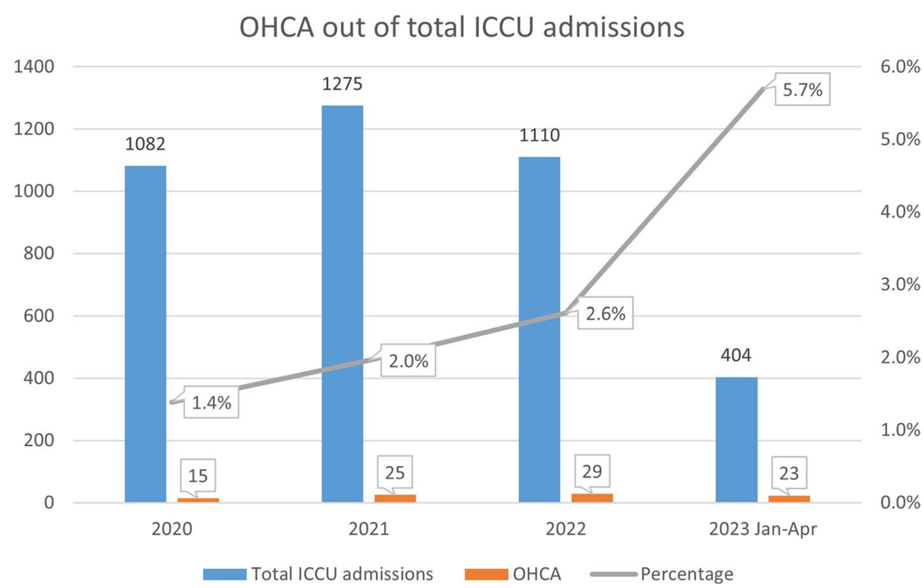

Fig. 1 OHCA patients out of total ICCU admissions by year

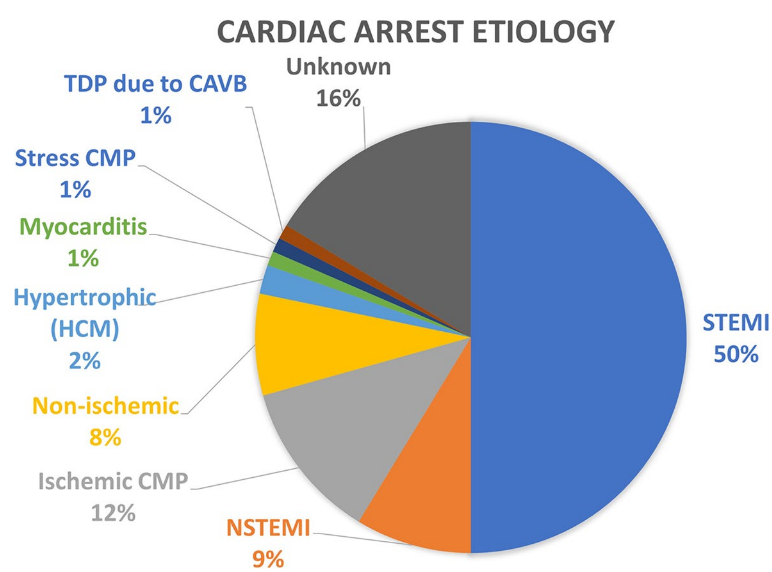

Fig. 2 The variety of etiologies of cardiac arrest

(79%) and were treated with at least one vasopressor (71%). Implantable cardioverter defibrillators were implanted in 22 (24%) patients, mainly in those patients without STEMI as the arrest etiology. Computed Tomography (CT), of the head and/or thorax, was performed in 43 (47%) patients, and Cardiac Magnetic Resonance Imaging (MRI) was performed in 14 (15%) patients to better understand the etiology of the cardiac arrest. Mechanical Circulatory Support (MCS) was required in 13 (14%) patients, 10 of whom received intra-aortic balloon pumps (IABP) (Table 4).

Outcomes

Overall, mortality rates in our study population were relatively low, with 16% in-hospital mortality and 26% 30-day mortality. Neurological status was favorable, 53% of patients were discharged with a CPC score of 1–2. There were no significant differences in in-hospital

Table 2 Patients characteristics according to OHCA etiology. Data displayed as n (%) for categorical variables and mean ± SD for continuous variables

Demographics	Total OHCA patients *n* = 92 (%)	ACS *N* = 54 (59%)	Non-ACS *N* = 38 (41%)	*P* value
Age (mean ± SD)	63.8 ± 13.8	63 ± 13.7	65 ± 15.5	NS
Male sex	75 (82%)	47 (87%)	28 (73%)	NS
BMI (mean ± SD)	27 ± 5.7	27 ± 5.6	27 ± 5.0	NS
Comorbidities				
Hypertension	52 (57%)	28 (52%)	24 (63%)	NS
Diabetes mellitus	24 (26%)	12 (22%)	12 (32%)	NS
Hyperlipidemia	41 (45%)	23 (43%)	18 (47%)	NS
Smoking	34 (37%)	24 (44%)	10 (26%)	NS
Family history of coronary artery disease	8 (9%)	6 (11%)	2 (5%)	NS
Coronary artery disease	26 (28%)	13 (24%)	13 (34%)	NS
Coronary artery bypass grafting	6 (7%)	3 (6%)	3 (8%)	NS
Stroke/TIA	12 (13%)	6 (11%)	6 (16%)	NS
Peripheral artery disease	5 (5%)	3 (6%)	2 (5%)	NS
Cardiomyopathy	14 (14%)	4 (7%)	10 (26%)	***P* = 0.01**
Pacemaker/ICD	4 (4%)	0 (0%)	4 (10%)	***P* = 0.05**
Atrial fibrillation/Flutter	18 (20%)	4 (7%)	14 (37%)	***P* < 0.01**
Malignancy	10 (11%)	4 (7%)	6 (16%)	NS
Chronic kidney disease	9 (10%)	3 (6%)	6 (16%)	***P* = 0.05**

BMI Body mass index, *TIA* Transient ischemic attack, *ICD* Implantable cardioverter defibrillator

Table 3 Patients characteristics according to shockable vs. non-shockable rhythm. Data displayed as n (%) for categorical variables and mean ± SD for continuous variables

Demographics	Total OHCA patients *n* = 92 (%)	Shockable rhythm *n* = 73 (79%)	Non- Shockable rhythm *n* = 19 (21%)	*P* value
Age (mean ± SD)	63.8 ± 13.8	64 ± 12.3	65 ± 18.4	NS
Male sex	75 (82%)	61 (84%)	14 (74%)	NS
BMI (mean ± SD)	27 ± 5.7	28 ± 6	25 ± 3.6	NS
Comorbidities				
Hypertension	52 (57%)	40 (54%)	12 (63%)	NS
Diabetes mellitus	24 (26%)	16 (22%)	8 (42%)	NS
Hyperlipidemia	41 (45%)	34 (46%)	7 (36%)	NS
Smoking	34 (37%)	29 (40%)	5 (26%)	NS
Family history of coronary artery disease	8 (9%)	7 (11%)	1 (5%)	NS
Coronary artery disease	26 (28%)	20 (27%)	6 (31%)	NS
Coronary artery bypass grafting	6 (7%)	4 (5%)	2 (10%)	NS
Stroke/ TIA	12 (13%)	9 (12%)	3 (16%)	NS
Peripheral artery disease	5 (5%)	3 (4%)	2 (10%)	NS
Cardiomyopathy	14 (14%)	11 (15%)	3 (16%)	NS
Pacemaker/ICD	4 (4%)	3 (4%)	1 (5%)	NS
Atrial fibrillation/Flutter	18 (20%)	13 (18%)	5 (26%)	NS
Malignancy	10 (11%)	8 (11%)	2 (11%)	NS
Chronic kidney disease	9 (10%)	6 (8%)	3 (16%)	NS

BMI Body mass index, *TIA* Transient ischemic attack, *ICD* Implantable cardioverter defibrillator

Table 4 Procedures, Interventions, Complications, and Outcomes during ICCU Hospitalization. Data displayed as n (%) for categorical variables and mean ± SD for continuous variables

Procedures & interventions	OHCA patients (*n* = 92)
Coronary angiography without PCI	26 (28%)
PCI	7 (8%)
Primary percutaneous coronary intervention	44 (48%)
Coronary artery bypass grafting	1 (1%)
Implantable cardioverter defibrillator	22 (24%)
Cardiopulmonary resuscitation	25 (27%)
DC cardioversion	14 (15%)
Mechanical ventilation	73 (79%)
Tracheostomy	14 (15%)
Arterial line	80 (87%)
Vasopressors	65 (71%)
Intra-aortic balloon pump	10 (11%)
Impella	1 (1%)
Extracorporeal membrane oxygenation	2 (2%)
Targeted temperature management	42 (46%)
Transesophageal echocardiography	5 (5%)
Computed tomography	43 (47%)
Cardiac MRI	14 (15%)
Complications in ICCU	OHCA patients (*n* = 92)
Malignant arrhythmia	10 (11%)
Distributive shock	13 (14%)
Acute renal failure	11 (12%)
Blood transfusion	8 (9%)
Left ventricular thrombus	1 (1%)
Outcomes	
ICCU length of stay (days)	5.9 ± 5.0
Cerebral Performance Category (CPC)	2.73 ± 1.7
• CPC 1–2	49 (53%)
• CPC 3–5	43 (47%)
ICCU mortality in the first 24 h	10 (11%)
ICCU mortality	15 (16%)
30-day mortality	24 (26%)

ICCU Intensive cardiac care unit, *PCI* Percutaneous coronary angiography, *DC* Direct current, *MRI* Magnetic resonance imaging

mortality between patients with the arrest etiology of ACS vs. non-ACS ($P = 0.48$) and between shockable vs. non-shockable rhythm ($P = 0.94$) on admission. Similarly, there was no significant difference in 30-day mortality between patients with the arrest etiology of ACS vs. non-ACS ($P = 0.31$) and between shockable vs. non-shockable rhythm ($P = 0.23$) on admission.

Discussion

Our current report includes a prospective cohort of patients admitted to a large tertiary medical center ICCU after surviving OHCA. The majority of our cohort were males of relatively young age, with a higher prevalence of cardiac risk factors compared to the general population. Overall, the short-term outcomes of our cohort were favorable, with the majority of patients surviving hospitalization, most of whom were discharged with good neurological status. Interestingly, despite being cardiac enriched cohort with only 16% in-house mortality, only about half (53%) had a truly favorable neurologic outcome. This has a meaningful implication for our patients. While we may track mortality as a very important metric of care, patients may view this very differently if only half survive with good neurologic recovery.

During 2020–2023 there was an increase in admission rates of OHCA patients to our ICCU. This may be explained by several possible factors, we have improved our working relationship (including professional education collaborations) with the local EMS, and hence we've got more STEMI and OHCA referrals. Moreover, in the past, the "more complex" patients were referred to general medical ICU whereas nowadays all are referred to us (with the exception of patients who need ECMO support). Finally, the COVID-19 pandemic might also play a role in the increase admission rates of OHCA survivors (although this is yet only a speculation).

As expected, the most common ICCU admission diagnosis and etiology of OHCA was ACS, followed by ischemic and non-ischemic cardiomyopathies. A significant number of patients in our cohort (16%) did not have clearly identified etiologies of OHCA (Fig. 2).

The vast majority of our cohort (84%) were presumed to have coronary artery disease as a trigger of cardiac arrest that required coronary angiography. The high number [77] of angiographies was due to suspected ACS as the arrest etiology soon after the admission. The diagnosis of ACS as arrest etiology was eventually made in 54 patients and out of them 44 patients underwent PPCI + 7 patients underwent PCI (after awakening) + 1 patient who was sent for CABG. Hence, 52 (56%) patients in total had revascularization (44/46 of STEMI patients underwent PPCI). Several recent studies investigating the etiologies of cardiac arrest had similar findings. Holmström et al. looked at coronary artery autopsies of patients who died after cardiac arrest from presumed acute coronary syndrome. They have found that only 48% of patients had an acute plaque abnormality causing coronary obstruction [18]. An additional study by Spirito et al. looked at OHCA patients secondary to NSTEMI. Interestingly, only up to 25% of their cohort, regardless of the hemodynamic status after ROSC, had an acute coronary lesion identified by coronary angiography [19]. Our findings are similar to these prior studies, which reaffirm that only approximately half of patients surviving OHCA were shown to have significant coronary artery disease.

It is important to note that 41% of patients in our cohort were not presumed to have OHCA secondary to ACS (Fig. 2). Out of the ACS patients, 86% had a cardiac cause not related to ACS. Interestingly 16% of patients had an unclear cause of cardiac arrest, despite presenting with shockable rhythm. In this group of patients with unclear arrest etiology we have utilized cardiac MRI which has assisted in arrest etiology clarification. These findings highlight significant knowledge gaps that remain, particularly in identifying the etiology of OHCA soon after attaining ROSC.

There is currently a wide diversity of management strategies for these complex patients. A recent study compared the admission of OHCA patients to cardiac arrest centers versus the geographically closest emergency departments, and there was no survival difference at 30 days [20]. Smaller hospitals and non-cardiac arrest centers will continue admitting and treating these complex patients, which further highlights the need for standardized universal guidelines for management of OHCA patients [20]. Universal evidence-based OHCA guidelines could assist in decision making during the initial post-resuscitation period [21], addressing common questions that could include whether or not to proceed with therapeutic and diagnostic procedures (a head CT, active temperature management, or whether all of these patients require coronary angiography).

Limitations

Our study has several limitations. This is a single center cohort with a selection bias due to a highly selected population eligible for ICCU admission. There was no standardized decision-making approach regarding imaging modalities utilized during the study period. The decision to proceed to coronary angiography after ROSC was based on the treating physician's clinical suspicion. We do not have any data regarding OHCA patients who did not arrive to hospital or were admitted to other units. This is a small sample size with lacking data regarding the pre-hospital arrest details which may influence the outcomes (down time, CPR length, etc.). The diagnosis of cardiogenic shock was made according to well-known clinical and laboratory parameters including cold extremities, low blood pressure, low urine output and elevated blood lactate levels. All those abnormalities may have an alternative explanation making the certainty of CS diagnosis a bit challenging: blood pressure may have been low due to sedative medications and/or mechanical ventilation. The drop in urine output and elevated serum lactate levels may be secondary to the initial insult of cardiac arrest. The time period of our cohort was during the COVID 19 pandemic, which may alter the outcomes of OHCA patients. The increased rate of OHCA admissions during the first 4 months of 2023 could be partially due to higher admission rates during the winter period.

Conclusion

OHCA survivors who arrive to our ICCU have overall favorable short-term clinical outcomes. The most common etiology was ACS, though many did not have ACS, and our ability to predict which patients had ACS was not optimal. We suggest the need for a national and/or regional registry of OHCA patients, as well as the development of specific evidence-based guidelines for these patients to assist physicians to better understand and manage these critically ill patients.

Authors' contributions

MT: Conceptualization, Investigation, Methodology, Formal Analysis, Writing—original draft, Writing—review & editing. NP: Conceptualization, Investigation, Writing—review & editing. LT: Conceptualization, Investigation, Writing—review & editing. IA: Investigation, Methodology, Writing—review & editing. RH: Investigation, Methodology, Writing—review & editing. TM: Investigation, Methodology, Writing—review & editing. MM: Investigation, Methodology, Writing—review & editing. MK: Investigation, Methodology, Writing—review & editing. NZ: Investigation, Methodology, Writing—review & editing. NL: Investigation, Methodology, Writing—review & editing. MS: Investigation, Methodology, Writing—review & editing. DM: Investigation, Methodology, Writing—review & editing. DG: Investigation, Methodology, Writing—review & editing. AJ: Investigation, Methodology, Writing—review & editing. M. Shuvy: Investigation, Writing—review & editing. EA: Conceptualization, Data Curation, Investigation, Methodology, Writing—original draft, Writing—review & editing.

All authors have read and approved the final version of the manuscript.

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Availability of data and materials

In order to protect the supporting data of this manuscript it will not be available publicly. Data may be provided by the author on a request bases.

Declarations

Ethics approval and consent to participate

The local Institutional Review Board (IRB), Helsinki committee of Shaare Zedek Medical Center, (approval number: 0315–19-SZMC) approved the study based on strict maintenance of participants' anonymity by de-identification during database analysis. Informed consent was waived by the local IRB.

Consent for publication

Not applicable.

Competing interests

The authors declare no competing interests.

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