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Prospective, multicenter, Turkish out-of-hospital cardiac arrest study: TROHCA

Alp Şener[1,2]*, Murat Pekdemir[3], Mehmet Muzaffer İslam[4], Ersin Aksay[5], Sevilay Karahan[6], Gokhan Aksel[4], Nurettin Özgür Doğan[3], Berkant Öztürk[7], Muhammet Hacımustafaoğlu[7], Çağrı Türkücü[7], Serkan Emre Eroğlu[4], Yusuf Yürümez[8], Nuray Aslan[8], Necip Gokhan Güner[8], Neşe Nur User[9], Hüseyin Aldemir[9], Abdullah Sadik Girişgin[10], Sedat Koçak[10], Sami Ataman[10], Ayhan Özhasenekler[1,2], Gul Pamukçu Günaydın[1,2], Mustafa Burak Sayhan[11], Ömer Salt[11], Satuk Bugra Han Bozatlı[11], Engin Deniz Arslan[12], Fevzi Yılmaz[12], Ramazan Sivil[12], Özlem Köksal[13], Vahide Aslıhan Durak[13], Fatma Özdemir[13], Mahmut Taş[14], Yenal Karakoç[14], Öner Avınca[14], Yunus Emre Arık[15], Adem Melekoğlu[15], Özgür Çevrim[15], Özlem Yiğit[16], Cem Oktay[16], Süleyman İbze[16], Salim Satar[17], Muge Gülen[17], Selen Acehan[17], Erhan Altunbaş[18], Melis Efeoğlu Saçak[18], Emir Ünal[18], Erdem Çevik[19], Dilay Satılmış[19], Hande Asan[19], Yunus Karaca[20], Melih İmamoğlu[20], Vildan Özer[20], Ahmet Demircan[21], Ayfer Keleş[21], Gültekin Kadı[21], Orhan Delice[22], Sibel Güçlü Utlu[22], Senol Arslan[22], Neslihan Yücel[23], Şükrü Gürbüz[23], Hüseyin Burak Ayhan[23], Abdullah Şen[24], Mahmut Yaman[24], Müge Günalp[25], Sinan Genç[25], Ahmet Baydın[26], Fatih Çalışkan[26], Şeyma Arzu Temür[26], Murat Ersel[27], Sercan Yalçınlı[27], Enver Özçete[27], Bulent Erbil[28], Elif Ozturk Ince[28], Mehmet Ali Karaca[28], Murat Çetin[29], Mehmet Demirbağ[30], Mustafa Sabak[31], Mustafa Bozkurt[31]

[1]Department of Emergency Medicine, Ankara Bilkent City Hospital, Ankara, Türkiye, [2]Department of Emergency Medicine, Ankara Yıldırım Beyazıt University, Faculty of Medicine, Ankara, Türkiye, [3]Department of Emergency Medicine, Kocaeli University, Faculty of Medicine, Kocaeli, Türkiye, [4]University of Health Sciences, Umraniye Training and Research Hospital, İstanbul, Türkiye, [5]Department of Emergency Medicine, İzmir Ekonomi University, Medical Point Hospital, Izmir, Türkiye, [6]Department of Biostatistics, Hacettepe University, Faculty of Medicine, Ankara, Türkiye, [7]Department of Emergency Medicine, Aksaray University, Aksaray Training and Research Hospital, Aksaray, Türkiye, [8]Department of Emergency Medicine, Sakarya University, Faculty of Medicine, Sakarya, Türkiye, [9]Department of Emergency Medicine, Afyonkarahisar Health Sciences University, Afyonkarahisar, Türkiye, [10]Department of Emergency Medicine, Necmettin Erbakan University, Faculty of Medicine, Konya, Türkiye, [11]Department of Emergency Medicine, Trakya University, Faculty of Medicine, Edirne, Türkiye, [12]Department of Emergency Medicine, University of Health Sciences, Antalya Training and Research Hospital, Antalya, Türkiye, [13]Department of Emergency Medicine, Bursa Uludağ University, Faculty of Medicine, Bursa, Türkiye, [14]Department of Emergency Medicine, University of Health Sciences, Gazi Yaşargil Training and Research Hospital, Diyarbakır, Türkiye, [15]Department of Emergency Medicine, University of Health Sciences, İstanbul Şişli Hamidiye Etfal Training and Research Hospital, İstanbul, Türkiye, [16]Department of Emergency Medicine, Akdeniz University, Faculty of Medicine, Antalya, Türkiye, [17]Department of Emergency Medicine, University of Health Sciences, Adana City Training and Research Hospital, Adana, Türkiye, [18]Department of Emergency Medicine, Marmara University Pendik Training and Research Hospital, İstanbul, Türkiye, [19]Department of Emergency Medicine, University of Health Sciences, Sultan 2.Abdülhamid Han Training and Research Hospital, İstanbul, Türkiye, [20]Department of Emergency Medicine, Karadeniz Technical University, Faculty of Medicine, Trabzon, Türkiye, [21]Department of Emergency Medicine, Gazi University, Faculty of Medicine, Ankara, Türkiye, [22]Department of Emergency Medicine, Erzurum City Hospital, Erzurum, Türkiye, [23]Department of Emergency Medicine, İnönü University, Turgut Özal Medical Center, Malatya, Türkiye, [24]Department of Emergency Medicine, Dicle University, Faculty of Medicine, Diyarbakır, Türkiye, [25]Department of Emergency Medicine, Ankara University, Faculty of Medicine, Ankara, Türkiye, [26]Department of Emergency Medicine, Ondokuz Mayis University, Faculty of Medicine, Samsun, Türkiye, [27]Department of Emergency

ORCID:
AŞ: 0000-0002-0583-2936
MP: 0000-0002-3917-0192
MMİ: 0000-0001-6928-2307
EA: 0000-0002-3249-2420
SK: 0000-0002-8692-7266
GA: 0000-0002-5580-3201
NÖD: 0000-0002-5209-8076
BÖ: 0000-0002-6645-7287
MH: 0000-0001-6368-6853
ÇT: 0009-0001-5534-5781
SEE: 0000-0002-3183-3713
YY: 0000-0003-3917-9434
NA: 0000-0001-8059-4862
NGG: 0000-0001-5052-9242
NNU: 0000-0003-3509-3254
HA: 0000-0002-8396-4854
ASG: 0000-0003-2669-0532
SK: 0000-0001-8265-9615
SA: 0000-0002-2197-4715
AÖ: 0000-0002-2707-4099
GPG: 0000-0001-8531-4591
MBS: 0000-0001-9335-9001
ÖS: 0000-0002-5557-6627
SBHB: 0000-0002-7695-9969

Address for correspondence:
Dr. Alp Şener, Department of Emergency Medicine, Faculty of Medicine, Ankara Bilkent City Hospital, Ankara Yıldırım Beyazıt University, Bilkent, Ankara, Türkiye.
E-mail: alpsener@gmail.com

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EDA: 0000-0002-0155-6903
FY: 0000-0002-3675-7457
RS: 0000-0002-6463-2117
ÖK: 0000-0003-2271-5659
VAD: 0000-0003-0836-7862
FÖ: 0000-0002-4278-1576
MT: 0000-0002-3894-4766
YK: 0000-0003-3607-9286
ÖA: 0000-0003-3109-6773
YEA: 0000-0002-4521-9546
AM: 0000-0002-5764-3678
ÖÇ: 0000-0002-5515-5232
ÖY: 0000-0002-3703-7590
CO: 0000-0001-7993-0566
Sİ: 0000-0002-0927-0029
SS: 0000-0001-6080-4287
MG: 0000-0002-5080-3501
SA: 0000-0003-4390-6593
EA: 0000-0002-5075-739X
MES: 0000-0002-8446-9898
EÜ: 0000-0003-2758-8214
EÇ: 0000-0003-1474-3166
DS: 0000-0003-3765-2208
HA: 0000-0002-6742-302X
YK: 0000-0002-0947-0565
Mİ: 0000-0003-4197-8999
VÖ: 0000-0002-2514-5674
AD: 0000-0002-7993-8098
AK: 0000-0003-4429-3100
GK: 0000-0002-9195-6635
OD: 0000-0003-1629-4245
SGU: 0000-0001-8635-1562
SA: 0000-0002-6636-5307
NY: 0000-0001-5845-2614
ŞG: 0000-0003-2616-0304
HBA: 0000-0002-8876-1378
AŞ: 0000-0001-6705-4079
MY: 0000-0002-0783-1419
MG: 0000-0001-8140-6720
SG: 0000-0002-0516-1028
AB: 0000-0003-4987-0878
FÇ: 0000-0001-7786-3929
ŞAT: 0009-0003-6564-2434
ME: 0000-0003-2282-5559
SY: 0000-0003-1780-8391
EÖ: 0000-0002-1685-2369
BE: 0000-0001-8555-0017
EÖİ: 0000-0002-6396-6668
MAK: 0000-0003-0876-2811
MÇ: 0000-0002-0667-7966
MD: 0000-0002-0475-872X
MS: 0000-0003-2777-2003
MB: 0000-0002-4400-6696

Medicine, Ege University, Faculty of Medicine, İzmir, Türkiye, [28]Department of Emergency Medicine, Hacettepe University, Faculty of Medicine, Ankara, Türkiye, [29]Dr.Behçet Uz Pediatric Diseases and Surgery Training and Research Hospital, Izmir, Türkiye, [30]Department of Emergency Medicine, Manisa Merkezefendi State Hospital, Manisa, Türkiye, [31]Department of Emergency Medicine, Gaziantep University, Şahinbey Research and Practice Hospital, Gaziantep, Türkiye
**Corresponding author*

Abstract:

OBJECTIVES: There is no sufficient data to provide a clear picture of out-of-hospital cardiac arrest (OHCA) across Türkiye. This study is the first to present the prognostic outcomes of OHCA cases and the factors associated with these outcomes.

MATERIALS AND METHODS: The study was conducted in a prospective, observational, multicenter design under the leadership of the Emergency Medicine Association of Turkey Resuscitation Study Group. OHCA cases aged 18 years and over who were admitted to 28 centers from Türkiye were included in the study. Survived event, return of spontaneous circulation (ROSC), survival to hospital discharge, and neurological outcome at discharge were investigated as primary outcomes.

RESULTS: One thousand and three patients were included in the final analysis. 61.1% of the patients were male, and the average age was 67.0 ± 15.2. Cardiopulmonary resuscitation (CPR) was performed on 86.5% of the patients in the prehospital period by emergency medical service, and bystander CPR was performed on only 2.9% by nonhealth-care providers. As a result, the survived event rate was found to be 6.9%. The survival rate upon hospital discharge was 4.4%, with 2.7% of patients achieving a good neurological outcome upon discharge. In addition, the overall ROSC and sustained ROSC rates were 45.2% and 33.4%, respectively. In the multiple logistic regression analysis, male gender, initial shockable rhythm, a shorter prehospital duration of CPR, and the lack of CPR requirement in the emergency department were determined to be independent predictors for the survival to hospital discharge.

CONCLUSION: Compared to global data, survival to hospital discharge and good neurological outcome rates appear to be lower in our study. We conclude that this result is related to low bystander CPR rates. Although not the focus of this study, inadequate postresuscitative care and intensive care support should also be discussed in this regard. It is obvious that this issue should be carefully addressed through political moves in the health and social fields.

Keywords:

Bystander cardiopulmonary resuscitation, cardiopulmonary resuscitation, cardiopulmonary resuscitation, out-of-hospital cardiac arrest, registry, return of spontaneous circulation, survival, survived event, Turkey, Türkiye

Box-ED section

What is already known about the study topic?

- Out-of-hospital cardiac arrest (OHCA) remains a global public health problem. Although there are varying rates, survival rates are far from satisfactory. Türkiye's data on this subject are limited; therefore, a multicenter study was needed.

How is this study structured?

- The study was planned under the supervision of the Emergency Medicine Association of Turkey Resuscitation Study Group for 1-year period with a prospective, observational, multicenter design in OHCA patients aged 18 years and over.

What does this study tell us?

- In this study, the rate of survival to hospital discharge for OHCA was found to be 4.4%; there are similar results in the literature. However, it is thought provoking that bystander cardiopulmonary resuscitation (CPR) was applied only in 2.9% of the patients.

What is the conflict on the issue? Is it important for readers?

- Bystander-initiated CPR is one of the key points of a chain of survival. In our country, where the prehospital system and emergency medicine are well developed, the low rate of hospital discharge of out-of-cardiac arrest victims may be due to the low bystander CPR rate. Therefore, improved policies are needed in the political and health fields to enable the public to early recognize OHCAs and start early bystander-initiated CPR.

Introduction

The overall incidence of out-of-hospital cardiac arrests (OHCAs) where cardiopulmonary resuscitation (CPR) was attempted was 56 per 100,000 population annually.[1] Although it is a frequently discussed issue in the literature, it remains an important public health problem. In particular, the American Heart Association (AHA) carries out regular updates of their recommendations.[2] Even if these guidelines are followed, survival data in OHCA cases are far from satisfactory globally and vary widely. These variations may be related to the design of the studies and the lack of standardization in the definitions used. To improve the results, it is necessary to expand these data, determine strategic goals with newly emerging data, and adapt them to life with the support of health-care and social policies. Assessing each step of the survival chain individually, particularly early recognition of cardiac arrest, prompt activation of emergency medical services (EMS), and enhancing bystander CPR rates, can be regarded as strategic objectives aimed at bolstering the survival rates.[3] It is known that bystander CPR rates are not sufficient worldwide and even this rate is far from expectations in Türkiye.

Data on this subject are limited in Türkiye. Generally, there are retrospective, single-center studies, as well as a few prospective studies with low sample size.[4-6] With these limited data, it is not possible to talk about the generalizability of the data such as survival, return of spontaneous circulation (ROSC), and bystander CPR. It is known that monitoring and keeping arrest records influence survival. With this prospective, multicenter study, we aimed to fill this data gap, shed light on future studies, and guide health policies.

Materials and Methods

Settings

This prospective, observational, multicenter study was planned to be conducted for 1 year (2023) in 30 health centers in Türkiye within the scope of the Emergency Medicine Association of Turkey Resuscitation Study Group. All study centers were third-level emergency department (ED) providing emergency medicine training, and these centers were selected from all 7 geographical regions of Türkiye, and all resuscitation practices are carried out in accordance with the AHA and/or European Resuscitation Council guidelines. Two centers were excluded from the study because data could not be obtained. Ultimately, the study was completed in 28 centers with a total of more than 8 million ED visits annually [Figure 1].

There is generally no specific protocol used for terminating resuscitation, and the decision depends on the physician's initiative. EMS system of Türkiye generally operates on the "load and go" principle. In the field, EMS staff rarely make end-of-life decisions, and the majority of patients are transported to the emergency department (ED). It has been accepted that this principle was followed throughout this study. We should also note that it is still not a legal obligation in Türkiye to install automated external defibrillators (AEDs), especially in all densely crowded places such as malls and bus stations.

Population

Patients who had a cardiac arrest in an out-of-hospital environment, were 18 years of age or older, and had ROSC before admission or were admitted as cardiac

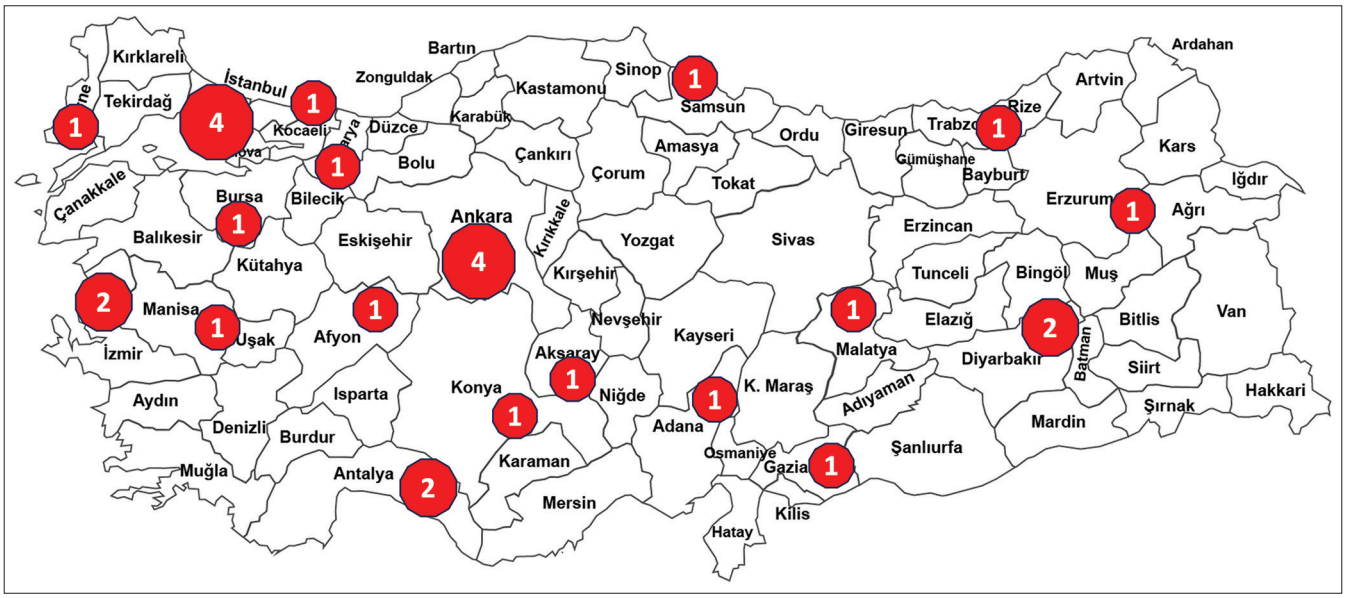

Figure 1: Distribution of the study centers

arrest to the ED were included 24/7 in the study. Informed consent was obtained from all patients/relatives. Patients experiencing traumatic cardiac arrest, those transferred to study centers from other hospitals, defined as deceased prior to admission, whose primary outcome data couldn't be obtained, and whose relatives did not provide consent for their participation in the study, were excluded from the study. According to the sample size calculation, based on the ROSC (24.8%) and survival to hospital discharge (5.6%) rates in the study of Şener *et al*. and assuming a 5% error, a total of at least 837 cases were planned to be included in the study.[6] Upon reaching this sample, the study was terminated on October 15, 2023, before the planned date.

Ethical approval was received from the Kocaeli University Non-Interventional Clinical Research Ethics Committee (No: KÜ GOKAEK-2022/18.24) at the coordinator center on November 10, 2022, and the study was carried out in accordance with the principles of the World Medical Association Declaration of Helsinki.

Data collection

Data obtained from the patients themselves or their relatives and recorded forms in Hospital Information Management Systems were checked and transferred to the online registry form (Google® Forms) by the local coordinator of the relevant center. Afterward, the relevant data were processed by the authorized researchers and directed for statistical analysis.

Definitions and outcomes

The data collection forms were primarily designed based on the Utstein Resuscitation Registry Templates for out-of-hospital cardiac arrest (OHCA), with additional variables incorporated.[7] Obtaining any rhythm with pulse for at least 5 min during resuscitation was defined as ROSC, and persistence of this condition for at least 20 min was defined as sustained ROSC. Patients who were admitted to the ED with a pulse that persisted 20 min or who completed 20 min with a pulse in the ED were defined as a survived event. Patients who were discharged with sustained ROSC were recorded as survival to hospital discharge. Patients who were still in ROSC at day 30 were also recorded as 30-day survival. Cerebral performance category (CPC) was evaluated at discharge and on the 30th day, and according to this scale, categories 1 and 2 were recorded as good neurological outcome and 3 and above were recorded as poor neurological outcome. The hospital parameter as cardiac arrest localization refers to patients who had cardiac arrest at the hospital entrance (parking lot, garden, entrance of the outpatient clinics or triage, etc.) before being delivered to the relevant health-care professional. A cardiac arrest which is seen by other people or is monitored by EMS is defined as witnessed arrest. CPR procedure initiated by witnessed people other than the EMS staff is defined as bystander CPR. The rhythm of the patient detected in the first monitoring was recorded as initial cardiac arrest rhythm, and pulseless ventricular tachycardia and ventricular fibrillation rhythms were recorded as shockable rhythm. The concept of airway procedure was used as the most advanced method performed. The concept of unsuccessful airway procedure refers to a patient who cannot be ventilated in any way. Survived event, ROSC, survival to hospital discharge, and neurological outcome at discharge were investigated as primary outcomes.

Statistical analysis

Statistical analyses of the study were performed with IBM SPSS Statistics for Windows, Version 26.0 (Armonk, NY, USA: IBM Corp). In comparing continuous data between two independent groups, the Mann–Whitney *U*-test or Independent samples *t*-test was used, depending on distribution. Continuous data are expressed as mean with standard deviation or median with interquartile range in accordance with distribution. The comparison of categorical data between independent groups was performed with Pearson's Chi-square and Fisher's exact tests; these data were expressed as sample numbers and percentages. In primary analyses, $P < 0.05$ level was used for statistical significance. Multiple logistic regression analysis was performed for sustained ROSC and discharge, and variables with $P < 0.250$ in univariate analysis but thought to be clinically significant were included in the model. For discharge outcome, "prehospital CPR, arrest cause, prehospital airway management, arrest location, use of magnesium sulfate in the emergency department (ED), and experiencing cardiac arrest again in the ED" were unable to be included in the model due to imbalances in sample counts across groups. Similarly, for sustained ROSC, "prehospital CPR, arrest etiology, prehospital airway management, and CPR administered in the ED" couldn't be included due to group imbalances. As a result, odds ratios were expressed with 95% confidence intervals. Cutoff values of pH variable used in logistic regression analysis were determined by ROC analysis.

Results

A total of 1060 patients were recorded in the data system from 28 centers in Türkiye. After ruling out missing data and samples that did not meet the criteria (such as trauma patients, inhospital arrests, and referrals from other hospitals), 1002 patients were included in the final analysis [Figure 2]. It was determined that 61.1% of the patients were male, the mean age was 67.0 ± 15.2 years, the etiology was acute coronary syndrome in 46.3%, and the localization of cardiac arrest was "home" in 61.3%. Witnessed arrest was detected in 83.9% of patients, transport with EMS in 97.4%, and shockable first arrest rhythm in 10.8%. CPR was performed on 86.5% of the

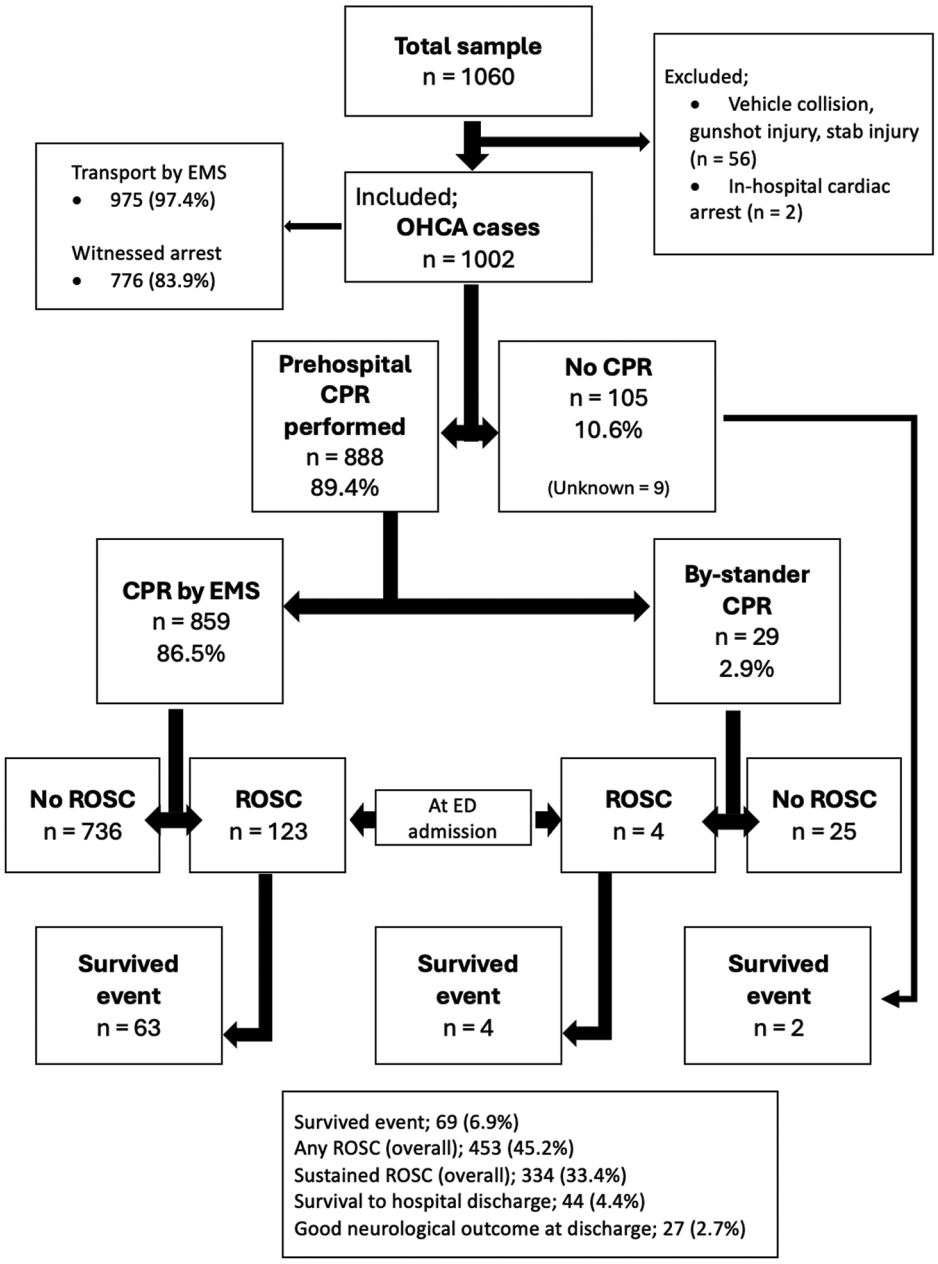

Figure 2: Flow diagram

patients in the prehospital period by EMS personnel, and bystander CPR was performed on only 2.9% by nonhealth-care providers (higher in male gender; 3.8 vs. 1.5). While the prehospital bag-valve-mask rate was 31.7%, successful endotracheal intubation (ETI) was found to be 47.6%. Peripheral intravenous access was presented in 88.4% of the patients, and 11.2% were delivered to the ED without any venous access [Table 1].

Primary outcomes

As a result, while the prehospital ROSC rate was 13.6%, the survived event rate was found to be 6.9% [Table 1]. While the mortality rate in the ED was 72.3%, 4.4% were discharged alive from the hospital and 2.7% were discharged with good neurological outcome. In addition, the ROSC rate for the entire process was determined as 45.2% and the sustained ROSC rate was 33.4%.

Secondary outcomes

In the EDs, mechanical chest compression device was used in 41.5% of patients, $EtCO_2$ monitoring in 30.1%, and ultrasound-guided CPR performed in 52.1% of patients [Table 2]. Primary comparative

Table 1: Demographic characteristics and prehospital descriptive variables

Variables	*n* (%) or mean±SD or median (25%–75%)
Time zone	
Day shift	386 (38.5)
Night shift and holidays	616 (61.5)
Gender	
Female	390 (38.9)
Male	612 (61.1)
Age (year), mean±SD	67.0±15.2
Etiology	
Acute coronary syndrome	464 (46.3)
Electrolyte disorder	51 (5.1)
Pulmonary embolism	43 (4.3)
Asthma	16 (1.6)
Drowning	16 (1.6)
Intoxication	9 (0.9)
Stroke	9 (0.9)
Electrocution	3 (0.3)
Anaphylaxis	2 (0.2)
Postprimary coronary intervention	2 (0.2)
Postbypass	2 (0.2)
Others	140 (14)
Unknown	245 (24.5)
Independent living	721 (77.4)
Chronic neurological disease	168 (17.9)
Chronic pulmonary disease	183 (19.4)
Chronic cardiovascular disease	496 (52.3)
Active malignancy	126 (13.4)
Ventricular assist device	7 (0.7)
ICD (or external cardioverter defibrillator)	24 (2.5)
Cardiac arrest location	
Home	603 (61.3)
Workplace	15 (1.5)
Public area	120 (12.2)
Nursing home	36 (3.7)
Ambulance	148 (15.1)
Hospital	40 (4.1)
Others	21 (2.1)
Witnessed arrest	776 (83.9)
Transport with EMS	975 (97.4)
Instructions from EMS dispatcher	98 (15.5)
Prehospital CPR	
None	105 (10.6)
Health-care provider	859 (86.5)
Bystander CPR	29 (2.9)
Prehospital CPR duration (min)	15 (8–20)
Time (min) from the arrest to the CPR	5 (1–10)
Initial cardiac arrest rhythm	
Asystole	682 (78.1)
PEA	97 (11.1)
VF	85 (9.7)
pVT	9 (1)
Shockable rhythm	
pVT/VF	94 (10.8)
Asystole/PEA	779 (89.2)
Prehospital defibrillation	118 (12.1)
Number of prehospital defibrillations	2 (1–3)
Time (min) from the arrest to the first defibrillation	6.5 (3–12.75)
Prehospital airway procedure	
Not performed	117 (11.7)
BVM	318 (31.7)
ETI - successful	477 (47.6)
Supraglottic	54 (5.4)
Surgical	4 (0.4)
Unsuccessful	32 (3.2)
Prehospital chest compression	888 (89.4)
Prehospital ventilation support	899 (90.8)
Prehospital mechanical CPR device	9 (0.9)
Prehospital venous access	
None	112 (11.2)
Peripheral	886 (88.4)
Intraosseous	2 (0.2)
Central	2 (0.2)
Prehospital vascular access - exists	890 (88.8)
Prehospital epinephrine	741 (76.6)
Prehospital epinephrine dose (mg)	3 (2–5)
Prehospital amiodarone	25 (2.5)
Prehospital lidocaine	1 (0.1)
Prehospital sodium bicarbonate	5 (0.5)
Prehospital calcium	2 (0.2)
Reported by EMS before ED admission	710 (75.3)
Presence of pulse at ED admission - ROSC	136 (13.6)
Pulse duration in ED admission, if exists (min)	
<20	100 (77.5)
≥20	29 (22.5)
Survived event	
No	933 (93.1)
Yes	69 (6.9)

SD: Standard deviation, ICD: Implantable cardioverter-defibrillator, EMS: Emergency medical service, CPR: Cardiopulmonary resuscitation, PEA: Pulseless electrical activity, VF: Ventricular fibrillation, pVT: Pulseless ventricular tachycardia, BVM: Bag-valve mask, ETI: Endotracheal intubation, ED: Emergency department, ROSC: Return of the spontaneous circulation

analyses between the two groups for the outcomes of survived event, overall sustained ROSC, survival to hospital discharge, and discharge with good neurological outcome are provided as supplemental files [Supplementary Tables 1-8]. It has been determined that the survival to hospital discharge rate is higher in male gender and patients with shockable rhythm and is lower, especially in the group of home localization and with mechanical chest compression devices [Supplementary Table 5]. In addition, it has been determined that both survived event, survival and good neurological outcome rates were higher in cases where bystander CPR was performed [Supplementary Tables 1, 5, and 7].

Table 2: Descriptive variables of emergency department period

Variables	*n* (%) or median (25%–75%)
First monitored rhythm at ED	
Asystole	682 (68.3)
PEA	124 (12.4)
VF	75 (7.5)
pVT	4 (0.4)
Pulse exists (any rhythm)	113 (11.3)
Shockable rhythm	
pVT/VF	79 (7.9)
Asystole/PEA	806 (80.8)
Pulse exists (any rhythm)	113 (11.3)
Advanced airway in ED	
Exists at admission	432 (43.1)
BVM	8 (0.8)
ETI	547 (54.6)
Supraglottic	7 (0.7)
Surgical	8 (0.8)
Venous access in ED	
None	1 (0.1)
Peripheral	943 (94.1)
Intraosseous	6 (0.6)
Central	52 (5.2)
Cardiac arrest again in ED	
No	232 (23.3)
Yes	218 (21.9)
No ROSC in ED	547 (54.9)
CPR time (min) to the first ROSC in ED	13 (7.5–20)
CPR in ED	950 (94.8)
Mechanical CPR device in ED	416 (41.5)
Defibrillation in ED	229 (22.9)
Number of defibrillations before first ROSC in ED	2 (1–3)
Total number of defibrillations in ED	3 (1–4)
Epinephrine in ED	941 (93.9)
Epinephrine dose before the first ROSC in ED (mg)	6 (3–10)
Total epinephrine dose in ED (mg)	6 (7–15)
Amiodarone in ED	157 (15.7)
Lidocaine in ED	5 (0.5)
Magnesium sulfate in ED	21 (2.1)
Sodium bicarbonate in ED	251 (25)
Calcium in ED	139 (13.9)
USG use during CPR in ED	522 (52.1)
Cardiac activity detected by USG	172 (33.1)
EtCO2 device use during CPR in ED	302 (30.1)
5th min ETCO2 during CPR (mmHg)	14 (10–21.5)
Last ETCO2 during CPR (mmHg)	14 (8–22)
Highest ETCO2 during CPR (mmHg)	22 (15–34)
Initial pH in ED	6.98 (6.85–7.08)
Initial lactate (mmol/L) in ED	11.80 (8.04–15.40)
Outcome in ED	
Exitus	724 (72.3)
Ward/ICU	212 (21.2)
Transferred to other hospitals	66 (6.6)
Outcome in hospital	
Exitus	958 (95.6)
Discharged	44 (4.4)
Neurological outcome at discharge	
Poor	967 (97.3)
Good	27 (2.7)
30-day survival	
Exitus	951 (94.9)
Survived	51 (5.1)
30-day neurological outcome	
Poor	966 (97.2)
Good	28 (2.8)
ST-segment elevation after ROSC	144 (34.4)
Coronary revascularization after ROSC	100 (23.9)
TTM after ROSC	9 (2.2)
Vasoactive drug after ROSC	271 (65.1)
ECLS after ROSC	1 (0.2)
IABP after ROSC	0
Surgery after ROSC	8 (2.0)
First pH after ROSC	7.05 (6.92–7.22)
First lactate (mmol/L) after ROSC	9.85 (5.59–13.93)
ROSC any (overall)	453 (45.2)
Sustained ROSC (overall)	334 (33.4)
Forensic case report	100 (10.0)

PEA: Pulseless electrical activity, VF: Ventricular fibrillation, pVT: Pulseless ventricular tachycardia, BVM: Bag-valve mask, ETI: Endotracheal intubation, ROSC: Return of the spontaneous circulation, ED: Emergency department, med: median, CPR: Cardiopulmonary resuscitation, min: minute, USG: Ultrasonography, EtCO2: End-tidal carbon dioxide, ICU: Intensive care unit, TTM: Targeted temperature management, ECLS: Extracorporeal Life Support, IABP: Intra-aortic balloon pump

According to regional distribution, the highest bystander CPR rates were found in the Marmara and Aegean regions and the highest survival rates in the Mediterranean and Black Sea regions. The good neurological outcome rate is higher in the Mediterranean region [Supplementary Table 9].

Multiple logistic regression analysis

As a result of multiple regression analyses, male gender (odds ratio [OR]: 2.691; 95% confidence interval [CI]: 1.186–6.103), prehospital initial shockable rhythm (OR: 6.480; 95% CI: 3.055–13.744), a shorter prehospital duration of CPR (OR: 0.919; 95% CI: 0.880–0.961), and the lack of CPR requirement in the ED (OR: 12.038; 95% CI: 5.000–28.984) were found to be positive independent predictors for the survival to hospital discharge [Table 3]. For sustained ROSC, presence of chronic pulmonary disease (OR: 1.677; 95% CI: 1.088–2.585), witnessed arrest (OR: 2.910; 95% CI: 1.588–5.336), arrest localization being hospital (OR: 3.703; 95% CI: 1.310–10.467; reference: home), shorter prehospital CPR duration (OR: 0.954; 95% CI: 0.933–0.975), not using mechanical chest compression device in ED (OR: 2.598; 95% CI: 1.774–3.803), the venous route used in the ED

Table 3: Multiple regression analysis for survival to hospital discharge

Variables	OR	95% CI	*P*
Day shift versus night shift and holidays	1.992	1.013–3.918	0.053
Gender (male vs. female)	2.691	1.186–6.103	0.018
Transport with EMS (EMS vs. not)	0.444	0.113–1.742	0.244
Prehospital initial shockable rhythm versus others	6.480	3.055–13.744	<0.001
Prehospital CPR duration (min)	0.919	0.880–0.961	<0.001
CPR in ED (none vs. performed)	12.038	5.000–28.984	<0.001
Sodium bicarbonate in ED (none vs. performed)	2.590	0.871–7.704	0.087

CI: Confidence interval, EMS: Emergency medical services, CPR: Cardiopulmonary resuscitation, ED: Emergency department, OR: Odds ratio

Table 4: Multiple regression analysis for overall sustained return of the spontaneous circulation

Variables	OR	95% CI	*P*
Chronic pulmonary disease	1.677	1.088–2.585	0.019
Witnessed arrest (yes vs. no)	2.910	1.588–5.336	0.001
Transport with EMS (EMS vs. non-EMS)	0.764	0.263–2.222	0.622
Cardiac arrest location (reference: Home)			
Workplace/public area	0.594	0.335–1.055	0.076
Nursing home	0.853	0.298–2.444	0.767
Ambulance	0.987	0.605–1.609	0.958
Hospital	3.703	1.310–10.467	0.014
Others	0.797	0.266–2.386	0.685
Prehospital CPR duration (min)	0.954	0.933–0.975	<0.001
Shockable rhythm at ED admission (reference: pVT/VF)			
Asystole/PEA	0.517	0.257–1.043	0.066
Pulse exists	2.031	0.840–4.911	0.116
Advanced airway in ED (ref: Exists at admission)			
BVM/supraglottic/surgical	0.151	0.017–1.304	0.086
ETI	0.824	0.555–1.225	0.339
Mechanical CPR device in ED (not performed vs. performed)	2.598	1.774–3.803	<0.001
Defibrillation in ED (performed vs. not)	1.583	0.984–2.547	0.058
Venous access in ED (others vs. peripheral)	2.105	1.051–4.219	0.036
Initial pH during CPR in ED (reference: pH<6.9)			
6.9 ≤ pH < 7.0	2.106	1.257–3.528	0.005
pH ≥ 7.0	3.005	1.941–4.652	<0.001

CI: Confidence interval, EMS: Emergency medical services, CPR: Cardiopulmonary resuscitation, ED: Emergency department, pVT: Pulseless ventricular tachycardia, VF: Ventricular fibrillation, PEA: Pulseless electrical activity, BVM: Bag-valve mask, ETI: Endotracheal intubation

being other than peripheral intravenous route (OR: 2.105; 95% CI: 1.051–4.219), and higher pH levels (for "6.9 ≤ pH < 7.0" OR: 2.106; 95% CI: 1.257–3.528 and for "pH ≥ 7.0" OR: 3.005; 95% CI: 1.941–4.652) were determined as independent predictors [Table 4].

Discussion

This descriptive prospective multicenter study investigated the epidemiology and outcomes of OHCA patients in prehospital and emergency settings across Türkiye and aims to provide a comprehensive overview of this critical patient population. Of the OHCA patients, 453 (45.2%) achieved any ROSC, 334 (33.4%) achieved sustained ROSC, and 278 (27.7%) had survived event, which were the outcomes that primarily pertain to prehospital and emergency medicine department settings. Upon reviewing our findings, it can be concluded that our results closely align with data reported in European and Australian studies. The EuRoCa TWO study, published in 2020, documented that any ROSC was achieved in 32.7% of 25,171 patients who experienced cardiac arrest and received CPR initiated by EMS or bystanders.[1] Similar findings have also been reported (23.8-37.8% for prehospital ROSC) in Australian and New Zealand data published by Beck *et al*.[8]

In a meta-analysis that examines 141 studies and nearly 4.6 million OHCA patients, the rate of sustained ROSC was reported as 29.7%. The authors conducted subgroup analyses by region and observed the highest sustained ROSC rate in Oceania countries (38.6%), followed by Europe (36.7%), and then Asian countries (22.1%).[9] While our sustained ROSC rates may not match those observed in Oceania and Europe, it can be inferred that our results are closely approximated. In the meta-analysis by Yan *et al*., the global incidence of survived event rates among OHCA patients was reported as 22%. Oceanic countries exhibited the highest rate of survived events at 33.5%,

while Asian countries showed the lowest at 15.6%.[9] Comparatively, British and Australian data suggest a survived event rate of 22% and 28%, respectively, while European data indicate a higher survived event rate of 35%.[1,8,10] Upon the examination of prehospital and emergency setting data, Türkiye's outcomes appear to closely align with studies conducted in developed countries.

Upon closer examination of the primary outcome measures, markedly different results stand out compared to those observed in the aforementioned studies. Of the OHCA patients in our study, 44 (4.4%) were discharged from the hospital. We can argue that our results were notably inferior compared to the findings reported in the literature conducted in the developed countries. Yan *et al*. reported a global hospital discharge rate of 8.8% in OHCA patients, which is approximately double the rate observed in our findings. In this meta-analysis, subgroup analyses by region revealed the highest survival to discharge rate in Oceania countries (16.2%) and the lowest in Asian countries (4.5%).[9] The rates of survival to discharge in Australia and New Zealand were reported to be 12.1%, while European countries reported rates of 8% and England 7.2%.[1,8,10] Consequently, our findings closely parallel the outcomes observed in Asian countries regarding survival to hospital discharge.

An intriguing detail worth noting from the EuRoCa TWO study, was a specific subgroup outcome. Among patients brought to the hospital while CPR was ongoing, the survival to hospital discharge rate was notably lower at 4%. All patients who received CPR exhibited an 8% survival to hospital discharge rate, whereas those brought directly to the hospital showed a 26% survival rate, and individuals achieving ROSC in the prehospital setting demonstrated a notably higher rate of 35%.[1] One potential explanation for the low survival-to-hospital discharge rate observed in our data could be the predominance of patients within this subgroup.

2021 data by Kotini-Shah *et al*. indicate that the rate of favorable neurological outcome of OHCA patients in the United States is 8.7%.[11] However, similar to the findings regarding survival to hospital discharge, our study revealed a relatively low rate of favorable neurological outcomes, with only 27 patients (2.7%) demonstrating positive results. We can observe similar rates in Asian countries in this aspect. In the study conducted by Okubo *et al*. in 2014, which analyzed OHCA data from a sizable cohort, the rate of favorable neurological outcomes was reported to be only 2%.[12]

It is interesting to note that while our outcomes that are related to the prehospital and emergency care are notably similar to the literature, our rates of discharge and favorable neurological survival are considerably low. This observation prompts consideration of potential factors influencing these relatively long-term outcomes.

The factors contributing to lower survival rates in Türkiye compared to global data warrant further investigation. While factors such as ED crowding in Türkiye may play a role, the lack of intensive care unit capacity in certain regions, coupling with the need for transfer of the critical patients, may have contributed to the observed poor outcomes. A comprehensive examination of all potential causes is necessary. It is imperative to escalate quality improvement initiatives nationwide to address this issue effectively. While the effectiveness of CPR is pivotal for inpatient discharge and favorable neurological outcomes, its success hinges on the coordination of multiple disciplines and is subject to various confounding factors. In this study, while ROSC rates in EMS and EDs align with global data, the underlying factors contributing to lower rates of live discharges and favorable neurological outcomes warrant investigation. These results suggest the possibility that patients in Türkiye may lack adequate support from intensive care and other multidisciplinary aspects in subsequent stages of treatment. Future studies should conduct detailed analyses to address this issue, and we believe the data presented here can significantly contribute to enhancing CPR success nationwide.

In the EuRoCa TWO study, approximately 58.8% of OHCA patients who received CPR had bystander CPR, leading to significantly higher rates of ROSC and discharge compared to those in whom EMS initiated CPR.[1] Similarly, data from Australia and New Zealand, as reported by Beck *et al*. in 2018, indicated that bystander CPR was administered in 67% of OHCA cases.[8] Despite relatively lower rates in British data, standing at 39.5%, these rates still surpass those observed in our study.[10] The notable discrepancy in bystander CPR rates in our data may be attributed to cultural disparities and variations in CPR awareness levels.[13] Barriers to access to AEDs and the lack of awareness of AED use remain important handicaps in Türkiye. In addition, the absence of Good Samaritan Law rules in Turkey may partially explain the hesitations about performing CPR in cardiac arrest cases.

We identified several independent predictors of survival to hospital discharge in the logistic regression analysis, including male gender, recorded initial shockable rhythm, a shorter prehospital duration of CPR, and the lack of CPR requirement in the ED.

The male gender predominance, which varies between 56% and 65% in the literature, is also evident in this study.[1,11,12] In the study of Kotini-Shah *et al*., it was

observed that better results were obtained in the male gender in terms of survival to hospital discharge and neurological outcome, but in multivariate analysis, the adjusted odds ratios were seen to be in favor of the female gender.[11] On the contrary, we observed better outcomes in male patients; we can attribute these results to the higher rates of bystander CPR in male gender.

The presence of an initial shockable rhythm as an independent predictor of survival to hospital discharge has been observed in various studies in different settings.[14-17] Additionally, in Li *et al*.'s data from Singapore, which shares similar characteristics and settings with our study and demonstrates a survival rate of 3.4%, shockable initial rhythm and shorter prehospital CPR duration were also identified as independent predictors.[14] It is evident that increasing the rate of bystander-initiated CPR can lead to improved outcome rates, highlighting the necessity for a nationwide educational campaign.

The presence of chronic pulmonary disease, witnessed arrest, cardiac arrest occurring at hospital perimeters, brief prehospital CPR duration, absence of mechanical CPR device uses in the ED, utilization of a venous access other than the peripheral intravenous route, and higher pH levels in the first blood gas obtained during CPR were identified as independent predictors of sustained ROSC.

A recent study by Balan *et al*. reported that witnessed cardiac arrest, initial shockable rhythm, and cardiac arrest occurring outside of home were found to be the independent predictors of hospital discharge in 3952 OHCA patients who achieved sustained ROSC.[16] Although our study populations and outcomes may differ, it is noteworthy that we obtained similar results.

The debate regarding whether mechanical or manual chest compressions yield different outcomes in cardiac arrest patients remains a hot topic of current research. Only a single 2015 randomized controlled study reported significant harm of mechanical compression device in OHCA patients in terms of survival with favorable neurological outcome.[18] A 2018 Cochrane review categorized existing studies as of medium-to-low quality and concluded that both methods were not superior to each other except in certain circumstances. It is important to note that this review included evaluations of both inhospital and OHCA patients, with trauma patients excluded.[19] Therefore, our findings may not align precisely with those of the aforementioned review.

We found that the sustained ROSC rate was significantly higher in patients who received prehospital respiratory support, particularly among those who underwent successful ETI before arrival at the hospital. However, the observational design of our study limits our ability to make definitive conclusions based solely on these findings. For instance, the recent AIRWAY-2 study investigated the impact of prehospital ETI and supraglottic airway (SGA) placement on 30-day survival in OHCA patients, finding no significant difference between the two methods.[20]

In our study, we observed a significantly higher rate of sustained ROSC among patients who received epinephrine prior to hospital arrival. This finding aligns with the PARAMEDIC2 study, a large-scale investigation conducted in 2018, which demonstrated higher rates of ROSC, survival to hospital admission, and 30-day survival in OHCA patients treated with prehospital epinephrine administration.[21] Consequently, the use of epinephrine in OHCA patients has gained stronger support, as reflected in the 2023 update of the AHA advanced cardiac life support guidelines.[22]

Limitations

First, it should be noted that significant missing data exist, and consecutive sampling could not be properly implemented. Disruption of the operational functioning of study centers due to the earthquake on February 6, 2023, was a major contributing factor to these missing data. Additionally, two of the study centers had to be excluded from the study due to data unavailability. However, it has not been assessed whether this situation negatively impacts the regional representation of the country. The inclusion of tertiary hospitals in the study may introduce bias when extrapolating the results to the general public and rural ED.

Patients who received CPR outside and were not brought to the study centers were not included in the study; excluding these data also increases the bias factor. Most previous registry studies included only patients transported by EMS.[1,8-10,12] Although the rate of patients transported by non-EMS people is very low (2.6%), the inclusion of this patient group should be taken into consideration when discussing results with previous literature. Since reliable data could not be obtained about the time for prehospital transport, it was not included in the analysis. In most of the patients, the possible etiology of cardiac arrest was estimated by the physician based on the available history. Lack of knowledge about exact no-flow time (for lay person) may have a negative influence on results.

Another point, the hospital arrest localization group causes confusion for the results. In this group, cardiac arrest occurs at the triage or the hospital entrance. Therefore, it is understood that interventions such as prehospital chest compressions and respiratory support are not applied in a significant part of this group, and it

is understood that the prognosis is better, probably due to rapid access to health-care providers.

Given the study's nonrandomized controlled trial design, it is important to acknowledge that certain subgroup analysis findings may be influenced by confounding factors. For instance, while the lower success rate of CPR with mechanical devices might appear accurate, it is plausible that this outcome could be influenced by factors such as the preference for mechanical CPR devices in patients with a lower life expectancy and longer CPR duration.

Conclusion

This study is the first multicenter, prospective study conducted in Türkiye revealing OHCA data. As a result, prognostic data obtained in the prehospital and ED periods are similar to those in developed countries; however, survival and good neurological outcome rates appear to be worse. Concepts such as ED crowding and intensive care quality can be discussed here. However, success in hospital discharge and neurological survival is an issue that requires multidisciplinary coordination. Although it is not the focus of this study, the correct approach would be to discuss these poor outcomes by focusing on the postcardiac arrest care step in the chain of survival.

Consistent with the literature, shockable initial rhythm and witnessed arrest were found to be associated with good outcomes. On the other hand, the bystander CPR rate, which is very low compared to developed countries, should be particularly scrutinized and efforts should be made to improve it by developing health policies and social policies.

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Author contributions
All authors conducted the study concept and design and acquisition of the data. AŞ and SK conducted the statistical analysis and interpretation of the data. AŞ and MMİ conducted the drafting of the manuscript. All authors conducted critical revision of the manuscript for important intellectual content.

Conflicts of interest
None declared.

Ethical approval
This multicenter study was carried out in 28 health centers in Türkiye within the scope of the Emergency Medicine Association of Türkiye (EMAT) Resuscitation Study Group, and approval was obtained from the Kocaeli University Non-Interventional Clinical Research Ethics Committee (KÜ GOKAEK-2022/18.24; November 10, 2022).

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Supplementary Table 1: Factors associated with survived event

Variables	Survived event, *n* (%)	*P*
Time zone		
Day shift	24 (6.2)	0.594
Night shift and holidays	45 (7.3)	
Gender		
Female	34 (8.7)	0.068
Male	35 (5.7)	
Independent living		
No	13 (6.2)	0.709
Yes	52 (7.2)	
Chronic neurological disease		
No	56 (7.3)	0.666
Yes	10 (6.0)	
Chronic pulmonary disease		
No	57 (7.5)	0.425
Yes	10 (5.5)	
Chronic cardiovascular disease		
No	26 (5.8)	0.242
Yes	38 (7.7)	
Active malignancy		
No	61 (7.5)	0.212
Yes	5 (4.0)	
Ventricular assist device		
No	66 (6.9)	0.399
Yes	1 (14.3)	
ICD (or external cardioverter defibrillator)		
No	65 (6.9)	0.680
Yes	2 (8.3)	
Witnessed arrest		
Yes	59 (7.6)	0.429
No	8 (5.4)	
Instructions from EMS dispatcher		
Yes	8 (8.2)	0.880
No	38 (7.1)	
Prehospital CPR		
None	1 (1)	0.016
Health-care provider	63 (7.3)	
Bystander CPR	4 (13.8)	
Initial arrest rhythm		
Asystole	46 (6.7)	0.811
PEA	5 (5.2)	
VF	7 (8.2)	
pVT	1 (11.1)	
Shockable rhythm		
pVT/VF	8 (8.5)	0.618
Asystole/PEA	51 (6.5)	
Prehospital defibrillation		
No	58 (6.8)	0.408
Yes	11 (9.3)	
Prehospital chest compression		
None	1 (1)	0.020
Performed	67 (7.5)	
Prehospital ventilation support		
None	2 (2.2)	0.097
Performed	67 (7.5)	
Prehospital mechanical CPR device		
None	66 (6.7)	0.122
Used	2 (22.2)	
Prehospital vascular access		
None	2 (1.8)	0.039
Yes	67 (7.5)	
Prehospital epinephrine		
None	4 (1.8)	0.001
Performed	63 (8.5)	
Prehospital amiodarone		
None	65 (6.8)	0.685
Performed	2 (8)	
Prehospital lidocaine		
None	67 (6.8)	0.069
Performed	1 (100)	
Prehospital sodium bicarbonate		
None	66 (6.7)	0.041
Performed	2 (40)	
Prehospital calcium		
None	68 (6.9)	1.000
Performed	-	
Reported by EMS before ED admission		
Yes	47 (6.6)	1.000
No	15 (6.4)	
Etiology		
Acute coronary syndrome	30 (6.5)	0.129
Pulmonary embolism	6 (14)	
Electrolyte disorder	3 (5.9)	
Asthma	3 (18.8)	
Drowning	3 (18.8)	
Others, unknown	24 (5.8)	
Prehospital airway procedure		
Not performed	3 (2.6)	<0.001*
BVM	13 (4.1)	
ETI - successful/surgical	51 (10.6)	
Supraglottic	1 (1.9)	
Unsuccessful	1 (3.1)	
Cardiac arrest location		
Home	43 (7.1)	0.239
Workplace/public area	13 (9.6)	
Nursing home	3 (8.3)	
Ambulance	6 (4.1)	
Hospital	3 (7.5)	
Others	-	

Pearson's Chi-square test, Fisher's exact test. ICD: Implantable cardioverter-defibrillator, EMS: Emergency medical service, CPR: Cardio-pulmonary resuscitation, PEA: Pulseless electrical activity, VF: Ventricular fibrillation, pVT: Pulseless ventricular tachycardia, ED: Emergency department, BVM: Bag-valve mask, ETI: Endotracheal intubation

Contd...

Supplementary Table 2: Factors associated with survived event - continues variables

Variables	Nonsurvived event	Survived event	*P**
Age (year)	67.1±15.1	65.9±15.7	0.655
Prehospital CPR duration (min)	15 (8–20)	15 (5.3–20)	0.897
Time from the arrest to the CPR (min)	5 (1–10)	10 (2–10)	0.714
Number of defibrillation (if exist)	2 (1–3)	2 (1–3)	0.712
Time from the arrest to the first defibrillation (min)	6.5 (3–11.8)	6.5 (2.3–15.3)	0.966

*Age: Independent samples *t*-test, mean±SD. Variables other than age: Mann–Whitney *U*-test, median (25%–75%). CPR: Cardio-pulmonary resuscitation, SD: Standard deviation

Supplementary Table 3: Factors associated with sustained return of the spontaneous circulation (overall)

Variables	Sustained ROSC, *n* (%)	*P*
Time zone		
Day shift	115 (29.9)	0.065
Night shift and holidays	219 (35.6)	
Gender		
Female	136 (35.1)	0.388
Male	198 (32.4)	
Independent living		
No	62 (29.5)	0.070
Yes	261 (36.3)	
Chronic neurological disease		
No	264 (34.3)	0.693
Yes	55 (32.7)	
Chronic pulmonary disease		
No	244 (32.1)	0.009
Yes	77 (42.3)	
Chronic cardiovascular disease		
No	154 (34.1)	0.708
Yes	163 (33.0)	
Active malignancy		
No	278 (34.1)	0.685
Yes	40 (32.3)	
Ventricular assist device		
No	320 (33.7)	0.049
Yes	5 (71.4)	
ICD (or external cardioverter defibrillator)		
No	320 (34.0)	1.000
Yes	8 (33.3)	
Witnessed arrest		
Yes	296 (38.2)	<0.001
No	26 (17.4)	
Instructions from EMS dispatcher		
Yes	32 (32.7)	0.625
No	187 (35.2)	
Prehospital CPR		
None	55 (52.4)	<0.001
Health-care provider	264 (30.8)	
Bystander CPR	11 (37.9)	
Prehospital initial cardiac arrest rhythm		
Asystole	206 (30.2)	<0.001
PEA	38 (39.6)	
VF	46 (54.1)	
pVT	3 (33.3)	
Prehospital shockable rhythm		
pVT/VF	49 (52.1)	<0.001
Asystole/PEA	244 (31.4)	
Prehospital defibrillation		
No	283 (33.1)	0.367
Yes	44 (37.3)	
Prehospital chest compression		
None	55 (52.4)	<0.001
Performed	275 (31.1)	
Prehospital ventilation support		
None	50 (54.9)	<0.001
Performed	282 (31.5)	

Contd...

Supplementary Table 3: Contd...

Variables	Sustained ROSC, *n* (%)	*P*
Prehospital mechanical CPR device		
None	328 (33.4)	1.000
Used	3 (33.3)	
Prehospital vascular access		
None	47 (42.0)	0.042
Yes	287 (32.4)	
Prehospital epinephrine		
None	104 (46.2)	<0.001
Performed	226 (30.6)	
Prehospital amiodarone		
None	320 (33.5)	0.640
Performed	10 (40.0)	
Prehospital lidocaine		
None	330 (33.6)	0.337
Performed	1 (100)	
Prehospital sodium bicarbonate		
None	329 (33.6)	1.000
Performed	2 (40)	
Prehospital calcium		
None	331 (33.7)	0.553
Performed	-	
Reported by EMS before ED admission		
Yes	206 (29.1)	<0.001
No	112 (48.3)	
Etiology		
Drowning	11 (68.8)	<0.001
Acute coronary syndrome	156 (33.6)	
Pulmonary embolism	19 (46.3)	
Electrolyte disorder	16 (31.4)	
Asthma	12 (75)	
Others, unknown	120 (29.2)	
Prehospital airway procedure		
Not performed	64 (54.7)	<0.001
BVM	82 (25.9)	
ETI - successful/surgical	170 (35.5)	
Supraglottic	13 (24.1)	
Unsuccessful	5 (15.6)	
Cardiac arrest location		
Home	177 (29.5)	<0.001
Workplace/public area	42 (31.1)	
Nursing home	8 (22.2)	
Ambulance	66 (44.9)	
Hospital	31 (77.5)	
Others	8 (38.1)	
Shockable rhythm at ED admission		
pVT/VF	44 (55.7)	<0.001
Asystole/PEA	203 (25.3)	
Pulse exists	85 (75.2)	
Advanced airway in ED		
Exists at admission	146 (34)	0.111
BVM/Supraglottic/surgical	3 (13)	
ETI	185 (33.9)	
CPR in ED		
None	52 (100)	<0.001
Performed	282 (29.8)	

Contd...

Supplementary Table 3: Contd...

Variables	Sustained ROSC, *n* (%)	*P*
Mechanical CPR device in ED		
None	236 (40.4)	<0.001
Used	98 (23.6)	
Defibrillation in ED		
None	234 (30.4)	<0.001
Performed	100 (43.7)	
Venous access in ED		
Others	32 (54.2)	<0.001
Peripheral	302 (32.1)	
Epinephrine in ED		
None	61 (100)	<0.001
Performed	273 (29.1)	
Amiodarone in ED		
None	263 (31.2)	0.001
Performed	71 (45.2)	
Lidocaine in ED		
None	332 (33.4)	1.000
Performed	2 (40)	
Magnesium sulfate in ED		
None	324 (33.1)	0.246
Performed	10 (47.6)	
Sodium bicarbonate in ED		
None	236 (31.5)	0.022
Performed	98 (39.4)	
Calcium in ED		
None	290 (33.7)	0.678
Performed	44 (31.9)	
USG use during CPR in ED		
None	156 (32.6)	0.578
Used	178 (34.2)	
If USG used, cardiac activity exists		
None	34 (9.8)	<0.001
Exists	143 (83.1)	
EtCO2 device use during CPR in ED		
None	257 (36.9)	<0.001
Used	77 (25.5)	

Pearson's Chi-square test, Fisher's exact test. ICD: Implantable cardioverter-defibrillator, EMS: Emergency medical service, CPR: Cardio-pulmonary resuscitation, PEA: Pulseless electrical activity, VF: Ventricular fibrillation, pVT: Pulseless ventricular tachycardia, ED: Emergency department, BVM: Bag-valve mask, ETI: Endotracheal intubation, USG: Ultrasonography, EtCO2: End-tidal carbon dioxide, ROSC: Return of the spontaneous circulation

Supplementary Table 4: Factors associated with sustained return of the spontaneous circulation (overall) - continues variables

Variables	No sustained ROSC	Sustained ROSC	*P**
Age (year)	67.4±15.4	66.2±14.9	0.242
Prehospital CPR duration (min)	15 (10–25)	10 (3–20)	<0.001
Prehospital time from the arrest to the CPR (min)	8 (2–10)	5 (1–10)	<0.001
Prehospital number of defibrillation (if exist)	2 (1–3)	2 (1–3)	0.967
Prehospital time from the arrest to the first defibrillation (min)	10 (5.5–15)	4 (1–9)	0.001
Number of defibrillations before first ROSC in ED	2 (1–3)	3 (1–4)	0.074
Total number of defibrillations in ED	3 (1–4)	3 (1–4)	0.648
Epinephrine dose (mg) before the first ROSC in ED	10 (5–14)	4 (2–6)	<0.001
Total epinephrine dose (mg) in ED	13 (10–15)	6 (3–11)	<0.001
CPR to the first ROSC in ED (min)	12.5 (5.5–21.8)	14 (8–20)	0.843
Initial pH during CPR in ED	6.93 (6.80–7.05)	7.02 (6.92–7.13)	<0.001
Initial lactate during CPR in ED (mmol/L)	12.5 (9–16)	10.24 (6.8–13.2)	<0.001
5th min ETCO2 during CPR in ED (mmHg)	12 (8.5–18)	18 (12–29.3)	<0.001
Last ETCO2 during CPR in ED (mmHg)	11 (6.75–16)	35 (24–54)	<0.001
Highest ETCO2 during CPR in ED (mmHg)	18 (13–25)	39 (30.5–55)	<0.001

*Age: Independent samples *t*-test, mean±SD. Variables other than age: Mann–Whitney *U*-test; median (25%–75%). ROSC: Return of the spontaneous circulation, CPR: Cardio-pulmonary resuscitation, ED: Emergency department, EtCO2: End-tidal carbon dioxide, SD: Standard deviation

Supplementary Table 5: Factors associated with survival to hospital discharge

Variables	Survival to hospital discharge, *n* (%)	*P*
Time zone		
Day shift	25 (6.5)	0.017
Night shift and holidays	19 (3.1)	
Gender		
Female	2 (2.3)	0.016
Male	35 (5.7)	
Independent living		
No	4 (1.9)	0.044
Yes	40 (5.5)	
Chronic neurological disease		
No	37 (4.8)	0.629
Yes	6 (3.6)	
Chronic pulmonary disease		
No	37 (4.9)	0.469
Yes	6 (3.3)	
Chronic cardiovascular disease		
No	27 (6)	0.061
Yes	16 (3.2)	
Active malignancy		
No	42 (5.1)	0.051
Yes	1 (0.8)	
Ventricular assist device		
No	44 (4.6)	1.000
Yes	-	
ICD (or external cardioverter defibrillator)		
No	44 (4.7)	0.622
Yes	-	
Witnessed arrest		
Yes	37 (4.8)	0.587
No	5 (3.4)	
Instructions from EMS dispatcher		
Yes	2 (2)	0.406
No	24 (4.5)	
Prehospital CPR		
None	11 (10.5)	0.001
Health-care provider	29 (3.4)	
Bystander CPR	4 (13.8)	
Prehospital shockable rhythm		
pVT/VF	17 (18.1)	<0.001
Asystole/PEA	19 (2.4)	
Prehospital defibrillation		
No	31 (3.6)	0.003
Yes	12 (10.2)	
Prehospital chest compression		
None	11 (10.5)	0.004
Performed	33 (3.7)	
Prehospital ventilation support		
None	12 (13.2)	<0.001
Performed	32 (3.6)	
Prehospital mechanical CPR device		
None	43 (4.4)	1.000
Used	-	

Contd...

Supplementary Table 5: Contd...

Variables	Survival to hospital discharge, *n* (%)	*P*
Prehospital vascular access		
None	9 (8)	0.081
Yes	35 (3.9)	
Prehospital epinephrine		
None	21 (9.3)	<0.001
Performed	23 (3.1)	
Prehospital amiodarone		
None	43 (4.5)	1.000
Performed	1 (4)	
Prehospital lidocaine		
None	44 (4.5)	1.000
Performed	-	
Prehospital sodium bicarbonate		
None	44 (4.5)	1.000
Performed	-	
Prehospital calcium		
None	44 (4.5)	1.000
Performed	-	
Survival event		
None	32 (3.4)	<0.001
Yes	12 (17.4)	
Reported by EMS before ED admission		
Yes	25 (3.5)	0.006
No	19 (8.2)	
Etiology		
Drowning	2 (12.5)	0.085
Acute coronary syndrome	28 (6)	
Pulmonary embolism	1 (2.3)	
Electrolyte disorder	1 (2)	
Asthma	-	
Others, unknown	12 (2.9)	
Prehospital airway procedure		
Not performed	17 (14.5)	<0.001
BVM	10 (3.1)	
ETI - successful/surgical	15 (3.1)	
Supraglottic	1 (1.9)	
Unsuccessful	1 (3.1)	
Cardiac arrest location		
Home	16 (2.7)	0.002
Workplace/public area	12 (8.9)	
Nursing home	-	
Ambulance	9 (6.1)	
Hospital	5 (12.5)	
Others	1 (4.8)	
Shockable rhythm at ED admission		
pVT/VF	13 (6.5)	<0.001
Asystole/PEA	17 (2.1)	
Pulse exists	14 (12.4)	
Advanced airway in ED		
Exists at admission	14 (3.2)	0.295
BVM/Supraglottic/Surgical	1 (4.3)	
ETI	29 (5.3)	

Contd...

Supplementary Table 5: Contd...

Variables	Survival to hospital discharge, *n* (%)	*P*
CPR in ED		
None	12 (23.1)	<0.001
Performed	32 (3.4)	
Mechanical CPR device in ED		
None	33 (5.6)	0.034
Used	11 (2.6)	
Defibrillation in ED		
None	27 (3.5)	0.018
Performed	17 (7.4)	
Venous access in ED		
Others	3 (5.1)	0.740
Peripheral	41 (4.3)	
Epinephrine in ED		
None	14 (23)	<0.001
Performed	30 (3.2)	
Amiodarone in ED		
None	30 (3.6)	0.005
Performed	14 (8.9)	
Lidocaine in ED		
None	43 (4.3)	0.201
Performed	1 (20)	
Magnesium sulfate in ED		
None	40 (4.1)	0.011
Performed	4 (19)	
Sodium bicarbonate in ED		
None	40 (5.3)	0.020
Performed	4 (1.6)	
Calcium in ED		
None	43 (5)	0.040
Performed	1 (0.7)	
Cardiac arrest again in ED		
None	40 (17.2)	<0.001
Yes	4 (1.8)	
No ROSC in ED	-	
USG use during CPR in ED		
None	21 (4.4)	1.000
Used	23 (4.4)	
If USG used, cardiac activity exists		
None	2 (0.6)	<0.001
Exists	21 (12.2)	
EtCO2 device use during CPR in ED		
None	34 (4.9)	0.353
Used	10 (3.3)	
ST segment elevation after ROSC		
No	21 (7.7)	0.014
Yes	23 (16)	
Coronary revascularization after ROSC		
No	17 (5.3)	<0.001
Yes	27 (27)	
TTM after ROSC		
No	39 (9.8)	0.055
Yes	3 (33.3)	
Vasoactive drug after ROSC		
None	22 (15.2)	0.019
Performed	20 (7.4)	
ECLS after ROSC		
None	44 (10.7)	1.000
Performed	-	
Surgery after ROSC		
No	43 (10.7)	0.601
Yes	1 (12.5)	
Forensic case report		
None	39 (4.3)	0.795
Performed	5 (5)	

Pearson's Chi-square test, Fisher's exact test. ICD: Implantable cardioverter-defibrillator, EMS: Emergency medical service, CPR: Cardio-pulmonary resuscitation, PEA: Pulseless electrical activity, VF: Ventricular fibrillation, pVT: Pulseless ventricular tachycardia, ED: Emergency department, BVM: Bag-valve mask, ETI: Endotracheal intubation, ROSC: Return of the spontaneous circulation, USG: Ultrasonography, EtCO2: End-tidal carbon dioxide, TTM: Targeted temperature management, ECLS: Extracorporeal life support

Contd...

Supplementary Table 6: Factors associated with survival to hospital discharge - continues variables

Variables	Exitus	Discharged	*P**
Age (year)	67.3±15.2	61.0±14.7	0.007
Prehospital CPR duration (min)	15 (10–20)	8.5 (0.13–12)	<0.001
Prehospital time from the arrest to the CPR (min)	5 (1–10)	3 (1–7.3)	0.036
Prehospital number of defibrillations (if exist)	2 (1–3)	1.5 (1–2)	0.353
Prehospital time from the arrest to the first defibrillation (min)	9 (4–15)	2 (0.8–4.3)	0.001
Number of defibrillations before first ROSC in ED	2 (1–3)	3 (1–5.5)	0.198
Total number of defibrillations in ED	3 (1–4)	3 (1–4.5)	0.711
Epinephrine dose (mg) before the first ROSC in ED	6.5 (3–10)	3 (2–5)	<0.001
Total epinephrine dose (mg) in ED	11 (8–15)	3 (2–4.8)	<0.001
CPR to the first ROSC in ED (min)	14.5 (8–22)	10 (5–12)	0.002
Initial pH during CPR in ED	6.97 (6.84–7.07)	7.11 (7–7.24)	<0.001
Initial lactate during CPR in ED (mmol/L)	12 (8.33–15.46)	7.98 (5.63–11.93)	<0.001
5th min ETCO2 during CPR in ED (mmHg)	14 (10–21)	16 (11–43.8)	0.148
Last ETCO2 during CPR in ED (mmHg)	14 (8–20)	47.5 (33–55.8)	<0.001
Highest ETCO2 during CPR in ED (mmHg)	20 (15–33.3)	49 (34.8–55.8)	<0.001
pH after ROSC in ED	7.03 (6.91–7.18)	7.25 (7.09–7.31)	<0.001
Lactate after ROSC in ED (mmol/L)	10.63 (6.33–14.13)	4.59 (3.08–7.91)	<0.001

*Age: Independent Samples *t*-test; mean±SD. Variables other than age: Mann–Whitney *U*-test; median (25%–75%). CPR: Cardio-pulmonary resuscitation, ROSC: Return of the spontaneous circulation, ED: Emergency department, EtCO2: End-tidal carbon dioxide, SD: Standard deviation

Supplementary Table 7: Factors associated with good neurological outcome at discharge

Variables	Good neurological outcome at discharge, *n* (%)	*P*
Time zone		
Day shift	16 (4.2)	0.041
Night shift and holidays	11 (1.8)	
Gender		
Female	5 (1.3)	0.044
Male	22 (3.6)	
Independent living		
No	-	0.009
Yes	27 (3.8)	
Chronic neurological disease		
No	25 (3.3)	0.067
Yes	1 (0.6)	
Chronic pulmonary disease		
No	25 (3.3)	0.076
Yes	1 (0.6)	
Chronic cardiovascular disease		
No	17 (3.8)	0.100
Yes	9 (1.8)	
Active malignancy		
No	26 (3.2)	0.038
Yes	-	
Ventricular assist device		
No	27 (2.9)	1.000
Yes	-	
ICD (or external cardioverter defibrillator)		
No	27 (2.9)	1.000
Yes	-	
Witnessed arrest		
Yes	24 (3.1)	0.160
No	1 (0.7)	
Instructions from EMS dispatcher		
Yes	1 (1)	0.488
No	15 (2.8)	
Prehospital CPR		
None	9 (8.7)	<0.001
Health-care provider	14 (1.6)	
Bystander CPR	4 (13.8)	
Prehospital shockable rhythm		
pVT/VF	15 (16)	<0.001
Asystole/NEA	5 (0.6)	
Prehospital defibrillation		
No	16 (1.9)	<0.001
Yes	10 (8.5)	
Prehospital chest compression		
None	9 (8.7)	0.001
Performed	18 (2)	
Prehospital ventilation support		
None	9 (10)	<0.001
Performed	18 (2)	
Prehospital mechanical CPR device		
None	26 (2.7)	1.000
Used	-	
Prehospital vascular access		
None	6 (5.4)	0.110
Yes	21 (2.4)	
Prehospital epinephrine		
None	18 (8)	<0.001
Performed	9 (1.2)	
Prehospital amiodarone		
None	26 (2.7)	0.508
Performed	1 (4)	
Prehospital lidocaine		
None	27 (2.8)	1.000
Performed	-	
Prehospital sodium bicarbonate		
None	27 (2.8)	1.000
Performed	-	
Prehospital calcium		
None	27 (2.8)	1.000
Performed	-	
Survival event		
None	20 (2.2)	0.001
Yes	7 (10.4)	
Reported by EMS before ED admission		
Yes	14 (2)	0.008
No	13 (5.6)	
Etiology		
Drowning	2 (12.5)	<0.001
Acute coronary syndrome	22 (4.8)	
Pulmonary embolism	-	
Electrolyte disorder	1 (2)	
Asthma	-	
Others, unknown	2 (0.5)	
Prehospital airway procedure		
Not performed	14 (12.1)	<0.001
BVM	6 (1.9)	
ETI - successful/surgical	7 (1.5)	
Supraglottic	-	
Unsuccessful	-	
Cardiac arrest location		
Home	6 (1.0)	<0.001
Workplace/public area	8 (6)	
Nursing home	-	
Ambulance	6 (4.1)	
Hospital	5 (12.5)	
Others	1 (4.8)	
Shockable rhythm at ED admission		
pVT/VF	12 (15.2)	<0.001
Asystole/PEA	6 (0.8)	
Pulse exists	9 (8.1)	
Advanced airway in ED		
Exists at admission	7 (1.6)	0.188
BVM/supraglottic/surgical	1 (4.3)	
ETI	19 (3.5)	
CPR in ED		
None	7 (14)	<0.001
Performed	20 (2.1)	

Contd...

Contd...

Supplementary Table 7: Contd...

Variables	Good neurological outcome at discharge, *n* (%)	*P*
Mechanical CPR device in ED		
None	20 (3.5)	0.133
Used	7 (1.7)	
Defibrillation in ED		
None	11 (1.4)	<0.001
Performed	16 (7)	
Venous access in ED		
Others	1 (1.7)	1.000
Peripheral	26 (2.8)	
Epinephrine in ED		
None	9 (15.3)	<0.001
Performed	18 (1.9)	
Amiodarone in ED		
None	15 (1.8)	<0.001
Performed	12 (7.7)	
Lidocaine in ED		
None	26 (2.6)	0.129
Performed	1 (20)	
Magnesium sulfate in ED		
None	23 (2.4)	0.002
Performed	4 (19)	
Sodium bicarbonate in ED		
None	25 (3.4)	0.054
Performed	2 (0.8)	
Calcium in ED		
None	26 (3)	0.160
Performed	1 (0.7)	
Cardiac arrest again in ED		
None	24 (10.7)	<0.001
Yes	3 (1.4)	
No ROSC in ED	-	
USG use during CPR in ED		
None	14 (3)	0.807
Used	13 (2.5)	
If USG used, cardiac activity exists		
None	-	<0.001
Exists	13 (7.6)	
EtCO2 device use during CPR in ED		
None	21 (3)	0.470
Used	6 (2)	
ST elevation after ROSC		
No	8 (3)	<0.001
Yes	19 (13.3)	
Coronary revascularization after ROSC		
No	5 (1.6)	<0.001
Yes	22 (22.2)	
TTM after ROSC		
No	24 (6.2)	0.445
Yes	1 (11.1)	
Vasoactive drug after ROSC		
None	17 (12.1)	0.001
Performed	9 (3.4)	

Contd...

Supplementary Table 7: Contd...

Variables	Good neurological outcome at discharge, *n* (%)	*P*
ECLS after ROSC		
None	27 (6.7)	1.000
Performed	-	
Surgery after ROSC		
No	26 (6.6)	0.430
Yes	1 (12.5)	
Forensic case report		
None	24 (2.7)	0.747
Performed	3 (3)	

Pearson's Chi-square test, Fisher's exact test. ICD: Implantable cardioverter-defibrillator, EMS: Emergency medical service, CPR: Cardio-pulmonary resuscitation, PEA: Pulseless electrical activity, VF: Ventricular fibrillation, pVT: Pulseless ventricular tachycardia, ED: Emergency department, BVM: Bag-valve mask, ETI: Endotracheal intubation, ROSC: Return of the spontaneous circulation, USG: Ultrasonography, EtCO2: End-tidal carbon dioxide, TTM: Targeted temperature management, ECLS: Extracorporeal life support

Supplementary Table 8: Factors associated with good neurological outcome at discharge - continuous variables

Variables	Poor	Good	*P**
Age (year)	67.3±15.2	57.3±12.4	0.001
Prehospital CPR duration (min)	15 (10–20)	2 (0–10)	<0.001
Prehospital time from the arrest to the CPR (min)	5 (1–10)	2 (0.5–5.5)	0.047
Prehospital number of defibrillations (if exist)	2 (1–3)	1.5 (1–2.5)	0.457
Prehospital time from the arrest to the first defibrillation (min)	9 (4–15)	2 (0.5–4.5)	0.002
Number of defibrillations before first ROSC in ED	2 (1–3)	3 (1–5.5)	0.198
Total number of defibrillations in ED	3 (1–4)	3 (1–4.8)	0.856
Epinephrine dose (mg) before the first ROSC in ED	6 (3–10)	3 (1.5–4.5)	<0.001
Total epinephrine dose (mg) in ED	11 (8–15)	4 (1.8–5)	<0.001
CPR to the first ROSC in ED (min)	14 (8–21.8)	8 (5–14.3)	0.009
Initial pH during CPR in ED	6.97 (6.84–7.07)	7.16 (7.04–7.27)	<0.001
Initial lactate during CPR in ED (mmol/L)	12 (8.33–15.42)	7.10 (5.30–11.80)	<0.001
5th min ETCO2 during CPR in ED (mmHg)	14 (10–21)	25.5 (12.5–47)	0.109
Last ETCO2 during CPR in ED (mmHg)	14 (8–20)	43 (30–60.5)	0.001
Highest ETCO2 during CPR in ED (mmHg)	21 (15–34)	44.5 (34.8–60.5)	0.002
pH after ROSC in ED	7.05 (6.91–7.19)	7.28 (7.09–7.33)	<0.001
Lactate after ROSC in ED (mmol/L)	10.35 (6.25–14)	4.05 (2.13–10.02)	<0.001

*Age: Independent samples *t*-test, mean±SD. Variables other than age: Mann–Whitney *U*-test, median (25%–75%). CPR: Cardio-pulmonary resuscitation, ROSC: Return of the spontaneous circulation, ED: Emergency department, EtCO2: End-tidal carbon dioxide, SD: Standard deviation

Supplementary Table 9: Distribution of outcomes in terms of regions

	Regions						
	Marmara, *n* (%)	Aegean, *n* (%)	Mediterranean, *n* (%)	Central Anatolia, *n* (%)	Black Sea, *n* (%)	Eastern Anatolia, *n* (%)	Southeastern Anatolia, *n* (%)
EMS	378 (97.7)	326 (96.4)	101 (98.1)	62 (96.9)	39 (97.5)	40 (100.0)	29 (100.0)
Bystander CPR	14 (3.6)	12 (3.6)	2 (2.0)	0	0	1 (2.5)	0
Shockable rhythm	37 (11.5)	3 (11.5)	23 (24.2)	24 (8)	2 (5.1)	3 (8.1)	2 (3.8)
Prehospital airway procedure							
Not performed	39 (10.1)	2 (6.9)	20 (19.4)	40 (11.8)	4 (10)	2 (5.0)	10 (15.6)
BVM	134 (34.6)	3 (10.3)	31 (30.1)	93 (27.4)	11 (27.5)	25 (62.5)	21 (32.8)
ETI - successful	185 (47.8)	22 (75.9)	48 (46.6)	159 (46.9)	22 (55)	11 (27.5)	30 (46.9)
Supraglottic	12 (3.1)	2 (6.9)	3 (2.9)	33 (9.7)	0	1 (2.5)	3 (4.7)
Surgical	1 (0.3)	0	0	1 (0.3)	2 (5.0)	0	0
Unsuccessful	16 (4.1)	0	1 (1)	13 (3.8)	1 (2.5)	1 (2.5)	0
Prehospital venous access							
None	35 (9.0)	1 (3.4)	9 (8.7)	45 (13.3)	5 (12.5)	9 (22.5)	8 (12.5)
Peripheral	351 (90.7)	27 (93.1)	93 (90.3)	293 (86.4)	35 (87.5)	31 (77.5)	56 (87.5)
Intraosseous	1 (0.3)	1 (3.4)	0	0	0	0	0
Central	0	0	1 (1.0)	1 (0.3)	0	0	0
Mechanical CPR device in ED	180 (46.5)	8 (27.6)	10 (9.7)	170 (50.1)	26 (65.0)	19 (47.5)	3 (4.7)
USG use during CPR in ED	129 (33.3)	19 (65.5)	75 (72.8)	229 (67.6)	22 (55.0)	5 (12.5)	43 (67.2)
EtCO2 device use during CPR in ED	96 (24.8)	6 (20.7)	46 (44.7)	136 (40.1)	16 (40.0)	2 (5.0)	0
Survived event	15 (3.9)	19 (5.6)	17 (16.5)	5 (7.8)	2 (5.0)	3 (7.5)	8 (27.6)
Sustained ROSC	102 (26.4)	114 (33.7)	59 (57.8)	21 (32.8)	12 (30.0)	12 (30.0)	14 (48.3)
Survival to hospital discharge	13 (3.4)	10 (2.9)	14 (13.6)	2 (3.1)	3 (7.5)	1 (2.5)	1 (3.4)
Good neurological outcome at discharge	11 (2.9)	4 (1.2)	11 (10.7)	0	0	1 (2.5)	0

EMS: Emergency medical service, CPR: Cardio-pulmonary resuscitation, BVM: Bag-valve mask, ETI: Endotracheal intubation, ED: Emergency department, USG: Ultrasonography, EtCO2: End-tidal carbon dioxide, ROSC: Return of the spontaneous circulation