RESUSCITATION PLUS 19 (2024) 100678

Available online at www.sciencedirect.com

Resuscitation Plus

journal homepage: www.elsevier.com/locate/resuscitation-plus

Clinical paper

Resuscitation of out-of-hospital cardiac arrest victims in Austria's largest helicopter emergency medical service: A retrospective cohort study

Julian M. Baumkirchner[a,b], Maximilian Havlicek[c], Wolfgang Voelckel[d,e,f], Helmut Trimmel[f,g,h,i,*]

Abstract

Background: Helicopter emergency medical services (HEMS) play a fundamental role in prehospital care. However, the impact of HEMS on survival of patients with out-of-hospital cardiac arrest (OHCA) is widely unknown. Therefore, the purpose of this study was to assess demographics, treatment, and outcome of patients with OHCA attended by physician-staffed helicopters.

Methods: Retrospective cohort study enrolling OHCA patients treated by HEMS during a ten-year period (2010–2019) in Austria. Patients were identified using electronic mission records of 13 HEMS bases run by the Austrian Automobile, Motorcycle and Touring Club (OEAMTC), and subsequently matched with the national register of deaths to determine 30-day and one-year survival rates. Results are reported according to the 2015 Utstein Style. Multivariable logistic regression analysis was used to identify factors associated with patient outcome.

Results: In total, 9344 presumed OHCA missions were identified. Cardiopulmonary resuscitation was attempted or continued by HEMS in 3889 cases. Approximately 32.2% of patients achieved return of spontaneous circulation (ROSC) and 22.5% sustained ROSC until arrival at the emergency department. Thirty-day and one-year survival rates were 14.0% and 12.4% respectively. HEMS response time, on-scene time, age, pathogenesis, arrest location, witness-status, first monitored rhythm, bystander automated external defibrillator (AED) use, airway type and administration of adrenaline were independent predictors of 30-day survival.

Conclusions: This study provides an extensive insight into the management of OHCA in an almost nationwide HEMS sample. Thirty-day and one-year survival rates are high, indicating high-quality care and systematic selection of patients with favorable prognosis.

Keywords: Out-of-hospital cardiac arrest, Resuscitation, Helicopter emergency medical service, Epidemiology, Outcome

Introduction

With an approximate incidence of 30.0–97.1 per 100,000 population,[1] out-of-hospital cardiac arrests (OHCAs) account for a significant number of emergency medical service (EMS) calls every day.[2] Since the 1960s, helicopters have been integrated into EMS systems to cover remote areas[3] and shorten transport times.[4–6] They provide specialized medical personnel and equipment to the emergency scene and are crucial for maintaining a high standard of care.[3,7] In Europe, Luxembourg, Switzerland and Austria are the countries with the highest density of rescue helicopters per population and area.[8]

While the impact of helicopters emergency medical services (HEMS) on the outcome of trauma patients has been studied extensively,[9] only few investigations have examined their influence on OHCA patients. Data from a Polish study[10] suggests that HEMS respond to a distinct OHCA population, characterized by a high rate of return of spontaneous circulation (ROSC). Research on medical,[11,12] traumatic[13,14] or pediatric[15,16] cardiac arrests treated by HEMS has provided inconsistent results, frequently lacking information on long-term outcome. We therefore set out to further explore the characteristics, treatment and long-term outcome of OHCA patients attended by HEMS and identify factors contributing to the survival of this particular population.

* Corresponding author at: Department of Anaesthesiology, Emergency Medicine and Intensive Care, County Hospital Wiener Neustadt, Corvinusring 3-5, A-2700, Wiener Neustadt, Austria.

E-mail address: Helmut.Trimmel@wienerneustadt.lknoe.at (H. Trimmel).

https://doi.org/10.1016/j.resplu.2024.100678

Received 3 April 2024; Received in revised form 12 May 2024; Accepted 23 May 2024

Methods

Study design

A retrospective cohort study was conducted on OHCA patients treated directly by a team of the Austrian Automobile, Motorcycle and Touring Club (OEAMTC) HEMS in Austria from January 1st, 2010, to December 31st, 2019. Mission data was matched with the national register of deaths by Statistics Austria to determine 30-day and one-year survival rates. The study design is based on the 2015 Utstein Recommendations for OHCA,[17] and follows the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE)[18] guidelines.

Study setting

Austria is a mountainous country, covering an area of 83,871 km^2 with a population of approximately 8.9 million people (2019).[19] As in many European countries,[20] EMS are provided by a two-tiered system. Ambulance units are staffed with emergency medical technicians (EMTs) or paramedics and provide general emergency treatment. Physician response units (ground- or helicopter-based) are dispatched additionally for critical emergencies. They consist of an emergency physician, a paramedic and, if applicable, a pilot. Whether a ground- or helicopter-based unit is dispatched, depends on its availability, the accessibility and the estimated time needed to reach the emergency scene. In general, the type of unit that is expected to reach the destination quickest will be dispatched.

Most of the Austria's HEMS stations are run by OEAMTC, a private organization contractually bound to provide nationwide air-rescue services. Additionally, 6 smaller companies[21] provide mostly seasonal helicopter rescue services in alpine regions during the wintertime. OEAMTC HEMS currently operates 19 helicopters serving all parts of the federal territory. Aspiring helicopter physicians (mostly anesthesiologists) must undergo supplementary training and present sufficient experience on ground-based units before being certified. HEMS missions are generally carried out from dawn to dusk; only one base provided services 24 h a day during the study period. Medical records and flight information are documented electronically using a proprietary documentation system (Leonardo™).

Inclusion and exclusion criteria

The mission records database was screened for patients categorized by the National Advisory Committee for Aeronautics (NACA) Score[22] as 6 (resuscitation) or 7 (death), and additionally for cases with documented chest compressions or defibrillation, regardless of NACA score. We excluded all records of inter-facility transfers and stand-downs as well as cases in which the patient had not suffered an OHCA. To accurately measure the impact of HEMS on OHCA outcome, patients (partially) treated by different emergency physicians (e.g. from ground-based units) were excluded. Ultimately, we assessed whether CPR had been initiated or continued by a HEMS team. If this was not the case or unknown, the datasets were omitted (Fig. 1).

Data definitions

Variables were defined to match the 2015 Utstein Style.[17] Where necessary, definitions were modified slightly to better fit the documentation system used. A complete list of data definitions and modifications is provided in the supplementary materials (Supplementary Table S1).

Additional variables were added to evaluate mission time intervals. Response time was estimated by adding a standardized 3-minute interval to the flight time to account for helicopter preparation and crew boarding. On-scene time was defined as the time between landing at and taking off from the emergency scene. Transport time was decided to be equal to the flight time to the hospital.

Data collection

Out of the 18 HEMS bases (Fig. 2), three (Vienna, Salzburg and Nenzing) are run in cooperation with local EMS organizations and could therefore not provide data due to data protection regulations. Two bases (St. Michael and Zurndorf) had not yet started operations by the end of the study period. Thus, the authors were provided with mission records from the remaining 13 HEMS bases. Only relevant sections of the mission records were transmitted by OEAMTC (Supplementary Table S2), strictly complying with data minimization requirements.

For variables with matching fields on the mission records, values were taken directly from the latter. In all other cases, the authors extracted information manually from the records, in accordance with the data definitions. If data was documented multiple times in a contradictory way, the value in main text field was assumed to be the correct one.

As mission records are not linked to hospital records, the Austrian register of deaths was decided to be most appropriate for determining long-term survival status. A patient was classified as alive if no entry in the register was found and the personal data (name, sex, date of birth) was complete. If a patient was explicitly classified as deceased in the mission record, they were also classified as deceased in this study, regardless of register query.

Statistical analysis

Categorical variables are presented as frequencies and percentages. For continuous variables median and interquartile range (IQR) are reported. Multivariable logistic regression analysis was used to identify factors associated with the endpoints "ROSC on arrival at emergency department (ED)", "30-day survival" and "one-year survival". All variables marked in Table 1 were tested individually for significant influence on the endpoints. Significant factors were added as covariates to a multivariable model, for which adjusted odds ratios (aOR) and 95% confidence intervals (CI) were calculated. A p-value of less than 0.05 (two-sided) was considered statistically significant. Missing data is reported for all descriptive analyses. Regression analyses were calculated based on complete datasets. All analyses were performed with IBM SPSS Statistics, Version 29.0 (IBM Corporation, Armonk, NY, USA).

Ethical approval

This study was approved by the Ethics Committee for the Federal State of Lower Austria (GS4-EK-4/703-2020).

Results

During the study period, OEAMTC HEMS responded to 9,344 potential OHCA missions, which equals 6.9% of the total workload (N = 135,969). After applying exclusion criteria, 3,889 cases (2.9% of all missions) with confirmed OHCA and treatment by HEMS were included in the analysis (Fig. 2).

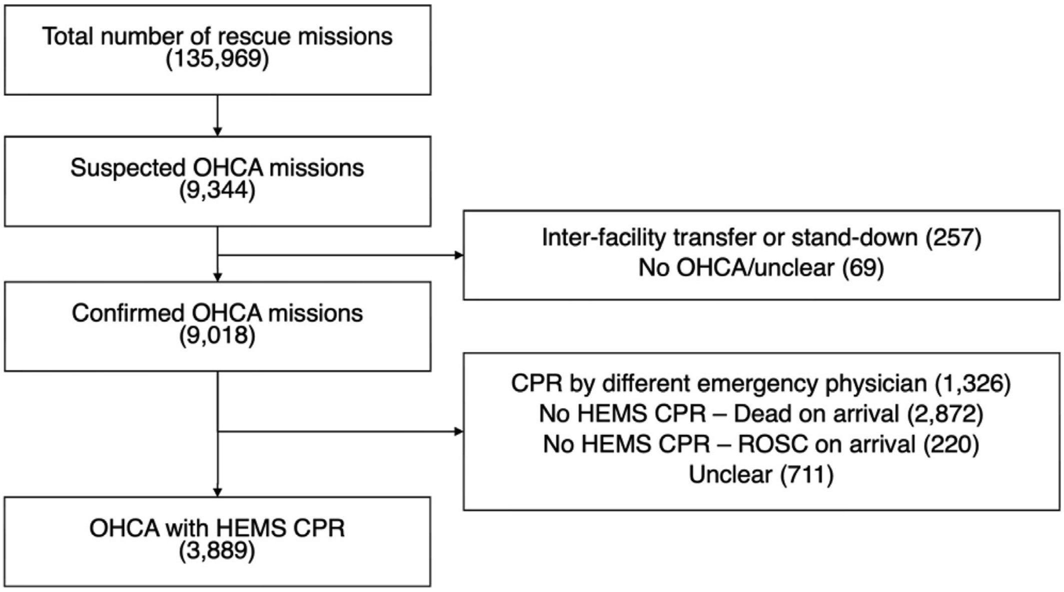

Fig. 1 – Flow chart of the study population. OHCA indicates out-of-hospital cardiac arrest; CPR, cardiopulmonary resuscitation; HEMS, helicopter emergency medical services; and ROSC, return of spontaneous circulation.

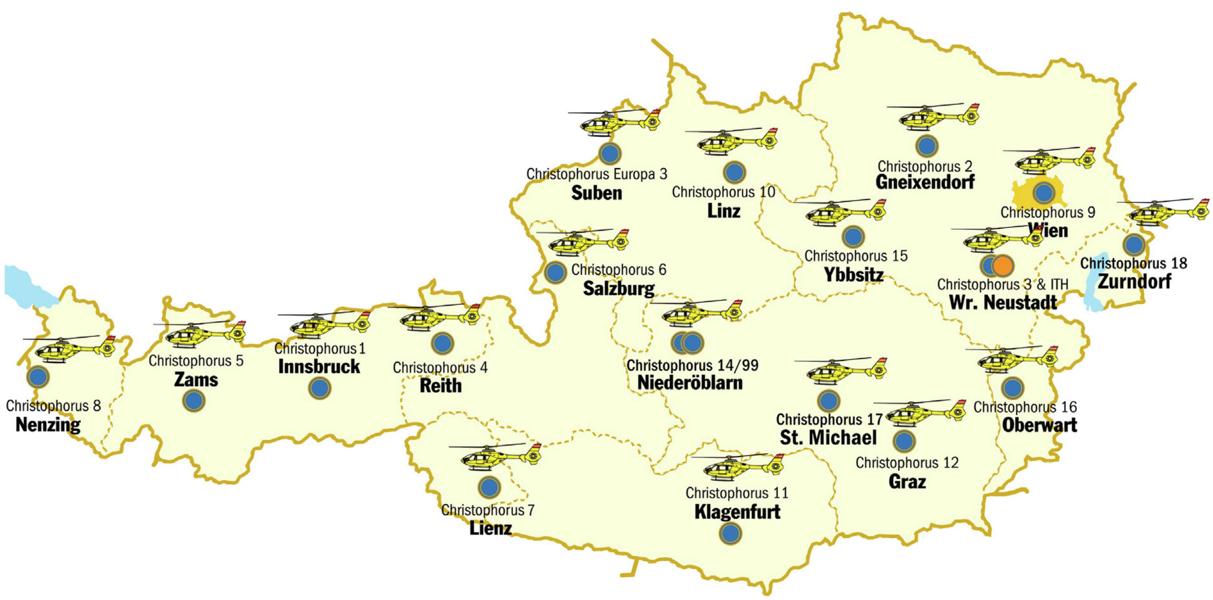

Fig. 2 – Distribution of OEAMTC HEMS bases in Austria. ITH indicates intensive care transfer helicopter.

OHCA missions were most frequently performed during the afternoon (47.3%, Supplementary Fig. S1). Median (IQR) response time was 12 min (9–14), on-scene time was 40 min (30–51) and time airlifting the patient to the hospital was 8 min (5–11). The HEMS team confirmed the preliminary dispatch diagnosis in 78.5%.

Patient characteristics

The majority of patients were male (72.7%). Median age was lower in men compared to women (67 vs. 74 years). A medical cause of OHCA was presumed in 85.0% of patients. Traumatic OHCA constituted 9.0% of the population. Home was the most reported arrest location, accounting for 48.7%, followed by sports/recreation events (10.8%). Although 53.0% OHCAs were bystander-, and 7.3% EMS-witnessed, the number of OHCA patients with an initial shockable rhythm was low (21.3%).

Prehospital treatment

The dispatcher provided CPR instructions in 3.8%, and bystander AED use was documented in 1.0% of all cases. At public arrest locations (i.e., sports/recreation, public building, street, workplace and other), bystander AED rate was 1.9%. Endotracheal intubation (ETI) was the primary strategy for airway management in 72.6% of patients. Bag-valve-mask (BVM) ventilation was the second most common approach (10.7%). In approximately 8.5% of patients, airway devices were changed at least once (i.e. laryngeal mask followed by endotracheal intubation). For drug administration,

Table 1 – Summary characteristics. EMS indicates emergency medical services; AED, automated external defibrillator; VF, ventricular fibrillation; PEA, pulseless electrical activity; VT, ventricular tachycardia; CPR, cardiopulmonary resuscitation; IV, intravenous; and IO, intraosseous.

System and patient characteristics		Value	Missing
Time of day*	Morning; n (%)	1634 (42.0)	0
	Afternoon; n (%)	1838 (47.3)	
	Evening; n (%)	409 (10.5)	
	Night; n (%)	8 (0.2)	
Time intervals	Response time; median (IQR)*	12 (9–14)	2
	On-scene time; median (IQR) *	40 (30–51)	225
	Transport time; median (IQR)	8 (5–11)	2591
Dispatch information	Accurate; n (%)	3052 (78.5)	559
	Not accurate; n (%)	278 (7.1)	
Sex*	Male; n (%)	2829 (72.7)	2
	Female; n (%)	1058 (27.2)	
Age*	Age; median (IQR)	69 (56–78)	4
Arrest characteristics		Value	Missing
Pathogenesis*	Medical; n (%)	3306 (85.0)	0
	Traumatic cause; n (%)	351 (9.0)	
	Asphyxial; n (%)	143 (3.7)	
	Drowning; n (%)	65 (1.7)	
	Poisoning; n (%)	18 (0.5)	
	Electrocution; n (%)	6 (0.2)	
Arrest location*	Home/residence; n (%)	1893 (48.7)	343
	Sports/recreation event; n (%)	421 (10.8)	
	Other; n (%)†	415 (10.7)	
	Street/highway; n (%)	341 (8.8)	
	Industrial/workplace; n (%)	283 (7.3)	
	Public building; n (%)	117 (3.0)	
	Transport; n (%)	40 (1.0)	
	Assisted living/nursing home; n (%)	36 (0.9)	
Witness status*	Bystander witnessed; n (%)	2062 (53.0)	321
	EMS witnessed; n (%)	285 (7.3)	
	Unwitnessed; n (%)	1221 (31.4)	
First monitored rhythm*	AED used, shock delivered; n (%)	40 (1.0)	578
	AED used, no shock delivered; n (%)	83 (2.1)	
	Asystole; n (%)	1800 (46.3)	
	VF; n (%)	755 (19.4)	
	PEA; n (%)	589 (15.1)	
	Pulseless VT; n (%)	32 (0.8)	
	Bradycardia; n (%)	12 (0.3)	
Bystander response	Bystander CPR; n (%)*	2432 (62.5)	1457‡
	Dispatcher provided CPR instructions; n (%)	147 (3.8)	3742‡
	Bystander AED use; n (%)*	39 (1.0)	3850‡
Treatment characteristics		Value	Missing
Airway control (type) *	Endotracheal tube; n (%)	2822 (72.6)	77
	Supraglottic airway; n (%)	203 (5.2)	
	Surgical airway; n (%)	6 (0.2)	
	Bag valve mask; n (%)	418 (10.7)	
	Multiple; n (%)	331 (8.5)	
	None; n (%)	32 (0.8)	
Vascular access (type) *	Peripheral IV; n (%)	2969 (76.3)	551
	IO; n (%)	258 (6.6)	
	Central line; n (%)	108 (2.8)	
	Endotracheal; n (%)	1 (0.0)	
	None; n (%)	2 (0.1)	
Drugs given*	Adrenaline; n (%)	3062 (78.7)	827‡

Table 1 (continued)

System and patient characteristics		Value	Missing
	Amiodarone; n (%)	814 (20.9)	3075‡
	Vasopressin; n (%)	101 (2.6)	3788‡
Chest compressions (type) *	Mechanical CPR; n (%)	53 (1.4)	3836‡

* Variable in univariate regression analysis.
† Includes unspecified public areas
‡ Includes cases in which the intervention was not performed, not excluded from regression analysis.

peripheral intravenous access was used in 76.3%, followed by intraosseous access in 6.6%. The establishment of a central line was reported in 2.8%. The majority of patients received adrenaline (78.7%). Amiodarone was given to 20.9% whereas vasopressin was only used in 2.6%. HEMS made use of a mechanical CPR device in 1.4%. Full details on patient and treatment characteristics are presented in Table 1.

Outcome

Out of 3,889 patients, 32.2% achieved ROSC during the resuscitation attempt. ROSC was sustained until arrival at the emergency department in 22.5%. In total, 546 (14.0%) patients were alive 30 days after the event. This number decreased to 483 (12.4%) after 12 months.

Patients with shockable bystander-witnessed OHCA (Utstein comparator group, $n = 570$) had the highest outcome rates of the subgroups studied. In this group, 56.1% achieved ROSC and 44.7% were admitted to the hospital alive. The corresponding 30-day survival rate was 34.4% whereas the one-year survival rate was 31.2%. A complete overview of outcome is provided in Table 2.

Factors affecting survival

Regarding 30-day survival, 12 (out of 18) parameters were included in multivariable regression after individual analysis. Response time and on-scene time were negatively correlated with outcome, with aORs of 0.93 (95% CI 0.90–0.96) and 0.97 (95%CI 0.96–0.98) respectively. Likewise, age was a significant predictor of survival (aOR 0.97, 95% CI 0.96–0.97). OHCA pathogenesis affected the outcome considerably: Trauma had lower odds of survival compared to a medical pathogenesis (aOR 0.41, 95% CI 0.22–0.76). In contrast, drowning (aOR 2.95, 95% CI 1.32–6.60), and poisoning (aOR 5.75, 95% CI 1.67–19.86) had higher odds of survival. Regarding arrest location, public buildings (aOR 2.11, 95% CI 1.19–3.76), and sports/recreation events (aOR 2.19, 95% CI 1.49–3.22) were associated with higher odds of survival when compared with home. Being witnessed by a bystander was linked to a higher chance of survival (aOR 2.93, 95% CI 2.04–4.22). The odds increased to 8.19 (95% CI 4.77–14.06) for EMS-witnessed cases. Similarly, bystander AED use led to higher odds of survival (aOR 2.78, 95% CI 1.01–7.59). Concerning first monitored rhythm, patients with pulseless ventricular tachycardia (VT) had the highest aOR of 7.43 (95% CI 3.02–18.29), followed by patients with ventricular fibrillation (aOR 7.02, 95% CI 4.89–10.06). BVM ventilation was negatively correlated with 30-day outcome when compared to ETI (aOR 0.25, 95% CI 0.13–0.51). The administration of adrenaline halved the odds of survival (aOR 0.54, 95% CI 0.37–0.78). Full results of regression analyses are reported in Table 3.

Discussion

With a population of 3,889 patients, this study provides the most comprehensive insight into OHCA treatment in HEMS to our knowledge. Moreover, it is the first to explore prehospital resuscitation data from most major states of the republic of Austria.

OHCA missions accounted for 6.6% of the total number of HEMS calls during the study period, which is lower than previously reported (10.1%).[11] From 9,018 missions dispatched for cardiac arrest, 14.7% were excluded because treatment was initiated or managed by another physician from ground EMS, suggesting that HEMS was primarily dispatched to shorten transport times. In 34.3% of all OHCAs, resuscitation efforts were neither initiated nor continued by HEMS,

Table 2 – Overview of survival rates. ROSC indicates return of spontaneous circulation; ED, emergency department; CPR, cardiopulmonary resuscitation; and EMS, emergency medical services.

Population	Amount	Any ROSC (%)		ROSC on arrival at ED (%)		30-day survival (%)	1-year survival (%)
		Yes	Unclear	Yes	Unclear	Yes	Yes
Total	3889	1253 (32.2)	483 (12.4)	875 (22.5)	207 (5.3)	546 (14.0)	483 (12.4)
Shockable bystander-witnessed; n (%)	570	320 (56.1)	13 (2.3)	255 (44.7)	28 (4.9)	196 (34.4)	178 (31.2)
Shockable bystander CPR; n (%)*	555	293 (52.8)	18 (3.2)	230 (41.4)	27 (4.9)	175 (31.5)	160 (28.8)
Non-shockable bystander CPR; n (%)*	1565	371 (23.7)	78 (5.0)	265 (16.9)	32 (2.0)	103 (6.6)	91 (5.8)

* EMS witnessed cases excluded.

Table 3 – Results of multivariable regression. ROSC indicates return of spontaneous circulation; ED, emergency department; EMS, emergency medical services; AED, automated external defibrillator; VF, ventricular fibrillation; PEA, pulseless electrical activity; VT, ventricular tachycardia; IV, intravenous; and IO, intraosseous.

Parameter		ROSC on arrival at ED		30-day survival		1-year survival	
		adjusted OR	95% CI	adjusted OR	95% CI	adjusted OR	95% CI
Response time		0.94	(0.92–0.97)	0.93	(0.90–0.96)	0.93	(0.90–0.97)
On-scene time		not included		0.97	(0.96–0.98)	0.97	(0.96–0.98)
Age		0.99	(0.98–0.99)	0.97	(0.96–0.97)	0.97	(0.96–0.97)
Sex	Female	not included		1.24	(0.92–1.68)	1.22	(0.88–1.69)
Pathogenesis	Medical	1.00 (reference)					
	Traumatic cause	0.82	(0.52–1.29)	0.41	(0.22–0.76)	0.49	(0.26–0.94)
	Asphyxial	4.28	(2.64–6.92)	1.41	(0.69–2.87)	1.09	(0.46–2.59)
	Drowning	3.65	(1.80–7.38)	2.95	(1.32–6.60)	2.81	(1.12–7.04)
	Poisoning	5.06	(1.62–15.76)	5.75	(1.67–19.86)	7.34	(2.04–26.48)
	Electrocution	0.66	(0.10–4.14)	0.61	(0.09–4.19)	0.68	(0.10–4.70)
Arrest location	Home/residence	1.00 (reference)					
	Sports/recreation event	0.86	(0.62–1.20)	2.19	(1.49–3.22)	2.29	(1.53–3.44)
	Other*	1.37	(1.01–1.85)	2.11	(1.45–3.08)	2.03	(1.35–3.05)
	Street/highway	1.08	(0.74–1.60)	1.07	(0.64–1.79)	1.04	(0.60–1.79)
	Industrial/workplace	0.83	(0.55–1.24)	1.50	(0.93–2.43)	1.55	(0.92–2.58)
	Public building	0.98	(0.59–1.65)	2.11	(1.19–3.76)	1.90	(1.01–3.57)
	Transport	0.72	(0.29–1.80)	0.84	(0.30–2.41)	0.81	(0.26–2.55)
	Assisted living/nursing home	2.31	(0.89–6.00)	1.62	(0.44–5.95)	3.15	(0.82–12.05)
Witness status	Unwitnessed	1.00 (reference)					
	Bystander witnessed	3.08	(2.38–4.00)	2.93	(2.04–4.22)	3.32	(2.19–5.03)
	EMS witnessed	4.95	(3.25–7.54)	8.19	(4.77–14.06)	9.36	(5.23–16.73)
First monitored rhythm	Asystole	1.00 (reference)					
	AED used, shock delivered	3.65	(1.56–8.54)	4.05	(1.52–10.82)	3.27	(1.11–9.64)
	AED used, no shock delivered	3.22	(1.50–6.88)	3.65	(1.40–9.56)	2.38	(0.75–7.52)
	VF	2.54	(1.94–3.35)	7.02	(4.89–10.06)	5.79	(3.93–8.53)
	PEA	1.75	(1.35–2.28)	2.30	(1.57–3.36)	2.13	(1.42–3.21)
	Pulseless VT	7.00	(2.89–16.93)	7.43	(3.02–18.29)	4.11	(1.59–10.65)
	Bradycardia	2.94	(0.64–13.40)	3.97	(0.74–21.40)	3.67	(0.66–20.33)
Bystander AED use		1.09	(0.42–2.83)	2.78	(1.01–7.59)	2.94	(1.05–8.29)
Airway control (type)	Endotracheal tube	1.00 (reference)					
	Supraglottic airway	0.80	(0.46–1.38)	0.74	(0.35–1.56)	0.84	(0.36–1.95)
	Surgical airway	0.00	–	0.00	–	0.00	–
	Bag valve mask	0.34	(0.18–0.64)	0.25	(0.13–0.51)	0.61	(0.28–1.34)
	None	1.04	(0.07–15.37)	0.49	(0.09–2.76)	1.96	(0.10–39.02)
	Multiple	0.97	(0.69–1.36)	1.08	(0.69–1.69)	0.79	(0.47–1.33)
Vascular access (type)	Peripheral IV	1.00 (reference)		not included			
	IO	0.62	(0.42–0.91)			0.61	(0.34–1.11)
	Central line	0.64	(0.35–1.16)			0.48	(0.19–1.24)
	Endotracheal	0.00	–			0.00	–
	None	0.00	–			0.00	–
Adrenaline		0.42	(0.29–0.59)	0.54	(0.37–0.78)	0.37	(0.24–0.56)
Amiodarone		1.33	(1.03–1.72)	1.11	(0.80–1.54)	1.24	(0.88–1.74)

* Includes unspecified public areas.

predominantly because the patient was considered dead on arrival (92.9%). This may be explained by the limited capabilities of EMTs/paramedics in Austria to withhold or terminate resuscitation treatment in futile situations. The subsequent arrival of a HEMS physician then leads to a higher share of OHCAs without CPR compared to countries with more extensive EMS training.[10,16] Adaption of the legal framework and training could help decrease the need for emergency physicians in these situations and improve system efficiency.

The median HEMS response time was 12 min, which is considerably shorter than in other European countries (15–23 min).[10,11,13] This could be attributed to the high density of rescue helicopters in Austria,[8] decreasing the average distance from HEMS base to emergency scene. Short response times were associated with higher chances of survival (aOR 0.93–0.94), emphasizing the importance of early advanced life support (ALS) in OHCA patients.[23,24] HEMS teams spent approximately 40 min on-scene, which is longer than in a polish study (26 min).[10] Longer on-scene times were also associated with lower long-term survival rates. However, due to a lack of data, the severity of injuries and comorbidities were not accounted for in our analysis. Correcting for these factors might have mitigated this effect, as previously demonstrated in trauma patients.[25]

As most OEAMTC HEMS bases do not operate at night, the majority of OHCAs were attended during the daytime (89.3%). Several registry studies[26,27] have suggested that the incidence of OHCA is indeed lowest at night. Interestingly, nighttime patients tend to have lower survival compared to daytime.[26–28] This can contribute to selection bias when studying EMS systems that primarily operate in the daytime. Time of day was not a significant predictor of outcome in this study; however, nighttime sample size was exceedingly small.

Approximately 48.7% of OHCAs occurred at home. Another study[11] on HEMS patients found a comparable percentage whereas registries[29,30] containing patients from ground-based EMS report much higher shares. In contrast, 40.6% of events occurred at a public location. Concerning arrest pathogenesis, trauma (9.0%) was more than twice as frequent in this study than in a European registry (3.9%).[29] Altogether, this indicates that HEMS cohorts might differ from ground-based OHCA cohorts, possibly affecting the chance of survival.[31–33] Moreover, Austria is a popular destination among outdoor sports enthusiasts, which might contribute to this observation.

In recent years, substantial efforts[34] have been made to improve AED access in public areas, as these devices significantly improve outcome after OHCA.[35,36] We encountered a remarkably low rate of bystander AED use in Austria (1.0%), which was only marginally higher (1.9%) at public arrest locations. HEMS regularly operate in rural regions where AED availability is poor, partially explaining the difference between our rates and those reported for the city of Vienna (19.2%).[37] As neighboring countries[38–40] also report higher bystander AED use rates, it must be questioned whether all cases were actually recorded. Adapting the documentation system might help improve data quality in this area for future studies.

ETI remained the most popular airway control strategy (72.6%), analogous to what is seen in other countries with physician-based EMS.[40,41] Correspondingly, the amount of supraglottic airway applications was low (5.2%). Identifying the optimal airway management strategy for OHCA has been an ongoing challenge, with numerous studies[42–44] providing inconsistent results. ETI was associated with a slight benefit over BVM in this study, most likely caused by cases in which BVM was chosen because of imminent termination of resuscitation. Any other device or multiple devices did not influence patient outcome, in line with current guidelines on ALS.[45]

In our study, the share of patients with any ROSC (32.2%) is significantly smaller than the one reported by Rzońca et al. (54.9%).[10] ROSC is generally associated with favorable long-term outcome.[46,47] However, it remains unclear whether this was actually observed in the Polish cohort as no follow-up survival data was provided. Two other studies on medical OHCA in HEMS patients reported high any ROSC (39.1%)[11] or event survival rates (31.9%).[12] Yet, survival to discharge (6.3–11.7%)[11,12] remained lower than 30-day survival in this study. Interestingly, HEMS studies[10–12] frequently include patients with ROSC prior to helicopter arrival, disguising the direct effect of HEMS on the resuscitation process.

A comparison with the German Resuscitation Registry (GRR, 2007–2018)[41] reveals that, in our cohort, fewer patients achieved ROSC (32.2 vs. 45.2% in GRR) and were admitted to the hospital alive (22.5 vs 38.1% in GRR). On the contrary, 30-day survival is slightly better (14.0 vs. 12.9% in GRR). This also applies when comparing our results with the European Registry of Cardiac Arrest (EuReCa) TWO study.[29] Eventually, 12.4% of OHCA patients survived for 12 months or longer, comparable to what was found by Yan et al. (12.3%)[48] during the same period. Long-term survivors tend to be in favorable neurological condition,[49] making this percentage an estimate of the share of patients with favorable outcome in a setting where this could not be determined.

We observed a ROSC rate of 56.1% in the Utstein comparator group, comparable to the EuReCA trials.[29,50] However, the share of patients surviving 30 days or longer in this subgroup is greater in our study (34.4% vs. 28–29.7% in EuReCa), indicating that HEMS could positively impact long-term survival of OHCA patients. This might be attributed to the quality of care provided by highly trained specialists as well as selection bias, resulting in a high share of daytime and public OHCAs in HEMS cohorts. To further evaluate these findings, a direct comparison of HEMS data with data from ground-based EMS should be carried out, taking into account the difference in patient characteristics. For Austria, this was not feasible due to a lack of ground-based data. We therefore strongly encourage the implementation of a nationwide resuscitation registry to facilitate future research.

Limitations

Like all retrospective trials, this study has several limitations. First, the authors needed to interpret mission records that were not compatible with the current Utstein definitions,[17] leading to missing information as well as possible misinterpretation. Underreporting may be present in all variables not explicitly mentioned on the data collection form. Second, due to limited resources and availability, no data on in-hospital treatment and neurological status was obtained. Third, outcome was determined in two different ways, possibly leading to a discrepancy between ROSC rates and long-term survival rates. Long-term survival was determined by the death register, which only provides data for Austrian residents. This may have led to false positive results when HEMS operated outside the federal border, which is frequently the case at the Christophorus Europa 3 base. Last, three HEMS bases that cover important urban regions, including Vienna and Salzburg, with a population of 2.7 million people[19] were not included in the analysis. Assuming equal OHCA incidences among HEMS bases, an estimated 2500 OHCA cases were therefore not considered. This reduces the generalizability of the study by predominantly depicting a rural population. Whether our findings can be translated to urban areas has to be determined in future studies.

Conclusions

This study provides an extensive insight into the management of OHCA in the Austrian HEMS system. HEMS populations seem to have distinct characteristics and above-average long-term outcome. Whether these findings are a direct consequence of high-quality patient care or primarily caused by systematic selection remains uncertain.

CRediT authorship contribution statement

Julian M. Baumkirchner: Writing – original draft, Methodology, Formal analysis, Data curation, Conceptualization. **Maximilian Havlicek:** Writing – review & editing, Data curation. **Wolfgang Voelckel:** Writing – review & editing, Resources. **Helmut Trimmel:** Writing – review & editing, Validation, Supervision, Resources, Funding acquisition, Conceptualization.

Declaration of competing interest

The authors declare the following financial interests/personal relationships which may be considered as potential competing interests: HT and WV are active emergency physicians at OEAMTC HEMS. There are no other conflicts of interest to declare.

Acknowledgements

This work was supported by the Karl Landsteiner Institute for Emergency Medicine. We would like to acknowledge the OEAMTC HEMS for providing us with the necessary data to support this study.

Appendix A. Supplementary material

Supplementary data to this article can be found online at https://doi.org/10.1016/j.resplu.2024.100678.

Author details

[a]Medical University of Vienna, Vienna, Austria [b]Department of Surgery, Zuger Kantonsspital, Baar, Switzerland [c]Johannes Kepler University, Linz, Austria [d]Departement of Anaesthesiology and Intensive Care Medicine AUVA Trauma Centre Salzburg, Academic Teaching Hospital of the Paracelsus Medical University, Salzburg, Austria [e]University of Stavanger, Network for Medical Science, Stavanger, Norway [f]Christophorus Air Rescue, OEAMTC, Vienna, Austria [g]Department of Anaesthesiology, Emergency Medicine and Intensive Care, County Hospital Wiener Neustadt, Wiener Neustadt, Austria [h]Karl Landsteiner Institute for Emergency Medicine, Wiener Neustadt, Austria [i]Danube Private University, Krems, Austria

REFERENCES

1. Kiguchi T, Okubo M, Nishiyama C, et al. Out-of-hospital cardiac arrest across the World: first report from the International Liaison Committee on Resuscitation (ILCOR). Resuscitation 2020;152:39–49. https://doi.org/10.1016/j.resuscitation.2020.02.044.
2. Berdowski J, Beekhuis F, Zwinderman AH, Tijssen JGP, Koster RW. Importance of the first link: description and recognition of an out-of-hospital cardiac arrest in an emergency call. Circulation 2009;119:2096–102. https://doi.org/10.1161/CIRCULATIONAHA.108.768325.
3. Krüger AJ, Skogvoll E, Castrén M, Kurola J, Lossius HM. ScanDoc Phase 1a Study Group. Scandinavian pre-hospital physician-manned Emergency Medical Services–same concept across borders? Resuscitation 2010;81:427–33. https://doi.org/10.1016/j.resuscitation.2009.12.019.
4. Diaz MA, Hendey GW, Bivins HG. When is the helicopter faster? A comparison of helicopter and ground ambulance transport times. J Trauma Inj Infect Crit Care 2005;58:148–53. https://doi.org/10.1097/01.TA.0000124264.43941.41.
5. Jang JY, Kwon W-K, Roh H, et al. Time-saving effects using helicopter transportation: comparison to a ground transportation time predicted using a social navigation software. Medicine (Baltimore) 2021;100:e26569. https://doi.org/10.1097/MD.0000000000026569.
6. Fjaeldstad A, Kirk MH, Knudsen L, Bjerring J, Christensen EF. Physician-staffed emergency helicopter reduces transportation time from alarm call to highly specialized centre. Dan Med J 2013;60:A4666.
7. Butler DP, Anwar I, Willett K. Is it the H or the EMS in HEMS that has an impact on trauma patient mortality? A systematic review of the evidence. Emerg Med J EMJ 2010;27:692–701. https://doi.org/10.1136/emj.2009.087486.
8. Jones A, Donald MJ, Jansen JO. Evaluation of the provision of helicopter emergency medical services in Europe. Emerg Med J EMJ 2018;35:720–5. https://doi.org/10.1136/emermed-2018-207553.
9. Samuel MG, Sikorski R, Hirshon JM, et al. Helicopter emergency medical services for adults with major trauma. Cochrane Database Syst Rev 2015. https://doi.org/10.1002/14651858.CD009228.pub3.
10. Rzońca P, Gałaôzkowski R, Panczyk M, Gotlib J. Polish Helicopter Emergency Medical Service (HEMS) response to Out-of-Hospital Cardiac Arrest (OHCA): a retrospective study. Med Sci Monit Int Med J Exp Clin Res 2018;24:6053–8. https://doi.org/10.12659/MSM.908962.
11. Lyon RM, Nelson MJ. Helicopter emergency medical services (HEMS) response to out-of-hospital cardiac arrest. Scand J Trauma Resusc Emerg Med 2013;21:1. https://doi.org/10.1186/1757-7241-21-1.
12. Chesters A, Harris T, Hodgetts TJ, Keefe N. Survival to discharge after cardiac arrest attended by a doctor-paramedic helicopter emergency medical service: an utstein-style multiservice review of 1085 activations. J Emerg Med 2015;49:439–47. https://doi.org/10.1016/j.jemermed.2015.05.001.
13. Houwen T, Popal Z, de Bruijn MAN, et al. Outcomes after prehospital traumatic cardiac arrest in the Netherlands: a retrospective cohort study. Injury 2021;52:1117–22. https://doi.org/10.1016/j.injury.2021.02.088.
14. Ter Avest E, Griggs J, Prentice C, Jeyanathan J, Lyon RM. Out-of-hospital cardiac arrest following trauma: what does a helicopter emergency medical service offer? Resuscitation 2019;135:73–9. https://doi.org/10.1016/j.resuscitation.2018.12.019.
15. Moors XRJ, Rijs K, Den Hartog D, Stolker RJ. Pediatric out-of-hospital cardiopulmonary resuscitation by helicopter emergency medical service, does it has added value compared to regular emergency medical service? Eur J Trauma Emerg Surg off Publ Eur Trauma Soc 2018;44:407–10. https://doi.org/10.1007/s00068-017-0815-5.
16. Moors XRJ, Alink MO, Bouman S, et al. A nationwide retrospective analysis of out-of-hospital pediatric cardiopulmonary resuscitation treated by helicopter emergency medical service in the Netherlands. Air Med J 2021;40:410–4. https://doi.org/10.1016/j.amj.2021.08.004.
17. Perkins GD, Jacobs IG, Nadkarni VM, et al. Cardiac Arrest and Cardiopulmonary Resuscitation Outcome Reports: Update of the

Utstein Resuscitation Registry Templates for Out-of-Hospital Cardiac Arrest: A Statement for Healthcare Professionals From a Task Force of the International Liaison Committee on Resuscitation (American Heart Association, European Resuscitation Council, Australian and New Zealand Council on Resuscitation, Heart and Stroke Foundation of Canada, InterAmerican Heart Foundation, Resuscitation Council of Southern Africa, Resuscitation Council of Asia); and the American Heart Association Emergency Cardiovascular Care Committee and the Council on Cardiopulmonary, Critical Care, Perioperative and Resuscitation. Resuscitation 2015;96:328–40. https://doi.org/10.1016/j.resuscitation.2014.11.002.
18. Vandenbroucke JP, von Elm E, Altman DG, Gøtzsche PC, Mulrow CD, Pocock SJ, et al. Strengthening the Reporting of Observational Studies in Epidemiology (STROBE): explanation and elaboration. PLoS Med 2007;4:e297. https://doi.org/10.1371/journal.pmed.0040297.
19. Statistics Austria. Population statistics 2023
20. Fleischmann T, Fulde G. Emergency medicine in modern Europe. Emerg Med Australas EMA 2007;19:300–2. https://doi.org/10.1111/j.1742-6723.2007.00991.x.
21. Verein HeliRescue. Flugrettungsbetreiber. HeliRescue.at 2023. https://web.helirescue.at/betreiber/ (accessed March 25, 2024).
22. Tryba M, Brüggemann H, Echtermeyer V. Klassifizierung von Erkrankungen und Verletzungen in Notarztsystemen. Notfallmedizin 1980:725–7.
23. Grunau B, Kawano T, Scheuermeyer F, et al. Early advanced life support attendance is associated with improved survival and neurologic outcomes after non-traumatic out-of-hospital cardiac arrest in a tiered prehospital response system. Resuscitation 2019;135:137–44. https://doi.org/10.1016/j.resuscitation.2018.12.003.
24. Kurz MC, Schmicker RH, Leroux B, et al. Advanced vs. basic life support in the treatment of out-of-hospital cardiopulmonary arrest in the resuscitation outcomes consortium. Resuscitation 2018;128:132–7. https://doi.org/10.1016/j.resuscitation.2018.04.031.
25. Ringburg AN, Spanjersberg WR, Frankema SPG, Steyerberg EW, Patka P, Schipper IB. Helicopter emergency medical services (HEMS): impact on on-scene times. J Trauma Acute Care Surg 2007;63:258. https://doi.org/10.1097/01.ta.0000240449.23201.57.
26. Karlsson LIM, Wissenberg M, Fosbøl EL, et al. Diurnal variations in incidence and outcome of out-of-hospital cardiac arrest including prior comorbidity and pharmacotherapy: a nationwide study in Denmark. Resuscitation 2014;85:1161–8. https://doi.org/10.1016/j.resuscitation.2014.06.012.
27. Kim YJ, Ryoo HW, Shin SD, et al. Diurnal variation in outcomes after out-of-hospital cardiac arrest in Asian communities: the Pan-Asian resuscitation outcomes study. Emerg Med Australas EMA 2017;29:551–62. https://doi.org/10.1111/1742-6723.12822.
28. Matsumura Y, Nakada T, Shinozaki K, et al. Nighttime is associated with decreased survival and resuscitation efforts for out-of-hospital cardiac arrests: a prospective observational study. Crit Care 2016;20:141. https://doi.org/10.1186/s13054-016-1323-4.
29. Gräsner J-T, Wnent J, Herlitz J, et al. Survival after out-of-hospital cardiac arrest in Europe – results of the EuReCa TWO study. Resuscitation 2020;148:218–26. https://doi.org/10.1016/j.resuscitation.2019.12.042.
30. The CARES surveillance group. CARES Annual Report 2019; 2020
31. Kim SY, Lee SY, Kim TH, Shin SD, Song KJ, Park JH. Location of out-of-hospital cardiac arrest and the awareness time interval: a nationwide observational study. Emerg Med J EMJ 2022;39:118–23. https://doi.org/10.1136/emermed-2020-209903.
32. Wittwer MR, Zeitz C, Beltrame JF, Arstall MA. Aetiology of resuscitated out-of-hospital cardiac arrest treated at hospital. Resuscitation 2022;170:178–83. https://doi.org/10.1016/j.resuscitation.2021.11.035.
33. Engdahl J, Bång A, Karlson BW, Lindqvist J, Herlitz J. Characteristics and outcome among patients suffering from out of hospital cardiac arrest of non-cardiac aetiology. Resuscitation 2003;57:33–41. https://doi.org/10.1016/s0300-9572(02)00433-1.
34. Schnaubelt S, Krammel M. PULS – Austrian Cardiac Arrest Awareness Association: an overview of a multi-tiered and multi-facetted regional initiative to save lives. Resusc plus 2023;15:100453. https://doi.org/10.1016/j.resplu.2023.100453.
35. Pollack RA, Brown SP, Rea T, et al. Impact of bystander automated external defibrillator use on survival and functional outcomes in shockable observed public cardiac arrests. Circulation 2018;137:2104–13. https://doi.org/10.1161/CIRCULATIONAHA.117.030700.
36. Karlsson L, Malta Hansen C, Wissenberg M, et al. Automated external defibrillator accessibility is crucial for bystander defibrillation and survival: a registry-based study. Resuscitation 2019;136:30–7. https://doi.org/10.1016/j.resuscitation.2019.01.014.
37. Juul Grabmayr A, Folke F, Tofte Gregers MC, et al. Public out-of-hospital cardiac arrest in residential neighborhoods. J Am Coll Cardiol 2023;82:1777–88. https://doi.org/10.1016/j.jacc.2023.08.036.
38. Scquizzato T, Gamberini L, D'Arrigo S, et al. Incidence, characteristics, and outcome of out-of-hospital cardiac arrest in Italy: a systematic review and meta-analysis. Resusc plus 2022;12:100329. https://doi.org/10.1016/j.resplu.2022.100329.
39. Gässler H, Helm M, Hossfeld B, Fischer M. Survival following lay resuscitation—an analysis of data from the German Resuscitation Registry. Dtsch Aerzteblatt Online 2020. https://doi.org/10.3238/arztebl.2020.0871.
40. Interassociation of Rescue (IVR-IAS). SWISSRECA Jahresbericht 2019–2021; 2022
41. Fischer M, Wnent J, Gräsner J-T, et al. Jahresbericht des Deutschen Reanimationsregisters – Außerklinische Reanimation 2019. Anästhesiol Intensivmed 2020;61:V89–93.
42. Jabre P, Penaloza A, Pinero D, et al. Effect of bag-mask ventilation vs endotracheal intubation during cardiopulmonary resuscitation on neurological outcome after out-of-hospital cardiorespiratory arrest: a randomized clinical trial. JAMA 2018;319:779–87. https://doi.org/10.1001/jama.2018.0156.
43. Wang HE, Schmicker RH, Daya MR, et al. Effect of a strategy of initial laryngeal tube insertion vs endotracheal intubation on 72-hour survival in adults with out-of-hospital cardiac arrest: a randomized clinical trial. JAMA 2018;320:769–78. https://doi.org/10.1001/jama.2018.7044.
44. Benger JR, Kirby K, Black S, et al. Effect of a strategy of a supraglottic airway device vs tracheal intubation during out-of-hospital cardiac arrest on functional outcome: The AIRWAYS-2 randomized clinical trial. JAMA 2018;320:779–91. https://doi.org/10.1001/jama.2018.11597.
45. Soar J, Böttiger BW, Carli P, et al. European Resuscitation Council Guidelines 2021: adult advanced life support. Resuscitation 2021;161:115–51. https://doi.org/10.1016/j.resuscitation.2021.02.010.
46. Sasson C, Rogers MAM, Dahl J, Kellermann AL. Predictors of survival from out-of-hospital cardiac arrest: a systematic review and meta-analysis. Circ Cardiovasc Qual Outcomes 2010;3:63–81. https://doi.org/10.1161/CIRCOUTCOMES.109.889576.
47. Wong XY, Ang YK, Li K, et al. Development and validation of the SARICA score to predict survival after return of spontaneous circulation in out of hospital cardiac arrest using an interpretable machine learning framework. Resuscitation 2022;170:126–33. https://doi.org/10.1016/j.resuscitation.2021.11.029.
48. Yan S, Gan Y, Jiang N, et al. The global survival rate among adult out-of-hospital cardiac arrest patients who received cardiopulmonary resuscitation: a systematic review and meta-analysis. Crit Care 2020;24. https://doi.org/10.1186/s13054-020-2773-2.
49. Poth JM, Buschmann CM, Kappler J, et al. Neurologisches Ergebnis und allgemeiner Gesundheitszustand bei Langzeitüberleben nach außerklinischer kardiopulmonaler Reanimation. Notf

Rettungsmedizin 2023;26:426–37. https://doi.org/10.1007/s10049-021-00929-2.
50. Gräsner J-T, Lefering R, Koster RW, et al. EuReCa ONE-27 Nations, ONE Europe, ONE Registry: a prospective one month analysis of out-of-hospital cardiac arrest outcomes in 27 countries in Europe. Resuscitation 2016;105:188–95. https://doi.org/10.1016/j.resuscitation.2016.06.004.