Polish Helicopter Emergency Medical Service (HEMS) Response to Out-of-Hospital Cardiac Arrest (OHCA): A Retrospective Study

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Background: Out-of-hospital cardiac arrest (OHCA) is a significant clinical challenge for emergency medical systems worldwide. The first step towards ensuring patient survival is achieving return of spontaneous circulation (ROSC). The purpose of the study was to analyze the cases of OHCA to which HEMS teams were dispatched.

Material/Methods: We performed a retrospective analysis of all HEMS calls in Poland for cases of OHCA between 1 January 2011 and 31 December 2016. Data were obtained from medical records maintained by the Polish HEMS.

Results: The total number of responses to cases of OHCA was 2447. Of this total, 308 cases were excluded from the study as the patient was found not to have cardiac arrest or was confirmed dead. ROSC was achieved in 1119 cases, including 335 cases where ROSC occurred before the arrival of the HEMS team. In the group studied, ROSC was achieved more commonly in women, in patients younger than age 40 years, in CA cases of cardiac origin, and in cases with shockable rhythms (p<0.05).

Conclusions: The study results are consistent with global trends in terms of OHCA incidence and the effectiveness of CPR performed on scene. The study also demonstrates that HEMS dispatch to OHCA cases is justified both as a means of providing assistance to EMS teams on scene and as the first choice.

MeSH Keywords: **Cardiopulmonary Resuscitation • Emergency Medical Services • Out-of-Hospital Cardiac Arrest**

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Background

Out-of-hospital cardiac arrest (OHCA) is the most common cause of mortality and severe neurological deficits among patients in Europe. Annually, OHCA occurs in 275 000 patients, which is in line with the incidence of 38–55 cases per 100 000 annually for which emergency medical teams performed cardiopulmonary resuscitation (CPR) [1–3]. The survival rate in OHCA ranges from 5% to 38% and is associated with differences in pre-hospital management [4].

Improving the quality and effectiveness of care for patients with OHCA is one of the tasks of emergency medical systems worldwide, which differ significantly in terms of structure and organization [4–7].

In most European countries, the pre-hospital care system includes helicopter emergency medical service (HEMS) teams, whose tasks include responding to cases of OHCA. The use of HEMS is particularly important in rural areas or other locations that are not easily reached by ground emergency medical teams. By implementing advanced protocols associated with airway management, electrotherapy, pharmaceutical treatment, and initiating pre-hospital post-resuscitation care combined with prompt transport to the hospital, HEMS teams increase the likelihood of patient survival with good neurological condition [8].

In Poland, the National Emergency Medical Services system is made up of both ground emergency medical teams and HEMS teams operating as part of the Polish Medical Air Rescue. Polish Medical Air Rescue provides advanced pre-hospital care in Poland. Its 21 permanent bases and 1 seasonal base (operating between June and September) ensure nationwide coverage (for 38 million residents) and are used to perform nearly 9000 missions annually. The most common incidents to which HEMS teams are dispatched include traffic accidents, cerebrovascular accidents, acute coronary syndromes, falls from height, and cardiac arrests. HEMS teams respond to nearly 500 cases of OHCA annually, accounting for approximately 6.5% of all HEMS missions [9].

The purpose of the study was to analyze the cases of OHCA to which HEMS teams were dispatched, including, in particular, the frequency of return of spontaneous circulation (ROSC). This is the first Polish study investigating OHCA in the work of HEMS teams.

Material and Methods

The study involved a retrospective analysis of missions performed by the Polish HEMS teams over a period of 6 years (between 1 January 2011 and 31 December 2016). The study included cases for which an HEMS team was dispatched to an OHCA incident. Cases for which the HEMS dispatch was cancelled, the patient was found not to have cardiac arrest, or the patient was confirmed dead were excluded from further analysis.

HEMS teams were dispatched by a medical dispatcher in the Emergency Response Center. The nearest helicopters were dispatched to the OHCA cases, taking off, depending on distance from the scene, within 3 min (60 km radius), 6 min (60 to 130 km), or 15 min (over 130 km) of the call being received by the emergency technician on duty. An HEMS team comprises a pilot, paramedic, and a physician. All helicopters carry the medical equipment and medication required to provide advanced pre-hospital post-resuscitation care, including advanced airway management, mechanical ventilation, and administration of muscle relaxants, sedatives, and inotropes.

Data were collected from HEMS medical records in line with the internationally recognized Utstein Style and captured in a Microsoft Excel database using the MS Office 2016 package for Windows 7. Statistical analysis of the results was performed using STATISTICA version 12.5 (StatSoft Poland). Quantitative data were described using the classical measures: arithmetical means (M), standard deviations (SD), and interquartile ranges (IQR). For qualitative data, numbers and percentages were reported. Significant differences between the qualitative variables analyzed were tested using the chi-squared test. Differences between 2 groups were tested using the nonparametric Mann-Whitney U test. Correlations and differences at $p < 0.05$ were considered statistically significant.

Results

In the study period, there were 42 271 HEMS missions, among which HEMS teams responded to 2447 cases of OHCA. Following the application of exclusion criteria, the total number of cases included was 2039. Out of 2039 patients provided with CPR by ground emergency medical teams or HEMS teams, ROSC occurred in 1119, which is 54.88% of all cases analyzed. In this patient group, ROSC was achieved before HEMS arrival on scene in 335 cases (29.94%) and during HEMS activities on scene in 784 cases (70.06%). Of the patients with ROSC, 915 (81.77%) were transported to hospital by the HEMS team and 204 (18.23%) by the ground team. The most common activities performed by HEMS teams were mechanical ventilation (n=755), sedation (n=438), and intubation (n=431). During CPR, the most commonly administered medication was adrenaline (n=760), and in post-resuscitation care, sodium hydrogen carbonate (n=214) and dopamine (n=182) (Figure 1).
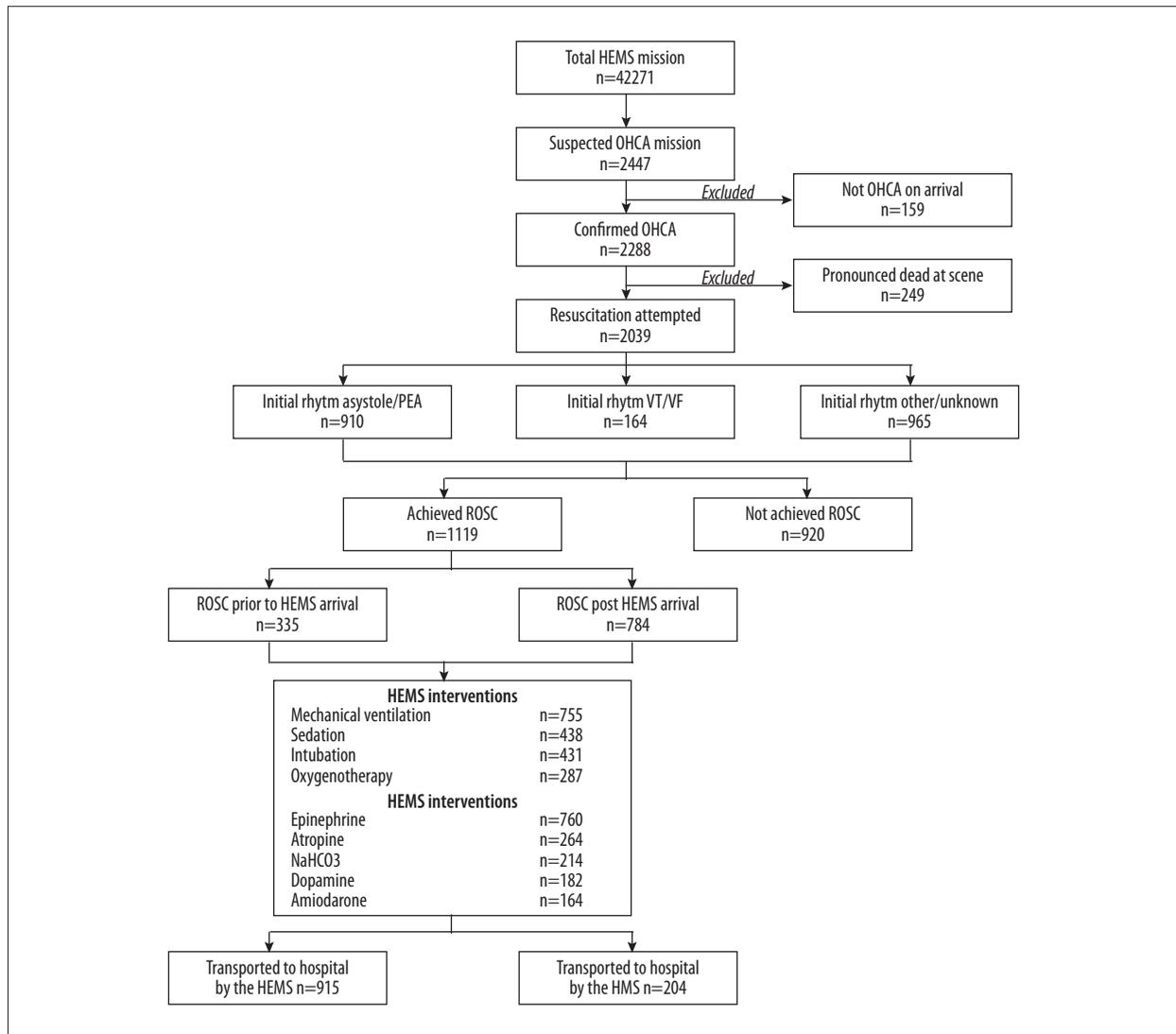
Figure 1. Summary of a HEMS mission in a case of OHCA and the medical interventions performed. HEMS – helicopter emergency medical service; EMS – emergency medical service; OHCA – out-of-hospital cardiac arrest; VT – ventricular tachycardia; VF – ventricular fibrillation; PEA – pulseless electrical activity; ROSC – return of spontaneous circulation; RSI – rapid sequence induction.

The patients studied were predominantly male (75.82%). Mean patient age was 59.82 years; OHCA occurred most commonly in patients aged 60–69 years (27.05%). HEMS teams were most commonly dispatched to assist the EMS team and were the first responders on scene in 187 cases (9.17%). The most common CA etiology in the group that was studied was cardiac (33.84%). In cases with unknown etiology, which accounted for nearly half of the cases (48.21%), a cardiac cause was assumed. The initial rhythm was most commonly unknown (38.74%), while asystole was the initial rhythm in most of the remaining cases (34.13%). Most patients in whom ROSC was achieved were transported to hospital by the HEMS team (81.77%) (Table 1).

Statistical analyses demonstrated that ROSC was correlated with sex, age, type of first responder, CA etiology, initial heart rhythm, and the team transporting the patient to hospital. In the group studied, ROSC occurred more commonly in women ($p < 0.05$), in patients younger than 40 ($p < 0.05$), in cases where an EMS team was the first responder on scene ($p < 0.001$), and in CA cases with a cardiac etiology ($p < 0.001$). An analysis of initial rhythms demonstrated that ROSC was achieved more often in cases with an unknown initial rhythm. In a comparison between shockable and non-shockable rhythms, ROSC occurred more frequently in cases with VF/VT ($p < 0.001$) and in patients transported to hospital by the HEMS team ($p < 0.001$) (Table 1).

Table 1. Characteristics and return of spontaneous circulation in patient subgroups.

	N (%)		ROSC (%)	Statistical analysis
Gender				
Female	488	(23.93)	60.66	
Male	1537	(75.38)	53.03	χ^2= 8.740 p=0.0031
Unknown	14	(0.69)	57.14	
	M (SD)		**ROSC (%)**	
Age, (years)				Z=4.334 p=0.0000
Mean	59.82	(18.38)	54.88	
	N (%)		**ROSC (%)**	
Age, (years)				
<40	161	(11.90)	65.81	
40–49	124	(9.16)	58.87	
50–59	296	(21.88)	56.42	
60–69	366	(27.05)	52.19	χ^2=18.555 p=0.0050
70–79	235	(17.37)	48.51	
80–89	157	(11.60)	46.50	
90+	14	(1.03)	42.86	
First responders				
HEMS	187	(9.17)	39.57	χ^2=19.483 p=0.0000
EMS	1852	(90.83)	56.43	
Aetiology				
Cardial	690	(33.84)	86.52	
Trauma	145	(7.11)	42.76	
Asphyxia	111	(5.44)	70.27	χ^2=898.960 p=0.0000
Other	146	(7.16)	59.59	
Unknown	293	(14.37)	78.50	
Missing	654	(32.07)	9.94	
Initial rhythm				
Asystole	696	(34.13)	15.09	
PEA	214	(10.50)	33.64	
VT/VF	164	(8.04)	42.68	χ^2=1064.672 p=0.0000
Bradycardia	56	(2.75)	75.00	
Unknown	790	(38.74)	96.84	
Missing	119	(5.84)	54.62	
Transported to hospital				
HEMS	915	(81.77)	99.78	χ^2=1922,263 p=0.0000
EMS	204	(18.23)	86.81	

Table 2. HEMS mission details.

	M (SD)		IQR
Time between HEMS call and take-off (min)	4	(2.2)	3–5
Time between HEMS call and arrival on scene (min)	23	(8.1)	17–26
Time between HEMS take-off and arrival on scene (min)	18	(6.9)	13–22
Time between HEMS call and patient hospitalisation (min)	71	(20.9)	61–86
Time of activities on scene (min)	26	(14.2)	17–32
Time of transport to hospital (min)	14	(5.7)	10–17
Distance to scene (km)	38	(20.4)	24–50
Distance to hospital (min)	37	(19.0)	23–47

The mean time between receipt of the call and take-off was 4 min (IQR 3–5 min). The mean time between receipt of the OHCA call and arrival on scene was 23 min (IQR 17–26 min). The mean distance that the HEMS teams traveled to arrive on scene was 38 km (IQR 24–50 km). The mean duration of activities on scene, regardless of outcome, was 26 min (IQR 17–31 min). In cases where ROCS was achieved and the patient was transported in the helicopter, the mean distance to hospital was 37 km (IQR 23–47 km), and the mean time in transport was 14 min (IQR 10–17 min). The mean duration of mission, from call receipt to patient hospitalization, was 71 min (IQR 61–86 min).

Discussion

Sudden cardiac arrest is a special situation that requires a great deal of effort and medical knowledge from the medical professionals performing CPR. A number of factors affect OHCA patient survival, illustrated by the "Chain of Survival" [5]. The first step to the ultimate goal, which is complete recovery after cardiac arrest, is the achievement of ROSC. The percentage of ROSC achievement varies, ranging between 10% and 50% [2]. In the present study, ROSC was achieved in 54.88% of cases overall and in 39.57% of cases for which the HEMS team was the only responder on scene. In a study by Lyon and Nelson (2013) investigating HEMS response to cases of OHCA, the ROSC percentage was 39% of all cases [8].

A study by Lyon and Nelson (2013) on HEMS responses to cases of OHCA reported a 39% ROSC for all cases [8]. In the present study, ROSC was achieved in 54.88% of cases overall, and in 39.57% of cases for which the HEMS team was the only responder on scene.

The present study shows that the percentage of OHCA was highest in male patients and in patients aged 60–69 (mean age: 59 years). In a study by Gräsner et al. (2016) presenting data on OHCA from 27 European countries, the mean age of OHCA patients was 66 years and 65.7% of the patients were male [2]. Similar results were obtained by Ong et al. (2015) in a study comprising 7 Asian countries. The mean age of OHCA patients was 69 years and 59.8% of all cases were male [10]. The present analysis also shows that in women and in patients younger than 40, resuscitation was successful and ROSC was achieved significantly more often. The present findings are also consistent with those reported by Kupari et al. (2017), Krishna et al. (2017), Requena-Morales et al. (2017), and Fan et al. (2017) in studies on OHCA [1,11–13].

Lyon and Nelson (2013) demonstrated that in England, in cases of OHCA, all HEMS calls were requests for assistance to EMS teams [8]. In the present study, HEMS teams were typically dispatched to assist emergency teams, and less commonly as first responders. Skogvoll et al. (2000) pointed out the effect of advanced post-resuscitation care provided by HEMS teams on improved survival rates in OHCA patients [14]. All HEMS teams in Poland include a physician, which affects the frequency of calls to assist ground EMS teams by providing advanced post-resuscitation care. This is due to the fact that EMTs and nurses in emergency teams are not authorized to implement some advanced protocols, such as administration of sedatives, muscle relaxants, or inotropics [9].

The identification of cardiac arrest etiology depends on multiple factors, including the region where a study was performed, or care in establishing the cause of cardiac arrest. In many cases, this information is difficult to obtain [10,15]. In the present study, the cause of cardiac arrest was most commonly cardiac. This finding is corroborated by a number of studies analyzing OHCA in Europe and in other regions of the world [2,10,15–17]. The large proportion of OHCA cases of cardiac origin is largely due to the Utstein definition of CA origin, in which "cardiac origin" comprises both cases with an obvious cardiac cause and cases where signs of other causes were absent [18]. Statistical analysis showed that ROSC occurs more often in CA cases of cardiac origin. The present results are confirmed by those reported by Kupari et al. (2017) [1].

The initial rhythm in the patient group studied was unknown, due to lack of this information in the medical documentation of the EMS teams working on scene before HEMS arrival. In those cases where the initial rhythm was known, the most common was asystole. In the present study, initial rhythms were non-shockable in most of the patients studied. A comparison of cases with shockable and non-shockable rhythms demonstrated that ROSC was achieved more often in cases where the initial rhythm was shockable. The studies by Cebula

et al. (2016), Krishna et al. (2017), Hawkes et al. (2017), Schewe et al. (2017), Hess et al. (2007), Requena-Morales et al. (2017), and Fan et al. (2017) corroborate the present findings, confirming the overall upward trend in the number of non-shockable rhythm cases in OHCA, as well as the higher effectiveness of resuscitation and higher percentage of ROSC [11–13,15,19–21].

The present study showed that most patients who have undergone ROSC are transported to hospital by the HEMS team, which demonstrates that dispatching HEMS teams to cases of OHCA is justified. According to Werman et al. (1999), advanced life support and quick transport to hospital, especially in cases of cardiac arrest due to an acute coronary syndrome, are justified, as the patients require quick coronary intervention [22]. Despite the lack of evidence for the effect of quick transport to hospital on survival after an OHCA, the use of helicopters for transporting patients following a cardiac arrest has many benefits, though it is also associated with risk and additional costs [7].

Conclusions

Our study results are consistent with global trends in terms of OHCA incidence and the effectiveness of CPR performed on scene. The study also demonstrates that HEMS dispatch to OHCA cases is justified both as a means of providing assistance to EMS teams on scene and as the first choice. Implementation of advanced post-resuscitation care on scene and during transport to hospital may increase the likelihood of patient survival until discharge from hospital with a good neurological condition. Further studies on the utility of HEMS interventions in cases of cardiac arrest are warranted.

Conflict of interests

None.

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