Does the presence of physician-staffed emergency medical services improve the prognosis in out-of-hospital cardiac arrest? A propensity score matching analysis

Kamil Bujak[1], Klaudiusz Nadolny[2, 3], Przemysław Trzeciak[1], Robert Gałązkowski[4], Jerzy Robert Ładny[5], Mariusz Gąsior[1]

[1]3rd Department of Cardiology, Faculty of Medical Sciences in Zabrze, Medical University of Silesia, Katowice, Poland
[2]Faculty of Medicine, Katowice School of Technology, Katowice, Poland
[3]Departament of Health Sciences, WSB University, Dąbrowa Górnicza, Poland
[4]Department of Emergency Medical Service, Medical University of Warsaw, Warszawa, Poland
[5]Department of Emergency Medicine, Medical University of Bialystok, Białystok, Poland

Correspondence to:
Kamil Bujak, MD,
3rd Department of Cardiology,
Faculty of Medical Sciences
in Zabrze,
Medical University of Silesia
in Katowice;
Silesian Center for Heart Diseases,
M Skłodowskiej-Curie 9,
41–800 Zabrze, Poland,
phone: +48 32 37 33 860,
e-mail: kamil_bujak@o2.pl;
k.bujak@sccs.pl

DOI: 10.33963/KP.a2022.0109

Received:
March 3, 2021

Accepted:
April 20, 2022

Early publication date:
April 21, 2022

ABSTRACT

Background: Substantial differences in survival after out-of-hospital cardiac arrest (OHCA) have been observed between countries. These might be attributed to the organization of emergency medical service (EMS) systems, including prehospital physician involvement. However, limited data exist on the physician's role in improving survival after OHCA.

Aims: To compare prehospital and in-hospital outcomes of OHCA patients attended by physician-staffed EMS vs. paramedic-staffed EMS units.

Methods: Among all patients enrolled in the regional, prospective registry of OHCA in southern Poland, we excluded those aged <18 years, with unwitnessed or EMS-witnessed cardiac arrest, without attempted cardiopulmonary resuscitation (CPR), attended by more than one EMS, or with traumatic cardiac arrest. The groups were matched 1:1 using propensity scores for baseline characteristic variables that might influence physician-staffed EMS dispatch.

Results: A total of 812 OHCA cases were included in the current analysis. Among them, 351 patients were attended by physician-staffed EMS. There were no differences in baseline characteristics in the propensity-score matched cohort consisting of 351 pairs. The return of spontaneous circulation (ROSC) was more often achieved in the physician-staffed EMS group (42.7% vs. 33.3%; $P = 0.01$). The prehospital survival rate was also higher in this group (34.1% vs. 19.2%; $P < 0.01$). However, there were no significant differences in survival rate to discharge between cases treated by physician-staffed and paramedic-staffed EMS (9.7% vs. 7.0%; $P = 0.22$).

Conclusions: OHCA patients attended by physician-staffed EMS were more likely to have ROSC and survive till hospital admission. However, better prehospital outcomes might not translate into improved in-hospital prognosis in these patients.

Key words: cardiopulmonary resuscitation, emergency medical service, out-of-hospital cardiac arrest, paramedic, physician

INTRODUCTION

Out-of-hospital cardiac arrest (OHCA) affecting 55 persons per 100 000 population per year worldwide is a significant public health problem [1]. In Poland, the incidence rate of OHCA has been shown to be even higher (over 25 000 cases yearly; 69 per 100 000 person-years) [2]. Even though within the last few years, improving temporal trends in OHCA outcomes have been observed in some countries [3–5]; globally, the survival to hospital discharge remains low, not exceeding 10% [1]. Substantial variability in OHCA outcomes between countries might be attributed to

WHAT'S NEW?

Data on the role of emergency medical service (EMS) physicians in out-of-hospital cardiac arrest (OHCA) is limited. Notably, there have not been any studies comparing outcomes of OHCA cases attended by physician-staffed EMS and paramedic-staffed EMS units in the context of the Polish EMS system. Using Utstein-style OHCA registry data and propensity-score matching, we have shown for the first time that OHCA patients attended by physician-led EMS are more likely to have the return of spontaneous circulation and have a higher survival rate to hospital admission. However, a higher pre-hospital survival rate in patients treated by physician-staffed EMS does not translate into improved in-hospital prognosis.

social, demographic, economic, and cultural factors, as well as differences in the organization of emergency medical service (EMS) systems, including prehospital physician involvement [6].

Although most of the recent observational studies showed improved outcomes for OHCA patients attended by physician-staffed EMS, compared with paramedic teams, controversies still exist about the physician's role in prehospital scenarios [3, 7–13]. Therefore, we aimed to assess whether the presence of physician-staffed EMS at the scene is associated with improved prehospital and in-hospital outcomes of OHCA compared with EMS teams without physicians, using a regional, prospective, Utstein-style registry of OHCAs in southern Poland.

METHODS

SIL-OHCA registry

The Silesian Registry of Out-of-Hospital Cardiac Arrests (SIL-OHCA; ClinicalTrials.gov Identifier: NCT03654859) was a prospective, population-based registry of OHCAs in Upper-Silesia, Poland (7% of Polish population; 2.7 million people). All EMS-treated OHCA patients between January 1, and December 31, 2018 were enrolled. Prehospital data were collected by EMS providing CPR using paper-based case-report forms conforming to the Utstein guidelines [14]. Subsequently, the prehospital data were digitalized, checked for duplicates and logical errors, and linked with the administrative data from a national insurer (National Health Fund [NHF]). The NHF database includes data on hospital stay duration, procedures performed during the index hospitalization, and in-hospital survival status. Information on medical procedures performed during index hospitalization was based on an International Classification System for Surgical, Diagnostic, and Therapeutic Procedures (ICD-9-CM) codes. Approval for research was waived by the Bioethics Committee of the Medical University of Silesia (no. PCN/CBN/0022/KB/159/21), given the observational nature of the study. The study design of SIL-OHCA and other details on the registry have been presented previously [15–17].

System description

The population served by Voivodeship Rescue Service in Katowice is 2.7 million people (7% of the Polish population), and the annual number of EMS responses is about 250 000. During the study period, the Voivodeship Rescue Service in Katowice was the only public EMS provider in the area covered by the registry (the Upper-Silesia region, which is a highly urbanized part of Poland; 1.2% of the area of Poland) and operated 88 EMS ambulances, including 59 paramedic-manned ambulances, consisting mainly of at least two paramedics (or less often EMS nurses) and 29 physician-manned ambulances (so-called "specialized teams") consisting of at least two paramedics or EMS nurses and one physician (in most cases specialist in anesthesiology and intensive care or emergency medicine, and rarely in internal diseases, general surgery, pediatrics, pediatric surgery or orthopedics, and traumatology). OHCA cases recognized by the dispatcher usually received priority for physician-staffed EMS dispatch if the expected response time for physician-staffed EMS and paramedic-staffed EMS were equal. However, in the case of a lack of available physician-staffed ambulances or an estimated longer response time of those teams, the first available paramedic team was dispatched to avoid delays.

In the case of OHCA, paramedics and EMS nurses in Poland are credentialed to perform procedures recommended by the European Resuscitation Council (ERC) guidelines on advanced life support (ALS), i.e., using a manual defibrillator, securing the airway with either a tracheal tube or supraglottic devices, and administering resuscitation drugs [18, 19]. Moreover, according to Polish law, paramedics and EMS nurses are allowed to withhold or terminate CPR. However, contrary to physicians, they are not credentialed to certify deaths. Furthermore, in Poland, the first-responder system has not been widely implemented, except for the firefighters of the State Fire Service, who are trained for CPR, including the use of an automated external defibrillator (AED), and may be dispatched by the dispatcher to initiate CPR when a long delay to EMS arrival is expected.

Patients

Out of all patients included in SIL-OHCA, we excluded from the current analysis those aged below 18 years, with unwitnessed collapse or cardiac arrest witnessed by EMS, without attempted or continued CPR by EMS, treated by more than one EMS team, those with traumatic cardiac arrest, or with missing data on the type of EMS. Subsequently, the included patients were divided into two groups according to

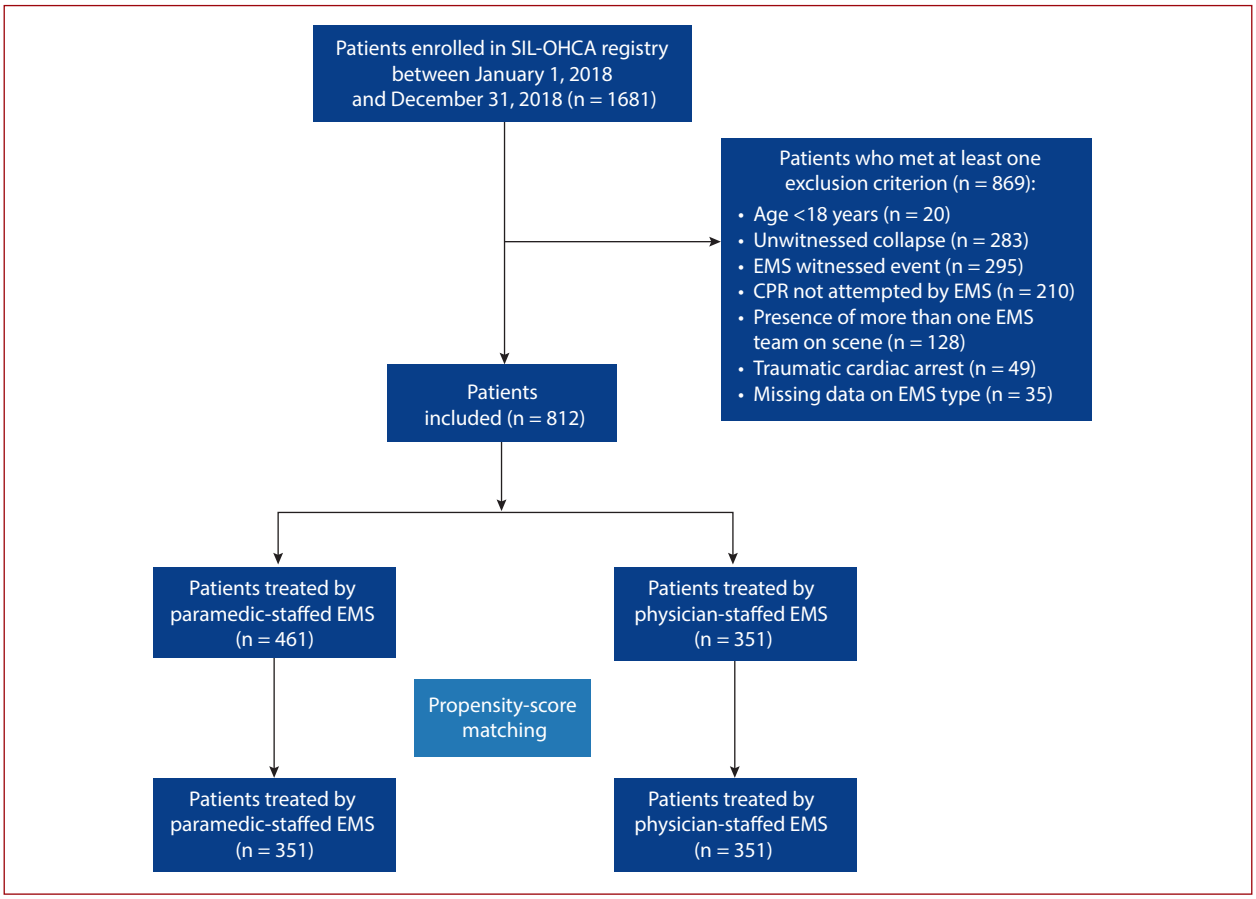

Figure 1. Flowchart of the study population

Abbreviations: SIL-OHCA, Silesian Registry of Out-of-Hospital Cardiac Arrests; other — see Table 1

the physician's presence or absence on board. A flowchart of the study has been shown in Figure 1.

Definitions

Return of spontaneous circulation (ROSC) was defined as the achievement of ROSC at any point during the resuscitation attempt. Survival to hospital admission was interpreted as arrival at the emergency department and transfer of care to the medical staff at the receiving hospital after ROSC. Survival to discharge was considered as discharging the patient from hospital alive. The medical etiology of OHCA refers to all cases without evidence of trauma, drowning, intoxication, electrocution, or asphyxia. Response time and defibrillation time were defined as the period from incoming call to arrival of the ambulance and the first shock delivery. The time to termination of CPR was the period from arrival of the ambulance to cessation of CPR. The above-mentioned and other definitions were based on the 2015 Utstein recommendations [14].

Statistical analysis

Categorical variables are shown as the number of patients and percentage. The normality of continuous data was assessed using the Shapiro–Wilk test, and owing to nonnormal distribution, these variables are shown as median and interquartile ranges. Categorical and continuous variables were compared by the χ^2 test and Mann–Whitney U test, respectively. To manage differences in the baseline characteristics between patients treated by physician-staffed and paramedic-staffed EMS, one-to-one propensity score matching (nearest neighbor algorithm) was used. The groups were matched for baseline characteristics that potentially might influence the decision of physician-staffed EMS dispatch, i.e., sex, age, previous cardiovascular disease, previous stroke, malignancy, chest pain before cardiac arrest, location of OHCA, cause of cardiac arrest, bystander CPR before EMS arrival, response time, and first monitored rhythm. Before matching, missing data on baseline characteristics were imputed using the k-nearest neighbors algorithm. Crude odds ratios (OR) and 95% confidence intervals (CI) were calculated for the association between the presence of physician-staffed EMS and ROSC, survival to hospital admission, and survival to hospital discharge in the propensity-score matched cohort. The level of statistical significance was P <0.05 (two-tailed). Statistica version 13.3 (TIBCO Software, Palo Alto, CA, US) was applied for all computational analyses.

Table 1. Baseline characteristics of OHCA patients attended by physician-staffed EMS vs. paramedic-staffed EMS (before propensity-score matching)

	Paramedic-staffed EMS (n = 461)	Physician-staffed EMS (n = 351)	*P*-value
Male sex, n (%)	327 (70.9)	244 (69.5)	0.66
Age, years, median (IQR)	67 (58–78)	66 (58–77)	0.41
Previous CVD, n (%)	141 (30.6)	98 (27.9)	0.41
Previous stroke, n (%)	41 (8.9)	21 (6.0)	0.12
Malignancy, n (%)	34 (7.4)	30 (8.6)	0.54
Chest pain before OHCA, n (%)	52 (11.3)	31 (8.8)	0.25
Location, n (%)			0.57
Home	347 (75.3)	258 (73.5)	
Other	114 (24.7)	93 (26.5)	
Cause, n (%)			0.08
Medical	423 (91.8)	309 (88.0)	
Other	38 (8.2)	42 (12.0)	
Bystander CPR, n (%)	253 (54.9)	172 (49.0)	0.10
Response time, minutes, median (IQR)	8 (6–10)	9 (6–12)	<0.01
First monitored rhythm			0.75
VF/pulseless VT, n (%)	128 (27.8)	101 (28.8)	
PEA/asystole, n (%)	333 (72.2)	250 (71.2)	

Categorical variables are shown as the number of patients (%). Continuous data are presented as median (IQR)

Abbreviations: CVD, cardiovascular disease; CPR, cardiopulmonary resuscitation; EMS, emergency medical service; OHCA, out-of-hospital cardiac arrest; PEA, pulseless electrical activity; VF, ventricular fibrillation; VT, ventricular tachycardia

Table 2. Prehospital and in-hospital outcomes of OHCA patients attended by physician-staffed vs. paramedic-staffed ambulances (before propensity-score matching)

	Paramedic-staffed EMS (n = 461)	Physician-staffed EMS (n = 351)	*P*-value
ROSC	147 (32.2)	147 (42.7)	<0.01
Survival to hospital admission	75 (18.2)	118 (34.1)	<0.01
Survival to hospital discharge	25 (6.3)	30 (9.7)	0.10

Data are shown as number of patients (%)

Abbreviations: ROSC, return of spontaneous circulation; other — see Table 1

RESULTS

A total of 812 OHCA patients were included in the analysis. Among them, 351 were attended by physician-led EMS and 461 by EMS without a physician. There were no differences in sex, age, comorbidities, presence of chest pain preceding OHCA, location of cardiac arrest, the rate of bystander CPR before EMS arrival, and initial shockable rhythm between groups. However, the response time of paramedic-staffed EMS was significantly shorter. Moreover, there was a trend towards a higher rate of other causes of OHCA than medical in cases treated by physician-staffed EMS teams (Table 1). The presence of a physician on the scene was associated with a higher rate of ROSC and higher survival to admission. However, there were no differences regarding survival status at discharge (Table 2).

After propensity-score analysis, there were no differences in baseline characteristics between 351 matched pairs of patients (Table 3). EMS physicians more frequently performed endotracheal intubation and were less likely to use supraglottic airway devices than paramedic-led EMS teams. Moreover, atropine and amiodarone were more often administered to patients receiving physician-led CPR. On the other hand, there was a trend regarding ECG e-transmission to the nearest invasive cardiology center after ROSC, which was less frequently performed by emergency teams with a physician on board. There were no other significant differences in prehospital and in-hospital treatment between the groups, including administration of other drugs, time to the first defibrillation and the total number of defibrillation shocks, vascular access, and coronary revascularization (Table 4). In patients who did not achieve ROSC, the decision of CPR termination was made earlier, when the physician was present on the scene. The duration of hospital stay was similar in both groups (Table 4).

The data on ROSC, survival to admission, and survival to discharge in propensity-matched cohorts were available for 692 (98.6%), 659 (93.9%), and 610 (86.9%), respectively. CPR provided by physician-staffed units was associated with a higher rate of ROSC and survival to hospital admission. However, there was no significant difference in survival to hospital discharge (Figure 2).

DISCUSSION

Emergency medical service systems' organization differs between countries, which may partially be the reason for

Table 3. Baseline characteristics of OHCA patients attended by physician-staffed EMS vs. paramedic-staffed EMS (after propensity-score matching)

	Paramedic-staffed EMS (n = 351)	Physician-staffed EMS (n = 351)	*P*-value
Male sex, n (%)	239 (68.1)	244 (69.5)	0.68
Age, years, median (IQR)	67 (57–77)	66 (58–77)	0.98
Previous CVD, n (%)	99 (28.1)	98 (27.9)	0.93
Previous stroke, n (%)	21 (6.0)	21 (6.0)	1.0
Malignancy, n (%)	27 (7.7)	30 (8.6)	0.67
Chest pain before OHCA, n (%)	29 (8.3)	31 (8.8)	0.79
Location, n (%)			0.67
Home	253 (72.1)	258 (73.5)	
Other	98 (27.9)	93 (26.5)	
Cause, n (%)			0.55
Medical	314 (89.5)	309 (88.0)	
Other	37 (10.5)	42 (12.0)	
Bystander CPR, n (%)	178 (50.7)	172 (49.0)	0.65
Response time, minutes, median (IQR)	8 (6–11)	9 (6–12)	0.1
First monitored rhythm, n (%)			0.62
VF/pulseless VT	107 (30.5)	101 (28.8)	
PEA/asystole	244 (69.5)	250 (71.2)	

Categorical variables are shown as the number of patients (%). Continuous data are presented as median (IQR)

Abbreviations: see Table 1

Table 4. Prehospital and in-hospital treatment of OHCA according to presence or absence of a physician on the scene (after propensity score matching)

	Paramedic-staffed EMS (n = 351)	Physician-staffed EMS (n = 351)	*P*-value
Prehospital treatment			
Defibrillation time, minutes, median (IQR)	10.5 (8–18)	13.5 (7–26)	0.43
Number of defibrillation shocks, median (IQR)	2 (1–4)	2 (1–4)	0.64
Supraglottic airway, n (%)	140 (42.8)	57 (17.1)	<0.01
Endotracheal intubation, n (%)	195 (59.6)	251 (75.4)	<0.01
Routes of medication administration, n (%)			0.31
Peripheral IV	317 (99.1)	314 (98.1)	
IO	3 (0.9)	6 (1.9)	
Adrenaline, n (%)	310 (97.5)	310 (95.4)	0.15
Amiodarone, n (%)	113 (35.5)	140 (43.1)	0.05
Atropine, n (%)	104 (32.7)	148 (45.5)	<0.01
Lidocaine, n (%)	1 (0.3)	2 (0.6)	0.57
Magnesium sulfate, n (%)	12 (3.8)	6 (1.9)	0.14
UFH, n (%)	11 (3.5)	19 (5.9)	0.15
ECG e-transmission after ROSC, n (%)	43 (42.2)	40 (30.8)	0.07
Transport to hospital without ROSC, n (%)	6 (1.9)	10 (2.9)	0.42
Time to termination of CPR, minutes, median (IQR)	37 (28–49.5)	32 (21–42.5)	<0.01
In-hospital treatment			
Coronary angiography, n (%)	22 (7.3)	32 (10.4)	0.18
Myocardial revascularization, n (%)	16 (6.1)	22 (9.2)	0.19
ICD/CRT-D implantation, n (%)	5 (1.7)	3 (1.0)	0.45
Duration of hospital stay, days, median (IQR)	9 (4–19)	11 (2–30)	0.45

Categorical variables are shown as the number of patients (%). Continuous data are presented as median (IQR)

Abbreviations: CRT-D, cardiac resynchronization therapy defibrillator; ECG, electrocardiogram; IO, intraosseous; IV, intravenous; UFH, unfractionated heparin; other — see Tables 1 and 2

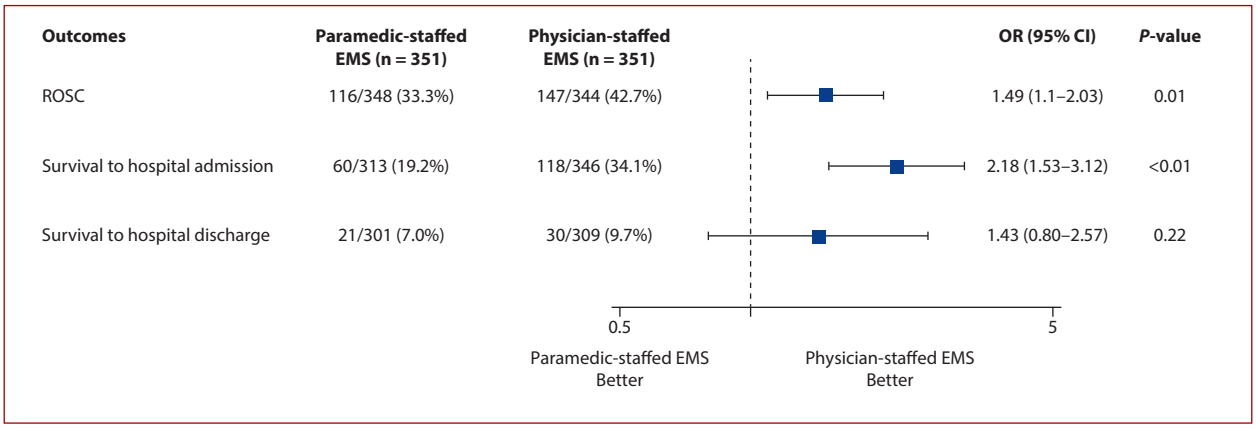

Figure 2. The prehospital and in-hospital outcomes of out-of-hospital cardiac arrest patients attended by physician-manned vs. paramedic-manned ambulances (after propensity-score matching)

Abbreviations: see Table 1 and 2

the variability of OHCA outcomes worldwide [10, 20]. One of these differences refers to the utilization of physician-led EMS or paramedic-led EMS [21]. Both models are being used in developed countries, and limited data support the advantage of one of these options [9, 21]. However, the physician-led EMS model is associated with increased costs [10]. Therefore, the application of physician-staffed EMS should be informed by robust, high-quality scientific data demonstrating improved patient outcomes.

Unfortunately, in the context of OHCA, there are no randomized clinical trials comparing physician- and paramedic-led EMS models, to the best of our knowledge. Moreover, such a randomized clinical trial may be challenging to carry out due to potential costs and logistic issues. Then, the best available evidence on the role of EMS-physician in OHCA so far comes from several observational studies and a meta-analysis pooling their results [3, 9, 13]. Almost all of them showed that the physician's presence in the prehospital setting is associated with improved prehospital outcomes, survival to discharge or 30-day survival, and 1-month neurologically intact survival [3, 8, 9, 13, 22–25]. On the contrary, our study has demonstrated that in the cohort of Polish, non-traumatic OHCA patients, physician-led CPR is associated with improved ROSC and survival-to-admission rates, but this does not translate into higher survival to discharge as compared to CPR provided by paramedics. Notably, there are remarkable differences in our study's design and EMS system in Poland as opposed to previous reports.

First, the presence of physicians on the scene in previous studies was defined in various ways [3, 9, 13]. Physicians are not an integral part of the EMS team in some EMS systems and arrive at the scene independently from EMS. Therefore, it is hard to assess their contribution to the CPR [9]. Moreover, in other studies, only physicians who had happened to be at the scene at the moment of the patient's collapse or who had happened to be in the ambulance for the training of the ambulance crew might have been engaged in prehospital CPR [8]. Contrary to these studies, in Poland, EMS physicians are an integral part of so-called "specialized" emergency medical units; they accounted for one-third of all ambulance teams in the area covered by our registry during the study period.

Second, OHCA cases in Poland usually receive priority for physician-staffed EMS dispatch (if both teams are available when receiving an emergency call and expected response times are the same). However, as we have shown in our study, most of the bystander witnessed, non-traumatic OHCA cases are attended by paramedic-staffed EMS to reduce response time. Thus, the absence of a physician on the scene is mainly driven by the lack of availability of physician-manned ambulances at a given moment, which is random. However, similar to previous studies, we could not exclude that physician-staffed EMS might not have been dispatched if it was futile in the assessment of dispatchers [3, 9]. Therefore, to reduce the selection bias, we excluded patients with initially poor prognosis, i.e., patients with unwitnessed collapse, traumatic cause, and those treated by more than one EMS team (as the dispatch of the second ambulance is usually associated with prolonged CPR and no ROSC); we also matched groups using propensity scores. Notwithstanding, our study still might be biased by unmeasured confounding owing to its observational design.

Third, not in all EMS systems paramedics are allowed the same scope of practice in terms of ALS as the EMS physicians [8–10]. Conversely, in Poland, in the prehospital settings, paramedics are credentialed to perform procedures such as endotracheal intubation, using manual defibrillators, obtaining intravascular access, and administering guideline-recommended medications during CPR. However, in our study, the physician-manned ambulance teams more often performed endotracheal intubation than paramedics. There are at least two possible explanations for this. First, considering that endotracheal intubation in the OHCA setting is challenging, and paramedics, who are

less experienced in this procedure than physicians (mostly anesthesiologists, who obtain these skills also during planned procedures in the operating room), were more likely to choose supraglottic airway (SGA) devices [26]. The second possible explanation is that the crew size of physician-manned ambulances is usually larger (three vs. two medically trained rescuers), which provides an extra pair of hands for endotracheal intubation. Although, it contrasts with previous randomized simulation trials, which have not shown the advantage of three rescuers compared to two rescuers in ALS effectiveness [27, 28].

Nonetheless, it is worth emphasizing that the advantage of endotracheal intubations during OHCA is controversial [26]. The only ALS interventions consistently shown to improve outcomes are high-quality chest compressions and early defibrillation [18, 19]. In this context, it should be noted that the time interval from call to ambulance arrival in the physician-staffed EMS group before propensity-score matching was significantly longer, probably due to the lower availability of these ambulances. Although the response time is one of many factors influencing ROSC and survival after OHCA, it is important to stress that the longer response time of physician-staffed ambulances might reduce the potential benefits of physician-led CPR.

Moreover, our study also has other limitations that should be acknowledged. Based on our data, we could not determine whether there are any differences in post-ROSC care, which may explain improved prehospital survival in patients treated by physician-led EMS. Patients after ROSC are often unstable, so there might be some potential benefits from physicians' experience and skills, but further studies need to evaluate this hypothesis. What is more, since in-hospital data was derived from administrative data, we had no information on neurological outcomes at discharge. Finally, the generalizability of our findings is limited and may not apply to other countries or regions with much different legislation and EMS systems organization.

In summary, our study showed that OHCA patients attended by physician-staffed EMS were more likely to have ROSC and survive till hospital admission. However, better prehospital outcomes might not translate into improved in-hospital prognosis in these patients.

Article information

Conflict of interest: None declared.

Funding: None.

REFERENCES

1. 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(1): 61, doi: 10.1186/s13054-020-2773-2, indexed in Pubmed: 32087741.
2. Nadolny K, Zyśko D, Obremska M, et al. Analysis of out-of-hospital cardiac arrest in Poland in a 1-year period: data from the POL-OHCA registry. Kardiol Pol. 2020; 78(5): 404–411, doi: 10.33963/KP.15241, indexed in Pubmed: 32191020.
3. Hamilton A, Steinmetz J, Wissenberg M, et al. Association between prehospital physician involvement and survival after out-of-hospital cardiac arrest: A Danish nationwide observational study. Resuscitation. 2016; 108: 95–101, doi: 10.1016/j.resuscitation.2016.08.007, indexed in Pubmed: 27565859.
4. Ro YS, Shin SDo, Kitamura T, et al. Temporal trends in out-of-hospital cardiac arrest survival outcomes between two metropolitan communities: Seoul-Osaka resuscitation study. BMJ Open. 2015; 5(6): e007626, doi: 10.1136/bmjopen-2015-007626, indexed in Pubmed: 26059524.
5. Buick JE, Drennan IR, Scales DC, et al. Improving temporal trends in survival and neurological outcomes after out-of-hospital cardiac arrest. Circ Cardiovasc Qual Outcomes. 2018; 11(1): e003561, doi: 10.1161/CIRCOUTCOMES.117.003561, indexed in Pubmed: 29317455.
6. Gräsner JT, Wnent J, Herlitz J, et al. Survival after out-of-hospital cardiac arrest in Europe — Results of the EuReCa TWO study. Resuscitation. 2020; 148: 218–226, doi: 10.1016/j.resuscitation.2019.12.042, indexed in Pubmed: 32027980.
7. Sato N, Matsuyama T, Akazawa K, et al. Benefits of adding a physician-staffed ambulance to bystander-witnessed out-of-hospital cardiac arrest: a community-based, observational study in Niigata, Japan. BMJ Open. 2019; 9(11): e032967, doi: 10.1136/bmjopen-2019-032967, indexed in Pubmed: 31772105.
8. Hagihara A, Hasegawa M, Abe T, et al. Physician presence in an ambulance car is associated with increased survival in out-of-hospital cardiac arrest: a prospective cohort analysis. PLoS One. 2014; 9(1): e84424, doi: 10.1371/journal.pone.0084424, indexed in Pubmed: 24416232.
9. Böttiger BW, Bernhard M, Knapp J, et al. Influence of EMS-physician presence on survival after out-of-hospital cardiopulmonary resuscitation: systematic review and meta-analysis. Crit Care. 2016; 20: 4, doi: 10.1186/s13054-015-1156-6, indexed in Pubmed: 26747085.
10. von Vopelius-Feldt J, Benger JR. Should physicians attend out-of-hospital cardiac arrests? Resuscitation. 2016; 108: A6–A7, doi: 10.1016/j.resuscitation.2016.08.030, indexed in Pubmed: 27616583.
11. Fukuda T, Ohashi-Fukuda N, Kondo Y, et al. Association of prehospital advanced life support by physician with survival after out-of-hospital cardiac arrest with blunt trauma following traffic collisions: japanese registry-based study. JAMA Surg. 2018; 153(6): e180674, doi: 10.1001/jamasurg.2018.0674, indexed in Pubmed: 29710068.
12. Jackson RJH, Nolan JP. Improving outcome in out-of-hospital cardiac arrest: impact of bystander cardiopulmonary resuscitation and prehospital physician care. Crit Care. 2011; 15(1): 101, doi: 10.1186/cc9356, indexed in Pubmed: 21244719.
13. Estner HL, Günzel C, Ndrepepa G, et al. Outcome after out-of-hospital cardiac arrest in a physician-staffed emergency medical system according to the Utstein style. Am Heart J. 2007; 153(5): 792–799, doi: 10.1016/j.ahj.2007.02.032, indexed in Pubmed: 17452155.
14. Perkins G, Jacobs I, Nadkarni V, et al. Cardiac arrest and cardiopulmonary resuscitation outcome reports: update of the utstein resuscitation registry templates for out-of-hospital cardiac arrest. Resuscitation. 2015; 96: 328–340, doi: 10.1016/j.resuscitation.2014.11.002.
15. Nadolny K, Bujak K, Kucap M, et al. The Silesian Registry of Out-of-Hospital Cardiac Arrest: Study design and results of a three-month pilot study. Cardiol J. 2020; 27(5): 566–574, doi: 10.5603/CJ.a2018.0140, indexed in Pubmed: 30444257.
16. Bujak K, Nadolny K, Ładny JR, et al. Epidemiology, management, and survival rate of out-of-hospital cardiac arrest in Upper Silesia, Poland: an Utstein-style report. Postepy Kardiol Interwencyjnej. 2021; 17(4): 366–375, doi: 10.5114/aic.2021.111926, indexed in Pubmed: 35126551.

17. Nadolny K, Bujak K, Obremska M, et al. Glasgow Coma Scale score of more than four on admission predicts in-hospital survival in patients after out-of-hospital cardiac arrest. Am J Emerg Med. 2021; 42: 90–94, doi: 10.1016/j.ajem.2021.01.018, indexed in Pubmed: 33497899.
18. Monsieurs KG, Nolan JP, Bossaert LL, et al. European Resuscitation Council Guidelines for Resuscitation 2015: Section 1. Executive summary. Resuscitation. 2015; 95: 1–80, doi: 10.1016/j.resuscitation.2015.07.038, indexed in Pubmed: 26477410.
19. Soar J, Böttiger BW, Carli P, et al. European Resuscitation Council Guidelines 2021: Adult advanced life support. Resuscitation. 2021; 161(4): 115–151, doi: 10.1016/j.resuscitation.2021.02.010, indexed in Pubmed: 33773825.
20. Gräsner JT, 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: 188–195, doi: 10.1016/j.resuscitation.2016.06.004, indexed in Pubmed: 27321577.
21. Borowicz A, Nadolny K, Bujak K, et al. Paramedic versus physician-staffed ambulances and prehospital delays in the management of patients with ST-segment elevation myocardial infarction. Cardiol J. 2021; 28(1): 110–117, doi: 10.5603/CJ.a2019.0072, indexed in Pubmed: 31313273.
22. Yasunaga H, Horiguchi H, Tanabe S, et al. Collaborative effects of bystander-initiated cardiopulmonary resuscitation and prehospital advanced cardiac life support by physicians on survival of out-of-hospital cardiac arrest: a nationwide population-based observational study. Crit Care. 2010; 14(6): R199, doi: 10.1186/cc9319, indexed in Pubmed: 21050434.
23. Schewe JC, Kappler J, Heister U, et al. Outcome of out-of-hospital cardiac arrest over a period of 15 years in comparison to the RACA score in a physician staffed urban emergency medical service in Germany. Resuscitation. 2015; 96: 232–238, doi: 10.1016/j.resuscitation.2015.07.025, indexed in Pubmed: 26303572.
24. Yen ZS, Chen YT, Ko PCI, et al. Cost-effectiveness of different advanced life support providers for victims of out-of-hospital cardiac arrests. J Formos Med Assoc. 2006; 105(12): 1001–1007, doi: 10.1016/S0929-6646(09)60284-9, indexed in Pubmed: 17185242.
25. Goto Y, Funada A, Goto Y. Impact of prehospital physician-led cardiopulmonary resuscitation on neurologically intact survival after out-of-hospital cardiac arrest: A nationwide population-based observational study. Resuscitation. 2019; 136: 38–46, doi: 10.1016/j.resuscitation.2018.11.014, indexed in Pubmed: 30448503.
26. Wang HE, Benger JR. Endotracheal intubation during out-of-hospital cardiac arrest: New insights from recent clinical trials. J Am Coll Emerg Physicians Open. 2020; 1(1): 24–29, doi: 10.1002/emp2.12003, indexed in Pubmed: 33000010.
27. Martin-Gill C, Guyette FX, Rittenberger JC. Effect of crew size on objective measures of resuscitation for out-of-hospital cardiac arrest. Prehosp Emerg Care. 2010; 14(2): 229–234, doi: 10.3109/10903120903572293, indexed in Pubmed: 20128704.
28. Tsai BM, Sun JT, Hsieh MJ, et al. Correction: Optimal paramedic numbers in resuscitation of patients with out-of-hospital cardiac arrest: A randomized controlled study in a simulation setting. PLoS One. 2020; 15(12): e0244400, doi: 10.1371/journal.pone.0244400, indexed in Pubmed: 33332453.