Age-related differences in the prehospital management of 2,500 patients with sudden cardiac arrest

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Abstract

Introduction: Prehospital care affects outcomes after out-of-hospital cardiac arrest (OHCA). The aim of the study is to analyze age-related differences in prehospital care and survival after OHCA and to define variables affecting the efficacy of cardiopulmonary resuscitation (CPR).
Material and methods: We performed analysis of differences in patient characteristics influencing the efficacy of CPR and analysis of survival in four age groups: < 65, 65–74, 75–84, and ≥ 85. This retrospective registry-based study aimed to compare prehospital care in OHCA patients across age groups.
Results: CPR was performed in 2,500 patients. Return of spontaneous circulation (ROSC) occurred in 1061 subjects. Of them, 339 had incomplete medical records, 201 survived at least 24 h, 115 up to 30 days and 78 were alive at 365 days after discharge. The occurrence of shockable rhythms and the ROSC rate decreased with age. Overall mortality increased with age. Such factors as age, gender, urban area, home location, time to arrival, and witnessed OHCA were predictors of the initial shockable rhythm. Gender, urban area, OHCA witnessed by family member, time to arrival, cardiac cause and shockable rhythm were predictors of ROSC. The risk of death increased with each age group by about 56% (HR = 1.56, p < 0.0001).
Conclusions: Shockable initial rhythm and urban location were the strongest predictors of ROSC. Survival at 30 and 365 days after OHCA decreased in older patients. Survival among older patients with OHCA is worse than in younger subjects, which results from lower efficacy of resuscitation and more frequent death declared upon arrival.

Key words: resuscitation, sudden cardiac death, out-of-hospital cardiac arrest, prehospital care, return of spontaneous circulation.

Introduction

The origins of cardiopulmonary resuscitation (CPR) date back to the 1950s. Since that time the procedure introduced in patients with out-of-hospital cardiac arrest (OHCA) has evolved with technology [1]. However, OHCA is still one of the leading causes of global death in subjects over 40 years of age [2, 3]. OHCA in Europe occurs with a frequency of 350,000–700,000 (mean: 500,000) events per year, which gives an

average of 55–113 per 100,000 inhabitants [4]. In 2016 in Poland, among approximately 388,000 deaths (202,000 men (52.1%) and 186,000 women (47.9%)), 43.7% of them were due to cardiovascular causes, mainly cardiac (60.6%) followed by cerebrovascular disease (17.3%) [5, 6]. The proportion of OHCA survivors discharged from hospitals ranges from 0 to 20% and has not changed for almost 30 years [7]. Importantly, aging is associated with a concomitant increase in OHCA incidence. Adults aged 70 years and older also have worse prognosis and the proportion of those discharged home is only 4.1% [8]. By 2050, low- and middle-income countries are estimated to have 80% of their populations aged 60 years or older, whereas 25% of Europe's population will be 65 years old or older [7]. According to estimates, over a quarter of the Polish population will be 65 years old or older by 2050, and by 2060, Poland will be considered one of the oldest societies in the European Union [9]. Poland's population has been declining in recent years. In 2017, there were 38,422,346 people (51.6% female) [10].

According to the forecasts, by 2050 the population of Poland will have decreased by 4,487,000 (11.7%) to 33,951,000 people. The strongest depopulation processes will occur in urban areas. Towns and cities will lose 18.7% of the population as compared with 1% in rural areas. Swietokrzyskie District will also experience the process of urban shrinkage. The population decline is expected to be 22.3%. This implies a faster rate of depopulation in Swietokrzyskie District than the average in Poland. In 2015 Swietokrzyskie District accounted for 3.3% of the population in the country, but this is predicted to decrease significantly to 2.9% by 2050 [11].

The first electrocardiogram recordings define qualification to typical cardiac procedures and pharmacotherapy, such as urgent coronary angiography and invasive treatment of coronary artery disease [12]. Data regarding out-of-hospital cardiac arrest have been obtained from several registries. One of them is the National Registry of Invasive Cardiology Procedures (ORPKI) [13]. In 2018, a national registry of OHCA was launched, which will replace regional registries and will become an excellent source of information regarding OHCA cases.

A variety of factors affect survival after an OHCA. Of them, the most important is the role of OHCA witnesses, bystander-performed CPR, and the role of emergency medical dispatchers. Age of the patient is less important [14, 15]. There are also programs for specialist treatment of patients at the scene. One such program is "ECMO for Greater Poland" promoting ECMO therapy in patients with OHCA [16].

Material and methods

In 2016, the medical team of the Intensive Coronary Care Unit at Świętokrzyskie Cardiology Centre, Regional Hospital in Kielce in cooperation with the medical and nursing team of the Świętokrzyskie Centre for Medical Emergency and Transport Services in Kielce launched a data registry for patients with cardiac arrest that occurred outside of a hospital setting. Preliminary analysis of the data collected in 2013–2016 together with a description of the study group and implications for prehospital care of OHCA patients have been published elsewhere. The present study is a retrospective registry for the period between 1 January 2013 and 31 December 2017. We analyzed the occurrence of OHCA in Świętokrzyskie District according to data published by Statistics Poland. Prehospital care information was obtained from medical documentation. Patients were selected from a population of subjects who had been evaluated by medical rescuers/physicians. Patients diagnosed with sudden cardiac arrest were candidates for the study. Early recognition of OHCA by the dispatcher was confirmed by emergency medical service (EMS) upon arrival. Data regarding the activity of Medical Rescue Teams were extracted from two types of records: 1. emergency rescue card orders, and 2. medical rescue procedure charts. Those who experienced an OHCA and achieved return of spontaneous circulation (ROSC) entered the study. Survival was determined based on the National Health Fund statistics regarding hospital admissions, hospital stays and deaths. Further steps in the process of patient selection are depicted in Figure 1. We evaluated all variables provided by EMS crews. An OHCA of cardiac etiology was defined as an event occurring in the presence of clinical and electrocardiographic symptoms of acute coronary syndromes or signs of heart failure or a shockable initial rhythm. Patients were divided into four-age groups: < 65, 65–74, 75–84 and patients aged 85 years and over. The study was approved by the Research Ethics Committee of the Faculty of Medicine and Health Sciences at Jan Kochanowski University in Kielce (Resolution no. 48/2016 of 9 December 2016).
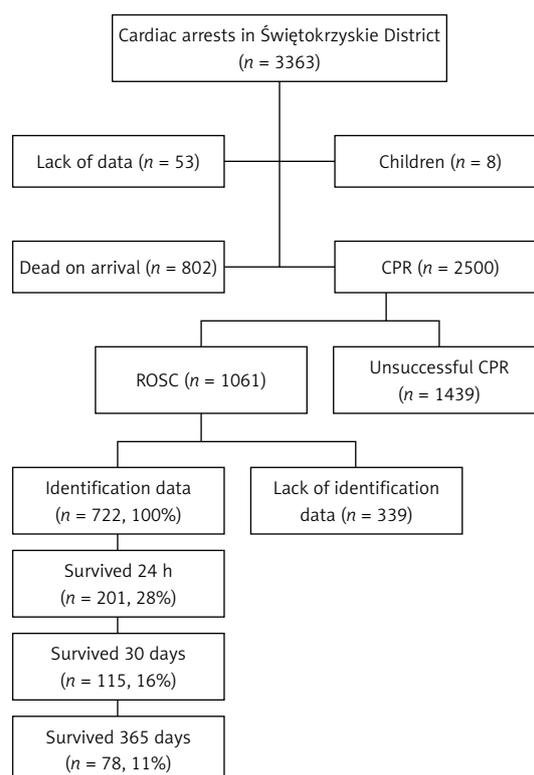
Statistical analysis

Descriptive statistics were used to present data collected over a 5-year period. Categorical variables are presented as counts and percentages. The Shapiro-Wilk test and Kolmogorov-Smirnov test were used to test for normality of distribution. Because of non-normal distribution quantitative variables are expressed as median and interquartile range, and the non-parametric Kruskal-Wallis test was used for comparing differences in quantitative

variables. Cross tabulation with the χ^2 test and the χ^2 test for trend were used for testing relationships between categorical variables. Univariate and multivariable logistic regression analysis was performed to estimate the odds ratio (OR) and 95% confidence interval (95% CI) in search of factors influencing the occurrence of OHCA with cardiac etiology, shockable initial rhythm and ROSC. Goodness of fit in multivariable regression logistic models was measured using area under the curve (AUC) statistic. The Kaplan-Meier survival curve and the Cox proportional hazards regression analysis model were used to estimate the probability of survival. Survival analysis was performed for patients who survived the first day of hospitalization. MedCalc Statistical Software version 19.1 (MedCalc Software, Ostend, Belgium) was used to perform statistical analyses [17].

Results

Between 2013 and 2017 there were 3,363 cases of OHCA. Of them, 53 cases with incomplete medical records and 8 pediatric OHCA patients were further excluded from the analysis. A total of 802 patients were found dead prior to admission to the hospital, and CPR was attempted by the attending ambulance crew in 2,500 patients. Initial CPR was unsuccessful in 1,439 patients, whereas ROSC occurred in 1,061 subjects. In the ROSC group medical records were incomplete in 339 patients and excluded from further analysis. Of 722 patients, 201 (28%) survived at least 24 h, 115 (16%) up to 30 days and 78 (11%) were alive at 365 days after discharge (Figure 1).

Table I summarizes baseline patient characteristics. The predominance of women was observed only in the oldest age group. In patients 65–74 years old time to arrival at the scene was shortest, and OHCA most frequently occurred in urban area. In each age group the OHCA rate was higher in rural compared to urban areas. OHCA occurred mainly at home and was witnessed by family members. Fewer patients were found dead upon arrival at the scene and CPR was attempted in most cases. Across four consecutive age groups OHCA was increasingly more frequent in rural areas. The number of patients found dead upon arrival increased only among those over 75 years of age. The population of Świętokrzyskie District was graphically represented as an age-gender-pyramid (Figure 2). Table II summarizes baseline characteristics of the patients who experienced CPR attempts. There were no differences in time to arrival at the scene, the number of witnesses and transport destination after resuscitation (intensive coronary care unit (ICCU) vs. emergency departments (ED)). In most groups there were more men than women, but the proportions gradually reversed and the oldest

Figure 1. Study patient flow chart. CPR, cardiopulmonary resuscitation. OHCA, out-of-hospital cardiac arrest

group was predominantly female. With increasing age CPR was more frequently attempted in the patient's home, in rural areas, and emergency calls were mainly made by family members. Among patients with CPR attempts the number of witnesses and the rate of ambulance transport to an ICCU were similar in each age group. Only the youngest patients more frequently experienced OHCA of non-cardiac etiology. The incidence of OHCA events of cardiac origin increased with age and was prevalent in the remaining three groups. In general, a shockable initial rhythm was less frequently found than the non-shockable rhythm, and the occurrence of shockable rhythms decreased with age. The rate of ROSC decreased with age, with the most remarkable drop among the oldest patients. Overall mortality, defined as the sum of patients dead on arrival and following unsuccessful CPR, increased with age. Multivariable logistic regression analysis demonstrated that age, male sex, OHCA witnessed by family member, and citizen-witnessed OHCA were independent predictors of OHCA of cardiac etiology. Age, male sex, urban area, home location, time to arrival, and witnessed OHCA independently predicted the initial shockable rhythm. Return of spontaneous circulation was best predicted by female sex, urban area, family-witnessed OHCA, time to arrival, cardiac etiology and the presence of a shockable initial rhythm (Table III). Receiver operating characteristic curves are shown in Figure 3.
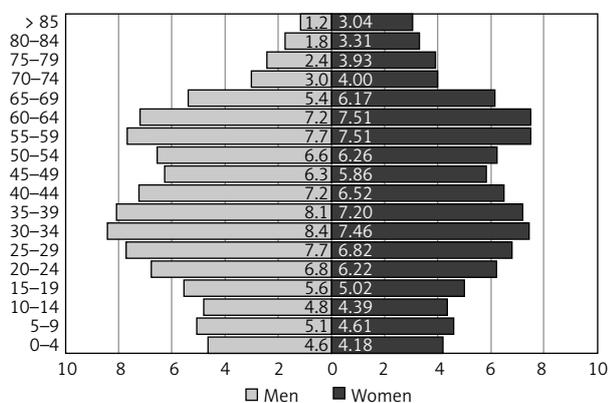
Janusz Sielski, Karol Kaziród-Wolski, Marta Solnica, Mirosław Data, Dominika Kukla, Kamil Woźnica, Marcin Sadowski

Table I. Baseline characteristics of patients with out-of-hospital cardiac arrest between 2013 and 2017

Variable	Age groups [years]				P-value	
	< 65	**65–74**	**75–84**	**≥ 85**	**Between groups**	**For trend**
Number	1385 (41.9)	717 (21.7)	709 (21.5)	491 (14.9)	< 0.001	NA
Age [years] median (IQR)*	57 (50–61)	69 (67–72)	80 (77–82)	88 (86–91)	< 0.001	NA
Time to arrival [min] median (IQR)*	10 (6–15)	9 (6–14)	10 (6–15)	10 (6–15)	0.03	NA
Sex*:						
Male	1082 (78.1)	478 (66.7)	396 (55.9)	193 (39.3)	< 0.001	< 0.001
Female	303 (21.9)	239 (33.3)	313 (44.1)	298 (60.7)		
Area:						
Urban	470 (33.9)	281 (39.2)	236 (33.3)	146 (29.7)	0.006	< 0.001
Rural	915 (66.1)	436 (60.8)	473 (66.7)	345 (70.3)		
Location*:						
Home	990 (71.5)	571 (79.6)	598 (84.3)	444 (90.4)	< 0.001	< 0.001
Others	395 (28.5)	146 (20.4)	111 (15.7)	47 (9.6)		
Eye-witness:						
Family	984 (71.1)	567 (79.1)	612 (86.3)	435 (88.6)	< 0.001	< 0.001
Other	400 (28.9)	150 (20.9)	97 (13.7)	56 (11.4)		
Dead on arrival:						
Yes	297 (21.4)	145 (20.2)	175 (24.7)	185 (37.7)	< 0.001	< 0.001
No	1088 (78.7)	572 (79.8)	534 (75.3)	306 (62.3)		

*Data are presented as number and percentages unless otherwise indicated; NA – not applicable; *data presented according to Utstein criteria.*

All models were statistically significant and well fitted the set of data. The highest area under the curve values were found for models accounting for the presence of shockable initial rhythm and ROSC achievement. There was a significant difference in survival in the consecutive age ranges, with the shortest survival in the oldest patients and the longest one in the youngest subjects (Figure 4). Proportions of OHCA survivors and hazard ratios in each age group were also calculated at 30 days and 365 days after the index event (Table IV). The risk of death increased with each age group by about 56% (HR = 1.56, $p < 0.0001$).

Discussion

The present analysis concerns Świętokrzyskie District, which covers an area of 11,710 km². In 2017, our district had 127,147 people aged 65–74 (55.7% female), 70,224 people aged 75–84 (64.2% female) and 28,482 people aged 85 years and over (72.6% female) [10]. In recent years there has been a remarkable demographic decline accompanied by population aging in the district. Between 2013 and 2016 the number of citizens decreased by 21,095 people (45.8% female) [10]. In line with the depopulation trend in the district, the emergency medical services system underwent major organizational changes.

Figure 2. Świętokrzyskie District population age-gender-pyramid

Table II. Baseline characteristics of patients who underwent cardiopulmonary resuscitation between 2013 and 2017

Variable	Age groups [years]				P-value	
	< 65	65–74	75–84	≥ 85	Between groups	For trend
Number	1088 (43.5)	572 (22.9)	534 (21.4)	306 (12.2)	< 0.001	NA
Age [years] median (IQR)*	57 (50–61)	69 (66–72)	80 (77–82)	88 (86–90)	< 0.001	NA
Time to arrival [min] median, (IQR)*:	10 (6–15)	9 (6–14)	10 (6–15)	10 (6–14)	0.15	NA
Sex*:						
Male	843 (77.5)	380 (66.4)	296 (55.4)	122 (39.9)	< 0.001	< 0.001
Female	245 (22.5)	192 (33.6)	238 (44.6)	245 (22.5)		
Location*:						
Home	740 (68.0)	445 (77.8)	442 (82.8)	273 (89.2)	< 0.001	< 0.001
Others	348 (32.0)	127 (22.2)	92 (17.2)	33 (10.8)		
Eye-witness:						
Family	745 (68.5)	440 (76.9)	451 (84.5)	260 (85.0)	< 0.001	< 0.001
Other	342 (31.5)	132 (23.1)	83 (15.5)	46 (15.0)		
Area:						
Urban	395 (36.3)	233 (40.7)	190 (35.6)	87 (28.4)	0.004	0.04
Rural	693 (63.7)	339 (59.3)	344 (64.4)	219 (71.6)		
Witnesses (bystander CPR)*:						
Yes	355 (32.6)	193 (33.7)	147 (27.5)	89 (29.1)	0.08	0.05
No	733 (67.4)	379 (66.3)	387 (66.3)	217 (70.9)		
Cause of OHCA*:						
Cardiac	506 (46.5)	325 (56.8)	337 (63.1)	188 (61.5)	<0.001	<0.001
Others	582 (53.5)	247 (43.2)	197 (36.9)	118 (38.6)		
Heart rhythm*:						
VT/VF	219 (20.1)	98 (17.1)	69 (12.9)	24 (7.8)	< 0.001	< 0.001
Other	869 (79.9)	474 (82.9)	465 (87.1)	282 (92.2)		
Transport*:						
ICCU	31 (6.5)	19 (7.4)	13 (5.9)	3 (2.8)	0.43	0.26
ED	447 (93.5)	238 (92.6)	207 (94.1)	103 (97.2)		
ROSC*:						
Yes	478 (43.9)	257 (44.9)	220 (41.2)	106 (34.6)	0.02	0.007
No	610 (56.1)	315 (55.1)	314 (58.8)	200 (65.4)		
Overall mortality*:	907 (65.5)	460 (64.2)	489 (69.0)	385 (78.4)	< 0.001	< 0.001

*Data are presented as number and percentages unless otherwise indicated. ED – emergency department, ICCU – intensive coronary care unit, NA – not applicable, OHCA – out-of-hospital cardiac arrest, ROSC – return of spontaneous circulation, VF – ventricular fibrillation, VT – ventricular tachycardia, *overall mortality – dead on arrival + unsuccessful resuscitation;*data presented according to Utstein criteria.*

Janusz Sielski, Karol Kaziród-Wolski, Marta Solnica, Mirosław Data, Dominika Kukla, Kamil Woźnica, Marcin Sadowski
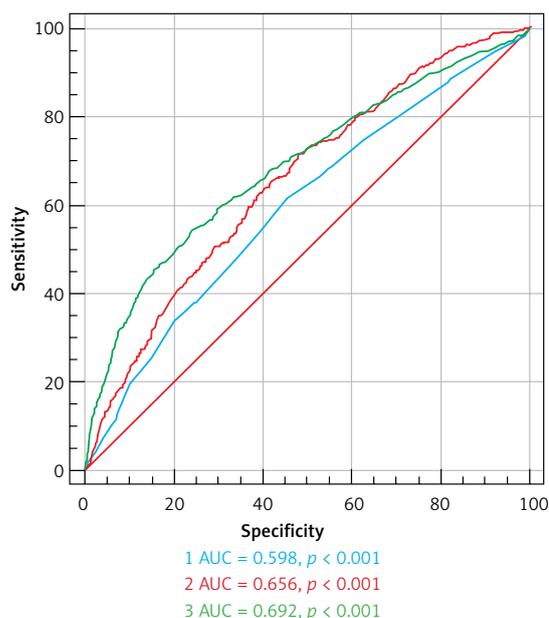
Table III. Logistic regression analysis for prediction of the cardiac cause of out-of-hospital cardiac arrest, shockable rhythm and return of spontaneous circulation

Variable	Univariable		Multivariable (enter)		Multivariable (forward)	
	OR (95% CI)	*P*-value	OR (95% CI)	*P*-value	OR (95% CI)	*P*-value
Prediction of the cardiac cause of out-of-hospital cardiac arrest:						
Age; per each group	1.29 (1.19–1.39)	< 0.001	1.33 (1.23–1.44)	< 0.001	1.32 (1.22–1.43)	< 0.001
Sex; male vs. female	1.09 (0.92–1.29)	0.31	1.30 (1.09–1.55)	0.003	1.30 (1.09–1.55)	0.01
Area; urban vs. rural	1.06 (0.89–1.25)	0.50	1.14 (0.95–1.37)	0.156	Not included	
Location; home vs. other	1.07 (0.89–1.28)	0.48	0.79 (0.61–1.02)	0.08	Not included	
Eyewitness; family vs. other	1.28 (1.06–1.54)	0.009	1.50 (1.16–1.93)	0.002	1.27 (1.04–1.53)	0.02
Time to arrival; per 1 min	0.99 (0.99–1.01)	0.87	1.00 (0.99–1.010)	0.89	Not included	
Witnesses; yes vs. no	1.32 (1.11–1.57)	0.001	1.41 (1.18–1.69)	0.001	1.40 (1.17–1.67)	< 0.001
Prediction of shockable rhythm:						
Age; per each group	0.73 (0.66–0.82)	< 0.001	0.8 (0.71–0.9)	< 0.001	0.8 (0.71–0.9)	0.01
Sex; male vs. female	1.72 (1.35–2.18)	< 0.001	1.46 (1.13–1.87)	0.004	1.46 (1.13–1.87)	0.01
Area; urban vs. rural	1.64 (1.33–2.03)	< 0.001	1.42 (1.11–1.82)	0.005	1.42 (1.11–1.82)	0.01
Location; home vs. other	0.48 (0.38–0.61)	< 0.001	0.6 (0.44–0.83)	0.002	0.61 (0.48–0.77)	< 0.001
Eyewitness; family vs. other	0.56 (0.45–0.71)	< 0.001	1.02 (0.74–1.41)	0.91	Not included	
Time to arrival; per 1 min	0.97 (0.95–0.99)	0.001	0.98 (0.96–0.99)	0.01	0.98 (0.96–0.995)	0.01
Witnesses; yes vs. no	1.56 (1.25–1.94)	0.001	1.52 (1.21–1.91)	< 0.001	1.52 (1.21–1.9)	0.01
Prediction of return of spontaneous circulation:						
Age; per each group	0.90 (0.84–0.97)	0.01	0.95 (0.87–1.04)	0.25	Not included	
Sex; male vs. female	0.96 (0.81–1.14)	0.64	0.80 (0.67–0.94)	0.02	0.83 (0.69–0.99)	0.04
Area; urban vs. rural	2.06 (1.74–2.43)	< 0.001	1.58 (1.31–1.92)	< 0.001	1.57 (1.30–1.91)	< 0.001
Location; home vs. other	0.56 (0.47–0.67)	< 0.001	0.99 (0.76 – 1.29)	0.93	Not included	
Eyewitness; family vs. other	0.49 (0.41–0.59)	< 0.001	0.56 (0.43–0.73)	< 0.001	0.53 (0.43–0.64)	< 0.001
Time to arrival; per 1 min	0.95 (0.94–0.96)	< 0.001	0.97 (0.77–1.29)	< 0.001	0.97 (0.96–0.99)	< 0.001
Witnesses; yes vs. no	1.3 (1.09–1.54)	0.01	1.17 (0.97–1.41)	0.1	Not included	
Cause of OHCA; cardiac vs. other	1.42 (1.21–1.66)	< 0.001	1.28 (1.07–1.52)	0.006	1.27 (1.07–1.51)	0.007
Shockable rhythm; yes vs. no	4.63 (3.66– 5.85)	< 0.001	3.99 (3.12–5.10)	< 0.001	4.10 (3.21–5.23)	< 0.001

Data are presented as odds ratios and 95% confidence intervals. AUC – area under the curve, OHCA – out-of-hospital cardiac arrest.

The current study addresses issues of equal access to treatment interventions related to OHCA among younger and older patients. The most important finding of this study is that male sex, rural area and home location strongly contributed to the ineffectiveness of resuscitation and more frequent death declared upon arrival, resulting in a poor short- and long-term prognosis in the elderly patients following OHCA. The presence of shockable initial rhythm, urban area and family-witnessed OHCA were the strongest predictors of survival. Similar reports on multiple predictors
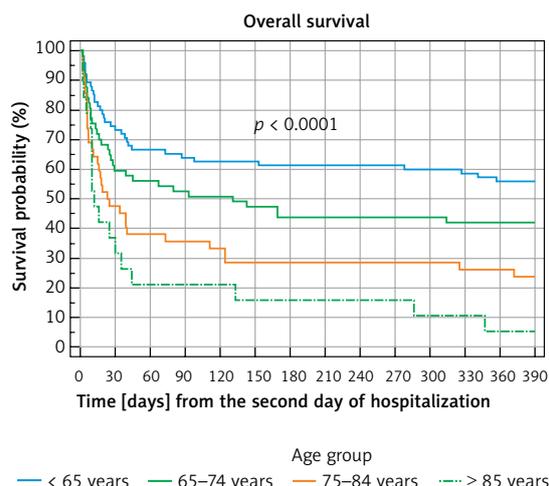
of mortality in OHCA patients stratified by age are scarce. Our four age group approach was similar to that reported by Tsunoyama *et al.* [14] and Deasy *et al.* [15]; however, they focused on dispatcher-guided CPR [14] or the studies were conducted in a setting other than Poland (i.e. Australia) [15]. Patient registries provide a wealth of clinical information. Results from meta-analysis of registry-based studies can be applied in clinical practice for diagnosing and treating diseases. Likewise, OHCA databases both on a European and national scale have been used for a number

1 AUC = 0.598, *p* < 0.001
2 AUC = 0.656, *p* < 0.001
3 AUC = 0.692, *p* < 0.001

Figure 3. Receiver operating characteristic curves for multivariable logistic regression model for (1) cardiac cause of out-of-hospital cardiac arrest, (2) initial shockable rhythm in out-of-hospital cardiac arrest, (3) return of spontaneous circulation. AUC, area under the curve

Figure 4. Probability of survival after out-of-hospital cardiac arrest depending on age groups

of years [18–20]. In Poland, registry-based studies on OHCA are also carried out, although there is no national registry of OHCA in the country as yet [21–23].

In the present study we analyzed the outcome of 2,500 patients who received CPR in a small district in one of the EU countries based on a regional OHCA registry. The fundamental question, extremely important from the viewpoint of both theory and practice, is which factors affect the success of resuscitation and whether they are equally considered in the whole population, especially in the elderly. In this report both univariate and multivariable regression analyses demonstrated that age was significantly associated with an OHCA of cardiac etiology and the presence of a shockable initial rhythm. These results are consistent with data obtained in large European studies. Wiel *et al*. in a large sample of 8,694 patients divided into those less than 65 and over 65 years old found a lower ROSC rate in relation to age [18]. In the Polish population, Nadolny *et al*. compared the

OHCA occurrence in younger and older patients living in various locations throughout the District of Silesia. A total of 1,603 patients with a mean age of 65.7 years who experienced OHCA were included in the study. The largest number of OHCA events was observed in patients over 65 years of age [21]. However, no further analysis of individual age groups and prehospital care is available. No comparative report on prehospital care in patients divided by age was found in the Polish literature. Time to EMS arrival is a crucial parameter in the quality assessment of the management of patients with OHCA across different age ranges. In the present report, both univariate and multivariable regression analysis showed that shorter time to arrival was associated with an OHCA of cardiac etiology and the presence of a shockable initial rhythm. In the study of Winther-Jensen *et al*. in a group of 2,509 patients divided into those below and over 80 years of age there were no differences in time to arrival and its effect on survival [19]. Bystanders and family members who recognize an impending cardiac arrest and call an ambulance play an important role in the chain of survival. In this survey, both univariate and multivariable regression analysis showed that family presence at the scene had a weaker relationship with a cardiac cause of OHCA and the occurrence of shockable initial rhythms. In contrast, bystander presence

Table IV. Survival proportions and hazard ratios based on Kaplan-Meier estimates

Survival time	Survival proportion (standard error) (%)				
	Total	< 65 years	65–74 years	75–84 years	≥ 85 years
30 days	59.8 (3.5)	73.3 (5.1)	59.6 (6.5)	47.6 (7.7)	31.6 (10.7)
365 days	40.4 (3.5)	56.0 (5.7)	42.1 (6.5)	26.2 (6.8)	5.3 (5.1)
Hazard ratio (95% CI) for the group under 65 years old		1	1.57 (1.05–2.36)	2.37 (1.46–3.85)	3.62 (1.72–7.62)

had a positive effect on both variables. It may be speculated that family members are familiar with the chief complaints of patients, especially the elderly ones and react differently than bystanders. In a systematic review by van de Glind et al. multivariable regression analysis of data reported in 10 papers showed that witnessed OHCA was a significant predictor of survival after ROSC [8]. Similarly, Requena-Morales et al. in an analysis of 422 OHCA cases occurring in the district of Alicante (similar to Świętokrzyskie District in terms of the number of inhabitants) confirmed the significant role of witnesses during OHCA and their effect on mortality [20]. The present findings do suggest that there is a relationship between time to arrival at the scene and the presence of shockable initial rhythms. In univariate and multivariable regression analysis the shorter the time to arrival is, the more probable is shockable initial rhythm. According to Gräsner et al. only 20–25% of patients have an initial recorded rhythm indicating ventricular fibrillation. Therefore, it may be speculated that if time to arrival at the scene was shorter, the chance of first defibrillation would be higher [16]. We confirmed the relationship between shockable initial rhythm and patient age, gender, location of the incident (urban/rural area), site of the incident (home/other) and the reporting subject, time to arrival at the scene and witnessed arrest. Gach et al. carried out a similar survey in Bielsko-Biala District including 272 OHCA cases and reported that failure to initiate chest compression by lay bystanders and non-shockable initial rhythm were the independent predictors of prehospital death associated with long-lasting hypoxia [21]. Nadolny et al. in a study of 1,603 patients with OHCA in Katowice District divided into those below and over 65 years of age demonstrated that early chest compression, age, early defibrillation and intubation with oxygen therapy, and ECG monitoring were the independent factors for better prognosis [22]. In the current study the Kaplan-Meier survival curves for patients categorized by age demonstrated the lowest survival rate for the oldest patients and highest among the youngest subjects. Analysis of survival proportions in the consecutive age groups at 30 days and 365 days after the OHCA showed the lowest survival index among the oldest patients and highest among the youngest subjects. These results reflect those of Segal et al., who also found the lowest survival in the oldest patients among 18,249 OHCA subjects [23]. The presence of multiple comorbidities in the elderly may have an impact on ROSC following OHCA, accounting for significantly worse outcomes in this age group. Nadolny et al. published the results of multidirectional analysis of prehospital care based on the POL-OHCA registry

[24]. The investigators analyzed 26,783 CPR attempts made in the whole of Poland in 2018. The results of our analysis, which was conducted for the 2013–2017 study period taking into account younger and older age groups within only one district, may supplement the information obtained from the national registry. This retrospective study seems to provide evidence that age is not an appropriate factor for evaluation of prehospital care in patients experiencing an OHCA. The roles of OHCA witnesses, CPR attempts, availability and use of an automated external defibrillator (AED), and medical emergency dispatchers appear to be of high clinical importance. In our district the availability of AED is very low. There are only 10 devices, which are placed in several offices, petrol stations and public buildings [25]. There has already been an attempt to establish a CPR-AED program to be implemented in lower and upper secondary schools [26]. Hopefully, all these actions will improve medical care for patients with OHCA.

In Swietokrzyskie District ECMO-facilitated resuscitation is not used in OHCA patients because of the lack of appropriate ambulance equipment. In Poland, ECMO in OHCA patients is tested as part of the pioneer Out-of-Hospital Cardiac Arrest Program implemented in Wielkopolskie District [16]. Recent evidence shows significantly improved survival in patients receiving ECMO-assisted cardiopulmonary resuscitation [27]. The present study appears to demonstrate that the effectiveness of CPR in the elderly (shockable rhythm and cardiac etiology decrease with age) is associated with performance of high quality cardiopulmonary resuscitation and active participation of the bystander in CPR (an especially recommended procedure for the elderly). Wide dissemination of AEDs throughout a community (for instance elderly care homes, reading rooms) with legible and understandable information on how to call an ambulance for a medical emergency (wall posters in public places, educational centers, places of worship) and first aid courses for senior citizens may contribute to better results. It would be valuable for medical professionals to participate in courses explaining the differences in providing first aid to OHCA patients with pacemakers and cardiac defibrillators. The new subcutaneous implantable cardioverter-defibrillator systems may be a promising alternative for the elderly [28]. Dissemination of accurate information by mass media (newspapers, radio, television) may increase the awareness of OHCA among bystanders. Primary care physicians can significantly contribute to education of patients (summary information booklets, chatting/talking with patients) on OHCA and CPR. Education in rural areas can be implemented in churches. Educational campaigns carried out by

the Polish Cardiac Society are a good source of information about cardiac arrest in public locations with nearby bystanders. A separate issue in the management of patients after OHCA is neuroprotection after cardiac arrest. As presented in the work of Arrich *et al.* in a meta-analysis of 7 studies involving 2,369 patients, early initiation of therapeutic hypothermia is important in improving the prognosis and reducing the risk of damage to the central nervous system after OHCA [29]. Also, Fröhlich *et al.* in a review of etiological factors and factors improving prognosis after in-hospital and out-of-hospital cardiac arrest highlighted the important role of neuroprotection with therapeutic hypothermia [30]. The study, where cases of neuroprotection in OHCA were assessed, come from the area of the Świętokrzyskie Voivodeship and the authors' center. Ciuraszkiewicz *et al.* describe the first experiences in implementing the method of mild therapeutic hypothermia after OHCA [31].

In conclusion, out of numerous factors influencing the efficacy of resuscitation the presence of shockable initial rhythm and urban location of an OHCA were the strongest predictors of return of spontaneous circulation. Survival at 30 and 365 days following OHCA decreased in older patients. Further work should be considered to establish special procedures for older patients with OHCA in order to eliminate age differences in prehospital care. Both older and younger individuals have equal access to prehospital critical care for OHCA. Survival among older patients with OHCA is worse than in younger subjects, which is a result of both lower efficacy of resuscitation and more frequent death declared upon arrival.

Conflict of interest

The authors declare no conflict of interest.

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Janusz Sielski, Karol Kaziród-Wolski, Marta Solnica, Mirosław Data, Dominika Kukla, Kamil Woźnica, Marcin Sadowski

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