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Kratko saopštenje

Prediktori pojave šokabilnog ritma i povrataka spontane cirkulacije kod pacijenata sa osvjedočenim srčanim zastojem

Predictors of occurrence of shockable rhythm and return of spontaneous circulation in patients with witnessed cardiac arrest

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SAŽETAK

Uvod: Vanbolnički srčani zastoj (OHCA) predstavlja globalni zdravstveni izazov sa prosečnom stopom preživljavanja od 8%. Ishodi zavise od faktora kao što su lokacija, vreme do povratka spontane cirkulacije (ROSC), demografske karakteristike pacijenata i tip inicijalnog srčanog ritma.

Materijal i metode: EuReCa_Srbija je deo studije EuReCa ONE o preživljavanju nakon vanbolničkog srčanog zastoja (OHCA) u Evropi. Uključeni su slučajevi OHCA koje su zbrinjavale ekipe hitne medicinske pomoći (HMP), uključujući pedijatrijske i nekardiogene slučajeve. Podaci su prikupljani prema protokolu EuReCa ONE u periodu od 1. oktobra 2014. do 31. decembra 2021. godine.

Rezultati: Ispitivali smo prediktore za šokabilni inicijalni ritam, ROSC i prijem u bolnicu koristeći univarijabilnu i multivarijabilnu binarnu logističku regresiju. OHCA u područjima sa više od 100.000 stanovnika i u domovima pacijenata imali su značajno manju verovatnoću za šokabilni ritam (57,4% i 65,4% manje), dok su mlađa životna dob i kardiogeni uzrok povećavali verovatnoću (1,7 i 8,5 puta više). Šokabilni ritam je značajni prediktor za ROSC, povećavajući verovatnoću 3,9 puta, a za ROSC pri prijemu u bolnicu 3,3 puta. Urbanizovane i stambene lokacije smanjivale su šanse za ROSC za 55,8% i 51,1%. Pomoć dispečera HMP povećala je verovatnoću za ROSC pri prijemu u bolnicu 1,7 puta, dok je kašnjenje od 10 ili više minuta od poziva HMP do defibrilacije smanjilo verovatnoću za 86,1%.

ABSTRACT

Introduction: Out-of-hospital cardiac arrest (OHCA) is a global health challenge with an average survival rate of 8%. Outcomes depend on factors such as arrest location, time to return of spontaneous circulation (ROSC), patient demographics, and initial rhythm type.

Material and methods: EuReCa_Serbia is part of the EuReCa ONE study on OHCA survival in Europe. It included OHCAs managed by EMS, including pediatric and non-cardiogenic cases. Data were collected per the EuReCa ONE protocol from October 1, 2014, to December 31, 2021.

Results: We examined predictors of shockable initial rhythms, ROSC, and hospital admission using univariable and multivariable binary logistic regression analysis. OHCAs in areas with over 100,000 inhabitants and at patient residences were significantly less likely to have shockable rhythms (57.4% and 65.4% less likely), while younger age and cardiogenic cause increased the likelihood (1.7 and 8.5 times more likely). Shockable rhythms strongly predicted any ROSC, increasing the likelihood by 3.9 times, and ROSC at hospital admission by 3.3 times. Urban and residential locations reduced the chances of ROSC by 55.8% and 51.1%, respectively. EMS dispatcher assistance improved the likelihood of ROSC at admission by 1.7 times, while a delay of 10 or more minutes from EMS call to defibrillation reduced the likelihood by 86.1%.

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Introduction

Out-of-hospital cardiac arrest (OHCA) represents a major global health concern, with survival rates at hospital discharge remaining low (on average 8%) [1,2]. Survival outcomes depend heavily on several factors, such as the location of the arrest[3,4,5], time to return of spontaneous circulation (ROSC)[6-8], patient demographics[1,2,9,10] and the type of initial cardiac rhythm[1,4,6, 11-13]. Shockable rhythms, such as ventricular fibrillation (VF) and ventricular tachycardia (VT), are particularly significant as they are more compliant to defibrillation, and their early detection can improve survival chances[1,4,6, 11-13]. In the past 3-4 decades there has been a significant shift, with non-shockable rhythms comprising the majority of recorded cases [14]. Identifying independent predictors of shockable rhythm, ROSC, and ROSC on hospital admission is crucial for refining resuscitation strategies and EMS protocols.

The European Resuscitation Council's EuReCa studies further underscored regional variations in OHCA outcomes across Europe, revealing that both the incidence of OHCA and survival rates vary significantly depending on local EMS performance and community-level interventions[1,10]. Additionally, a meta-analysis from 2022 demonstrated a three-fold variation in survival outcomes between continents, with Europe and Australasia reporting significantly higher survival rates than North America [15].

Given the complexities of OHCA outcomes, this study aims to identify independent predictors of shockable rhythm, any ROSC, and ROSC on hospital admission in witnessed OHCA cases.

Material and Methods

The study included epidemiologic data on OHCA collected through the European Resuscitation Council (ERC) EuReCa study questionnaire. The inclusion criterion was OHCA taken care of by the EMS team. Pediatric patients as well as patients with cardiac arrest of non-cardiogenic cause (including traumatic cardiac arrest) were included in the analysis. The created database consisted of information defined by the unique protocol of the EuReCa ONE study in the period from October 1, 2014 to December 31, 2021. After completing each questionnaire, the data were entered into a unique electronic database at each research center and then into a centralized database.

EuReCa_Serbia is part of the international, prospective, multicenter EuReCa ONE study of survival (epidemiology, treatment and outcomes) of patients who experienced OHCA in Europe. The study was initiated and subsequently conducted in accordance with the protocol defined and registered at "clinicaltrials.gov" (registration number: NCT02236819) by the ERC.

In this study, data were collected on the proportion of initiation/non-initiation of CPR, as well as six-hour time periods during the day and seasons.

The data were collected from 16 municipalities in Serbia, which represent 24.13% of the population of Serbia. Municipalities were included in the study on a voluntary basis after sending a call for enrollment to a randomly selected sample of municipalities with developed local EMS systems.

Statistical analysis of the data was performed using SPSS Statistics for Windows v27.0 statistical software (IBM Corp, Armonk, New York). Variables are presented as frequencies and percentages. Analytical statistical steps included a Chi-square test that examined associations between categorical variables.

Results

During the period 2014-2021, a total of 3927 confirmed cases of OHCA were registered (Figure 1). The median age was 70 (IQR 61-79) years. There were 2424/3927 (61.7%) patients older than 65 years, while 35/3927 of them were younger than 18 years (0.9%). There were 1510/3297 (38.5%) female patients.

A bystander witnessed the accident in 3167/3297 cases (80.6%) (Figure 1). The application of CPR measures was started in 2669/3297 cases (68.0%). A bystander started CPR measures before the arrival of the EMS team at the scene of the accident in 369/2669 cases (13.8%). In that group, dispatcher assistance was present in 213/369 cases (57.7%). In the same group, the bystander, in addition to chest compressions, applied ventilation in 139/369 cases (37.7%), while in other cases he applied only chest compressions.

A shockable initial rhythm was detected in 554/3927 cases (14.1%), any ROSC in 519/3927 (13.2%), while 458/3927 patients (11.7%) survived to the nearest hospital (Figure 1).

A total of 2837/3927 cases (72.2%) were registered during working days of the week, and 3178/3927

(80.9%) in the period of the day from 6 am to 10 pm. Time from emergency call to DC shock delivery was 10 minutes or less in 35 cases.

The distribution of the etiological factors of OHCA and the location of the accident in patients whose accident was proven is shown in Table 1.

Causal-consecutive association of potential predictors of shockable initial rhythm, return of spontaneous circulation and hospital admission was examined using univariable and multivariable binary logistic regression analysis. In the first act, all potential predictors were examined by univariable analysis, and those that showed statistically significant predictive potential were included as part of the predictive model in multivariable analysis, which obtained statistically significant independent predictors of shockable initial rhythm. The results of univariable and multivariable binary logistic regression analysis are shown in Tables 2, 3 and 4.

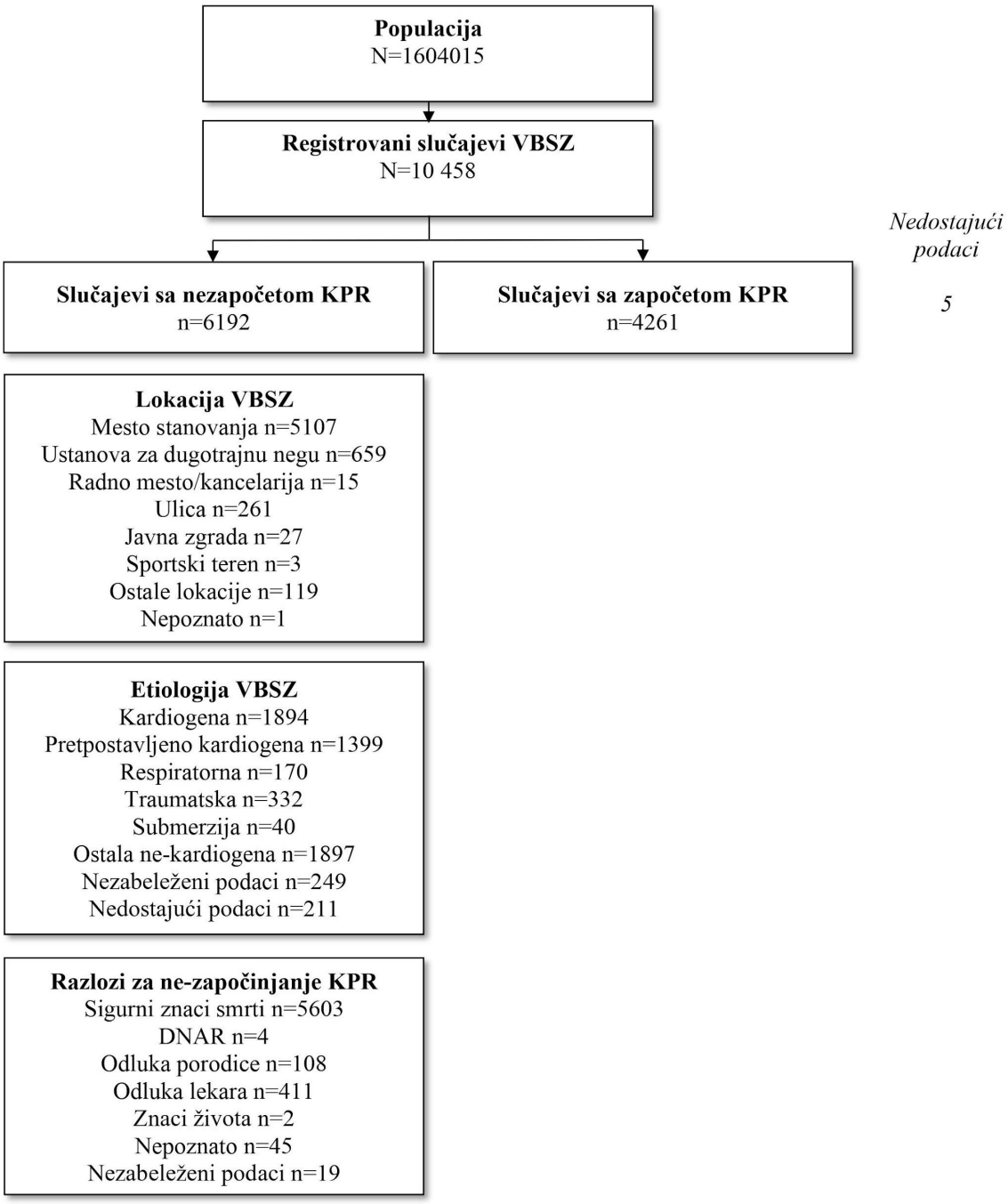

Figure 1. Utstein flowchart

Table 1. Distribution of etiological factors and location of OHCA

	Characteristics	Frequency	Percent
Etiology	not recorded	195	5.0
	cardiac	1420	36.2
	trauma	104	2.6
	submersion	4	0.1
	respiratory	141	3.6
	other non-cardiac	482	12.3
	unknown (presumed cardiac)	1384	35.2
	Total	3730	95.0
Location	residence	3098	78.9
	long-term care	82	2.1
	work/office	57	1.5
	street	262	6.7
	public building	123	3.1
	sports facility	17	0.4
	outpatient hospital	23	0.6
	ambulance car	11	0.3
	other	254	6.5
	Total	3927	100.0

Table 2. Predictors of shockable initial rhythm in patients with witnessed OHCA

Predictors	Univariable analysis			Multivariable analysis		
	p	OR	95% CI	p	OR	95% CI
EMS covered area with more than 100,000 inhabitants	<0.01	0.389	0.292-0.519	<0.01	0.426	0.336-0.541
Patient age ≤ 65 years	<0.01	1.763	1.373-2.264	<0.01	1.657	1.341-2.046
Pediatric age	0.124	0.320	0.075-1.368			
Female gender	<0.01	0.644	0.489-0.848	0.027	0.772	0.614-0.971
Working day of the week	0.158	1.224	0.924-1.622			
Night time (22-6h)	0.211	0.813	0.587-1.125			
Cardiac OHCA cause	<0.01	8.008	3.504-18.303	<0.01	8.523	1.745-15.308
Patient's residence as OHCA location	<0.01	0.460	0.352-0.602	<0.01	0.346	0.276-0.432
EMS dispatcher assistance	<0.01	2.055	1.486-2.843	0.003	1.734	1.211-2.482
Artificial ventilation during CPR	0.488	1.201	0.716-2.015			

Table 3. Predictors of any ROSC in patients with witnessed OHCA

Predictors	Univariable analysis			Multivariable analysis		
	p	OR	95% CI	p	OR	95% CI
EMS covered area with more than 100,000 inhabitants	<0.01	0.351	0.274-0.449	0.140	0.613	0.320-1.173
Patient age ≤ 65 years	0.01	1.354	1.087-1.688	0.102	1.657	0.905-3.033
Pediatric age	0.197	0.381	0.088-1.649			
Female gender	0.759	0.964	0.766-1.215			
Working day of the week	0.865	0.976	0.739-1.290			
Night time (22-6h)	0.089	0.776	0.580-1.039			
Cardiac OHCA cause	0.628	0.906	0.607-1.352			
Patient's residence as OHCA location	<0.01	0.332	0.263-0.419	0.236	0.683	0.364-1.283
EMS dispatcher assistance	<0.01	1.988	1.452-2.720	0.825	0.932	0.501-1.737
Artificial ventilation during CPR	0.66	0.625	0.378-1.032	0.088	0.602	0.336-1.079
Shockable first recorded rhythm	<0.01	5.328	4.033-7.039	<0.01	3.889	2.095-7.219
10 minutes or more between EMS call and DC shock	<0.01	0.326	0.226-0.471	0.016	3.748	1.281-10.970

Table 4. Predictors of hospital admission ROSC in patients with witnessed OHCA

Predictors	Univariable analysis			Multivariable analysis		
	p	OR	95% CI	p	OR	95% CI
EMS covered area with more than 100,000 inhabitants	<0.01	0.249	0.185-0.334	<0.01	0.442	0.337-0.580
Patient age ≤ 65 years	0.116	1.237	0.949-1.661			
Pediatric age	0.178	0.249	0.033-1.882			
Female gender	0.633	1.070	0.812-1.410			
Working day of the week	0.689	0.943	0.706-1.259			
Night time (22-6h)	0.177	0.785	0.553-1.115			
Cardiac OHCA cause	0.502	0.868	0.573-1.313			
Patient's residence as OHCA location	<0.01	0.394	0.298-0.521	<0.01	0.489	0.379-0.632
EMS dispatcher assistance	<0.01	1.952	1.374-2.771	<0.01	1.741	1.176-2.580
Artificial ventilation during CPR	0.291	0.733	0.411-1.306			
Shockable first recorded rhythm	<0.01	4.679	3.515-6.229	<0.01	3.273	2.535-4.226
10 minutes or more between EMS call and DC shock	<0.01	0.069	0.034-0.137	<0.01	0.139	0.066-0.292

Discussion

This study identified several independent predictors of shockable rhythm, any ROSC, and ROSC on hospital admission in witnessed OHCA cases. Our findings are consistent with previous studies in some respects, but they also reveal context-specific variations in predictors, such as the EMS covered area with more than 100 000 inhabitants.

Shockable Rhythm Predictors

We found that OHCAs in areas with over 100 000 inhabitants and those occurring at a patient's residence were associated with a significantly lower likelihood of shockable rhythms (57.4% and 65.4% less likely), while younger age and cardiogenic cause increased the chance of shockable rhythms (1.7 and 8.5 times more likely). These findings align with the

study by Randjelovic et al. which reported a lower incidence of shockable rhythms in residential locations and a greater likelihood in OHCAs with a cardiac cause[13]. Similarly, the COSTA group, a collaboration network of resuscitation researchers in Copenhagen, Oslo, Stockholm, and Amsterdam, observed an overall decline in shockable initial rhythms in residential settings [16], likely due to slower recognition and delayed intervention. Additionaly, during the last years of their study period, from 2011 to 2015, the overall proportion of a shockable initial rhythm remained stable for both residential and public OHCA[16]. Study by Martinell et al also found that cardiac arrest occurring at home is an independent predictor of a poor outcome[5]. The lower likelihood of shockable rhythms in areas with over 100 000 inhabitants could be influenced by several factors such as increased response time and bystander intervention. While urban areas might generally have better healthcare infrastructure, in densely populated areas EMS response times can be longer due to traffic, distance, or logistical challenges. Secondly, bystanders may be less likely to initiate CPR or use an automated external defibrillator (AED) due to crowd hesitation, lack of AED availability, or low bystander confidence. This contrasts with Barry et al, who found that urban locations were associated with better survival rates[3], thus further research is needed in order to gain more insight into this specific topic.

Our finding that younger age increased the likelihood of shockable rhythms aligns with the broader literature. Several studies indicated that older age typically corresponds to worse survival[3,5,8,12,17], often due to non-shockable rhythms[18, 19]. Barry et al. also observed reduced survival with increasing age and also with increasing call response interval in minutes[3]. A review by Holmström et al. points out a significant shift in initial rhythms, where schockable rhythms continue to progressively decrease in contrast to non-shockable, which now comprise more than 70% of cases[14].

Any ROSC Predictors

Shockable rhythms were the strongest predictor of any ROSC in our study, with a 3.9 times higher chance of achieving ROSC in cases with an initial shockable rhythm. This is consistent with findings from several other studies which identified shockable rhythms as key predictors of ROSC and survival[1,4,6, 11-13]. Some studies also highlighted the importance of bystander CPR, which plays a crucial role in achieving favourable outcomes[2,4,13]. The EuReCa studies also revealed considerable variability in OHCA outcomes across different regions, emphasizing how local EMS performance and public awareness can affect survival rates. [1,10].

The finding that residential locations were associated with lower ROSC rates has been consistently reported across the literature. Randjelovic et al. and the COSTA group both noted that OHCAs at home are less likely to result in ROSC, largely due to delayed intervention[13,16]. Emoto et al. also found that bystander CPR and AED use significantly improved ROSC chances, reinforcing the need for timely intervention in residential OHCAs[20]. However, there is still great disparity between different regions. For example, the rate of bystander CPR ranges from 13% in Serbia to 83% in Norway and incidence of resuscitation attempted per 100 000 inhabitants ranges from 19 in Spain, to 97 in Poland[10].

ROSC on Admission Predictors

The analysis of predictors for return of spontaneous circulation upon hospital admission showed that an initial shockable rhythm increased the likelihood of ROSC at admission to 3.3 times, whereas urban and residential locations were found to decrease the chances, making ROSC 55.8% and 51.1% less likely, respectively). Similar findings were reported by Nikolovski et al, who emphasized the importance of shockable rhythms for achieving ROSC both pre-hospital and upon hospital admission[4]. Additionally, our findings indicated that assistance from EMS dispatchers increased the likelihood of ROSC upon hospital admission to 1.7 times, while a delay of 10 minutes or more between the EMS call and defibrillation significantly reduced the chances of ROSC, making it 86.1% less likely. Similarly, Randjelovic et al. demonstrated that the probability of ROSC drops significantly after 17 minutes from the emergency call, emphasizing the critical role of rapid response [7]. A study from Ireland by Barry et al also concluded that increasing call response interval in minutes was associated with reduced survival [3]. Gowens' meta-analysis further confirmed that EMS performance significantly influences survival outcomes, with European and Australasian regions achieving better results compared to North America, potentially due to differences in EMS response times and practices. Gowen's MA also found that among initial shockable arrests, study duration and region remained

the only variables associated with survival to hospital discharge or 30 days in the multivariable analysis [15]. A study conducted in Japan revealed that among patients under 81 years old, a time of less than 10 minutes from collapse to the first shock resulted in a better prognosis, with a predictable favorable neurological survival rate of 62.1%. Additionally, if the interval from collapse to the first shock was delayed by 10 minutes or longer in these patients, bystander CPR became the next critical factor influencing outcomes [8].

Despite extensive research on OHCA outcomes, there is limited literature specifically addressing the influence of predictors on the occurrence of shockable rhythm, any ROSC, and ROSC on hospital admission in patients with witnessed OHCA. Further research is needed to explore these interactions in diverse populations and regions, as well as to develop tailored interventions that can improve pre-hospital and in-hospital outcomes.

Conclusion

In conclusion, our study identified several independent predictors influencing the occurrence of shockable rhythm, any ROSC, and ROSC on admission in witnessed OHCA cases. Younger age and cardiogenic cause increased the chance of shockable rhythms, while events occurring in areas with more that 100 000 inhabitants and residential settings were linked to lower chances of any ROSC and ROSC on admission.

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Abbreviations:

EMS – Emergency medical services
ERC – European Resuscitation Council
CPR – Cardiopulmonary resuscitation
OHCA – Out-of-hospital cardiac arrest
ROSC – Return of spontaneous circulation
VF – Ventricular fibrillation
VT – Ventricular tachycardia

Conflict of interest

The authors declare no conflict of interest regarding the publication of this study.

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