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ARTYKUŁ ORYGINALNY / *ORIGINAL ARTICLE*

Emergency medical system response time does not affect incidence of return of spontaneous circulation after prehospital resuscitation in one million central European agglomeration residents

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Abstract

Background: The survival of out-of-hospital sudden cardiac arrest (OHSCA) in Europe still remains low. The State Medical Rescue System is composed of several elements. The efficacy of each of these elements may have an influence on the victim's survival. Until now, the incidence of return of spontaneous circulation (ROSC) and its correlation with rescue services time in the city of Poznan has not been determined.

Aim: The main purpose of this study was to assess incidents of OHSCA and prehospital frequency of ROSC after OHSCA in Poznan city and district. We also wanted to analyse whether ROSC depends on Emergency Medical System (EMS) reaction time.

Methods: Retrospective analysis based on medical documentation conducted in 2015 in Poznan EMS.

Results: Return of spontaneous circulation was achieved in 68.88% of cases. It was most frequent when OHSCA occurred in public places ($p = 0.000$, contingency factor = 0.233) and victims were younger ($p = 0.042$, contingency factor = 0.129). 63.17% of patients were male, but sex did not affect the incidence of ROSC. The median time of system response was 8.53 min, while time from ambulance departure to arrival was 5.42 min. We did not find any statistically significant difference between the number of deaths and those parameters ($p = 0.723$, $p = 0.891$). However, longer team response time correlated with the highest mortality ($p = 0.042$, contingency factor = 0.126). In the group where ROSC was achieved the median time of EMS response was 8.18 min, while among the group of deceased the median was 8.63 min.

Conclusions: The incidence of OHSCA in our region is similar to other Polish and European cities. EMS response time does not affect the frequency of ROSC. ROSC was achieved more often if OHSCA occurred in public and the victim was younger.

Key words: resuscitation, treatment efficacy, emergency medical services

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INTRODUCTION

According to statistics provided by the European Resuscitation Council (ERC), the annual incidence of out-of-hospital sudden cardiac arrest (OHSCA) in Europe is 55–113/100,000 inhabitants. The leading causes of OHSCA are cardiovascular system diseases [1]. Despite the significant development of diagnostic and treatment procedures, the OHSCA survival rate still remains low. The development of medical rescue in Poland in the last 20 years has significantly contributed to increasing access to medical help for sudden cardiac arrest (SCA) victims. Widely available first aid training, which is implemented at the level of early childhood education, as well as training in the context of occupational health and safety or driving courses, raises citizens' awareness and willingness to provide first aid. This willingness is declared by 54–70% of the Polish population [2, 3]. More and more we hear about public accessed defibrillation programmes, the effectiveness of which has already been proven. Available world literature indicates the relationship between OHSCA survival rate and Emergency Medical System (EMS) response time [4, 5]. Although this includes research that takes up the problem of OHSCA victims in Poland, there is still a lack of data that

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clearly describe the impact of the Polish State Medical Rescue System on survival rate. The collecting of information about prehospital incidence of return of spontaneous circulation (ROSC) and its correlation with EMS reaction time intervals is a valuable source of OHSCA epidemiology and may be treated as one of the indicators of the system's efficiency. The primary aims of this study were as follows: (1) To investigate if the incidence of OHSCA in the city and district of Poznan depends on the victims' sex and age, the place, the hour, and the month of occurrence; (2) To evaluate incidence of ROSC in OHSCA; and (3) To ascertain the correlation between emergency system reaction time and incidence of ROSC.

METHODS

Organisation of EMS in Poznan city and district

In 2015, the city of population of Poznan was 548,028 inhabitants (population density 2092/km^2) and the district of Poznan 352,395 inhabitants (population density 185/km^2). This population was secured by 23 medical rescue teams (MRT). Seven physician-staffed second-tier teams, and 16 paramedics-staffed first-tier teams [6]. The total number of ambulance interventions in 2015 was 69,977. Of this number 1.07% concerned OHSCA. Emergency calls are received by medical dispatchers from a 999 number, who conduct a short interview and decide if the notification should be responded to by MRT and they define the priority of response. If necessary, dispatchers also provide first-aid instructions. Notifications are received and transferred using a computer system. If the dispatcher finds a potentially life-threatening situation, she or he should send MRT within no longer than 1 min. The dispatched MRT must leave station also within 1 min. This type of responding is called "code one" (K1). In case of potentially not-life-threatening situations, dispatch time is 2 min and departure time is also 2 min ("code two" [K2]) [7]. The median time to arrive on scene should be no longer than 8 min in cities of more than 10,000 inhabitants and 15 min outside these cities.

Data collection

We used data contained in the computer system of the Regional Ambulance Service in Poznan. The conducted survey was a retrospective analysis based on the MRT medical documentation, where the diagnosis was "sudden cardiac arrest" (ICD-10: I46). From 639 cases of OHSCA nine were rejected due to technical system errors (incorrect date and time indicating that the ambulance left before the dispatcher received the call). Of the remaining 630 events, in 511 cases cardiopulmonary resuscitation (CPR) was taken, while in the other 119 death occurred before MRT arrival. The analysis of ROSC was conducted only for cases in which a CPR attempt was made. The rest of the correlations were defined for all 630 cases. The test group was divided into two subgroups: the first comprising the cases where ROSC after CPR was achieved (n = 352) and a second where, despite CPR, patients died (n = 159). We took into account the patients' age, sex, and place where OHSCA occurred. We also analysed the correlation of ROSC to the month and time of day. MRT were responding both to code one and two. In determining the intervals of action of individual components of the system we adopted the following distribution: the time from receiving a call from a witness by medical dispatcher to MRT dispatch (Dispatch Centre [DC] reaction), the time from dispatch to MRT departure (MRT reaction time), the time from departure to arrival (MRT arrival time), and the time from receiving the call to ambulance arrival (EMS response time). The results were processed using Statistica 12 PL (analysis of statistical significance using the χ^2 test, with the level of alpha = 0.05).

RESULTS

Medical rescue teams were dispatched to SCA 724 times (first tier: 420 times, second tier: 304 times), while in 97 cases two units were sent to the same victim — first paramedics and then a physician at the paramedics' request. Ambulances responded to 630 patients with SCA, of which women accounted for 33.49% (n = 211) and men 63.17% (n = 398). In 21 (3.33%) cases the gender of the victim was not definite. Figure 1 shows the distribution of SCA victim's age. Most cases of cardiac arrest occurred in private homes (74.13%), in the rest of incidences (25.87%) ambulances responded in public places. Statistically important difference between place and incidence of ROSC was found (p = 0.000, contingency factor = 0.233). The results of the correlation are summarised in Table 1.

The incidents of OHSCA varied slightly depending on the month — the lowest events were recorded in July — 6.19%, in August — 5.87%, and in September — 5.87% and the most in January, February, and October (respectively, 9.84%, 10.00%, and 10.48%). The largest number of events occurred in the morning — between 8.00 and 12.00 — and in the afternoon between 16.00 and 20.00. The exact distribution of hours is shown in Figure 2. The percentage of deaths before MRT arrival was 19.62% for the second tier and 19.01% for the first tier. Of 511 victims in whom CPR was provided, ROSC was achieved in 68.88% of cases. Among women and men, we noted a similar percentage of the occurrence of ROSC and death. Transport to hospital of 69.01% of women and 66.77% of men with restored vital signs was undertaken. A statistical relationship between the occurrence of ROSC and patients' gender was not found (p = 0.615). We found a statistical relationship between the victim's age and the occurrence of ROSC (p = 0.042, contingency factor = 0.129). Younger victims had a higher chance to achieve ROSC (Table 2).

Dispatchers diagnosed cardiac arrest in over 30% of cases; however, it should be noted that cardiac arrest could occur after receiving the notification and sending the ambulance. The types of calls are shown in Figure 3. 92.54% of MRT responded with the highest priority, called "code one" (K1). A statistical relationship between urgency code and

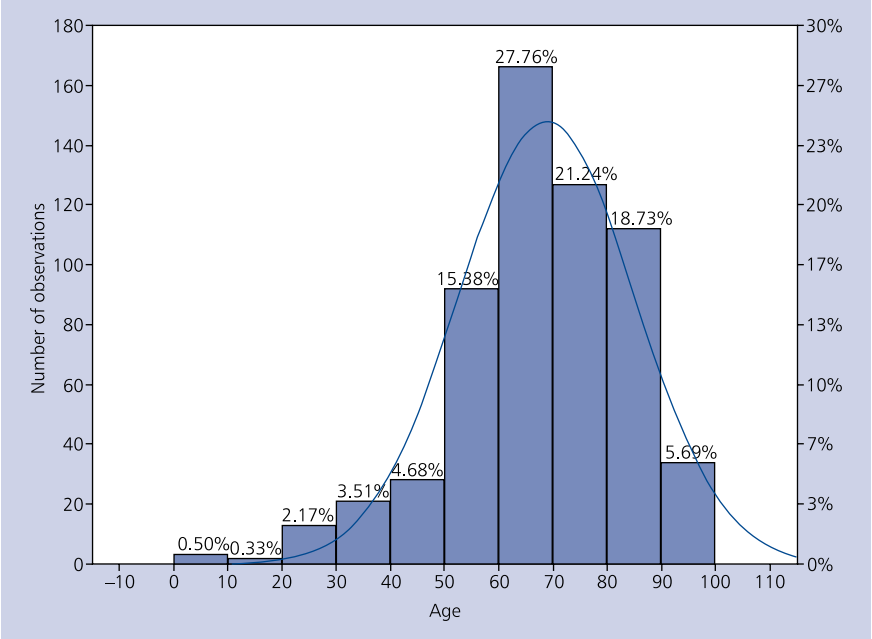

Figure 1. The age of cardiac arrest victims

Table 1. Incidence of return of spontaneous circulation (ROSC) depending on localisation of sudden cardiac arrest

	Public place	Private home
ROSC	87.79%	62.37%
Death	12.21%	37.63%

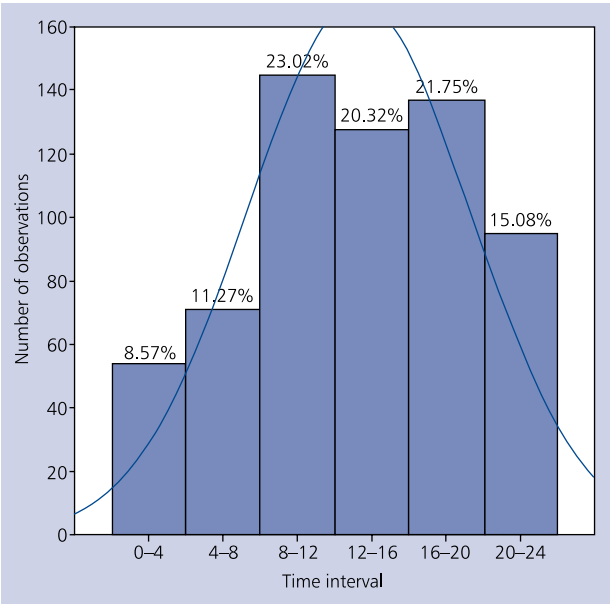

Figure 2. The exact distribution of hours at which ambulances responded to cardiac arrest

incidence of ROSC was not found (p = 0.096). Details are shown in Table 3.

Average DC response time was 1.87 min (median 0.81 min). 75% disposal was submitted within 1.78 min or less from receiving the call. The average MRT response time stood at 1.51 min (median 1.20 min). This time in the group of people who achieved ROSC before hospital admission was 1.44 min, while in the decease group it was 1.52 min. We found a statistical relationship between the MRT response time and the occurrence of ROSC (p = 0.042, contingency factor = 0.126). The longer the MRT reaction, the higher the risk of the patient's death (Table 4).

The average time from ambulance departure to arrival on the scene was 7.00 min (median 5.42 min). In 70.95% of the cases the route to the destination was achieved by an ambulance in a maximum of 8 min. Ambulance arrival time longer than 15 min was related with the highest mortality. A statistical relationship was not found (p = 0.891) (Table 5).

The average EMS response time was 10.38 min (median 8.53 min). In 75% of cases, from receiving a call in DC to ambulance arrival took 12.65 min or less. In cases when ROSC was achieved the time was 9.93 min (median 8.18 min), while among the group of deceased it was 10.46 min (median 8.63 min). There was no statistical significant difference between the number of deaths and the system response time (p = 0.723). The relation of ROSC to EMS response time is shown in Table 6.

DISCUSSION

This paper was the first attempt to determine the incidence of OHSCA and the incidence of ROSC according to response

Table 2. Incidence of return of spontaneous circulation (ROSC) depending on victims' age

	Age ≤ 40 years	Age 40 < × ≤ 60 years	Age 60 < × ≤ 80 years	Age > 80 years
ROSC	87.50%	70.30%	63.14%	66.67%
Death	12.50%	29.70%	36.86%	33.33%

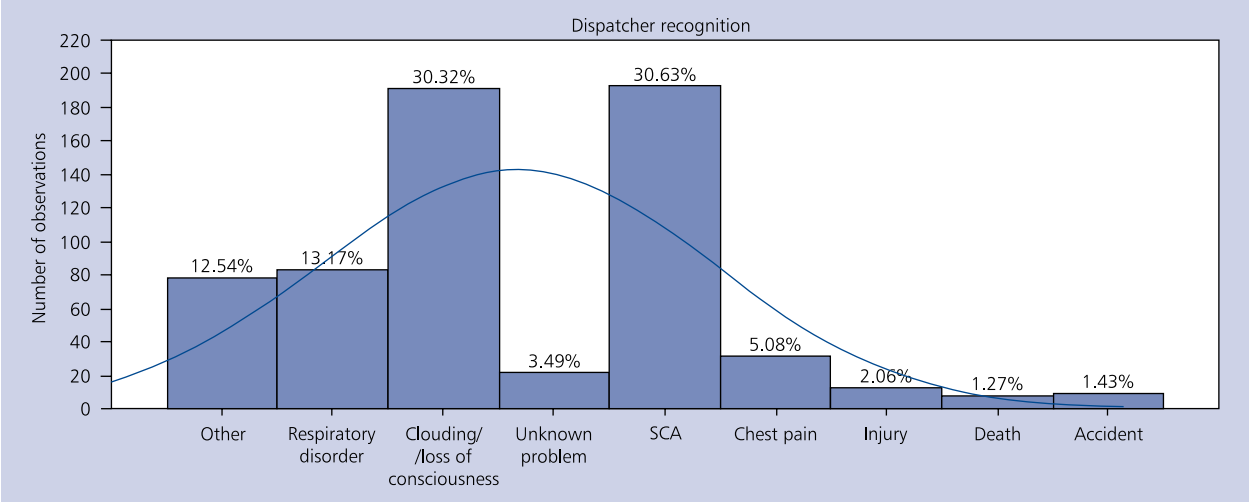

Figure 3. Types of calls recorded by medical dispatchers; SCA — sudden cardiac arrest

Table 3. Incidence of return of spontaneous circulation (ROSC) depending on urgency code of ambulance response

	ROSC	Death
Code 1	67.93%	32.07%
Code 2	81.08%	18.2%

time of the State Medical Rescue System in Poznan and Poznan district as an example of local EMS. The epidemiology of OHSCA in the study area is similar to that in other Polish and European cities.

As mentioned in the literature review, OHSCA more often concerns men [8–11]. In addition, one of the studies indicated that men more often than women receive CPR prior to ambulance arrival (64% vs. 58%, $p = 0.03$) and also that men survive significantly more often until hospital discharge (52% vs. 38%, $p < 0.001$). This has been associated with the presence of different comorbidities. In men coronary artery disease was observed more frequently, while in women more chronic obstructive pulmonary disease was seen [12]. In our research we found that the occurrence of prehospital ROSC does not depend on gender. The median age is also in agreement with other authors [8, 11, 13]. Only in a study conducted in Johannesburg, the median age of the victims was 53 years, so more than 10 years lower than in Europe. The relationship between the occurrence of SCA and the time of day and the year seems to be interesting. Most events were recorded in the morning hours, between 8 and 12. This is the time of increased sympathetic nervous system activity, and higher cortisol concentration and prothrombotic activity [14]. These results support previous research from Saxony [8] and Szczecin [15]. Bagai et al. [16] showed that most OHSCA cases occur on weekends, and the least on Tuesdays. There was no statistically significant difference in the number of people who survived until hospital admission, but more victims who suffered OHSCA on a working day survived until hospital discharge. The dependence of OHSCA occurrence on time (most between 7.00 and 15.00), the season (most in autumn), and the month (most on December) was also found. Our study group, in comparison with the discussed paper, was much smaller, which could also affect our findings. OHSCA occurred more often at home or at a private place. It was less likely to achieve ROSC in these places. According to Rudner et al. [13], out of home OHSCA occur on the street (47%), in public buildings (29%), and at work (9%). A higher survival rate was observed when OHSCA occurred in the workplace or inside buildings, as compared to on the street. This is probably due to the fact that in a public place witnesses, who activated the EMS, were present. One of the aims of this study was to determine the incidence of ROSC after OHSCA. The indicated incidence of ROSC among all patients to whom CPR was given (68.88%) seems to be quite satisfying, if compared to other European cities. In literature we can find varied

Table 4. Incidence of return of spontaneous circulation (ROSC) depending on ambulance response time (medical rescue teams [MRT])

	MRT response time ≤ 1 min	MRT response time 1 < × ≤ 2 min	MRT response time 2 < × ≤ 3 min	MRT response time > 3 min
ROSC	74.42%	68.36%	61.54%	56.10%
Death	25.58%	31.64%	38.46%	43.90%

Table 5. Incidence of return of spontaneous circulation (ROSC) depending on time to ambulance arrival

	Arrival time ≤ 8 min	Arrival time 8 < × ≤ 15 min	Arrival time > 15 min
ROSC	69.40%	68.07%	65.38%
Death	30.60%	31.93%	34.62%

Table 6. Incidence of return of spontaneous circulation (ROSC) depending on Emergency Medical System (EMS) response time

	EMS response time ≤ 8 min	EMS response time 8 < × ≤ 15 min	EMS response time > 15 min
ROSC	70.20%	68.59%	65.33%
Death	29.80%	31.41%	34.67%

results: Oslo — 31% [9], Copenhagen — 39.1% [15]. These results indicate the number of patients alive at admission. In County Cork in Ireland it was demonstrated that 56.8% of cardiac arrest victims were transported to a hospital. The return of spontaneous circulation was achieved, however, in only 15% of patients [11]. In 2002–2003 in Szczecin, return of spontaneous circulation after resuscitation at the scene were achieved, respectively, in 31.1% and 45.3% of patients [15]. The organisation of EMS is different in various countries. Also, the advancement of medical procedures that are allowed to be performed by the ambulance crew is varied. These factors can contribute to diverse results. Our finding, if compared with others', may indicate good organisation of prehospital care in Poznan. Conversely to the fact that there was no statistical difference between arrival time and ROSC, in most cases the ambulance crew abandoned medical procedures when the time was longer than 15 min. The final effect of the efficiency of the system consists of multiple links that dependent of many variables, e.g. the skilfulness of the team, system overload, its fluency, traffic and weather conditions, and the system of communication between dispatcher and MRT. For comparison, in Sweden, the average response time of the rescue system for patients who survived SCA was 11 min and 15 min in cases of death. The authors of this study also indicated that a higher survival rate was observed in areas where more ambulances are based, and not on the density of population [17]. In one research project conducted in Poland the authors defined that ambulance arrival time was 9 min for patients with ROSC and 11 min for deceased. Their results are similar to ours, despite different median times [18]. The median MRT arrival time that we obtained in most cases meets the requirements of the Act of State Medical Rescue System. In 2015 the average number of Poznan EMS interventions was 192 times per day. A previous study noted that 56.4% of all MRT responses was not associated with the occurrence a life-threatening situation [19]. Providing immediate medical care to a person in a life-threatening condition when the system is overloaded might be difficult. The most disturbing finding of this analysis may be the fact that in less than half of the cases MRT response time was lower than 1 min. This time is also estimated in the mentioned Act of State Medical Rescue System as appropriate for life-threatening events and should not exceed 1 min if the medical dispatcher give the highest priority of immediate response.

Limitations of the study

This paper has also several limitations. Compared to the other studies, our sample was quite small. The term "return of spontaneous circulation" refers to restoration of haemodynamically efficient heart function. Moreover, the fate of the patients was evaluated only until hospital admission. Therefore, the research does not assess the survival of OHSCA victims but only shows their fate, taking into account EMS response time. In our study we did not take into account the factors that might have a direct impact on the results, either: CPR performed by bystanders or the use of an automated external defibrillator (AED). This information was not contained in medical documentation. This deficiency may be significant because a crucial

indicator of survival after OHSCA is not the occurrence of ROSC but rather the time from onset of SCA to ROSC. We took into account only cases featured with ICD-10: I46. It is possible that we omitted some cases with other codes specifying the death (R9x). Based on numerous papers, we already know that the OHSCA survival rate depends on CPR that has been performed by the witnesses and the early use of an AED. The role of the medical rescue teams is limited to "sustain the chance" of survival given to the victim by a witness. We also estimated incidents of OHSCA not only for resuscitated patients but also for those to whom resuscitation attempts were not taken. We are aware of these imperfections and believe that this research is only an introduction, and the subject of OHSCA in our agglomeration requires further investigation.

CONCLUSIONS

1. Emergency Medical System reaction time for patients with OHSCA in our region does not differ from other data available in the literature.
2. There is no relationship between the system reaction time and the incidence of ROSC, although longer time of departure of ambulance leads to decreased ROSC incidence.
3. The younger the victim, the higher the chances of achieving ROSC.
4. Return of spontaneous circulation was more often achieved when OHSCA occurred in a public place.

Conflict of interest: *none declared*

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Czas reakcji służb ratownictwa medycznego nie wpływa na częstość przywrócenia spontanicznego krążenia u osób po resuscytacji w warunkach przedszpitalnych w milionowej środkowoeuropejskiej aglomeracji

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Streszczenie

Wstęp: Przeżycie pozaszpitalnego nagłego zatrzymania krążenia (OHSCA) w Europie wciąż pozostaje na niskim poziomie. System Państwowego Ratownictwa Medycznego składa się z kilku elementów. Sprawność działania każdego z tych ogniw może wpływać na szanse przeżycia nagłego zatrzymania krążenia. Dotychczas liczba przypadków przywrócenia spontanicznego krążenia (ROSC) po resuscytacji prowadzonej w warunkach przedszpitalnych oraz jej korelacja z czasem reakcji służb ratownictwa medycznego na terenie Poznania nie została określona.

Cel: Głównym celem pracy była ocena występowania OHSCA i częstość przypadków ROSC u jego ofiar w mieście oraz powiecie poznańskim. Drugim celem pracy było określenie zależności występowania ROSC od czasu reakcji poszczególnych ogniw systemu ratownictwa medycznego.

Metody: Przeprowadzono retrospektywną analizę opartą na elektronicznej dokumentacji medycznej prowadzonej w Rejonowej Stacji Pogotowia Ratunkowego w Poznaniu w 2015 r.

Wyniki: Przywrócenie spontanicznego krążenia uzyskano w 68,88% przypadków. Zjawisko to było częściej obserwowane, gdy do nagłego zatrzymania krążenia dochodziło w miejscu publicznym ($p = 0{,}000$; wsp. kontyngencji = 0,233) oraz u młodszych pacjentów ($p = 0{,}042$, wsp. kontyngencji = 0,129). 63,17% pacjentów stanowili mężczyźni, jednak płeć nie wpływała na liczbę ROSC. Mediana czasu reakcji systemu wyniosła 8,53 min, z kolei mediana czasu od wyjazdu karetki do przybycia na miejsce zdarzenia — 5,42 min. Nie wykazano różnicy istotnej statystycznie między liczbą zgonów a tymi parametrami ($p = 0{,}723$; $p = 0{,}891$). Jednak dłuższy czas reakcji zespołu ratownictwa medycznego wiązał się z wyższą śmiertelnością ($p = 0{,}042$, wsp. kontyngencji = 0,126). W grupie, w której uzyskano ROSC, mediana czasu reakcji systemu wyniosła 8,18 min, natomiast w grupie osób zmarłych — 8,63 min.

Wnioski: Występowanie OHSCA w mieście i powiecie poznańskim jest podobna do innych polskich i europejskich miast. Czas reakcji systemu ratownictwa medycznego nie wpływa na częstość występowania ROSC. Większą liczbę przypadków ROSC uzyskiwano, gdy do OHSCA dochodziło w miejscu publicznym, a jego ofiara była młodsza.

Słowa kluczowe: resuscytacja, skuteczność leczenia, służby ratownictwa medycznego

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