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The influence of emergency medical procedures and event circumstances on the acute effectiveness of resuscitation in out-of-hospital sudden cardiac arrest in adults

Wpływ udzielanych czynności medycznych a skuteczność resuscytacji z pozaszpitalnym nagłym zatrzymaniem krążenia u osób dorosłych

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Keywords

sudden cardiac arrest, emergency medical procedures, return of spontaneous circulation, resuscitation

Słowa kluczowe

nagle zatrzymanie krążenia, medyczne czynności ratunkowe, powrót spontanicznego krążenia, resuscytacja

Conflict of interest

Konflikt interesów

None
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Summary

Introduction. Sudden cardiac arrest is a serious medical event that may occur unexpectedly. It is a serious medical and social issue.

Aim. The aim of the study is an analysis of the relationship between the type of medical rescue actions taken and return of spontaneous circulation (ROSC) in adults.

Material and methods. The case-control study was based on the medical documentation of the Rescue Service in Katowice collected in 2017. The results have been presented by means of proportions (sample size and sampling rate), median and IQR. Non-parametric methods (Pearson's chi-squared test or Mann-Whitney U test) were used to compare the group of ROSC-patients with the group of no-ROSC-patients. The default statistical significance adopted for the purpose of all analyses was 0.05.

Results. The analysis covered 1713 out-of-hospital sudden cardiac arrest (SCA) cases. Male patients constituted 63.68% (N = 1091) of the group, whereas female patients constituted only 34.5% (N = 591) of the cases. Women were older than men (69.5 vs. 62.9; p = 0.000). However, defibrillation was more frequently applied in men than in women (p = 0.000). In a majority of cases, SCA occurred in domestic conditions (p = 0.000) during the day (p = 0.000). ROSC was reported in 591 cases (34.51%). The ROSC rate was higher in cases when witnesses provided first aid to patients (35.6 vs. 31.41%; p = 0.08). The rate was also higher in patients with ventricular fibrillation than in patients with asystole (56.27 vs. 24.95%; p = 0.000).

Conclusions. ROSC depends on the emergency medical procedures actions performed at the place of incident. The ROSC rate in patients is significantly higher when procedures are performed according to the current medical knowledge.

Streszczenie

Wstęp. Nagłe zatrzymanie krążenia jest poważnym zdarzeniem medycznym, które może wystąpić w najmniej oczekiwanym miejscu i czasie. Jest bardzo poważnym problemem medycznym i społecznym.

Cel pracy. Celem pracy była ocena udzielanych świadczeń medycznych u pacjentów, u których wystąpiło pozaszpitalne nagłe zatrzymanie krążenia i skuteczności powrotu parametrów życiowych.

Materiał i metody. Badanie kliniczno-kontrolne przeprowadzono na podstawie dokumentacji medycznej Pogotowia Ratunkowego w Katowicach za 2017 rok. Wyniki zaprezentowano za pomocą wskaźników struktury (liczebności i odsetki) oraz mediany i IQR. Do porównania grup pacjentów „ROSC” oraz „no ROSC” wykorzystano statystyki nieparametryczne: test χ^2 Pearsona lub U Manna-Whitneya. Dla wszystkich analiz jako domyślny poziom istotności statycznej przyjęto wartość 0,05.

Wyniki. Do analizy włączono 1713 przypadków pozaszpitalnego NZK. Mężczyźni stanowili 63,68% (N = 1091), a kobiety jedynie 34,5% (N = 591). Kobiety były starsze niż mężczyźni (średnia wieku 69,5 vs 62,9 roku, $p = 0,000$). Natomiast częściej wykonywano defibrylację u mężczyzn niż u kobiet ($p = 0,000$). Najczęściej do wystąpienia pozaszpitalnego NZK dochodziło w warunkach domowych ($p = 0,000$), najczęściej w ciągu dnia ($p = 0,000$). Wyższy wskaźnik ROSC odnotowano, kiedy świadek udzielał pierwszej pomocy (35,6 vs. 31,41%, $p = 0,08$). Pacjenci z VF mieli większy wskaźnik ROSC niż z asystolią (56,27 vs. 24,95%, $p = 0,000$).

Wnioski. ROSC zależy od wykonywanych medycznych czynności ratunkowych na miejscu zdarzenia. Postępowanie zgodnie z aktualną wiedzą medyczną powoduje większy odsetek skuteczności resuscytacji.

INTRODUCTION

Sudden cardiac arrest (SCA) is a serious medical event that may occur unexpectedly. It is a serious medical and social issue (1). SCA may be caused by various factors (both diseases and traumas) and requires taking immediate rescue actions performed by witnesses as well as by qualified medical emergency teams. In Europe, SCA is diagnosed in 38/100 000 inhabitants per annum (2, 3), whereas in the USA, SCA is diagnosed in 76/100 000 per year (4). Globally, there are numerous registers of out-of-hospital SCA (5, 6).

The definition of SCA is closely related to the notion of sudden cardiac death (SCD). SCD is universally defined as a natural death from a cardiovascular cause presenting loss of consciousness and death within one hour from the occurrence of symptoms (the one-hour period is arbitrary) (7). In spite of the fact that SCA registers have recently indicated an increase in the return of spontaneous circulation (ROSC) rate in Europe and in the world, SCA mortality still remains incredibly high: only 10.6% of SCA patients survive to leave hospital (8).

Witnesses of the incidents play an important role in successful rescue actions. Prompt reaction and resuscitation performed by a third party increase the chances of ROSC (9). Ventricular fibrillation was the first rhythm diagnosed by the emergency medical team in only about 20-25% of cases (10). In such a numerous population that the USA has, shockable rhythms are reported in only 23% of patients, where the survival rate amounts to 22 vs. 8% as far as the non-shockable rhythms are concerned (11, 12). However, when the witness uses an AED (Automated External Defibrillator), the survival rate will reach from 59% up to 79% (13-15).

AIM

The aim of this research was the assessment of the effectiveness of emergency medical procedures performed by emergency medical teams in prehospital care in reference to the ROSC rate in the 2.7-million-population monitored by the Voivodeship Rescue Service (VRS) in Katowice.

MATERIAL AND METHODS

Study design and population

The case-control study was based on the medical documentation of the Emergency Medical Ser-

vices (EMS) units of Voivodeship Rescue Service (VRS) in Katowice covering 2.7 million inhabitants and collected in 2017 ($n = 254\ 673$). The research involved exclusively individuals older than 18 years, with non-hospital SCA. After considering the above inclusion criteria, there were 1713 dispatch order forms (0.67% of all dispatch orders) involved in further research. Consent of the Bioethics Committee was not required.

Data collection and processing

Demographic data (i.e. gender, age, location, time of the day) of the incidents with non-hospital SCA were analyzed. Calls between emergency medical dispatchers and witnesses of the incidents were analyzed as far as first aid instructions and main reporting reason were concerned. Emergency medical teams were divided into two groups, i.e. teams with doctors and teams without doctors. In Poland, the only indicator of the system's quality is the median of time from team dispatch to team arrival at destination. The median was calculated for both emergency priority codes: C-1 and C-2. Based on the emergency medical procedure forms, the actions of emergency medical teams were verified as far emergency medical procedures (endotracheal intubation, the use of suction pumps, defibrillation, the use of alternatives providing airway patency, the mechanism of cardiac arrest etc.) and ROSC were concerned. The case-control study did not cover actions performed after transfers of patients to intensive care units (ICU). No hospital medical procedures were analyzed.

Statistical analysis

Descriptive statistics involved the calculation of proportions (sample size and sampling rate for non-metric variables), and median, as well as IQR in the case of quantitative variables. Depending on the measurement scale, Pearson's chi-squared test or Mann-Whitney U test were used to compare the group of ROSC-patients with the group of no-ROSC-patients. The model of logistic regression was applied to estimate the probability of ROSC. The dependent variable was the presence of ROSC (value: 1) or the absence of ROSC (value: 0). STATISTICA 13.1 (StaSoft® Inc.) and IBM® SPSS 24.0 software were used to analyze data. The default statistical significance adopted for the purpose of all analyses was 0.05.

RESULTS

All non-hospital SCA cases involved 1091 male individuals (63.68%) and 591 female individuals (34.5%). There were 31 patients (1.81%) with no gender reported in medical documentation. Moreover, the analyzed cases of non-hospital SCA included 1035 (60.42%) patients aged over 65 years (the age median 66.1 years). Female patients were older than male patients (age mean: 69.5 vs. 62.9; $p = 0.000$), which was true also for the group of patients aged over 65 years. However, defibrillation was more often performed in men than in women ($p = 0.000$) (tab. 1). What is more, defibrillation was more frequently performed in patients aged over 65 years than in younger patients ($p = 0.011$) (tab. 2).

Tab. 1. A comparative analysis of selected variables according to gender

Variable	Male individuals	Female individuals	P-value*
Age \geq 65 years	538 (48.2%)	319 (69.1%)	0.000
Priority code 1 (urgent)	991 (90.09%)	487 (82.4%)	0.002
Ventilation frequency – ventilation bag	641 (61.8%)	335 (55.7%)	0.017
Defibrillation	270 (25.3%)	92 (15.3%)	0.000
Location (at home)	704 (68.8%)	434 (74.5%)	0.025
Death	721 (67.2%)	404 (67.5%)	NS

*Pearson’s chi-squared test

Tab. 2. A comparative analysis of selected variables according to age

Variable	Age \geq 65 years	Age < 65 years	P-value*
Defibrillation	221 (21.35%)	183 (26.99%)	0.011
Location (at home)	713 (68.8%)	471 (73.82%)	NS
Priority code 1 (urgent)	871 (84.1%)	611 (90.1%)	0.017
Total time from dispatch to arrival up to 8 minutes	414 (40%)	252 (37.16%)	NS
Intubation	521 (50.33%)	371 (54.71%)	NS

*Pearson’s chi-squared test

SCA most frequently occurred during the day (between 07.01 a.m. and 07.00 p.m.) ($n = 1062$; 61.99%). SCA cases were less frequently reported in the evenings and at night (between 07.01 p.m. and 07.00 a.m.) ($n = 651$; 38.01%).

Most non-hospital SCA cases occurred in domestic conditions ($n = 1211$; 70.69%), next in public places ($n = 261$; 15.23%) and at school ($n = 3$; 0.17%). Patients who suffered from SCA at home were older than patients with SCA that occurred outside their homes (age mean 65.8 vs. 63.8; $p = 0.026$). SCA in male patients occurred more frequently outside their homes than at home ($p = 0.012$) (tab. 3).

Tab. 3. A comparative analysis of selected variables according to incident location

Variable	At home	Not at home	P-value*
Defibrillation	234 (20.6%)	120 (25.6%)	0.027
Death	786 (66.13%)	356 (69.7%)	NS
Priority code 1 (urgent)	1071 (88.1%)	443 (88.4%)	NS
Total time from dispatch to arrival up to 6 minutes	497 (41.2%)	204 (40.9%)	NS

*Pearson’s chi-squared test

There was a witness of non-hospital SCA in 1141 cases (66.6%). Further 184 cases (10.74%) occurred in the presence of emergency medical teams. Other cases ($n = 388$; 22.65%) occurred without any witness.

According to the emergency medical documentation and the recordings of conversations with emergency medical dispatchers, there were some actions performed by the third person who witnessed the incident in 861 cases (50.26%). In 184 cases, the witnesses were emergency medical team members. Consequently, actions were taken in 1045 cases in total. However, patients did not receive any assistance in 668 cases of non-hospital SCA.

Most frequent actions performed included chest compression (indirect heart massage, 982 cases; 93.97%). Defibrillation attempts were made in 128 patients (including 120 patients assisted by emergency medical teams and 8 cases were used Automated External Defibrillation by the witnesses of the event), and artificial respiration was performed in 222 individuals (21.24%). A higher ROSC rate was observed in cases of any resuscitation actions performed at the place of the incident (35.6% when actions were taken vs. 31.41% when no resuscitation actions were performed, with a trend $p = 0.07$).

Depending on the priority code of the incident, the average median of the highest priority code C-1 was 6 min 17 sec from dispatch to arrival at destination. It is worth emphasizing that the time from dispatch to arrival in the case of the C-2 code (lower priority code) is much longer (9 min 24 sec). The performance of advanced emergency medical procedures increases survival rate in C-1 code. It is in this priority code that a higher frequency of defibrillation was observed (257 vs. 130; $p = 0.000$).

In 911 cases of non-hospital SCA (53.18%), a specialist team was dispatched (i.e. a team with minimum three team members qualified to perform emergency medical procedures, including physician and a nurse or a paramedic). In other cases ($n = 802$; 46.82%) a basic team was dispatched (i.e. a team with at least two team members qualified to perform emergency medical procedures, including a nurse of the system or a paramedic). The particular emergency medical actions performed by the teams at place of incident have been summarized below. The most frequent elements of providing patients with airway patency were endo-

tracheal intubation (n = 958; 55.92%) and laryngeal mask (n = 272; 15.87%). An alarming tendency is that a respirator was used rarely (n = 475; 27.72%), and patients' breathing was provided by means of a ventilation bag (n = 1071; 62.52%). The first diagnosed rhythm was asystole (n = 966; 56.39%). Ventricular fibrillation was reported in 387 cases (22.59%). It was observed that defibrillation was more frequently performed in younger patients, i.e. in individuals younger than 65 years (p = 0.011).

In 1713 cases of diagnosed non-hospital SCA with cardiopulmonary resuscitation, ROSC was reported in 591 cases (34.51%), and an unsuccessful resuscitation was noted in 1122 cases (65.51%). Patients with diagnosed ventricular fibrillation presented a higher ROSC rate than patients with non-shockable rhythm (VF – 56.27% vs. asystole – 24.93%; p = 0.000) (tab. 4).

Tab. 4. A comparative analysis of variables (particular components of rescue procedures) and ROSC in cases of non-hospital SCA

Variable	ROSC (N = 591)	No ROSC (N = 1122)	P-value*
Endotracheal intubation	391 (66.15%)	567 (50.53%)	0.000
Respirator	241 (40.77%)	234 (20.85%)	0.000
Ventilation – ventilation bag	380 (64.29%)	636 (56.68%)	0.003
Defibrillation	178 (30.11%)	209 (18.62%)	0.000

*Pearson's chi-squared test

In order to compare the outcomes of this research with other studies, the results have been presented according to the Utstein-protocol guidelines adopted by the Polish Resuscitation Council. The protocol was modified due to the selected sample of the analysis in question. The results refer exclusively to the resuscitation actions performed as a part of pre-hospital care. The neurological condition of patients and the follow-up on patients' history one month after the incident were not included. Results according to the Utstein protocol are depicted on figure 1.

DISCUSSION

The objective of this research was the analysis of emergency medical actions performed in patients with prehospital SCA and the successful return of vital signs in the population controlled by the Voivodeship Rescue Service (VRS) in Katowice. The analysis covered a 12-month research period.

The attack rate amounted to 62.96/100 000 inhabitants of the population in question. There is a significant difference between the above number and the numbers provided in the available literature. Although the information provided by Gach et al. (16) is related to the same region (the Silesian Voivodeship), the rate is three times higher (170/100 000, in 2013) than the rate provided in this research. In other west-European countries, the rate is similar to the outcome of this research, e.g. 34/100 000 in Denmark (17) and

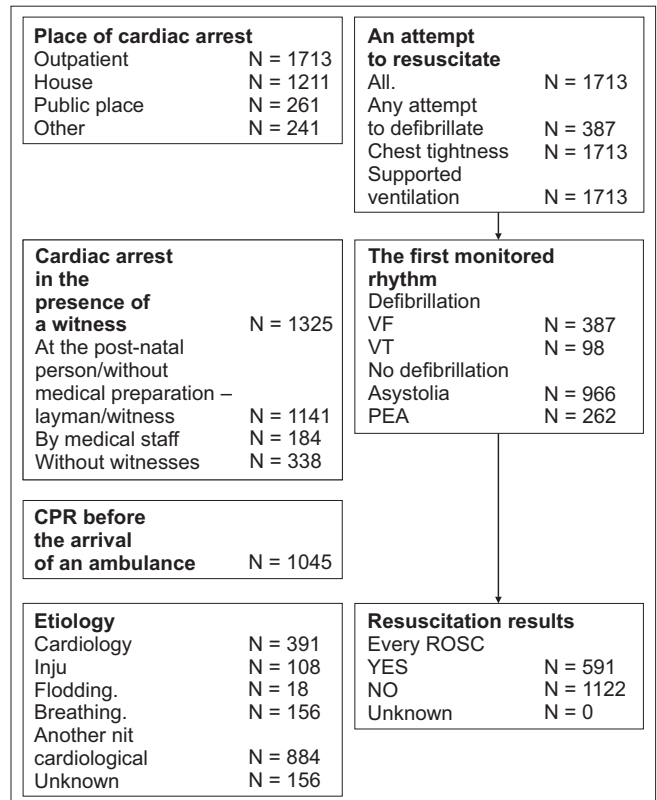


Fig. 1. Obtained results according to the Utstein protocol (based on the Polish Resuscitation Council)

52/100 000 in Sweden (18). However, in Austria, the rate is even higher than in the study by Gach et al., i.e. 206/100 000 (19). The differences may result from different characteristics of the populations or various systems of reporting and collecting medical data. It is worth emphasizing that, in Poland, there is no universal country SCA register (neither in the prehospital- nor in the hospital care). It was even in the case of the Eu-ReCa program that only 6% of the country area was involved in the study (20).

Prehospital SCA was twice as high in men as in women. A similar rate can be found in other publications (21, 22). The age median of the patients amounted to 66.1 years. Women were generally older than men, which is related to the average life expectancy (an average woman lives 8 years longer than an average man). In spite of the numerous differences, the hospital survival rate and the neurological result are usually similar (23). SCA most frequently occurred at patient's home. However, SCA is related to senior patients with a usually long health history. SCA most frequently occurs in the presence of a witness, although the rate of such cases is considerably higher than in own research (24, 25). There is no doubt that the presence of the witness at the place of incident results in a significantly faster reaction of the emergency medical system and considerably shorter time until chest compression (the most important rescue element) is started. According to the emergency medical documentation and recordings of conversations between

witnesses and medical dispatchers, medical rescue actions were performed by the witness of the incident before the arrival of the team in 50% of cases. It is worth emphasizing that almost 11% of the SCA cases occurred in the presence of emergency team members. In the literature, a publication on Beijing (China) can be found, where witnesses perform medical rescue action in only 25% of cases (26). A low rate of resuscitation performed by witnesses of the incidents has also been noted in some other publications (27, 28), also in the Polish research (29, 30). Early resuscitation is crucial because rescue actions performed by witnesses and advanced procedures performed by emergency medical teams are significant elements in the chain of survival, and, at the same time, important factors that increase the chances of ROSC (31). The results indicate that witnesses performing resuscitation increase the probability of return of spontaneous circulation (35.6 vs. 31.41%). In scientific literature, the SCA incidence may vary depending on the time of the day, the month (32), living conditions and/or weather conditions (33). Season changes may consequently depend on the relative climate- and weather changes (34). Regardless of the SCA conditions, the longer the time from loss of patients' consciousness to cardiopulmonary resuscitation, the lower patients' chances of survival. The ROSC rate of the whole group amounted to 34.51% (N = 591), whereas in Europe, the average rate is 38.0% (10). The resulting rate is similar to the rates provided by other sources (35, 36).

It has been estimated that the most frequent primary SCA rhythm is the shockable rhythm (ventricular fibrillation or pulseless ventricular tachycardia) (37). In the study, ventricular fibrillation was diagnosed in 22.59% of the cases. Scientific literature reports that, in 20-25% of cases, the first reported rhythm is either ventricular fibrillation or ventricular tachycardia, which relates to both Europe and the USA (10, 38). There are also countries with a higher frequency of ventricular fibril-

lation (39). The first rhythm diagnosed by the medical emergency team members is a significant indicator of the chances of ROSC. In the case of ventricular fibrillation, the ROSC rate amounts to 55.27%, whereas in the case of asystole, the rate equals only 24.95%.

Securing airway patency by means of resuscitation equipment is an important aspect of resuscitation. Recommendations indicate that a person qualified in endotracheal intubation should use this method (40). According to the research, 55.92% of patients were intubated, and a large number of patients was provided assistance with supraglottic airway methods. However, an alarming fact is that emergency medical teams applied respirators at the place of incident in only 28% of cases. It is difficult to explain this phenomenon by means of short time routes to the closest hospitals with capacities of intensive care units. The research pointed out that endotracheal intubation and the use of a respirator significantly increase the chances of ROSC. Ventilation by means of a ventilation bag with a facial mask alone is often unsuccessful and causes leaks that result in hypoventilation and a high amount of air flow to the stomach, increasing the risk of regurgitation (41, 42). Endotracheal intubation should be perceived as the optimal method of securing airway patency in SCA patients (43).

CONCLUSIONS

OHCA is more frequent in men than in women. It usually occurs in domestic conditions during the day in the presence of a witness. The chances of return of spontaneous circulation increase with a shorter time of emergency medical team's arrival at destination, advanced resuscitation procedures, and SCA in shockable rhythms. Performing any resuscitation activities by the witness of the incident tends to increase the ROSC rate. Any pre-medical basic life support provided by bystanders of the event was prone to increase ROSC rate.

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