An analysis of the relationship between the applied medical rescue actions and the return of spontaneous circulation in adults with out-of-hospital sudden cardiac arrest

Klaudiusz Nadolny, MSc, EMT-Pa, Lukasz Szarpak, PhDb,∗, Joanna Gotlib, PhDc, Mariusz Panczyk, PhDb, Maciej Sterlinski, PhDd, Jerzy Robert Ladny, MD, PhDb, Jacek Smereka, PhDb, Robert Galazkowski, PhDf

Abstract
Sudden cardiac arrest (SCA) is a significant medical and social issue, the main cause of death in Europe and the United States. The aim of the research was to evaluate the effectiveness of emergency medical procedures applied by emergency medical teams in prehospital care in the context of return of spontaneous circulation (ROSC). The case–control study was based on the medical documentation of the Rescue Service in Katowice (responsible for monitoring 2.7 million inhabitants of the region) referring to 2016. The research involved exclusively adults (ie, individuals older than 18 years) with out-of-hospital cardiac arrest (OHCA). After considering the above inclusion criteria, there were 1603 dispatch order forms (0.64% of all dispatch orders) involved in further research. On the basis of the emergency medical procedure forms, the actions of emergency medical teams were verified as medical procedures (endotracheal intubation, the use of suction pumps, defibrillation, the use of alternatives providing airway patency and ROSC) were determined.

The analysis covered 1603 cases of OHCA. SCA turned out more frequent in men than in women (P = .000). Most often, SCA occurred in domestic conditions during the day and was witnessed by a third person. In 59.9% of the cases, actions were taken by witnesses, which increased the probability of ROSC. Patients were usually intubated (51.4%). Respirators were used less frequently (20.2%). Ventricular fibrillation (VF) was reported only in 22.0% of the cases. The ROSC rate was higher in the group of patients with diagnosed VF than in those with nonshockable rhythms (VF, 55.43% vs asystole, 24.05%; P = .000).

Successful resuscitation depends on the quality of emergency medical procedures performed at the place of incident. The highest probability of ROSC is related with defibrillation (in the cases of VF or ventricular tachycardia with no pulse), intubation, the application of a respirator, and performing mechanical ventilation, as well as with a shorter time from dispatch to arrival.

Abbreviations: AED = automated external defibrillator, CPR = cardiopulmonary resuscitation, ECG = electrocardiogram, EMS = emergency medical services, ICU = intensive care unit, OHCA = out-of-hospital cardiac arrest, OR = odds ratio, ROSC = return of spontaneous circulation, SCA = sudden cardiac arrest, SCD = sudden cardiac death, VF = ventricular fibrillation, VRS = Voivodship Rescue Service.

Keywords: cardiopulmonary resuscitation, emergency medicine, return of spontaneous circulation, sudden cardiac arrest

1. Introduction
Sudden cardiac arrest (SCA) is a significant medical and social issue, and the most important cause of death.[1] It is the main cause of death in Europe and the United States. Depending on the definition, SCA is diagnosed in 38/100,000 inhabitants of Europe per annum[2–4] and in 76/100,000 US citizens per year.[5] Globally, there are numerous registers of out-of-hospital cardiac arrest (OHCA).[6,7]

The definition of SCA is closely related with the notion of sudden cardiac death (SCD). SCD is universally defined as a natural death from a cardiovascular cause within 1 hour from the occurrence of symptoms (the 1-hour period is arbitrary).[8] However, in spite of the fact that the SCA survival rate is increasing, the overall SCA mortality still remains incredibly high: only 10.6% of patients with prehospital SCA survive to leave hospital.[9] In such a numerous population as that of the United States, shockable rhythms are reported in only 23% of patients, and the survival rate amounts to 22% versus 8% for the nonshockable rhythms.[10,11] If the rhythm is verified, for example, by means of an automated external defibrillator...
(AED), immediately after loss of consciousness, the survival rate will reach 59% or even 79%.[12,13] A high number of patients with SCA may survive if the witnesses of the incident react immediately, that is, when ventricular fibrillation (VF) is still present.[14,15]

The aim of the research was to evaluate the effectiveness of emergency medical procedures applied by emergency medical teams in prehospital care in the context of return of spontaneous circulation (ROSC) in the population monitored by the Voivodeship Rescue Service (VRS) in Katowice (2.7 million inhabitants).

2. Material and methods

2.1. Study design and participants

The case-control study was based on the medical documentation of the VRS in Katowice referring to 2016 (n=249,872 patients). The VRS in Katowice dispatches emergency medical services (EMS) units, operates 88 emergency medical teams, and monitors 2.7 million inhabitants. The research involved exclusively adults (ie, individuals older than 18 years) with OHCA. After considering the above inclusion criteria, there were 1603 dispatch order forms (0.64% of all dispatch orders) involved in further research. The study protocol was approved by the Institutional Review Board of the Polish Society of Disaster Medicine (approval number: 23.08.2017.IRB).

2.2. Data collection and processing

Data referring to patient’s gender and age, as well as to the location or time of the day of the incidents with OHCA were analyzed. Calls between emergency medical dispatchers and witnesses of the incidents were investigated as far as first aid instructions and main reporting reason were concerned. Emergency medical teams were divided into 2 groups, that is, teams with physicians and teams without physicians. In Poland, the only indicator of the system quality is the median of time from dispatch to team arrival at destination. The median was calculated for both emergency priority codes: C-1 (dispatch with physician present) and C-2 (dispatch without physician present). On the basis of the emergency medical procedure forms, the actions of emergency medical teams were verified to determine emergency medical procedures (endotracheal intubation, the use of suction pumps, defibrillation, and the use of alternatives providing airway patency) and ROSC.

2.3. Follow-up and outcome definition

The case-control study did not cover actions performed after transfers of patients to intensive care units (ICUs). No hospital medical procedures were analyzed.

2.4. Statistical analysis

Descriptive statistics involved the calculation of proportions (sample size and sampling rate for nonmetric variables) and median, as well as interquartile range in the case of quantitative variables. Depending on the measurement scale, Pearson 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). The quasi-Newton method with determination of asymptotic standard errors was applied to estimate the parameters of the regression function. The particular predictors and 2-factorial interactions were added to the model by means of the forward selection method. The model with the variables that met the criteria of minimal borderline significance (P<.1) was considered to be the best adjusted model. Odds ratio (OR) and the 95% confidence interval were defined for each predictor added to the model to estimate the probability of ROSC incidence. The STATISTICA 13.1 (StatSoft Inc, Tulsa, OK) and the IBM SPSS 24.0 software were used to analyze the data. The default statistical significance adopted for the purpose of all analyses was 0.05.

3. Results

All OHCA cases involved 1005 males (62.7%) and only 566 females (35.3%). There were 32 patients (2.0%) with no gender reported in medical documentation. Moreover, the analyzed cases of OHCA included 956 (59.6%) patients aged over 65 years (the age median amounted to 65.7 years). Female patients were older than male ones (mean age, 69.3 vs 62.7; P=.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=.000) (Table 1). Additionally, defibrillation was more frequently performed in patients aged under 65 years than in older ones (P=.011) (Table 2).

Most OHCA cases occurred in domestic conditions (n=1136; 71.1%), in public places (n=234; 14.5%), and at school (n=1; 0.1%). Patients who suffered from OHCA at home were older than those with SCA that occurred outside their homes (mean age, 65.6 vs 63.6; P=.027). OHCA in male patients occurred more frequently outside their homes than at home (P=.015) (Table 3). The OHCA was mostly observed during the day (between 07.01 am and 07.00 pm) (n=1013; 63.2%), less frequently in the evening, and at night (between 07.01 pm and 07.00 am) (n=590; 36.8%).

Table 1

| Variable                  | Male individuals | Female individuals | P* |
|---------------------------|------------------|--------------------|----|
| Age ≥ 65 y                | 486 (48.3%)      | 392 (69.2%)        | .000 |
| Priority code 1 (urgent)  | 1021 (90.0%)     | 576 (84.9%)        | .002 |
| Ventilation frequency –   |                  |                    | .017 |
| ventilation bag           | 621 (61.8%)      | 315 (55.7%)        |     |
| Defibrillation            | 256 (25.4%)      | 88 (15.5%)         | .000 |
| Location (at home)        | 692 (68.8%)      | 422 (74.5%)        | .025 |
| Consequence (death)       | 678 (67.4%)      | 383 (67.7%)        | NS  |

* Pearson Chi-squared test. NS = not significant.

Table 2

| Variable | Age ≥ 65 y | Age < 65 y | P* |
|----------|------------|------------|----|
| Defibrillation | 187 (19.5%) | 162 (25.0%) | .011 |
| Location (at home) | 691 (72.0%) | 445 (68.8%) | NS  |
| Priority code 1 (urgent) | 628 (86.6%) | 568 (80.0%) | .017 |
| Total time from dispatch to arrival up to 8 min | 373 (59.0%) | 231 (55.7%) | NS  |
| Intubation        | 477 (49.9%) | 347 (53.6%) | NS  |

* Pearson Chi-squared test. NS = not significant.
There was a witness of OHCA in 1065 cases (66.4%). Further 175 cases (10.9%) occurred in the presence of emergency medical teams. In the other patients (n = 363; 22.7%), OHCA took place without any witness.

According to the emergency medical documentation and the recordings of conversations with emergency medical dispatchers, there were some actions performed by a third person who witnessed the incident in 785 cases (49.0%). In 175 cases (10.9%), the witnesses were emergency medical team members. Consequently, actions were taken in 960 cases in total (59.9%). However, 643 OHCA patients did not receive any assistance.

It is worth noticing that out of the 1240 cases (77.35%) in which the incident occurred in the presence of a witness, actions were performed in 960 cases (77.41%). Most frequently, chest compressions were applied (indirect chest compressions, 865 cases; 90.1%). Defibrillation attempts were made in 104 patients (including 96 patients assisted by emergency medical teams), that is, in 10.83% of the cases. Artificial respiration was performed in 198 individuals (20.62%). A higher ROSC rate was observed in cases of any resuscitation actions performed at the place of the incident (35.1% vs 30.94% of patients with no resuscitation action performed, with a trend toward statistical significance P = .08).

In 980 cases of OHCA (61.1%), a specialist team was dispatched (ie, a team with minimum 3 members qualified to perform emergency medical procedures, including a physician, and a nurse, or a paramedic). In other cases (n = 623; 38.9%), a basic team was dispatched (ie, a team with at least 2 members qualified to perform emergency medical procedures, including a nurse or a paramedic).

The particular emergency medical actions performed by the teams at place of incident are summarized as follows. The most frequent elements of providing patients with airway patency were endotracheal intubation (n = 824; 51.4%) and laryngeal mask (n = 235; 14.7%). An alarming tendency is that a respirator was used rarely (n = 324; 20.2%), and the patients’ breathing was provided by means of a ventilation bag (n = 949; 59.2%). The first diagnosed rhythm was asystole (n = 910; 56.8%). VF was reported in 354 cases (22.1%) (Fig. 1). It was observed that defibrillation was more frequently performed in younger patients, that is, in individuals aged below 65 years (P = .011).

In Poland, the only indicator of the emergency medical system quality is the median of time from team dispatch to team arrival at destination. Depending on the priority code of the incident, the average median of the highest priority code C-1 was 6 minutes 29 seconds 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 minutes 32 seconds). The performance of advanced emergency medical procedures increases the survival rate in the C-1 code. It is in this priority code that a higher frequency of defibrillation was observed (332 vs 22; P = .000).

In 1603 cases of diagnosed OHCA with cardiopulmonary resuscitation (CPR), ROSC was reported in 536 patients

| Variable At home | Not at home | P² |
|------------------|------------|----|
| Suction          | 234 (20.6%)| 120 (25.6%)| .227|
| Consequence (death) | 744 (65.49%)| 323 (69.1%)| NS|
| Priority code 1 (urgent) | 1001 (88.1%)| 413 (88.4%)| NS|
| Total time from dispatch to arrival up to 6 min | 462 (40.7%)| 189 (40.5%)| NS|

* Pearson Chi-squared test.
NS = not significant.

Figure 1. Type of initial rhythms during out-of-hospital cardiac arrest. PEA = pulseless electrical activity.
Table 4
A comparative analysis of variables (particular components of rescue procedures) and ROSC in cases of out-of-hospital sudden cardiac arrest.

| Variable                  | ROSC (n = 536) | No ROSC (n = 1067) | P    |
|---------------------------|---------------|-------------------|-----|
| Endotracheal intubation    | 318 (59.3%)   | 506 (47.4%)       | .000|
| Respirator                | 189 (35.2%)   | 135 (12.7%)       | .000|
| Ventilation – ventilation bag | 345 (64.4%) | 604 (56.7%)       | .003|
| Defibrillation            | 161 (30.0%)   | 193 (18.0%)       | .000|
| Venipuncture              | 514 (95.9%)   | 865 (81.0%)       | .000|
| Total time from dispatch  | 314 (58.5%)   | 691 (64.7%)       | .018|

Table 5
The results of the logistic regression.

| Predictors                  | β   | OR   | Low  | High | Walda | P    |
|-----------------------------|-----|------|------|------|-------|-----|
| Intercept                   | −1.054 | 0.348 | 0.277 | 0.438 | 82.3  | .000|
| Respirator (no/yes)         | 1.324 | 3.757 | 2.756 | 5.123 | 70.1  | .000|
| Oxygen therapy (no/yes)     | 1.639 | 5.151 | 3.280 | 8.088 | 50.7  | .000|
| Other activities (no/yes)   | −0.572 | 0.564 | 0.398 | 0.799 | 10.4  | .001|
| Monitoring/ECG (no/yes)     | −0.625 | 0.458 | 0.265 | 0.725 | 10.3  | .001|
| Heart massage × Age         | −0.025 | 0.975 | 0.968 | 0.983 | 43.6  | .000|
| Defibrillation and monitoring | 0.648 | 1.912 | 1.301 | 2.610 | 10.9  | .001|
| Intubation and the use of oxygen | −0.693 | 0.500 | 0.317 | 0.789 | 8.9   | .003|
| Venipuncture × Age          | 0.012 | 1.012 | 1.006 | 1.019 | 13.7  | .000|
| Heart massage and monitoring/ECG | 1.178 | 3.247 | 1.794 | 5.678 | 15.1  | .000|

β = regression coefficient; CI = confidence interval; ECG = electrocardiogram; OR = odds ratio; Walda = value of the test statistic.
reporting reasons indicates that only in about 37% of cases, the information provided by the witness pointed to OHCA (the patient was unconscious), although lack of consciousness does not necessarily determine CPR. Very frequently, the reported reasons were chest pain, dyspnea, fainting, and others. Specialist teams (with a physician) were sent to OHCA more often than basic teams (61.1% vs 38.9%). One should emphasize that in 2016, the number of specialist teams and the number of basic teams (with paramedics) was equal. However, according to some legal aspects, a physician was required at the place of incident. Numerous publications provide evidence that no significant ROSC increase can be observed when comparing CPR supervised by physicians with CPR supervised by paramedics or nurses.29

It has been estimated that the most frequent primary SCA mechanism is the defibrillation mechanism (VF and ventricular tachycardia with no pulse).30 In 22.8% of the cases under research, the primary diagnosed rhythm was VF, and in 9.8%, the rhythm was ventricular tachycardia with no pulse. In other publications, about 20% to 25% of cases present VF or ventricular tachycardia with no pulse as the first registered rhythm, which is true for both Europe and the United States.31,32 However, there are also countries where more frequent VF has recently been reported.33 The primary rhythm diagnosed by medical emergency team members is to a large extent the indicator of ROSC probability. This probability rate amounts to 55.4% for VF, and reaches only 24.1% for asystole.

There are 2 emergency priority codes in Poland: C-1 and C-2. This research indicates that teams dispatched in the highest priority code (C-1) frequently go with VF, which has a significant impact on the effectiveness of resuscitation. Therefore, the shorter the time from dispatch to arrival at destination, the higher the probability of ROSC.

Securing airway patency is an important aspect of resuscitation.34,35 Recommendations indicate that a person qualified in endotracheal intubation should use this method.36 According to the research, 51.4% of patients were intubated, and a large number of them were provided assistance with supraglottic airway methods. An alarming fact is that in more than 20% of cases, emergency medical teams applied respirators at the place of incident. It is difficult to explain this phenomenon by means of short time routes to the closest hospitals with ICU capacities. The research pointed out that endotracheal intubation and the use of a respirator significantly increased the probability of ROSC. Ventilation by means of a ventilation bag with facial mask alone is often unsuccessful and causes leaks that result in hyperventilation and a high amount of air flow to the stomach, increasing the risk of regurgitation.37,38 Endotracheal intubation should be perceived as an optimal method of providing SCA patients with airway patency.39

In the group under research, the ROSC rate amounted to 33.43% (546 cases), whereas the average value for Europe reaches 38%. The value in Cyprus equals 50%; in Greece, in turn, the share is about 9%.40

5. Conclusion
Successful resuscitation depends on the quality of emergency medical procedures performed by emergency team members at the place of incident. The ROSC rate is significantly higher when procedures are performed in accordance with current medical knowledge. Physicians, paramedics, and nurses should be trained at least once per year as far as advanced resuscitation procedures in adults are concerned. Regular trainings will ensure the maintenance of the teams’ skills and knowledge at the highest level.

Author contributions

Conceptualization: Klaudiusz Nadolny, Mariusz Panczyk, Jerzy Robert Ladny, Jacek Smereka.

Data curation: Klaudiusz Nadolny.

Formal analysis: Lukasz Szarpak, Jerzy Robert Ladny.

Investigation: Klaudiusz Nadolny.

Methodology: Lukasz Szarpak, Maciej Sterlinski, Robert Galakowski.

Resources: Klaudiusz Nadolny, Maciej Sterlinski.

Software: Joanna Gotlib.

Supervision: Lukasz Szarpak, Jerzy Robert Ladny, Robert Galakowski.

Validation: Lukasz Szarpak, Mariusz Panczyk, Jacek Smereka.

Visualization: Lukasz Szarpak.

Writing – original draft: Klaudiusz Nadolny, Lukasz Szarpak, Mariusz Panczyk, Maciej Sterlinski, Jerzy Robert Ladny, Jacek Smereka, Robert Galakowski.

Writing – review & editing: Klaudiusz Nadolny, Lukasz Szarpak, Joanna Gotlib, Jerzy Robert Ladny, Jacek Smereka.

References

[1] Roger VL, Go AS, Lloyd-Jones DM, et al. Executive summary: heart disease and stroke statistics – 2012 update: a report from the American Heart Association. Circulation 2012;125:188–97.
[2] Berdowski J, Berg RA, Tiggesen JG, et al. Global incidences of out-of-hospital cardiac arrest and survival rates: systematic review of 67 prospective studies. Resuscitation 2010;81:1479–87.
[3] Grasner JT, Herlitz J, Koster RW, et al. Quality management in resuscitation – towards a European cardiac arrest registry (EuReCa). Resuscitation 2011;82:989–94.
[4] Grasner JT, Bosmaert L. Epidemiology and management of cardiac arrest: what registries and revealing. Best Pract Res Clin Anaesthesiol 2013;27:293–306.
[5] Mozaffarian D, Benjamin EJ, Go AS, et al. Heart disease and stroke statistics – 2015 update: a report from the American Heart Association. Circulation 2015;131:e29–322.
[6] Cebula GM, Osdnik S, Wysocki M, et al. Comparison of the early neurologic outcome after out-of-hospital cardiac arrest. Results of the Andalusian out-of-hospital cardiopulmonary arrest registry. Rev Esp Cardiol 2016;69:494–500.
[7] Grupo de Trabalho da American College of Cardiology/American Heart Association sobre orientações práticas e da comissão da European Society of Cardiology para orientações práticas ACU/AH/ESC: 2006 guidelines for the management of patients with ventricular arrhythmias and the prevention of sudden cardiac death – executive summary [in Portuguese]. Rev Port Cardiol 2007;26:883–937.
[8] Centers for Disease Control and Prevention. 2013 Cardiac Arrest Registry to Enhance Survival (CARES): National Summary Report. Available at: https://mycares.net/sitepages/uploads/2013/04/CARES_Evaluation_Report_Final.pdf. Accessed October 30, 2015.
[9] Kong MH, Fomarrow GC, Peterson ED, et al. Systematic review of the incidence of sudden cardiac death in the United States. J Am Coll Cardiol 2011;57:794–801.
[10] Nichol G, Thomas E, Callaway CW, et al. Regional variation in out-of-hospital cardiac arrest incidence and outcome. JAMA 2008;300:1423–31.
[11] Weinfield ML, Stiato CM, Ornato JP, et al. Survival after application of automatic external defibrillators before arrival of the emergency medical
system: evaluation in the resuscitation outcomes consortium population of 21 million. J Am Coll Cardiol 2010;55:1713–20.
[13] Van Alem AP, Vrenken RH, De Vos R, et al. Use of automated external defibrillator by first responders in out-of-hospital cardiac arrest: prospective controlled trial. BMJ 2003;327:1312.
[14] Wissenberg M, Lippert FK, Folke F, et al. Association of national initiatives to improve cardiac arrest management with rates of bystander intervention and patient survival after out-of-hospital cardiac arrest. JAMA 2013;310:1377–84.
[15] Hiltunen P, Kuisma M, Silfvast T, et al. Regional variation and outcome in out-of-hospital cardiac arrest. J Vasc Nurs 2013;33:131.
[16] Gach D, Nowak J, Krzych L. Epidemiology of out-of-hospital cardiac arrest in the Bielsko-Biala district: a 12-month analysis. Kardiol Pol 2016;74:1180–7.
[17] Hiltunen P, Kuisma M, Silfvast T, et al. Regional variation and outcome of out-of-hospital cardiac arrest (OHCA) in Finland – the Finnsusci study. Scand J Trauma Resusc Emerg Med 2012;20:80.
[18] Stromsoe A, Svensson L, Axelsson AB, et al. Improved outcome in Sweden after out-of-hospital cardiac arrest and possible association with improvements in every link in the chain of survival. Eur Heart J 2015;36:863–71.
[19] Margey R, Browne L, Murphy E, et al. The Dublin cardiac arrest registry: temporal improvement in survival from out-of-hospital cardiac arrest reflects improved pre-hospital emergency care. Eurospace 2011;13:1157–65.
[20] Do A, Cretikos M, Muscatello D, et al. Epidemiology of Out-of-Hospital Cardiac Arrest NSW, 2012: Time, Place and Person. Centre for Epidemiology and Evidence, NSW Ministry of Health, Sydney, 2013.
[21] Bougouin W, Lamhaut L, Marion E, et al. Characteristics and prognosis of sudden cardiac death in Greater Paris: population-based approach from the Paris Sudden Death Expertise Center (Paris-SDEC). Intensive Care Med 2014;40:846–54.
[22] Goto Y, Maeda T, Goto Y. Decision-tree model for predicting outcomes after out-of-hospital cardiac arrest in the emergency department. Crit Care 2013;17:R135.
[23] Shao F, Li G, Liang L, et al. Outcome of out-of-hospital cardiac arrests in Beijing, China. Resuscitation 2014;85:1411–7.
[24] Henry K, Murphy A, Willis D, et al. Out-of-hospital cardiac arrest in Cork, Ireland. Emerg Med J 2013;30:496–500.
[25] Ballesteros-Pena , Abecia-Inchaurregui L, Echevarria-Orella E. Factors associated with mortality in out-of-hospital cardiac arrests attended in basic life support units in the Basque Country (Spain). Rev Esp Cardiol (Engl Ed) 2013;66:269–74.
[26] Rudrer R, Jalowiczki P, Wartaq M, et al. Ocena wybranych czynników wpływających na wyniki postępowania reanimacyjnego w pożazepiśmiennych zatrzymaniach klęskowego. Anest Intens Ter 2005;3:174–80.
[27] Monsieurs KG, Nolan JP, Bossaert LL, et al. European Resuscitation Council Guidelines for Resuscitation 2015: Section 1. Executive summary. Resuscitation 2015;95:1–80.
[28] Brooks SC, Hsu JH, Tang SK, et al. Determining risk for out-of-hospital cardiac arrest by location type in a Canadian urban setting to guide future public access defibrillator placement. Ann Emerg Med 2013;61:530–538.e2.
[29] Olausveengen TM, Lund-Kordahl L, Stehen PA, et al. Out of hospital advanced life support with or without a physician: effects on quality of CPR and outcome. Resuscitation 2009;80:1248–52.
[30] Perkins GD, Jacobs IG, Nadkarni VM, et al. Cardiac arrest and cardiopulmonary resuscitation outcome reports: update of the Utstein Resuscitation Registry Templates for Out-of-Hospital Cardiac Arrest: a statement for healthcare professionals from a task force of the International Liaison Committee on Resuscitation (American Heart Association, European Resuscitation Council, Australian and New Zealand Council on Resuscitation, Heart and Stroke Foundation of Canada, InterAmerican Heart Foundation, Resuscitation Council of Southern Africa, Resuscitation Council of Asia); and the American Heart Association Emergency Cardiovascular Care Committee and the Council on Cardiopulmonary, Critical Care, Perioperative Resuscitation. Resuscitation 2015;96:328–40.
[31] Grasner JT, Lefering R, Koster RW, et al. EuReCa ONE-27 Nations, ONE Europe, ONE Registry: a prospective one month analysis of out-of-hospital cardiac arrest outcomes in 27 countries in Europe. Resuscitation 2016;105:188–95.
[32] Keller SP, Halperin HR. Cardiac arrest: the changing incidence of ventricular fibrillation. Curr Treat Options Cardiovasc Med 2015;17:392.
[33] Hullemann M, Zijlstra JA, Beesems SG, et al. Causes for the declining proportion of ventricular fibrillation in out-of-hospital cardiac arrest. Resuscitation 2015;96:23–9.
[34] Smereka J, Starparz L, Ladny JR. The LMA Fastrach as a conduit for cardiac arrest by location type in a Canadian urban setting to guide future public access defibrillator placement. Ann Emerg Med 2013;61:530–538.e2.
[35] Doerges V, Sauer C, Ocker H, et al. Smaller tidal volumes during cardiopulmonary resuscitation: comparison of adult and paediatric self-inflatable bags with three different ventilatory devices. Resuscitation 1999;43:31–7.
[36] Ocker H, Wenzel V, Schmucker P, et al. Effectiveness of various airway management techniques in a bench model simulating a cardiac arrest patient. J Emerg Med 2001;20:7–12.
[37] Benoit JL, Gerecht RB, Steuerwald MT, et al. Endotracheal intubation versus supraglottic airway placement in out-of-hospital cardiac arrest: a meta-analysis. Resuscitation 2015;95:20–6.