Emergency Cardiopulmonary Resuscitation of Out-of-Hospital Cardiac Arrest: Why Should we Care

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Abstract

Background: Cardiopulmonary resuscitation (CPR) plays an essential role in the treatment of sudden cardiac arrest (SCA), we aimed to evaluate the influencing factors on the effects of CPR in patients with SCA, to provide insights into the management of SCA.

Methods: Patients who underwent CPR in the emergency department of our hospital from January 1, 2019 to June 30, 2021 were selected. We collected and analyzed the clinical characteristics of CPR patients. Logistic regression analyses were conducted to identify the risk factors of CPR failure.

Results: A total of 308 CPR patients were included, the incidence of CPR success was 35.71%. There were significant differences in the age, time to the start of CPR, the type of heart rhythm in the first monitoring, duration of CPR and cumulative adrenaline dosage between CPR success and failure group (all $P < 0.05$). No significant differences in the gender, cause of cardiac arrest and ventilation methods were found (all $P > 0.05$). Logistic regression analyses indicated that age ≥ 65 y (OR 2.132, 95CI% 1.127~4.334), time to the start of CPR ≥ 12 min (OR 2.503, 95CI% 1.015~3.583), unable to defibrillation (OR 1.856, 95CI% 1.107~3.031), duration of CPR ≥ 40 min (OR 2.162, 95CI% 1.242~4.178), cumulative adrenaline dosage ≥ 6 mg (OR 1.627, 95CI% 1.151~2.472) were the independent risk factors of CPR failure (all $P < 0.05$).

Conclusions: The success and failure of CPR are affected by many factors. Early and effective interventions should be taken for these influencing factors in clinical practice. Due to the limitation of sample size, future large-sample and multi-center studies need to further explore the relevant influencing factors of CPR.

Background

Sudden cardiac arrest (SCA) refers to the sudden cessation of cardiac activity accompanied by hemodynamic disorders, usually caused by persistent ventricular tachycardia (VT)/ventricular fibrillation (VF)[1]. Most of these events occur in patients with organic heart disease especially coronary heart disease) that may not have been diagnosed before SCA[2]. In the rescue of SCA patients, cardiopulmonary resuscitation (CPR) plays a vital role, and chest compression combined with mouth-to-mouth breathing is the basis of modern CPR[3]. Although CPR, defibrillation and other advanced resuscitation techniques continue to develop, the survival rate of cardiac arrest is still very low[4, 5]. Therefore, how to improve the effects and safety of CPR is essential to the prognosis of patients with SCA.

Cardiac arrest is a kind of clinical emergency and critical illness, the success of CPR is closely related to the cause of the cardiac arrest, the time of the arrest, and the correct first aid measures[6, 7]. With the widespread clinical application of CPR, patients with SCA have been effectively treated, but the success rate of resuscitation is still low[8]. Studies[9, 10] have shown that the success rate of resuscitation in patients with cardiac arrest in different locations is also different, only 6.0–10.8% of patients with out-of-hospital SCA can survive, while about 25.8% of patients with in-hospital cardiac arrest can survive and

discharge. Therefore, improving the success rate of CPR is still one of the major challenges of clinical work. To this end, we took CPR patients in the emergency department of our hospital as the research population, we retrospectively analyzed the clinical characteristics of patients with SCA in order to analyze the factors affecting the success of PCR, and to provide reference for the rescue of critically ill patients.

Methods

Ethical approval

In this study, all methods were performed in accordance with the relevant guidelines and regulations. This present study protocol had been checked and approved by the ethical committee of Hangzhou First People's Hospital(approval number:ED20180049M), and written informed consents had been obtained from the relatives of included patients.

Patients

In this study, patients who underwent CPR in the emergency department of our hospital from January 1, 2019 to June 30, 2021 were selected as the research populations. The inclusion criteria were as following: (1)patients with SCA; (2) patients underwent PCR in our department; (3)patients with age>10 years old; (4) The relatives of included patients agree to participant in this study and signed the written informed consents. The exclusion criteria were as following: (1) family members who gave up rescue and refused to perform PCR; (2) patients with incomplete or missing data on the treatment during hospitalization.

CPR

The CPR program referred to the American Heart Association(AHA) cardiopulmonary resuscitation and cardiovascular first aid guidelines[11, 12], specifically as follows: (1) we performed chest compressions at a rate of 100~120 times/min, and kept the depth of chest compressions at 5~6 cm; (2) The airway was opened at the same time as the chest compressions were started. A balloon mask was usually used to maintain sufficient oxygen supply. If necessary, tracheal intubation would be performed. The ventilation rate was maintained at 10 breaths per minute; (3) For patients with ventricular fibrillation or pulseless ventricular tachycardia detected at the beginning or midway would receive electrical defibrillation immediately; (4) For patients who did not need electrical defibrillation, epinephrine would be used as soon as possible, 1 mg each time, An intravenous injection is given in 3 to 5 minutes intervals; (5) Patients with cardiac arrest caused by different reasons would be treated as soon as possible to remove the risk factors. After completing 5 cycles, we evaluated the patient's condition. The criteria for successful CPR were: (1) palpable aortic pulsation or audible heart sounds; (2) measurable blood pressure, blood

pressure maintained above 90/60 mmHg, and it could be maintained for 24 hours (3) The patient regained his light reflex.

Data collection

We collected the patient's name, gender, age, time of cardiac arrest, place of onset, main cause of cardiac arrest, type of heart rhythm monitored for the first time, whether to receive electrical defibrillation, whether to accept tracheal intubation, cumulative epinephrine dosage, total duration of CPR according to the registration content of Utstein model registration form.

Statistical method

We used SPSS25.0 statistical software to analyze the collected data. All measurement data are first tested for normality. Data conforming to the normal distribution were expressed as mean $\pm$ standard deviation, and independent sample t test is used for comparison between groups; count data was expressed as frequency or percentage, and comparison between groups was used χ^2 test. Logistic regression analyses were conducted to identify the risk factors of CPR failure. The tests were all two-sided, and $P<0.05$ indicated that that the difference was statistically significant.

Results

The characteristics of included patients

A total of 308 CPR patients were enrolled in this study, including 185 males and 123 females. As presented in Figure 1, the average age was (66.34 ± 16.62) years old, of which 71-80 years old had the largest number of patient, followed by 61-70 years old. And the main causes of cardiac arrest in patients with CPR were presented in Table 1.

Table 1

The main causes of cardiac arrest in patients with CPR(n=308)

Causes	Cases	Percentage
Acute myocardial infarction	115	37.34%
Unclear causes	57	18.51%
Respiratory depression	35	11.36%
Disorders of electrolyte metabolism	30	9.74%
Severe hypotension	25	8.12%
Sepsis	18	5.84%
Poisoning	14	4.55%
Severe trauma	10	3.25%
Others	4	1.30%

Of the included 308 SCA patients, 110 patients had the survived from the CPR, the incidence of CPR success was 35.71%. As indicated in Table 2, there were significant differences in the age, time to the start of CPR, the type of heart rhythm in the first monitoring, duration of CPR and cumulative adrenaline dosage between CPR success and failure group (all $P < 0.05$). No significant differences in the gender, cause of cardiac arrest and ventilation methods were found (all $P > 0.05$).

Table 2
the characteristics of included patients

Items	CPR success group(n= 110)	CPR failure group(n= 198)	t/c ²	P
Male/female	69/41	116/82	1.295	0.078
Age	55.34±10.77	73.05±12.84	13.122	0.005
Cause of cardiac arrest			1.626	0.053
Cardiac associated	54(49.09%)	61(30.81%)		
Non-cardiac associated	56(50.91%)	137(69.19%)		
Time to the start of CPR(min)	9.07±1.29	15.44±3.31	2.198	0.027
The type of heart rhythm in the first monitoring			1.604	0.022
Able to defibrillation	48(43.64%)	35(17.68%)		
Unable to defibrillation	62(56.36%)	163(82.32%)		
Ventilation method			1.459	0.086
Tracheal intubation	81(73.64%)	132(66.67%)		
Balloon mask	29(26.36%)	66(33.33%)		
Duration of CPR[min]	33.04±6.09	46.32±7.57	10.478	0.013
Cumulative adrenaline dosage (mg)	4.38±2.61	8.16±2.99	2.129	0.025

The risk factors of CPR failure

The variable assignments of multivariate logistic regression were showed in Table 3. As presented in Table 4, logistic regression analyses indicated that age $\geq$ 65y(OR2.132, 95CI%1.127~4.334), time to the start of CPR $\geq$ 12min(OR2.503, 95CI%1.015~3.583), unable to defibrillation(OR1.856, 95CI%1.107~3.031), duration of CPR $\geq$ 40min(OR2.162, 95CI%1.242~4.178), cumulative adrenaline dosage $\geq$ 6mg(OR1.627, 95CI%1.151~2.472) were the independent risk factors of CPR failure(all P<0.05).

Table 3

The variable assignment of multivariate logistic regression

Factors	Variables	Assignment
CPR failure	Y	Yes=1, no=2
Age(y)	X_1	$\geq 65=1$, $<65=2$
Time to the start of CPR(min)	X_2	$\geq 12=1$, $<12=2$
The type of heart rhythm in the first monitoring	X_3	Unable to defibrillation=1, able to defibrillation =2
Duration of CPR(min)	X_4	$\geq 40=1$, $<40=2$
Cumulative adrenaline dosage (mg)	X_5	$\geq 6=1$, $<6=2$

Table 4

The logistic regression analysis on the risk factors of CPR failure

Variables	β	S`x	OR	95%CI	p
Age $\geq 65y$	0.123	0.203	2.132	1.127~4.334	0.011
Time to the start of CPR $\geq 12min$	0.102	0.132	2.503	1.015~3.583	0.025
Unable to defibrillation	0.114	0.102	1.856	1.107~3.031	0.043
Duration of CPR $\geq 40min$	0.126	0.117	2.162	1.242~4.178	0.021
Cumulative adrenaline dosage $\geq 6mg$	0.115	0.142	1.627	1.151~2.472	0.018

Discussion

Cardiac arrest is one of the most critical and dangerous clinical conditions. Although the level of medical treatment has made great progress in recent decades, the prognosis of cardiac arrest is still poor[13]. A report[14] analyzed the outcomes of more than 12,000 patients, these patients were the patients treated by Emergency Medical Service (EMS) staff in Seattle, USA during the 24 years, the patients treated in 1998-2001 and the patients treated in 1977-1981 were compared, the ratio of survival to discharge did not improve significantly (15.7% vs 17.5%). The United States Improved Survival Cardiac Arrest Registry (CARES) registry study prospectively included 70,027 American patients with out-of-hospital SCA from 2005 to 2012, and found that the discharge survival rate increased significantly from 5.7% in 2005 to 2012 8.3% of the year[15]. The success rate of CPR in our study was 35.71%. All patients in this study treated in the department of emergency of our hospital and received timely and correct treatment. Therefore, the success rate of CPR is higher than that of previous reports[16-18]. And we have found that age $\geq 65y$, time to the start of CPR $\geq 12min$, unable to defibrillation, duration of CPR $\geq 40min$, cumulative

adrenaline dosage ≥ 6 mg are the independent risk factors of CPR failure, early alert and preventions are needed for those patients.

The ratio of men to women in SCA patients in this preset study is 1.46:1, but the univariate analysis showed that gender had no significant effect on the success rate of cardiopulmonary resuscitation. Age is an independent factor affecting the success rate of CPR. Younger patients have a higher success rate of CPR. This is consistent with the results of previous related studies[19-21]. The reason may be that most elderly patients have circulatory and respiratory diseases, and the body function is poor[22]. Once cardiac arrest occurs, the tolerance of various organs to ischemia and hypoxia is poor[23]. For patients with emergency cardiac arrest, medical staff can effectively monitor their initial heart rhythm type. The results of this article have found that the success rate of CPR is higher in patients with defibrillating heart rhythm than in patients with non-defibrillating heart rhythm, and the initial heart rhythm type is the influencing factor of CPR success. Studies[24, 25] have found that in patients with cardiac arrest in the hospital, if the initial heart rhythm type is a defibrillating heart rhythm, their CPR success rate, survival rate after discharge, and neurological recovery at discharge are all improved than those who cannot defibrillate, which is in line with the findings of our study. The reason may be that when the initial heart rhythm is ventricular fibrillation or ventricular tachycardia, the heart is in a weak and irregular contraction state, and there is weak tissue perfusion in the body, so the effect of CPR is better[20, 26].

In the process of CPR, chest compressions are the primary rescue method, but the choice of ventilation methods is still controversial. In this study, compared with balloon masks, tracheal intubation has no positive effect on the success rate of cardiopulmonary resuscitation. Previous study[27] has pointed out that compared with balloon mask-assisted ventilation, the establishment of advanced airway will increase the adverse effect on the long-term prognosis. This may be because cardiac arrest patients are usually accompanied by irritability, vomiting, difficult tracheal intubation, longer length of intubation process[28-30]. Besides, it is inevitable to terminate the heart compression during the intubation process, so that the coronary artery blood perfusion is interrupted for too long[31, 32]. However, there are also reports[33, 34] suggesting that for patients with pulmonary disease, tracheal intubation may be a favorable factor for the success of CPR, so it is necessary to choose a suitable ventilation method according to the specific situation.

Regarding the dose of epinephrine used, the CRP group had a larger amount of epinephrine, but it is not clear whether the prolonged resuscitation time caused the larger epinephrine use, or whether the large amount of epinephrine used adversely affect the resuscitation process[35]. Studies[36-38] have shown that adrenaline can increase myocardial oxygen consumption and reduce blood perfusion of other organs, which will adversely affect the long-term survival rate of discharged patients and the recovery of neurological function. Therefore, further research is needed to clarify the dose and timing of epinephrine in the CPR process.

Conclusions

In summary, cardiogenic disease is the main cause of cardiac arrest, and age $\geq$ 65y, time to the start of CPR $\geq$ 12min, unable to defibrillation, duration of CPR $\geq$ 40min, cumulative adrenaline dosage $\geq$ 6mg are the independent risk factors of CPR failure, clinical early alert and targeted preventions are needed for those patients to increase the success rate of CPR, to improve the prognosis of SCA patients. However, limited by sample size, future studies with larger sample size and multi-centers are needed for further confirmation on the influencing factors of PCR, to provide more reliable evidences to the management and treatment of SCA.

Abbreviations

CPR: cardiopulmonary resuscitation

SCA: sudden cardiac arrest

VT: ventricular tachycardia

VF: ventricular fibrillation

AHA: American Heart Association

Declarations

Ethics approval and consent to participate

In this study, all methods were performed in accordance with the relevant guidelines and regulations. This present study protocol had been checked and approved by the ethical committee of Hangzhou First People's Hospital(approval number:ED20180049M), and written informed consents had been obtained from the relatives of included patients.

Consent for publication

Not applicable.

Availability of data and materials

All data generated or analyzed during this study are included in this published article.

Competing interests

The authors declare that they have no competing interests.

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Author contributions

L H, X M designed research; L H, J C, B Y, C T, X M conducted research; L H, J C analyzed data; X M wrote the first draft of manuscript; X M had primary responsibility for final content. All authors read and approved the final manuscript.

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Figures

Figure 1

Age distribution of patients with CPR

Supplementary Files

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