Analysis of factors influencing cardiopulmonary resuscitation and survival outcome in adults after in-hospital cardiac arrest: a retrospective observational study

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To the Editor: Cardiopulmonary resuscitation (CPR) guidelines, especially the latest 2020 guidelines issued by the American Heart Association (AHA), have emphasized the importance of high-quality CPR.[1] The research on cardiac arrest (CA) and CPR has dramatically increased in recent years, and the international recovery guidelines are also being revised and implemented. However, the outcome of in-hospital cardiac arrest (IHCA) remains poor, and the understanding of the prognostic factors for survival outcome after IHCA is lacking, especially in China. Patients with CA are often poorly treated, and the incidence and mortality of CA are increasing yearly.[2] This study analyzed the effects of CPR, and explored the factors that affect survival outcome after IHCA in adults.

This research was approved by the scientific investigation ethical review board of Tianjin Medical University General Hospital (No. IRB2019–076-01), the written informed consent was waived.

The retrospective observational study was conducted at Tianjin Medical University General Hospital, in which the emergency care team consists of a senior resident, two or three junior residents, registered nurses, a senior anesthesia, or an emergency resident. All resuscitation procedures were regulated according to the latest guidelines of the AHA. This study was conducted on 467 adult (age ≥18 years) patients who required CPR in our hospital from September 2019 to September 2020. Inclusion criteria: patients with IHCA and without CPR contraindications; age ≥ 18 years. Exclusion criteria: (1) patients with out-hospital cardiac arrest; (2) the exact time of CA was uncertain; (3) patients with defective medical records; (4) patients with advanced tumor; and (5) patients with non-neoplastic multiple organ failure. The data on patients' age, sex, smoking history, drinking history, body mass index, the location of IHCA, age-adjusted Charlson Comorbidity Index (ACCI), diagnosis of CA, initial rhythm, interval time between CA and CPR, defibrillation, intubation, epinephrine doses, and duraion of resuscitation were collected. The primary outcome of this study was return of spontaneous circulation (ROSC), and the secondary outcome was survival to hospital discharge.

For continuous variables, the normality test was conducted. If each group met the normality assumption, the mean (standard deviation) was used for statistical description, and the student's *t*-test was performed for comparison; otherwise, the median (Q_1, Q_3) was used for statistical description and the non-parametric test (Mann-Whitney *U*-test) was performed for comparison. Categorical variables were compared by the chi-squared test or Fisher's exact test, and the statistical description was expressed as *n* (%). Those variables which were significant in univariable analysis or considered to have clinical value were included in multivariable analysis for identifying the predictors of resuscitation outcome. Kaplan-Meier analysis was used to demonstrate the survival rate of discharged patients, and the *P* value was calculated by the log-rank test. Statistical analyses were performed using the Statistics Package for Social Sciences software version 26.0 (IBM Corp, Armonk, NY, USA) and GraphPad Prism9 (GraphPad Software, San Diego, CA, USA).

There were 467 patients with IHCA from September 2019 to September 2020, including 24 cases with defective medical records, 65 cases with advanced tumor, and 54 cases with non-neoplastic multiple organ failure. At last, a total of 324 patients were included in the study, including 224 inpatients and 100 outpatient and emergency patients in whom CA occurred during the emergency observation [Supplementary Figure 1, http://links.lww.com/CM9/B260].

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Table 1: Characteristics associated with the return of spontaneous circulation and survival to hospital discharge in patients with in-hospital cardiac arrest.

Characteristics	ROSC				Survival to hospital discharge			
	No ($n=211$)	Yes ($n=113$)	Statistics	*P* values	No ($n=294$)	Yes ($n=30$)	Statistics	*P* values
Male	141 (66.8)	66 (58.4)	2.260*	0.133	191 (65.0)	16 (53.3)	1.597*	0.206
Age (years)	71 (69–73)	67 (64–69)	−2.333†	0.020	70 (68–72)	65 (61–69)	−2.251†	0.029
Smoking history			2.095*	0.351			0.197*	0.896
Never	119 (56.4)	55 (48.7)			159 (54.1)	15 (50.0)		
Previous	61 (28.9)	41 (36.3)			92 (31.3)	10 (33.3)		
Current	31 (14.7)	17 (15.0)			43 (14.6)	5 (16.7)		
Drinking history			2.184*	0.336			2.389*	0.323
Never	136 (64.5)	76 (67.3)			189 (64.3)	23 (76.6)		
Previous	45 (21.3)	17 (15.0)			57 (19.4)	5 (16.7)		
Current	30 (14.2)	20 (17.7)			48 (16.3)	2 (6.7)		
BMI			0.171*	0.679			0.090*	0.787
<25.0 kg/m^2	181 (85.8)	95 (84.1)			251 (85.4)	25 (83.3)		
≥25.0 kg/m^2	30 (14.2)	18 (15.9)			43 (14.6)	5 (16.7)		
ACCI	8 (5–11)	7 (5–10)	−0.906†	0.365	8 (5–11)	4 (6–9)	−2.432†	0.015
Cardiogenic diseases	89 (42.2)	65 (57.5)	6.946*	0.008	131 (44.6)	23 (76.7)	11.254*	0.001
Shockable initial rhythm	9 (4.3)	31 (27.4)	36.502*	<0.001	24 (8.2)	16 (53.3)	51.326*	<0.001
Interval between CA and CPR (min)	3 (3–4)	2 (1–2)	−5.485†	<0.001	3 (2–3)	1 (1–2)	−6.632†	<0.001
Defibrillation	31 (14.7)	49 (43.4)	32.532*	<0.001	63 (21.4)	17 (56.7)	18.179*	<0.001
Intubation	102 (48.3)	73 (64.6)	7.833*	0.005	162 (55.1)	13 (43.3)	1.518*	0.218
Epinephrine doses (mg)	5 (3–8)	2 (0–3)	−8.712†	<0.001	4 (2–7)	1 (0–2)	−5.796†	<0.001
Duration of resuscitation (min)	30 (21–37)	5 (2–14)	−12.763†	<0.001	25 (14–33)	4 (1–10)	−6.689†	<0.001

Data are presented as *n* (%) or median (Q_1, Q_3). * χ^2 values; † *Z* values. ROSC was defined as the recovery of heart function such that the heart sound can be heard, the carotid artery can be palpated and the blood pressure ≥90/60 mmHg (1 mmHg=0.133 kPa) is maintained for at least 20 min after CA. ACCI: Age-adjusted Charlson Comorbidity Index; BMI: Body mass index; CA: Cardiac arrest; CPR: Cardiopulmonary resuscitation; ROSC: Return of spontaneous circulation.

The median age of patients with IHCA was 72 years (Q_1, Q_3: 61–81 years). Overall, males account for 63.9% of the patients ($n=207$). The rate of ROSC was 34.9% ($n=113$), and the rate of survival to hospital discharge was 9.26% ($n=30$). The other demographic and clinical characteristics are presented in Supplementary Table 1, http://links.lww.com/CM9/B260.

The clinical variables associated with resuscitation outcomes are summarized in Table 1. Compared with the ROSC group, the patients with non-ROSC were older (71 [69–73] years *vs.* 67 [64–69] years; $U=-2.333$; $P=0.020$), had lower rate of diagnosis of cardiogenic diseases (42.2% [89/211] *vs.* 57.5% [65/113]; $\chi^2=6.964$; $P=0.008$), lower rate of initial shockable rhythms (4.3% [9/211] *vs.* 27.4% [31/113]; $\chi^2=36.502$; $P<0.001$), longer interval time between CA and CPR (3 [3–4] min *vs.* 2 [1–2] min; $U=-5.485$; $P<0.001$), lower rate of defibrillation (14.7% [31/211] *vs.* 43.4% [49/113]; $\chi^2=32.532$; $P<0.001$), lower rate of intubation (48.3% [102/211] *vs.* 64.6% [73/113]; $\chi^2=7.833$; $P=0.005$), higher doses of epinephrine (5 [3–8] mg *vs.* 2 [0–3] mg; $U=-8.712$; $P<0.001$), and longer resuscitation duration (30 [21–37] min *vs.* 5 [2–14] min; $U=-12.763$; $P<0.001$). Compared with those who survived to hospital discharge, the non-survivors had older age (70 [68–72] years *vs.* 65 [61–69] years; $U=-2.251$; $P=0.029$), higher scores of ACCI (8 [5–11] *vs.* 4 [6–9]; $U=-2.432$; $P=0.015$), lower rate of being diagnosed with cardiogenic diseases (44.6% [131/294] *vs.* 76.7% [23/30]; $\chi^2=11.254$; $P=0.001$), lower rate of initial shockable rhythms (8.2% [24/294] *vs.* 53.3% [16/30]; $\chi^2=51.326$; $P<0.001$), longer interval time between CA and CPR (3 [2–3] min *vs.* 1 [1–2] min; $U=-6.632$; $P<0.001$), lower rate of defibrillation (21.4% [63/294] *vs.* 56.7% [17/30]; $\chi^2=18.179$; $P<0.001$), higher doses of epinephrine (4 [2–7] mg *vs.* 1 [0–2] mg; $U=-5.796$; $P<0.001$) and longer resuscitation duration (25 [14–33] min *vs.* 4 [1–10] min; $U=-6.689$, $P<0.001$).

According to the multivariable logistic regression analysis, age, defibrillation, epinephrine doses, intubation and duration of resuscitation were independent predictors for ROSC [Supplementary Figure 2A, http://links.lww.com/CM9/B260]. The duration of resuscitation, the interval between CA and CPR and initial rhythm were independent predictors for survival to hospital discharge [Supplementary Figure 2B, http://links.lww.com/CM9/B260].

During the follow-up of discharged patients, patients of cerebral performance category (CPC) 1–2 had a longer survival time than patients of CPC 3–5 ($P<0.001$) [Supplementary Figure 3, http://links.lww.com/CM9/B260]. Hence, we should pay more attention to the protection of neurologic function in patients after successful ROSC.

CA is a medical emergency that may occur anytime and anywhere. The outcome of IHCA is not only affected by the patient's own health-related factors, but also by the CPR intervention of well-trained personnel. This study illustrated that shorter resuscitation duration is a good predictor for ROSC and survival to hospital discharge, which are consistent with previous study.[3] The patients with neurological outcome of CPC 1–2 had a longer survival time than those with CPC 3–5. However, the rate of survival to hospital and neurological outcomes at discharge were unsatisfactory in this study. The reasons for it may be related with that most of the patients included in the study were elderly patients, and lots of patients had comorbidities.

In addition, age is an independent risk factor for successful ROSC. This may be because older patients often have atherosclerosis, which results in cardiovascular and cerebrovascular diseases, and affects the ROSC after CPR. Early identification and intervention of patients with IHCA risk are important for faster and better resuscitation and early defibrillation.

This study showed that epinephrine doses and duration of resuscitation were independent predictors for ROSC. What's more, duration of resuscitation was an independent predictor for survival to hospital discharge. Being an observational study, we were unable to separate the effects of the epinephrine doses and the duration of resuscitation from the duration of CA and the severity of primary diseases, both of which are known to be the influencing factors for outcome.

This study showed that intubation is an independent predictor for ROSC. Endotracheal intubation is an effective and safe method for oxygen supply and may be a necessary treatment for reversing the pathological process of IHCA.[4] What's more, intubation should be performed by rescue workers who are proficient in airway management, avoiding interruption of chest compression. If necessary, intubation can be postponed after the ROSC.[5]

Research showed that initial shockable rhythm or shorter interval time between CA and CPR benefit for patients survival to hospital discharge. It is generally accepted that initial shockable rhythm is always beneficial for patients with IHCA.[6] It is well known that starting CPR as soon as possible is critical to improving survival rates, which decrease with the delay of treatment; this may be because starting CPR as soon as possible can reduce the time of ischemia and hypoxia in patients, especially in the brain.[7]

This is a retrospective observational study, which can only establish associations between independent and dependent variables, not causality. In the future, further studies with a prospective and multicenter design are warranted.

In summary, age, defibrillation, epinephrine doses, intubation and duration of resuscitation were independent predictors for ROSC after CPR in adults with IHCA. The duration of resuscitation, initial rhythm and interval between CA and CPR were independent predictors for survival to hospital discharge. Patients with favorable neurologic status are likely to have superior survival outcome.

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Conflicts of interest

None.

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