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Analysis of Factors Influencing the Return of Spontaneous Circulation and Prognosis in Patients with In-Hospital Cardiac Arrest Under a Rapid Response System

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Abstract: *Objective*: To investigate the influencing factors and prognosis of the return of spontaneous circulation (ROSC) in patients with unexpected in-hospital cardiac arrest (IHCA) under the rapid response system. *Methods*: According to the Utstein template, a retrospective analysis was conducted on the clinical data of 263 patients with unexpected IHCA from a tertiary-level hospital in Zhenjiang City from May 2019 to May 2024. The primary outcomes were categorized into the ROSC group and the Non-ROSC group based on post-resuscitation outcomes, while the secondary outcomes were divided into the discharged alive group and the non-discharged alive group. Logistic regression analysis was employed to identify the influencing factors and prognosis of ROSC, and the Kaplan-Meier method was used to plot survival curves. *Results*: (1) A total of 263 patients with IHCA were included in this study, with 166 cases (63.5%) achieving ROSC and 54 cases (32.5%) surviving for 7 days, among whom 42 cases (15.9%) were discharged alive. (2) Multivariate regression analysis revealed that age, abnormal BMI, duration of cardiopulmonary resuscitation (CPR), ventilation method during resuscitation, and the initial cumulative dosage of epinephrine were independent influencing factors for Non-ROSC in IHCA patients ($p < 0.05$). The NRS2002 score, recurrent resuscitation events, initial cumulative dosage of epinephrine, and duration of CPR were independent influencing factors for non-discharge alive in IHCA patients ($p < 0.05$). *Conclusion*: The ROSC rate of IHCA under the rapid response system has improved, but the rate of discharged alive remains relatively low. The system plays a certain role in reducing in-hospital mortality; however, further strengthening of the links in each stage is necessary to enhance patient prognosis.

Keywords: Rapid response system; In-hospital cardiac arrest; Return of spontaneous circulation; Emergency; Survival

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1. Introduction

In-hospital cardiac arrest (IHCA) refers to the sudden cessation of mechanical activity of the heart's pumping function that occurs within a hospital setting, resulting in the interruption of systemic blood circulation, cessation of respiration, and loss of consciousness [1]. It represents a critical in-hospital event that severely endangers patient lives and is associated with high mortality rates [2]. The incidence of IHCA abroad ranges from 1.2 to 9–10 per 1,000 hospital admissions [3–5]. The survival rate to discharge ranges from 15% to 34%. In contrast, China reports a higher IHCA incidence of 1.75%, with a discharge survival rate of only 9.1%, indicating a significant gap compared to developed countries [6]. Since the introduction of the survival chain for IHCA patients in 2015, patient outcomes have significantly improved, although only a small proportion of patients survive with good neurological function.

Return of spontaneous circulation (ROSC) is a core indicator for judging the success of resuscitation and evaluating patient prognosis, representing the first step towards long-term survival, neurological recovery, and favorable outcomes. Previous studies have indicated that the time to defibrillation and cardiopulmonary resuscitation in cardiac arrest patients is inversely proportional to survival chances, while delayed response times due to incorrect disease identification and delayed calls are primary contributors to poor outcomes in IHCA patients [7,8]. In 2023, expert consensus proposed the establishment of a rapid response system (RRS) to achieve early warning and timely management of in-hospital emergencies through standardized and systematic management, aiming to reduce the incidence of adverse events and improve patient survival rates [9]. Some studies have also confirmed the role of the rapid response system in reducing IHCA and improving rescue success rates, although controversy remains regarding its impact on mortality reduction [10].

Reports on the implementation effects of RRS in domestic hospitals are scarce. Since 2015, our hospital has established a "24-hour in-hospital life rescue team" (hereinafter referred to as the "Life Rescue Team") to further improve the emergency medical service system (EMSS). This study has consistently adhered to standardized management, focusing on restoring spontaneous circulation and achieving discharge survival. Monthly statistics and information tracking of emergency rescue data have been conducted, and the system has been operating effectively for nearly a decade. Therefore, the purpose of this article is to explore the status of spontaneous circulation recovery and discharge survival among IHCA patients across the hospital under the rapid response system. Through retrospective clinical research analysis, this study aimed to summarize experiences and evaluate outcomes.

2. Materials and methods

2.1. Study subjects

Medical records of patients with unexpected in-hospital cardiac arrest (IHCA) from May 2019 to May 2024 were continuously collected from a tertiary hospital in Zhenjiang. Potential IHCA cases were identified by retrieving cardiac arrest-related medical orders from the hospital's HIS system. Based on resuscitation outcomes, patients were divided into the ROSC group, Non-ROSC group, survival-to-discharge group, and non-survival-to-discharge group.

2.1.1. Inclusion criteria

All patients aged 18 and above (410 cases).

2.1.2. Exclusion criteria

(1) Out-of-hospital cardiac arrest, including patients who underwent cardiopulmonary resuscitation (CPR) on

the way to the hospital via 120 emergency services (89 cases);

(2) Patients with obvious signs of irreversible diseases (e.g., advanced cancer) (7 cases);

(3) Patients with incomplete data (12 cases);

(4) Patients who received a do-not-resuscitate order (39 cases).

2.1.3. Details

Ultimately, 263 patients were included in this study. This study was approved by the Ethics Committee of the Affiliated People's Hospital of Jiangsu University (Ethics Approval Number: K-2025038-W).

2.2. Study tools and indicators

Data were collected using a self-made form based on the Utstein template for study variables.

(1) Sociodemographic data

Age, gender, BMI, BI, NRS2002 score, Charlson comorbidity index (CCI), underlying diseases, educational level, smoking and alcohol history, and bedridden status.

(2) Disease-related information: length of hospital stay, location of cardiac arrest (emergency department, ICU, general ward), time period of cardiac arrest, CPR performed by the first witness, etiology of cardiac arrest (cardiogenic, non-cardiogenic), initial rhythm, duration of CPR (min), whether mechanical ventilation was administered before arrest, whether emergency tracheal intubation was performed during arrest, cumulative initial epinephrine dosage (mg), whether mechanical support was used during resuscitation, and recurrent resuscitation events.

(3) Prognostic indicators included the ROSC rate and survival-to-discharge rate.

ROSC was defined as the sustained return of spontaneous circulation for more than 20 minutes after resuscitation, during which no external chest compressions were performed [11].

Ventricular fibrillation (VF) and ventricular tachycardia (VT) were classified as shockable rhythms, while pulseless electrical activity (PEA) and asystole were classified as non-shockable rhythms. If a patient experienced more than one cardiac arrest during hospitalization, only the first episode was included. The resuscitation time was defined as the interval from the first chest compression (or recognition of the need for defibrillation when the initial rhythm was ventricular tachycardia or ventricular fibrillation) to sustained ROSC (> 20 minutes) or termination of resuscitation efforts. The cause of cardiac arrest was considered "determined" if the emergency physician reported it in the ED discharge diagnosis. Patients who abandoned treatment and requested discharge with tracheal intubation or other tubes in place were considered deceased.

2.3. Statistical methods

All data processing and statistical analyses in this study were performed using SPSS 25.0 statistical software. Continuous data were expressed as mean ± standard deviation ($\bar{x} \pm s$), categorical data were described as "rate (%) or composition ratio (%)", and non-normally distributed continuous data were expressed as median (interquartile range) [M (Q1, Q3)]. Differences between categorical data groups were compared using the χ^2 test. Survival curves were plotted using the Kaplan-Meier method, and multivariate analysis was performed using binary logistic regression to analyze the correlation between resuscitation success rate and in-hospital mortality. A significance level of $\alpha = 0.05$ was selected, and a p-value < 0.05 was considered statistically significant.

3. Results

3.1. General data analysis

This study included a total of 263 patients who experienced unexpected in-hospital cardiac arrest (IHCA). Among them, there were 178 males (71.1%) and 85 females (32.3%). The age of the included subjects was (74 ± 14.25) years, with a minimum age of 21 years and a maximum age of 99 years. Among the causes of IHCA, 49 cases (18.6%) were due to cardiogenic cardiac arrest. The median length of hospital stay before cardiac arrest was 3 days (interquartile range: 1, 11), and the duration of CPR was (19.5 ± 19.03) minutes. Return of spontaneous circulation (ROSC) was achieved in 166 patients (63.1%), with a median survival period of 72 hours. Among these patients, 54 (32.5%) survived for 7 days, and 42 (16%) were discharged alive.

3.2. Univariate logistic regression analysis

Univariate analysis indicated that among the factors influencing ROSC after resuscitation, age, BMI, BI index, NRS2002 score, comorbid diabetes, length of hospital stays, whether the cardiac arrest was cardiogenic, location of cardiac arrest, time period of cardiac arrest, duration of CPR, cumulative initial epinephrine dosage, and ventilation method during resuscitation showed statistically significant differences ($p < 0.05$). Regarding patient survival to discharge, the NRS2002 score, bedridden status before admission, length of hospital stays, whether the cardiac arrest was cardiogenic, location of cardiac arrest, CPR duration ≥ 30 minutes, cumulative initial epinephrine dosage, and recurrent resuscitation events showed statistically significant differences ($p < 0.05$). See **Table 1** for details.

3.3. Multivariate logistic regression analysis

Values with a univariate p-value < 0.05 were used as independent variables, and the occurrence of endpoint events (Non-ROSC = 1, death = 1) was used as the dependent variable. A stepwise forward regression method was employed, with the assignment methods for independent variables detailed in **Table 2**. Multivariate logistic regression analysis revealed that BMI, the cause of IHCA, duration of CPR, ventilation method during resuscitation, and the initial cumulative dosage of epinephrine were independent influencing factors for Non-ROSC in IHCA patients ($p < 0.05$), as shown in **Table 3**. The final chi-square value (14.560, $p = 0.068$) indicated a relatively high goodness-of-fit for the model. Additionally, the NRS2002 score, recurrent resuscitation events, initial cumulative dosage of epinephrine, and ventilation method during resuscitation were influencing factors for the survival to discharge of IHCA patients, as shown in **Table 4**.

Table 1. Univariate analysis of factors affecting the recovery of autonomic circulation (n = 263)

Variable	Total N = 263	ROSC (n = 166)	Non-ROSC (n = 97)	Statistic	*p*-value	Survived to Discharge (n = 42)	Did not survive to Discharge (n = 162)	Statistic	*p*-value
Age	263	72 (61, 82)	77.5(68.25, 85)	-3.115	0.002	72 (56.75, 79.5)	74 (64, 84)	-1.430	0.153
Gender	Male 178 (67.7) Female 85 (32.3)	107 (64.1) 60 (35.9)	71 (74) 25 (26)	2.724	0.099	28 (66.7) 14 (33.3)	150(67.9) 71(32.1)	0.023a	0.878
BMI	18.5–23.9 = 219 (83.3) < 18.5 = 23 (8.7) 24.0–27.9 = 17 (6.5) ≥ 28.0 = 4 (1.5)	151 (90.4) 8 (4.8) 6 (3.6) 2 (1.2)	68 (70.8) 15 (15.6) 11 (11.5) 2 (2.1)	17.139	0.001	37 (88.1) 3 (7.1) 1 (2.4) 1 (2.4)	182 (82.4) 20 (9.0) 16 (7.2) 3 (1.4)	1.819a	0.611
Barthel index (BI)	No Dependence = 33 (12.5) Mild Dependence = 36 (13.7) Moderate Dependence = 22 (8.4) Severe Dependence = 172 (65.4)	17 (10.2) 19 (11.4) 11 (6.6) 120 (71.9)	16 (16.7) 17 (17.7) 11 (11.5) 52 (54.2)	8.476	0.037	3 (7.1) 3 (7.1) 3 (7.1) 33 (78.6)	30 (13.6) 33 (14.9) 19 (8.6) 139 (62.9)	4.143a	0.246
NRS2002 score	< 3 = 166 (63.1) ≥ 3 = 97 (36.9)	95 (56.9) 72 (43.1)	71 (74) 25 (26)	7.632	0.006	26 (61.9)	74 (33.5)	12.097a	0.001
CCI	1 = 32 (12.2) 2 = 75 (28.5) 3 = 156 (59.3)	23 (13.8) 52 (31.1) 92 (55.1)	9 (9.4) 23 (24) 64 (66.7)	3.448	0.178	8 (19) 15 (35.7) 19 (45.2)	24 (10.9) 60 (27.1) 137 (62)	4.522a	0.104
Number of comorbidities	0 = 75 (28.5) 1–2 = 127 (48.3) ≥ 3 = 61 (23.2)	45 (26.9) 78 (46.7) 44 (26.3)	30 (31.3) 49 (51) 17 (17.7)	2.595	0.273	17 (40.5) 14 (33.3) 11 (26.2)	58 (26.2) 113 (51.1) 50 (22.6)	5.015a	0.081
Comorbidities									
CAD	45	27	18	0.287	0.592	19	26	0.335a	0.563
Hypertension	144	95	49	0.214	0.643	52	92	0.707a	0.401
diabetes mellitus	88	64	24	3.045	0.027	34	54	0.003a	0.956
AMI	5	4	1	0.599	0.439	3	2	1.005a	0.316
Renal insufficiency	24	18	5	0.986	0.321	11	13	0.616a	0.432
COPD	14	9	5	0.004	0.950	5	9	0.045a	0.832
Stroke	47	29	18	0.080	0.778	16	31	0.460a	0.498
Heart failure	9	6	3	0.040a	0.841	4	5	0.144a	0.705

Table 1 (Continued)

Variable	Total N = 263	ROSC (n = 166)	Non-ROSC (n = 97)	Statistic	*p*-value	Survived to Discharge (n = 42)	Did not survive to Discharge (n = 162)	Statistic	*p*-value
arrhythmia	35	22	13	0.007a	0.933	11	20	0.127a	0.722
	Illiterate = 16 (6.1)	13 (7.8)	3 (3.1)			13 (31)	105 (47.5)		
	Primary School = 118 (44.9)	71 (42.5)	47 (49)			15 (35.7)	64 (29)		
Educational level	Middle School = 79 (30)	52 (31.3)	27 (28.1)	8.840a	0.065	7 (16.7)	4 (9.5)	5.907a	0.206
	High School = 24 (9.1)	19 (11.4)	5 (5.1)			4 (9.5)	22 (10)		
	College or Above = 26 (9.9)	12 (7.2)	14 (14.6)			13 (31)	105 (47.5)		
Smoking	41 (15.6)	27 (16.2)	14 (14.6)	0.116	0.733	6 (14.3)	35 (15.8)	0.065a	0.799
Alcohol consumption	26 (9.9)	17 (10.2)	9 (9.4)	0.044a	0.833	7 (16.7)	19 (8.6)	2.580a	0.108
bedridden	21 (8)	15 (9.0)	6 (6.3)	0.619a	0.431	0 (0)	21 (9.5)	4.337a	0.037
Length of hospital stay	263	2 (1, 6)	8 (2, 17)	-5.768	< 0.001	1 (1, 3)	4 (1, 12)	-3.562	< 0.001
Bystander CPR present	232 (88.2)	148 (88.6)	84 (87.5)	0.074	0.786	37 (88.1)	195 (88.2)	0.001	0.979
	ICU = 47 (17.9)	33 (19.8)	14 (14.6)			6 (14.3)	41 (18.6)		
Location of cardiac arrest	Emergency/Examination Room = 68 (25.9)	63 (37.7)	5 (5.2)	41.232a	< 0.001	23 (54.8)	45 (20.4)	22.207a	< 0.001
	General Ward = 148 (56.3)	71 (42.5)	77 (80.2)			13 (31)	135 (61.1)		
Cardiac etiology of arrest	49 (18.6)	21 (12.6)	28 (29.2)	11.069	0.001	3 (7.1)	46 (20.8)	4.351	0.037
	08:00-15:59 = 111 (42.2)	71 (42.5)	40 (41.7)			20 (47.6)	91 (41.2)		
Time of cardiac arrest	16:00-23:59 = 69 (26.2)	53 (31.7)	16 (16.7)	10.181a	0.006	14 (33.3)	55 (24.9)	3.786a	0.151
	00:00-07:59 = 83 (31.6)	43 (25.7)	40 (41.7)			8 (19)	75 (33.9)		
CPR duration ≥ 30 min	87 (33.2)	32 (19.3)	55 (57.3)	39.630a	< 0.001	6 (14.3)	81 (36.8)	8.073	0.004
Initial cumulative epinephrine dose	263	2 (1, 3)	3 (2, 5)	-5.083	< 0.001	1 (0.75, 2)	2 (1, 4)	-3.259	< 0.001

Table 1 (Continued)

Variable	Total N = 263	ROSC (n = 166)	Non-ROSC (n = 97)	Statistic	*p*-value	Survived to Discharge (n = 42)	Did not survive to Discharge (n = 162)	Statistic	*p*-value
Shockable rhythm	No = 206 (78.3)	128 (76.6)	78 (81.3)	0.761a	0.383	9 (21.4)	48 (21.7)	0.002a	0.967
	Yes = 57 (21.7)	39 (23.4)	18 (18.8)						
Ventilation mode pre-arrest	Non-endotracheal intubation = 226 (87.3)	145 (89.0)	81 (84.4)	1.141a	0.285	39 (95.1)	187 (85.8)	2.709a	0.100
	Endotracheal intubation = 33 (12.7)	18 (11.0)	15 (15.6)			2 (4.9)	31 (14.2)		
Ventilation mode during resuscitation	Bag-Valve-Mask Ventilation = 44 (16.7)	13 (7.8)	31 (32.3)	26.281a	< 0.001	3 (7.1)	41 (18.6)	2.709a	0.100
	Endotracheal Intubation = 219 (83.3)	154 (92.2)	65 (67.7)			39 (92.9)	180 (81.4)		
Mechanical support during resuscitation	No = 241 (91.6)	152 (91.0)	89 (92.7)	0.227a	0.634	39 (92.9)	202 (91.4)	0.097a	0.755
	Yes = 22 (8.4)	15 (9.0)	7 (7.3)			3 (7.1)	19 (8.6)		
Recurrent resuscitation Events	85 (32.3)	-	-	-	-	3 (7.1)	82 (37.1)	14.484a	< 0.001
CRRT after ROSC	57	-	-	-	-	11 (26.2)	46 (20.8)	0.601a	0.438

Table 2. Assignment of independent variables

Variable		Quantitative assignment
Age	X1	Enter original value
BMI (kg/m^2)	X2	1 = 18.5– ≤ 23.9, 2 = < 18.5, 3 = 24.0– ≤ 27.9, 4 = ≥ 28.0
Barthel Index (BI)	X3	1 = 100 points, 2 = 61–99 points, 3 = 41–60 points, 4 = 0–40 points
NRS2002 Score ≥ 3	X4	No = 0, Yes = 1
Comorbid with diabetes	X5	No = 0, Yes = 1
Length of hospital stay	X6	Enter original value
IHCA department	X7	1 = ICU, 2 = Emergency room/Examination department, 3 = General ward
Cardiac cause of arrest	X8	No = 0, Yes = 1
IHCA time period	X9	1 = 08:00–15:59, 2 = 16:00–23:59, 3 = 00:00–07:59
CPR duration ≥ 30 min	X10	No = 0, Yes = 1
Cumulative dose of first epinephrine administered	X11	Enter original value
Ventilation method during resuscitation	X12	1 = Bag-mask ventilation, 2 = Emergency endotracheal intubation
Bedridden status	X13	No = 0, Yes = 1
Repeated resuscitation events	X14	No = 0, Yes = 1
Non-ROSC	Y1	No = 0, Yes = 1
Not surviving to discharge	Y2	No = 0, Yes = 1

Table 3. Multifactorial analysis affecting the recovery of autonomic circulation

Variable	B	S.E.	Wald χ^2	p	OR	95% CI
Constant	-0.972	0.634	2.354	0.125	0.378	-
BMI			12.167	0.007		
BMI (1)	1.773	0.604	8.612	0.003	5.888	1.802 – 19.242
BMI (2)	1.351	0.661	4.178	0.041	3.860	1.051 – 14.098
BMI (3)	1.235	1.264	0.955	0.329	3.440	0.289 – 40.993
Cardiac cause of arrest	-1.270	0.431	8.691	0.003	0.281	0.121 – 0.653
CPR duration ≥ 30 min	1.238	0.369	11.257	0.001	3.448	1.673 – 7.106
Ventilation method during resuscitation	-2.235	0.447	21.988	< 0.001	0.107	0.042 – 0.272
Cumulative initial epinephrine dose	0.274	0.077	12.484	< 0.001	1.315	1.130 – 1.530

Table 4. Multifactorial analysis of survival to discharge

Variable	B	S.E.	Wald χ^2	p	OR	95% CI
Constant	2.128	0.839	6.434	0.011	8.396	-
NRS ≥ 3 points	-0.832	0.411	4.105	0.043	0.435	0.195 – 0.973
Recurrent resuscitation events	2.467	0.649	14.438	< 0.001	11.792	3.303 – 42.103
Cumulative dose of initial epinephrine use	0.373	0.127	8.595	0.003	1.452	1.132 – 1.863
Ventilation method during resuscitation	-1.505	0.689	4.774	0.029	0.222	0.058 – 0.856

3.4. Kaplan-Meier survival curve

Among the 263 patients with cardiac arrest who underwent cardiopulmonary resuscitation (CPR), 166 patients (63.5%) achieved ROSC. Of these, 132 patients (79.5%) survived within 24 hours, 54 patients (32.5%) survived within 7 days, and 40 patients (24%) survived to discharge. The survival rate of patients with cardiac arrest decreased significantly within 24 hours after CPR, and then gradually declined over time, as illustrated in **Figure 1**.

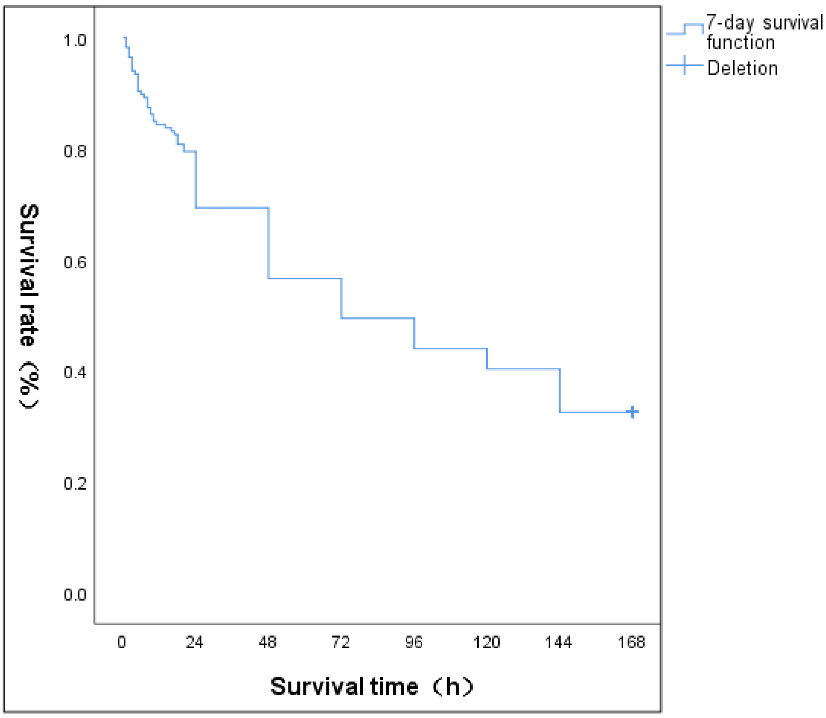

Figure 1. 7-day survival scale.

4. Discussion

This study reveals that the rates of return of spontaneous circulation (ROSC) and survival to hospital discharge among patients with in-hospital cardiac arrest (IHCA) under the rapid response system are 63.5% and 15.9%, respectively (**Table 1**). In comparison, the ROSC rate is higher than that reported in other studies, confirming that the ROSC rate among IHCA patients under rapid response system intervention is higher than usual, though the survival to hospital discharge rate requires further validation, consistent with previous research findings [12–15].

The rapid response system plays a crucial role in the rescue of IHCA patients, particularly in non-monitoring and auxiliary departments. Promptly initiating an integrated, multi-departmental collaborative in-hospital rapid rescue system in emergencies is essential for shortening response times, improving the rate of spontaneous circulation recovery, and enhancing prognosis. Our hospital has established an in-hospital emergency rescue team involving multiple departments, dividing the entire hospital into regions based on the layout of the ward buildings and considering the principle of proximity. When cardiac arrest occurs anywhere in the hospital, the witness implements a primary care responsibility system, assessing the vital signs of patients with cardiac arrest and critical signs, and immediately initiating cardiopulmonary resuscitation (CPR). A unified emergency call number and call language are specified to report the incident location. Meanwhile, the operator on duty at the switchboard repeats and confirms the information before initiating an emergency call to the rescue team, directing the elevator to stand by, and ensuring that team members responsible for the region arrive at the scene within 5 minutes. The general principle of "first rescue on-site, then transfer nearby" is implemented. Guided by the goals of restoring spontaneous circulation and survival to hospital discharge, this study describes the influencing factors of ROSC and outcomes in IHCA patients under the in-hospital rapid response team. It reveals that the etiology of IHCA, body mass index (BMI), CPR duration, ventilation method during rescue, and the initial cumulative dose of epinephrine are independent influencing factors for Non-ROSC in IHCA patients; whereas the NRS2002 score, recurrent resuscitation events, initial cumulative dose of epinephrine, and ventilation method during rescue are influencing factors for survival to hospital discharge in IHCA patients.

The etiology of IHCA is typically recorded according to clinical data using the Utstein mode, categorized into cardiac and non-cardiac causes. According to an international literature review, multiple studies tend to classify cardiac arrest (CA) of unknown etiology as cardiac causes [16]. In this study, we define cardiac causes of IHCA as cardiac arrest resulting from a clearly identified primary cardiac disease. **Table 1** shows that non-cardiac diseases account for 81.4% of IHCA cases, consistent with the conclusions of multiple studies, suggesting that IHCA is mostly caused by non-cardiac diseases such as severe electrolyte and acid-base balance disorders, hypoxia, and stroke [17,18]. A three-year retrospective study in Denmark shows that compared to patients with non-cardiac causes of cardiac arrest, those with cardiac causes have a higher rate of favorable neurological outcomes [19]. Additionally, logistic regression results in this study indicate that cardiac causes of cardiac arrest are an independent protective factor for Non-ROSC but do not show an impact on survival prognosis. This may be because most patients with cardiac diseases have completed cardiac function tests before arrest and are under monitoring equipment detection; furthermore, patients with cardiac IHCA have a high incidence of ventricular tachycardia, ventricular fibrillation, and myocardial infarction, with the former showing a shockable rhythm during cardiac arrest, which can be intervened with defibrillation, and the latter undergoing percutaneous coronary intervention, which also helps improve prognosis [20].

Previous studies have shown that an increased BMI in IHCA patients is positively correlated with a favorable prognosis, known as the "obesity paradox", which refers to the association of mildly elevated BMI with favorable outcomes [21,22]. However, other studies have shown a negative correlation between increased BMI and favorable prognosis. **Table 3** shows that in this study, patients with a BMI < 18.5 have a nearly six-fold higher chance of Non-ROSC compared to patients with a normal BMI, and those with a mildly elevated BMI of 24.0– ≤ 27.9 have a nearly four-fold higher chance of Non-ROSC compared to patients with a normal BMI, similar to other research findings. Wang believes that IHCA patients with a BMI > 23.2 kg/m^2 have a lower likelihood of a favorable outcome [23]. Another meta-analysis found that both obesity and underweight are associated with higher in-hospital mortality, with underweight also being associated with worse neurological outcomes [24]. The reason may be that BMI is positively correlated with the anterior-posterior depth of subcutaneous adipose tissue, and increased BMI makes resuscitation more difficult. Compared to patients with a normal BMI, those with a high BMI likely receive shallower chest compressions, suggesting that for IHCA patients with a high BMI, end-tidal carbon dioxide partial pressure and other physiological parameters should be monitored in conjunction during rescue to monitor CPR. Additionally, the relationship between BMI and mortality remains unclear and requires further stratified research. The NRS2002 score in this study shows a protective effect for survival to hospital discharge in IHCA patients (OR = 0.435). Another study did not find a relationship between this score and prognosis, and due to the limited sample size in this study, further validation is needed [23].

Previous studies consider a CPR duration of 20–30 minutes as an important cutoff point. Ahmad believes that CPR lasting more than 20 minutes may be clinically meaningless, and the survival rate of patients with in-hospital cardiac arrest exceeding 30 minutes significantly decreases [25]. Recently, Okubo M quantified the time-dependent probability of survival and favorable functional outcomes, concluding that when CPR duration exceeds 39 minutes, the survival probability drops below 1%, and the probability of favorable functional outcomes also decreases below 1% when CPR duration exceeds 32 minutes, providing important quantitative evidence for clinical decision-making on whether to continue CPR at specific time points for IHCA patients [26]. However, different individuals may still benefit from prolonged CPR, and there is currently controversy over the optimal duration of CPR. This study shows that patients with a CPR duration < 30 minutes have a 3.5-fold higher chance of ROSC and a 4.5-fold higher chance of survival to hospital discharge compared to those with a duration ≥ 30 minutes (**Table 4**). The possible reason is that prolonged CPR exceeds physiological compensation, leading to ischemia and hypoxia in organs such as the heart and brain, as well as reperfusion injury, increasing the risk of irreversible damage and reducing the success rate of resuscitation [27]. Additionally, in this study, 21% of cardiac arrest patients have a CPR duration ≥ 30 minutes without restoring spontaneous circulation. How should the optimal cessation time be monitored for such patients?

In resuscitation science, ventilation research lags behind studies on chest compressions and defibrillation. This study shows that emergency tracheal intubation during CPR can serve as a protective factor for ROSC, consistent with previous research findings. Both chest compressions and ventilation during CPR are crucial for promoting oxygen delivery. A prospective observational study found a dose-dependent relationship between baseline and dynamic changes in oxygen content and the likelihood of restoring spontaneous circulation (ROSC) [28]. However, in clinical practice, the etiology of CA is also one of the factors to consider when choosing a ventilation method. Expert consensus indicates that for cardiac diseases, residual oxygen is present during cardiac arrest, and restoring circulation should be prioritized. As the body's stored oxygen is depleted, assisted ventilation is required to achieve oxygen transport. For pulmonary-induced CA, which is caused by the depletion of the body's stored oxygen leading to cardiac arrest, assisted ventilation and chest compressions should be performed simultaneously to restore circulation. Andersen analyzed the intubation time in 43,314 cases of IHCA and found that patients who completed emergency intubation within 15 minutes had lower ROSC and survival to hospital discharge rates compared to those who did not complete intubation within that time [26]. However, some studies have reported that early tracheal intubation is beneficial for the outcome of CA. Qian Shaobing improved the ROSC success rate to 40.00% in IHCA patients after early tracheal intubation, compared to 22% in those without intubation [29]. In summary, early tracheal intubation can quickly establish effective ventilation and oxygen uptake channels, provide airway protection for patients, prevent insufficient carbon dioxide and blood oxygen saturation, and enhance the effectiveness of CPR. However, the academic community holds different views, and implementation should be based on guideline recommendations combined with clinical practice.

The 2022 American Heart Association (AHA) Guidelines for Cardiopulmonary Resuscitation and Emergency Cardiovascular Care continue to recommend epinephrine as a first-line rescue medication for cardiac arrest. During cardiac arrest, epinephrine can improve myocardial blood supply through its α-adrenergic effects, causing peripheral vasoconstriction, dilating the bronchi, and improving cerebral perfusion, thereby promoting ROSC, and is widely used in clinical practice. The results of this study suggest that a lower initial cumulative dose of epinephrine is a protective factor for ROSC and survival to hospital discharge in patients. This is consistent with the findings of most studies on adult in-hospital cardiac arrest [30–32]. The guidelines for epinephrine use indicate that for non-shockable rhythms, epinephrine should be administered early, with survival rates increasing by 4% for every minute earlier the drug is given. In summary, the dose of epinephrine is crucial for restoring spontaneous circulation, but clinical use should be based on the patient's specific condition and the latest research evidence, with reasonable dose adjustments to improve the success rate of resuscitation and the patient's long-term survival rate.

Additionally, **Table 4** shows that recurrent resuscitation events in IHCA patients are an independent risk factor affecting survival to hospital discharge (OR = 11.55). The incidence of recurrent cardiac arrest is 32.3%, similar to other research findings [33]. A significant proportion of patients who achieve spontaneous circulation recovery will experience cardiac arrest again due to various causes, with a low success rate of rescue and poor clinical prognosis for recurrent cardiac arrest, remaining a major challenge. This emphasizes and suggests that careful management of patients who have successfully

5. Conclusion

In summary, the establishment of a rapid response system within the hospital can enhance the rate of return of spontaneous circulation (ROSC) in patients. By analyzing the current status of in-hospital cardiac arrest (IHCA), it provides objective indicators for evaluating post-resuscitation outcomes. It also suggests the need to strengthen the connections between various rescue links, improve the clinical early warning scoring system, and promptly activate the rapid response team, with the aim of shortening the time to initiate cardiopulmonary resuscitation and improving the success rate of resuscitation outcomes.

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