Do carboxyhemoglobin and methemoglobin levels predict the return of spontaneous circulation and prognosis of cardiac arrest patients?

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Abstract

Introduction: Early prediction of return of spontaneous circulation (ROSC) for cardiac arrest (CA) patients is a major challenge. This study's goal was to investigate the value of the carboxyhemoglobin (COHb) and methemoglobin (MetHb) levels as a predictive marker for ROSC and prognostic marker for patients who achieve ROSC. Methods: A total of 241 adult patients (109 female, 132 male) diagnosed as non-traumatic CA were included in the study. The patients were divided into two groups based on whether they achieved ROSC. Complete blood count parameters, routine biochemistry measurements, coagulation parameters, and blood gas analysis, and cardiac markers values were compared between the groups. Results: COHb levels were significantly lower in the non-ROSC group (0.71 ± 0.57%) than in the ROSC group (0.95 ± 0.76%) and in the non-survival group (0.78 ± 0.53%) compared to the survivor group (1.45 ± 1.31%) (p =0.002, 0.022 respectively). There was no significant difference between the ROSC and non-ROSC groups and survivor group and non-survivor groups in terms of MetHb levels (p = 0.769 and 0.668, respectively). Conclusions: COHb levels in the blood gas analysis at the time of admission could be used as a predictive marker for ROSC and prognostic marker for the patients who achieved ROSC.

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Keywords: Carboxyhemoglobin, cardiac arrest, methemoglobin, ROSC, prognosis

What is already known about this topic?

The significance of the COHb and MetHb levels for the prognosis of cardiac arrest patients is unknown.

What does this article add?

COHb levels could be used as a post-CPR prognostic marker for cardiac arrest patients.

Introduction

The prognosis of cardiac arrest (CA) remains poor, despite the advances in treatment in recent years (1). The primary goal of cardiopulmonary resuscitation (CPR) is to achieve the return of spontaneous circulation (ROSC). Deciding when to stop CPR and not knowing how long the CPR will take and how it will end are the main problems for rescuers. Biomarkers, such as Interleukin-6, High sensitive C reactive protein, and S-100 B protein, have been studied as an early marker of post-CPR prognosis and predictors for ROSC (2,3). However, these biomarkers are not routinely performed in the emergency department, add cost, and incur a time delay. These delays diminish their value for CA patients. Studies of routinely available laboratory markers have shown that high blood sugar, low potassium, high platelet count, and elevated lactate levels are associated with poor prognosis in patients with CA. Nevertheless, a consensus has not been achieved on a standardized biomarker in this regard (4–7). For healthcare professionals, blood gas analysis with rapid results is an important tool in terms of diagnosis and treatment of reversible causes of CA (hypoxia, hyperpotassemia, hypopotassemia, hypovolemia, and acidosis). Carboxyhemoglobin (COHb) and methemoglobin (MetHb) levels can be easily measured by blood gas analysis and do not require additional costs.

COHb and MetHb are variants of normal hemoglobin. Both molecules are formed from hemoglobin as a result of different biochemical processes (8). COHb is formed by the binding of carbon monoxide (CO), which is formed endogenously by hemoglobin metabolism or exogenously inhaled (8). It has been reported that CO is involved in various functions, such as vasodilation, angiogenesis, vascular remodeling, and inflammatory response (8,9). The reported blood COHb level is approximately 1.0% in non-smokers and 5.5% in patients with a smoking history (10). In some studies, it has been reported that high and low COHb levels are associated with poor clinical prognosis in various pathological conditions, including pulmonary embolism (PTE), acute ischemic heart disease, and critically ill patients in intensive care units (ICU) (11–13).

MetHb formation results from oxidative processes in which one or more of the four iron atoms in the hemoglobin molecule are converted to a ferric state and, thus, unable to bind oxygen. When naturally produced nitric oxide (NO) interacts with hemoglobin endogenous MetHb is formed. Large amounts of NO can be produced in various critical diseases, such as sepsis or septic shock (14). Increased free NO levels in the circulation can cause the formation of MetHb (15,16). In conclusion, it has been reported that MetHb levels increase in patients with sepsis and PTE (11,14). To our knowledge, no study has yet investigated the predictive value of COHb and MetHb levels in CA cases.

This study aimed to investigate the role of the COHb and MetHb levels in predicting the ROSC in patients with non-traumatic cardiac arrest who underwent CPR and to determine the predictive value of the COHb and MetHb levels in patients who achieve ROSC.

Methods

The study was approved by the Ethics Committee for the Non-Invasive Research at the Gulhane Health Sciences University (Committee IRB approval number: 2020/06-decision no: 2020/126).

Study design and patient selection

All non-traumatic cardiac arrest patients admitted to the emergency department from November 1 2016 to January 31 2020 were screened in the electronic patient management system (FONET®, Information Technology Incorporation, Turkey). Patient charts were screened, as well as an electronic patient management

system. Patients who were younger than 18 years and who had missing information were excluded. All non-traumatic CA patients without the exclusion criteria were included in the study (Figure-1).

Age, gender, complete blood count (CBC) parameters of the patients, routine biochemistry measurements, coagulation parameters, and blood gas analysis, cardiac markers, whether ROSC was achieved or not, the initial rhythm [Asystole, Ventricular Fibrillation (VF), Pulseless Ventricular Tachycardia (VT), Pulseless Electrical Activity (PEA)], duration of CPR (min), and hospital admission status were recorded. The patients were divided into two groups as patients in whom ROSC was achieved (ROSC group) or those in whom ROSC was not achieved (non-ROSC group). ROSC was defined as spontaneous circulation and was achieved longer than 20 min. The ROSC group was also divided into two subgroups as survivors (discharged from the hospital) and non-survivors (mortality occurred during hospital stay).

Power analysis

The sample size was calculated with an alpha value of 0.05, 80% power, an enrollment ratio of 1, and COHb values of 0.9 in group 1 (ROSC group) and 0.54 in group 2 (no-ROSC group), yielding that 26 patients in either group making a total of 52 participants would be included in the study (17,18).

Laboratory analysis

By the protocol of the emergency service where the study was conducted, blood samples are taken simultaneously for CBC, routine biochemistry, blood gas analysis, cardiac markers, and coagulation parameters within the first 4 mins of the onset of CPR.

CBC (Beckman Coulter Unicell DxH 800, CA 92821 USA), blood gas parameters (Radiometer ABL800 FLEX, 2700 Bronshoj Denmark), routine biochemistry (Beckman Coulter AU680, CA 92821 USA), cardiac Troponin (cTn), creatine kinase MB isoenzymes (CKMB) (Beckman Coulter DxI 800 Access immunoassay systems, CA 92821 USA), PTZ-INR, and D-Dimer (Sysmex CS-2500, Kobe 651-0073 Japan) were measured in the emergency biochemistry laboratory.

Statistical analysis

The categorical variables were presented as frequency and percentages. Continuous variables were presented as mean ± standard deviation. The Kolmogorov Smirnov test was used for testing whether the variables were distributed normally. Student's t-test was used for binary comparison of continuous variables conforming to the normal distribution, Mann-Whitney U test for non-compliant ones, and Chi-square test for comparison of categorical data. A p-value of < 0.05 was considered statistically significant. The statistical analysis software was SPSS Statistics for Windows, version 22.0 (SPSS Statistics for Windows, Version 22.0. IBM Corp., Armonk, N.Y., USA).

Results

A total of 241 patients (109 female, 132 male) were included in the study. Of the patients (n = 241), 56.01% (n = 135) were in the ROSC group and 43.98% (n = 106) were in the non-ROSC group. There were no statistically significant differences in age and gender between the ROSC and non-ROSC groups (Table I).

CPR duration was 14.12 ± 11.67 min in the ROSC group, while it was 48.26 ± 10.61 min in the non-ROSC group, and the difference between them was statistically significant ($p < 0.001$). In terms of the initial arrest rhythm (Asystole, VF, VT, PEA); there was a statistically significant difference between the ROSC group (n = 91, 8, 3, and 21, respectively) and the non-ROSC group (n = 95, 0, 0, and 10, respectively) ($p = 0.003$).

When comparing the ROSC group and the non-ROSC group in terms of routine biochemistry and cardiac markers, the urea, creatinine, potassium, and cTn levels in the non-ROSC group (125.91 ± 88.71 mg dL-1, 2.47 ± 1.73 mg dL-1, 5.13 ± 1.33 mmol L-1, and 971.05 ± 2674.55 pg mL-1, respectively) were higher than the ROSC group (88.6 ± 65.08 mg dL-1, 1.87 ± 1.32 mg dL-1, 4.69 ± 1.29 mmol L-1, and 578.69 ± 1770.28 pg mL-1, respectively) and the differences between them were statistically significant ($p < 0.001$, 0.001, 0.014,

and 0.005, respectively). There was no statistically significant difference between these groups in terms of other routine biochemistry and cardiac markers (Table II).

When comparing the ROSC group and the non-ROSC group in terms of blood gas parameters, the COHb level in the non-ROSC group (0.71 ± 0.57%) was lower than the COHb level in the ROSC group (0.95 ± 0.76%), and the difference between them was statistically significant (p = 0.002) (Table II). There was no statistically significant difference between these groups in terms of other blood gas parameters.

Of the patients who achieved ROSC and could be followed up (n = 78), 82.05% (n = 64) died (non-survivor group), and 17.95% (n = 14) were discharged from the hospital (survivor group). The mean age of the non-survivor group was 71.98 ± 11.95 years, while the mean age of the survivor group was 59.36 ± 20.96 years and the difference between them was statistically significant (p = 0.025). In terms of gender, there was no statistically significant difference between these groups (Table III).

The CPR duration was 17.17 ± 14.65 min in the non-survivor group, while it was 6.29 ± 2.84 min in the survivor group, and the difference between them was statistically significant (p < 0.001). In terms of the initial arrest rhythm (Asystole, VF, VT, PEA); there was a statistically significant difference between the non-survivor group (n = 45, 1, 1, and 7; respectively) and the survivor group (n = 5, 6, 0, and 2; respectively) (p < 0.001) (Table III).

When comparing the non-survivor group and the survivor group in terms of routine biochemistry and cardiac markers, the urea, creatinine, potassium, lactate dehydrogenase (LDH), and cTn levels in the non-survivor group (91.51 ± 58.06 mg dL-1, 2.08 ± 1.64 mg dL-1, 4.93 ± 1.22 mmol L-1, 1072.14 ± 3119.52 U L-1, and 685.39 ± 1687.14 pg mL-1, respectively) were higher than in the survivor group (40.62 ± 20.49 mg dL-1, 1.09 ± 0.49 mg dL-1, 3.60 ± 0.68 mmol L-1, 282.44±76.02, and 62.30 ± 115.67 pg mL-1, respectively) and the differences between them were statistically significant (p = 0.001, 0.005, 0.001, 0.010, and 0.008, respectively). There was no statistically significant difference between these groups in terms of other parameters (Table IV).

When comparing the non-survivor and survivor groups in terms of blood gas parameters, the COHb, bicarbonate (HCO3) and tCO2 levels in the non-survivor group (0.78 ± 0.53%, 15.44 ± 5.62 mmol L-1, and 34.64 ± 12.36 mmol L-1, respectively) were lower than survivor group (1.45 ± 1.31%, 20.14 ± 5.84 mmol L-1, and 44.76 ± 13.15, respectively), and the difference between them was statistically significant (p = 0.022, 0.016, and 0.017, respectively). There was no statistically significant difference between these groups in terms of other blood gas parameters (Table IV).

Discussion

Based on the unique data we have obtained from our study, we propose that CA patients' COHb level can be a predictor for ROSC. To our knowledge, this is the first study investigating the relationship between ROSC and COHb and MetHb levels.

In the study by Neukamm et al. (19) investigating the impact of response time reliability on CPR incidence and resuscitation success, 2330 patients were resuscitated in the seven different emergency medical service (EMS) systems. In 46.7%, spontaneous circulation could be achieved. There were no significant differences between the centers for the ROSC rate (42.6% vs. 53.1%, p = 0.32). However, survival after 24 h varied between centers (15.1% vs 30.3% p < 0.001). Discharge rates were between 13.8% and 16.6% (p = 0.50). The ROSC and survival rates found in the current study are compatible with the literature.

In their study, Rohlin et al. (20) investigated the effect of CPR duration on 30-day survival. These authors concluded that the survival rate increased as the CPR duration period was shortened. Similarly, in the current study, the CPR duration was significantly shorter in the ROSC group than in the non-ROSC group. Similarly, in our study, the CPR duration was considerably shorter in the survivor group compared to the non-survivor group.

Gilje et al. (21) investigated the predictive value of cTn in out-of-hospital cardiac arrest (OHCA) patients,

and reported that high cTn was an independent risk factor for mortality. Similarly, in our study, the cTn levels were higher in the non-ROSC and non-survivor groups compared to ROSC and survival groups.

In the systemic review by Sasson et al. (22), the predictors for survival in CA cases were investigated. These authors concluded that the survival rates of patients with VF and VT as the initial rhythm were higher than in other rhythms. Similarly, in our study, the amount of VF and VT in the initial rhythm detected in the ROSC group was higher than in the no ROSC group. Additionally, the amount of VF and VT was higher in the survivor group compared to the nonsurvivor group.

Melley et al. (13) evaluated patients who were hospitalized in ICU after cardiothoracic surgery and reported that minimum COHb levels were higher in patients who stayed in intensive care for a short time and discharged compared to patients who died. Fazekas et al. [(18)]reported that COHb levels in patients with mortality were significantly lower than those discharged in a non-surgical ICU. Additionally, low COHb levels in intensive care patients were associated with high mortality, regardless of the severity of the disease and organ failure type. Kakavas et al. reported that low COHb level was associated with high mortality in the study in which 159 patients were followed up in chest diseases clinic with the diagnosis of PTE involved (11). Similarly, in the current study, the COHb levels in the ROSC group were significantly higher compared to the non-ROSC group. Additionally, the COHb levels of the survivor group were significantly higher compared to the non-survivor group. CO is synthesized naturally in the body and has a very important role in range of physiological functions including vasodilation, angiogenesis, vascular remodeling, protection against tissue damage, and formation of the inflammatory response (8,9). In this current study, the low CO-Hb level in the non-survivors may have been due to the failure to activate the inflammatory system.

Schuerholz et al. reported that MetHb levels were associated with sepsis severity in the intensive care unit patients (14). Kakavas et al. reported that MetHb levels might increase in high-risk PTE patients (11). Conversely, Uzer et al. reported no correlation between MetHb and COHb levels and the severity of PE (17). According to our results, the MetHb levels did not have a predictive value in terms of ROSC in CA patients.

This was a retrospective and single-center study, subject to the limitations in generalizability with this research design.

Conclusions:

The author concluded that the COHb levels in the blood gas analysis at the time of admission could be used as a predictive marker for ROSC in CA patients. It was also emphasized that COHb levels could be used as a post-CPR prognostic marker for mortality prediction. In this regard, we recommend that resuscitation teams consider the COHb level in their CPR termination decisions. On the other hand, MetHb levels had no value as a predictive marker for ROSC and prognostic marker for patients who achieved ROSC. Further randomized controlled studies are needed to confirm the current study findings.

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Conflict of Interest: The Authors declare that there is no conflict of interest.

Author contributions

The article concept and design were developed jointly by all authors. All authors were involved in the data interpretation, and all provided input in each draft of the manuscript

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Table I. Demographics of the groups.	**Table I.** Demographics of the groups.	**Table I.** Demographics of the groups.	**Table I.** Demographics of the groups.	**Table I.** Demographics of the groups.	**Table I.** Demographics of the groups.
Parameter	**Groups**	**n**	**Mean±SD**	**95% CI**	**p**
Age	ROSC	135	72.47±13.48	-4.12-2.98	0.695 ***
	Non-ROSC	106	73.04±14.37		
Gender (Erkek/Kadın)	ROSC	73/62	N/A	N/A	0.896 **
	Non-ROSC	59/47	N/A		
CPR duration (min)	ROSC	134	14.12±11.67	-37.01-(-31.27)	<**0.001 *** **
	Non-ROSC	106	48.26±10.61		
Initial rhythm (Asistoli/VF/VT/PEA)	ROSC	91/8/3/21	N/A	N/A	**0.003 ** **
	Non-ROSC	95/0/0/10	N/A		
CI: Confidence interval, CPR: Cardiopulmonary resuscitation, N/A: Non-applicable, PEA: Pulseless electrical activity, ROSC: Return of spontaneous circulation, SD: Standard deviation,VF: Ventricular fibrillation, VT: Ventricular tachycardia, * Student's t-test ** Chi-Square test ***Mann-Whitney U test	CI: Confidence interval, CPR: Cardiopulmonary resuscitation, N/A: Non-applicable, PEA: Pulseless electrical activity, ROSC: Return of spontaneous circulation, SD: Standard deviation,VF: Ventricular fibrillation, VT: Ventricular tachycardia, * Student's t-test ** Chi-Square test ***Mann-Whitney U test	CI: Confidence interval, CPR: Cardiopulmonary resuscitation, N/A: Non-applicable, PEA: Pulseless electrical activity, ROSC: Return of spontaneous circulation, SD: Standard deviation,VF: Ventricular fibrillation, VT: Ventricular tachycardia, * Student's t-test ** Chi-Square test ***Mann-Whitney U test	CI: Confidence interval, CPR: Cardiopulmonary resuscitation, N/A: Non-applicable, PEA: Pulseless electrical activity, ROSC: Return of spontaneous circulation, SD: Standard deviation,VF: Ventricular fibrillation, VT: Ventricular tachycardia, * Student's t-test ** Chi-Square test ***Mann-Whitney U test	CI: Confidence interval, CPR: Cardiopulmonary resuscitation, N/A: Non-applicable, PEA: Pulseless electrical activity, ROSC: Return of spontaneous circulation, SD: Standard deviation,VF: Ventricular fibrillation, VT: Ventricular tachycardia, * Student's t-test ** Chi-Square test ***Mann-Whitney U test	CI: Confidence interval, CPR: Cardiopulmonary resuscitation, N/A: Non-applicable, PEA: Pulseless electrical activity, ROSC: Return of spontaneous circulation, SD: Standard deviation,VF: Ventricular fibrillation, VT: Ventricular tachycardia, * Student's t-test ** Chi-Square test ***Mann-Whitney U test

Table II. Comparison of ROSC group and Non-ROSC group. Parameter	**Table II. Comparison of ROSC group and Non-ROSC group. Groups**	**Table II. Comparison of ROSC group and Non-ROSC group. Mean ± SD**	**Table II. Comparison of ROSC group and Non-ROSC group. 95% CI**	**Table II. Comparison of ROSC group and Non-ROSC group. p**
White blood cell count (10^9 cells mL-1)	ROSC	13.96±8.22	-3.11-1.57	0.379 ***
	Non-ROSC	14.74±9.64		
Hematocrit (%)	ROSC	37.75±7.47	-2.13-2.35	0.931 *
	Non-ROSC	37.65±9.74		
Hemoglobin (g dL-1)	ROSC	12.02±2.65	-0.83-0.72	0.891 *
	Non-ROSC	12.08±3.26		
Glucose (mg dL-1),	ROSC	202.15±96.52	-35.15-32.94	0.075 ***
	Non-ROSC	203.25±159.66		
Urea (mg dL-1)	ROSC	88.6±65.08	-57.35-(-17.09)	<0.001 ***
	Non-ROSC	125.91±88.71		
Creatinine (mg dL-1)	ROSC	1.87±1.32	-0.99-(-0.19)	0.001 ***
	Non-ROSC	2.47±1.73		
Sodium (mmol L-1)	ROSC	138.64±7.45	-2.95-1.37	0.727 ***
	Non-ROSC	139.44±9.05		
Potassium (mmol L-1)	ROSC	4.69±1.29	-0.79-(-0.09)	0.014 *
	Non-ROSC	5.13±1.33		
pH	ROSC	7.16±0.18	-0.05-0.06	0.869 *
	Non-ROSC	7.16±0.23		
tCO2 (mmol L-1)	ROSC	38.66±13.70	-1.99-5.61	0.351 *
	Non-ROSC	36.86±15.31		
PCO2 (%)	ROSC	50.31±20.73	-3.89-7.40	0.306 ***
	Non-ROSC	48.56±22.06		
Lactate (mmol L-1)	ROSC	8.00±5.80	-2.39-0.87	0.524 ***
	Non-ROSC	8.77±6.73		
HCO3 (mmol L-1)	ROSC	17.45±6.32	-1.33-2.14	0.481 ***
	Non-ROSC	17.05±6.86		
COHb (%)	ROSC	0.95±0.76	0.07-0.42	0.002 ***
	Non-ROSC	0.71±0.57		
MetHb (%)	ROSC	1.60±0.97	-0.21-0.28	0.769 *
	Non-ROSC	1.57±0.89		
INR	ROSC	1.63±1.19	-0.23-0.36	0.465 ***
	Non-ROSC	1.57±0.88		
Prothrombin time (seconds)	ROSC	19.11±14.27	-2.22-4.59	0.467 ***
	Non-ROSC	17.93±9.35		

Troponin (pg ml-1)	ROSC	578.69±1770.28	-1012.29-227.59	0.005 ***
	No ROSC	971.05±2674.55		
CK (U L-1)	ROSC	254.83±435.26	-269.69-50.46	0.071 ***
	Non-ROSC	364.45±508.10		
CK-MB (ng mL-1)	ROSC	9.55±15.39	-12.58-1.90	0.150 ***
	Non-ROSC	14.89±34.01		
LDH(U L-1)	ROSC	708.43±2058.14	-805.63-(-339.86)	0.004 ***
	Non-ROSC	941.32±1829.76		
aPTT (seconds)	ROSC	32.76±9.61	-3.54-3.97	0.426 ***
	Non-ROSC	32.54±11.94		
proBNP (pg mL-1)	ROSC	7419.37±12595.36	-5595.97-4071.09	0.397 ***
	Non-ROSC	8181.80±10068.79		
D-dimer (mg L-1)	ROSC	11.09±13.15	-23.67-1.83	0.138 ***
	Non-ROSC	22.01±25.35		
CI: Confidence interval, INR: International normalized ratio, ROSC: Return of spontaneous circulation, SD: Standard deviation * Student's t-test ** Chi-Square test ***Mann-Whitney U test	CI: Confidence interval, INR: International normalized ratio, ROSC: Return of spontaneous circulation, SD: Standard deviation * Student's t-test ** Chi-Square test ***Mann-Whitney U test	CI: Confidence interval, INR: International normalized ratio, ROSC: Return of spontaneous circulation, SD: Standard deviation * Student's t-test ** Chi-Square test ***Mann-Whitney U test	CI: Confidence interval, INR: International normalized ratio, ROSC: Return of spontaneous circulation, SD: Standard deviation * Student's t-test ** Chi-Square test ***Mann-Whitney U test	CI: Confidence interval, INR: International normalized ratio, ROSC: Return of spontaneous circulation, SD: Standard deviation * Student's t-test ** Chi-Square test ***Mann-Whitney U test

Table III. Demographics of the sub-groups Parameter	**Table III. Demographics of the sub-groups Groups**	**Table III. Demographics of the sub-groups n**	**Table III. Demographics of the sub-groups Mean±SD**	**Table III. Demographics of the sub-groups 95% CI**	**Table III. Demographics of the sub-groups p**
Age	Non-survivor	64	71,98±11.95	4.45-20.80	**0.025 *****
	Survivor	14	59.36±20.96		
Gender (Erkek/Kadın)	Non-survivor	34/30	N/A	N/A	**0.486 ****
	Survivor	6/8	N/A		
CPR duration (min)	Non-survivor	64	17,17±14.65	3.02-18.76	**0.000 *****
	Survivor	14	6.29±2.84		
Initial rhythm (Asistoli/VF/VT/PEA)	Non-survivor	45/1/1/7	N/A	N/A	**0.000 ****

	Survivor	5/6/0/2	N/A		
CI: Confidence interval, CPR: Cardiopulmonary resuscitation, N/A: Non-applicable, PEA: Pulseless electrical activity, ROSC: Return of spontaneous circulation, SD: Standard deviation, VF: Ventricular fibrillation, VT: Ventricular tachycardia, * Student's t-test ** Chi-Square test ***Mann-Whitney U test	CI: Confidence interval, CPR: Cardiopulmonary resuscitation, N/A: Non-applicable, PEA: Pulseless electrical activity, ROSC: Return of spontaneous circulation, SD: Standard deviation, VF: Ventricular fibrillation, VT: Ventricular tachycardia, * Student's t-test ** Chi-Square test ***Mann-Whitney U test	CI: Confidence interval, CPR: Cardiopulmonary resuscitation, N/A: Non-applicable, PEA: Pulseless electrical activity, ROSC: Return of spontaneous circulation, SD: Standard deviation, VF: Ventricular fibrillation, VT: Ventricular tachycardia, * Student's t-test ** Chi-Square test ***Mann-Whitney U test	CI: Confidence interval, CPR: Cardiopulmonary resuscitation, N/A: Non-applicable, PEA: Pulseless electrical activity, ROSC: Return of spontaneous circulation, SD: Standard deviation, VF: Ventricular fibrillation, VT: Ventricular tachycardia, * Student's t-test ** Chi-Square test ***Mann-Whitney U test	CI: Confidence interval, CPR: Cardiopulmonary resuscitation, N/A: Non-applicable, PEA: Pulseless electrical activity, ROSC: Return of spontaneous circulation, SD: Standard deviation, VF: Ventricular fibrillation, VT: Ventricular tachycardia, * Student's t-test ** Chi-Square test ***Mann-Whitney U test	CI: Confidence interval, CPR: Cardiopulmonary resuscitation, N/A: Non-applicable, PEA: Pulseless electrical activity, ROSC: Return of spontaneous circulation, SD: Standard deviation, VF: Ventricular fibrillation, VT: Ventricular tachycardia, * Student's t-test ** Chi-Square test ***Mann-Whitney U test

Table IV. Comparison of the non-survivor group and survivor group. Parameter	**Table IV. Comparison of the non-survivor group and survivor group. Groups**	**Table IV. Comparison of the non-survivor group and survivor group. Mean ± SD**	**Table IV. Comparison of the non-survivor group and survivor group. 95% CI**	**Table IV. Comparison of the non-survivor group and survivor group. p**
White blood cell count (10^9 cells mL-1)	Non-survivor	15.10±9.95	-4.24-7.34	0.847 ***
	Survivor	13.54±6.22		
Hematocrit (%)	Non-survivor	38.00±7.43	-7.95-1.48	0.151 ***
	Survivor	41.23±8.40		
Hemoglobin (g dL-1)	Non-survivor	11.92±2.76	-3.18-0.28	0.097 ***
	Survivor	13.37±2.94		
Glucose (mg dL-1),	Non-survivor	220.77±97.94	-30.52-83.14	0.471 ***
	Survivor	194.46±58.28		
Urea (mg dL-1)	Non-survivor	91.51±58.06	18.07-83.71	0.000 ***
	Survivor	40.62±20.49		
Creatinine (mg dL-1)	Non-survivor	2.08±1.64	0.7-1.91	0.005 ***

	Survivor	1.09±0.49		
Sodium (mmol L-1)	Non-survivor	138.42±6.25	-6.81-0.56	0.051 ***
	Survivor	141.54±4.46		
Potassium (mmol L-1)	Non-survivor	4.93±1.22	0.62-2.03	0.000 ***
	Survivor	3.60±0.68		
pH	Non-survivor	7.15±0.20	-0.19-0.05	0.234 ***
	Survivor	7.22±0.19		
tCO2	Non-survivor	34.64±12.36	-17.86-(-2.39	0.017 ***
	Survivor	44.76±13.15		
PCO2 (%)	Non-survivor	47.12±21.96	-19.80-8.00	0.490 ***
	Survivor	53.02±24.90		
Lactate (mmol L-1)	Non-survivor	9.49±5.90	-2.39-0.87	0.104 ***
	Survivor	7.55±7.71		
HCO3 (mmol L-1)	Non-survivor	15.44±5.62	-1.93-5.80	0.016 ***
	Survivor	20.14±5.84		
COHb	Non-survivor	0.78±0.53	-1.12-(-0.21	0.022 ***
	Survivor	1.45±1.31		
MetHb	Non-survivor	1.60±0.97	-0.52-0.72	0.668 ***
	Survivor	1.50±1.12		
INR	Non-survivor	1.83±1.50	-0.35-1.67	0.012 ***
	Survivor	1.18±0.388		
Prothrombin time (seconds)	Non-survivor	21.98±18.23	-3.65-20.99	0.007 ***
	Survivor	13.31±4.00		
Troponin (pg ml-1)	Non-survivor	685.39±1687.14	-492.93-1649.10	0.008 ***
	Survivor	62.30±115.67		
CK (U L-1)	Non-survivor	241.52±338.84	-247.05-344.08	1.000 ***
	Survivor	193.00±238.78		
CK-MB (ng mL-1)	Non-survivor	9.43±16.03	-12.78-11.24	0.469 ***
	Survivor	10.20±22.29		
LDH(U L-1)	Non-survivor	1072.14±3119.52	-1316.75-2896.14	0.010 ***
	Survivor	282.44±76.02		
aPTT (seconds)	Non-survivor	34.98±11.99	-3.13-17.73	0.102 ***
	Survivor	27.68±7.80		
proBNP (pg mL-1)	Non-survivor	11144.41±17874.26	-16486.91-37011.73	0.060 ***
	Survivor	882.00±876.81		
D-dimer (mg L-1)	Non-survivor	12.54±14.59	-13.80-27.05	0.732 ***
	Survivor	5.92±4.47		

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Figure-1: Flow Chart

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