Factors Related to Resuscitation Success and Prognosis of Cardiopulmonary Arrest Cases

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Abstract

Background: In cases where return of spontaneous circulation (ROSC) is provided in the Emergency Department (ED) after cardiopulmonary arrest (CA), it is important to investigate the parameters affecting ROSC rates, to determine the factors affecting the survival status and prognosis in the short and medium term, and to determine to what extent these factors affect the prognosis.

Materials and methods: This is a cross-sectional study that retrospectively investigates the factors affecting the success of resuscitation over a 5-year period in out-of-hospital cardiac arrest (OHCA) cases.

Results: We determined that ROSC was achieved in 26.1% of 1616 adult cardiopulmonary arrest cases, 14.8% survived the first 24 hours, and 3.8% were discharged from the hospital.

Conclusion: We determined that ROSC decreased by 21% with a 1-mg increase in the amount of adrenaline used, by 98% with a 1 mmol/L increase in HCO_3 (std) value, by 27% with a 1 mmol/L increase in BE (B) value, and by 15% with a 1 mmol/L increase in lactate value. In terms of short-term survival, we found that a 1 mmol/L increase in lactate value reduced the probability of survival by 12%, and a 1 mEq/L increase in K value decreased the probability by 29%. With regard to the probability of survival in the medium term, we determined that the growth in age by 1 year decreased the probability by 4%, and the increase in K value by 1 mEq/L decreased the probability by 35%.

Keywords: Clinical outcomes, Cardiopulmonary arrest, Prognosis, Resuscitation.

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Highlights

To predict the success of ED, resuscitation, and the short- and medium-term prognosis of the cases, the amount of adrenaline used in resuscitation, HCO_3, BE, potassium, lactate, age, and some other parameters of the case can be evaluated. Evaluation of these parameters together will be very beneficial for the physician to determine the treatment strategy and to inform the patient's relatives.

Introduction

There are approximately 800 trillion living cells in the human body. For the functions of the body, these cells need to carry out their life-sustaining duties, repair themselves, and export waste products. It is the task of the circulatory system to provide the oxygen and nutrients required by the cells to generate the energy they will use in these processes and to export and remove the waste products formed.[1,2] Sudden and unexpected cessation of adequate blood circulation that disrupts this vital cycle is called cardiopulmonary arrest (CPA). Cardiopulmonary arrest, which manifests itself with the disappearance of circulatory signs, has many different causes in its etiology.[2,3] Resuscitation literally means revitalization. Throughout history, people have attempted some behaviors that resemble a kind of resuscitation interfering with the CPA situation. About 3500 years ago, the Egyptians used the inversion method for resuscitation. In the 1500s, hot air was blown to the face of the person for resuscitation, and this practice continued for about 300 years. Although the origin of resuscitation in this sense is much older, closed-chest cardiac massage was defined for the first time in 1960 in the modern sense.[2,4,5] The main purpose of CPR is to

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maintain blood circulation until ROSC is achieved and to ensure effective perfusion, especially in the central nervous system.[6–8] As reported in the American Heart Association (AHA) Heart Disease and Stroke Statistics 2020 Update, more than 347,000 adults and 7,000 children with out-of-hospital cardiac arrest (OHCA) have been served in the United States. Intrahospital cardiac arrests (IHCA) are estimated to occur in 9.7 of every 1,000 adult cardiac arrests (approximately 292,000 events per year).[9] In Europe, the annual incidence of OHCA is between 67 and 170 per 100,000 patients.[10] In the data announced by the Centers for Disease Control and Prevention (CDC), it is stated that the social cost of CPA is higher than all other causes of death and it is an important public health problem due to its serious effects on human health and welfare.[11]

The aim of this study is to investigate mortality rates in patients who underwent CPR in ED, to determine the parameters that affect these rates in cases with ROSC, to determine the factors that affect survival and prognosis in the short and medium term, and to determine to what extent these factors affect the prognosis.

MATERIALS AND METHODS

The study is a retrospective cross-sectional study investigating the factors affecting the success of resuscitation in CPA cases.

Study Population

We conducted our study from 01.01.2015 to 31.12.2019 using the ED patient file records of the University of Health Sciences Konya Training and Research Hospital in Konya, Turkey.

We have aimed to reach all OHCA cases that presented to the ED within a 5-year time frame.

Patients with OHCA were included in the study. Patients with missing patient files and no citizenship number, and pediatric and pregnant patients were excluded from the study.

Data Collection

While collecting the study data, we have found ED admissions between 01.01.2015 and 31.12.2019 from patient files and identified those who received the ICD-10 diagnostic code together with I46 and subcodes. Evaluating the exclusion criteria stated in the previous title, we included 1,616 cases that have met the inclusion criteria (Flowchart 1).

Statistical Analysis

We accepted the success of ED resuscitation and the status in the first 24 hours as the short-term outcome and the status at discharge from the hospital as the mid term outcome.

As independent variables: age, gender, reason for coming to the hospital, medical or traumatic reasons, arrival to the hospital with or without an ambulance, where the endotracheal intubation procedure was performed, the waiting time in the emergency department after resuscitation, the amount of adrenaline used, whether amiodarone or lidocaine was used, and blood gas parameters were accepted. As dependent variables, ED resuscitation success (EX, ROSC), status in the first 24 hours (EX, Alive), and how the patient was discharged (EX, Discharge) were accepted.

In descriptive analyses, we presented frequency data as percentages and numbers, continuous numerical data as arithmetic mean ± standard deviation, and ordinal variables using median (1st quartile and 3rd quartile) values. We used Chi-square (χ^2) test to compare categorical data, Mann–Whitney U test and Student's t-test to compare two groups with ordinal data. We used logistic regression analysis to show the effects of independent variables that we found as statistically significant, on the dependent variables.

We used IBM SPSS 23.0 (IBM SPSS Statistics, Version 23.0/Armonk, NY: IBM Corp.) to analyze the data and accepted the statistical significance level for all tests as $p < 0.05$.

RESULTS

Sociodemographic and General Characteristics

The mean age of the cases was 66 ± 19 years, and while the youngest case was 18 years old, the oldest case was 106 years old. Majority of the patients were in the 18–64 age group. There was a statistically significant difference between being discharged from the hospital or EX status and age in the medium term ($U = 26817.00$; $p < 0.001$) (Table 1).

Among cases who were discharged from the hospital, 75.4% (46) were men and 24.6% (15) were women. In the medium term, 4.5% (46) of men and 2.5% (15) of women were discharged (Table 1). We found a statistically significant difference between being male or female and being EX or discharged in the medium term ($\chi^2 = 4.42$, $p = 0.03$).

There was a statistically significant difference between having medical or traumatic CPA and mid-term outcomes ($\chi^2 = 14.26$, $p < 0.001$). We determined that 8.3% of the patients applied for traumatic reasons and left the hospital alive, and 3.1% of the medical cases were discharged from the hospital (Table 1).

Emergency Service Resuscitation Success, Short-, and Medium-term Outcomes

We found that 73.9% (1,195) of the cases admitted after the CPR application were EX, however, ROSC was achieved in 26.1% (421) of them.

We detected 182 patients who were hospitalized for treatment as EX in the first 24 hours. Considering the short-term results (ED resuscitation success and status in the first 24 hours), 14.8% were alive. When the medium-term results (how the patient was

Flowchart 1: Schematic diagram of methodology
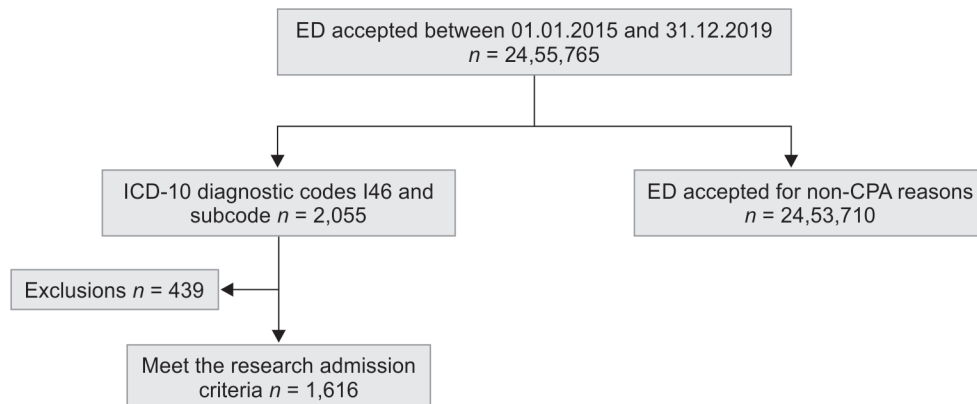
ED, emergency department; ICD, international classification of diseases

Table 1: Socio-demographic and general characteristics of cardiopulmonary arrest cases

| | | n | % | Short-term result | | Medium-term result |
				Emergency department	In the first 24 hours	
Age	18–64	607	37.6			
	65–74	357	22.1			
	75–84	382	23.6			
	≥85	270	16.7	$p = 0.46$*	$p = 0.69$*	$p < 0.001$*
	Total	1,616	100			
	Min	Mean	Max			
	18	66 ± 19	106			
Gender	Men	1,012	62.6			
	Women	604	37.4	$p = 0.66$**	$p = 0.49$**	$p = 0.03$**
	Total	1,616	100			
		1,400	86.6			
Medical–traumatic	Total	216	13.4	$p = 0.65$**	$p = 0.21$**	$p < 0.001$**
		1,616	100			
	Min	Mean	Max			
Waiting time in ED	3 min	196 ± 154 min	1598 min		$p = 0.91$***	$p = 0.17$***
	Mean ± SD			p*	p*	p*
pH	7.08 ± 0.22			<0.001	<0.001	<0.001
$PaCO_2$	53.3 ± 23.6 mm Hg			<0.001	0.26	0.04
HCO_3 (act)	13.8 ± 6.2 mmol/L			<0.001	<0.001	<0.001
HCO_3 (std)	15.6 ± 6.4 mmol/L			<0.001	<0.001	<0.001
BE (B)	−13.1 ± 9.4 mmol/L			<0.001	<0.001	<0.001
BE (ecf)	−9.1 ± 9.8 mmol/L			<0.001	0.71	0.79
Lactate	9.4 ± 9.2 mmol/L			<0.001	<0.001	<0.001
Na	138.7 ± 7.5 mEq/L			0.26	0.08	0.34
Cl	102.9 ± 7.8 mEq/L			0.16	0.41	0.63
K	4.9 ± 1.5 mEq/L			<0.001	<0.001	<0.001
Ca	1.14 ± 0.25 mmol/L			<0.001	<0.001	0.17
Glucose	240 ± 142 mg/dL			0.55	0.03	0.26
Osmolarity	290 ± 15.4 mmol/kg			1.26	0.03	0.12

*Mann–Whitney *U* test; **Chi-square test; ***Student's *t*-test; act, actual; B, blood; ecf, extracellular fluid; ED, emergency department; EX, exitus; min, minute; std, standard; rosc, return of spontaneous circulation; sd, standard deviation

discharged) were examined, it was found that 3.8% of 1,616 cases who presented to ED were alive and discharged from the hospital (Table 1).

Factors Affecting Emergency Service Resuscitation Success, Short-, and Medium-term Prognosis

As a result of statistical tests, the independent variables (summarized in Table 2) that were found to make a significant difference in terms of ROSC in ED or being EX, being alive in the short term or being EX, and being alive or being EX in the medium term were evaluated with logistic regression analysis.

Factors Affecting Success of Emergency Service Resuscitation

When we examined the logistic regression result in terms of the factors affecting the success of ED resuscitation, 1 unit increase in the amount of adrenaline used decreased the probability of ROSC by 21% (CI = 0.74–0.84, $p < 0.001$), 1 unit increase in HCO_3 (std) value increased the probability of ROSC by 98% (CI = 1.29–3.04, $p = 0.002$), 1-unit increase in BE (B) value reduced the probability of ROSC by 27% (CI = 0.55–0.98, $p = 0.04$), and 1-unit increase in lactate value reduced the probability of ROSC by 15% (CI = 0.76–0.95, $p = 0.03$) (Table 3).

Factors Affecting Short-term Prognosis

When we evaluated the significant findings in terms of factors affecting short-term prognosis as a result of the logistic regression analysis (Table 4), we determined that a 1-unit increase in lactate value reduces the probability of survival by 12% (CI = 0.82–0.95, $p < 0.001$), while a 1-unit increase in K value reduces the probability of survival by 29% (CI = 0.59–0.86, $p < 0.001$).

Table 2: Factors affecting resuscitation success, short-term, and medium-term prognosis

	Affecting factors	
Short-term result	Emergency department resuscitation success	Coming by ambulance, pH, PaCO$_2$, HCO$_3$ (act), HCO$_3$ (std), BE (B), BE (ecf), lactate, Ca, K, glucose, amount of adrenaline used
	In the first 24 hours	Coming by ambulance, pH, HCO$_3$ (act), HCO$_3$ (std), BE (B), lactate, Ca, K, glucose, osmolarity, amount of adrenaline used
Medium-term result		Age, gender, medical–traumatic status, pH, PaCO$_2$, HCO$_3$ (act), HCO$_3$ (std), BE (B), lactate, K

act, actual; b, blood; ecf, extracellular fluid; std, standard

Table 3: Logistic regression analysis findings of factors affecting emergency service resuscitation success

	B	p	OR	95% CI
Coming by ambulance	−0.44	0.22	0.64	0.32–1.29
Amount of adrenaline used	−0.24	<0.001	0.79	0.74–0.84
pH	−0.15	0.97	0.86	0.0–3331.1
PaCO$_2$	0.05	0.08	1.05	1.01–1.09
HCO$_3$ (std)	0.68	0.002	1.98	1.29–3.04
HCO$_3$ (act)	−0.36	0.08	0.70	0.47–1.04
BE (B)	−0.31	0.04	0.73	0.55–0.98
BE (ecf)	0.08	0.34	1.09	0.92–1.29
Lactate	−0.16	0.003	0.85	0.76–0.95
K	−0.23	0.08	0.80	0.62–1.02
Ca	−0.56	0.62	0.57	0.06–5.14
Glucose	0.00	0.43	1.00	1.0–1.0

act, actual; b, blood; ecf, extracellular fluid; std, standard

Table 4: Findings of logistic regression analysis of factors affecting short-term prognosis

	B	p	OR	95% CI
Coming by ambulance	−0.42	0.06	0.66	0.43–1.01
pH	−1.27	0.56	0.28	0.0–19.25
HCO$_3$ (std)	0.02	0.81	1.02	0.85–1.24
HCO$_3$ (act)	−0.02	0.84	0.98	0.84–1.15
BE (B)	0.05	0.49	1.05	0.92–1.20
Lactate	−0.13	<0.001	0.88	0.82–0.95
K	−0.34	<0.001	0.71	0.59–0.86
Ca	0.01	0.99	1.01	0.26–3.84
Osmolarity	0.00	0.76	1.00	0.98–1.01
Glucose	0.00	0.94	1.00	1.0–1.0

act, actual; b, blood; ecf, extracellular fluid; std, standard

Table 5: Findings of logistic regression analysis of factors affecting medium-term prognosis

	B	p	OR	95% CI
Age	−0.04	<0.001	0.96	0.95–0.98
Gender	0.31	0.39	1.37	0.67–2.80
Medical or Traumatic	0.09	0.84	1.09	0.47–2.53
pH	5.73	0.09	309.40	
PaCO$_2$	0.03	0.24	1.03	0.98–1.08
HCO$_3$ (std)	0.11	0.43	1.11	0.86–1.44
HCO$_3$ (act)	−0.03	0.84	0.97	0.72–1.31
BE (B)	−0.13	0.19	0.88	0.72–1.07
Lactate	−0.10	0.14	0.91	0.80–1.03
K	−0.42	0.01	0.65	0.46–0.92

act, actual; b, blood; ecf, extracellular fluid; std, standard

Factors Affecting Medium-term Prognosis

When we evaluate the significant findings as a result of logistic regression analysis in terms of the factors affecting the medium-term prognosis (Table 5), we found that 1-unit increase in age decreased the probability of survival by 4% (CI = 0.95–0.98, $p < 0.001$), and 1-unit increase in K value decreased the probability of survival by 35% (CI = 0.59–0.86, $p < 0.001$).

DISCUSSION

In the OPALS study, the average was found to be 68[12] in OHCAs and in the NRCPR study, whereas IHCAs were found to be 67.6 in the NRCPR study.[13] In another study conducted in Europe, it was reported that the average age of IHCA cases was 74 years, and the average age of OHCA cases was 73 years, and there was no difference between them (61). In our study, 1616 adult patients evaluated for CPA were in the average age range of 66 ± 19 years. It is understood from the literature that the average age of CPA cases worldwide may differ according to regions.[12–14] Although it is thought that this situation may be caused by the socioeconomic

status, health infrastructure, and average life expectancy of the countries, our study has a similar average age to the literature.[15,16]

There are publications with similar results to our study ($p < 0.001$) that elderly patients survived less after CPR.[15,16] In the medium term, it is thought that the survival of elderly patients is lower because they have comorbid diseases.

While there are publications reporting that gender has no effect on survival, there are also reports of high survival rates in the male gender, which is consistent with our study ($p = 0.03$).[17,18] More studies are needed on the effect of gender on survival. In the literature, it is mentioned that the rates of ROSC are 17–33% in OHCA cases and slightly higher with 40–44% in IHCA cases.[19,20] ROSC recovery rates are generally consistent with our study (26.1% ROSC).[21,22] There are also publications with better findings than our study, which reported 68% of survivors.[23] It was thought that this difference may be related to the etiological cause of CPA, the elderly population, and the care conditions of hospitals. When CPA medium-term data are examined, it is stated that the discharge rates vary in a wide range between 0% and 25%, although they differ regionally.[5,24] In our study, the rate of survivors after discharge

from the hospital was found to be 3.8%, within the range specified in the literature and close to the lower limit.

- In terms of achieving ROSC in ED:
  - We found that a 1-mg increase in the amount of adrenaline used in patients decreased the probability of ROSC by 21% ($p < 0.001$). In the literature, it is stated that the increase in the amount of adrenaline reduces the rate of ROSC.[25] The amount of adrenaline used in prolonged CPR situations increases, therefore, the expectation of success in resuscitation decreases with the prolongation of the CPR period and the increase in the amount of adrenaline used.
  - We determined that 1 mmol/L increase in HCO_3 (std) value increased the probability of ROSC by 98% ($p = 0.002$). This finding shows that the success of resuscitation increases with higher HCO_3 values, which is consistent with the studies in the literature.[26] Although the latest guidelines do not recommend routine bicarbonate administration, the high HCO_3 values of patients with ROSC suggest that there may be changes in this issue in the future.
  - We determined that 1 mmol/L increase in BE (B) value decreased the probability of ROSC by 27% ($p = 0.04$). Since the BE value is indirectly related to the HCO_3 value, this result confirms the relationship obtained with HCO_3.
  - One of our other findings is that 1 mmol/L increase in lactate value reduces the probability of ROSC by 15% ($p = 0.03$). In the literature, a significant difference was found between high lactate levels and providing ROSC, which is consistent with our study.[27] Since lactate is a parameter that indirectly indicates circulatory dysfunction and cellular functions, its high level is a poor prognostic criterion in terms of showing the extent of cellular and tissue damage.[5,28] The relationship between the results we obtained in our study and the success of resuscitation confirms this information.

- In terms of survival in the short term:
  - We found that 1 mmol/L increase in lactate value decreased the probability of survival by 12% ($p < 0.001$). In the literature, similar results were obtained between high lactate levels and short-term survival or being EX status, in line with our study.[29]
  - We determined that 1 mEq/L increase in K value decreased the probability of survival by 29% ($p < 0.001$). Similar to our study, there are publications in the literature reporting that high K values are a predictive parameter for poor prognosis.[30]

- Considering the factors affecting the prognosis in the medium term:
  - In the literature, similar to our study, a similar relationship was found between the state of discharge from the hospital and age, and the survival rates decreased in the medium term as the age of the patients increased.[31,32] The increase in comorbid diseases with age was thought to be an important factor in this.
  - We found that 1 mEq/L increase in K value reduced the probability of survival by 35% ($p = 0.01$). Potassium is the most important intracellular cation and is very important for the membrane potentials of the neuromuscular system, myocardial cells, and other cells. In addition, as a result of cellular damage that will occur with the effect of impaired circulation as a result of CPA, potassium values may be found to be high both as a cause and a result of CPA.[30] K value affects the short- and medium-term prognosis in accordance with the literature.

Studies on the factors affecting the success of resuscitation in ED and the prognosis of CPA patients in the following period are increasing in the literature.[17,25,31–33] Identification and use of these factors will be more needed when multiple cases of CPA in ED come and there is limited opportunity or space for further treatment.

Conclusion

We can summarize the findings that we think may provide benefit in predicting the success of ED resuscitation and short- and medium-term prognosis in adult CPA patients as follows:

- Regarding the probability of achieving ROSC in ED, it was determined that 1 mg increase in the amount of adrenaline used decreases the probability by 21%, 1 mmol/L increase in HCO_3 (std) value increases it by 98%, 1 mmol/L increase in BE (B) value decreased it by 27%, and 1 mmol/L increase in lactate value decreased it by 15%.
  - In terms of short-term survival probability, it was determined that 1 mmol/L increase in lactate value decreased it by 12% and 1 mEq/L increase in K value decreased it by 29%.
  - In terms of survival in the medium-term probability, it was determined that 1-unit increase in age decreased it by 4% and 1 mEq/L increase in K value decreases 35%.

The results are important in terms of showing that the prognosis can be predicted by looking at K, HCO_3, BE, and lactate values, and that treatment strategies for these values can change during resuscitation interventions.

It has been observed that recent studies in the literature are more common on the factors affecting the success of resuscitation in ED and the prognosis of CPA patients. Determining these factors will also support efforts to develop scales for prognosis in CPA cases.

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