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Evaluation of Survival Rates and Associated Factors After Cardiopulmonary Resuscitation

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Abstract

Aim: The aim of this study was to determine survival rates in patients who underwent cardiopulmonary resuscitation (CPR) and to evaluate related demographic characteristics, clinical findings, and laboratory results.

Materials and Methods: Data from 620 patients who were transported by ambulance to the emergency department while receiving CPR were retrospectively analysed. Demographic characteristics, clinical findings, laboratory values, and time variables were recorded. Factors associated with survival were evaluated using the chi-square test, independent samples t-test, correlation analysis, and logistic regression analysis.

Results: The median age of the 620 patients included in the study was 67 years (IQR: 54-79), and 64.52% (n=400) were male. 95.32% (n=591) of the calls received by the emergency call centre originated from the region. 98.55% of patients (n=611) lived in urban areas. The one-month survival rate after CPR was found to be 12.42%. Successful resuscitation was achieved in 7.90% of these patients (n=49). In multivariate logistic regression analysis, pH ≤6.817 (OR: 37.39, 95% CI: 14.48-96.52, p<0.001), PO_2 (OR: 0.990, 95% CI: 0.984-0.996, p=0.002), platelet count (OR: 0.99, 95% CI: 0.99-1.00, p=0.034), neutrophil-to-lymphocyte ratio (OR: 0.83, 95% CI: 0.72-0.94, p=0.004), basophil count (OR: 0.18, 95% CI: 0.06-0.55, p=0.002), and MCHC (OR: 1.01, 95% CI: 1.01-1.01, p<0.001) were identified as significant independent predictors of mortality. The combined model incorporating pH and PO_2 demonstrated excellent discriminative ability with an AUC of 0.923 (95% CI: 0.875-0.971), sensitivity of 97.8%, and specificity of 83.1% at a cut-off probability of 0.700.

Conclusion: This study demonstrated that arterial blood gas findings (particularly pH ≥6.817 and PO_2 ≤45.5 mmHg) and certain hematological markers (platelet, neutrophil-to-lymphocyte ratio, basophil) have high diagnostic value in predicting mortality after cardiac arrest.

Keywords: Cardiopulmonary resuscitation, survival, platelet/lymphocyte ratio, neutrophil/lymphocyte ratio, predictive factors

Introduction

Cardiac arrest is defined as the cessation of systemic circulation following the termination of the heart's mechanical activity (1). Cardiopulmonary resuscitation (CPR) is a vital intervention in cardiac arrest and increases the likelihood of survival when performed successfully (2). However, post-CPR survival rates vary worldwide and are often below the desired level (3).

The literature reports survival rates of 8% after out-of-hospital cardiac arrest in European countries, while this rate reaches 10-12% in the United States. A study conducted in the United States in the case of in-hospital cardiac arrests found that the survival rate was approximately 25% (4,5). Recent literature reports that these rates have improved over the years (6,7). A study conducted in Türkiye found that the survival rate after out-of-hospital cardiac arrest was 6.9% (8).

Identifying the factors that influence survival rates is crucial for improving the effectiveness of CPR, various factors that may affect survival after cardiac arrest have been identified. These include age, the location and time of cardiac arrest, the occurrence of ventricular fibrillation, and ventricular tachycardia defined as shockable rhythms, diagnosis of cardiac arrest, the time to initiation of basic life support, and the time to defibrillation (9,10).

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Recently, the effect of hematological parameters and inflammatory markers on prognosis after cardiac arrest has also been investigated (11-13). Hematological parameters such as the neutrophil-to-lymphocyte ratio (NLR) and platelet-lymphocyte ratio (PLR), which are indicators of the systemic inflammatory response, have been reported to have prognostic value in various cardiovascular diseases (14,15). These parameters are gaining importance in clinical practice as low-cost, easily accessible biomarkers that can be calculated from routine laboratory tests.

The pathophysiological process following cardiac arrest is complex and involves many components, including ischemia-reperfusion injury, systemic inflammatory response syndrome, multiple organ failure, and permanent neurological damage (16,17). In this process, changes in hematological parameters can reveal both the severity of the damage and the body's potential for self-repair. In particular, changes in the activities of leukocyte subpopulations can provide valuable information about the severity of the systemic inflammatory response and patient prognosis (18,19).

The aim of this study is to evaluate the survival rates of patients who underwent CPR at the scene and the related demographic, clinical, and laboratory factors. The findings obtained may contribute to the identification of practical and effective biomarkers that can be used in early prognostic assessment after CPR.

Materials and Methods

This retrospective cohort study included 620 patients who underwent CPR between January 2020 and December 2022. The study was conducted with the approval of the İstanbul Medipol University Non-Interventional Clinical Research Ethics Committee (desicion number: E-10840098-772.02-3157, date: 01.07.2021).

Demographic characteristics (age, gender), clinical findings (level of consciousness, respiratory status, pulse rate), laboratory values, and time variables (command response time, station response time, transport time, intervention time, time to hospital arrival) were recorded.

Level of consciousness was assessed in three categories: conscious, confused, and unresponsive. Respiratory status was analysed in seven categories: normal, rapid, superficial, irregular, shortness of breath, none. Pulse status was assessed in four categories: normal, arrhythmic, thready and no pulse.

Laboratory values were assessed using venous and arterial blood samples taken upon patient admission. Parameters: white blood cell (WBC, $10^3/\mu L$), red blood cell (RBC, $10_2/\mu L$), hemoglobin (HGB, g/dL), hematocrit (HCT, %), platelet (PLT, $10^3/\mu L$), neutrophil (NEUT, $10^3/\mu L$), lymphocyte (LYMPH, $10^3/\mu L$), monocyte (MONO, $10^3/\mu L$), eosinophil (EO, $10^3/\mu L$), basophil (BAS, $10^3/\mu L$), creatinine (mg/dL), aspartate aminotransferase (AST, U/L), alanine aminotransferase (ALT, U/L), C-reactive protein (CRP, mg/L), and blood gas values (pH, PO_2 in mmHg, PCO_2 in mmHg) were included. Derived parameters such as the NLR and PLR were also calculated.

Successful CPR is defined as the restoration of spontaneous circulation and the recovery of sustained vital functions in a patient who has experienced cardiac arrest or respiratory arrest.

Long-term success: patients who survived for more than 24 hours were considered successful. Complete success: defined as 30-day survival and good neurological status (20).

Statistical Analysis

SPSS (Statistical Package for the Social Sciences) version 25.0 software was used for data analysis. Continuous variables are expressed as arithmetic distributed data, while categorical variables are expressed as frequency and percentage distributions.

The Shapiro-Wilk test was used to assess the normal distribution of the data. The Student's t-test was used to compare the quantitative data of two groups showing normal distribution. Pearson's chi-square analysis was used to compare frequencies. The relationship between survival and continuous variables was evaluated using Pearson correlation analysis.

Logistic regression analysis was used to determine the factors affecting survival. For the combined predictive model, pH and PO_2 values were first evaluated as continuous variables in Univariate logistic regression. Subsequently, optimal cut-off values for pH (≤6.817) and PO_2 (≤45.5 mmHg) were determined using receiver operating characteristic (ROC) curve analysis with Youden's index (sensitivity + specificity - 1) to maximize both sensitivity and specificity. These dichotomized variables, along with other significant hematological parameters, were then entered into a multivariate logistic regression model using the enter method. The predicted probabilities from the final model were used to construct a ROC curve, and the optimal cut-off probability (0.700) for mortality prediction was determined using Youden's index. The level of statistical significance was set at $p<0.05$.

Table 1. Demographic characteristics of patients	
Gender, n (%)	
Female	220 (35.48)
Male	400 (64.52)
Region, n (%)	
Inland	591 (95.32)
External	29 (4.68)
Place of residence, n (%)	
Urban	611 (98.5)
Rural	9 (1.45)
Age, years, median (min-max)	67 (54-72)

Results

The median age of the 620 patients included in the study was 67 years (IQR: 54-79), and 64.52% (n=400) were male. 95.32% (n=591) of the calls received were made from within the region. 98.55% (n=611) of the patients lived in urban areas. Fully successful CPR was achieved in 7.90% (n=49) of these patients (Tables 1, 2).

12.10% of patients (n=75) had respiratory disease, 1.77% (n=11) had trauma due to a fall, 0.65% (n=4) had heart disease, 0.65% (n=4) had oncological disease, and 0.48% (n=3) had internal disease.

pH and PO_2 values were very low in deceased patients ($p<0.001$). PCO_2 values were similar in surviving and deceased patients (p=0.186). WBC, PLT, PLT/LYMPH ratio, BAS, MCV, and PCT were significantly lower in deceased patients (MCV: p=0.003, others: $p<0.001$). HGB, PLT/NEUT ratio, EO, MCH, MCHC, and PDW values were significantly higher in deceased patients (PLT/NEUT: p=0.038, other values: $p<0.001$) (Table 3).

In Univariate logistic regression analysis, the parameters with a significant effect on mortality were pH, pH ≤6.817 group variable, PO_2, and PO_2 ≤45.5 group variable, RBC, HGB, HCT, PLT, NEUT, LYMPH, PLT/LYMPH, NEUT/LYMPH, EO, BAS, MCV, MCH, MCHC, and PDW (Table 3).

In the multivariate logistic regression analysis, the mortality risk was 37.39 times higher in the pH ≤6.817 group (reference group: pH >6.817), [95% confidence interval (CI): 14.48-96.52, p=0.001].

For every 1-unit increase in values, the mortality risk is increased by 1% for PO2, 0.5% for PLT, 17% for NEUT/LYMPH, 82% for BASO, and 1% for MCHC (Table 3).

At a cut-off probability of 0.700 for the combined predictive model (pH + PO_2), the sensitivity of the predicted probabilities was 0.978, specificity was 0.831, positive predictive value was 0.976, and negative predictive value was 0.842 (Table 4).

The mortality prediction model, with an area under the curve (AUC) value of 0.923 (95% CI: 0.875-0.971), demonstrated significantly better performance than the pH and the PO_2 (DeLong test: p=0.017 for both) (Figure 1).

Table 2. Clinical characteristics of patients	
Triage code, n (%)	
Yellow	15 (2.42)
Red	561 (90.48)
Black	44 (7.1)
Level of consciousness, n (%)	
Conscious	32 (5.17)
Confused	13 (2)
Unconscious	575 (92.7)
Pupils, n (%)	
Normal	66 (10.63)
Anisocoric	7 (1.08)
Fixed dilated	219 (35.52)
Isochoric	2 (0.36)
Myotic	18 (2.88)
Mydriatic	21 (3.41)
No response	287 (46.31)
Respiratory, n (%)	
Normal	18 (2.86)
Rapid	1 (0.19)
Superficial	7 (1.14)
Irregular	14 (2.29)
Shortness of breath	14 (2.29)
None	566 (91.24)
Skin, n (%)	
Normal	55 (8.91)
Cyanotic	321 (51.87)
Pale	217 (34.94)
Sweaty	17 (2.67)
Hyperemic	2 (0.36)
Icteric	2 (0.36)
Dry	6 (0.89)
Pulse, n (%)	
Normal	40 (6.53)
Arrhythmic	23 (3.73)
Filamentous	19 (2.99)
Not in use	538 (86.75)

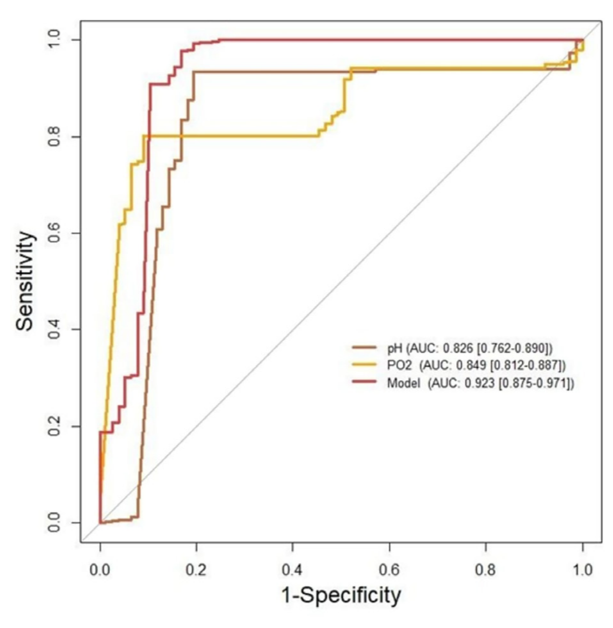

Figure 1. Receiver operating characteristic curves for mortality prediction using pH, PO_2, and the combined model (pH + PO_2)
AUC: Area under the curve

Table 3. Results of logistic regression analysis for mortality prediction using laboratory parameters						
	Univariate logistic regression analysis			Multivariate logistic regression analysis		
	Odds ratios	**95% CI**	**p value**	**Odds ratios**	**95% CI**	**p value**
pH	13.75	4.46-42.36	**<0.001**	-	-	-
pH ≤6.817	58.21	30.16-112.35	**<0.001**	37.39	14.48-96.52	**<0.001**
PCO_2	1.00	1.00-1.00	0.809	-	-	-
PO_2	0.990	0.986-0.993	**<0.001**	0.990	0.984-0.996	**0.002**
PO_2 ≤45.5	40.28	18.01-90.09	**<0.001**	-	-	-
WBC	1.00	0.99-1.00	0.369	-	-	-
RBC	1.64	1.29-2.09	**<0.001**	-	-	-
HGB	1.02	1.01-1.02	**<0.001**	-	-	-
HCT	1.07	1.04-1.10	**<0.001**	-	-	-
PLT	0.98	0.98-0.99	**<0.001**	0.99	0.99-1	**0.034**
NEUT	0.97	0.96-0.98	**<0.001**	-	-	-
LYMPH	1.03	1.02-1.05	**<0.001**	-	-	-
PLT/NEUT	0.96	0.91-1.01	0.116	-	-	-
PLT/LYMPH	0.91	0.89-0.93	**<0.001**	-	-	-
NEUT/LYMPH	0.75	0.70-0.81	**<0.001**	0.83	0.72-0.94	**0.004**
MONO	1.00	0.98-1.03	0.855	-	-	-
EO	1.60	1.28-1.99	**<0.001**	-	-	-
BAS	0.05	0.02-0.13	**<0.001**	0.18	0.06-0.55	**0.002**
MCV	1.05	1.01-1.08	**0.009**	-	-	-
MCH	1.39	1.24-1.56	**<0.001**	1.16	0.97-1.39	0.098
MCHC	1.01	1.00-1.01	**<0.001**	1.01	1.01-1.01	**<0.001**
MPV	1.13	0.88-1.44	0.340	-	-	-
PCT	0.94	0.74-1.20	0.632	-	-	-
PDW	2.39	1.52-3.75	<0.001	1.52	0.96-2.39	0.074

PLT: Platelet, NEUT: Neutrophil, LYMPH:Lymphocyte, WBC: White blood cell, RBC: Red blood cell, HGB: Hemoglobin, HCT: Hematocrit, MONO: Monocyte, EO: Eosinophil, BAS: Basophil, MCV: Mean corpuscular volume, MCH: Mean corpuscular hemoglobin, MCHC: Mean corpuscular hemoglobin concentration, MPV: Mean platelet volume, PCT: Plateletcrit, PDW: Platelet distribution width

Table 4. Diagnostic performance of pH, PO_2, and the combined model (pH + PO_2)			
	Combined model (pH + PO_2)	**pH**	**PO_2**
AUC (95% CI)	0.923 (0.875-0.971)	0.826 (0.762-0.890)	0.849 (0.812-0.887)
Cut-off point	0.700	6.817	45,500
Sensitivity	0.978	0.934	0.801
Specificity	0.831	0.805	0.909
Positive predictive value	0.976	0.971	0.984
Negative predictive value	0.842	0.633	0

AUC: Area under the curve, CI: Confidence interval

Discussion

This study aimed to investigate the effect of sociodemographic, clinical, and laboratory parameters on mortality in patients undergoing CPR during cardiac arrest monitoring. A retrospective analysis of 620 patients revealed the role of arterial blood gas parameters and hematological biomarkers in predicting mortality risk.

A study published in 2024 observed that 67.5% of out-of-hospital cardiac arrest cases were in patients over 65 years of age (21).

The median age of the patients included in the study was 67 years (IQR: 54-79), and 64.5% were male, supporting that cardiac arrest is more common in older individuals and males (22). This finding is consistent with the literature showing that cardiovascular risk factors increase with age and are more prevalent in males.

98.5% of patients lived in urban areas indicates that intervention at the scene was faster. However, our study found no significant difference in positively affecting survival rates after CPR. This indicates that the effectiveness of CPR should not be evaluated based solely on geographical location.

The successful resuscitation rate is only 7.9%, and a study reported in the literature indicates that out-of-hospital cardiac arrest survival rates are 9% in Europe, 6% in North America, 11% in Australia, and 2% in Asia (23). Our findings are consistent with international values.

Recent evidence from the 2024 update of the Utstein Out-of-Hospital Cardiac Arrest Reporting Template provides an important context for interpreting survival rates (24). The updated guidelines emphasise the importance of standardised reporting and risk adjustment for key Utstein factors such as age, gender, location of arrest, and bystander status. When evaluated against these current standards, our observed survival rate reflects the complex interaction of multiple prognostic factors.

A key finding from recent research shows that cardiac arrest survival rates deteriorated significantly during the coronavirus disease 2019 pandemic, with survival rates falling significantly in 2020 and remaining below pre-pandemic levels (25). This temporal context is particularly relevant to our study period (2020-2022) and suggests that the survival rates we observed may reflect both traditional prognostic factors and pandemic-related healthcare system challenges.

Although there were variations between countries, a generally low survival rate was observed. Possible reasons include delayed intervention, failure to recognise cardiac arrest, or serious comorbidities before cardiac arrest. Since 95% of calls were due to medical reasons, with 12% of these being respiratory system diseases, it indicates that acute respiratory decompensation plays a significant role in the development of cardiac arrest.

In our study, analyses of laboratory data revealed that arterial blood gas parameters, particularly pH and PO_2 values, were the strongest predictors of mortality. In Univariate and multivariate logistic regression analyses, the mortality risk was 37.4 times higher in patients with pH ≤6.817. This finding indicates that metabolic acidosis developing after arrest is incompatible with life. von Auenmueller et al. (26) specifically investigated the value of arterial blood gas parameters for predicting mortality in out-of-hospital cardiac arrest survivors, and reported that pH and lactate were the most relevant parameters because they were strongly and independently associated with mortality.

Hypoxaemia was found to be similarly an independent predictor of mortality, with the mortality rate increasing dramatically below PO_2 ≤45.5 mmHg. These findings support the critical role of oxygenation in resuscitation success and the need to integrate early arterial blood gas measurements into clinical decision support systems (27).

Hematological parameters also yielded noteworthy results. PLT counts were significantly higher in survivors, and each unit increase in PLT levels was associated with a 0.5% reduction in mortality risk. This demonstrates that microvascular dysfunction and systemic inflammation following cardiac arrest can be monitored via hematological markers (28).

In particular, the PLT/LYMPH ratio and NEUT/LYMPH ratio provide information about the nature of the inflammatory response. The increase in mortality with a decrease in the NEUT/LYMPH ratio suggests that suppression of the immune response after cardiac arrest may be an indicator of poor prognosis. This finding is consistent with studies showing that immune functions play an important role in the early period after cardiac arrest (29).

The inverse relationship between BAS and mortality, and the significant difference in EO values, are also noteworthy. These findings may reflect the immunomodulatory effects of the granulocyte series and suggest that some hematological parameters may represent the disruption of immune balance after arrest. High erythrocyte indices such as MCH and MCHC likely reflect the compensatory response to hypoxic stress and oxygen-carrying capacity after arrest, and this is consistent with the literature (30).

In our study, the predictive power of the model was also evaluated using ROC analysis. The AUC value of the model including the pH and PO_2 parameters was found to be 0.923 (95% CI: 0.875-0.971). This high AUC value indicates that the model has a strong discriminatory power in predicting mortality.

Specifically, when using a threshold value of 0.700, the sensitivity and specificity of the model were calculated as 97.8% and 83.1%, respectively. This performance may provide significant advantages in clinical practice for early prognosis determination (31).

Study Limitations

The main limitations of this study are its retrospective nature and the absence of certain clinical variables (CPR duration, witness to cardiac arrest).

Conclusion

In conclusion, this study demonstrated that arterial blood gas findings (particularly ≤6.817 and PO_2 ≤45.5 mmHg) and certain hematological markers (PLT, NEUT/LYMPH ratio, BAS) have high diagnostic value in predicting mortality after cardiac arrest. These findings are promising as they can be used in early triage and clinical decision-making processes. Prospective and multicentre studies could strengthen the integration of these parameters into clinical practice.

Ethics

Ethics Committee Approval: The study was conducted with the approval of the İstanbul Medipol University Non-Interventional Clinical Research Ethics Committee (desicion number: E-10840098-772.02-3157, date: 01.07.2021).

Informed Consent: This retrospective study.

Footnotes

Author Contributions

Surgical and Medical Practices: K.A.T., Concept: M.K., Design: M.K., Data Collection or Processing: M.K., Analysis or Interpretation: G.A., Literature Search: A.Y.G., Writing: G.A.

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