

The prognostic value of eosinophil count in emergency department cardiac arrest patients

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Abstract

Aim: Cardiac arrest remains a major cause of mortality despite advances in resuscitation techniques. Identifying early prognostic markers is crucial for optimizing patient management in the emergency department (ED). Eosinophil count, a simple and widely available hematological parameter, has been investigated as a prognostic marker in various critical conditions. However, its role in cardiac arrest patients remains unclear. This study aims to evaluate the prognostic value of eosinophil count in cardiac arrest patients and its association with the return of spontaneous circulation (ROSC).

Methods: This retrospective observational study included 322 patients who experienced cardiac arrest either upon arrival at the ED or during their ED follow-up. Demographic characteristics, complete blood count parameters, and blood gas measurements were recorded. Patients were categorized into ROSC-positive (n=294) and ROSC-negative (n=28) groups. Logistic regression and receiver operating characteristic (ROC) analyses were performed to assess the predictive value of eosinophil count and other parameters.

Results: Patients who did not achieve ROSC had significantly higher eosinophil counts than those who survived (median: 0.025 vs. 0.01, $p=0.045$). Additionally, low bicarbonate, low pH, and high lactate levels were strongly associated with mortality ($p<0.001$). ROC analysis showed that eosinophil count had moderate predictive value, while lactate and bicarbonate demonstrated better discrimination.

Conclusion: Eosinophil count was significantly higher in non-survivors, suggesting a potential association with mortality in cardiac arrest patients. Given its rapid availability, eosinophil count may serve as an additional prognostic marker in the ED. However, further large-scale prospective studies are needed to validate its clinical utility.

Keywords: Eosinophils, complete blood count, cardiac arrest, prognosis, emergency department

Introduction

Cardiac arrest is a life-threatening condition characterized by the sudden cessation of cardiac activity, leading to circulatory failure that cannot be reversed without resuscitative interventions (1). Despite advancements in resuscitation strategies, global survival rates after cardiac arrest remain below 10% (1,2). Due to its high mortality and morbidity, cardiac arrest is recognized as a major public health concern, highlighting the continued need for research and advancements in its management (3). Identifying reliable prognostic indicators that can guide clinical decision-making is crucial for improving patient outcomes. In the literature, a wide range of biomarkers have been explored for their prognostic significance in various critical conditions (4-6). In this context, evaluating the prognostic value of complete blood count (CBC) parameters, which are rapid, accessible, and commonly used in emergency departments (EDs), has gained increasing importance.

Several biomarkers, including C-reactive protein (CRP), procalcitonin, and lactate, have been investigated for their prognostic utility in critically ill patients (7,8). However, many of these markers are not readily available in all healthcare settings and may require longer processing times, limiting their practicality in emergency scenarios. Hematologic parameters, on the other hand, offer a rapid, cost-effective, and widely accessible alternative, making them particularly valuable in ED settings.

Eosinophils, a subgroup of leukocytes, play a crucial role in inflammatory responses, allergic reactions, and parasitic infections. Recent studies have demonstrated that eosinophil levels may also serve as prognostic indicators in critical illnesses such as sepsis, myocardial infarction, and acute respiratory distress syndrome (ARDS) (9, 10). Eosinopenia, defined as a marked reduction in circulating eosinophils, has been associated with severe inflammatory responses, physiological stress, and increased mortality in critically ill patients (11, 12). However, the role of eosinophils in cardiac arrest patients, particularly their association with return of spontaneous circulation (ROSC), remains unclear, with conflicting findings reported in the literature. Given that many established prognostic markers are costly or require extensive processing times, eosinophil count may serve as a simple, rapidly accessible, and clinically useful biomarker in predicting patient outcomes.

Considering these conflicting results, further research is necessary to clarify the potential role of eosinophil levels in predicting ROSC and short-term mortality. In this study, we aimed to evaluate the prognostic significance of eosinophil levels in cardiac arrest patients presenting to the ED. By comparing eosinophil counts between patients who achieved ROSC and those who did not, we examined the impact of this hematologic parameter on clinical outcomes. Additionally, by assessing the relationship between eosinophil levels and traditional metabolic markers such as lactate, pH, and bicarbonate, we aimed to determine

the prognostic utility of integrating hematologic and biochemical markers in cardiac arrest patients.

Materials and Methods

Ethics committee approval was received for this study from the Ankara Etlik City Hospital Research Ethics Committee, with the approval number: 2024-419.

This study was designed as a retrospective observational analysis. We examined patients admitted to the adult emergency department of Ankara Etlik City Hospital due to out-of-hospital cardiac arrest, as well as those who experienced cardiac arrest during their follow-up in the emergency department. Patients meeting the inclusion criteria between October 1, 2022, and April 30, 2024, were analyzed and included in the study.

For each patient, demographic data, mortality status, hospitalization details, hemogram values, and blood gas parameters were recorded. Patients who did not survive in the emergency department were compared with those who achieved return of spontaneous circulation (ROSC) and were subsequently admitted to the intensive care unit. The parameters influencing clinical outcomes were evaluated.

Inclusion Criteria

- Patients ≥ 18 years of age
- Patients admitted to the emergency department due to out-of-hospital cardiac arrest
- Patients who experienced cardiac arrest in the emergency department

Exclusion Criteria

- Patients without a history of cardiac arrest
- Patients under 18 years of age
- Patients with unavailable laboratory blood results
- Patients with traumatic cardiac arrest
- Patients on beta-blocker therapy
- Patients who received prehospital administration of epinephrine
- Patients with a known history of steroid use or immunodeficiency.

A graphical illustration of the study is shown in Figure 1.

Statistical Analysis

Data were analyzed using SPSS V26 software (IBM Inc., Armonk, NY, USA).

The Kolmogorov-Smirnov test assessed normality. Categorical variables were presented as n (%), normally distributed continuous variables as mean $\pm$ SD, and non-normally distributed variables as median (min-max). Group comparisons were made using the independent samples t-test for normally distributed data and the

Mann-Whitney U test for non-normally distributed data. Chi-square or Fisher's exact test was applied to categorical data. Independent risk factors for ROSC were identified via univariate analysis, followed by multivariate logistic regression using a stepwise forward likelihood ratio method. The ROC curve (AUC) and Youden index determined the diagnostic performance and optimal cut-off values for blood parameters. AUC values were classified as: excellent (0.90-1.00), very good (0.80-0.90), good (0.70-0.80), fair (0.60-0.70), poor (0.50-0.60), and random (0.50). The correlation between survival time and blood parameters was analyzed using

Pearson or Spearman correlation, with strength categorized as very weak (0.00-0.10), weak (0.10-0.30), moderate (0.30-0.50), strong (0.50-0.70), very strong (0.70-0.90), and perfect (0.90-1.00). Univariate Cox regression evaluated factors affecting survival, with significant variables included in a multivariate Cox regression model, reported as adjusted hazard ratios (HRs). Patients were classified into two groups based on the median eosinophil count ($0.02 \times 10^3/\mu\text{L}$), and survival differences were analyzed using Kaplan-Meier curves and the log-rank test. A p -value <0.05 was considered statistically significant.

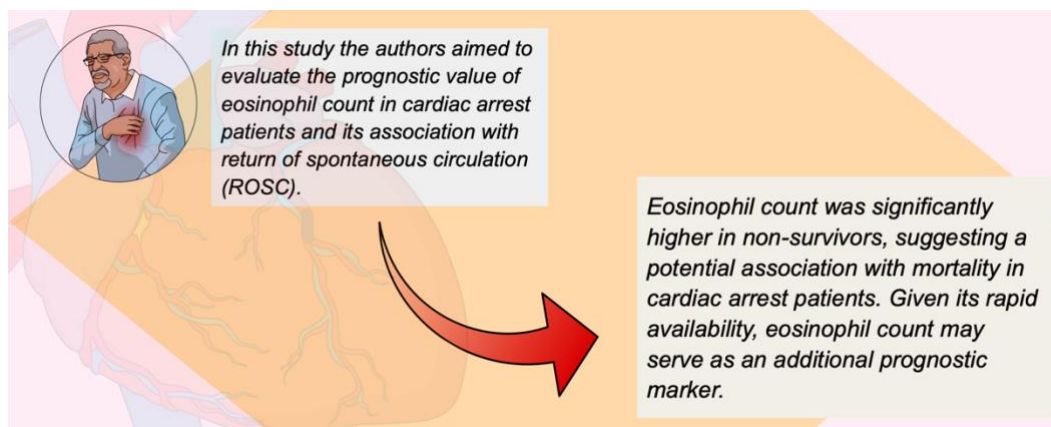


Figure 1. Graphical illustration of the study

Results

A total of 322 patients who experienced cardiac arrest in the emergency department or upon arrival and met the inclusion criteria were included. Baseline characteristics are shown in Table 1. The median age was 73 years, and 54.7% were male. ROSC was achieved in 294 patients, who were subsequently admitted to the ICU, with a median survival of 6 days. ROSC was not achieved in 28 patients.

There was no significant difference in age or gender between patients with and without ROSC. However, patients who achieved ROSC had significantly higher pH and HCO_3^- levels and lower lactate and base deficit values ($p<0.001$). Lymphocyte counts were significantly lower in the ROSC group ($p<0.001$), while WBC, neutrophil, monocyte, and platelet counts showed no significant differences.

The median eosinophil count was 0.01 in ROSC patients and 0.025 in non-ROSC patients, with this difference being statistically significant ($p=0.045$) (Fig. 2).

According to the univariate logistic regression analysis (Table 2), a decrease in eosinophil count increased the likelihood of ROSC by 96% (OR: 0.040, $p=0.015$). Similarly, each unit decrease in lymphocyte count increased ROSC probability by 21% (OR: 0.788, $p<0.001$), while each unit decrease in lactate level increased ROSC probability by 19% (OR: 0.813, $p<0.001$).

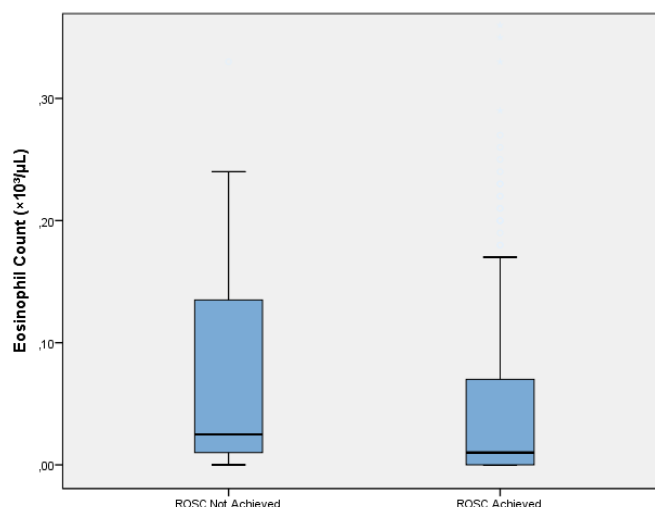


Figure 2. Distribution of Eosinophil count in patients by ROSC status

Conversely, each unit increase in pH level raised ROSC probability 92-fold (OR: 92.234, $p<0.001$), while HCO_3^- and base deficit increases were associated with 17% (OR: 0.961, $p<0.001$) and 12% (OR: 0.959, $p<0.001$) higher ROSC probability, respectively.

Table 1. Comparison of demographic and laboratory parameters

	Total Patients (n=322)	ROSC Not Achieved (n=28)	ROSC Achieved (n=294)	p-value
Age (year)*	73 (20,96)	69 (36, 94)	73 (20,96)	0.732
Male (%)	176 (54.7)	11 (39.3)	165 (56.1)	0.087
Female (%)	146 (45.3)	17 (60.7)	129 (43.9)	
WBC ($\times 10^3/\mu\text{L}$)*	12.97 (0.49, 57.54)	13.49 (3.09, 57.54)	12.84 (0.49, 41.23)	0.451
Eosinophil ($\times 10^3/\mu\text{L}$)*	0.02 (0, 3.87)	0.025 (0, 0.59)	0.01 (0, 3.87)	0.045
Lymphocyte ($\times 10^3/\mu\text{L}$)*	1.14 (0.07, 20.97)	2.66 (0.24, 16.16)	1.06 (0.07, 20.97)	<0.001
Neutrophil ($\times 10^3/\mu\text{L}$)*	10.32 (0.4, 40.66)	10.05 (1.13, 38.32)	10.32 (0.4, 40.66)	0.457
pH*	7.33 (6.60, 7.61)	7.09 (6.60, 7.54)	7.35 (6.69, 7.61)	<0.001
HCO ₃ (mEq/L)**	20.31 $\pm$ 7.50	13.23 $\pm$ 6.45	20.98 $\pm$ 7.25	<0.001
Lactate (mmol/L)*	3.13 (0.34, 19.45)	8.55 (1.6, 19.45)	2.92 (0.34, 17.26)	<0.001
Base excess (mEq/L)*	-4.95 (-34.2, 23)	-15.25 (-34.2, -1)	-4.25 (-30.4, 23)	<0.001

*median (min, max), ** arithmetic mean $\pm$ standard deviation

Statistically significant variables from the univariate analysis, which did not cause multicollinearity, were further evaluated using the stepwise forward likelihood ratio method and included in the multivariate logistic regression analysis. The base deficit variable was excluded due to multicollinearity. In the final model, eosinophil count (OR: 0.023, 95% CI: 0.001-0.462, $p=0.014$), lactate (OR: 1.106, 95% CI: 1.019-1.200, $p=0.016$), and HCO₃ (OR: 0.888, 95% CI: 0.800-0.986, $p=0.026$) were identified as independent predictors of ROSC.

Figure 3 illustrates the ROC curves for eosinophil count, HCO₃, and lactate levels, which were identified as the strongest predictors of ROSC survival in multivariate analysis. The ROC analysis results for these parameters are presented in Table 3.

None of the laboratory parameters alone demonstrated excellent or very good discrimination for ROSC. HCO₃ (AUC: 0.787, 95% CI: 0.709-0.865) and lactate (AUC: 0.783, 95% CI: 0.696-0.871) exhibited good predictive value, while eosinophil count (AUC: 0.616, 95% CI: 0.507-0.726) showed moderate predictive value. According to ROC analysis, lactate had the highest sensitivity (82%), whereas eosinophil count had the highest specificity (94%). The combined model incorporating lactate, eosinophil count, and HCO₃ demonstrated very good discrimination, achieving the highest AUC value (AUC: 0.841, 95% CI: 0.778-0.903).

Figure 4 presents the Kaplan-Meier survival curves comparing patients with eosinophil counts <0.02 and >0.02. The results of this analysis are summarized in Table 4. The median survival time for patients with eosinophil count >0.02 was 8 days, whereas for those with eosinophil count <0.02, it was 3 days. The log-rank test demonstrated a statistically significant difference in survival time between the two groups ($p = 0.041$).

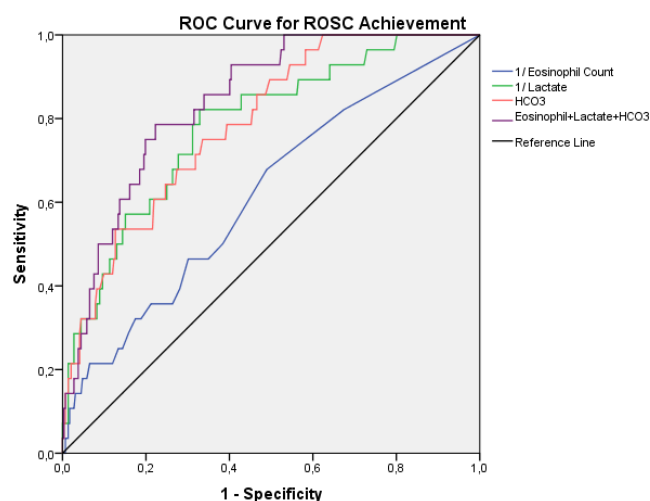
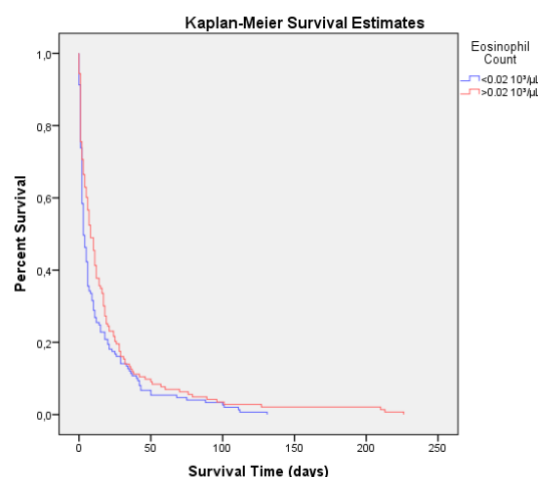
**Figure 3.** ROC curve for predicting ROSC based on Eosinophil count, HCO₃, and Lactate**Figure 4.** Kaplan-Meier survival curve based on Eosinophil count

Table 2. Predictive factors for ROSC achievement

	B	SE	p-value	OR	%95 CI	B	SE	p-value	OR	%95 CI
Univariate Logistic Regression Analysis						Multivariate Logistic Regression Analysis				
Lymphocyte ($\times 10^3/\mu\text{L}$)	-0.239	0.066	<0.001	0.788	0.692-0.896					
Eosinophil ($\times 10^3/\mu\text{L}$)	-3.208	1.322	0.015	0.040	0.003-0.540	-3.588	1.529	0.014	0.023	0.001-0.462
HCO ₃ (mEq/L)	0.157	0.032	<0.001	1.170	1.099-1.246	0.101	0.042	0.016	1.106	1.019-1.200
Lactate (mmol/L)	-0.207	0.039	<0.001	0.813	0.753-0.878	-0.119	0.053	0.026	0.888	0.800-0.986
pH	4.529	0.875	<0.001	92.70 2	16.67-515.57					
Base excess (mEq/L)	0.114	0.022	<0.001	1.120	1.073-1.170					

Table 3. Diagnostic accuracy of Eosinophil count, HCO₃ and Lactate in predicting ROSC

ROSC achievement	AUC	%95 CI	Optimal Cut-off	p-value	Sensitivity	Specificity
Eosinophil	0.616	0.507-0.726	0.22	0.042	0.21	0.94
HCO ₃	0.787	0.709-0.865	18.5	<0.001	0.66	0.75
Lactate	0.783	0.696-0.871	4.43	<0.001	0.82	0.67
Lactate+ eosinophil+ HCO ₃	0.841	0.778-0.903	-	<0.001	-	-

Table 4. Survival time analysis by Eosinophil count

Eosinophil count ($\times 10^3/\mu\text{L}$)	Estimate day (median)	SE	95% CI	p-value
<0.02	3	0.763	1.505-4.495	0.041
>0.02	8	1.359	5.337-10.663	

Discussion

Our study investigated the prognostic value of eosinophil count in patients who were admitted to the emergency department with cardiac arrest or who experienced arrest during emergency department follow-up. The results demonstrated that eosinophil counts were significantly higher in patients with a mortal prognosis. Furthermore, blood gas parameters, including low bicarbonate, acidosis, and elevated lactate levels, were found to be significantly associated with mortality.

Eosinophils are a crucial component of inflammatory responses and are widely recognized as markers in various conditions, including inflammatory diseases, allergic reactions, parasitic infections, and other immune-related disorders (13-17). Brusselle et al. examined the relationship between eosinophilia and asthma, emphasizing the role of IL-5 in eosinophil production and highlighting inconsistencies in the literature regarding its impact on disease severity (18). Similarly, Possa et al. evaluated eosinophilia in allergic

asthma, demonstrating that elevated eosinophil levels were closely associated with allergic lung inflammation, while also stressing the importance of targeted treatments to mitigate eosinophil-driven inflammation (19).

Multiple studies have explored the role of eosinophils in critical illness, with conflicting results. Some research supports eosinopenia as a predictor of poor prognosis, while others suggest no significant association with mortality. The role of eosinophils in critical illnesses such as sepsis and ARDS has been the subject of several investigations. Lin et al., in a meta-analysis assessing the prognostic significance of eosinophil count in sepsis, found that eosinopenia was significantly associated with disease severity and poor prognosis (9). Similarly, Duhailib et al. identified eosinopenia as a biomarker of bacterial sepsis and a poor prognostic indicator in ARDS patients, emphasizing that prolonged eosinopenia in sepsis was correlated with higher mortality rates (11). Supporting this, Davido et al. observed that eosinophil counts tended to increase significantly following appropriate treatment in bacterial

infections, suggesting that eosinophil recovery may reflect disease resolution (20). Masterson et al., in an experimental study on mice, demonstrated that eosinophil-deficient mice developed more severe colitis, reinforcing the immunomodulatory role of eosinophils in maintaining tissue homeostasis (21). In the emergency setting, Rahimi-Rad et al. evaluated eosinophil count as a biomarker in COPD exacerbations, frequently encountered in the ED, and reported that patients with eosinopenia had a more severe disease course with higher mortality, suggesting that eosinophil count could be an important prognostic factor in COPD-related hospitalizations (22). Additionally, Yan et al. found a significant association between eosinopenia and mortality in COVID-19 patients, further demonstrating the potential role of eosinophil count in predicting outcomes in critically ill patients (23). Like all these examples, there are many studies in the literature on the importance of eosinopenia seen in infectious processes.

Despite the growing body of evidence supporting the role of eosinopenia in predicting disease severity and mortality, some studies have reported conflicting results. Valdivia et al. found no significant association between eosinophil counts at ICU admission and mortality, suggesting that eosinophil count alone may not be a reliable predictor in all critical conditions (24). Similarly, Georgakopoulou et al. examined hematologic abnormalities in COVID-19 patients and reported that while eosinopenia was not directly linked to mortality, it was correlated with worse clinical outcomes (25). Borgne et al. also found that eosinophil count was associated with infection severity but not directly with mortality, raising questions about its utility as a standalone prognostic marker (26). In a study involving 1,158 COPD patients, Lan et al. reported that eosinophil levels were not predictive of mortality, further contributing to the variability in findings across different patient populations (27). While these studies indicate that eosinopenia is commonly observed in severe infections and inflammatory conditions, its direct impact on mortality remains controversial. Furthermore, the number of studies evaluating eosinophil count in cardiac arrest patients is extremely limited, underscoring the need for further research in this specific patient population.

Korkmaz et al. and Işık et al. investigated the relationship between eosinopenia and mortality in cardiac arrest patients and reported a statistically significant association (15, 28). In our study, we evaluated patients who experienced cardiac arrest in the emergency department or were brought in with arrest. We compared patients who achieved ROSC with those who had a mortal outcome and found that eosinophil counts were significantly higher in patients who did not survive.

Unlike previous studies that focused on eosinopenia as an isolated predictor, our study primarily compared the relative eosinophil levels between ROSC and non-ROSC groups. We believe that this fundamental difference in study design may explain why our results appear contradictory. While previous studies primarily

focused on eosinopenia as a standalone prognostic factor, our study assessed eosinophil count in relation to ROSC status, which inherently changes the interpretation of its prognostic value. This methodological difference likely explains why our results appear contradictory. Additionally, while previous studies often analyzed eosinophil levels over a prolonged period, our study focused on eosinophil measurements at the time of admission, which may capture a different phase of immune response.

It is important to emphasize that our study applied strict exclusion criteria, minimizing potential confounding variables that could influence eosinophil levels. This approach represents a key distinction from previous studies on sepsis, mortality, and respiratory pathologies, which often include a wide range of patients with various confounders. Unlike these studies, we excluded factors such as epinephrine administration—one of the fundamental treatments for cardiac arrest—allowing for a more precise evaluation of eosinophil count as a prognostic marker. By implementing these stringent criteria, we believe our findings offer a more controlled and reliable assessment, enhancing the study's validity and clinical relevance.

Our findings introduce a novel perspective to the literature, supporting the potential utility of hemogram parameters as simple, rapid, and cost-effective prognostic tools in emergency medicine. Just as severe lactate elevation or profound acidosis suggests a low likelihood of ROSC, our study suggests that eosinophil count may serve as an additional prognostic indicator. Furthermore, we confirmed that low bicarbonate, low pH, and high lactate levels were strongly associated with mortality, aligning with previous research (4,29,30).

We prioritized hemogram parameters because hemogram analyzers are widely available, even in smaller healthcare facilities where blood gas analysis may not be accessible. Given the critical importance of rapid decision-making in cardiac arrest, any additional prognostic tool that provides real-time information could be invaluable in guiding resuscitation efforts. While our findings highlight the potential role of eosinophil count in predicting ROSC and mortality, further multicenter prospective studies are necessary to validate these results and clarify their clinical implications.

Limitations

This study has some limitations. Its single-center, retrospective design may limit the generalizability of the results. Additionally, eosinophil levels were only measured at admission, meaning time-dependent variations and their impact on prognosis were not evaluated. Despite applying strict exclusion criteria, biological variability among patients cannot be entirely eliminated. Nevertheless, this study represents one of the few investigations into the prognostic role of eosinophil count in cardiac arrest patients, providing a valuable foundation for future research.

Conclusion

This study investigated the prognostic value of eosinophil count in cardiac arrest patients presenting to the emergency department. Our results demonstrate that higher eosinophil levels were associated with increased mortality, and blood gas parameters such as low bicarbonate, low pH, and high lactate correlated with poor outcomes. Given the widespread availability and rapid processing of hemogram tests, we propose that eosinophil count may serve as a useful prognostic marker in ROSC prediction. However, further large-scale, multicenter studies are needed to confirm these findings. If validated by larger prospective studies, eosinophil count could become a useful, rapid, and accessible biomarker to aid in the early stratification of cardiac arrest patients, allowing for better resource allocation and patient management in emergency settings.

Disclosures

Ethical Approval: Ethics committee approval was received for this study from the Ankara Etlik City Hospital Research Ethics Committee, in accordance with the World Medical Association Declaration of Helsinki, with the approval number: 2024-419.

Peer-review: Externally peer-reviewed.

Author Contributions: Concept - Ö.F.T.; Design - Ö.F.T.; Supervision - Ö.F.T.; Materials - Ö.F.T., Ş.G.; Data collection &/or processing - Ş.G.; Analysis and/or interpretation - Ö.F.T., Ş.G.; Literature search - Ö.F.T.; Writing - Ö.F.T.; Critical review - Ö.F.T., Ş.G.

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