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Research Article

Prediction of Mortality Using Hematological and Biochemical Markers in Pneumonia Patients Followed in the Intensive Care Unit: A Retrospective Observational Study

Hacer Ozlem Kalayci[1], Emine Serap Yilmaz[2], Ahmet Burak Gurpinar[3]

[1]Ordu University, Faculty of Medicine, Department of Medical Microbiology, Ordu, Türkiye
[2]Ordu University, Faculty of Medicine, Department of Pulmonary Medicine, Ordu, Türkiye
[3]Tokat Gaziosmanpaşa University, Faculty of Medicine, Department of Medical Biochemistry, Tokat, Türkiye

Abstract

Aim: Pneumonia remains a leading cause of mortality among patients admitted to intensive care units (ICUs). The use of hematological and biochemical markers has gained increasing importance in enhancing the accuracy of diagnosis and prognosis. Biomarkers such as the neutrophil-to-lymphocyte ratio (NLR), platelet-to-lymphocyte ratio (PLR), neutrophil-to-platelet ratio (NPR), and the C-reactive protein/albumin ratio, which are calculated using complete blood count parameters, may aid in assessing the severity of systemic inflammation and predicting mortality. Our study examined how NLR, PLR, NPR, and CRP/Albumin ratios affect mortality in ICU patients hospitalized with pneumonia.

Material and Method: This retrospective observational study was conducted at a single center and involved 163 patients diagnosed with pneumonia and admitted to the ICU between May 1, 2021, and March 31, 2025. Demographic data, mortality status, and laboratory parameters at admission were obtained from the hospital information management system. Based on hematological (hemoglobin, neutrophil, lymphocyte, platelet) and biochemical (CRP, albumin) data, NLR, PLR, NPR, and CRP/Albumin ratios were calculated. Patients were categorized into survivors and non-survivors according to 30-day outcomes, and the relationship between the biomarker levels and mortality was analyzed statistically.

Results: A cohort comprising 163 ICU patients diagnosed with pneumonia underwent evaluation, revealing a 30-day mortality rate of 35% (n=57) within this patient population. No significant differences in age or sex were observed between survivors and non-survivors ($p>0.05$). The CRP levels were significantly lower, while albumin and hemoglobin levels were significantly higher in the survivor group ($p<0.05$). The CRP/albumin ratio was significantly elevated in non-survivors ($p=0.001$). Although no statistically significant differences were found for NLR, PLR, and NPR between the groups, these markers tended to be lower in survivors.

Conclusion: According to the findings of our study, low hemoglobin and albumin levels, as well as high CRP levels and CRP/Albumin ratios, were associated with mortality. NLR, PLR and NPR were found to be high in survivors, although not statistically significant. The CRP/Albumin ratio stands out as a reliable biomarker for predicting mortality, whereas NLR, PLR, and NPR, despite their limited sensitivity, may be used as supportive parameters due to their high specificity.

Keywords: Pneumonia, C-reactive protein, neutrophil, lymphocyte, albumin

INTRODUCTION

Pneumonia, characterized by an acute infection of the pulmonary parenchyma, continues to be the most prevalent cause of infectious mortality globally. When diagnosing pneumonia, both clinical symptoms and laboratory and radiological findings are evaluated with a holistic approach (1). For this reason, the importance of evaluating laboratory parameters and clinical findings together in diagnosis and prognosis has increased.

Recent research has increasingly emphasized the diagnostic and prognostic utility of diverse biochemical markers in individuals afflicted with pneumonia (2). Complete blood count (CBC) is a routine laboratory method used in intensive care units (ICUs), offering a low-cost and accessible means of evaluating blood cells. Hematological parameters, including the neutrophil-to-lymphocyte ratio (NLR), platelet-to-lymphocyte ratio (PLR), and neutrophil-to-platelet ratio (NPR), have

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Corresponding Author: Hacer Ozlem Kalayci, Ordu University, Faculty of Medicine, Department of Medical Microbiology, Ordu, Türkiye
E-mail: ozlemtekeli55@hotmail.com

been extensively demonstrated in numerous studies to function as biomarkers for systemic inflammation and infection across diverse diseases (3). In particular, NLR has been identified as an important prognostic biomarker in diseases such as diabetes mellitus, cardiovascular diseases, respiratory disorders and malignant neoplasms (4). Similarly, PLR has been utilized in assessing the severity of infectious diseases such as pneumonia and is also considered a marker of systemic inflammatory response and vascular thrombosis (5).

C-reactive protein (CRP) is a biomarker that exhibits elevated concentrations in response to inflammatory conditions, particularly infections and autoimmune diseases. Furthermore, in pathologies characterized by chronic inflammation, such as chronic obstructive pulmonary disease, notable increases in classic inflammatory markers, including CRP and erythrocyte sedimentation rate, alongside heightened levels of NLR and PLR, have been documented (6). Conversely, albumin functions as a negative acute-phase reactant, with reduced serum concentrations commonly observed during inflammatory states. Hypoalbuminemia is considered an independent prognostic marker associated with increased mortality in various clinical conditions (7). An elevation in the CRP/Albumin ratio has been shown to be more sensitive in predicting prognosis than an elevation in CRP or albumin levels (8,9).

Given the high mortality associated with severe pneumonia, timely prognostic evaluation is essential for implementing comprehensive and effective treatment strategies. In recent years, various biomarkers have been extensively studied in numerous clinical conditions due to their rapid, accurate, and cost-effective results. This study aims to evaluate the predictive value of NLR, PLR, and NPR along with the CRP/Albumin ratio, in forecasting mortality among patients admitted to the ICU with a diagnosis of pneumonia.

MATERIAL AND METHOD

This single-center retrospective study utilized data from 163 patients (65 females, 98 males) aged over 18 years who were admitted to the ICUs of Ordu University Training and Research Hospital with a diagnosis of pneumonia between May 1, 2021, and March 31, 2025. Data regarding patients' age, sex, length of hospital stay, mortality status, and laboratory results at admission were retrospectively retrieved from the hospital information management system.

For laboratory evaluations, samples were analyzed using a Cobas 8000 c 702 fully automatic biochemistry analyzer (Roche Diagnostics, Mannheim, Germany) for analysis of CRP and albumin levels.

Samples for hematological parameters (Hb, neutrophils, lymphocytes, platelets) were analyzed using the Sysmex XN-1000 fully automatic hematology analyzer (Sysmex Corporation, Kobe, Japan).

Systemic inflammation indices were computed using the following formulas based on admission laboratory parameters: NLR= Absolute neutrophil count / Absolute lymphocyte count, PLR= Absolute platelet count / Absolute lymphocyte count, NPR= Absolute neutrophil count / Absolute platelet count.

Participants were stratified into two cohorts according to their 30-day clinical outcomes: survivors and non-survivors. Comparative analyses were conducted to evaluate differences in NLR, PLR, NPR, CRP, albumin levels, and CRP/albumin ratios between the two mortality groups.

The study protocol received approval from the Clinical Research Ethics Committee of Ordu University (Approval Date: April 11, 2025; Application No: BAEK 128; Decision No: 2025/118).

Statistical Analysis

All statistical evaluations were performed using MedCalc statistical software (version 20.009; Ostend, Belgium). Continuous variables were expressed as mean±standard deviation (SD), as well as median with interquartile ranges (25th–75th percentiles), while categorical variables were summarized as counts and percentages. Group differences for categorical data were assessed using the chi-square test.

Receiver Operating Characteristic (ROC) curve analysis was performed to evaluate and compare the diagnostic performance of measured and calculated laboratory parameters in predicting pneumonia-related mortality. The Youden J index was used to identify optimal cutoff thresholds. Sensitivity, specificity, positive predictive value, negative predictive value, and area under the curve (AUC) were reported. A p-value <0.05 was considered indicative of statistical significance in all tests.

RESULTS

A total of 163 patients were enrolled in the study, comprising 65 females (39.9%) and 98 males (60.1%). Among the patient population analyzed, 57 patients (35.0%) died. Detailed demographic data and laboratory findings for all participants are presented in Table 1.

Table 1. Demographic characteristics and laboratory data of the patients

Variables		Total patients (n=163)
Gender	Female, n (%)	65 (39.9)
	Male, n (%)	98 (60.1)
Age, Median (25p-75p)		77 (65-83)
Mortality	Non-survivor, n (%)	57 (35)
	Survivor, n (%)	106 (65)
NLR, Median (25p-75p)		7.2 (3.9-12.1)
PLR, Median (25p-75p)		203.3 (138-369)
NPR, Median (25p-75p)		0.03 (0.02-0.05)
CRP/Albumin, Median (25p-75p)		28.1 (9.5-56.3)

25p-75p: 25. persentil-75. persentil, SD: standard deviation, NLR: neutrophil-to-lymphocyte ratio, PLR: Platelet-to-lymphocyte ratio, NPR: neutrophil-to-platelet ratio, CRP: C-reactive protein, n: number

There were no statistically significant differences between the survivor and non-survivor groups regarding

sex or age (p=0.448 and p=0.304, respectively). However, CRP levels were significantly lower in the survivor group, whereas albumin and hemoglobin (Hb) levels were notably higher (p=0.028, p<0.001, and p=0.002, respectively). The CRP-to-albumin ratio was also found to be significantly reduced in survivors (p=0.001).

When evaluating hematologic parameters, neutrophil, lymphocyte, and platelet counts did not show statistically significant differences between groups. Nonetheless, survivors tended to have lower neutrophil counts and relatively elevated lymphocyte and platelet levels. Similarly, inflammation-based indices (NLR, PLR, and NPR) did not differ significantly between groups, though lower values were observed among survivors (p=0.095, p=0.791, and p=0.197, respectively) (Table 2).

Table 2. Comparison of gender, age, measured and calculated laboratory parameters according to mortality status

		Groups				P-value
		Non-survivor		Survivor		
		N=57		N=106		
Gender	Female, n (%)	25	43.9	40	37.7	0.448
	Male, n (%)	32	56.1	66	62.3	
Age (years), Median (25p-75p)		77	65.8-88.2	77	65-82	0.304
CRP (mg/L), Median (25p-75p)		136	49.3-213.2	85	26.5-150.6	0.028
Albumin (g/L), Median (25p-75p)		2.7	2.8-3.3	3.5	3.1-4	<0.0001
Hb (g/dL), Mean (SD)		10.5	2.32	11.6	2.08	0.002
Neutrophils (10^3/L), Median (25p-75p)		8.8	5.5-13	7.8	5.1-11.5	0.409
Lymphocytes (10^3/L), Median (25p-75p)		1.07	0.72-1.56	1.17	0.86-1.78	0.122
PLT (10^3/L), Median (25p-75p)		217	138-318	251	197-323	0.075
NLR, Median (25p-75p)		9.56	3.9-14.4	6.85	3.9-10.9	0.095
PLR, Median (25p-75p)		207	139-333	202	138-371	0.791
NPR, Median (25p-75p)		0.04	0.02-0.07	0.03	0.02-0.05	0.197
CRP/Albumin, Median (25p-75p)		42.3	13.9-79.1	22.4	7.8-47.1	0.001

NLR: neutrophil-to-lymphocyte ratio, PLR: platelet-to-lymphocyte ratio, NPR: neutrophil-to-platelet ratio, CRP: C-reactive protein, n: number, Hb: hemoglobin, PLT: platelet

In the ROC curve analysis conducted to assess the predictive value of calculated laboratory markers for pneumonia-related mortality, the optimal threshold for NLR was identified as 12.35, yielding a sensitivity of 37% and specificity of 84%. For PLR, the cutoff was 162.7, with corresponding sensitivity and specificity values of 72% and 39%. The optimal cutoff for NPR was found to be 0.063, with 32% sensitivity and 91% specificity.

Among all variables examined, only hemoglobin and the CRP/albumin ratio demonstrated statistically significant diagnostic accuracy for predicting mortality. The ideal threshold for Hb was <10.6 (AUC=0.646, p=0.002), while that for the CRP/albumin ratio was >50 (AUC=0.660, p=0.001), as shown in Table 3.

Table 3. Diagnostic values of laboratory parameters associated with mortality due to pneumonia

	Cut-off	Sensitivity	Specificity	PPV	NPV	AUC	P-value
Hb (g/dL)	≤10.6	56	70	50.0	74.7	0.646	0.002
CRP/Albumin	>50	47	81	57.4	74.1	0.660	0.001
NLR	>12.35	37	84	55.3	71.2	0.579	0.111
PLR	>162.7	72	39	38.7	71.9	0.513	0.795
NPR	>0.063	32	91	64.3	71.1	0.561	0.224

NLR: neutrophil-to-lymphocyte ratio, PLR: platelet-to-lymphocyte ratio, NPR: neutrophil-to-platelet ratio, CRP: C-reactive protein, Hb: hemoglobin, PLT: platelet, PPV: positive predictive value, NPV: negative predictive value, AUC: area under the curve

DISCUSSION

Pneumonia is defined as an acute infectious process of the pulmonary parenchyma and is considered one of the leading causes of morbidity and mortality worldwide, being the most common infectious cause of death globally (10).

ICUs are hospital departments where critically ill patients are monitored and treated, often with high mortality rates. Among the critical factors influencing prognosis within this patient cohort, age stands out, with advanced age having consistently demonstrated a significant association with elevated mortality rates (11). Indeed, Kocaoğlu and Alatlı reported that the mean age of non-survivors was

statistically significantly elevated in comparison to that of survivors (12). Despite optimal treatment strategies, 30-day mortality in pneumonia has been reported to range between 10% and 12% (13). However, the mortality rate observed in our current study (34.9%) was significantly higher than that reported in the literature. This finding may be attributed to the fact that our study sample consisted mostly of elderly individuals.

Combining clinical findings with scoring systems offers important indicators for identifying pneumonia patients at risk. The use of such prognostic markers is increasingly favored both to predict disease progression and to guide timely and appropriate antibiotic therapy (14,15). With the increasing number of critically ill patients and consequently higher mortality rates, early identification of high-risk cases has become imperative, highlighting the growing need for alternative biomarkers.

As components of standard laboratory panels, neutrophil and lymphocyte counts provide valuable insight into inflammatory status (16). Inflammatory conditions often result in increased platelet activation and fragmentation, leading to elevated platelet counts (17).

NLR is a practical and effective biomarker that reflects systemic inflammation (18). Huang et al. reported that NLR serves as a reliable prognostic parameter in septic patients, with higher NLR levels correlating with worse outcomes (19). Consistent with these findings, our study also demonstrated elevated NLR levels in the non-survivor group. Infections trigger cytokine release, which subsequently stimulates bone marrow activity and promotes platelet production, thereby leading to increased PLR values (17,20). Both PLR and NPR have been reported to play important roles in predicting prognosis across various conditions, including community-acquired pneumonia, malignancies, and myocardial infarction (21,22). Supporting this, Kumar et al. and Altaş & Kızılkaya identified NLR and PLR as significant predictors of mortality, while Wang et al. emphasized NLR alone as a reliable prognostic indicator (17,23,24). Conversely, Çiğri et al. observed a significant association between NLR and pneumonia severity but reported no corresponding changes in PLR (25). Similarly, Kocaoğlu & Alatlı and Bıyıklı et al. concluded that PLR is not a sufficiently robust prognostic marker in ICU populations (12,26). In line with these observations, our study also found no statistically significant difference in PLR levels, although survivors exhibited comparatively lower values. NPR has likewise been associated with mortality in multiple studies (27,28). Consistent with the findings of Doğancı et al., we observed elevated NPR levels in the non-survivor cohort (29).

Anemia is a common condition among ICU patients. Various randomized trials have associated low Hb values with poorer life quality outcomes (30). Similarly, our study found a significant relationship between low Hb levels and mortality, indicating that Hb should be considered a key prognostic parameter in ICU settings.

Elevated CRP concentrations are indicative of an unfavorable prognosis across a multitude of clinical conditions, encompassing, but not limited to, coronary artery disease, ischemic stroke, sepsis, and diverse malignant neoplasms (31). Among patients in critical care, albumin levels demonstrate an inverse relationship with mortality risk. When CRP's role in acute inflammation is taken into account alongside albumin's predictive value, their ratio may offer enhanced diagnostic sensitivity and specificity. Consistent with the literature, our study found that patients who died had lower albumin levels and higher CRP and CRP/albumin ratios (31). Several studies also support the prognostic value of this ratio (32,33). However, Hoşgün et al. found that this ratio was not a significant prognostic value in pneumonia-related mortality (34). The CRP/Albumin ratio is considered a stronger prognostic marker than any single parameter alone.

Evaluations of NLR cut-off values suggest that this index may possess prognostic utility in clinical practice. Altaş and Kızılkaya reported a threshold of 11.3, which yielded 81.3% sensitivity and 77.1% specificity (17). Similarly, Zhang et al. identified an optimal cut-off of 5.92 with prognostic relevance (35). In contrast, our study demonstrated that an NLR cut-off of 12.35 achieved 37% sensitivity and 84% specificity. Taken together, these results indicate that although elevated NLR values carry prognostic significance, the index alone may not be sufficiently robust as a screening tool.

Kumar et al. reported a PLR cut-off value of 235, yielding 63% sensitivity and 74% specificity in predicting mortality (23). Similarly, Altaş and Kızılkaya identified a cut-off of 227, with 67.2% sensitivity and 62.5% specificity (17). In our study, a lower PLR cut-off of 162.7 achieved 72% sensitivity but only 39% specificity. These findings indicate that although PLR demonstrates relatively high sensitivity, its specificity remains limited. Therefore, PLR may be valuable in excluding mortality risk; however, its standalone diagnostic utility appears restricted.

In the study by Akan & Bilgir, the average NPR in deceased patients was reported as 0.022 (27). In our study, an NPR value >0.063 showed the highest specificity among all parameters.

The limitations of the present study include its retrospective design and single-center setting, which collectively contributed to a relatively small sample size. To corroborate these findings, further prospective, multi-center studies involving larger patient populations are warranted.

CONCLUSION

Our findings suggest that high CRP/Albumin ratios and CRP levels and low albumin and Hb levels may serve as rapid and practical predictors of mortality in pneumonia patients. The combined evaluation of these parameters holds the potential to enhance the precision of mortality prediction and contribute significantly to the timely initiation of diagnosis and treatment. Taking

into account the cut-off values of laboratory tests may help clinicians to develop early treatment strategies. Although NLR, PLR, and NPR serve as useful markers of systemic inflammation, further comprehensive studies are required to validate their effectiveness and reliability in the general population and across diverse infectious etiologies.

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