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ORIGINAL RESEARCH

Assessing the Prognostic Performance of Pan Immune-Inflammation Value and Inflammatory Biomarkers in Critically Ill Patients with Community-Acquired Pneumonia

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ABSTRACT

Community-acquired pneumonia (CAP) remains a major cause of morbidity and mortality, particularly among critically ill patients in intensive care units (ICUs). Although various clinical scoring systems are used for prognostic stratification, their limitations have prompted interest in novel biomarkers. The pan-immune-inflammation value (PIIV) is a recently proposed index assessing systemic inflammation and immune status. This study investigates the relationship between PIIV, traditional inflammatory markers, and mortality outcomes in ICU-admitted CAP patients.

A total of 248 CAP patients were retrospectively analyzed. Demographic, clinical, and laboratory data were obtained from electronic medical records. Associations between these variables and 30-day mortality were evaluated. Univariate and multivariate logistic regression analyses identified independent mortality predictors, and Receiver Operating Characteristic (ROC) analysis assessed diagnostic performance.

Among 248 patients, 156 (62.9%) died. PIIV, procalcitonin, lactate, and neutrophil-lymphocyte ratio (NLR) levels were significantly higher in non-survivors. Multivariable analysis identified PIIV (adjusted OR: 1.227; 95% CI: 1.097–1.372; $p < 0.001$), lactate (adjusted OR: 1.637; 95% CI: 1.290–2.077; $p < 0.001$), and procalcitonin (adjusted OR: 1.017; 95% CI: 1.002–1.033; $p = 0.022$), as independent predictors of 30-day mortality. ROC analysis showed optimal cut-off values: PIIV ≥1928.3 (54.5% sensitivity, 70.7% specificity), lactate ≥1.6 mmol/L (75.6% sensitivity), and procalcitonin ≥1.26 ng/mL (73.7% sensitivity, 61.9% specificity).

PIIV is an independent prognostic indicator of mortality in CAP patients, reflecting systemic inflammation through multiple hematological parameters. It may capture complex immune-inflammatory dynamics and serve as a useful adjunctive biomarker alongside established markers.

Keywords: Community acquired pneumonia. Prognosis. Mortality. Pan-immune-inflammation value.

Şiddetli Toplum Kökenli Pnömonili Hastalarda Pan-İmmün-İnflamasyon Değerinin 30 Günlük Mortaliteyi Öngörmedeki Rolü

ÖZET

Toplum kökenli pnömoni (TKP), özellikle yoğun bakım ünitelerine (YBÜ) yatırılan kritik hastalarda önemli morbidite ve mortalite nedenidir. Prognostik sınıflamada yaygın olarak kullanılan çeşitli klinik skorlama sistemleri bulunsa da, bu sistemlerin sınırlılıkları yeni biyobelirteçlere olan ilgiyi artırmıştır. Pan-immün-inflamasyon değeri (PIIV), sistemik inflamasyon ve bağışıklık durumunu değerlendirmede yeni tanımlanmış bir biyobelirteçtir. Bu çalışmada, YBÜ'ye yatırılan TKP hastalarında PIIV ile diğer geleneksel inflamatuar belirteçler ve mortalite arasındaki ilişki araştırılmıştır.

Çalışmaya retrospektif olarak toplam 248 TKP hastası dahil edilmiştir. Elektronik arşivlerden elde edilen demografik, klinik ve laboratuvar verileri ile 30 günlük mortalite arasındaki ilişki değerlendirilmiştir. Bağımsız mortalite belirleyicilerini tanımlamak amacıyla univaryant ve multivaryant lojistik regresyon analizleri yapılmış, ROC analizi ile tanısal performans değerlendirilmiştir.

Çalışmadaki 248 hastanın 156'sı (%62,9) hayatını kaybetmiştir. PIIV, prokalsitonin, laktat ve nötrofil-lenfosit oranı (NLO), sağ kalamayan hastalarda anlamlı düzeyde yüksek bulunmuştur. Çok değişkenli analizde, PIIV (düzeltilmiş OR: 1,227; %95 CI: 1,097–1,372; $p < 0,001$), laktat (düzeltilmiş OR: 1,637; %95 CI: 1,290–2,077; $p < 0,001$) ve prokalsitonin (düzeltilmiş OR: 1,017; %95 CI: 1,002–1,033; $p = 0,022$) 30 günlük mortalitenin bağımsız belirleyicileri olarak tanımlandı. ROC analizinde PIIV için 1928,3 kesim değerinde %54,5 duyarlılık ve %70,7 özgüllük elde edilmiştir. Laktat en yüksek duyarlılığı (%75,6) gösterirken, prokalsitonin %73,7 duyarlılık ve %61,9 özgüllüğe sahiptir.

PIIV, TKP hastalarında mortaliteyi öngörmede bağımsız ve değerli bir biyobelirteçtir. Çok sayıda hematolojik parametreyi entegre ederek bağışıklık-inflamasyon dengesini yansıtabilir ve mevcut belirteçlerle birlikte kullanıldığında klinik karar süreçlerine katkı sağlayabilir.

Anahtar Kelimeler: Toplum kökenli pnömoni. Prognoz. Mortalite. Pan-immün-inflamasyon değeri.

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Community-acquired pneumonia (CAP) represents a severe infectious condition, especially in the elderly population, and is associated with substantial morbidity and mortality[1]. Timely recognition and early treatment of disease progression in both pediatric and adult patientsis essential to prevent serious adverse outcomes, including sepsis or death. Therefore, the use of clinical scoring systems for prognostic prediction is of great importance and has become increasingly common[2]. Unfortunately, the limitations in the sensitivity and specificity of these scoring systems, as well as the distinct mortality predictors, necessitate new and specific biomarkers in clinical practice.

Several scoring systems are currently employed to predict the disease course in CAP. The Pneumonia Severity Index (PSI), CURB-65, and the National Early Warning Score (NEWS) are among the most widely used tools[3-5]. These scoring systems typically integrate clinical symptoms, physical examination findings, and laboratory parameters to help clinicians evaluate disease severity, estimate mortality risk, and guide decisions regarding hospitalization and treatment strategies. Recently, several comprehensive inflammatory indices have gained wide attention, such as the pan-immune inflammation value (PIIV), neutrophil-lymphocyte ratio (NLR), and monocyte-lymphocyte ratio (MLR), to predict disease course in several disease states including sepsis, coronary artery disease, appendicitis, acute pancreatitis, and tumoral condition[6-10]. Although inflammation plays a key role in CAP pathophysiology, there is scarce evidence in the literature mentioning the role of PIIV in the prediction of mortality in CAP patients[11].

PIIV is a composite index reflecting the dynamic nature of immune cells such as neutrophils, lymphocytes, and monocytes. PIIV is thought to have a potential role particularly in evaluating tissue damage and organ failure processes caused by an excessive immune response in infections[12]. In this context, it is crucial to understand the predictive role of PIIV in CAP-associated mortality in order to support risk stratification of patients and the determination of treatment strategies, especially in intensive care unit (ICU) settings. Moreover, it can be speculated that the predictive value of PIIV, in combination with other inflammatory markers such as procalcitonin and CRP, may be enhanced—potentially leading to more accurate risk stratification and improved clinical decision-making in patients with CAP. The incorporation of composite indices such as PIIV into routine clinical practice may contribute to more effective risk stratification of CAP patients and the development of personalized treatment approaches.

The present study, therefore, aims to evaluate the potential role of PIIV in mortality prediction and to compare its prognostic capability with traditional biomarkers such as lactate. Thus, the effect of several inflammatory markers, such as white blood cell count (WBC), NLR, and procalcitonin, on mortality was also investigated.

Material and Method

Study Design and Population

This retrospective cohort study was carried out at Canakkale Onsekiz Mart University (COMU) Hospital between September 2021 and March 2025 and included 248 consecutive adult patients (≥18 years) diagnosed with CAP.

Definition of CAP and exclusion criteria

CAP was diagnosed based on the detection of a new pulmonary infiltrate on chest radiography, accompanied by at least one of the following clinical features: fever (≥38.0°C) or hypothermia (≤36.0°C); new-onset cough (with or without sputum); pleuritic chest pain; dyspnea; or abnormal auscultatory findings, in the absence of an alternative diagnosis during follow-up[13]. Exclusion criteria of the study is as follows; patients under age 18, pregnant women and patients diagnosed with pulmonary embolism or aspiration pneumonia. Additionally, those with severe immunosuppression, and individuals presenting with trauma were not included.

Data Collection

After obtaining approval from the COMU Local Ethics Committee (Approval No: 2025-118), hospital medical records were retrospectively evaluated. All patient data were anonymized and handled confidentially.

Demographic, clinical, and laboratory data were extracted from electronic medical records, including the following baseline characteristics: age, sex, and comorbidities; vital signs at admission; and laboratory

parameters collected within 24 hours of admission, such as complete blood count (WBC, neutrophil, lymphocyte, monocyte counts, NLR), biochemical tests (LDH, AST, albumin, urea), inflammatory markers (CRP, procalcitonin), PIIV (calculated as [neutrophil count x platelet count × monocyte count] / lymphocyte count), and lactate levels. The primary outcome of the present study was 30-day in-hospital mortality. Clinical severity scores such as APACHE II, SOFA, or the Charlson Comorbidity Index were not included in the multivariable analysis because these parameters were not routinely or consistently available in the retrospective dataset.

Statistical Analysis

Statistical Package for the Social Sciences (SPSS), version 24.0 (IBM Corp., Armonk, NY, USA) was used to analyze the data obtained from the study. Continuous variables were presented as mean ± standard deviation (SD) or median (interquartile range [IQR]), depending on the normality of distribution, assessed by the Shapiro–Wilk test. Categorical variables were expressed as frequencies and percentages (%). In comparisons between groups, Student's t-test or Mann–Whitney U test was used for continuous variables, and Chi-square test or Fisher's exact test was used for categorical variables. Univariate and multivariate logistic regression analyses were performed to determine mortality predictors. Variables with a p-value < 0.1 in the univariable analysis were included in the multivariable model using backward stepwise elimination. Results were reported as odds ratios (ORs) with 95% confidence intervals (CIs). Receiver operating characteristic (ROC) curve analysis was conducted to determine the optimal cut-off values for mortality prediction. Diagnostic performance was evaluated using the area under the ROC curve (AUROC), sensitivity, specificity, positive predictive value (PPV), and negative predictive value (NPV). A two-tailed p-value of < 0.05 was considered statistically significant.

Results

Demographic and Clinical Characteristics

The study included 248 patients diagnosed with CAP, of whom 156 (62.9%) died and 92 (37.1%) survived. As presented in Table I, age (p=0.441) and gender distribution (p=0.281) did not differ significantly between survivors and non-survivors. In contrast, comorbidities were notably more prevalent among non-survivors compared to survivors (96.8% vs. 90.2%, p=0.039).

Hematological Parameters

Statistically significant differences in complete blood count (CBC) parameters were observed between the two groups (Table I). Deceased patients had significantly higher WBC counts (15.9 vs.

Table I. Demographic, Clinical, and Laboratory Characteristics of Survivors and Non-Survivors Among CAP Patients.

Parameters	All Patients n=248 (100)	Survivors n=92 (37.1)	Deceased n=156 (62.9)	P value
Demographic				
Age (years), median (IQR)	75.0 (20.0)	76.0 (16.0)	75.0 (21.5)	0.441*
Sex/Female, n(%)	113 (45.6)	46 (50.0)	67 (42.9)	0.281***
Complete Blood Count				
WBC (x10^3/uL), median (IQR)	13.5 (9.3)	11.0 (6.7)	15.9 (11.7)	<0.001*
Hemoglobin(g/dL), mean ± SD	10.3 ± 2.1	10.4 ± 2.2	10.3 ± 2.1	0.958**
Hematocrit(%), mean ± SD	32.3 ± 6.3	32.4 ± 6.3	32.2 ± 6.5	0.754**
Platelet(x10^3/uL), median (IQR)	243.0 (195.0)	225.5 (150.0)	261.5 (225.5)	0.112*
Neutrophil (x10^3/uL), median (IQR)	11.3 (8.5)	8.7 (7.2)	14.0 (11.6)	<0.001*
Lymphocyte (x10^3/uL), median (IQR)	0.88 (0.89)	0.91 (0.87)	0.88 (0.93)	0.921*
NLR, median (IQR)	14.6 (18.9)	10.9 (13.2)	18.3 (19.2)	<0.001*
Biochemical measurements, median (IQR)				
Blood glucose (mg/dL)	146.5 (77.8)	141.0 (80.0)	150.0 (80.0)	0.848*
Urea (mg/dL)	86.5 (81.0)	75.5 (72.3)	95.5 (77.0)	0.037*
Creatinine (mg/dL)	1.58 (1.80)	1.26 (1.73)	1.84 (1.90)	0.103*
Total bilirubin (mg/dL)	0.5 (0.5)	0.5 (0.4)	0.5 (0.5)	0.721*
ALT (U/L)	16.0 (23.3)	16.0 (20.3)	16.0 (24.5)	0.806*
AST (U/L)	26.0 (34.8)	23.0 (26.5)	29.0 (40.8)	0.031*
LDH (U/L)	279.0 (214.8)	239.5 (144.3)	291.5 (319.0)	<0.001*
Albumin (g/dL)	2.9 (0.8)	3.1 (0.6)	2.8 (0.8)	<0.001*
D-dimer (ug/mL)	3.35 (6.0)	2.9 (3.3)	3.8 (7.0)	0.013*
CRP (mg/L)	154.5 (154.3)	130.5 (174.5)	159.0 (141.6)	0.263*
Procalcitonin(ng/mL)	1.90 (8.51)	0.74 (2.34)	3.56 (11.9)	<0.001*
PIIV	1790.6 (4059.2)	1222.2 (1955.8)	2249.4 (5502.9)	<0.001*
Lactate (mmol/L)	1.8 (2.0)	1.4 (0.9)	2.4 (2.5)	<0.001*

*Mann Whitney U test, median (IQR), **T-test, mean ± SD, ***Chi-Square test, n (%)

11.0×10³/μL, p < 0.001), neutrophil counts (14.0 vs. 8.7×10³/μL, p<0.001), monocyte counts (0.69 vs. 0.54×10³/μL, p = 0.012), and NLR values (18.3 vs. 10.9, p<0.001) compared to survivors. No significant difference in terms of platelet counts was observed between survivors and non-survivors (p=0.112). PIIV values were significantly higher in deceased patients (2249.4 vs. 1222.2, p<0.001) (Table I). Figure 1 illustrates a bar graph with error bars showing PIIV, WBC, procalcitonin, and lactate levels according to mortality.

Biochemical Markers and Inflammatory Parameters

Several biochemical markers presented in Table I demonstrated statistically significant differences between the survivor and non-survivor groups. Non-survivors had elevated levels of urea (95.5 vs. 75.5 mg/dL, p = 0.037), AST (29.0 vs. 23.0 U/L, p = 0.031), LDH (291.5 vs. 239.5 U/L, p<0.001), D-dimer (3.8 vs. 2.9 μg/mL, p=0.013), procalcitonin (3.56 vs. 0.74 ng/mL, p<0.001), and lactate (2.4 vs. 1.4 mmol/L, p<0.001). Conversely, albumin levels were significantly lower in deceased patients (2.8 vs. 3.1 g/dL, p<0.001).

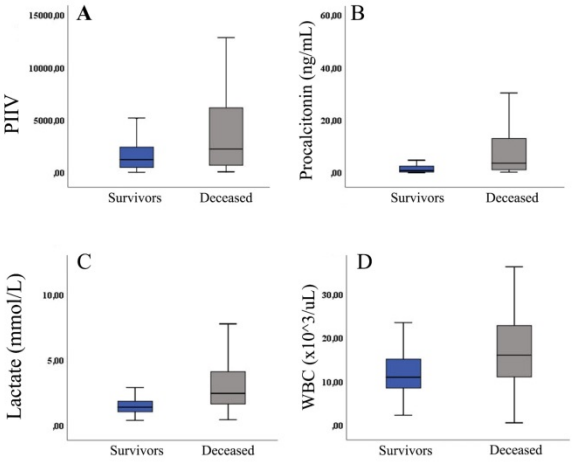

Figure 1.
Comparison of inflammatory and hematological biomarkers between survivors and non-survivors in community-acquired pneumonia patients; (A) Pan-Immune-Inflammation Value (PIIV), (B) Procalcitonin, (C) Lactate, and (D) White Blood Cell Count (WBC) according to 30-day mortality status.

Univariable and Multivariable Analysis of Mortality Risk Factors

Table II demonstrates the results of univariable and multivariable logistic regression analyses for several significant predictors of mortality. Among these, PIIV (OR: 1.233; 95% CI: 1.111–1.369; p<0.001), NLR

Table II. Logistic regression analysis of mortality predictors in ICU patients with community-acquired pneumonia

	Death (n=156)			
	Univariable analysis		Multivariable analysis	
	Odds ratio (95% CI)	p value	Odds ratio (95% CI)	p value
Age (years)	1.011 (0.993-1.029)	0.249		
Gender M[F(ref)]	0.753 (0.449-1.263)	0.282		
Comorbidities (n=)	3.275 (1.063-10.092)	0.039		
PIIV/10³	1.233 (1.111-1.369)	<0.001	1.227 (1.097-1.372)	<0.001
Urea	1.003 (0.999-1.008)	0.131		
AST	1.002 (1.000-1.004)	0.072		
Albumin	1.009 (0.909-1.119)	0.869		
D-dimer	1.027 (0.991-1.064)	0.147		
Procalcitonin	1.018 (1.003-1.032)	0.017	1.017 (1.002-1.033)	0.022
Lactate	1.759 (1.378-2.246)	<0.001	1.637 (1.290-2.077)	<0.001

Table III. Diagnostic performance of PIIV and other biomarkers in predicting 30-day mortality in Community-acquired pneumonia patients

	Cut-off	AUROC (95% CI)	Sensitivity % (95% CI)	Specificity % (95% CI)	PPV % (95% CI)	NPV % (95% CI)	Accuracy % (95% CI)
PIIV	≥1928.3	0.642 (0.574-0.711)	54.5 (46.3-62.5)	70.7 (60.2-79.7)	75.9 (68.9-81.7)	47.8 (42.4-53.2)	60.5 (54.1-66.6)
WBC	≥11.5	0.682 (0.615-0.749)	71.2 (63.4-78.1)	57.6 (46.9-67.9)	74.0 (68.7-78.7)	54.1 (46.5-61.4)	66.1 (60.0-72.0)
NLR	≥11.2	0.638 (0.566-0.710)	66.7 (58.7-74.0)	53.3 (42.6-63.7)	70.8 (65.4-75.6)	48.5 (41.3-55.8)	61.7 (55.3-67.8)
Lactate	≥1.6	0.739 (0.676-0.801)	75.6 (68.1-82.2)	58.7 (48.0-68.9)	75.6 (70.6-80.1)	58.7 (50.7-66.3)	69.4 (63.2-75.0)
Procalcitonin	≥1.26	0.713 (0.644-0.781)	73.7 (66.1-80.4)	61.9 (51.2-71.9)	76.7 (71.4-81.3)	58.2 (50.5-65.4)	69.4 (63.2-75.0)

(OR: 1.026; 95% CI: 1.007–1.044; p=0.005), procalcitonin (OR: 1.018; 95% CI: 1.003–1.032; p=0.017), and lactate (OR: 1.759; 95% CI: 1.378–2.246; p<0.001) emerged as prominent predictors and remained independently associated with mortality in the multivariable analysis: PIIV (adjusted OR: 1.227; 95% CI: 1.097–1.372; p<0.001), procalcitonin (adjusted OR: 1.017; 95% CI: 1.002–1.033; p=0.022), and lactate (adjusted OR: 1.637; 95% CI: 1.290–2.077; p<0.001). Additional laboratory parameters included in the analysis are also presented in Table II.

Diagnostic Performance of Biomarkers

ROC curve analysis for predicting mortality based on admission laboratory parameters is shown in Table III. At the optimal cut-off values, PIIV ≥1928.3 yielded a sensitivity of 54.5% and specificity of 70.7%; lactate ≥1.6 mmol/L had a sensitivity of 75.6% and specificity of 58.7%; and procalcitonin ≥1.26 ng/mL demonstrated a sensitivity of 73.7% and specificity of 61.9% for predicting mortality. The AUROC for PIIV was 0.642 (95% CI: 0.574–0.711), for lactate was 0.739 (95% CI: 0.676–0.801), and for procalcitonin was 0.713 (95% CI: 0.644–0.781). Similar analyses were also conducted for WBC and NLR (Table III).

Discussion and Conclusion

This study has demonstrated a significant relationship between PIIV and mortality. In multivariate analysis, PIIV, with an adjusted OR of 1.225 (95% CI: 1.089–1.379), showed promising results in predicting mortality. A cut-off value of ≥1928.3 for PIIV showed a sensitivity of 54.5% and a specificity of 70.7% for mortality prediction. Additionally, lactate exhibited the highest AUROC (0.739, 95% CI: 0.676–0.801), followed by procalcitonin (0.713, 95% CI: 0.644–0.781). Although the combination of these biomarkers showed increased diagnostic accuracy compared to individual parameters, formal combination analysis was not conducted. Overall, our findings suggest that PIIV, in conjunction with other inflammatory markers, may serve as a valuable prognostic marker of mortality in patients with CAP.

The observed 30-day mortality in our cohort (62.9%) was higher than that reported in many community-acquired pneumonia series. This difference is likely attributable to the characteristics of our study population, which consisted of critically ill patients managed in the ICU rather than an unselected CAP population. In our cohort, the median age was high, and comorbid conditions were highly prevalent, particularly among non-survivors, suggesting a substantial baseline vulnerability and limited physiological reserve. Therefore, the elevated mortality rate should be interpreted in the context of case-mix severity and potential selection bias inherent to retrospective ICU-based cohorts. Accordingly, our findings may not be directly generalizable to all CAP patients but are most applicable to high-risk, critically ill individuals requiring intensive care management.

There have been ongoing attempts to develop a superior prognostic scoring system that can predict adverse outcomes in CAP patients admitted to the ICU. Therefore, it is not surprising to see an increasing number of studies focusing on novel biomarkers and scoring models that aim to enhance early risk stratification and guide clinical decision-making in this high-risk population. In this context, PSI, CURB-65, and NEWS are promising tools for predicting mortality[14]. Unfortunately, the CURB-65 score primarily considers physiological and demographic variables without accounting for comorbidities or radiological findings that could impact CAP outcomes, and PSI is more complex, requiring additional time for data collection and calculation, making it less practical in resource-limited settings[14-16]. Moreover, NEWS, although commonly used in clinical practice, lacks disease-specific parameters and may not reliably reflect the severity of CAP in critically ill patients. Therefore, a laboratory-based, simple scoring system that incorporates readily available biomarkers could offer a more practical and objective approach to early risk assessment and prognostication in ICU settings.

Recent evidence has confirmed that various inflammatory markers such as NLR, PLR, MLR, and particularly MPV are associated with prognosis in distinct disease states[6,7,17-19]. Additionally, the relationship between these indices and CAP has been confirmed by several studies[20-22]. Thus, recent studies found that PIIV, which incorporates four distinct blood cell count parameters, can better reflect the inflammatory and immune condition and may offer a more detailed expression of the body's inflammatory and immune status, including cardiac, tumoral, and inflammatory origins[8-10,23-26]. However, despite its potential, there is scarce evidence specifically exploring the prognostic utility of PIIV in patients with CAP in ICU settings. In this context, the study by Zheng et al.[11] is promising, as it demonstrates the potential role of PIIV as a marker associated with prolonged ICU stay in pneumonia patients.

The present study highlights the clinical and prognostic importance of novel biomarkers such as PIIV in patients with CAP. Furthermore, our data also demonstrate that NLR, lactate, procalcitonin, as well as WBC, are significantly associated with disease severity and mortality. PIIV emerged as an independent predictor of mortality in multivariate analyses alongside these parameters. Considering that NLR is calculated from parameters that are also partially included in the PIIV calculation, its role as a prognostic marker in CAP should not be overlooked.

NLR has previously been associated with systemic inflammation and adverse outcomes in various infectious and non-infectious conditions, including CAP.

A recent study by Sharma et al.[26] demonstrated that while the NLR independently predicts adverse outcomes in patients with CAP, it does not enhance the prognostic accuracy of the CURB-65 scoring system. Similarly, Cui et al.[27] showed that increased NLR was related to reduced overall survival, while elevated NLR, PLR, and MLR were all correlated with increased ICU admission rates. Both higher NLR and higher basophil-to-lymphocyte ratio were associated with increased mortality in ICU settings. Therefore, while NLR and PLR remain useful and accessible markers, PIIV may offer superior prognostic insight in CAP by capturing a broader spectrum of host responses and providing a more comprehensive reflection of the immune and inflammatory status by integrating additional hematological parameters such as platelet and monocyte counts.

This study demonstrated the fundamental role of PIIV values in predicting mortality. Mean PIIV values were found to be significantly elevated in deceased patients compared to those who survived, indicating a strong association between heightened inflammatory response and poor clinical outcomes. Multivariable regression analysis identified PIIV as an independent predictor of mortality, suggesting that PIIV is not merely a response to inflammatory burden but also serves as a valuable prognostic tool. Although the exact mechanisms underlying these findings remain a matter of debate, in addition to systemic inflammation, endothelial dysfunction and immune dysregulation appear to play vital roles in the underlying pathophysiology. PIIV likely reflects pathological processes such as neutrophil activation, cytokine storm, and coagulopathy. This observation aligns with the hypothesis that exaggerated immune activation contributes to organ failure commonly observed in severe infections[10]. However, it must be acknowledged that, based on the PIIV AUROC of 0.642, its standalone discriminative ability remains moderate and may not be sufficient for precise risk stratification in clinical settings. Therefore, the combined use of other biomarkers (e.g., lactate and procalcitonin) with PIIV could enhance mortality prediction.

Lactate and procalcitonin are also two other parameters that demonstrated increased mortality prediction in both univariate and multivariable analyses in this study. In multivariable analysis, lactate proved to be a strong predictor of mortality with an OR of 1.637 (95% CI: 1.290–2.077, $p < 0.001$). Notably, with an AUROC value of 0.739, lactate was shown to be the most powerful prognostic marker in this study, supporting the role of pathological processes such as tissue hypoxia and shock in mortality prediction. Procalcitonin was also found to be an important parameter that predicts mortality in CAP patients admitted to the ICU (OR: 1.017, 95% CI: 1.002–1.033, $p = 0.022$). Procalcitonin is a well-established biomarker that reflects the severity of systemic bacterial infections and is particularly valuable in distinguishing bacterial from non-bacterial causes of inflammation[28]. Elevated procalcitonin levels are associated with severe sepsis and septic shock and have been shown to predict CAP-associated mortality in several studies.

Although the discriminative ability of PIIV in our study was modest, as reflected by an AUROC of 0.642, this finding should be interpreted in the context of its intended clinical role. Lactate and procalcitonin were associated with higher AUROC values, consistent with their established links to tissue hypoxia and bacterial burden, respectively. In contrast, PIIV integrates multiple immune cell components derived from routine complete blood counts without additional cost or laboratory burden. Therefore, PIIV should not be considered a replacement for lactate or procalcitonin, but rather a complementary marker reflecting the host immune–inflammatory response. Its potential clinical value lies in early, readily available risk stratification at ICU admission, particularly in resource-limited settings. The combined interpretation of PIIV with established biomarkers may provide a more comprehensive assessment of disease severity in critically ill CAP patients.

In a retrospective study by Doğancı et al.[29], conducted in patients with pneumosepsis or pneumonia-related septic shock, persistent elevation and concurrent increases in procalcitonin, CRP, and leukocyte levels—along with distinct demographic characteristics and clinical scoring systems—were found to be significantly associated with 3-month mortality. In a narrative review performed by Ozbay et al.[30], procalcitonin was identified as a more effective predictor than many other acute-phase inflammation markers—such as CRP—for diseases such as pneumonia, bacteremia, sepsis, and adverse clinical outcomes, despite the presence of some contradictory findings in the literature.

Several limitations of this study should be acknowledged. First, this study was conducted at a single center with a retrospective design, which may limit the generalizability of the findings. Additionally, only baseline laboratory parameters obtained at ICU admission were evaluated, and dynamic changes during the clinical course were not assessed. Furthermore, clinical severity and comorbidity scores such as APACHE II, SOFA, or the Charlson Comorbidity Index were not incorporated into the multivariable models because these parameters were

not routinely or consistently available in the retrospective dataset. Therefore, elevated PIIV levels may, at least in part, reflect underlying physiological stress or organ dysfunction rather than disease-specific prognostic information alone. Nevertheless, PIIV was not intended to replace established clinical scoring systems but rather to serve as a readily available, laboratory-based adjunctive marker for early risk stratification in critically ill patients with community-acquired pneumonia.

Our study comprehensively examined the prognostic power of PIIV and other inflammatory markers in predicting mortality in ICU patients with CAP. Our results suggest that PIIV has great potential as a novel marker for mortality prediction in CAP patients, based on its AUROC, specificity, and sensitivity values. Nevertheless, we must emphasize that PIIV and other inflammatory parameters, in conjunction with well-established scoring systems, should be validated in large prospective studies to effectively stratify CAP patients upon ICU admission.

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