

Research Article

Correlation of Neutrophil-to-Lymphocyte Ratio with Disease Severity and Clinical Outcomes in Patients with Community-Acquired Pneumonia: A Prospective Observational Study

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Abstract

Background: Community-acquired pneumonia (CAP) remains an important cause of hospitalization and mortality, particularly among older adults and patients with comorbidities. Early identification of patients at risk of severe disease is essential for appropriate triage and management. The neutrophil-to-lymphocyte ratio (NLR) is an inexpensive inflammatory marker derived from a routine complete blood count and may have prognostic value in CAP.

Objective: To evaluate the correlation of admission NLR with disease severity and clinical outcomes among adult patients hospitalized with CAP.

Materials and Methods: This prospective observational study included 180 adult patients admitted with CAP to a tertiary-care hospital

over 18 months. Demographic characteristics, clinical findings, comorbidities, laboratory parameters, NLR, and CURB-65 score were recorded at admission. Disease severity was categorized using CURB-65. Primary outcomes included intensive care unit (ICU) admission and in-hospital mortality, while secondary outcomes included requirement for mechanical ventilation and length of hospital stay. Correlation, receiver operating characteristic (ROC) analysis, and multivariable logistic regression were performed.

Results: The mean age of participants was 57.8 ± 16.4 years, and 112 (62.2%) were male. Median NLR increased progressively across CURB-65 severity categories, from 4.8 (IQR 3.4-6.5) among patients with CURB-65 0-1 to 9.7 (IQR 7.1-13.8) with scores 2-3 and 16.4 (IQR 11.8-22.6) with scores 4-5 (p<0.001). NLR

demonstrated a significant positive correlation with CURB-65 score (Spearman $r=0.61$, $p<0.001$). Patients requiring ICU admission had significantly higher median NLR than those managed in the ward (14.8 vs 6.7; $p<0.001$). Similarly, non-survivors had higher NLR than survivors (17.6 vs 7.1; $p<0.001$). An NLR cut-off of ≥ 10.5 predicted ICU admission with 78.4% sensitivity and 75.5% specificity (AUC 0.82). Elevated NLR remained independently associated with adverse clinical outcome after adjustment for age, diabetes, chronic lung disease, and CURB-65 score.

Conclusion: Admission NLR showed a significant correlation with CAP severity and adverse clinical outcomes. As an inexpensive and readily available marker, NLR may complement established severity scores for early risk stratification of hospitalized CAP patients.

Keywords: Community-acquired pneumonia; neutrophil-to-lymphocyte ratio; NLR; CURB-65; pneumonia severity; ICU admission; mortality.

Introduction

Community-acquired pneumonia (CAP) is an acute infection of the pulmonary parenchyma acquired outside healthcare facilities and continues to represent an important cause of morbidity, hospitalization, and mortality worldwide. Clinical presentation ranges from mild disease suitable for outpatient management to severe pneumonia complicated by respiratory failure, septic shock, intensive care unit (ICU) admission, and death. Early assessment of disease severity is therefore an essential component of CAP management.[1,2]

Several clinical prediction tools have been developed for risk stratification. The Pneumonia Severity Index (PSI) and CURB-65 score are among the most widely studied systems. Current guidelines emphasize the use of validated

prediction rules together with clinical judgment when determining the appropriate level of care.[1] Although these scores provide useful prognostic information, they require multiple clinical and biochemical variables and may not fully reflect the intensity of the systemic inflammatory response.

The host response to bacterial infection is characterized by neutrophilia resulting from activation of innate immunity and relative lymphopenia associated with physiological stress and immune dysregulation. The neutrophil-to-lymphocyte ratio (NLR), calculated by dividing the absolute neutrophil count by the absolute lymphocyte count, integrates these two inflammatory pathways into a single readily available parameter.[3,4] Unlike several inflammatory biomarkers, NLR requires no additional laboratory investigation or cost because it can be calculated from a routine complete blood count.

Growing evidence indicates that elevated NLR is associated with increased disease severity, prolonged hospitalization, ICU requirement, and mortality among patients with CAP.[5-8] Recent large-scale evidence has demonstrated an independent association between elevated NLR and adverse CAP outcomes, although its incremental prognostic value over established severity scores remains uncertain.[7] Recent Indian data have similarly demonstrated a strong relationship between NLR, CURB-65 score, ICU requirement, and mortality.[8]

Considering its simplicity, availability, and low cost, NLR may be particularly valuable in resourceconstrained healthcare settings. However, prospective evidence from Indian populations remains limited. The present study was therefore undertaken to evaluate the relationship between admission NLR and disease severity and to determine its ability to

predict clinical outcomes among adults hospitalized with CAP.

Aim

To evaluate the correlation of neutrophil-to-lymphocyte ratio with disease severity and clinical outcomes in adult patients with community-acquired pneumonia.

Materials and Methods Study Design and Setting

This prospective observational study was conducted in the Department of Medicine/Respiratory Medicine of a tertiary-care teaching hospital in Central India over a period of 18 months.

Study Population

Adult patients aged ≥ 18 years admitted with a diagnosis of community-acquired pneumonia were screened consecutively for eligibility. CAP was defined as the presence of a new pulmonary infiltrate on chest radiography or computed tomography together with compatible acute clinical features such as fever, cough, sputum production, dyspnea, pleuritic chest pain, or abnormal respiratory examination, with infection acquired outside the hospital.

Inclusion Criteria

- Age ≥ 18 years.
- Clinical and radiological evidence of CAP.
- Hospitalization required.
- Written informed consent provided.

Exclusion Criteria

- Hospital-acquired or ventilator-associated pneumonia.
- Active pulmonary tuberculosis.
- Hematological malignancy or recent chemotherapy.
- Long-term systemic corticosteroid or immunosuppressive therapy.
- Severe immunodeficiency or known conditions substantially affecting leukocyte counts.
- Incomplete baseline investigations.

Sample Size

Assuming a moderate correlation ($r=0.25$) between NLR and CAP severity, with a two-sided alpha error of 5% and 90% statistical power, the minimum required sample was approximately 164 patients. After allowing for approximately 10% incomplete observations or loss to follow-up, the final target sample was rounded to 180 patients.

Data Collection

At enrollment, demographic characteristics, smoking history, presenting symptoms, duration of illness, comorbidities, vital parameters, oxygen saturation, and relevant physical examination findings were recorded using a predefined study proforma.

Laboratory investigations included complete blood count, blood urea, serum creatinine, blood glucose, liver function tests, electrolytes, and other clinically indicated investigations. Chest radiography was performed at admission. Absolute neutrophil and lymphocyte counts were obtained from the first complete blood count collected before or shortly after initiation of treatment.

NLR was calculated as: $NLR = \text{Absolute neutrophil count} / \text{Absolute lymphocyte count}$.

Assessment of Disease Severity

Disease severity at admission was assessed using the CURB-65 score, comprising confusion, elevated blood urea, respiratory rate $\geq 30/\text{min}$, low blood pressure, and age ≥ 65 years. Patients were categorized as low severity (CURB-65 0-1), moderate severity (2-3), and high severity (4-5). The decision regarding ward or ICU management was made by the treating clinical team independently of the study analysis.

Outcome Measures

The primary outcomes were ICU admission and in-hospital mortality. Secondary outcomes included invasive or non-invasive mechanical

ventilation and duration of hospitalization. A composite adverse outcome was defined as occurrence of ICU admission, mechanical ventilation, or in-hospital death.

Ethical Considerations

The study protocol was approved by the Institutional Ethics Committee before commencement of recruitment. Written informed consent was obtained from all participants or their legally authorized representatives. Patient confidentiality was maintained throughout the study, and management decisions were made according to institutional protocols without interference from study participation.

Statistical Analysis

Data were analyzed using IBM SPSS Statistics version 29.0. Continuous normally distributed variables were expressed as mean $\pm$ standard deviation, whereas skewed variables were presented as median and interquartile range (IQR). Categorical variables were expressed as frequencies and percentages. The independent-samples t-test or Mann-Whitney U test was used

for continuous variables as appropriate. Categorical variables were compared using the chi-square test or Fisher exact test. Differences in NLR across multiple CURB-65 categories were assessed using the Kruskal-Wallis test. Spearman correlation coefficient was used to evaluate the relationship between NLR and CURB-65 score. Receiver operating characteristic (ROC) curves were constructed to assess the ability of NLR to predict ICU admission and mortality. The optimal cut-off was determined using the Youden index. Multivariable logistic regression was performed to identify independent predictors of adverse outcomes. Adjusted odds ratios (AORs) with 95% confidence intervals (CIs) were calculated. A pvalue <0.05 was considered statistically significant.

Results

A total of 196 patients were screened, of whom 16 were excluded because of predefined exclusion criteria or incomplete investigations. Thus, 180 patients were included in the final analysis

. Table 1. Baseline characteristics of the study population (n=180)

Characteristic	Value
Age, years, mean $\pm$ SD	57.8 $\pm$ 16.4
Age ≥ 65 years	68 (37.8%)
Male	112 (62.2%)
Female	68 (37.8%)
Current/former smoker	76 (42.2%)
Diabetes mellitus	58 (32.2%)
Hypertension	64 (35.6%)
Chronic respiratory disease	39 (21.7%)
Chronic kidney disease	16 (8.9%)
Fever	148 (82.2%)
Cough	163 (90.6%)
Dyspnea	131 (72.8%)
SpO ₂ $<90\%$ at admission	51 (28.3%)
Median NLR (IQR)	7.8 (4.9-12.6)

Cough was the most frequent presenting symptom, followed by fever and dyspnea. Approximately one-third of patients had diabetes or hypertension, while 28.3% presented with oxygen saturation below 90%.

Table 2. NLR according to CURB-65 disease severity

CURB-65 category	n (%)	Median NLR (IQR)	p-value
0-1	84 (46.7)	4.8 (3.4-6.5)	
2-3	78 (43.3)	9.7 (7.1-13.8)	<0.001
4-5	18 (10.0)	16.4 (11.8-22.6)	

Median NLR increased progressively with increasing CAP severity. Patients with CURB-65 scores of 4-5 demonstrated more than threefold higher median NLR than those in the low-severity group. Spearman analysis demonstrated a significant positive correlation between NLR and CURB-65 score ($r=0.61$, $p<0.001$).

Table 3. NLR according to major clinical outcomes

Outcome	n (%)	Median NLR (IQR)	Comparison group NLR	p-value
ICU admission	51 (28.3)	14.8 (10.2-19.6)	6.7 (4.4-9.3)	<0.001
Mechanical ventilation	29 (16.1)	16.1 (11.7-21.8)	7.0 (4.6-10.5)	<0.001
In-hospital mortality	18 (10.0)	17.6 (12.8-23.4)	7.1 (4.6-10.9)	<0.001

Patients experiencing adverse outcomes consistently demonstrated higher NLR values. The difference was particularly evident for mechanical ventilation and mortality.

Table 4. Clinical outcomes according to admission NLR

Outcome	NLR <10.5 (n=119)	NLR ≥10.5 (n=61)	p-value
ICU admission	11 (9.2%)	40 (65.6%)	<0.001
Mechanical ventilation	5 (4.2%)	24 (39.3%)	<0.001
In-hospital mortality	3 (2.5%)	15 (24.6%)	<0.001
Hospital stay >7 days	28 (23.5%)	38 (62.3%)	<0.001

ROC Curve Analysis

For prediction of ICU admission, NLR demonstrated an AUC of 0.82 (95% CI 0.75-0.88; $p<0.001$). An NLR cut-off of ≥ 10.5 provided sensitivity of 78.4% and specificity of 75.5%. For in-hospital mortality, NLR demonstrated an AUC of 0.84 (95% CI 0.76-0.92; $p<0.001$). A higher NLR threshold of approximately ≥ 14.5 showed the best balance between sensitivity and specificity for mortality prediction.

Table 5. Multivariable logistic regression for adverse clinical outcome

Predictor	Adjusted OR	95% CI	p-value
Age ≥ 65 years	1.62	0.82-3.21	0.165
Diabetes mellitus	1.48	0.76-2.89	0.251
Chronic respiratory disease	1.57	0.74-3.34	0.239

CURB-65 ≥ 3	3.12	1.53-6.38	0.002
NLR ≥ 10.5	3.76	1.82-7.78	<0.001

After adjustment for relevant demographic characteristics, comorbidities, and CAP severity, NLR ≥ 10.5 remained independently associated with adverse clinical outcome (AOR 3.76; 95% CI 1.82-7.78; $p < 0.001$).

Discussion

The present study demonstrated a significant relationship between admission NLR and severity of community-acquired pneumonia. NLR increased progressively across CURB-65 categories and showed a moderately strong positive correlation with the CURB-65 score. Furthermore, elevated NLR was associated with ICU admission, mechanical ventilation, prolonged hospitalization, and in-hospital mortality. These findings support the potential role of NLR as a simple adjunctive prognostic marker in hospitalized patients with CAP.

The biological basis for this relationship is plausible. Acute bacterial infection promotes neutrophil recruitment and activation through innate inflammatory pathways. Simultaneously, severe physiological stress may produce relative lymphopenia through redistribution and apoptosis of lymphocytes. Consequently, an increased NLR reflects both enhanced nonspecific inflammation and suppression of adaptive immune responses.[3,4] Because these changes tend to become more pronounced with systemic inflammatory burden, NLR may serve as a readily measurable indicator of disease severity.

In the present study, median NLR increased from 4.8 among patients with CURB-65 scores of 0-1 to 16.4 among those with scores of 4-5. The significant correlation between NLR and CURB-65 ($r=0.61$) suggests that NLR broadly

parallels conventional clinical severity assessment.

These observations are consistent with recent Indian evidence. Das et al.[8], in a prospective observational study of hospitalized CAP patients from Northeast India, reported a strong positive correlation between NLR and CURB-65. They found that higher NLR was associated with ICU requirement and mortality. The similarity between these observations and our findings strengthens the potential relevance of NLR in Indian CAP populations.

Sharma et al.[7] evaluated a large cohort of CAP admissions and reported that elevated NLR was independently associated with prolonged hospital stay, ICU admission, and in-hospital mortality after adjustment for several confounding variables. However, the discriminative ability of NLR alone for mortality was modest, and addition of NLR did not substantially improve the predictive performance of CURB-65. These findings suggest that NLR should be considered a complementary marker rather than a replacement for validated clinical prediction rules.

The association between NLR and adverse outcomes observed in our study was particularly notable. Patients admitted to the ICU had a median NLR of 14.8 compared with 6.7 among those managed outside the ICU. Similarly, median NLR was 17.6 among non-survivors compared with 7.1 among survivors. ROC

analysis demonstrated good discrimination for both ICU requirement and mortality. Recent observational research has also examined the relationship between cellular inflammatory indices and established pneumonia scores. Calis et al.[9] reported significant relationships between NLR, CURB-65, PSI, and mortality in hospitalized CAP patients, further supporting the prognostic relevance of hematological inflammatory indices.

Our multivariable analysis demonstrated that $\text{NLR} \geq 10.5$ remained independently associated with adverse outcomes even after adjustment for CURB-65 and important comorbidities. This finding is clinically relevant because NLR is automatically derivable from a complete blood count, requires no specialized equipment, and imposes virtually no additional cost.

Nevertheless, NLR should not be interpreted in isolation. It is a nonspecific inflammatory marker and can be influenced by bacterial or viral infections, systemic inflammatory disorders, corticosteroid administration, malignancy, physiological stress, and other conditions. Clinical judgment and established severity assessment remain essential. Current CAP guidance recommends validated prediction tools together with clinical assessment when determining disease severity and treatment setting.[1,2]

An important practical implication of the present study is the possible use of NLR for rapid preliminary risk stratification in emergency departments and resource-limited hospitals. A markedly elevated NLR at presentation may alert clinicians to patients requiring closer observation, early escalation of respiratory support, or assessment for intensive care. However, prospective multicenter validation is necessary before any single NLR threshold can be incorporated into routine treatment algorithms.

Limitations: This study has several limitations. First, it was conducted at a single tertiary-care center, potentially limiting generalizability. Second, NLR was primarily evaluated at admission; serial changes during treatment were not analyzed. Third, factors influencing leukocyte subpopulations cannot be completely excluded despite predefined eligibility criteria. Fourth, microbiological etiology could not be established in every patient. Finally, the relatively small number of deaths limits the precision of mortality-specific estimates. Future multicenter studies with larger populations should assess serial NLR measurements and evaluate whether combining NLR with CURB-65, PSI, C-reactive protein, or other biomarkers improves prognostic accuracy.

Conclusion

The neutrophil-to-lymphocyte ratio demonstrated a significant positive correlation with disease severity among patients hospitalized with community-acquired pneumonia. Elevated admission NLR was associated with increased ICU requirement, mechanical ventilation, prolonged hospital stay, and in-hospital mortality. $\text{NLR} \geq 10.5$ independently predicted adverse clinical outcomes after adjustment for conventional risk factors and CURB-65 severity. Because NLR is inexpensive, rapidly available, and easily calculated from routine complete blood counts, it may serve as a useful adjunct to established clinical severity scores for early risk stratification of CAP. It should, however, complement rather than replace validated clinical prediction tools and clinical judgment.

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Conflict of interest: The authors declare no conflicts of interest.

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