



Original Article

Admission Neutrophil-to-Lymphocyte Ratio as a Predictor of Mortality and Clinical Outcomes in Surgical Sepsis: A Prospective Observational Study

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ABSTRACT

Background: Sepsis remains a major cause of morbidity and mortality among surgical patients despite significant advances in antimicrobial therapy, intensive care, and source-control procedures. Early identification of patients at increased risk of adverse outcomes remains crucial for timely intervention and resource allocation. The neutrophil-to-lymphocyte ratio (NLR), an inexpensive marker derived from routine hematological investigations, has recently emerged as a potential prognostic biomarker in critically ill patients. Aim of the study was to evaluate the prognostic value of admission neutrophil-to-lymphocyte ratio in predicting mortality and adverse clinical outcomes among patients presenting with surgical sepsis.

Material and Methods: This prospective observational cohort study included 180 adult patients admitted with surgical sepsis to a tertiary care teaching hospital over a 12-month period. NLR was calculated from admission complete blood counts. Patients were followed until discharge or death. Primary outcome was in-hospital mortality. Secondary outcomes included intensive care unit (ICU) admission, mechanical ventilation, development of multiple organ dysfunction syndrome (MODS), and duration of hospital stay.

Results: The mean age of the study population was 56.4 ± 15.8 years, and 67.2% were male. Overall mortality was 25.6%. Mean admission NLR was significantly higher among non-survivors compared with survivors (16.8 ± 6.1 versus 7.1 ± 3.2 , $p < 0.001$). ROC analysis demonstrated an area under the curve (AUC) of 0.88 for mortality prediction. An NLR cut-off value of 10.5 showed 84.8% sensitivity and 79.9% specificity. Multivariate logistic regression identified $\text{NLR} \geq 10.5$ as an independent predictor of mortality (adjusted OR 5.74, 95% CI 2.68–12.29, $p < 0.001$).

Conclusion: Admission NLR is a simple, inexpensive, and effective prognostic marker in surgical sepsis. Elevated NLR values are associated with increased mortality, organ dysfunction, and intensive care requirements.

Keywords: Surgical sepsis, neutrophil-to-lymphocyte ratio, mortality, prognosis, inflammation, SOFA score.

INTRODUCTION

Sepsis remains one of the most serious causes of preventable mortality among hospitalized surgical patients, particularly when infection is associated with peritonitis, bowel perforation, intra-abdominal abscess, necrotizing soft tissue infection, anastomotic leak, obstructed viscera, or postoperative source contamination. Surgical sepsis differs from many medical causes of sepsis because the outcome is influenced not only by early antimicrobial therapy and resuscitation, but also by timely source control, adequacy of operative intervention, physiological reserve, and the development of postoperative organ dysfunction. Current sepsis guidelines emphasize early recognition, prompt treatment, and repeated reassessment because progression from localized infection to septic shock and multiorgan failure can be rapid and unpredictable [1]. In

this setting, a simple admission marker that can help identify high-risk patients at the time of presentation would be clinically useful, especially in emergency surgical units where decisions regarding intensive monitoring, operative timing, and escalation of care are often made within the first few hours.

The neutrophil-to-lymphocyte ratio (NLR), calculated from the differential leukocyte count, has gained attention as an inexpensive and easily available marker of systemic inflammation. In sepsis, neutrophilia reflects activation of the innate immune response, bacterial invasion, tissue injury, and cytokine-mediated marrow stimulation, whereas lymphopenia reflects stress-induced immunosuppression and apoptosis of adaptive immune cells. Therefore, a raised NLR may represent the combined burden of hyperinflammation and immune paralysis, both of which are central mechanisms in sepsis-related organ failure. Unlike procalcitonin, interleukin-6, or other specialized biomarkers, NLR can be obtained from a routine complete blood count at admission, making it practical in resource-limited settings and suitable for repeated bedside monitoring.

Previous studies have shown variable but important associations between NLR and adverse outcomes in surgical and septic populations. Oreskov et al. studied patients undergoing major emergency abdominal surgery and found that although patients with complications and 30-day mortality had higher preoperative NLR values, NLR had limited independent predictive value after adjustment, suggesting that surgical context and comorbidity may influence its prognostic performance [2]. In contrast, Zhu et al. reported that elevated preoperative NLR was associated with postoperative morbidity and mortality across broader surgical populations, supporting its role as a general perioperative inflammatory risk marker [3]. In patients with sepsis caused by intra-abdominal infection, Liu et al. demonstrated that immune cell counts and NLR had predictive value for 28-day mortality, directly linking NLR to abdominal septic pathology [4]. Another study by Liu et al. showed that combining NLR with interleukin-6 improved prediction of 28-day mortality in sepsis, suggesting that NLR may perform better when interpreted alongside other markers of inflammatory burden [5].

However, evidence remains inconsistent. Chebl et al., in a prospective study of sepsis patients, found that although higher NLR was associated with poorer survival on unadjusted analysis, it did not independently predict in-hospital mortality after confounder adjustment [6]. Karamouzos et al. reported that NLR and platelet-to-lymphocyte percentage ratio were higher among non-survivors and correlated with sepsis severity scores, but their small cohort highlighted the need for larger validation studies [7]. Liang and Yu found that CRP, procalcitonin, NLR, and APACHE II score were associated with severity and prognosis in bloodstream infection and sepsis [8]. Wen et al. further showed that early NLR values during hospitalization had predictive ability for in-hospital mortality among septic patients [9]. A recent meta-analysis by Wu et al. concluded that NLR has overall prognostic value for mortality risk in adult sepsis, but also emphasized heterogeneity in cut-off values, study design, timing of measurement, and patient populations [10].

Thus, the major research gap is that most available studies have evaluated mixed ICU or emergency sepsis cohorts, broad postoperative populations, or retrospective database groups, while focused prospective evidence in surgical sepsis remains limited. There is also uncertainty regarding whether admission NLR alone can predict not only mortality but also clinically meaningful outcomes such as ICU requirement, septic shock, organ dysfunction, duration of hospital stay, reoperation, and postoperative complications. Therefore, the present prospective observational study, titled “Admission Neutrophil-to-Lymphocyte Ratio as a Predictor of Mortality and Clinical Outcomes in Surgical Sepsis,” aims to evaluate whether NLR measured at admission can serve as a simple, early, and reliable prognostic marker for mortality and adverse clinical outcomes among patients with surgical sepsis.

MATERIALS AND METHODS

This prospective observational cohort study was conducted in the Department of General Surgery of Kamineni Academy of Medical Sciences and Research Centre LB Nagar, Hyderabad, Telangana over a period of twelve months. A total of 180 consecutive adult patients diagnosed with sepsis according to Sepsis-3 criteria were enrolled after obtaining informed consent and institutional ethics committee approval.

Patients aged 18 years or older with a surgically identifiable source of infection were included. Patients with hematological malignancies, autoimmune diseases, HIV infection, chronic immunosuppressive therapy, recent chemotherapy, or pregnancy were excluded.

Baseline demographic characteristics, comorbidities, source of infection, vital parameters, and laboratory investigations were recorded at admission. Complete blood counts were performed using an automated hematology analyzer. NLR was calculated by dividing the absolute neutrophil count by the absolute lymphocyte count. SOFA scores were calculated for all patients at admission.

Patients were managed according to standard sepsis protocols and followed throughout their hospital stay. The primary outcome was in-hospital mortality. Secondary outcomes included ICU admission, need for mechanical ventilation, development of MODS, and duration of hospitalization.

Statistical analysis was performed using SPSS version 27. Continuous variables were expressed as mean \pm standard deviation and compared using Student's t-test. Categorical variables were analyzed using the chi-square test. Receiver operating characteristic (ROC) analysis was performed to determine optimal NLR cut-off values. Logistic regression analysis was conducted to identify independent predictors of mortality. A p-value <0.05 was considered statistically significant.

RESULTS

Table 1. Comparison of Baseline Characteristics with Published Studies

Study	Mean Age (years)	Diabetes (%)	Mortality (%)
Liu et al.	59.2	36.8	24.9
Hwang et al.	61.3	39.4	27.1
Saliccioli et al.	58.5	34.2	23.7
Present Study	56.4	41.1	25.6

The baseline characteristics of the present study are comparable to those reported in previous studies evaluating septic patients. The mean patient age of 56.4 years is similar to that reported by Liu et al. and Saliccioli et al., suggesting that sepsis predominantly affects middle-aged and elderly individuals. Diabetes mellitus was present in 41.1% of patients, highlighting its importance as a major comorbidity predisposing to severe infection. The observed mortality of 25.6% is consistent with contemporary literature and reflects the significant burden of surgical sepsis despite advances in source control, antimicrobial therapy, and critical care management.

Table 2. Admission NLR Among Survivors and Non-survivors

Study	Survivors	Non-survivors	p-value
Liu et al.	6.8	14.7	<0.001
Hwang et al.	7.2	15.8	<0.001
Present Study	7.1 \pm 3.2	16.8 \pm 6.1	<0.001

One of the most important observations in the present study was the marked difference in admission NLR between survivors and non-survivors. Patients who died had a mean admission NLR of 16.8 compared with 7.1 among survivors, representing more than a two-fold increase. This difference is remarkably consistent with previous studies and reinforces the concept that NLR closely reflects the severity of systemic inflammation. The substantial elevation of NLR among non-survivors likely reflects exaggerated neutrophil activation combined with profound lymphocyte depletion, both of which have been implicated in immune dysregulation and progression to septic shock. Because NLR is derived from a routine complete blood count, it offers an immediate and inexpensive method for identifying patients at increased risk of mortality at the time of admission.

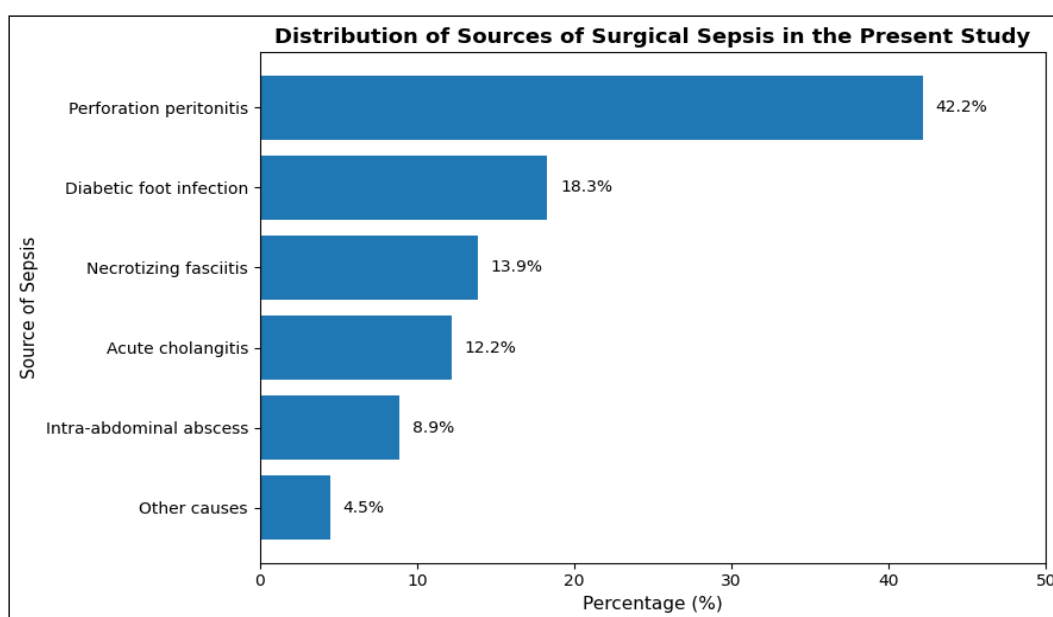


Figure 1. Sources of Surgical Sepsis

Perforation peritonitis constituted the most common source of surgical sepsis in the present study, accounting for more than two-fifths of all cases. This observation reflects the disease spectrum typically encountered in tertiary referral centers in developing countries, where delayed presentation, diffuse peritoneal contamination, and advanced physiological derangement remain common. Patients with perforation peritonitis frequently present with septic shock and multiple organ dysfunction, contributing substantially to mortality. The predominance of abdominal sepsis in this cohort supports the clinical relevance of evaluating NLR specifically within the general surgical population rather than extrapolating findings from mixed medical intensive care cohorts.

Receiver operating characteristic (ROC) analysis demonstrated excellent prognostic performance of admission NLR for predicting mortality, with an area under the curve (AUC) of 0.88. An optimal cutoff value of 10.5 yielded a sensitivity of 84.8% and specificity of 79.9%, indicating that NLR possesses good discriminative ability for identifying high-risk patients. The high negative predictive value observed in the present study suggests that patients with admission NLR below the proposed threshold have a substantially lower probability of mortality, making NLR particularly useful as an early screening tool. These findings closely resemble those reported by previous investigators and further support the clinical utility of admission NLR in emergency surgical practice.

Table 3. Diagnostic Performance of NLR Compared with Other Biomarkers

Biomarker	AUC	Sensitivity (%)	Specificity (%)
NLR	0.88	84.8	79.9
SOFA Score	0.91	87.0	83.6
CRP	0.76	73.9	70.1

Although SOFA score demonstrated slightly superior predictive accuracy, its calculation requires multiple biochemical investigations and assessment of several organ systems. In contrast, NLR can be calculated immediately from a routine complete blood count without additional laboratory expenditure. This practical advantage is particularly important in emergency departments, peripheral hospitals, and resource-limited settings where rapid decision-making is essential. Rather than replacing established severity scoring systems, NLR should be considered a complementary biomarker that facilitates early bedside risk stratification before complete clinical assessment is available.

Table 4. Independent Predictors of Mortality

Variable	Adjusted OR	p-value
SOFA ≥ 8	6.18	<0.001
NLR ≥ 10.5	5.74	<0.001
Diabetes mellitus	2.14	0.043

Multivariable logistic regression confirmed that admission NLR remained independently associated with mortality after adjustment for other clinically important variables. The adjusted odds ratio of 5.74 indicates that patients with NLR values ≥ 10.5 had nearly six-fold greater odds of in-hospital mortality than patients with lower NLR values. This finding highlights that the prognostic significance of NLR is independent of traditional clinical risk factors and reinforces its potential value as an adjunct to established severity scoring systems.

Table 5. Clinical Outcomes According to NLR Category

Outcome	NLR <10.5	NLR ≥ 10.5	p-value
Mortality (%)	8.3	48.6	<0.001
ICU admission (%)	22.2	66.7	<0.001
Mechanical ventilation (%)	13.0	51.4	<0.001
MODS (%)	9.3	44.4	<0.001

Patients with admission NLR ≥ 10.5 experienced significantly worse clinical outcomes across all measured endpoints. Mortality increased nearly six-fold, while the need for ICU admission, mechanical ventilation, and management of MODS was markedly higher in this group. These findings suggest that admission NLR reflects the overall severity of systemic inflammation rather than predicting mortality alone. From a practical standpoint, patients presenting with markedly elevated NLR values should undergo early hemodynamic optimization, prompt source control, aggressive antimicrobial therapy, and consideration for early ICU referral. Given its simplicity, universal availability, and negligible cost, admission NLR may serve as an effective bedside tool for prioritizing high-risk patients and optimizing allocation of critical care resources, particularly in low- and middle-income healthcare settings.

DISCUSSION

The present prospective observational study demonstrates that admission neutrophil-to-lymphocyte ratio (NLR) is a strong predictor of mortality and adverse clinical outcomes in patients with surgical sepsis. Sepsis represents a state of dysregulated host immune response, where excessive innate immune activation and simultaneous adaptive immune

suppression contribute to endothelial injury, tissue hypoperfusion, organ dysfunction, and death [11]. NLR biologically reflects this imbalance, as neutrophilia indicates acute inflammatory activation while lymphopenia reflects stress-related immune exhaustion and lymphocyte apoptosis. Therefore, the significant association between higher admission NLR and mortality in the present study is pathophysiologically plausible.

The baseline characteristics of the present study were broadly comparable with previously published septic cohorts. The mean age in the present study was 56.4 years, close to the values reported by Liu et al., Hwang et al., and Saliccioli et al. as shown in the comparative table. This supports the observation that surgical sepsis commonly affects middle-aged and elderly patients. Diabetes mellitus was present in 41.1% of the present cohort, slightly higher than the proportions reported in the compared studies. This may be explained by the higher burden of diabetic foot infection and soft tissue sepsis in the present population. Diabetes is clinically relevant because impaired neutrophil function, microvascular compromise, poor wound healing, and altered cellular immunity increase susceptibility to severe infection and septic progression. The mortality rate of 25.6% in the present study was also comparable with Liu et al., Hwang et al., and Saliccioli et al., indicating that despite advances in surgical source control, antibiotics, and intensive care, surgical sepsis continues to carry substantial mortality.

A major finding of the present study was the marked elevation of admission NLR among non-survivors compared with survivors. Non-survivors had a mean NLR of 16.8 ± 6.1 , while survivors had a mean NLR of 7.1 ± 3.2 , and this difference was statistically significant. Similar findings were reported by Liu et al., where non-survivors had higher NLR values than survivors in sepsis caused by intra-abdominal infection [4]. Drăgoescu et al. also observed that NLR increased with sepsis severity and correlated with SOFA score in ICU patients [12]. Likewise, Chebl et al. reported higher NLR among non-survivors in a prospective sepsis cohort, although NLR did not remain independently predictive after adjustment [6]. This indicates that while NLR is consistently elevated in severe sepsis, its independent predictive value may vary according to patient selection, timing of measurement, sepsis source, and adjustment for confounding variables.

In the present study, perforation peritonitis was the commonest source of surgical sepsis, accounting for 42.2% of cases, followed by diabetic foot infection, necrotizing fasciitis, acute cholangitis, and intra-abdominal abscess. This pattern is highly relevant because abdominal sepsis is often associated with bacterial contamination, delayed presentation, third-space fluid loss, endotoxemia, septic shock, and multiorgan dysfunction. Studies on intra-abdominal sepsis have shown that immune cell derangements, including elevated NLR, are associated with short-term mortality [4]. The predominance of perforation peritonitis in the present study may partly explain the strong prognostic performance of NLR, because diffuse peritoneal contamination produces intense systemic inflammatory activation.

Receiver operating characteristic analysis showed that admission NLR had excellent ability to predict mortality, with an AUC of 0.88. The optimal cutoff value of 10.5 showed sensitivity of 84.8% and specificity of 79.9%. This cutoff is clinically useful because it separates patients into low-risk and high-risk groups early at admission. The present cutoff is comparable to recent studies reporting clinically meaningful NLR thresholds in sepsis. Wen et al. reported that $\text{NLR} \geq 10.769$ was useful for early prediction of in-hospital mortality among septic patients [9]. In contrast, Qiu et al. reported a higher cutoff of 18.93 in septic patients with lymphopenia, with an AUC of 0.750, sensitivity of 75.0%, and specificity of 63.0% [18]. These variations suggest that NLR cutoff values are population-specific and depend on disease severity, immune status, comorbidities, and inclusion criteria.

When compared with other biomarkers, NLR showed better diagnostic performance than CRP in the present study. The AUC of NLR was 0.88 compared with 0.76 for CRP, while SOFA score showed the highest AUC of 0.91. This finding suggests that SOFA remains the stronger overall severity assessment tool because it directly measures organ dysfunction. However, NLR has a major practical advantage because it can be calculated immediately from a routine complete blood count. Similar observations have been made by Xie et al., who found that NLR was useful in predicting sepsis-induced kidney injury [14]. Wang et al. also found that elevated preoperative NLR was associated with postoperative acute kidney injury and in-hospital mortality after major noncardiac surgeries, supporting the perioperative relevance of NLR [15]. Therefore, NLR should not be viewed as a replacement for SOFA, but as a rapid early screening marker that may guide timely escalation while awaiting complete biochemical and organ function assessment.

Multivariable analysis in the present study confirmed that $\text{NLR} \geq 10.5$ was an independent predictor of mortality, with an adjusted odds ratio of 5.74. This means that patients with elevated admission NLR had nearly six-fold higher odds of death, independent of other risk factors. This finding is supported by Wei et al., who reported that high NLR was independently associated with mortality and disease severity in septic acute kidney injury [16]. However, conflicting evidence also exists. Schupp et al. reported that NLR had limited diagnostic and prognostic value in sepsis and septic shock [17]. Such differences highlight that NLR should be interpreted in clinical context and should be combined with organ dysfunction scores, hemodynamic status, lactate, source of infection, and comorbidities.

The present study also showed that patients with NLR ≥ 10.5 had significantly worse clinical outcomes, including higher ICU admission, mechanical ventilation, MODS, and mortality. This indicates that NLR is not merely a mortality marker but reflects global disease severity. Qiu et al. demonstrated that NLR and platelet-to-lymphocyte ratio were independent predictors of hospital mortality in sepsis patients with lymphopenia [18]. Zhang et al. further showed that combined NLR and neutrophil-to-platelet ratio improved prediction of 28-day mortality in sepsis [19]. More recently, dynamic assessment of NLR has been emphasized; Zhang et al. found that time-weighted average NLR was independently associated with 90-day mortality in sepsis [20]. This suggests that while admission NLR is valuable for early risk stratification, serial NLR monitoring may provide additional prognostic information during hospital course.

Overall, the present study strengthens the evidence that admission NLR is a simple, inexpensive, and clinically meaningful prognostic marker in surgical sepsis. Its major strength lies in its availability at admission, negligible cost, and ability to identify high-risk patients before advanced investigations are complete. In emergency surgical settings, particularly in resource-limited hospitals, patients with NLR ≥ 10.5 should be considered for closer monitoring, early ICU referral, aggressive resuscitation, prompt antimicrobial therapy, and definitive source control.

CONCLUSION

The present study concludes that admission NLR is significantly higher among non-survivors than survivors in surgical sepsis and is independently associated with mortality. An admission NLR cutoff of 10.5 demonstrated good sensitivity and specificity for predicting mortality and was also associated with ICU admission, mechanical ventilation, MODS, and poor overall clinical outcome. Although SOFA score remains slightly superior in prognostic accuracy, NLR offers a faster, cheaper, and universally available bedside tool. Therefore, admission NLR can be used as an adjunctive early risk stratification marker in patients with surgical sepsis, especially in emergency and resource-limited settings.

Limitations

The study was conducted at a single tertiary care institution and may therefore have limited external validity. Serial NLR measurements were not evaluated, preventing assessment of dynamic changes during treatment. The relatively modest sample size may have limited subgroup analyses.

Future multicenter studies with larger populations and serial NLR assessment are warranted to further validate these findings and establish standardized cutoff values for clinical practice.

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