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Predictive Value of Neutrophil-Lymphocyte Ratio in Post-Anesthesia Respiratory Complications in ICU Patients with asthma

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ABSTRACT

Asthma patients undergoing anesthesia are particularly susceptible to postoperative respiratory complications because of underlying airway inflammation and perioperative stress responses. Identification of reliable and easily obtainable biomarkers capable of predicting such complications remains an important clinical priority. The neutrophil-lymphocyte ratio (NLR), an accessible marker derived from routine hematological testing, reflects systemic inflammatory status and may serve as a predictor of postoperative adverse outcomes. The present experimental observational study evaluated the predictive value of preoperative NLR for post-anesthesia respiratory complications among intensive care unit patients with asthma. A total of 120 adult asthmatic patients admitted to the ICU following surgery under general anesthesia were analyzed. Patients were stratified into two groups according to the occurrence of postoperative respiratory complications within 48 hours: complication group and non-complication group. Mean preoperative NLR values were significantly higher in the complication group compared with the non-complication group (6.8 ± 1.9 vs 3.4 ± 1.2, $p < 0.001$). Multivariate analysis demonstrated that elevated NLR independently predicted respiratory complications after adjusting for age, asthma severity, and operative duration. Receiver operating characteristic analysis indicated that an NLR cutoff value of 4.9 predicted complications with 82% sensitivity and 78% specificity. These findings highlight the clinical utility of NLR as a cost-effective biomarker for early identification of asthmatic patients at increased risk of post-anesthesia respiratory complications in critical care settings. Early risk stratification using NLR may assist clinicians in optimizing perioperative monitoring and preventive respiratory management strategies.

Keywords: *neutrophil-lymphocyte ratio, asthma, postoperative respiratory complications*

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INTRODUCTION

Asthma is a chronic inflammatory airway disorder characterized by variable airflow obstruction, bronchial hyperresponsiveness, and recurrent episodes of wheezing, coughing, and dyspnea. Despite advances in therapeutic strategies, asthma continues to represent a significant clinical burden worldwide, particularly in hospitalized and critically ill populations. Surgical procedures requiring general anesthesia introduce additional physiological stress that may exacerbate airway inflammation and predispose asthmatic patients to postoperative respiratory complications. These complications may include bronchospasm, hypoxemia, prolonged mechanical ventilation, atelectasis, and respiratory failure, all of which contribute to increased morbidity, extended hospital stay, and elevated healthcare costs [1-3].

The perioperative period represents a vulnerable phase for patients with chronic respiratory diseases. Anesthetic agents, airway manipulation, and mechanical ventilation can provoke inflammatory responses and alter bronchial tone. In asthmatic individuals, these physiological alterations are further amplified by underlying airway hyperreactivity and immune dysregulation. Recent clinical observations have indicated that systemic inflammatory activity during the perioperative period plays a pivotal role in the development of respiratory complications after anesthesia. Consequently, identification of biomarkers capable of

reflecting inflammatory status before surgery has gained increasing importance for risk stratification in susceptible patients [4-5].

In recent years, attention has been directed toward simple hematological indices derived from routine complete blood counts as potential predictors of clinical outcomes. Among these markers, the neutrophil-lymphocyte ratio has emerged as a reliable indicator of systemic inflammation. The NLR reflects the balance between neutrophil-mediated innate immune activation and lymphocyte-dependent adaptive immune regulation. Elevation of this ratio indicates heightened inflammatory activity combined with relative lymphocytic suppression, both of which are commonly observed in physiological stress and inflammatory diseases. Because neutrophil and lymphocyte counts are routinely measured in clinical practice, the NLR provides a convenient and cost-effective tool for evaluating inflammatory status without requiring specialized laboratory testing [6-9].

Increasing evidence suggests that elevated NLR values are associated with adverse outcomes in various medical conditions, including cardiovascular diseases, malignancies, infections, and respiratory disorders. Recent studies conducted in critically ill populations have demonstrated that higher NLR values correlate with increased severity of systemic inflammation and poorer clinical prognosis. In respiratory medicine, the NLR has also been investigated as a marker of disease activity in asthma and chronic obstructive pulmonary disease. Elevated NLR levels have been reported in patients experiencing acute asthma exacerbations, indicating that systemic inflammatory responses accompany airway inflammation in these individuals [10-12].

Perioperative inflammatory responses represent another important clinical context in which NLR may provide valuable predictive information. Surgical trauma and anesthesia induce immune activation characterized by neutrophilia and relative lymphocyte suppression. This inflammatory cascade may influence postoperative recovery and contribute to the development of complications, particularly in patients with preexisting respiratory conditions. Several recent investigations have demonstrated that elevated preoperative NLR levels may predict postoperative complications such as infections, cardiovascular events, and respiratory dysfunction. However, the specific role of NLR in predicting post-anesthesia respiratory complications among asthmatic ICU patients remains insufficiently explored.

Critically ill asthmatic patients admitted to intensive care units following surgical procedures represent a particularly high-risk population. These individuals frequently present with severe airway inflammation, impaired pulmonary reserve, and heightened susceptibility to perioperative stress. In this context, early identification of patients at increased risk for respiratory complications is essential to enable proactive clinical management. Predictive biomarkers capable of guiding perioperative monitoring and respiratory support strategies may significantly improve patient outcomes and reduce the burden on critical care resources.

Although several inflammatory markers have been investigated for predicting postoperative complications, many require complex laboratory assays or incur significant costs, limiting their routine clinical applicability. The neutrophil-lymphocyte ratio offers a practical alternative due to its accessibility, affordability, and rapid availability from standard blood tests. Moreover, its ability to reflect systemic immune responses makes it particularly relevant for conditions in which inflammation plays a central role, such as asthma.

Recent advances in perioperative medicine emphasize the importance of personalized risk assessment and targeted monitoring strategies. Integrating inflammatory biomarkers into perioperative evaluation may enhance clinicians' ability to anticipate complications and tailor management accordingly. For asthmatic patients undergoing anesthesia, this approach could facilitate early implementation of preventive interventions such as optimized bronchodilator therapy, intensified respiratory monitoring, and timely ventilatory support.

Despite the growing recognition of NLR as a prognostic marker in several clinical settings, limited evidence currently exists regarding its predictive significance for respiratory complications in asthmatic patients admitted to intensive care units after anesthesia. Most available studies have focused on general surgical populations rather than individuals with preexisting airway disease. Consequently, an important gap remains in understanding whether systemic inflammatory markers such as NLR can effectively identify asthmatic patients at elevated risk during the immediate postoperative period.

The present study was designed to investigate the predictive value of the neutrophil-lymphocyte ratio in post-anesthesia respiratory complications among ICU patients with asthma. By evaluating the association between preoperative NLR levels and postoperative respiratory outcomes, the study aims to determine whether this readily available biomarker can serve as an effective tool for early risk stratification in critical care settings. The findings may contribute to improved perioperative assessment strategies and support the integration of inflammatory markers into clinical decision-making for patients with asthma undergoing surgical procedures.

MATERIAL AND METHODS

An observational analytical study was conducted at Liaquat National Medical College and Hospital over a period of twelve months. The study population consisted of adult patients with a confirmed diagnosis of asthma who underwent surgical procedures under general anesthesia and required postoperative ICU monitoring. Ethical approval was obtained from the institutional review committee prior to initiation of the study. All participants or their legally authorized representatives provided verbal informed consent after receiving a detailed explanation regarding the purpose of the research, confidentiality of information, and voluntary nature of participation.

Sample size was calculated using OpenEpi software by applying a two-sided confidence level of 95%, statistical power of 80%, and an anticipated proportion of postoperative respiratory complications of 30% among asthmatic surgical patients based on recent clinical observations. The calculated minimum sample size was 108 participants; however, to increase statistical power and compensate for potential missing data, a total of 120 patients were enrolled using consecutive sampling.

Patients were categorized into two groups based on the occurrence of respiratory complications within 48 hours following anesthesia. Group A included patients who developed postoperative respiratory complications such as bronchospasm, oxygen desaturation requiring ventilatory support, respiratory distress, atelectasis, or prolonged mechanical ventilation. Group B consisted of patients who did not develop such complications during the same postoperative period.

Adult patients aged between 18 and 70 years with previously diagnosed asthma and scheduled for elective or emergency surgery under general anesthesia were included. Patients with active systemic infections, hematological disorders, chronic inflammatory diseases other than asthma, malignancy, immunosuppressive therapy, chronic kidney disease, or recent steroid pulse therapy were excluded to avoid confounding effects on inflammatory biomarkers.

Demographic data including age, sex, body mass index, smoking history, asthma severity classification, and type of surgical procedure were recorded. Preoperative blood samples were obtained within 24 hours prior to surgery for complete blood count analysis. Absolute neutrophil and lymphocyte counts were measured using an automated hematology analyzer, and the neutrophil-lymphocyte ratio was calculated by dividing neutrophil count by lymphocyte count. Perioperative variables including duration of surgery, type of anesthesia, and need for mechanical ventilation were also documented.

Postoperative monitoring was performed in the ICU for at least 48 hours. Respiratory complications were identified based on clinical evaluation, oxygen saturation monitoring, arterial blood gas analysis, and chest radiographic findings when indicated. All collected data were entered into a structured data sheet and analyzed using statistical software. Continuous variables were expressed as mean and standard deviation, while categorical variables were presented as frequencies and percentages. Independent sample t-tests were applied to compare mean values between groups, and chi-square tests were used for categorical data. Multivariate logistic regression analysis was performed to determine the independent predictive role of NLR after adjusting for potential confounding factors. A p-value of less than 0.05 was considered statistically significant.

RESULTS

Table 1: Demographic and Clinical Characteristics of Study Participants

Variable	Complication Group (n=42) Mean ± SD	Non-Complication Group (n=78) Mean ± SD	p-value
Age (years)	54.3 ± 9.1	48.6 ± 10.2	0.004
BMI (kg/m^2)	28.7 ± 3.4	26.9 ± 3.1	0.012
Duration of surgery (minutes)	124 ± 32	98 ± 28	<0.001
Asthma duration (years)	11.5 ± 4.2	9.3 ± 3.8	0.018

Explanation: Patients who developed postoperative respiratory complications were significantly older and had longer surgical durations compared with those without complications.

Table 2: Comparison of Hematological Inflammatory Markers

Parameter	Complication Group Mean ± SD	Non-Complication Group Mean ± SD	p-value
Neutrophil count (×10^9/L)	7.9 ± 1.6	5.8 ± 1.4	<0.001
Lymphocyte count (×10^9/L)	1.18 ± 0.34	1.73 ± 0.41	<0.001
Neutrophil-Lymphocyte Ratio	6.8 ± 1.9	3.4 ± 1.2	<0.001

Explanation: The complication group demonstrated significantly higher neutrophil counts and NLR values with reduced lymphocyte counts, indicating stronger systemic inflammatory responses.

Table 3: Predictive Performance of NLR for Respiratory Complications

Parameter	Value
Optimal NLR cutoff	4.9
Sensitivity	82%
Specificity	78%
Odds ratio	3.7
p-value	<0.001

Explanation: Receiver operating characteristic analysis demonstrated that an NLR value greater than 4.9 significantly predicted postoperative respiratory complications with high sensitivity and specificity.

DISCUSSION

Postoperative respiratory complications remain a major concern in patients with asthma undergoing anesthesia, particularly in critical care settings. The current investigation evaluated the predictive value of the neutrophil-lymphocyte ratio as an indicator of systemic inflammation associated with adverse respiratory outcomes. The findings demonstrated that patients who developed respiratory complications exhibited significantly elevated preoperative NLR values compared with those who experienced uncomplicated postoperative recovery. This observation suggests that systemic inflammatory status prior to surgery may play an important role in determining postoperative respiratory stability among asthmatic individuals [13-15].

Elevated neutrophil counts observed in the complication group may reflect intensified inflammatory activity triggered by chronic airway disease and perioperative physiological stress. Neutrophils are known to participate actively in inflammatory cascades through the release of proteolytic enzymes, cytokines, and reactive oxygen species. These mediators contribute to airway epithelial injury, increased bronchial hyperresponsiveness, and impaired mucociliary clearance. Consequently, excessive neutrophilic activation may predispose patients to bronchospasm and other respiratory disturbances during the postoperative period [16].Post-anesthesia respiratory complications remain a clinically significant challenge in patients with pre-existing airway diseases, particularly asthma. The perioperative period involves a complex interaction of physiological stress responses, inflammatory activation, and airway mechanical alterations, all of which may precipitate respiratory instability. The present investigation further strengthens the evidence that systemic inflammatory status, as reflected by the neutrophil–lymphocyte ratio, has a substantial relationship with the development of postoperative respiratory complications in asthmatic patients admitted to intensive care units. The elevated NLR values observed among patients who experienced respiratory complications emphasize the potential of this simple hematological parameter as a surrogate marker of perioperative immune dysregulation. Asthma is characterized by chronic airway inflammation that involves multiple immune pathways including neutrophilic and eosinophilic inflammatory responses. During the perioperative period, exposure to anesthetic drugs, airway instrumentation, and mechanical ventilation can intensify inflammatory cascades already present in asthmatic airways. Surgical stress is known to stimulate sympathetic nervous system activation and endocrine responses that alter immune cell distribution in the circulation. These responses typically produce neutrophilia and relative lymphopenia, resulting in an increased neutrophil–lymphocyte ratio. Such systemic inflammatory shifts may amplify airway reactivity, increase mucosal edema, and impair pulmonary gas exchange, thereby contributing to postoperative respiratory deterioration.

The results of the present study demonstrate that patients with respiratory complications exhibited significantly higher neutrophil counts and lower lymphocyte counts compared with those without complications. This pattern reflects a systemic inflammatory environment that may exacerbate airway instability during the postoperative period. Neutrophils play a critical role in the pathogenesis of airway inflammation by releasing proteases, inflammatory cytokines, and reactive oxygen species. These mediators contribute to epithelial damage, mucus hypersecretion, and bronchial hyperresponsiveness. Consequently, elevated neutrophil activity may intensify bronchospasm and airway obstruction in susceptible patients following anesthesia.

Simultaneously, the reduction in lymphocyte counts observed among patients with complications may indicate suppression of adaptive immune responses during acute physiological stress. Lymphopenia has been widely recognized as a marker of systemic stress and inflammatory imbalance. When neutrophilia occurs in combination with lymphocyte depletion, the resulting increase in the neutrophil-lymphocyte ratio represents a more comprehensive reflection of immune dysregulation than individual leukocyte parameters alone. This combined indicator therefore provides greater predictive accuracy for

inflammatory complications [17-18].In contrast, the reduction in lymphocyte counts observed among patients who developed complications may indicate suppression of adaptive immune responses during physiological stress. Lymphocytes are essential for maintaining immune regulation and preventing excessive inflammatory activity. Stress-induced lymphopenia has been documented in critically ill individuals and is frequently associated with adverse outcomes. The imbalance between neutrophil activation and lymphocyte suppression therefore provides a plausible explanation for the higher NLR values observed in patients experiencing respiratory complications. This imbalance may represent an early indicator of inflammatory dysregulation before clinical deterioration becomes evident.

Another important finding emerging from the present analysis is the predictive performance of NLR as demonstrated by receiver operating characteristic analysis. The identified cutoff value showed relatively high sensitivity and specificity for predicting postoperative respiratory complications. Such predictive accuracy suggests that NLR may serve as a valuable screening parameter during preoperative evaluation of asthmatic patients. Early identification of individuals at elevated risk may facilitate implementation of preventive strategies including intensified respiratory monitoring, optimization of bronchodilator therapy, and early physiotherapeutic interventions aimed at maintaining airway patency and lung expansion.Age-related differences observed in the demographic analysis further support the multifactorial nature of postoperative respiratory risk. Advanced age was significantly associated with a greater incidence of complications, which may reflect the cumulative effects of reduced pulmonary compliance, weakened respiratory muscles, and diminished immune responsiveness. Aging is also associated with alterations in inflammatory regulation, often referred to as inflammaging, characterized by persistent low-grade systemic inflammation. When combined with surgical stress and pre-existing airway disease, these physiological changes may increase susceptibility to postoperative respiratory events.

The duration of surgery also demonstrated a statistically significant association with respiratory complications. Prolonged operative time typically results in extended exposure to anesthetic agents and mechanical ventilation, both of which may influence pulmonary function. Mechanical ventilation can contribute to alveolar collapse, impaired mucociliary clearance, and ventilation-perfusion mismatch, particularly in patients with reactive airways. Additionally, longer surgical procedures may provoke stronger systemic inflammatory responses due to greater tissue trauma. The interaction between operative stress and pre-existing airway inflammation may therefore explain the higher complication rates observed among patients undergoing longer surgeries.

The clinical implications of these findings are substantial, particularly within intensive care environments where early recognition of deteriorating respiratory status is critical. The neutrophil–lymphocyte ratio provides a rapid and inexpensive tool that can be easily integrated into routine preoperative laboratory assessment. Unlike more complex inflammatory biomarkers that require specialized assays, NLR is derived from standard complete blood count measurements available in virtually all healthcare settings. This accessibility enhances its potential utility as a screening tool for perioperative risk assessment in resource-limited as well as advanced medical facilities.Integration of inflammatory biomarkers into perioperative evaluation represents an evolving area of clinical research. Increasing emphasis has been placed on identifying objective parameters capable of predicting complications before clinical manifestations occur. Traditional risk assessment tools often rely on demographic and clinical variables but may not fully capture the underlying inflammatory processes that influence postoperative recovery. The incorporation of hematological inflammatory indices such as NLR may therefore enhance predictive models by providing insight into systemic immune activity.

Another relevant consideration involves the potential role of NLR in guiding postoperative management decisions. Patients presenting with elevated preoperative NLR values may benefit from closer postoperative surveillance, including continuous oxygen saturation monitoring and early pulmonary rehabilitation strategies. Additionally, clinicians may consider adjusting anesthetic techniques or perioperative medication regimens to minimize airway irritation and inflammatory activation in high-risk individuals. By identifying vulnerable patients before complications develop, NLR-based risk stratification may contribute to improved patient outcomes and reduced healthcare resource utilization.The study findings also support the broader concept that systemic inflammation plays a central role in postoperative respiratory complications. Inflammatory mediators released during surgical stress may influence pulmonary vascular permeability, airway smooth muscle tone, and immune cell recruitment to lung tissues. These processes may culminate in bronchospasm, hypoxemia, and impaired gas exchange. By serving as an indirect measure of inflammatory activity, the neutrophil–lymphocyte ratio provides valuable insight into these underlying mechanisms.

Despite the promising results observed in this investigation, several factors should be considered when interpreting the clinical significance of NLR. Systemic inflammatory markers may be influenced by a variety of physiological conditions including infections, metabolic disorders, and medication effects. Although

efforts were made to exclude patients with confounding inflammatory conditions, residual influences cannot be entirely eliminated. Nevertheless, the consistent association between elevated NLR and respiratory complications suggests that this marker retains predictive value even within complex clinical environments.

Future research may further explore the role of NLR in combination with other inflammatory indices to enhance predictive accuracy. Composite biomarkers incorporating platelet counts, C-reactive protein levels, or other immune cell ratios may provide a more comprehensive assessment of inflammatory status. In addition, prospective multicenter studies involving larger patient populations may help validate the optimal cutoff values for NLR and determine whether its predictive performance remains consistent across different surgical specialties and healthcare settings. Another potential direction for investigation involves examining the dynamic changes in NLR during the perioperative period. Monitoring trends in inflammatory markers before and after surgery may provide additional insights into the evolution of systemic immune responses and their relationship with clinical outcomes. Such longitudinal analysis could identify critical time points at which inflammatory activity becomes predictive of respiratory deterioration, thereby guiding the timing of preventive interventions.

Overall, the extended findings presented in this study reinforce the clinical relevance of systemic inflammatory markers in perioperative risk assessment. The neutrophil–lymphocyte ratio demonstrates strong potential as an accessible biomarker capable of identifying asthmatic patients at increased risk for post-anesthesia respiratory complications. By reflecting the balance between innate inflammatory activation and adaptive immune suppression, this ratio provides meaningful insight into the physiological processes that influence postoperative recovery.

The incorporation of NLR into routine perioperative evaluation may represent a practical step toward more personalized clinical management strategies for patients with asthma. Through early identification of high-risk individuals, healthcare providers may implement targeted monitoring and therapeutic measures designed to reduce respiratory morbidity. Continued investigation into inflammatory biomarkers will likely contribute to the development of more refined predictive models capable of improving outcomes in surgical patients with chronic respiratory diseases

The statistical analysis revealed that NLR values were markedly higher in the complication group, and the difference remained significant after adjustment for potential confounding factors such as age and operative duration. This finding highlights the independent predictive role of NLR in identifying patients at risk for postoperative respiratory deterioration. The calculated cutoff value of 4.9 demonstrated strong sensitivity and specificity, indicating that this threshold may be clinically useful for early risk stratification in perioperative care [19-20].

Recent clinical investigations conducted between 2021 and 2024 have increasingly emphasized the importance of inflammatory biomarkers in predicting perioperative outcomes. Systemic inflammatory indices derived from hematological parameters have been associated with complications across multiple surgical specialties. The results of the present study extend this growing body of evidence by specifically examining asthmatic patients in intensive care environments, a population that has received comparatively limited attention in previous research.

Another important observation from the demographic analysis was the association between advanced age and increased incidence of respiratory complications. Older patients frequently exhibit diminished pulmonary reserve, altered immune responses, and higher prevalence of comorbidities, all of which may contribute to increased vulnerability during the perioperative period. Additionally, prolonged surgical duration was identified as a significant factor associated with complications, likely reflecting extended exposure to anesthetic agents and mechanical ventilation.

The findings of this study highlight the clinical advantages of utilizing NLR as a predictive biomarker. Because the ratio is derived from routine laboratory tests, it can be obtained rapidly without additional financial burden. Early identification of high-risk patients may enable clinicians to implement targeted preventive measures, including intensified respiratory monitoring, optimization of bronchodilator therapy, and early physiotherapeutic interventions. Such strategies may reduce postoperative morbidity and improve recovery among asthmatic surgical patients.

Despite the promising results, certain considerations should be acknowledged when interpreting the findings. Inflammatory markers may be influenced by multiple physiological and pathological factors, and the predictive performance of NLR may vary across different patient populations. Nonetheless, the consistent association between elevated NLR and postoperative respiratory complications observed in this investigation underscores the potential value of this marker in perioperative clinical assessment.

Overall, the study contributes important evidence supporting the integration of systemic inflammatory markers into risk evaluation models for asthmatic patients undergoing anesthesia. By providing an accessible and reliable indicator of perioperative inflammatory status, the neutrophil-lymphocyte ratio

may enhance clinical decision-making and support the development of more individualized perioperative management strategies.

CONCLUSION

Elevated preoperative neutrophil-lymphocyte ratio was significantly associated with the development of post-anesthesia respiratory complications among ICU patients with asthma. The findings demonstrate that NLR serves as a practical and cost-effective biomarker for early risk stratification in the perioperative period. Incorporation of NLR into clinical assessment protocols may improve preventive management strategies and guide future research focusing on inflammation-based prediction models.

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