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Original Research Article

Neutrophil–Lymphocyte Ratio, Platelet–Lymphocyte Ratio, and Lymphocyte–Monocyte Ratio in Predicting Systemic Inflammatory Response Syndrome and Sepsis after Percutaneous Nephrolithotomy

Archanraj Darji[1], Hotilal Gupta[2], Manish Gupta[3], Subhash Jat[4], Ashish Sharma[5], Trilokchand Sadasukhi[6], Nripesh Sadasukhi[7], Bhumi Chauhan[8]

[1,2,3,4,5,6,7]Department of Urology, MGMCH, Jaipur

[8]Deprtment of Anesthesia, Index Medical College, Indore

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Corresponding Author: Dr. Archanraj Darji

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Abstract:

Background: Percutaneous nephrolithotomy (PCNL) is a common surgical procedure for removing kidney stones larger than 2 cm. Postoperative complications such as systemic inflammatory response syndrome (SIRS) and sepsis are significant concerns. Biomarkers like neutrophil–lymphocyte ratio (NLR), platelet–lymphocyte ratio (PLR), and lymphocyte–monocyte ratio (LMR) may help to predict these complications.

Methods: In this prospective observational study, 100 patients undergoing PCNL were evaluated. Preoperative NLR, PLR, and LMR were calculated from routine blood tests. Stone characteristics and intraoperative factors were recorded. Postoperative SIRS and sepsis were defined using standard criteria. Statistical analyses included univariate and multivariate analyses to identify predictors of SIRS and sepsis.

Results: Out of 100 patients, 11% developed SIRS and 4% developed sepsis post-PCNL. Patients with SIRS had significantly lower hemoglobin levels, higher total leukocyte counts, higher NLR and PLR, and lower LMR ($p < 0.05$). Staghorn stones and longer operative times were also associated with increased risk of SIRS. On multivariate analysis, elevated preoperative TLC, NLR, PLR, and low LMR were independent predictors of SIRS. ROC analysis identified optimal cut-off values for NLR (>2.03), PLR (>110.62), and LMR (<3.23) in predicting SIRS.

Conclusion: Preoperative NLR, PLR, and LMR are independent, accessible, and cost-effective biomarkers for early identification of patients at risk of post-PCNL SIRS and sepsis. Patients exceeding these cut-off values should be monitored closely for postoperative infective complications.

Keywords: Neutrophil–lymphocyte ratio, Platelet–lymphocyte ratio, Lymphocyte–monocyte ratio, percutaneous nephrolithotomy, Systemic inflammatory response syndrome, Sepsis.

Introduction

Percutaneous nephrolithotomy (PCNL) is the preferred surgical intervention for the management of upper urinary tract calculi larger than 2 cm and selected cases of smaller stones [1]. Despite its efficacy, PCNL carries the risk of postoperative complications, particularly infectious ones such as systemic inflammatory response syndrome (SIRS) and sepsis [2]. Sepsis remains a leading cause of perioperative mortality following PCNL, with reported urosepsis rates ranging from 0.9% to 4.7% [3,4].

Several risk factors have been identified for post-PCNL SIRS and sepsis, including female gender, diabetes mellitus, and presence of pyuria, larger stone burden, staghorn stones, infected stones, positive pelvic urine cultures, and the use of nephrostomy tubes [5–8]. However, there remains a need for reliable, easily accessible, and cost-effective biomarkers to predict these complications preoperatively. Recent studies have highlighted the potential of hematological ratios such as the neutrophil–lymphocyte ratio (NLR), platelet–lymphocyte ratio (PLR), and lymphocyte–monocyte ratio (LMR) as indicators of systemic inflammation and predictors of outcomes in various medical conditions [9–12].

These ratios, derived from routine complete blood counts, have been associated with prognostic implications in malignancies [13], cardiovascular diseases [14], and metabolic syndromes [15]. In the context of urology, elevated NLR, PLR, and decreased LMR have been associated with urinary tract infections and stone formation [16]. The inflammatory response induced by kidney stones can lead to alterations in these hematological parameters, potentially serving as predictive markers for postoperative infectious complications.

This study aims to assess the clinical significance of preoperative NLR, PLR, and LMR as potential biomarkers for predicting post-PCNL SIRS and sepsis. By identifying patients at higher risk, proactive measures can be implemented to mitigate postoperative complications, ultimately improving patient outcomes.

Materials and Methods

Study Design and Population: This prospective observational study was conducted in the Department of Urology at Mahatma Gandhi Hospital and Medical College, Jaipur, over six months. Institutional ethical committee approval was obtained (No. 2022/1124, dated 26/10/2022), and informed consent was secured from all participants.

A total of 100 patients scheduled for PCNL were randomly selected. Inclusion criteria encompassed all patients undergoing PCNL. Exclusion criteria included patients opting for medical management and those with significant medical illnesses increasing anesthetic risk.

Data Collection: Preoperative demographic data collected included age, gender, body mass index (BMI), comorbidities (hypertension, diabetes mellitus), and history of previous PCNL. Laboratory investigations included hemoglobin (Hb), total leukocyte count (TLC), and serum creatinine levels.

The NLR, PLR, and LMR were calculated by dividing the absolute counts of neutrophils, platelets, lymphocytes, and monocytes obtained from routine complete blood counts performed one day prior to surgery. Stone characteristics such as location, volume, Hounsfield unit (HU), and presence of staghorn stones were assessed using non-contrast computed tomography (NCCT) or intravenous pyelography (IVP). Intraoperative factors recorded included puncture site (supracostal or infracostal), tract size and number, operative time, need for blood transfusion, stone clearance status, and use of ureteral stent or nephrostomy tube.

Operative Procedure: All patients underwent standard prone PCNL under general anesthesia. Intravenous third-generation cephalosporin was administered at induction. The procedure was performed using fluoroscopic guidance, with tract dilation as necessary. Postoperative management included monitoring vital signs, laboratory parameters, and providing analgesia with parenteral tramadol.

Outcome Measures: Postoperative complications were recorded using the modified Clavien–Dindo grading system [12]. SIRS was defined based on the presence of two or more criteria: body temperature >38°C or <36°C, heart rate >90 beats/min, respiratory rate >20 breaths/min, and white blood cell count $>12\times10^9$/L or $<4\times10^9$/L. Sepsis was defined as SIRS plus a positive postoperative blood or urine culture [13].

Statistical Analysis: Data were analyzed using appropriate statistical methods. Continuous variables were expressed as mean ± standard deviation. Univariate and multivariate logistic regression analyses were performed to identify predictors of post-PCNL SIRS and sepsis. Receiver operating characteristic (ROC) curves were generated to determine optimal cut-off values for NLR, PLR, and LMR. A p-value <0.05 was considered statistically significant.

Results

Patient Characteristics: A total of 100 patients with a mean age of 46.91 ± 15.01 years were included in the study. Of these, 77% were male and 23% were female. Postoperatively, 11 patients (11%) developed SIRS, and 4 patients (4%) developed sepsis.

Preoperative Findings: Patients who developed SIRS had significantly lower preoperative hemoglobin levels (11.89 ± 2.12 g/dL vs. 13.43 ± 1.90 g/dL, p = 0.03) and higher TLC (10.3 ± 1.9 ×10³/mm^3 vs. 8.4 ± 2.8 ×10³/mm^3, p < 0.001) compared to those without SIRS. NLR and PLR were significantly higher in the SIRS group (NLR: 3.7 ± 2.4 vs. 2.49 ± 1.1, p < 0.001; PLR: 130.31 ± 58.52 vs. 116.78 ± 69.56, p < 0.001), while LMR was lower (2.8 ± 1.8 vs. 3.4 ± 1.6, p < 0.01).

Stone Characteristics and Operative Findings: Staghorn stones were more prevalent in patients who developed SIRS (13% vs. 4%, p < 0.01). Operative time was longer in the SIRS group (58.89 ± 15.34 minutes vs. 56.10 ± 17.26 minutes, p < 0.05). Length of hospital stay was significantly increased in patients with SIRS (3.4 ± 1.81 days vs. 2.28 ± 1.70 days, p < 0.01).

Predictors of Postoperative SIRS and Sepsis: Univariate and multivariate logistic regression analyses identified elevated preoperative TLC, NLR, PLR, and decreased LMR as independent predictors of postoperative SIRS (Table 2). History of previous ipsilateral PCNL was also an independent risk factor (p = 0.02). For sepsis, high BMI (p = 0.04), diabetes mellitus (p < 0.05), high stone density (HU), and low LMR (p < 0.05) were significant predictors.

ROC Analysis: ROC curve analysis determined the optimal cut-off values for predicting postoperative SIRS: NLR >2.03 (sensitivity 63.6%, specificity 80.89%), PLR >110.62 (sensitivity 81.8%, specificity 73%), and LMR <3.23 (sensitivity 27.3%, specificity 43.8%) (Figure 1). For predicting sepsis, the cut-off values were NLR >2.45, PLR >120.25, and LMR <2.88 (Figure 2).

Postoperative Outcomes: All patients with sepsis were managed with intravenous antibiotics based on culture sensitivity. None required intensive care support. The presence of sepsis significantly increased the length of hospital stay (3.51 ± 1.89 days vs. 2.48 ± 1.68 days, p = 0.0001).

Table 1: Demographic and Clinical Characteristics of Patients with and Without Postoperative Sirs

Variable	SIRS− (n=89)	SIRS+ (n=11)	p-value
Age (years)	46.58 ± 15.61	46.4 ± 13.37	0.97
Male (%)	69 (89.61%)	8 (10.39%)	0.75
Female (%)	20 (86.95%)	1 (13.05%)	
BMI (kg/m²)	24.31 ± 2.61	24.71 ± 2.21	0.82
Hemoglobin (g/dL)	13.43 ± 1.90	11.89 ± 2.12	0.03*
TLC (×10³/mm³)	8.4 ± 2.8	10.3 ± 1.9	<0.001*
NLR	2.49 ± 1.1	3.7 ± 2.4	<0.001*
PLR	116.78 ± 69.56	130.31 ± 58.52	<0.001*
LMR	3.4 ± 1.6	2.8 ± 1.8	<0.01*
Staghorn stones (%)	4%	13%	<0.01*
Operative time (minutes)	56.10 ± 17.26	58.89 ± 15.34	<0.05*
Length of hospital stay (days)	2.28 ± 1.70	3.4 ± 1.81	<0.01*

***Significant p-value.**

Table 2: Univariate and Multivariate Analyses for Predictors of Post-PCNL Sirs

Variable	Univariate OR (95% CI)	p-value	Multivariate OR (95% CI)	p-value
Hemoglobin	0.91 (0.74–1.09)	0.03*	0.88 (0.68–1.14)	0.06
TLC	1.21 (1.12–1.31)	<0.001*	1.26 (1.01–1.51)	<0.01*
NLR	1.33 (1.06–1.80)	<0.001*	1.71 (1.29–2.32)	<0.001*
PLR	1.004 (1.00–1.008)	0.005*	1.009 (1.004–1.013)	0.006*
LMR	1.22 (1.08–1.36)	0.005*	1.29 (1.05–1.43)	0.001*
History of previous PCNL	1.9 (0.56–4.89)	0.28	1.14 (0.48–1.63)	0.02*

***Significant p-value.**

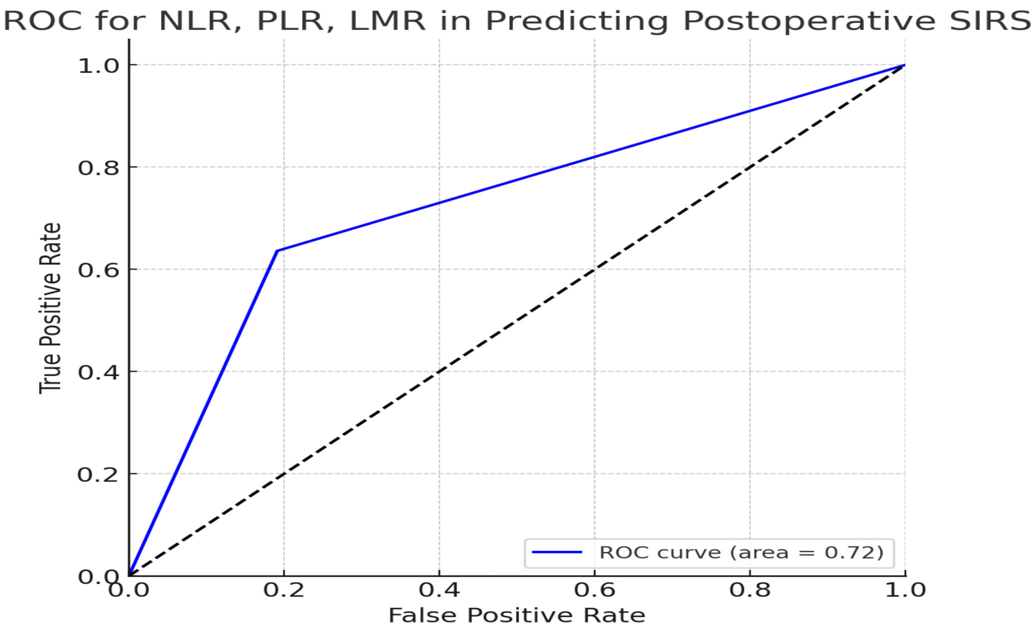

Figure 1: Roc Curves for NLR, PLR, and LMR in Predicting Postoperative Sirs

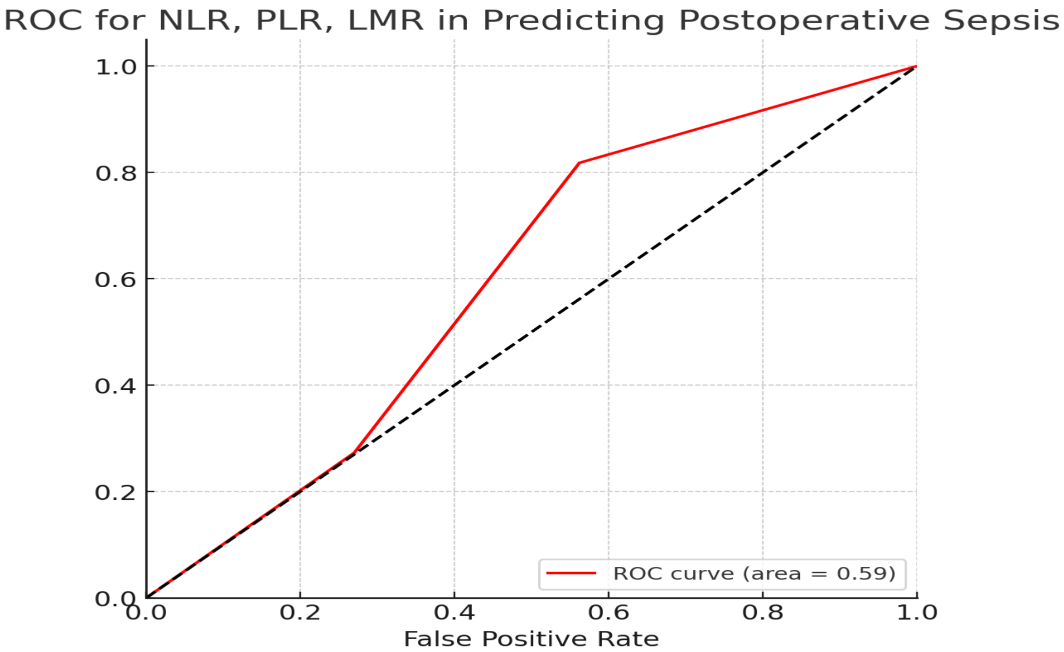

Figure 2: Roc Curves for NLR, PLR, and LMR in Predicting Postoperative Sepsis

Discussion

Postoperative infectious complications remain a significant concern following PCNL, with SIRS and sepsis contributing to morbidity and mortality [14]. In our study, the incidence of SIRS was 11%, which is lower than previously reported rates ranging from 16.7% to 27.4% [2,7,16]. This reduction may be attributed to strict preoperative urine sterilization protocols.

Our findings demonstrate that preoperative hematological ratios—specifically NLR, PLR, and LMR—are valuable predictors of post-PCNL SIRS and sepsis. Elevated NLR and PLR, along with decreased LMR, indicate an ongoing inflammatory response, aligning with the systemic inflammatory milieu associated with urolithiasis. These ratios have been previously utilized as prognostic markers in various conditions, including malignancies, inflammatory disorders, and cardiovascular diseases.

The pathophysiology behind these associations may involve the release of inflammatory mediators such as interleukins and tumor necrosis factor-alpha, which contribute to neutrophil proliferation and lymphocyte suppression. Platelets, rich in pro-inflammatory agents, further exacerbate the inflammatory response, while monocytes play a critical role in systemic inflammation. In our cohort, staghorn stones and longer operative times were significantly associated with increased risk of SIRS. Staghorn stones often harbour bacteria, making complete preoperative sterilization challenging and increasing the risk of postoperative infection. Longer operative times may lead to increased irrigation pressures and absorption of irrigation fluids, facilitating bacterial translocation. Comparatively, other studies have identified similar risk factors for postoperative SIRS, including low preoperative hemoglobin, diabetes mellitus, and complex stone burden. However, factors such as stone size, number of tracts, and intraoperative blood transfusion were not significant predictors in our study, suggesting variability in predictive factors across different populations.

The utilization of NLR, PLR, and LMR as cost-effective and readily available biomarkers offers a practical approach for risk stratification. Unlike other biomarkers such as C-reactive protein or procalcitonin, which may incur additional costs, hematological ratios can be easily derived from routine blood counts.

Our ROC analysis identified specific cut-off values for NLR, PLR, and LMR, which can aid in clinical decision-making. Patients exceeding these thresholds should be closely monitored for early signs of infection and may benefit from prophylactic interventions.

Limitations of our study include the single-center design and relatively small sample size. Additionally, the variability in cut-off values reported across studies highlights the need for standardized thresholds [15]. Future multicenter prospective studies with larger cohorts are necessary to validate these findings and establish universally accepted cut-off values.

Conclusion

The pathogenesis of postoperative infection following PCNL is multifactorial. Preoperative NLR, PLR, and LMR serve as independent, accessible, and cost-effective predictors of post-PCNL SIRS and sepsis. Patients with NLR >2.03, PLR >110.62, and LMR <3.23 are at increased risk and should be monitored closely for early detection of infective complications. Incorporating these hematological ratios into preoperative assessment can enhance risk stratification and improve patient outcomes. Further large-scale studies are warranted to validate these findings and refine the predictive accuracy of these biomarkers.

Declarations

Ethical Approval: The study was conducted in accordance with the ethical standards of the institutional and national research committee and with the 1964 Helsinki Declaration and its later amendments. Institutional ethical committee approval was obtained (No. 2022/1124).

Informed Consent: Informed consent was obtained from all individual participants included in the study.

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