Systemic Immune-Inflammation Index and Neutrophil-to-Platelet Ratio as Predictors of Intensive Care Requirement and Hospital Stay in Acute Obstructive Pyelonephritis Requiring Percutaneous Nephrostomy

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Purpose: There is a growing need for rapid, simple, and cost-effective biomarkers that facilitate early risk stratification in patients with severe upper urinary tract infections. This study aimed to investigate whether the systemic immune-inflammation index (SII) and neutrophil-to-platelet ratio (NPR) at hospital admission can predict the need for intensive care unit (ICU) admission and the duration of hospitalization in patients with acute obstructive pyelonephritis managed with percutaneous nephrostomy.

Materials and Methods: Patients aged ≥18 years who were hospitalized with acute obstructive pyelonephritis and underwent emergency percutaneous nephrostomy between June 19, 2020, and July 30, 2025, were evaluated retrospectively. A comparative analysis was conducted between patients who required ICU admission and those who did not. Admission SII and NPR were calculated, and their associations with ICU requirement and length of hospital stay were analyzed using multivariable logistic and linear regression models, receiver operating characteristic curves, and the Youden index.

Results: A total of 440 patients were analyzed, of whom 29 required ICU care. Patients requiring ICU admission exhibited significantly higher median SII, NPR, leukocyte counts, neutrophil counts, and procalcitonin levels, along with lower hemoglobin and lymphocyte concentrations. In multivariable logistic regression adjusted for class imbalance, elevated SII independently predicted ICU admission (odds ratio, 1.70; 95% confidence interval, 1.34–2.17; $P < .001$). Admission SII was positively associated with the duration of hospital stay ($\beta = 0.184$; $P < .001$).

Conclusion: SII represents an accessible, cost-effective biomarker for early identification of patients at heightened risk of clinical deterioration requiring ICU transfer and prolonged hospitalization in acute obstructive pyelonephritis.

Keywords: biomarkers; intensive care units; nephrostomy, percutaneous; pyelonephritis; systemic immune-inflammation index

INTRODUCTION

Obstructive pyelonephritis represents an acute urological emergency characterized by upper urinary tract infection occurring in the setting of mechanical urinary tract obstruction, most commonly secondary to ureteral calculi. In this setting, the coexistence of severe infection and high-pressure obstruction can rapidly progress to urosepsis, septic shock, and multiorgan dysfunction syndrome if not recognized and decompressed promptly. Urosepsis accounts for approximately 25% of all sepsis presentations, with obstructive uropathy recognized as the primary underlying etiology in a substantial proportion of patients.[1] Urgent decompression of the renal collecting system via retrograde ureteral stent placement or percutaneous nephrostomy, administered in conjunction with prompt broad-spectrum intravenous antimicrobial therapy, constitutes the cornerstone of clinical management. This timely therapeutic strategy is associated with reduced mortality, decreased length of hospitalization, and improved overall outcomes in acute obstructive pyelonephritis complicated by sepsis.[2]

Systemic inflammatory biomarkers have gained substantial clinical attention as readily accessible, minimally invasive, and cost-effective instruments for risk stratification in critically ill individuals. Among these, the Systemic Immune-Inflammation Index (SII)—calculated from peripheral neutrophil, lymphocyte, and platelet counts—and the neutrophil-to-platelet ratio (NPR) have demonstrated robust prognostic utility across sepsis, acute kidney injury, and various severe systemic infections.[3] Recent investigations and meta-analyses indicate that an elevated admission SII correlates with higher short-term mortality and an increased likelihood of progressive organ failure in septic patients.[4] Similarly, NPR has been linked to heightened inflammatory activity, disease severity, and adverse outcomes in diverse critical illness scenarios.[5] Although platelet- and leukocyte-derived inflammatory ratios have been investigated extensively in general sepsis cohorts, their specific prognostic utility in acute obstructive pyelone-

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Table 1. Basic demographic data and laboratory parameters of the patients according to intensive care unit requirement.

Variables	ICU Required (n = 29)	ICU Not Required (n = 411)	*P* Value
Age (years), mean ± SD	58.48 ± 18.92	55.64 ± 16.34	.436*
CRP (mg/L), median (IQR)	236.00 (172.00–293.00)	199.00 (131.50–282.50)	.163‡
PCT (µg/L), median (IQR)	4.67 (0.59–36.40)	1.46 (0.30–9.65)	.029‡
Hemoglobin (g/dL), median (IQR)	9.40 (7.90–10.50)	11.00 (9.50–12.50)	< .001‡
WBC (×103/µL), median (IQR)	19.05 (12.79–20.59)	12.88 (9.97–16.44)	< .001‡
Neutrophil (×103/µL), median (IQR)	16.94 (10.50–19.82)	10.49 (7.64–14.02)	< .001‡
Lymphocyte (×103/µL), median (IQR)	0.83 (0.61–1.19)	1.13 (0.78–1.65)	.005‡
Platelet (×103/µL), median (IQR)	237.00 (160.00–377.00)	227.00 (175.00–323.50)	.313‡
Creatinine (mg/dL), median (IQR)	1.72 (1.17–3.77)	1.71 (1.15–3.20)	.539‡
SII, median (IQR)	4327.72 (2624.09–7097.53)	2111.42 (1292.62–3879.30)	< .001‡
NPR, median (IQR)	0.04 (0.03–0.09)	0.03 (0.01–0.06)	.006‡

Abbreviations: CRP, C-reactive protein; ICU, intensive care unit; IQR, interquartile range; NPR, neutrophil-to-platelet ratio; PCT, procalcitonin; SD, standard deviation; SII, systemic immune-inflammation index; WBC, white blood cell count.
* Student's *t*-test.
‡ Mann–Whitney *U* test.

phritis requiring emergent percutaneous decompression remains insufficiently characterized.

Given the propensity for rapid clinical deterioration in obstructive pyelonephritis, identifying simple, rapidly obtainable admission markers that support early clinical decision-making is of high clinical value. Hematologic indices derived from routine complete blood counts, including the SII and NPR, represent practical candidates because of their rapid turnaround and ability to reflect systemic inflammatory burden alongside immune-thrombocytic interactions. However, the diagnostic and prognostic utility of these indices in patients requiring urgent percutaneous nephrostomy for obstructive pyelonephritis has not been established. Therefore, this study aimed to investigate the association of admission SII and NPR with the requirement for intensive care unit (ICU) support and the overall length of hospital stay in this high-risk patient population.

MATERIALS AND METHODS

Compliance with Ethical Standards

This study was conducted in accordance with the ethical principles of the Declaration of Helsinki and was approved by the Institutional Ethics Committee of the University of Health Sciences Basaksehir Cam and Sakura City Hospital (approval date: February 26, 2025; approval number: 2025-51).

Study Design and Patient Population

Adult patients aged ≥18 years who were hospitalized in our urology department with a diagnosis of acute obstructive pyelonephritis and had an indication for percutaneous nephrostomy between June 19, 2020, and July 30, 2025, were evaluated retrospectively (n = 480). Because of the retrospective cohort design, no a priori sample size calculation was performed; all eligible consecutive patients treated during the study timeframe were screened. Pregnant or postpartum individuals (n = 18), breastfeeding women (n = 3), patients with concomitant non-urinary infectious foci (n = 16), and those presenting with profound altered mental status or requiring direct ICU admission upon initial presentation (n = 3) were excluded. The remaining 440 patients were stratified into two cohorts according to whether they subsequently required ICU admission during hospitalization: an ICU group (n = 29) and a non-ICU group (n = 411) (**Figure 1**).

Baseline demographic characteristics (age, sex, comorbidities), presence of urinary tract calculi, duration of hospital stay, necessity for intensive care, microbiological urine cultures, acute-phase reactants, and complete hematological parameters were obtained from electronic medical records. SII was calculated as follows: SII = (platelet count × neutrophil count) / lymphocyte count. NPR was calculated as the absolute neutrophil count divided by the platelet count. ICU transfer was indicated in patients developing respiratory failure requiring advanced ventilatory support, hemodynamic compromise necessitating vasoactive agent titration, or evolving acute multiorgan failure. The quick Sequential Organ Failure Assessment (qSOFA) score was used as an adjunct bedside triage tool to identify patients at risk of deterioration, but was not applied as an isolated mandatory criterion.[6] Final admission decisions were determined by the attending intensivist based on comprehensive clinical assessment.

Statistical Analysis

All statistical computations were performed using Python version 3.10 (incorporating the pandas, statsmod-

Table 2. Univariable and multivariable logistic regression analyses evaluating predictors of intensive care unit requirement.

Variable	Univariable OR	95% CI	*P* Value	Multivariable OR	95% CI	*P* Value
Age	1.01	0.99–1.03	.371	—	—	—
CRP	1.00	0.999–1.006	.220	—	—	—
PCT	1.01	1.00–1.02	.042	1.01	0.99–1.02	.097
Hemoglobin	0.66	0.54–0.81	< .001	0.68	0.55–0.83	.001
Creatinine	1.00	0.98–1.02	.942	—	—	—
SII	1.34	1.07–1.68	.011	1.20	0.96–1.51	.108
NPR	1.14	0.92–1.41	.245	—	—	—

Abbreviations: CI, confidence interval; CRP, C-reactive protein; NPR, neutrophil-to-platelet ratio; OR, odds ratio; PCT, procalcitonin; SII, systemic immune-inflammation index.

Table 3. Oversampling-adjusted multivariable logistic regression analysis assessing independent predictors of intensive care unit admission.

Variable	OR	95% CI	*P* Value
Hemoglobin	0.68	0.63–0.74	< .001
PCT	1.01	1.01–1.02	< .001
SII	1.70	1.34–2.17	< .001

Abbreviations: CI, confidence interval; OR, odds ratio; PCT, procalcitonin; SII, systemic immune-inflammation index.

Table 4. Comparative discriminative performance of inflammatory markers and incremental value of SII for intensive care unit requirement.

Variable / Model	AUC (95% CI)	ΔAUC	*P* Value
SII	0.717 (0.616–0.807)	—	—
NPR	0.652 (0.549–0.747)	0.065*	.391
PCT	0.619 (0.516–0.720)	0.099*	.160
CRP	0.564 (0.462–0.661)	0.153*	.033
CRP + PCT	0.618 (0.515–0.716)	Reference	—
CRP + PCT + SII	0.703 (0.610–0.787)	+0.085†	.031

Abbreviations: AUC, area under the receiver operating characteristic curve; CI, confidence interval; CRP, C-reactive protein; NPR, neutrophil-to-platelet ratio; PCT, procalcitonin; SII, systemic immune-inflammation index.
* ΔAUC and P values represent pairwise DeLong comparisons against SII.
† Comparison with the CRP + PCT baseline model; likelihood-ratio test: $\chi 2 = 4.792$, $P = .029$.

els, scikit-learn, and scipy packages). Continuous variables exhibiting normal distribution were presented as mean ± standard deviation (SD), whereas skewed continuous variables were expressed as median and interquartile range (IQR; Q1–Q3). Distributional normality was evaluated using visual inspection of histograms, Q–Q plots, and the Kolmogorov–Smirnov test. Intergroup comparisons for normally distributed continuous variables were performed using the independent-samples t-test (or Welch's t-test when Levene's test indicated heteroscedasticity), whereas the Mann–Whitney *U* test was used for non-normally distributed parameters. Categorical variables were expressed as frequencies and percentages and compared using the Pearson Chi-square test or Fisher's exact test.

Univariable logistic regression analysis was performed to determine factors associated with ICU admission. The linearity-in-the-logit assumption for continuous predictors was verified using the Box–Tidwell test. Because SII is derived directly from neutrophil, lymphocyte, and platelet counts, its constituent blood cell components were omitted from regression modeling to prevent collinearity. Variables demonstrating $P < .20$ in univariable analysis were entered simultaneously into a multivariable logistic regression model. Given the number of ICU events (n = 29), the multivariable model was restricted to three candidate variables to avoid model overfitting. Because of the class imbalance between cohorts (6.6% ICU vs. 93.4% non-ICU), a class-weighted logistic regression model (class weight = 'balanced') was implemented. Odds ratios (ORs) and 95% confidence intervals (CIs) were computed per one SD increment for both SII and NPR to permit standardized comparisons. In addition, an oversampling-adjusted sensitivity analysis using random oversampling of the minority class was performed to test model robustness under balanced outcome conditions.

The relationship between admission SII and length of hospital stay was examined using simple linear regression with log-transformed variables to meet normality and homoscedasticity assumptions (verified via Breusch–Pagan test). Receiver operating characteristic (ROC) curves were constructed to determine the discriminative ability of SII in predicting ICU admission, and the optimal cut-off value was calculated using the Youden index. Pairwise comparisons of area under the curve (AUC) values across markers were executed us-

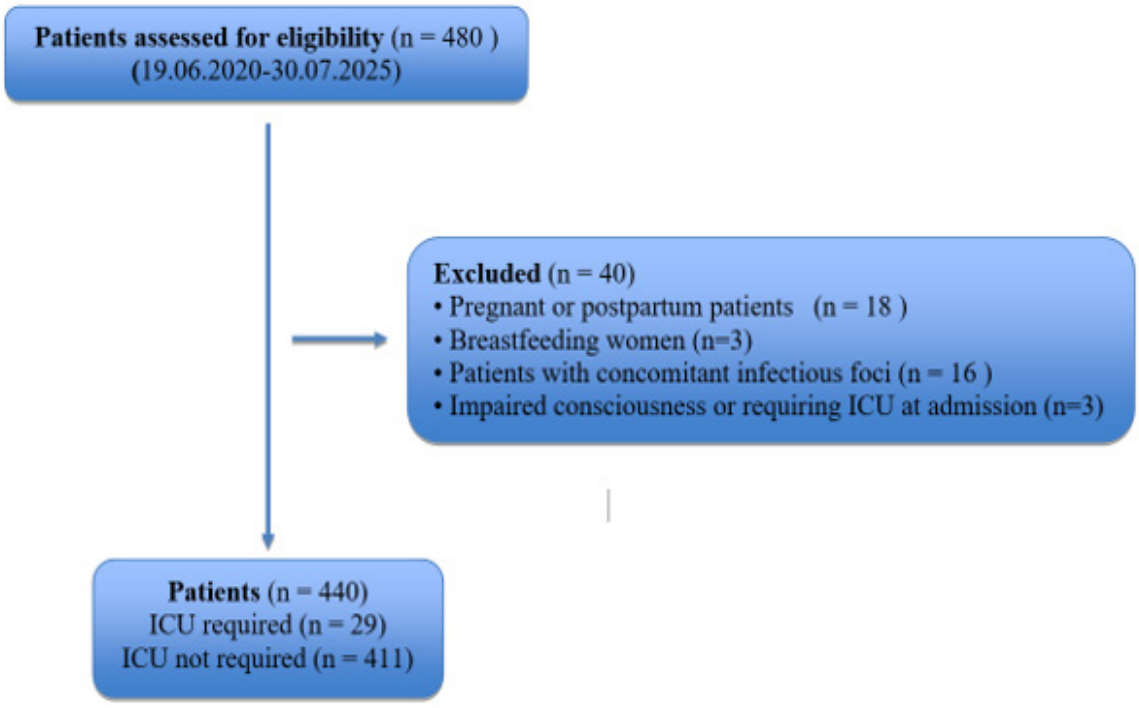

Figure 1. Flowchart of study design and patient selection.

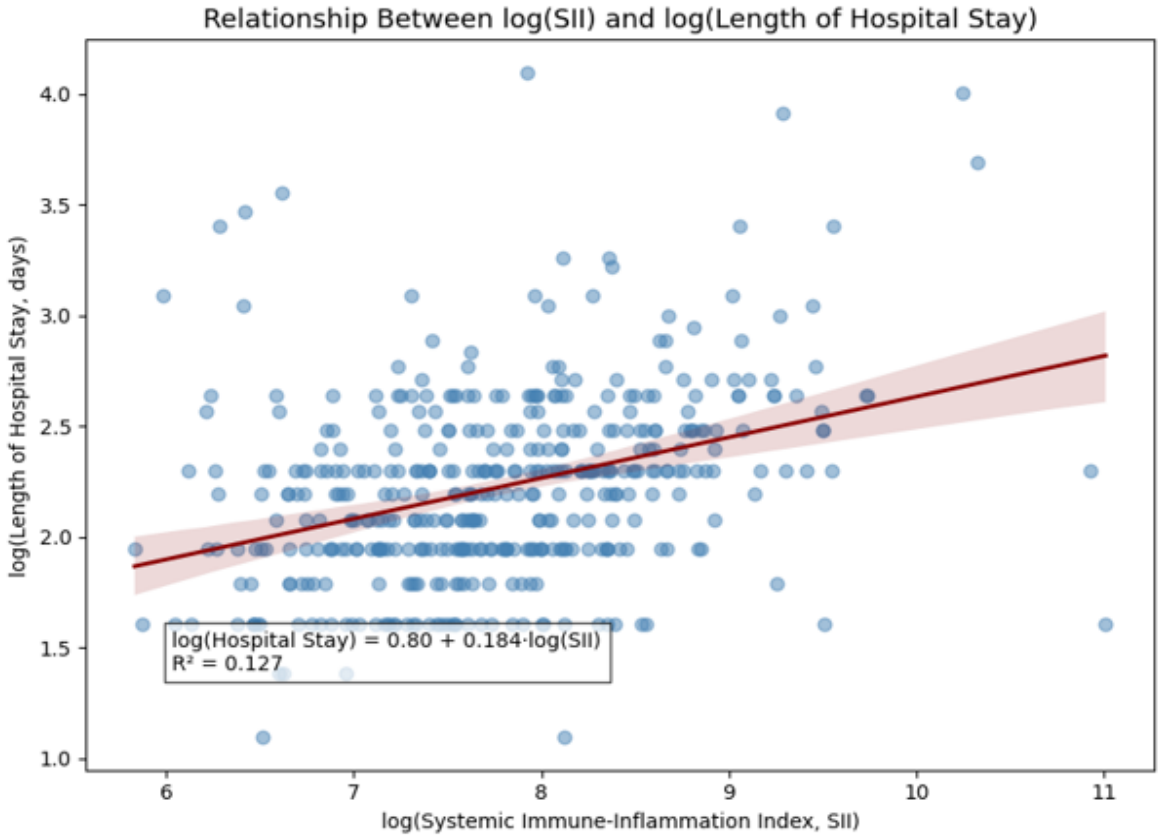

Figure 2. Scatter plot with fitted regression line illustrating the relationship between log-transformed Systemic Immune-Inflammation Index (SII) and log-transformed length of hospital stay.

ing DeLong's test. The incremental prognostic value of adding SII to standard inflammatory markers (C-reactive protein [CRP] and procalcitonin [PCT]) was assessed using likelihood-ratio testing. A two-tailed $P < .05$ was considered statistically significant.

RESULTS

Baseline Patient Characteristics

A total of 440 patients with acute obstructive pyelonephritis treated with percutaneous nephrostomy were included. Baseline demographic characteristics and laboratory parameters are summarized in **Table 1**. Patients requiring ICU admission (n = 29) exhibited significantly higher median levels of PCT, white blood cell count, absolute neutrophil count, SII, and NPR, alongside significantly lower baseline hemoglobin and absolute lymphocyte counts, compared with patients treated exclusively in the general ward (n = 411). Age, serum creatinine, and platelet counts did not differ significantly between the groups.

Predictors of Intensive Care Unit Admission

In univariable logistic regression analysis (**Table 2**), elevated PCT (OR, 1.01; 95% CI, 1.00–1.02; $P = .042$), lower hemoglobin (OR, 0.66; 95% CI, 0.54–0.81; $P < .001$), and elevated SII (OR, 1.34; 95% CI, 1.07–1.68; $P = .011$) were significantly associated with an increased likelihood of ICU requirement. NPR was not significantly associated with ICU admission in the univariable analysis (OR, 1.14; 95% CI, 0.92–1.41; $P = .245$).

In the initial multivariable logistic regression model incorporating hemoglobin, PCT, and SII, lower hemoglobin remained an independent predictor of ICU admission (OR, 0.68; 95% CI, 0.55–0.83; $P = .001$), whereas SII did not achieve statistical significance (OR, 1.20; 95% CI, 0.96–1.51; $P = .108$) (**Table 2**). In the oversampling-adjusted sensitivity analysis performed to address the outcome imbalance (**Table 3**), all three candidate parameters were independently associated with ICU admission: hemoglobin (OR, 0.68; 95% CI, 0.63–0.74; $P < .001$), PCT (OR, 1.01; 95% CI, 1.01–1.02; $P < .001$), and SII (OR, 1.70; 95% CI, 1.34–2.17; $P < .001$).

Association Between SII and Length of Hospital Stay

Linear regression analysis demonstrated a significant positive relationship between log-transformed SII and log-transformed length of hospital stay ($F(1,438) = 64.0$; $P < .001$; $R2 = 0.127$), indicating that admission SII accounted for 12.7% of the variance in hospitalization duration (**Figure 2**). The standardized regression coefficient was $\beta = 0.184$ (95% CI, 0.139–0.229; $P < .001$), signifying that each 1% increase in admission SII was accompanied by an estimated 0.18% increase in hospital stay. Heteroscedasticity was not observed (Breusch–Pagan test, $P = .469$).

Diagnostic Accuracy and Incremental Value of Inflam-

matory Indices

ROC curve analysis for the overall cohort demonstrated an AUC of 0.724 for admission SII in predicting ICU admission (**Figure 3**). The optimal Youden-derived cut-off threshold was 2300, providing a sensitivity of 86.2% and a specificity of 53.8%.

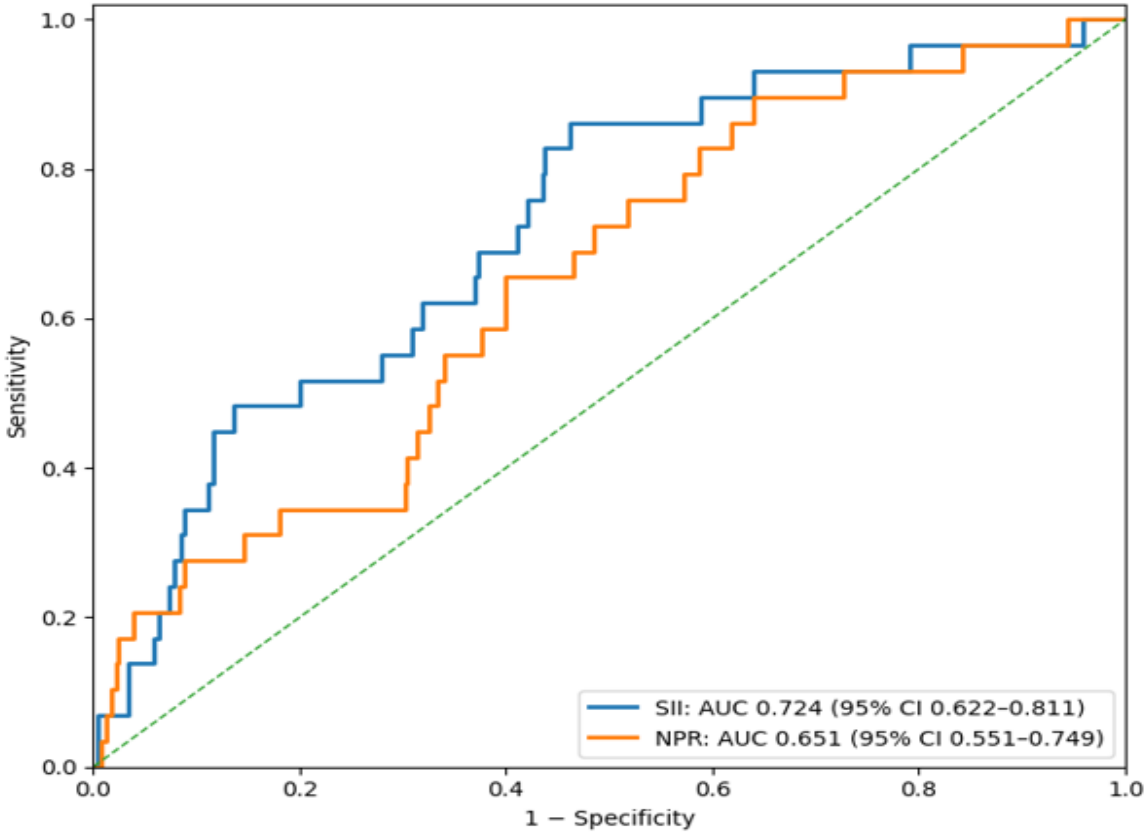

Figure 3. Receiver operating characteristic (ROC) curves evaluating the discriminative capacity of admission SII and NPR for predicting intensive care unit requirement.

In complete-case comparative analysis (n = 411; **Table 4**), SII showed the highest individual discriminative performance for ICU transfer (AUC, 0.717; 95% CI, 0.616–0.807) compared with NPR (AUC, 0.652), PCT (AUC, 0.619), and CRP (AUC, 0.564). Pairwise DeLong testing demonstrated that the AUC of SII was significantly higher than that of CRP (ΔAUC = 0.153; P = .033), whereas differences versus PCT and NPR did not reach statistical significance. Adding SII to a baseline model containing CRP and PCT increased the combined AUC from 0.618 to 0.703 (ΔAUC = 0.085; DeLong P = .031) and significantly improved overall model goodness-of-fit ($\chi 2$ = 4.792; P = .029).

DISCUSSION

Systemic inflammation–based hematologic markers such as the SII and NPR have emerged as rapid, inexpensive, and readily available clinical indices for evaluating acute disease severity. The SII, which integrates circulating neutrophil, lymphocyte, and platelet counts into a single composite value, has shown prognostic utility for predicting short-term mortality, ICU transfer, and acute organ dysfunction across critically ill patient groups.[7-9] Similarly, NPR has been investigated as an indicator of inflammatory response and has demonstrated prognostic relevance in various infectious conditions.[10] Nevertheless, the performance of these composite hematologic markers in acute obstructive pyelonephritis requiring emergency percutaneous drainage has not been well characterized. In the present study, admission SII levels were significantly elevated in patients who developed indications for ICU admission, reflecting the marked systemic inflammatory burden associated with complicated upper urinary tract infection. A cut-off value of 2300 for SII yielded an AUC of 0.724, with 86.2% sensitivity. Although SII did not retain independent significance in the multivariable model using the raw unbalanced dataset, its effect size remained notable. When the class imbalance was handled via oversampling analysis, SII emerged as an independent predictor of ICU transfer, indicating that its predictive performance should be considered in clinical risk appraisal.

In contrast, NPR did not show independent predictive capability for ICU admission in our cohort, despite being significantly elevated on univariable comparison among patients requiring intensive care. Although previous investigations in septic populations identified associations between elevated NPR and adverse clinical outcomes,[5,10,11] NPR appears to be less resilient than tripartite markers such as SII. Because it relies solely on two circulating cell lineages, NPR may be more vulnerable to acute shifts in platelet activation, sequestration, or transient demargination. Furthermore, the cellular components of NPR overlap with those encompassed by SII, which may account for its lack of independent discriminative capacity when evaluated concurrently. Consequently, NPR appears to offer limited incremental utility for early clinical risk assessment in this clinical setting.

Duration of hospitalization serves as a pragmatic proxy

for illness severity and resource utilization, as patients with advanced uroseptic presentations require prolonged intravenous antimicrobial administration and clinical monitoring.[12] In this cohort, admission SII exhibited a positive linear association with length of hospital stay, indicating that the magnitude of the initial systemic inflammatory response parallels the clinical recovery timeline. While severe systemic inflammation in sepsis has been linked to prolonged recovery, limited literature has specifically examined SII in relation to inpatient stay duration in urological infections.[13]

These findings suggest that routinely measured complete blood count parameters can provide valuable early risk stratification in obstructive pyelonephritis. Because clinical deterioration in infected hydronephrosis can progress rapidly, objective markers available at presentation may facilitate timely decision-making before extensive microbiological or cross-sectional imaging data are fully established. SII demonstrated consistent associations with markers of disease severity, suggesting potential utility in identifying patients who may benefit from closer hemodynamic monitoring or early intensive care consultation. Moreover, this study evaluates these parameters in a well-defined cohort of patients undergoing percutaneous nephrostomy, a group in whom validated risk-stratification scores remain scarce.

Several methodological limitations of this study should be recognized. First, the investigation utilized a retrospective, single-center design, which carries inherent potential for selection bias and may restrict external generalizability. Second, post-discharge survival data, such as 30-day or 90-day all-cause mortality, were not captured, precluding examination of longer-term outcomes. Third, although multivariable regression was performed, the relatively small number of ICU events (n = 29) constrained model complexity and may have limited statistical power. Fourth, although oversampling was utilized to explore the effect of class imbalance, this technique represents an exploratory sensitivity tool and does not increase the underlying number of clinical events. Finally, unmeasured non-infectious comorbidities or acute hematological conditions could have influenced circulating blood counts. Notwithstanding these limitations, the study evaluated a consecutive cohort managed with emergency percutaneous nephrostomy, and the combination of linear and logistic regression models provides a comprehensive evaluation of admission inflammatory indices in acute obstructive pyelonephritis.

Future prospective, multicenter studies with larger sample sizes and higher numbers of critical care endpoints are warranted to externally validate these findings. Investigating serial changes in SII during hospitalization and evaluating its integration into existing clinical risk scores (such as SOFA or APACHE II) may further establish its clinical utility in emergency urological care.

CONCLUSIONS

In this cohort of patients with acute obstructive pyelonephritis requiring percutaneous nephrostomy, elevated admission SII was associated with an increased requirement for intensive care unit admission and longer hospital stay, whereas NPR provided limited prognostic value. SII also demonstrated modest incremental discriminative utility when combined with CRP and procalcitonin. Prospective multicenter studies are warranted to validate these observations and determine whether incorporating SII into clinical decision pathways improves patient triage and outcomes.

SUMMARY

Higher SII levels were linked to a greater need for intensive care and longer hospital stay in patients with obstructive pyelonephritis, while NPR showed limited value. SII may help identify higher-risk patients.

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CONFLICT OF INTEREST

The authors declare that they have no conflicts of interest related to this study.

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