The New Journal of Urology
eISSN 3023-6940
doi: https://doi.org/10.33719/nju1635892

RESEARCH ARTICLE

Are the Preoperative Systemic Immune-Inflammation (SII) Index and Hematological Inflammatory Parameters Predictors for Systemic Inflammatory Response Syndrome (SIRS) After Retrograde Intrarenal Surgery (RIRS)?

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Submitted: 2025-02-08
Accepted: 2025-06-14

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Abstract

Objective: The study aimed to evaluate whether there is a relationship between the preoperative values of the platelet lymphocyte ratio (PLR), the neutrophil lymphocyte ratio (NLR), and systemic immune inflammation (SII) index and the development of systemic inflammatory response syndrome (SIRS) in patients undergoing retrograde intrarenal surgery (RIRS) for kidney stones.

Material and Methods: Demographic and laboratory data of patients who underwent RIRS were collected. NLR, PLR, and SII indices were obtained from the complete blood count parameters. Stone characteristics were obtained from preoperative non-contrast computed tomography. Univariate and multivariate analyses were performed to identify risk factors of SIRS.

Results: SIRS was detected in 27 (3.6%) of 748 patients included in the study. Stone volume, Hb level, operation time, and SII index were independent risk factors in predicting SIRS. The established threshold for predicting SIRS based on stone volume is 1589 mm^3, demonstrating a sensitivity of 88.9%, specificity of 70.0%, and an area under the curve (AUC) of 0.863. The hemoglobin level cut-off is 14.9 g/dl, with a sensitivity of 96.3%, specificity of 56.0%, and AUC of 0.198. The SII index threshold is 703, yielding a sensitivity of 81.5%, specificity of 73.5%, and AUC of 0.820. The operation time cut-off is 62.5 minutes, showing a sensitivity of 88.3%, specificity of 93.3%, and AUC of 0.967.

Conclusion: The SII index appears to be an independent, easily accessible, and cost-effective predictor for SIRS following RIRS.

Keywords: renal stones, retrograde intrarenal surgery, SII index, SIRS

Cite; Aksakalli T, Cinislioglu AE, Demirdogen SO, Utlu A, Akkas F, Karabulut I. Are the Preoperative Systemic Immune-Inflammation (SII) Index and Hematological Inflammatory Parameters Predictors for Systemic Inflammatory Response Syndrome (SIRS) After Retrograde Intrarenal Surgery (RIRS)?. New J Urol. 2025;20(2):79-88. **doi:** https://doi.org/10.33719/nju1635892

INTRODUCTION

Retrograde intrarenal surgery (RIRS) is the preferred minimal invasive surgical method for treating kidney stones smaller than 2 cm. It has also been shown to be effective for stones larger than 2 cm in selected cases (1). Compared to percutaneous nephrolithotomy (PNL) and open stone surgery, RIRS is less invasive, resulting in a shorter recovery time and lower complication rates (2). The overall complication rate after RIRS ranges from 9% to 25%, and most complications are classified as Clavien grade I or II (3). Urinary tract infections are the most common complication after RIRS and can lead to urosepsis and subsequent mortality (4).

Older age, diabetes mellitus (DM), ischemic heart disease, positive urine culture, preoperative stent placement, and longer surgical time were reported as risk factors in literature (5). Even without these risk factors, the development of urosepsis after RIRS has generated interest in other predictive markers. The immune system's response to an inflammatory condition can be reflected by changes in the sub-groups of white blood cells (6). Recently, hematological inflammatory markers such as neutrophil-to-lymphocyte ratio (NLR), platelet-to-lymphocyte ratio (PLR), and the systemic immune-inflammation (SII) index, which are frequently evaluated in malignancies, infectious diseases, and inflammatory diseases, have shown promising results (7).

The study aims to evaluate whether preoperative NLR, PLR, and SII index can be used to predict systemic inflammatory response syndrome (SIRS) in patients undergoing RIRS for renal stones.

MATERIALS AND METHODS

Patient Selection and Study Design

The Ataturk University Local Ethics Committee approved this study on 30.03.2023 (approval number: B.30.2.ATA.0.01.00/235). The data of patients who underwent RIRS between January-2020 and March-2023 were retrieved from patient files. Patients with congenital anomalies, DM, obesity (BMI>30kg/m2), immunosuppression, systemic inflammatory diseases (familial Mediterranean fever, systemic lupus erythematosus, Behçet's disease, etc.), chronic renal failure, diagnosed malignancy, and hematological disorders were excluded from the study. In addition, patients with the following criteria were also excluded from the study: preoperative positive urine culture results and C-reactive protein (CRP) levels above 5 ng/l, preoperative fever above 38°C, an operation time exceeding 90 minutes, intraoperative infectious findings such as purulent materials, positive stone culture results, a history of previous ESWL, PNL or pyelolithotomy, patients whom a ureteral access sheath (UAS) was not used during RIRS, double J (DJ) stents were not inserted after RIRS (Figure1), and DJ stents placement more than 30 days.

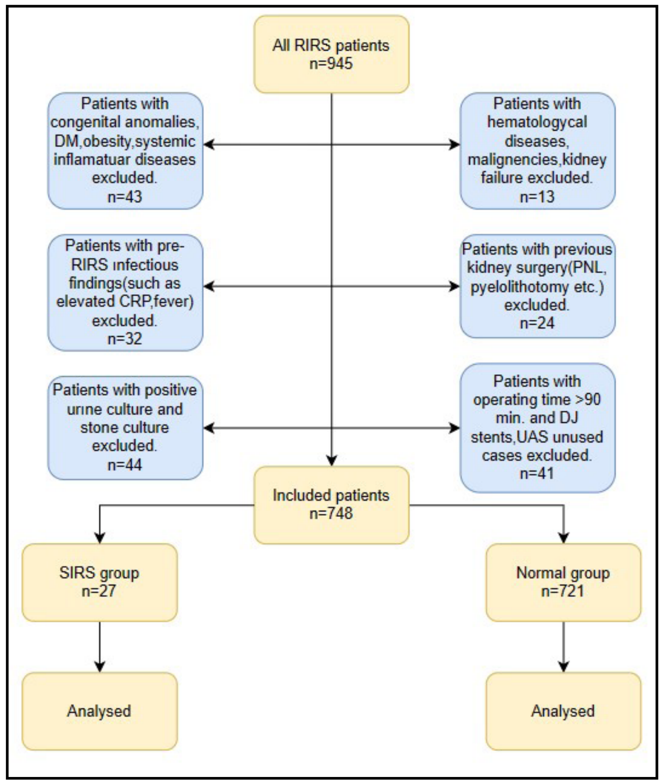

Figure 1. Exclusion criteria and study design

Demographic and clinical data such as age, gender, body mass index (BMI), comorbidities, presence of DJ stent before RIRS, complete blood count parameters obtained before RIRS; white blood cell (WBC) ($\times10^9$/L), red blood cell (RBC) ($\times10^{12}$ /L), platelet (Plt) ($\times10^9$/L), neutrophil ($\times10^9$/L), lymphocyte ($\times10^9$/L), hemoglobin (Hb) level (g/dL), SII index (calculated using the formula; SII = platelet count × neutrophil count/lymphocyte count (P x N)/L), Neutrophil/ Lymphocyte ratio (NLR), and Platelet/Lymphocyte ratio (PLR), stone characteristics, operation time, presence of SIRS/sepsis after RIRS were retrospectively recorded. The stone characteristics such as stone diameter, stone volume, Hounsfield unit (HU), laterality, and location were obtained from preoperative non-contrast computed tomography (NCCT). The stone diameter was determined by measuring the largest diameter of the stone, and the stone volume was calculated using the formula (length×width×depth×π×0.167) (8). The Hounsfield Unit (HU) measurement was conducted using a bone window and magnification on the longest stone diameter. The operation time was recorded as the time between the placement of the ureteral access sheath (UAS) and the placement of the DJ stent at the end of the operation. SIRS was defined by the presence of two or more of the following: body temperature above 38°C or below 36°C, heart rate above 90 beats/min, respiratory rate above 20/min, and white blood cell count above 12,000/mm3 or below 4000/mm3. Sepsis is defined, according to the Sepsis-3 criteria, as a life-threatening organ dysfunction caused by a dysregulated host response to infection (9).

Surgical Technique and Clinic Management

In our clinical practice, patients who apply for RIRS are first hospitalized, and laboratory tests such as complete blood count, serum creatinine, and urine culture are routinely performed. Urine culture was obtained using mid-stream urine sample, and urine cultures given 5 days or earlier before the operation were renewed. Surgical prophylaxis is performed intravenously with third-generation cephalosporins 30 minutes before the procedure. The procedure is performed under general anesthesia in the lithotomy position. Preoperative DJ stenting was applied to patients who were unable to insert ureteral access because of a thin ureter and preoperative obstructed, infected kidney because of a ureteral stone. A semi-rigid ureteroscope (URS) was used to reach the bladder and to visualize the ureter. Then, a 0.035-inch guidewire (Boston Scientific Corporation®, Natick MA) was placed through the working channel of the URS to the pelvicalyceal system. URS was removed, and the UAS (9 fr. UAS, Cook Medical Inc., USA) was placed through the guidewire. Then a fiber-optic flexible URS (8 fr. Karl Storz GmbH & Co. KG, Tuttlingen, Germany) was inserted to reach the stone and a Quanta®Litho 30 holmium: yttrium aluminum-garnet (Ho:YAG) laser lithotripter with 272-µm holmium laser used to fragment the stone. After fragmentation, a DJ stent was placed in the pelvicalyceal system. If the ureteral orifice is too narrow to allow the advancement of the URS, a DJ stent is inserted for passive dilatation, and RIRS is performed in the next session.

In the postoperative period, all patients were monitored in the urology service for pain, fever, SIRS, and sepsis. If patients developed fever or SIRS, blood cultures and urine cultures were obtained. In cases of persistent fever or sepsis, antibiotherapy was adjusted based on the recommendations of infectious disease specialists and the results of blood and urine cultures. The patients were discharged once sterile cultures were obtained and when antibiotherapy was completed. Patients who did not develop SIRS or fever were discharged on the first postoperative day. Patients who presented with SIRS findings after discharge were hospitalized and also included in the study. The DJ stents were removed using a flexible cystoscope 3 weeks after the procedure.

Statistical Analysis

All data were analyzed using SPSS, version 23.0 (SPSS Inc, Chicago, Illinois, USA). Categorical variables were given as frequencies and percentages, while continuous variables were presented as mean and standard deviation. The normal distribution of continuous variables was evaluated using the Shapiro-Wilk test. The means of two independent groups showing a normal distribution were compared using the independent samples t-test. In contrast the means of groups not showing a normal distribution were compared using the Mann-Whitney U test. The percentages of categorical variables were compared using Pearson's chi-square test and Fisher's exact test. The predictive values for SIRS were determined using ROC curve analysis. Univariable and multivariable logistic regression tests were used to identify predictive factors for SIRS. A p-value <0.05 was considered statistically significant.

RESULTS

The demographic and clinical characteristics, stone characteristics, and hematological inflammatory parameter values of the 748 included patients are summarized in Table 1. The mean age in our cohort was determined to be 45.6 ± 12.4 years, with a male and female percentage of 65.2% and 34.8%, respectively. Post-RIRS, SIRS was detected in 27 patients, accounting for 3.6% of the total cases. 12 (1.6%) patients were followed in ICU. Sepsis was detected in 5 of these patients with a percentage of 0.6%, and all sepsis developed patients were followed in the ICU. No mortality was observed during the follow-up of the patients.

Table 1. Demographic data, stone characteristics and hemogram parameters of the whole study sample

	Mean ± SD, (min.- max.)
Age ± SD, (yrs)	45.6 ± 12.4 (19.0-76.0)
Gender, n(%)	
Male	488 (65.2)
Female	260 (34.8)
BMI ± SD, kg/m^2	23.0 ± 2.13 (18.0-28.1)
ASA, n(%)	
ASA 1	347 (46.4)
ASA 2	311 (41.6)
ASA 3	71 (9.5)
ASA 4	19 (2.5)
Stone diameter ± SD, mm	14.9 ± 3.03 (8.0-20.0)
Stone volume ± SD, mm^3	1981 ± 1123 (268.4-4195.0)
Stone density ± SD, HU	965 ± 194
Stone location, n(%)	
Middle calyx	141 (18.9)
Renal pelvis	397 (53.1)
Inferior calyx	146 (19.5)
Superior calyx	64 (8.6)
Presence of DJS preoperatively, n(%)	610 (81.6)
Creatinine value ± SD, mg/dL	0.88 ± 0.16 (0.40-1.21)
WBC count ± SD, µ/L	8.36 ± 2.26 (2.89-24.25)
Lymphocyte count ± SD, µ/L	2.47 ± 0.95 (0.50-18.45)
Neutrophil count ± SD, µ/L	4.99 ± 1.89 (1.21-15.70)
RBC count ± SD, 10^6 µ/L	5.20 ± 0.55 (2.93-7.67)
HGB count ± SD, g/dl	14.9 ± 1.75 (8.0-20.4)
PLT count ± SD, 10^3 µ/L	283 ± 73.3 (107-699)
NLR ± SD	2.27 ± 1.38 (0.21-13.16)
PLR ± SD	125 ± 47.5 (8.83-385.03)
SII ± SD	510 ± 294 (34.5-6045.1)
SIRS rate postoperatively, n(%)	27 (3.6)
ICU patients, n(%)	12 (1.6)
Surgical duration ± SD, min.	41.9 ± 14.4 (14-78)

SD standart deviation, **BMI** body mass index, **ASA** American Society of Anaesthesiology, **HU** Hounsfield Unite, **DJS** double j stent, **WBC** white blood cell, **RBC** red blood cell, **NLR** neutrophil to lymphocyte ratio, **PLR** platelet to lymphocyte ratio, **SIRS** systemic inflammatory response syndrome, **ICU** Intensive care unit

When comparing the SIRS-developing group with the normal group, no statistically significant differences were found in age, gender, BMI, HU, stone localization, preoperative DJ stent presence, mean creatinine, mean WBC, and platelet values. The patients in the SIRS group were found to have significantly higher ASA score ($p < 0.001$), stone diameter (19.4 ± 2.93 vs. 14.8 ± 2.90, $p < 0.001$), stone volume (1438 [1152-3058] vs. 1769 [906-3058], $p < 0.001$), NLR (3.54 ± 0.89 vs. 2.22 ± 1.37, $p < 0.001$), PLR (162 ± 60.1 vs. 123 ± 46.4, $p < 0.001$), SII ındex (957 ± 330 vs. 634 ± 465, $p < 0.001$) and operation time (42 [29-56] vs. 72 [43-86], $p < 0.001$). Additionally, lymphocyte count (1.77 ± 0.45 vs. 2.49 ± 0.95, $p < 0.001$) and hemoglobin level (13.1 ± 1.35 vs. 15.0 ± 1.73, $p < 0.001$) were found to be significantly lower in the SIRS group. The comparison of clinical characteristics between the two groups is summarized in Table 2.

Univariable and multivariable binary logistic regression analyses were conducted to determine the factors predicting SIRS (Table 3). In the univariable analysis, stone volume, lymphocyte count, hemoglobin level, NLR, PLR, SII index, and operation time were identified as significant risk factors. In the multivariable logistic regression, we avoided using the stone diameter and volume, NLR, PLR, SII, RBC, and HGB at the same time because these variables are highly correlated with each other, and this could cause problems of multicollinearity. With this analysis, independent risk factors for SIRS were found to be stone volume, SII index, and operation time.

A Spearman correlation analysis was performed to determine the relationship between SII index, operation duration, stone volume, and hemoglobin level. In the correlation analysis, a weak negative correlation was found between hemoglobin level and operation duration as well as SII index ($r = -0.185$, $r = -0.266$ respectively), which was statistically significant ($p < 0.001$). There was no significant correlation found between the SII index, operation time, and stone volume (Table 4).

Table 2. Comparison of groups normal group and SIRS group

	Normal	SIRS	P value	
Variables	**Mean ± SD/Median IQR**	**Mean ± SD/Median IQR**		
Number of patients	721	27		
Age, median [IQR], (yrs)	45 [36-56]	50 [32-61]	0.553**	
Gender, n(%)			0.282#	
Male	473 (65.6)	15 (55.6)		
Female	248 (34.4)	12 (44.4)		
BMI, median [IQR] , (kg/m²)	23.1 [21.5-24.2]	24.1 [21.4-25.2]	0.100**	
ASA, n(%)			<0.001&	1 vs 2 0.333
ASA 1	340 (47.2)	7 (25.9)		1 vs 3 <0.001
ASA 2	300 (41.7)	10 (37.0)		1 vs 4 0.350
ASA 3	62 (8.6)	9 (33.3)		2 vs 3 0.003
ASA 4	18 (2.5)	1 (3.7)		2 vs 4 0.485
				3 vs 4 0.682
Stone diameter ± SD, mm	14.8 ± 2.90	19.4 ± 2.93	<0.001*	
Stone volume, median [IQR], mm³	1438 [1152-3058]	1769 [906-3058]	<0.001**	
Stone density ± SD, HU	965 ± 194	961 ± 198	0.919*	
Stone location, n(%)			0.931#	1 vs 2 0.599
Middle calyx	135 (18.7)	6 (22.2)		1 vs 3 0.951
Renal pelvis	384 (53.3)	13 (48.1)		1 vs 4 1.000
Inferior calyx	140 (19.4)	6 (22.2)		2 vs 3 0.639
Superior calyx	62 (8.6)	2 (7.4)		2 vs 4 1.000
				3 vs 4 1.000
Presence of DJS preoperatively, n(%)	588 (81.6)	22 (81.5)	0.992#	
Mean creatinine value ± SD, mg/dL	0.88 ± 0.16	0.90 ± 0.20	0.565*	
WBC count , median [IQR] ,(μ/L)	8.08 [6.8-9.5]	8.21 [7.85-8.96]	0.809**	
Lymphocyte count ± SD, μ/L	2.49 ± 0.95	1.77 ± 0.45	<0.001*	
Neutrophil count ± SD, μ/L	4.95 ± 1.90	6.05 ± 1.26	0.003*	
RBC count ± SD, 10^6 μ/L	5.22 ± 0.55	4.84 ± 0.60	<0.001*	
HGB count ± SD, g/dl	15.0 ± 1.73	13.1 ± 1.35	<0.001*	
PLT count ± SD, 10^3 μ/L	284 ± 73.8	269 ± 58.0	0.309*	
NLR ± SD	2.22 ± 1.37	3.54 ± 0.89	<0.001*	
PLR ± SD	123 ± 46.4	162 ± 60.1	<.001*	
SII ± SD	634 ± 465	957 ± 330	<0.001*	
Operation time, median [IQR], min.	42 [32-52]	72 [43-86]	<0.001**	

SD standart deviation, * Independent sample t test, **Mann whitney U test, # Pearson chisquare test, **&** Fisher's exact test, **SD** standart deviation, **IQR** Interquartile range, **BMI** body mass index, **ASA** American society of anaesthesiology, **HU** hounsfield unite, **DJS** double j stent, **WBC** white blood cell, **RBC** red blood cell, **NLR** neutrophil to lymphocyte ratio, **PLR** platelet to lymphocyte ratio, **SIRS** systemic inflammatory response syndrome

Table 3. To predict SIRS, univariable and multivariable binary logistic regression analyses were performed

	Univariable			**Multivariable**		
	OR	**95% CI**	**P value**	**OR**	**95% CI**	**P value**
Age (yr)	1.010	0.979-1.041	0.546			
Gender (female)	1.526	0.703-3.310	0.285			
BMI (kg/m^2)	1.191	.995-1.426	0.057			
Stone diameter (mm)	2.104	1.667-2.655	<0.001			
Stone volume (mm^3)	1.001	1.001-1.002	<0.001	1.001	1.001-1.002	<0.001
Stone density (HU)	0.998	0.992-1.004	0.563			
Stone location	0.956	0.600-1.523	0.851			
Presence of DJS	1.005	0.374-2.702	0.992			
Creatinine value (mg/dL)	1.993	0.190-20.883	0.565			
WBC count (μ/L)	0.916	0.760-1.105	0.360			
Lymphocyte count (μ/L)	0.180	0.088-0.370	<0.001			
Neutrophil count (μ/L)	1.256	1.074-1.469	0.004			
RBC count (10^6 μ/L)	0.308	0.159-0.597	<0.001			
HGB count (g/dl)	0.578	0.467-0.715	<0.001	0.747	0.517-1.080	0.121
PLT count (10^3 μ/L)	0.997	0.991-1.003	0.307			
NLR	1.412	1.200-1.661	<0.001			
PLR	1.011	1.006-1.017	<0.001			
SII	1.001	1.000-1.001	0.003	1.001	1.000-1.002	0.008
Operation time (min.)	1.282	1.189-1.382	<0.001	1.232	1.139-1.333	<0.001

OR odds ratio, **CI** confidence interval, **BMI** body mass index, **HU** hounsfield unite, **DJS** double j stent, **WBC** white blood cell, **RBC** red blood cell, **NLR** neutrophil to lymphocyte ratio, **PLR** platelet to lymphocyte ratio, **SIRS** systemic inflammatory response syndrome, **SII** systemic immune inflamatuar index

Table 4. Correlation analysis between independent risk factors

Spearman's rho		**SII-index**	**OT**	**SV**	**HL**
SII-index	r	1.000	0.050	0.007	-0.266
	p		0.168	0.851	**0.001**
Operation time	r		1.000	0.055	-0.185
	p			0.133	**0.001**
Stone Volume	r			1.000	-0.040
	p				0.277
Hemoglobin level	r				1.000

ROC analysis was performed on the variables identified as independent risk factors in the multivariable regression analysis (Figure 2). For hemoglobin level to predict SIRS, the cut-off value was 14.9 g/dl, with a sensitivity of 96.3%, specificity of 56.0%, and AUC of 0.198 ($p < 0.001$). For the SII index to predict SIRS, the cut-off value was 703, with a sensitivity of 81.5%, specificity of 73.5%, and AUC of 0.820 ($p < 0.001$). For the operation time to predict SIRS, the cut-off value was 62.5 min., with a sensitivity of 88.3%, specificity of 93.3%, and AUC of 0.967 ($p < 0.001$).

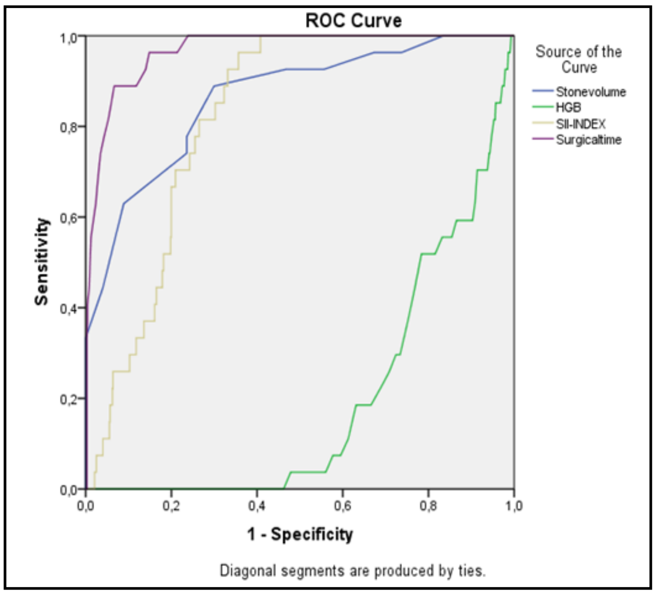

Figure 2. ROC curve for independent variables to predict SIRS post-RIRS

(AUC value: 863, Cut-off value:1589[Sensitivity: 88.9%; specificity: 70.0%] for stone volume; AUC value: 198, Cut-off value:14.9[Sensitivity: 96.3%; specificity: 56%] for Hgb; AUC value: 820, Cut-off value:703[Sensitivity: 81.5%; specificity: 73.5%] for SII index; AUC value: 967, Cut-off value:62.5[Sensitivity: 88.3%; specificity: 93.3%] for surgical time). AUC is the area under the curve.

DISCUSSION

This study emphasizes that patients with prolonged operation time, increased stone volume, and high systemic immune-inflammation index (SII) are at greater risk for developing SIRS after RIRS. These findings highlight the importance of identifying high-risk patients preoperatively and suggest that management strategies targeting modifiable risk factors, such as minimizing operation time and ensuring closer postoperative clinical follow-up, may help reduce the incidence of infectious complications in this population.

Infectious complications are the most commonly encountered and potentially life-threatening complications following RIRS for renal stones. Urosepsis is the most severe form of these complications and can lead to mortality rates ranging from 28.3% to 41.1% (10). In a systematic review conducted by Dybowsk et al., including 17 studies and 8294 patients, the rates of infectious complications after RIRS were reported to range from 2.8% to 7.5% (11). Although the exact rates of urosepsis after RIRS (retrograde intrarenal surgery) are not fully known, a systematic review and meta-analysis conducted by Bhojani et al., including 13 studies and 5597 patients, reported an incidence of urosepsis after URS (ureteroscopy) ranging from 0.2% to 17.8% (12). In the globally conducted multicenter FLEXOR study, fever and infectious complications were identified at a rate of 6.1%, while sepsis was observed at a rate of 1.3% (13). In our study, the incidence of SIRS in patients was 3.6%, and the sepsis rate was 0.6%. We determined that these rates were consistent with the results of the meta-analysis conducted by Bhojani et al. However, the lower rates compared to Dybowski et al. and the FLEXOR study may be attributed to the fact that many of the studies included in these analyses did not exclude patients with diabetes, obesity, hematological diseases, or positive urine cultures. We believe that the exclusion of clinical conditions that could be risk factors for SIRS and patients with positive urine cultures during the preoperative period in our study could explain the lower incidence of SIRS and sepsis rates observed in our study.

Risk factors for sepsis following RIRS include patient-related factors such as female gender, obesity, diabetes mellitus (DM), and stone size, as well as center and surgeon-related factors such as procedure duration, irrigation fluid pressure, stent placement for more than 30 days, and low case volume (14). In the study conducted by Yong Xu et al., positive preoperative urine culture, irrigation rate, and operation duration were reported as independent risk factors for infectious complications (15). In this study, although the authors did not provide specific cut-off values for operation duration and irrigation rate, the operation time should be less than 60 minutes. The association of operative time and infectious complications, which is generally accepted in the literature, was also observed in our study. We found that operative time was an independent risk factor in the multivariate analysis for the detection of SIRS. In our study, we performed ROC analysis for independent risk factors in predicting SIRS, and the cut-off value for operation time was 62.5 minutes, with 88% sensitivity and 93.3% specificity.

In another study conducted by Moses et al., it was reported that an operation time longer than 120 minutes and preoperative DJ stent placement were independent risk factors for predicting SIRS after RIRS (16). The cut-off values given in this study for the operation duration are stated as longer than our study and other studies. In this study, the identified independent risk factors may have been indirectly influenced by the lack of evaluation of stone characteristics. Additionally, the absence of specifying the timing of DJ stent placement and the high rate of positive preoperative urine cultures can be considered as limitations and reasons for the observed findings. While no relationship was found between stone location and SIRS, stone volume was an independent risk factor for predicting SIRS in our study. Through ROC analysis, we determined a cut-off value of 1589 mm3 for stone volume, with 88.9% sensitivity and 70.0% specificity.

Despite of the recommended practices in current guidelines to minimize risk factors, patients can still develop SIRS and sepsis after RIRS. Hematological inflammatory parameters such as NLR, PLR, and SII index, have been utilized in predicting the prognosis of malignancies such as gastric, cervical, and thyroid cancers, as well as in chronic conditions like hypertension, rheumatoid arthritis, multiple sclerosis, and acute conditions such as COVID-19, acute pancreatitis, acute coronary syndrome, and sepsis (17-22). One of the significant studies evaluating these factors in urolithiasis is the study conducted by Akshay Kriplani et al., which reported that high NLR and PLR ratios were statistically significant in predicting SIRS. Additionally, in this study, the preoperative NLR had a cut-off value of 2.03 with 82% sensitivity and 31% specificity for predicting postoperative SIRS, while the PLR had a cut-off value of 110.62 with 80.2% sensitivity and 50.5% specificity for postoperative SIRS (23). In our study, using multivariate logistic regression analysis, we identified the SII index as an independent risk factor, and through ROC analysis, we determined a cut-off value of 703 for predicting preoperative SIRS with better sensitivity (81.5%) and specificity (73.5%). Similar to the findings of Akshay Kriplani et al., we found that high NLR and PLR were relative risk factors for SIRS after RIRS. However, it is worth noting that Akshay Kriplani et al. did not exclude factors associated with SIRS such as DM, obesity, staghorn stones, and positive preoperative urine culture, which increases the possibility that the observed changes in hematological inflammatory markers may be attributed to these factors rather than being predictive. The cohort in our study was designed to minimize the potential effects of these risk factors on hematological inflammatory parameters. Thus we believe that our study's results are more meaningful compared to those of Akshay et al.

Furthermore, in contrast to Akshay Kriplani et al.'s study, where hemoglobin levels were reported as a relative risk factor. We identified hemoglobin levels as an independent risk factor and determined a cut-off value of 14.9 g/dL with 96.3% sensitivity and 56.0% specificity through ROC analysis. Our study group was formed by excluding patients who had factors that could potentially affect NLR, PLR, and SII index and were at a high risk of postoperative infection. This was conducted to minimize the effect of other related factors on hematological inflammatory parameters and to ensure that the results are more specifically associated with RIRS and urolithiasis.

The main limitations of the study include its retrospective design, the procedure not being performed by a single surgeon, and the small number of patients in the SIRS group within the sample. Another disadvantage of the retrospective design is the inability to evaluate other criteria reported as risk factors in the literature, such as increased intrapelvic pressure, irrigation rate and the preoperative use of DJ stents, which have not been standardized. However, despite all these limitations, we believe that the cut-off we determined for the SII index, which can be calculated from routine complete blood count, could serve as a cost-effective tool for clinicians in considering other factors such as operation time and planning close monitoring in the postoperative period for patients exceeding this value.

CONCLUSIONS

In conclusion, we have identified the SII index as an independent risk factor for predicting SIRS after RIRS.

Clinicians can consider the risk factors for SIRS reported in the literature and adjust their management strategies accordingly, particularly when the SII index exceeds 703. However, for these parameters to be clinically applicable, comparative, large-scale, prospective studies are needed.

Funding: This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

Data Sharing Statement: The data that support the findings of this study are available from the corresponding author upon reasonable request.

Conflict of Interest: All authors declare no potential conflict of interest with this publication.

Informed Consent: Informed consent was obtained from all participants in this study.

Ethical Approval: This study was approved by the Ataturk University Local Ethics Committee 30.03.2023 (approval number: B.30.2.ATA.0.01.00/235).

Author's Contribution: TA, and AEC designed the study protocol. SOD, and FA collected the data and did the statystical analysis. IK, and AU revised the manuscript. All authors wrote and revised the main text.

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