JURNAL LOCUS: Penelitian & Pengabdian
Volume 5 No. 11 November 2026, pp 10267-10283
E-ISSN 2829-7334
DOI: 10.58344/locus.v5i11.6517

The Relationship Between Inflammation Levels and The Degree of Obstruction in Urinary Tract Stones Based on Platelet-Lymphocyte Ratio (PLR) and Computed Tomography Stonography

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Keywords:
Urinary Tract Stones; Platelet-to-Lymphocyte Ratio; Hydronephrosis; Obstruction; CT Stonography.

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Abstract

This study aimed to analyze the relationship between the platelet-to-lymphocyte ratio (PLR) and the degree of urinary tract obstruction in patients with urinary tract stones, as assessed by computed tomography (CT) stone protocol imaging. This analytical observational study employed a cross-sectional design using secondary data from patients with urinary tract stones who underwent CT imaging at Dr. Moewardi General Hospital, Surakarta, between March and August 2025. A total of 51 patients met the inclusion criteria, comprising 36 men (70.6%) and 15 women (29.4%). The most common stone location was the lower renal calyx (21.6%), while the most frequent stone size category was 11–20 mm (39.2%). Stone location differed significantly between the mild and significant obstruction groups ($p = 0.046$), whereas stone size categories showed no statistically significant difference ($p = 0.059$). The median PLR increased from 109.7 in grade 0 to 236.6 in grade 4, with a statistically significant difference across obstruction grades (Kruskal–Wallis $H = 18.884$; $p = 0.001$). Post hoc analysis revealed a significant difference between grades 0 and 4 (Bonferroni-adjusted $p = 0.001$). The median PLR was significantly higher in the significant obstruction group than in the mild obstruction group (226.8 vs. 112.3; $p < 0.001$). Spearman's rank correlation analysis demonstrated a strong positive association between PLR and obstruction severity ($\rho = 0.609$; $p < 0.001$). Logistic regression analysis indicated that each 10-unit increase in PLR was associated with 1.262-fold higher odds of significant obstruction (odds ratio = 1.262; 95% confidence interval: 1.101–1.447; $p = 0.001$). These findings demonstrated a statistically significant, strong positive association between PLR and the degree of urinary tract obstruction assessed by CT imaging in patients with urinary tract stones.

INTRODUCTION

Urinary tract stones, or urolithiasis (*batu saluran kemih*, BSK), are characterized by the formation of hard mineral deposits within the urinary system, including the kidneys, ureters, bladder, and urethra (Noegroho & Daryanto, 2023). Urolithiasis is a common urological condition, with its prevalence increasing in various countries. In the United States, the prevalence of urinary tract stones has been estimated at 10.6% among men and 7.1% among women (Abbas et al., 2020). Globally, urolithiasis affects approximately 5–10% of the

population and remains one of the most frequently encountered conditions in urology outpatient clinics in Indonesia. Data from the Indonesian Ministry of Health indicate that the prevalence of urinary tract stones in Indonesia reaches 12% of the population (Abdurrosid et al., 2021). At Dr. Moewardi General Hospital, Surakarta, secondary medical record data collected between March and August 2025 indicated that urinary tract stone cases accounted for 0.7% of all outpatient visits. Most urinary tract stones contain calcium, particularly calcium oxalate. In Jakarta, calcium oxalate stones have been reported in 72% of urinary tract stone cases, compared with 53.3% in Semarang (Rusdi et al., 2022).

Urinary stone formation generally begins with urinary supersaturation involving minerals and substances such as calcium, oxalate, and uric acid. This condition promotes crystal nucleation, growth, and aggregation (Shastri et al., 2023). Crystals may adhere to the renal tubular epithelium, inducing oxidative stress, epithelial injury, and inflammatory responses that contribute to stone formation and progression (Ying et al., 2025). When stones migrate into the ureters and obstruct urinary flow, intraluminal pressure increases. Persistent obstruction may cause dilation of the renal collecting system, impaired urinary drainage, reduced renal filtration function, and clinical manifestations such as renal colic, hematuria, nausea, and vomiting (Shih et al., 2021).

The severity of urolithiasis cannot be adequately assessed solely by determining the presence or absence of stones (Geraghty et al., 2025). Stone size, location, attenuation, and the degree of urinary tract obstruction must also be considered because these characteristics may influence complication risks and treatment decisions. Ureteral stones may cause partial or complete urinary obstruction. Radiologically, obstruction may be associated with varying degrees of hydronephrosis, commonly classified as mild, moderate, or severe. Although more pronounced hydronephrosis may indicate greater urinary tract dilation associated with obstruction, hydronephrosis severity does not always directly reflect the functional degree or duration of obstruction. Urinary obstruction accompanied by infection may further aggravate the patient's condition and increase the risk of urosepsis (Noegroho & Daryanto, 2023; Taguchi et al., 2019).

Noncontrast computed tomography (NCCT), commonly performed using a dedicated urinary stone protocol and sometimes referred to as CT stonography, is a principal imaging modality for evaluating suspected urolithiasis. This examination enables the detection of urinary calculi, determination of stone size and location, measurement of stone attenuation in Hounsfield units (HU), and assessment of secondary signs of obstruction, including hydronephrosis. CT imaging may also identify periureteral changes and increased ureteral wall thickness (UWT), which may reflect localized inflammatory changes associated with stone impaction. Stone size, location, attenuation, UWT, and hydronephrosis severity have been investigated as factors associated with ureteral stone characteristics and the likelihood of spontaneous stone passage (Aghaways et al., 2022; Kadırhan et al., 2026).

Systemic inflammatory responses are another important consideration in patients with urolithiasis. Impacted ureteral stones may cause mucosal irritation, edema, and localized inflammation surrounding the affected ureteral segment. These inflammatory changes may be accompanied by alterations in hematologic parameters. In patients with ureteral stones measuring less than 10 mm who underwent NCCT, increased UWT was associated with elevated neutrophil-to-lymphocyte ratio (NLR) and platelet-to-lymphocyte ratio (PLR). A

moderate positive correlation between PLR and UWT (r = 0.426) suggested that PLR may reflect systemic inflammatory responses associated with ureteral stone impaction and localized radiologic abnormalities (Aghaways et al., 2022).

The platelet-to-lymphocyte ratio (PLR) is calculated by dividing the platelet count by the absolute lymphocyte count obtained from a complete blood count. Elevated platelet counts may reflect inflammatory activation, whereas reduced lymphocyte counts may occur during systemic inflammatory or physiological stress responses (Rossaint et al., 2018). Consequently, PLR has been investigated as an accessible and inexpensive marker of systemic inflammation. Because PLR can be calculated from routinely available hematologic measurements without requiring additional specialized laboratory testing, it may provide useful supplementary information when evaluating patients with urinary tract stones, particularly those presenting with urinary obstruction (Balta & Ozturk, 2015; Gasparyan et al., 2019).

Previous research has identified associations between PLR and the clinical and radiologic characteristics of ureteral stones. Among patients presenting to emergency departments with ureteral stones, PLR, NLR, and C-reactive protein (CRP) levels were higher in patients with stones measuring ≥5 mm than in those with stones measuring less than 5 mm. The study also examined stone location and the degree of hydronephrosis (Jeong et al., 2021). Elevated PLR has additionally been associated with failure of spontaneous stone passage in patients with ureteral calculi, alongside factors such as stone size and moderate to severe hydronephrosis (Abou Heidar et al., 2020). These findings suggest that increased PLR may be associated with clinical and radiologic characteristics that reduce the likelihood of spontaneous ureteral stone passage.

In patients with unilateral ureteral stones measuring ≤10 mm who underwent NCCT, failure of spontaneous stone passage was associated with larger stone size, higher stone attenuation, increased UWT, more severe hydronephrosis, and elevated NLR and PLR values (Kadırhan et al., 2026). PLR has also been investigated in patients with obstructing ureteral stones and suspected urinary tract infections. In these patients, PLR and NLR were associated with urosepsis risk, vasopressor requirements, and intensive care admission (Villanueva-Congote et al., 2024). Collectively, these findings support the hypothesis that PLR may reflect systemic inflammatory activity and be associated with more severe clinical presentations among patients with urinary tract stones.

Most previous investigations of PLR in patients with ureteral stones have focused on spontaneous stone passage, infection risk, or postoperative complications. Research specifically examining the relationship between PLR and the degree of urinary tract obstruction assessed through CT imaging remains relatively limited. In particular, the association between PLR and hydronephrosis grade as a radiologic indicator of urinary tract dilation associated with obstruction requires further investigation. Combining PLR measurements obtained from routine blood examinations with CT findings may provide supplementary information for evaluating obstruction-related changes in patients with urinary tract stones (Jeong et al., 2021; Abou Heidar et al., 2020; Aghaways et al., 2022; Kadırhan et al., 2026).

Based on these considerations, further investigation was warranted to examine the relationship between systemic inflammation, as reflected by PLR, and the degree of urinary tract obstruction, as assessed by hydronephrosis grading on CT imaging, among patients with

urinary tract stones at Dr. Moewardi General Hospital, Surakarta. The findings were expected to provide additional evidence regarding the potential clinical utility of PLR as a simple, inexpensive, and readily available inflammatory marker that may complement radiologic assessment of urinary tract obstruction.

The novelty of this study lies in its specific examination of the association between PLR and CT-based hydronephrosis grading in patients with urinary tract stones. Previous studies have investigated inflammatory biomarkers and radiologic characteristics in relation to different clinical outcomes. Jeong et al. (2021) reported higher NLR, PLR, and CRP levels among patients with ureteral stones measuring ≥5 mm, whereas the present study examined PLR in relation to radiologically assessed obstruction severity. Villanueva-Congote et al. (2024) identified associations between hematologic inflammatory ratios and urosepsis risk in patients with obstructing ureteral stones, while the present study focused on hydronephrosis severity rather than infectious complications. Patil et al. (2025) investigated PLR and mean platelet volume (MPV) as predictors of spontaneous distal ureteral stone passage, whereas this study evaluated the degree of obstruction. Lee and Bae (2025) examined associations between systemic inflammatory markers and kidney stone risk, while the present investigation addressed the relationship between PLR and obstruction severity. Similarly, Kadırhan et al. (2026) investigated CT findings, including hydronephrosis, stone attenuation, and UWT, alongside NLR and PLR as factors associated with spontaneous stone passage, whereas this study considered hydronephrosis grade as the primary radiologic outcome. Aghaways et al. (2022) and Abou Heidar et al. (2020) examined inflammatory markers and radiologic characteristics in relation to ureteral stone impaction or spontaneous passage, while the present study specifically assessed the association between PLR and hydronephrosis severity. Furthermore, Kriplani et al. (2022) investigated the association between PLR and systemic inflammatory response syndrome (SIRS) or sepsis following percutaneous nephrolithotomy (PCNL), whereas this study focused on radiologic evidence of urinary tract obstruction rather than postoperative complications. The present study also examined stone characteristics, including size, location, and CT attenuation expressed in HU, providing additional institution-specific evidence from Dr. Moewardi General Hospital, Surakarta. Importantly, HU measurements were interpreted as indicators of stone attenuation rather than definitive evidence of stone composition.

Accordingly, the primary research question was whether PLR, as a marker of systemic inflammation, was associated with the degree of urinary tract obstruction assessed through hydronephrosis grading on CT imaging in patients with urinary tract stones. This study aimed to analyze the relationship between PLR and hydronephrosis severity, classified into grades 0–4, among patients undergoing CT stone protocol imaging at Dr. Moewardi General Hospital, Surakarta. The findings were expected to contribute to the scientific understanding of the relationship between systemic inflammatory markers and radiologic manifestations of urinary tract obstruction. From a clinical perspective, the study sought to provide preliminary evidence regarding the potential value of PLR as a supplementary parameter alongside CT findings when assessing patients with urinary tract stones. For hospital services, the findings may offer additional information to support clinical assessment, risk stratification, and treatment planning. However, PLR should be interpreted as a nonspecific inflammatory marker and

should not replace imaging examinations or established clinical criteria for evaluating urinary tract obstruction.

METHOD

Research Design and Location

This analytical observational study employed a cross-sectional design to examine the relationship between systemic inflammation, as measured by the platelet-to-lymphocyte ratio (PLR), and the degree of urinary tract obstruction, as assessed by computed tomography (CT) stone protocol imaging, in patients with urinary tract stones. Retrospective secondary data were obtained from medical records, CT images stored in the Picture Archiving and Communication System (PACS) in Digital Imaging and Communications in Medicine (DICOM) format, and laboratory test results. The study was conducted at the Radiology Department and Medical Records Department of Dr. Moewardi General Hospital, Central Java, Indonesia. Data were collected from patients who underwent examinations between March and August 2025, following the approval of the study protocol by the relevant research ethics committee.

Population and Sample

The target population is all adult patients with a diagnosis of urinary tract stones. The affordable population is patients aged ≥18 years with a diagnosis of urinary tract stones who undergo CT stenography at Dr. Moewardi Hospital in the period from March to August 2025. Samples were taken using the total sampling technique, namely all patients from the affordable population who met the inclusion criteria and did not meet the exclusion criteria.

Inclusion criteria are male or female patients ≥18 years of age, diagnosed with urinary tract stones and have undergone CT stenography, and have complete blood results with a type count that allows PLR counting. Exclusion criteria are (1) incomplete medical, laboratory, or CT imaging data; (2) infections or diseases of active inflammation other than those caused by urinary tract stones, such as urinary tract infections with systemic signs, urosepsis, pneumonia, intraabdominal infection or inflammation, and active autoimmune diseases; (3) diabetes mellitus, hematologic abnormalities, active malignancies, or other conditions that affect platelet and lymphocyte counts; and (4) history of urinary tract stones (ESWL, URS, PCNL, or other surgery), installation of double-J stents, nephrostomy, or other urinary diversion prior to CT and laboratory examination being analyzed.

The minimum sample size is calculated by the correlation formula:

$$n = [(Z\alpha + Z\beta) / (0.5 \times \ln((1 + r)/(1 - r)))]^2 + 3$$

with $Z\alpha = 1.96$ ($\alpha = 0.05$), $Z\beta = 0.84$ (80% power), and $r = 0.42$. The r-value refers to Aghaways et al. (2022) who reported a Pearson correlation between PLR and ureteral wall thickness of 0.426, which was rounded to 0.42 as a conservative estimate of the relationship between PLR and obstruction severity. The calculation yielded 43 subjects, and after adding 10% to anticipate incomplete data, the minimum number required was 48 subjects. Because it uses total sampling, this number serves as the minimum limit of sample adequacy, not a restricted number.

Data Collection Procedure

After the proposal was approved, the researcher submitted an ethical clearance to the Health Research Ethics Commission of Dr. Moewardi Hospital as well as research permits and data access at the Medical Record Installation and Radiology Installation. After the permit was

obtained, the researcher recorded all urinary tract stone patients who underwent CT stonoography during the study period, selected them based on inclusion and exclusion criteria, then collected medical record data, DICOM images, and laboratory results for each subject.

CT images were obtained from PACS on the MSCT GE Revolution scanner, and the type of machine and examination protocol were confirmed through medical records, DICOM, and examination codes or billing data; outpatient or hospitalization status became supporting data only. The degree of hydronephrosis, location, size, and suspected type of stones were assessed from the imagery. PLR values were calculated from complete blood results with automatic type counts at the Clinical Pathology Laboratory Installation, which were examined with automated hematology analyzers (Sysmex XR-1000, Abbott Alinity hq, Beckman Coulter DxH900, or Mindray BC-6800). All data were recorded on a data collection sheet with a subject code without the patient's identity, then analyzed and presented in the form of text, graphs, and tables on the study results.

Data Analysis

The analysis was performed using SPSS. Categorical data were presented as frequency and percentage, while numerical data were tested for normality with Shapiro-Wilk and presented as average ± SD if normal or median and IQR if abnormal.

The difference in PLR between obstruction grades (0–4) was analyzed with the Kruskal-Wallis test, followed by the post hoc Dunn test with the Bonferroni correction when meaningful. The comparison of PLR between mild and significant obstructions used the Mann-Whitney test (or independent t-test if the distribution is normal). The relationship between PLR and the degree of ordinal obstruction (grades 0–4) was assessed with Spearman correlation to see the direction and strength of the relationship. The magnitude of the effect of PLR on the likelihood of meaningful obstruction was assessed by binary logistic regression and expressed as an odds ratio (OR) with a 95% confidence interval, per 1-point increment and 10-point PLR. These two analyses complement each other: the Spearman correlation describes the pattern of relationships across degrees, while the logistic regression measures the effect on the threshold of meaningful obstruction.

The differences in subject characteristics between the mild and significant obstruction groups were tested with the unpaired t-test for age (when normal), as well as the Fisher exact test (table 2×2) or the Fisher-Freeman-Halton exact test (larger table) for the categorical variable. This study was not intended to establish diagnostic cut-off values so ROC curve analysis was not performed. The $p<0.05$ value was considered significant.

RESULTS AND DISCUSSION

This study was carried out at the Radiology Installation of Dr. Moewardi Hospital Surakarta using secondary data from urinary tract stone patients who underwent CT stonographic examination in the period March to August 2025. From the data collection process, 51 subjects were obtained who met the research criteria and had complete platelet-to-lymphocyte ratio (PLR) data and degree of obstruction. All of these subjects were analyzed in the following section. All study subjects (n = 51) did not have a history of DJ stent insertion or other urinary diversion actions prior to CT stenography examination, so the degree of hydronephrosis assessed represented the actual degree of obstruction due to urinary tract stones.

The Shapiro-Wilk normality test showed that the variable age was normally distributed ($p = 0.285$), while PLR was not normally distributed ($p < 0.001$). Despite the wide distribution of PLR, all subjects were still analyzed because they met the study criteria. Because the PLR distribution was abnormal, the presentation of PLR emphasized the median value along with the interquartile range (IQR), and the relationship analysis was conducted using nonparametric tests, namely the Spearman correlation, the Kruskal-Wallis test, and the Mann-Whitney test.

Table 1. Research Characteristics

Characteristics	Total n=51	Mild obstruction n=21	Obstruction means n=30	p
Age, year	55.5 ± 10.3	52.9 ± 11.9	57.2 ± 8.7	0.140a
	Gender			0.064b
Male	36 (70,6%)	18 (85,7%)	18 (60,0%)	
Women	15 (29,4%)	3 (14,3%)	12 (40,0%)	
	Stone location			0.046c
Superior Kaliks	7 (13,7%)	3 (14,3%)	4 (13,3%)	
Medial calix	9 (17,6%)	5 (23,8%)	4 (13,3%)	
Inferior kaliks	11 (21,6%)	8 (38,1%)	3 (10,0%)	
Renal pelvis	9 (17,6%)	1 (4,8%)	8 (26,7%)	
Proximal ureter	6 (11,8%)	1 (4,8%)	5 (16,7%)	
Distal ureter	8 (15,7%)	2 (9,5%)	6 (20,0%)	
Urinary Bladder	1 (2,0%)	1 (4,8%)	0 (0,0%)	
	Stone size category			0.059c
≤5 mm	12 (23,5%)	9 (42,9%)	3 (10,0%)	
6–10 mm	10 (19,6%)	3 (14,3%)	7 (23,3%)	
11–20 mm	20 (39,2%)	7 (33,3%)	13 (43,3%)	
>20 mm	9 (17,6%)	2 (9,5%)	7 (23,3%)	
	Suspected stone types based on HU			0.002c
Calcium	35 (68,6%)	9 (42,9%)	26 (86,7%)	
Struvit	2 (3,9%)	1 (4,8%)	1 (3,3%)	
Gout	12 (23,5%)	9 (42,9%)	3 (10,0%)	
Undefinable	2 (3,9%)	2 (9,5%)	0 (0,0%)	
PLR	160,5 (109,7–236,3)	112,3 (94,1–149,0)	226,8 (160,5–259,5)	<0.001d

Remarks: Categorical data are presented as n (%). Age is presented as the average ± of elementary school. PLR is presented as median (IQR). Mild obstruction = grade 0–1; meaningful obstruction = grade 2–4.

a. The t-test is not paired.
b. Fisher exact test.
c. Fisher-Freeman-Halton exact test.
d. Mann-Whitney test.

Based on Table 1, the number of subjects with mild obstruction was 21 patients, while the subjects with meaningful obstruction were 30 patients. The mean age in the mild obstruction group was 52.9 ± 11.9 years, while in the mean obstruction group it was 57.2 ± 8.7 years, with a statistically insignificant difference ($p = 0.140$). Sex also showed no significant difference between the two groups ($p = 0.064$), although the proportion of males was higher in the mild obstruction group.

Based on the characteristics of the stones, the location of the stones showed a significant difference between the minor obstruction and the significant obstruction groups (p = 0.046). In the mild obstruction group, the location of the stones was most predominantly found in the inferior calices, while in the mean obstruction group the stones were more predominantly found in the renal pelvis, proximal ureters, and distal ureters. The stone size category showed no statistically significant differences between the two groups (p = 0.059), although there was a tendency for the proportion of larger stones to be more in the significant obstruction group.

The alleged stone type based on HU showed a significant difference between the two groups (p = 0.002). Calcium stones were more found in the significant obstruction group, while uric acid stones were more common in the mild obstruction group. PLR values also showed significant differences between the two groups, with the median PLR being higher in the significant obstruction group than in the mild obstruction group, which was 226.8 compared to 112.3 (p < 0.001).

Table 2. Distribution of subjects by degree of Obstruction

Degree of obstruction	Quantity (n)	Percentage	P
Grade 0 – no dilatation	12	23,5%	0.765a
Grade 1 – lightweight	9	17,6%	
Grade 2 – medium	8	15,7%	
Grade 3 – weight	9	17,6%	
Grade 4 – very heavy	13	25,5%	
Total	**51**	**100%**	

The degree of obstruction was assessed based on the grade of hydronephrosis on CT (ordinal scale 0–4). a Chi-square goodness-of-fit test for even distribution; χ^2 =1,843; df = 4; p = 0.765.

Based on Table 2, the most degrees of obstruction were grade 4 with 13 subjects (25.5%), followed by grade 0 with 12 subjects (23.5%), grade 1 and grade 3 with 9 subjects each (17.6%), and grade 2 with 8 subjects (15.7%). The chi-square suitability test showed that the distribution of subjects between degrees of obstruction was not significantly different from the even distribution (χ^2 = 1.843; df = 4; p = 0.765).

Table 3. PLR values by degree of obstruction

Degrees	N	PLR, median (IQR)	Average ± Elementary School	p*
Grade 0	12	109,7 (87,1–136,4)	109.3 ± 39.4	
Grade 1	9	131,1 (104,9–155,0)	138.5 ± 51.3	
Grade 2	8	177,7 (118,8–276,8)	213.0 ± 125.9	
Grade 3	9	199,9 (175,0–240,4)	195.9 ± 63.5	
Grade 4	13	236,6 (222,6–260,0)	321.0 ± 279.5	
Inter-grade	–	**H = 18,884**	–	**0,001**

Median (IQR) is the main presentation; the average ± SD is listed as complementary. SD = standard deviation. *Kruskal-Wallis test between five groups of obstruction degrees; H = Kruskal-Wallis statistics. A p value < 0.05 is considered significant.

Based on Table 3, it can be seen that the median value of PLR increases as the degree of obstruction increases. The median PLR increased from 109.7 in grade 0; 131.1 in grade 1; 177.7 in grade 2; 199.9 in grade 3; to 236.6 in grade 4. This difference between groups is statistically significant in the Kruskal-Wallis test (H = 18.884; p = 0.001). With this pattern, PLR tends to increase as the degree of obstruction increases.

Table 4. Comparison of PLR in mild versus significant obstruction

Markers	Mild obstruction (grade 0–1), n = 21	Meaningful obstruction (grades 2–4), n = 30	p*
PLR, median (IQR)	112,3 (94,1–149,0)	226,8 (160,5–259,5)	< 0.001

*Mann-Whitney test. Meaningful obstruction is defined as moderate to very severe hydronephrosis (grade ≥2). IQR = interquartile range.

Based on Table 4, the grouping of subjects into mild obstruction (grade 0–1) and significant obstruction (grade ≥2) reinforces the previous findings. PLR values differed significantly between the light obstruction and significant obstruction groups (p < 0.001), with the median PLR in the significant obstruction group being higher than in the mild group (226.8 vs 112.3).

Table 5. Results of the Spearman correlation test to the degree of obstruction

Variable	Correlation coefficient (rho)	P
PLR	0,609	< 0.001

Based on Table 5, PLR has a significant positive correlation with the degree of obstruction (rho = 0.609; p < 0.001). The higher the PLR value, the more severe the degree of obstruction. PLR shows a strong positive correlation with the degree of obstruction.

Table 6. Post hoc analysis of Dunn with Bonferroni correction

Comparison of degrees of obstruction	Mean rank difference	Z	p before correction	p Bonferroni	Conclusion
Grade 0 vs Grade 1	-5,64	-0,860	0,390	1,000	Meaningless
Grade 0 vs Grade 2	-14,79	-2,180	0,029	0,293	Meaningless
Grade 0 vs Grade 3	-17,42	-2,657	0,008	0,079	Meaningless
Grade 0 vs Grade 4	**-23,65**	**-3,974**	**<0.001**	**0,001**	**Meaningful**
Grade 1 vs Grade 2	-9,15	-1,267	0,205	1,000	Meaningless
Grade 1 vs Grade 3	-11,78	-1,681	0,093	0,928	Meaningless
Grade 1 vs Grade 4	-18,01	-2,794	0,005	0,052	Meaningless
Grade 2 vs Grade 3	-2,63	-0,363	0,716	1,000	Meaningless
Grade 2 vs Grade 4	-8,86	-1,326	0,185	1,000	Meaningless
Grade 3 vs Grade 4	-6,23	-0,967	0,334	1,000	Meaningless

Remarks: Post hoc analysis using the Dunn test with Bonferroni correction, conducted after the Kruskal-Wallis test showed a significant difference between the degrees of obstruction. Bonferroni's p-value <0.05 was considered significant. Z = Dunn test statistics.

Based on Table 6, the post hoc analysis of the Dunn test with Bonferroni correction conducted after the Kruskal-Wallis test showed a significant difference in PLR values mainly between grade 0 and grade 4, with Bonferroni p values = 0.001. The comparison between grade 1 and grade 4 yielded a Bonferroni p value = 0.052 so that it did not meet the limits of statistical significance. Comparisons between other pairs of degrees of obstruction showed no significant differences after Bonferroni correction. Thus, the difference in PLR values was most clearly visible between patients without obstruction and patients with the most severe degree of obstruction.

Table 7. PLR binary logistic regression of meaningful obstruction

Models	Exp(B) = OR	IK95%	p
Per 1 PLR point increase	1,024	1,010–1,038	0,001
Per 10 PLR points increase	1,262	1,101–1,447	0,001

Description:
The outcome is a meaningful obstruction, with codes 0 = mild obstruction grade 0–1 and 1 = meaningful obstruction grade 2–4. OR = odds ratio; IK95% = 95% confidence interval.

Based on Table 7, binary logistic regression analysis shows that PLR is significantly related to the occurrence of meaningful obstruction. Every 1-point increase in the PLR value increases the probability of significant obstruction occurring by 1.024 times (OR = 1.024; 95% IK1.010–1.038; p = 0.001).

To facilitate clinical interpretation, PLR was also analyzed per 10-point increment. The result was that every 10-point increase in the PLR value increased the odds of significant obstruction by 1,262 times (OR = 1,262; 95% IK1,101–1,447; p = 0.001). Thus, the higher the PLR value, the more likely the patient is to experience meaningful obstruction.

The main finding of this study was that there was a significant positive association between PLR and the degree of urinary tract obstruction based on CT stenography (rho = 0.609; $p < 0.001$). The increase in PLR that accompanied the increase in the degree of hydronephrosis suggests that PLR may reflect a systemic inflammatory response related to the degree of obstruction.

When compared to the reference value of the healthy adult population, which is a median value of around 116 with an upper reference limit of 200.6 in males and 216.9 in females (Fei et al., 2020), the median PLR value in subjects without hydronephrosis (grade 0), which is 109.7, is still within the normal range. In contrast, the median PLR value at grade 4, which is 236.6, has exceeded the upper limit of the referral, which is used as an indicative comparison considering the unavailability of specific PLR reference values for the Indonesian population. This comparison shows that the increase in PLR in severe obstruction is not only statistically significant, but also exceeds the range of values commonly found in healthy adult individuals.

The comparison between the mild obstruction (grade 0–1) and significant obstruction (grade ≥2) groups reinforces the picture. The median PLR in the mean obstruction group was higher than in the mild group (226.8 vs 112.3), and the difference was statistically significant ($p < 0.001$). This pattern shows that the PLR value increases as the degree of obstruction increases. The selection of grade 2 as the threshold for meaningful obstruction in this study is consistent with previous research, so this study is conceptually comparable to previous research (Kadırhan et al., 2026).

Post hoc analysis provides a more detailed picture of the pattern. Significant differences in PLR values after Bonferroni correction were found only between grade 0 and grade 4 ($p = 0.001$), while comparisons between grade 1 and grade 4 were right at the limit of significance ($p = 0.052$). Comparisons between adjacent degrees showed no meaningful differences. This pattern showed a gradual increase in PLR and was statistically significant when compared between extreme degrees of obstruction. The meaninglessness of the differences between adjacent degrees most likely reflected the limited number of subjects in each group, which ranged from only 8 to 13 people, so the power of the test to detect small differences was limited. This does not negate the tendency for a consistent increase in PLR, as shown by the Spearman correlation test.

The results of binary logistics regression reinforce these findings quantitatively. Every 10-point increase in the PLR value increases the odds of a meaningful obstruction by 1.262 times (95% IK1.101–1.447; $p = 0.001$). It should be emphasized that the value represents an increase in odds, not an increase in risk directly. In studies with a cross-sectional design and a high prevalence of outcomes, which was 58.8% in this study, the odds ratio was understood as a measure of the direction and strength of the association between PLR and the degree of obstruction, not as an absolute risk estimate that could be directly applied to the patient. This interpretation is in accordance with the nature of a cross-sectional design that assesses associations at a single point in time, where the primary analysis of the relationship is based on Spearman correlations, while binary logistic regression serves as a supporting analysis.

Pathophysiologically, this relationship can be explained through an inflammatory response related to obstruction. Stones that obstruct the kidneys and urinary tract can cause dilatation, ischemia, and injury to the urinary tract epithelium, which then release damage-associated molecular patterns (DAMPs). These molecules are recognized by innate immune receptors and can activate sterile inflammatory pathways, including the NLRP3 inflamasome, thereby triggering the release of pro-inflammatory cytokines such as IL-6 and IL-1. This response tends to trigger relative lymphopenia due to lymphocyte redistribution and apoptosis, while stimulating platelet production. It is this change in cellular composition that is thought to underlie platelet increases accompanied by lymphocyte decreases, which are reflected as PLR increases. Platelets are cells that have many pro-inflammatory mediators and play an active role in the inflammatory process, so the ratio involving platelets such as PLR can be an informative indicator of the degree of inflammation related to obstruction (Wyczanska & Lange-Sperandio, 2020).

These findings are in line with a number of previous studies linking blood count-based inflammatory markers to the severity of stone disease. Kadırhan et al. reported that PLR was higher in patients with spontaneous passivity failure of ureteral stones, and that the chances of stone exit decreased as the degree of hydronephrosis increased (Kadırhan et al., 2026). A similar pattern was reported by Abou Heidar et al., who found an inverse association between PLR and spontaneous stone exit, where moderate to severe hydronephrosis was also a predictor of stone exit failure (Abou Heidar et al., 2020). Aghaways et al. also showed a significant correlation between increased PLR and thickening of the ureteral wall thickness around the stone, which is a marker of local impaction and inflammation associated with obstruction (Aghaways et al., 2022). The findings of this study reinforce the concept that the heavier the

degree of obstruction, the more likely it is to be accompanied by a higher systemic inflammatory response, as illustrated by PLR values. As additional evidence, PLR has also been associated with urological inflammatory processes in other contexts, such as the risk of urosepsis in obstructing stones (Villanueva-Congote et al., 2024) as well as as as a predictor of systemic inflammatory response syndrome and postoperative sepsis of percutaneous nephrolithotomy (Kriplani et al., 2022); although the context of the two studies differs from the assessment of the degree of obstruction based on CT, both confirm the association of PLR with inflammation in stone disease.

In addition to PLR, the radiological characteristics of the stones also need to be considered. In this study, the stone size category did not differ significantly between the minor obstruction and significant obstruction groups ($p = 0.059$), although there was a tendency for the proportion of larger stones in the significant obstruction group. The location of the stones differed significantly between the two groups ($p = 0.046$), with stones in the renal pelvis and ureters more in the significant obstruction group, while inferior calcified stones were more abundant in the light obstruction group. These findings are in line with the understanding that stones in the renal pelvis and ureters have more potential to inhibit urine flow than calcified stones which are often non-obstructive. Meanwhile, the alleged stone type based on HU is only a radiological estimate and cannot definitively replace the analysis of stone composition.

The Platelet to Lymphocyte Ratio (PLR), in practical terms, is a parameter that can be calculated directly from a routine complete blood test, at no additional cost, and is available in almost all healthcare facilities. The relationship to the degree of obstruction in this study is that PLR has the potential to be a supporting parameter in the initial assessment of urinary stone patients, particularly to help mark patients with more severe obstruction. The findings in the broader population are also the same, namely high levels of inflammatory markers associated with kidney stone disease, especially in the elderly group (Lee & Bae, 2025).

This study has a number of limitations that need to be considered in interpreting the results. First, the research design is cross-sectional with secondary data from one center, so the relationships found are associative and cannot conclude cause and effect. Second, the PLR values in this study have a wide distribution with a number of extreme values. Therefore, the data presentation emphasizes median and IQR and uses nonparametric tests to keep interpretation accurate. Third, PLR is influenced by various other clinical factors outside of obstruction, such as infection, other systemic inflammation, physiological stress, comorbidities, blood sampling time, and previous history of action. Fourth, the location of stones in this study is heterogeneous which includes intrarenal stones, ureters, and urinary vesicles so that the source of obstruction is not always homogeneous, considering that calico stones do not necessarily cause obstructions such as ureteral or renal pelvic stones. Fifth, the alleged type of stone is based on the HU value and not the definitive composition analysis. Sixth, the PLR was measured once at the time of examination so as not to depict its changing trend over time. Further research is suggested using a prospective, multi-flashing design, with a larger number of subjects and serial PLR measurements to confirm and reinforce these findings.

Overall, PLR is believed to be a simple supporting parameter in the assessment of the degree of obstruction, but its interpretation must still be combined with the findings of CT stenography and the patient's condition.

Novelty values

The novelty of this research lies in the integration of simple systemic inflammatory biomarkers with the assessment of the degree of obstruction radiologically. Based on the comparison with the previous research used in the thesis, the new contribution of this research can be formulated as follows.

1. The study placed a direct relationship between PLR and the degree of obstruction based on CT stenography as the main output. Previous studies have assessed PLR more in relation to stone size, the likelihood of spontaneous stone exit, ureteral wall thickness, urosepsis, or post-action complications.
2. The degree of obstruction was assessed in stages using the Society for Fetal Urology's (SFU) hydronephrosis grade 0–4 (Fernbach et al., 1993), and then analyzed as mild obstruction (grade 0–1) and significant obstruction (grade 2–4). This approach allows for an assessment of the relationship between PLR and the severity spectrum of obstruction, not just based on the presence or absence of hydronephrosis.
3. The study not only showed differences in PLR between groups, but also measured the pattern of PLR increase by grade, the strength of correlation with the degree of obstruction, as well as the change in the odds of obstruction significance at every 10-point increase in PLR. Thus, the relationship was assessed more quantitatively and clinically.
4. The study combined routine laboratory data with CT stonography characteristics, including stone size, location, and density, providing a more comprehensive picture of the association of systemic inflammation and radiological findings in urinary tract stones.
5. The study provided data on the adult population in Indonesia, especially patients of Dr. Moewardi Surakarta Hospital. Local data on the relationship between PLR and the degree of radiological obstruction are still limited, so the results of this study add relevant evidence for radiology and urology practice in Indonesia.
6. The findings of the study introduce PLR as a supporting parameter that is inexpensive, easy to obtain, and does not require additional examination to help flag patients with more likely obstructions. However, the study remains affirmed that PLR does not replace CT stonoography as the primary modality of obstruction assessment.

Research Limitations

This study has several limitations that need to be considered in interpreting the results and applying the findings to a wider population.

1. The cross-sectional research design and the use of secondary data showed only a relationship at one observation time. Therefore, the results could not confirm the time sequence or cause-effect relationship between the increase in platelet-to-lymphocyte ratio (PLR) and the increase in the degree of obstruction.
2. The study was conducted in one health care center with a sample of 51 subjects. The number of subjects in each grade of hydronephrosis was relatively small, which was about 8–13 patients, so the statistical power to detect differences in PLR between adjacent grades was limited. This condition also limited the generalization of results to other populations and health facilities.

3. PLR values have a wide distribution and there are a number of extreme values. Although the analysis has used medians, interquartile ranges, and nonparametric tests, these variations can still affect the stability of the relationship estimates.
4. PLR values are non-specific markers of inflammation and can be affected by infection, other systemic inflammation, physiological stress, comorbidities, medications, blood sampling time, and history of previous actions. The application of exclusion criteria can reduce the influence of these factors, but does not completely eliminate the possibility of residual confounding.
5. The location of stones in the study subjects was heterogeneous, including intrarenal stones, renal pelvis, ureters, and urinary vesicles. The mechanism and potential for obstruction at each location are not the same; for example, callicular stones can be nonobstructive, while stones in the renal pelvis or ureters more directly inhibit the flow of urine.
6. The alleged composition or type of stone was determined based on the density of the Hounsfield Unit on CT stenography and was not confirmed by laboratory analysis of the composition of the stone. Therefore, the classification of the stone type in this study is a radiological estimate, not a definitive composition diagnosis.
7. The morphology or surface characteristics of the stone, such as slippery, rough, or jagged surfaces, were not assessed in this study because they were not consistently recorded on CT stonographic reports and medical records. These characteristics may influence mucosal irritation and local inflammatory responses, thus potentially being a residual confounding factor in the relationship between PLR values and degrees of obstruction.
8. PLR values were measured only once at the time of examination, so studies have not been able to describe changes in PLR before and after obstruction, after decompression, or during the patient's clinical journey.
9. Regression analysis primarily assessed the association of PLR with meaningful obstruction, while other clinical and radiological factors, such as age, sex, stone size, stone location, and comorbidities, had not been entirely controlled simultaneously in a multivariate model. Thus, some of the associations found may still be influenced by other confounding factors.

CONCLUSION

Based on the findings of this study, a statistically significant, strong positive correlation was identified between the platelet-to-lymphocyte ratio (PLR) and the degree of urinary tract obstruction, as assessed by computed tomography (CT) stone protocol imaging, in patients with urinary tract stones. Higher PLR values were associated with greater obstruction severity, suggesting that PLR may serve as a supplementary inflammatory marker in the clinical evaluation of these patients. Clinicians may consider PLR as an additional parameter during the initial assessment of patients with suspected significant urinary tract obstruction. Radiologists should interpret CT findings in conjunction with relevant clinical and laboratory parameters, including PLR, to support a more comprehensive assessment of disease severity. Healthcare facilities may incorporate PLR measurements derived from routine complete blood counts as an accessible and inexpensive supplementary parameter. However, PLR values should be interpreted cautiously because they may be influenced by concurrent infections, systemic inflammatory conditions, comorbidities, and previous medical interventions. Given the observational, cross-sectional design of this study, the findings demonstrate an association

rather than a causal relationship between PLR and obstruction severity. Future prospective, multicenter studies involving larger sample sizes are recommended to validate these findings, improve their generalizability, and further investigate the clinical utility of PLR in assessing urinary tract obstruction.

FUNDING

The author states that no financial support has been received for the implementation of this research and/or the publication of this article.

CONFLICT OF INTEREST

The author states that this research was conducted without any commercial or financial relationship that can be interpreted as a potential conflict of interest.

AUTHOR'S CONTRIBUTION

Author 1: conceptualization of research, design of methodology, implementation of experiments, data collection, data analysis, preparation of manuscripts, and revision of manuscripts, supervision of research, validation of research results, provision of scientific input, and review and revision of manuscripts. All authors have read and approved the final version of the manuscript.

GENERATIVE ARTIFICIAL INTELLIGENCE USAGE STATEMENT

The author states that generative artificial intelligence (AI) is used in the preparation of this manuscript to help improve language clarity, improve grammar, and refine the structure of writing. Generative AI is not used to generate, manipulate, or analyze research data. The entire content of the manuscript has been reviewed and verified by the author. The author is solely responsible for the accuracy, integrity, and final content of the manuscript.

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