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Neutrophil to Lymphocyte Ratio And Bacterial Pattern In Urine of Patients with Urinary Tract Infection at Haji Adam Malik General Hospital

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Abstract

Introduction: Urinary tract infections (UTIs) are among the most prevalent infectious diseases globally, with a significant burden in developing countries due to limited healthcare access and antibiotic resistance. The neutrophil to lymphocyte ratio (NLR) has emerged as a potential hematological marker reflecting systemic inflammation in bacterial infections. However, its correlation with specific uropathogens remains underexplored, particularly in Indonesian tertiary hospitals.
Objective: To evaluate the association between neutrophil to lymphocyte ratio (NLR) and the pattern of bacterial isolates in urine cultures of UTI patients at Haji Adam Malik General Hospital.
Methods: This cross-sectional observational study included 97 patients diagnosed with UTI between April and May 2025. Data were obtained from medical records, including NLR values and urine culture results. NLR was categorized as low ($<1.0\times10^9$/L), normal (1.0–17.5×10^9/L), or high ($>17.5\times10^9$/L). Bacterial isolates were identified and classified. Statistical analysis using Chi-square or Fisher's exact test determined the association between NLR and bacterial patterns.
Results: Most patients (68.00%) had normal NLR values, while 27.80% had elevated and 4.10% had low NLR. Escherichia coliwas the most frequently isolated pathogen (71.10%), followed by Klebsiella spp. (10.30%), Staphylococcus saprophyticus(7.20%), Proteus spp. (4.10%) Enterococcus spp. (4.10%), and Pseudomonas aeruginosa (3.10%). Although Proteus spp.and Enterococcus spp. were more commonly associated with elevated NLR, the association between NLR and specific bacterial isolates was not statistically significant ($p = 0.08$).
Conclusion: The neutrophil to lymphocyte ratio varies among UTI patients but is not significantly associated with the type of uropathogen. While NLR may reflect systemic inflammation in certain bacterial infections, its standalone diagnostic value in predicting bacterial etiology remains limited. Further studies with larger populations and integration of additional biomarkers are warranted to clarify the role of NLR in UTI management.
Keywords: Urinary tract infection, neutrophil to lymphocyte ratio, uropathogen, Escherichia coli.

1. INTRODUCTION

Urinary tract infections (UTIs) represent one of the most common infectious diseases worldwide. According to the World Health Organization (WHO), approximately 150 million UTI cases occur globally each year, with a significantly higher prevalence in females compared to males. In the Asian region, the incidence of UTIs varies, with developing countries exhibiting a higher burden due to suboptimal hygiene, limited access to healthcare services, and rising antibiotic resistance. In Indonesia, UTIs are among the leading causes of nosocomial infections, especially in academic hospitals. In Medan, North Sumatra, data from Haji Adam Malik

General Hospital show that UTIs are among the most frequently diagnosed infections in emergency and inpatient settings, with an increasing trend in incidence each year.[1-4]

The high prevalence of UTIs necessitates a deeper understanding of the factors contributing to the infection, including the host immune response. One hematological parameter gaining interest as a marker of immune response is the neutrophil to lymphocyte ratio (NLR), which reflects the balance between innate inflammatory activity and adaptive immune regulation. Elevated NLR levels have been documented in patients with bacterial infections. However, there remains a lack of studies specifically correlating NLR values with bacterial culture profiles in urine specimens from UTI patients.[5,6]

Assessing the NLR in UTI patients may offer a rapid and cost-effective method to evaluate infection severity and possibly infer the type of bacterial pathogens involved. This approach could enhance the diagnostic process, particularly in resource-limited settings, and support the development of hematology-based diagnostic algorithms for infectious diseases. A key research gap lies in the limited number of studies exploring the association between NLR and urinary bacterial patterns in Indonesia, particularly in the context of tertiary referral hospitals such as RSUP Haji Adam Malik. The practical gap observed is the underutilization of hematological parameters like NLR as predictive markers in the routine diagnosis and management of UTIs in primary and secondary care.[7]

The pathophysiology of UTIs involves a complex interplay between uropathogenic bacteria and the host immune system. Bacterial entry into the urinary tract typically occurs via the urethra, followed by adherence to uroepithelial cells, proliferation, and initiation of localized inflammation. This immune response includes the recruitment of neutrophils and macrophages and the release of pro-inflammatory cytokines such as interleukin-6 (IL-6) and tumor necrosis factor-alpha (TNF-α), which contribute to a systemic rise in circulating neutrophils.[8,9]

Escherichia coli, particularly the uropathogenic strains (UPEC), remains the most prevalent causative agent of community-acquired and nosocomial UTIs, accounting for more than 70% of outpatient cases and about 50% of hospital-associated infections. Other notable uropathogens include Klebsiella pneumoniae, Proteus mirabilis, and Enterococcus faecalis, which are frequently isolated from catheter-associated and complicated UTIs, especially in patients with prolonged hospitalization or underlying urological conditions.[10,11]

The NLR serves as a practical inflammatory marker that may provide insight into the systemic immune status during bacterial infections. In the context of UTI, an elevated NLR is indicative of a shift in the immune response toward an acute inflammatory state, commonly observed in the presence of bacterial pathogens. Several studies have demonstrated a correlation between high NLR values and infection severity, as well as antibiotic resistance, making NLR a potentially useful tool in UTI assessment.[12]

From a pathophysiological perspective, the role of NLR in detecting bacterial infections in UTIs can be explained by the immune cascade triggered by bacterial invasion. Uropathogens such as E. coli activate the innate immune system, leading to neutrophil migration to the infection site and increased neutrophil counts in the bloodstream. Simultaneously, systemic inflammation can result in lymphocyte suppression, thus elevating the NLR. Therefore, increased NLR values may serve as an accessible surrogate marker of infection severity and help guide empirical treatment choices in clinical settings.[13]

Therefore, this study aims to analyze the profile of neutrophil to lymphocyte ratio and the pattern of bacterial isolates found in urine cultures of UTI patients treated at Haji Adam Malik General Hospital. The findings are expected to contribute to the existing body of evidence supporting the diagnostic utility of hematological indices in infectious disease management and to promote more targeted therapeutic interventions in UTI care.

2. METHODS

2.1. Methods

This was an observational analytic study with a cross-sectional design aimed at evaluating the association between the neutrophil to lymphocyte ratio (NLR) profile and the bacterial pattern in urine specimens of patients diagnosed with urinary tract infection (UTI). The study was conducted at Haji Adam Malik General Hospital, a tertiary referral center in Medan, North Sumatra. Data collection was carried out following ethical clearance from the Health Research Ethics Committee of the Faculty of Medicine, Universitas Sumatera Utara.

2.2. Population

The study population included all patients diagnosed with UTI at the hospital between April and May 2025. The sample was drawn using a consecutive sampling technique, where all eligible patients who met the inclusion criteria and did not meet any exclusion criteria were enrolled until the required sample size was achieved. The minimum required sample size was calculated using the Lemeshow formula, considering the estimated proportion of UTI patients with elevated NLR. The result of the calculation indicated a minimum of 97 participants was needed to ensure adequate power for statistical analysis.

Inclusion criteria were patients diagnosed with UTI confirmed by urinalysis, who had undergone both NLR testing and urine culture. Exclusion criteria included patients with congenital abnormalities of the urinary tract, a history of recent antibiotic use prior to sampling, or incomplete clinical and laboratory records. The independent variable in this study was the neutrophil to lymphocyte ratio, categorized as low ($<1.0\times10^9$/L), normal ($1.0–17.5\times10^9$/L), or high ($>17.5\times10^9$/L). The dependent variable was the urinary bacterial pattern based on culture results, including common uropathogens such as Escherichia coli, Klebsiella spp., Proteus spp., Staphylococcus aureus, Enterobacter spp., Pseudomonas aeruginosa, Acinetobacter spp., and Candida albicans.

2.3. Ethical Compliance

This research already followed the ethical standard that had bee granted by each institution according to Helsinki Declaration. This study was also reviewed by Ethical Committee for Health Research Universitas Sumatera Utara as the Institutional Research.

2.4. Statistical Analysis

Data were obtained from secondary sources in the form of medical records. Collected data included demographic information, NLR values from hematology tests, and bacterial culture results from urine specimens. All variables were recorded, categorized, and tabulated. Descriptive statistics were used to present frequencies, percentages, means, and standard deviations, as appropriate. Bivariate analysis was conducted using the Chi-square test to determine associations between NLR and urinary bacterial patterns. If the assumptions for Chi-square were not met, Fisher's exact test or other non-parametric alternatives were applied. A p-value of less than 0.05 was considered statistically significant.

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3. RESULTS

This study enrolled a total of 97 patients who were diagnosed with urinary tract infection (UTI) at Haji

Adam Malik General Hospital. The demographic analysis revealed that the mean age of participants was 49.89 years with a standard deviation of 14.42 years, indicating that the majority of the patients were middle-aged adults. The gender distribution was relatively balanced, comprising 45 male patients (46.40%) and 52 female patients (53.60%). Regarding the anatomical site of infection, 70.10% of patients were diagnosed with lower urinary tract infection, while 29.90% had upper urinary tract infection. These findings reflect the common epidemiological profile of UTIs, which predominantly affect females and are more frequent in the lower urinary tract.

Table 1. Demographic Characteristics of UTI Patients at Haji Adam Malik General Hospital

Characteristics	**(mean ± SD)**	
Age	49.89 ± 14.42	
	n	**%**
Sex		
Male	45	46.40
Female	52	53.60
Site of UTI		
Upper UTI	29	29.90
Lower UTI	68	70.10
Total	97	100.00

The analysis of neutrophil to lymphocyte ratio (NLR) profiles showed that a majority of UTI patients (68.00%) had NLR values within the normal range. Elevated NLR values, indicative of systemic inflammation or infection, were observed in 27.80% of patients, while only 4.10% of subjects had NLR values classified as low. These data suggest that although NLR remains within normal range in most UTI patients, a significant proportion exhibits elevated values, possibly reflecting varying degrees of host immune response or infection severity.

Bacteriological analysis from urine cultures revealed that *Escherichia coli* was the predominant uropathogen, identified in 69 out of 97 isolates (71.10%). Other bacteria identified included *Klebsiella* spp. (10.30%), *Staphylococcus saprophyticus* (7.20%), *Proteus* spp. (4.10%), *Enterococcus* spp. (4.10%), and *Pseudomonas aeruginosa* (3.10%). These findings are consistent with global epidemiological trends in community-acquired UTI, where *E. coli* continues to be the most prevalent causative agent. The diversity in bacterial patterns also underscores the importance of routine culture and sensitivity testing for appropriate antibiotic stewardship.

Table 2. Distribution of Neutrophil to Lymphocyte Ratio (NLR) in UTI Patients

NLR Category	**n**	**%**
Low	4	4.10
Normal	66	68.00
High	27	27.80
Total	97	100.00

A statistically significant association was observed between the presence of type 2 diabetes mellitus and the incidence of colorectal cancer ($p = 0.042$), as presented in Table 2. Among the 61 subjects, 23 individuals (37.7%) had a confirmed history of type 2 diabetes, while 38 individuals (62.3%) did not. The chi-square test confirmed that the presence of diabetes mellitus was significantly correlated with the incidence of colorectal cancer in this patient population.

Table 3. Distribution of Bacterial Isolates in Urine of UTI Patients

Bacterial Species	**Frequency**	**Percentage**
Escherichia coli	69	71.10%
Klebsiella spp.	10	10.30%
Staphylococcus saprophyticus	7	7.20%
Proteus spp.	4	4.10%
Pseudomonas aeruginosa	3	3.10%
Enterococcus spp.	4	4.10%
Total	97	100.00%

An analysis examining the relationship between NLR profiles and specific bacterial patterns was performed to assess whether systemic inflammatory response differed according to the type of uropathogen. Among the 69 patients with *E. coli* infection, 47 had normal NLR values, 20 had high NLR, and 2 had low NLR. In the 10 *Klebsiella* cases, most patients had normal NLR (8 cases) while 2 had low NLR, and none had high NLR. Interestingly, *Proteus* spp. and *Enterococcus* spp. were more frequently associated with elevated NLR values (3 and 2 cases, respectively), suggesting a possible stronger systemic inflammatory response in infections caused by these pathogens. Nevertheless, statistical analysis using the Chi-square test did not show a significant association between NLR profile and the type of bacterial isolate (p-value = 0.08).

Table 4. Correlation between NLR Profile and Bacterial Pattern in UTI Patients

Bacterial Species	**Low NLR**	**Normal NLR**	**High NLR**	**Total**
Escherichia coli	2	47	20	69
Klebsiella spp.	2	8	0	10
Staphylococcus saprophyticus	0	5	2	7
Proteus spp.	0	1	3	4
Pseudomonas aeruginosa	0	3	0	3
Enterococcus spp.	0	2	2	4
Total	4	66	27	97

The study findings indicate that the neutrophil to lymphocyte ratio may vary according to the causative organism in urinary tract infections. However, despite observable trends, no statistically significant relationship was established between NLR levels and specific uropathogens. These results highlight the need for further studies with larger sample sizes to elucidate whether NLR can serve as a reliable biomarker in predicting the severity or microbial etiology of UTI. Nonetheless, the predominance of *E. coli* and the relatively high proportion of patients with elevated NLR provide valuable insight into the inflammatory profiles associated with UTI in this patient population.

4. DISCUSSION

The findings of this study highlight that age plays a crucial role in the incidence and severity of urinary tract infections (UTIs). The mean age of patients was 49.89 years, indicating that UTIs are not limited to the elderly but also affect individuals in their productive years. This aligns with previous studies, such as that by Faine et al. (2022), reporting a median age of 62.9 years and by Jagadeesan et al. (2022), who found a mean age of 52.18 ± 9.06 years. Similarly, Risdinar et al. (2022) in Lampung found the highest UTI incidence in the

56–65 age group. These findings support the idea that aging impacts immune responsiveness, contributing to higher UTI risks in both middle-aged and older populations.[14-16]

Aging-associated immune and structural changes in the bladder significantly impact host susceptibility to UTI. As demonstrated by Ligon et al. (2023), uropathogenic Escherichia coli (UPEC) can evade the immune response by forming intracellular bacterial communities (IBC) and quiescent intracellular reservoirs (QIRs). In the aged bladder, increased permeability, higher QIRs accumulation, and tertiary lymphoid tissue (bTLT) formation with active germinal centers lead to altered mucosal immunity. These mechanisms underscore how immunosenescence compromises bladder defense, predisposing older adults to persistent and recurrent UTIs.17

Sex-based anatomical and physiological differences also influence UTI prevalence. This study found a slightly higher proportion of female patients (53.6%), consistent with findings from Diriba et al. (2025), Zhan et al. (2024), and Kurniawan et al. (2023). The shorter urethra and proximity of the female urethral meatus to the vagina and rectum increase susceptibility to ascending infections. Moreover, vaginal dysbiosis is implicated in UTI pathogenesis in women, further supported by studies such as P. et al. (2022).[18-21]

In this study, 70.10% of cases involved the lower urinary tract, indicating that lower tract infections like cystitis are more common than upper tract infections such as pyelonephritis (29.90%). These findings differ from the distribution reported by Swamy et al. (2022) and Ehsanipour et al. (2017) but are consistent with Kocaaslan et al. (2024), who also observed a higher proportion of non-renal involvement in neonates. The higher prevalence of lower tract infections in this study may be attributed to the predominance of female patients, whose urothelial estrogen receptor (ERβ) expression differs significantly from that in males.[22-25]

Estrogen and progesterone receptor expression in the female urinary tract contributes to infection susceptibility. Estrogen receptor β (ERβ) is predominantly expressed in female urothelium, influencing immune responses through regulation of progesterone receptor (PR) expression. Alterations in ERα signaling reduce PR-positive cells in the urethra, weakening mucosal defenses. In contrast, such regulatory pathways are absent or inactive in males, reinforcing the notion that hormonal factors modulate UTI vulnerability differently between sexes.[25]

The neutrophil-to-lymphocyte ratio (NLR) has emerged as a non-invasive marker of systemic inflammation. This study identified normal NLR values in the majority (68%) of patients, with elevated NLR in 27.8%. These findings suggest that while NLR may aid early UTI diagnosis and risk stratification, systemic inflammation may not always be present in uncomplicated UTI cases. As noted by Yoon et al. (2013), NLR is useful in identifying high-risk patients and can serve as an adjunct to CRP in guiding early treatment.[26]

The elevated NLR observed in some cases may be explained by pro-inflammatory cytokine release, including IL-1α, IL-6, IL-7, and others, as reported by Huang et al. (2018). However, the predominance of normal NLR in this study may indicate that most UTI cases were mild without systemic inflammatory response. This interpretation aligns with Asik (2021) and Kriplani et al. (2022), who observed that although NLR and PLR are elevated in infections, they should be interpreted alongside clinical features to determine disease severity.[27-29]

Low NLR values, found in 4.1% of patients, may reflect impaired neutrophil recruitment or lymphocytosis. Haraoka et al. (1999) demonstrated in C3H/HeJ mice that deficient neutrophil recruitment permits bacterial persistence. In contrast, effective neutrophil response in C3H/HeN mice enabled bacterial clearance. Low NLR may thus signify a compromised innate response, increasing the risk of prolonged or recurrent infection, especially in cases of underlying immune dysregulation such as viral-induced lymphocytosis.[30,31]

The identification of Escherichia coli as the dominant uropathogen (71.1%) corroborates findings from Jalil and Al Atbee (2022) and Khan et al. (2020), who reported prevalence rates of approximately 68.3% and similar figures globally. E. coli's dominance is attributed to its virulence factors, including Type 1 and P fimbriae, biofilm formation, and intracellular replication capabilities, allowing immune evasion and persistent colonization.[32-35]

Other uropathogens such as Klebsiella pneumoniae and Staphylococcus saprophyticus were also notable. Klebsiella spp. are common healthcare-associated pathogens with significant antibiotic resistance, as reported by Chapelle et al. (2021) and Rosana et al. (2020). S. saprophyticus, though typically community-acquired, was identified in sexually active young women, accounting for 42% of cases in certain demographics, though it was third most common in this study.[36,37]

Proteus spp. and Enterococcus spp., each found in 4.1% of samples, were associated with catheter-associated UTI (CA-UTI), aligning with findings from Abu-Aqil et al. (2023) and Jamil et al. (2017). Proteus spp. are particularly concerning due to their ability to form crystalline biofilms and produce cytotoxins that damage urothelium. Pseudomonas aeruginosa, though less common (3.1%), poses a significant clinical challenge due to multidrug resistance, as previously reported by AL-Khikani and Ayit (2022) and Mohapatra et al. (2022).[38-41]

The NLR profile analysis across bacterial species revealed that while E. coli was the most common, it did not correlate with elevated NLR in most cases, suggesting minimal systemic inflammation. Conversely, Proteus spp. and Enterococcus spp. were more frequently associated with higher NLR, possibly reflecting more severe or nosocomial infections. These findings are supported by T. et al. (2018) and Hyun et al. (2019), who emphasized the role of these pathogens in complex, biofilm-associated infections.[42,43]

Although trends were observed between pathogen type and NLR levels, the statistical analysis did not yield significant associations ($p = 0.08$). This may reflect the sample size limitation, potential biases, and unmeasured confounders. Nonetheless, the trend indicates a possible clinical value that warrants further investigation with larger cohorts or more sensitive analytical techniques. This study has several limitations. The small sample size ($n = 97$) reduces statistical power and generalizability. The absence of control groups limits comparison, particularly in assessing NLR's predictive utility. Furthermore, the study did not include other inflammatory markers like CRP or PCT, which could have strengthened diagnostic interpretations.

The cross-sectional design restricted temporal analysis of NLR dynamics. The consecutive sampling method, while practical, may introduce selection bias. The use of secondary data from medical records may also pose risks of incomplete or inaccurate documentation, particularly regarding immune status, antibiotic use history, or comorbid conditions. Despite these limitations, this study provides valuable insight into the inflammatory profile and microbiological patterns of UTI patients at Haji Adam Malik General Hospital. Future studies should incorporate larger sample sizes, prospective designs, and broader biomarker analysis to enhance the understanding of NLR as a prognostic and diagnostic tool in urinary tract infections.

5. CONCLUSION

This study demonstrates that the majority of urinary tract infection (UTI) cases at Haji Adam Malik General Hospital occurred in middle-aged patients with a nearly equal sex distribution and a predominance of lower urinary tract involvement. Most patients exhibited normal neutrophil-to-lymphocyte ratio (NLR) values, while a smaller proportion showed elevated or low levels, indicating that systemic inflammatory response varies among individuals with UTI. Escherichia coli was identified as the predominant uropathogen, followed by Klebsiella spp., Staphylococcus saprophyticus, Proteus spp., Enterococcus spp., and Pseudomonas aeruginosa.

Although patients infected with Proteus spp. and Enterococcus spp. tended to have higher NLR values, statistical analysis revealed no significant association between NLR and bacterial pattern. These findings underscore the need for cautious interpretation of NLR in UTI cases and highlight the importance of further research with larger, more diverse samples and integration of additional inflammatory biomarkers such as CRP and PCT. Future studies should also employ longitudinal and multivariate approaches to better elucidate the role of NLR in clinical risk stratification and prognosis of UTI.

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Conflict of Interest

The authors affirm that no conflicts of interest exist in relation to the publication of this article. The research was conducted independently, free from any financial ties or personal associations that could have influenced its conception, implementation, or presentation. All work reflects a commitment to academic honesty and adheres to the ethical standards of the affiliated institution.

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