Turkish Journal of Pediatric Disease

Original Article

Urinary system anomalies and inflammatory markers in children aged 1–36 months with urinary tract infection

Cemre Demirel[1], Evra Çelikkaya[2], Tülin Güngör[2]

[1]Department of Pediatrics, Dr. Halil İbrahim Özsoy Bolvadin State Hospital, Afyonkarahisar, Türkiye, [2]Department of Pediatric Nephrology, Ankara Etlik City Hospital, Ankara, Türkiye

Corresponding Author: **Cemre Demirel** e-mail: kocak.cemre@gmail.com

Received : 12.05.2026 , Accepted : 02.09.2026 DOI: 10.12956/TJPD.2026.1367

ABSTRACT

Objective: Urinary tract infections (UTIs) are among the most common serious bacterial infections in early childhood and are associated with significant morbidity, particularly in children under 36 months of age. This study aimed to evaluate the clinical and laboratory characteristics of children aged 1–36 months diagnosed with UTI, determine the frequency of accompanying urinary system anomalies, and assess the role of inflammatory markers in differentiating upper and lower UTIs.

Materials and Methods: This retrospective study included 260 children aged 1–36 months diagnosed with UTI between September 2022 and April 2023. Demographic, clinical, laboratory, and imaging data were analyzed. Patients were classified as having upper or lower UTI based on clinical and laboratory findings.

Results: The mean age of the sample was 8.22±7.38 months. Of the 260 patients (136 males and 124 females), 60.4% had lower UTI and 39.6% had upper UTI. Urinary system anomalies were detected in 20% of patients and were significantly more frequent in those with upper UTI (p=0.040). The most common pathogen was *Escherichia coli* (78.8%). Inflammatory markers including IG percentage, CRP, SII, ANC, and white blood cell count were significantly higher in the upper UTI group (p<0.001, p<0.001, p=0.003, p<0.001 and p<0.001, respectively). ROC analysis demonstrated that CRP (AUC: 0.74), IG percentage (AUC: 0.73), ANC (AUC: 0.72), and SII (AUC: 0.71) had moderate diagnostic performance in predicting upper UTI. IG percentage and SII showed relatively high sensitivity and specificity at optimal cut-off values.

Conclusion: Urinary system anomalies are more common in children with upper UTI and should be carefully investigated in this group. Inflammatory markers, particularly IG percentage and SII, may serve as useful, easily accessible biomarkers in differentiating upper from lower UTI in early childhood. Their combined use with clinical findings may improve early diagnosis and management.

Keywords: Children, inflammation, urogenital abnormalities,urinary tract infections

Introduction

Urinary tract infection (UTI) is one of the most common serious bacterial infections in early childhood and represents a significant cause of morbidity, particularly in children under 36 months of age. Clinical manifestations in this age group are often nonspecific, and fever is frequently the sole presenting symptom. This may lead to delays in diagnosis and treatment, thereby increasing the risk of both short- and long-term complications (1,2). UTIs in early childhood are of particular clinical importance due to their strong association with renal scarring, hypertension, proteinuria, and progression to chronic kidney disease (CKD). Congenital anomalies of the kidney and urinary tract are important risk factors for the development of UTIs and are detected in a proportion of affected children. These anomalies not only increase the risk of recurrent infections but also contribute significantly to long-term renal damage. Distinguishing between lower and upper UTIs is also of considerable clinical importance. Upper urinary tract involvement is known to be associated with a more pronounced inflammatory response and a higher risk of permanent renal damage (3,4). In recent years, in addition to commonly used inflammatory markers such as C-reactive protein (CRP), there has been growing interest in hematological indices derived from complete blood count parameters, including immature granulocyte (IG) percentage and systemic immune-inflammation index (SII). These parameters may help identify high-risk patients at an early stage and predict upper urinary tract involvement (5-7).

The aim of this study was to evaluate the clinical and laboratory characteristics of children aged 1–36 months diagnosed with UTI, determine the frequency of accompanying urinary system anomalies, and assess the role of inflammatory markers in differentiating between upper and lower UTIs.

Materials and Methods

Study Population

This retrospective study was conducted by reviewing the medical records of 260 patients diagnosed with urinary tract infection (UTI) at the Pediatric Nephrology Department of

© 2026 Author(s). Published by Ankara Bilkent City Hospital, Children's Hospital. This is an open-access article distributed under the Creative Commons Attribution License (CC BY), which permits unrestricted use, distribution, and reproduction in any medium or format, provided the original work is properly cited.

Ankara Etlik City Hospital between September 2022 and April 2023. Patients aged 1–36 months, in whom the diagnosis of UTI was confirmed based on clinical and laboratory findings, and who had concurrent inflammatory marker data at the time of diagnosis (complete blood count, CRP, etc.), were included in the study.

Patients with concomitant systemic infections, those who had received antibiotic therapy prior to diagnosis, and those with underlying immunodeficiency, malignancy, or congenital metabolic diseases that could affect inflammatory marker levels were excluded from the study.

Identification and Classification

The diagnosis of UTI was based on the presence of pyuria in urinalysis and bacterial growth in urine culture. Pyuria was defined as the presence of ≥5 leukocytes per high-power field (×40 magnification) in urine sediment under light microscopy. UTI was confirmed when urine culture demonstrated growth of ≥50.000 colony-forming units (CFU)/mL in catheterized urine samples, and ≥100.000 CFU/mL in midstream or bag urine samples. Cases with growth of two or more microorganisms in culture were excluded from the study. Patients were classified as having lower UTI or upper UTI based on clinical and laboratory findings. The differential classification was made according to elevated acute phase reactants and clinical findings such as fever, altered mental status, nausea, and flank pain. All cases not meeting the criteria for upper UTI were classified as lower UTI.

Data Collection from the Patients and the Laboratory

The medical records of the included patients, system-based electronic data, and previously completed forms were reviewed to collect information on sex, age, urine culture results, age at first UTI episode, follow-up duration, prophylactic antibiotic use, and family history. Radiological and scintigraphic imaging results, including ultrasonography (USG), voiding cystourethrography (VCUG), dimercaptosuccinic acid (DMSA), diethylenetriamine pentaacetic acid (DTPA), and mercaptoacetyltriglycine (MAG3), were evaluated. The presence of urinary tract abnormalities such as vesicoureteral reflux (VUR), posterior urethral valves (PUV), renal scarring, ureteropelvic junction (UPJ) obstruction, neurogenic bladder, and voiding dysfunction was recorded. Estimated glomerular filtration rate (eGFR) was calculated using the Schwartz formula (8). Inflammatory markers measured during the UTI episode included C-reactive protein (CRP), white blood cell (WBC) count, absolute neutrophil count (ANC), immature granulocyte (IG) percentage, and systemic immune-inflammation index (SII). Complete blood count parameters and IG percentage were measured using an automated hematology analyzer. Neutrophil/lymphocyte ratio (NLR), platelet/lymphocyte ratio (PLR), and SII were calculated from peripheral blood samples using neutrophil, lymphocyte, and platelet counts. SII was calculated using the formula: SII = (platelet × neutrophil) / lymphocyte.

Patients treatment regimens and whether they received prophylaxis were also recorded. In patients receiving prophylactic therapy, the type of antibiotic and duration of use were documented. At the 3-month follow-up, all surviving patients were classified according to the Kidney Disease: Improving Global Outcomes (KDIGO) chronic kidney disease (CKD) classification (9).

Statistical Analysis

Statistical analysis was performed using IBM SPSS Statistics for Windows, version 22.0 (IBM Corp., Armonk, NY, USA). The Kolmogorov–Smirnov test was used to determine the distribution normality of the study's variables. Parametric variables were presented as mean and standard deviation (SD), and nonparametric variables were presented as median and interquartile range (IQR). Categorical variables were expressed as numbers and percentages. While the Student's t-test was used to compare parametric variables, the Mann–Whitney U-test was performed to compare nonparametric variables. Fisher's exact test or chi-square test were performed to compare the categorical variables. Receiver operating characteristic (ROC) curves were utilized to evaluate the diagnostic value of the hematologic parameters, and the Youden index method was used to determine the optimal cut-off values. To compare the performance of each marker in terms of its ability to predict upper UTI, the area under the curve (AUC) was calculated. Sensitivity and specificity, as well as the positive and negative predictive values of each marker, were calculated. Univariate logistic regression analysis was performed to assess the association between each hematologic parameter and upper UTI, and the results were expressed as odds ratios (ORs) with 95% confidence intervals (CIs). For this analysis, the parameters were entered into the model as dichotomous variables based on the optimal cut-off values determined by ROC analysis. The results were considered statistically significant at $p<0.050$.

Results

The study included 260 children (136 males and 124 females) diagnosed with UTIs. The mean age of the cohort was 8.22 ±7.38 months. Regarding medical history, antenatal urinary system abnormalities were present in 64 patients (24.6%). A history of oligohydramnios was detected in 5 patients (1.9%). Consanguinity was present in 4.6% of families. A history of previous UTI in family members was reported in 21.5%, while urinary system anomalies were reported in 5.4% of family histories. The most common urinary system anomaly among family members was vesicoureteral reflux (VUR), observed in 2.7%. At presentation, 101 patients (38.8%) had fever, 81 (31.2%) had vomiting, 45 (17.3%) had irritability, 17 (6.5%) had changes in urine color/odor, 3 (1.2%) had abdominal pain, and 2 (0.8%) had jaundice. Eleven patients (4.2%) were asymptomatic at presentation. Vomiting was the most common presenting symptom in the 1–3 month age group, whereas fever was the most common symptom in the 3–6 month, 6–12 month, and 12–36 month age groups. There was a statistically significant difference in presenting symptoms across age groups ($p=0.002$) (Figure 1).

A total of 157 patients (60.4%) were diagnosed with lower UTI, while 103 patients (39.6%) were diagnosed with upper UTI. No statistically significant difference was found between age groups in terms of UTI localization ($p=0.800$) (Figure 2).

The most frequently isolated pathogen in urine cultures was *Escherichia coli* (78.8%), followed by *Klebsiella pneumoniae* (15.8%), *Enterococcus faecium* (2.3%), and *Proteus mirabilis*

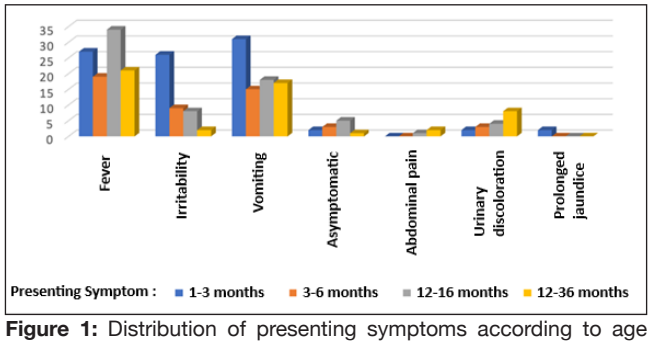


Figure 1: Distribution of presenting symptoms according to age groups

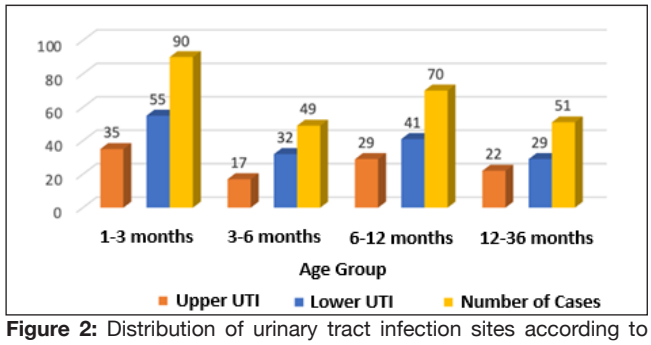


Figure 2: Distribution of urinary tract infection sites according to age groups

(1.9%). Less commonly, *Staphylococcus aureus, Pseudomonas aeruginosa*, and *Acinetobacter baumannii* were each identified in 0.4% of cases. At presentation, the mean serum creatinine level was 0.24±0.10 mg/dL, and the mean estimated glomerular filtration rate (eGFR) was 125.12±31.66 mL/min/1.73 m². Regarding treatment, 49.6% of patients were hospitalized and received intravenous antibiotic therapy. The most commonly used antibiotics were cefotaxime/ceftriaxone (63.6%) and amikacin (29.5%). The remaining 50.4% of patients were followed up on an outpatient basis. Antibiotic therapy was adjusted when necessary according to urine culture results.

The most common ultrasonographic finding was hydronephrosis, observed in 28.8% of patients. Dimercaptosuccinic acid (DMSA) scintigraphy was performed in 22 patients (8.4%), revealing renal scarring in 5.8%. Unilateral renal agenesis was detected in 2 patients (0.8%), unilateral multicystic dysplastic kidney in 2 (0.8%), ectopic kidney in 1 (0.4%), horseshoe kidney in 1 (0.4%), and unilateral renal hypoplasia in 1 (0.4%).Voiding cystourethrography (VCUG) was performed in 39 patients (15%), and vesicoureteral reflux (VUR) was detected in 7.3% of them. MAG-3 renography was performed in 21 patients (8%), with complete obstruction identified in 0.4%.

Urinary system anomalies were detected in 52 patients (20%). Of these, 19 (36.5%) were aged 1–3 months, 8 (15.3%) were 3–6 months, 15 (28.8%) were 6–12 months, and 10 (19.2%) were 12–36 months. There was no significant difference between age groups in terms of the presence of urinary system anomalies (p=0.900).Among patients with urinary system anomalies, 5 (9.6%) had additional organ anomalies; gastrointestinal system anomalies were the most common, observed in 3 patients (5.8%). Although the overall rate of urinary system anomalies among all patients was 20% (n=52), this rate was 26.2% (n=27)

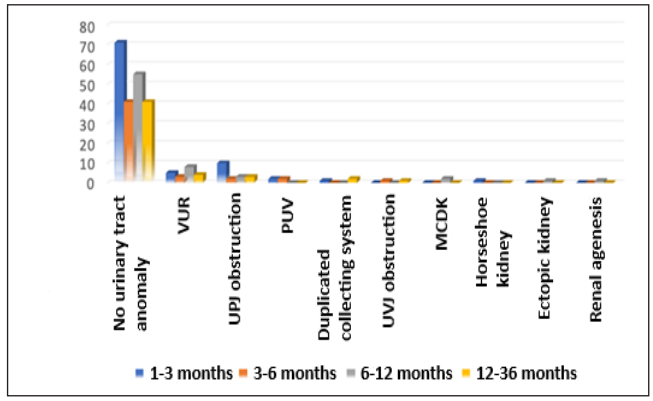


Figure 3: Distribution of anomaly types by age groups in patients with urinary system anomalies. **VUR:** Vesicoureteral reflux, **UPJ obstruction:** Ureteropelvic junction obstruction, **PUV:** Posterior urethral valve, **UVJ obstruction:** Ureterovesical junction obstruction; **MCDK:** Multicystic dysplastic kidney

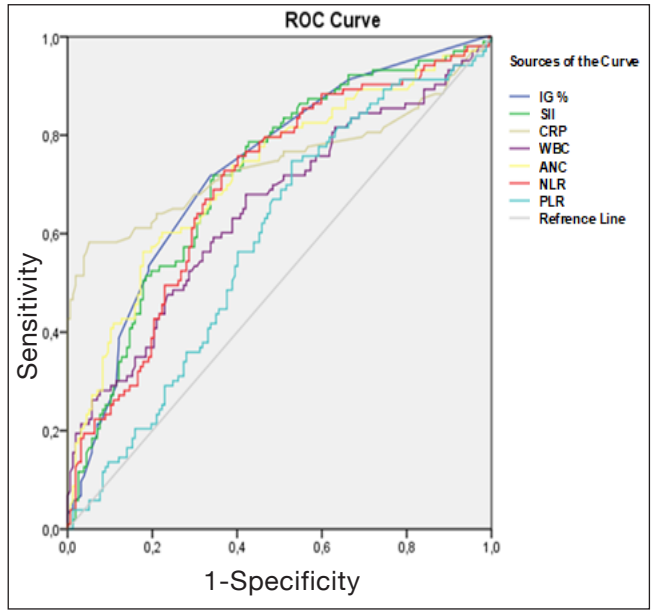


Figure 4: ROC curve of IG percentage and other infection markers for predicting upper UTI. **IG %:** immature granulocyte (IG) percentage, **SII:** systemic immune-inflammation index, **CRP:** C-reactive protein; **WBC:** white blood cell, **ANC:** absolute neutrophil count, **NLR:** neutrophil/lymphocyte ratio, **PLR:** platelet/lymphocyte ratio

in patients with upper urinary tract infection. The presence of urinary system anomalies was significantly higher in patients with upper urinary tract infection (p=0.040).

Among the patients included in the study, vesicoureteral reflux (VUR) was the most common anomaly, detected in 20 patients (7.6%). Among patients with VUR, 1 (0.4%) also had a hypoplastic kidney and 1 (0.4%) had unilateral renal agenesis. Other anomalies, in descending order of frequency, were ureteropelvic junction (UPJ) obstruction in 18 patients (6.9%), posterior urethral valve (PUV) in 4 patients (1.5%), duplex collecting system in 3 patients (1.2%), ureterovesical (UV) junction obstruction and multicystic dysplastic kidney (MCDK) in 2 patients (0.8%), and horseshoe kidney, unilateral renal agenesis, and ectopic kidney in 1 patient each (0.4%). Among patients with UPJ obstruction, 1 (0.4%) also had an ectopic

Table I: Sensitivity, specificity, and predictive values of inflammatory markers

	AUC	Predictive value	Sensitivity	Specificity	PPV	NPV
IG (%)	0.73	>0.27	71.8	66.2	58.2	78.2
ANC(x 10^9/L)	0.72	>3380	68	65	56	75.6
SII	0.71	>219.81	70.9	66.2	57.9	77.6
CRP (mg/L)	0.74	>6.7	64.1	79	66.7	77

PPV: *Positive predictive value,* ***NPV:*** *Negative predictive value,* ***AUC:*** *Area under the curve,* ***IG:*** *Immature granulocyte,* ***ANC:*** *Absolute neutrophil count,* ***SII:*** *Systemic immune-inflammation index,* ***CRP:*** *C-reactive protein*

kidney. Among those with PUV, 2 (0.8%) had bilateral dysplastic kidneys. Among patients with a duplex collecting system, 1 (0.4%) also had unilateral renal agenesis. Multiple urinary system anomalies were detected in 6 patients (2.3%) (Figure 3).

Inflammatory markers were compared between patients with upper and lower urinary tract infections (UTIs). Inflammatory markers were compared between patients with upper and lower UTIs. In the upper UTI group, the mean IG percentage was significantly higher than in the lower UTI group (0.55±0.66 vs. 0.28±0.31, respectively; p<0.001). Similarly, the mean CRP level (37.22±44.31 vs. 4.31±6.12, respectively; p<0.001) and SII (565.75±964.20 vs. 294.61±487.77, respectively; p=0.003) were significantly higher in patients with upper UTI. ANC was also significantly higher in the upper UTI group compared with the lower UTI group (6.148.35 ±5.015.50 vs. 3.265.48±2.767.12×10^9/L, respectively; p <0.001). Likewise, WBC count (13.471.75±5.949.76 vs. 10.554.71±3.610.57 ×10^9/L, respectively; p<0.001) and NLR (1.51±2.42 vs. 0.77±1.24, respectively; p=0.001) were significantly higher in patients with upper UTI. For predicting upper UTI, the area under the curve (AUC) was 0.74 for CRP (95% confidence interval (CI): 0.67–0.81), 0.73 for IG percentage (95% CI: 0.67–0.79), 0.72 for ANC (95% CI: 0.65–0.78), and 0.71 for SII (95% CI: 0.65–0.78) (Figure 4).

The odds ratio (OR) for IG percentage was 5 (95% CI: 2.91–8.61, p<0.001), and other markers also significantly predicted upper UTI. The OR was 6.7 for CRP (95% CI: 3.84–11.69, p<0.001), 4.77 for SII (95% CI: 2.78–8.18, p<0.001), and 3.93 for ANC (95% CI: 2.32–6.67, p<0.001). When the cut-off value for IG percentage was 0.27, sensitivity was 71.8% and specificity was 66.2%. For SII, a cut-off value of 219.81 yielded a sensitivity of 70.9% and specificity of 66.2%. For CRP, a cut-off value of 6.7 resulted in a sensitivity of 64.1% and specificity of 79%. For ANC, a cut-off value of 3380 provided a sensitivity of 68% and specificity of 65%. These findings indicate that, among all parameters, IG percentage and SII have high sensitivity, specificity, and predictive value for predicting upper UTI when appropriate cut-off values are applied (Table I).

The inflammatory markers were compared between patients with and without urinary tract anomalies. The mean WBC count was 11.522.16±4.877.68/µL in patients without urinary anomalies and 12.462.88±4.874.76/µL in those with urinary anomalies (p=0.215). The mean ANC was 4.452.45±4.307.85/µL and 4.227.88±2.916.18/µL, respectively (p=0.722). The mean NLR was 1.10±1.96 in patients without urinary anomalies and 0.88±1.17 in those with urinary anomalies (p=0.431). The mean PLR was 91.27±109.96 and 70.63±48.63, respectively (p=0.188). The mean SII was 427.30±798.85 and 300.91±270.99, respectively (p=0.262). The mean IG% was 0.37±0.45 and 0.44±0.66, respectively (p=0.368). The mean CRP level was 17.03±33.52 mg/L in patients without urinary anomalies and 18.64±28.29 mg/L in those with urinary anomalies (p=0.749). None of the inflammatory markers differed significantly between the two groups.

Prophylactic antibiotics were administered to 97 patients (37.3%). The most commonly used agent was trimethoprim-sulfamethoxazole. Antibiotic prophylaxis was changed in 18 patients (6.9%) due to resistance. The proportion of patients receiving prophylactic antibiotics was significantly higher in the group with urinary system anomalies than in the group without urinary system anomalies (p<0.001).

The mean follow-up duration of the patients was 11.70±1.79 months. At the last follow-up, patients with urinary system anomalies had significantly higher mean creatinine levels (0.31±0.32 vs. 0.21±0.69 mg/dL) and lower mean eGFR values (117.38±27.98 vs. 132.49±27.13 mL/min/1.73 m^2) compared with those without urinary system anomalies (p<0.001). Chronic kidney disease (CKD) was present in 4 patients (1.5%). Among patients with CKD, hypertension was detected in 1 (25%) and proteinuria in 1 (25%). All patients with CKD were in the group with urinary system anomalies.

Discussion

Urinary tract infection is one of the most common bacterial infections in childhood and may lead to long-term renal morbidity, particularly when the upper urinary tract is involved (10-12). In our study, 39.6% of patients had upper UTI, and urinary system anomalies were detected in 20% of patients and were significantly more frequent in the upper UTI group. In addition, IG percentage, CRP, SII, ANC, and WBC count were significantly higher in patients with upper UTI. Notably, IG percentage and SII showed relatively high sensitivity and specificity, suggesting that these markers may be useful in predicting upper UTI in children.

Previous studies have shown that urinary tract infections (UTIs) are more common in boys during infancy and in girls after the first year of life. Meta-analyses have demonstrated a higher prevalence of UTIs in male infants, particularly within the first three months of life, whereas the incidence shifts toward females with increasing age (11,12). Consistent with the literature, the majority of patients in our cohort were infants, and a male predominance was observed among those aged ≤3 months. These findings support the notion that age and sex significantly influence the epidemiology of UTIs in early childhood.

Antenatal urinary system findings may provide important clues for the early detection of congenital urinary tract anomalies. In our study, the presence of antenatal urinary system findings in 24.6% of patients indicates that prenatal ultrasonographic evaluation plays a significant role in the early identification of these cases. Oligohydramnios was observed at a lower rate of 1.9%. The literature reports that antenatal urinary system anomalies and oligohydramnios are among the key predictors of congenital urinary tract

abnormalities (10,12). Additionally, in our study, a family history of urinary tract infection (21.5%) and urinary system anomalies (5.4%) was identified, suggesting that genetic predisposition and familial factors may play a role in disease development.

The clinical manifestations of urinary tract infections (UTIs) are often non-specific, especially in young children, which may lead to delayed diagnosis (13,14). In our study, the most common presenting symptom was fever (38.8%), followed by vomiting (31.2%) and irritability (17.3%). When evaluated according to age groups, vomiting was the most frequent symptom in infants aged 1–3 months, whereas fever was the predominant symptom in older age groups. The significant difference in presenting symptoms across age groups indicates that the clinical presentation of UTIs in early childhood may vary with age. Therefore, UTI should always be considered in infants presenting with unexplained fever or gastrointestinal symptoms.

In our study, 60.4% of patients had lower UTI, while 39.6% had upper UTI. The lack of a significant difference between age groups in terms of infection localization suggests that age alone is not a determining factor for the site of infection. From a microbiological perspective, the most frequently isolated pathogen was *Escherichia coli* (78.8%). This finding is consistent with numerous studies reporting *E. coli* as the predominant causative agent in pediatric UTIs (15,16). *Klebsiella pneumoniae* was the second most common pathogen (15.8%), while other organisms were observed at much lower rates. These findings indicate that *E. coli* and other enteric Gram-negative bacteria should be primarily considered when selecting empirical antibiotic therapy. Antibiotic therapy remains the cornerstone of UTI management. Current guidelines recommend initiating empirical antibiotic treatment based on local resistance patterns. Approximately half of the patients in our cohort required hospitalization and intravenous antibiotic therapy. Treatment regimens were adjusted according to culture and sensitivity results in line with international recommendations (17-19).

In children with urinary tract infections (UTIs), the most common urinary tract risk factor is vesicoureteral reflux (VUR), with a reported incidence of 17–33% in the literature, increasing up to 30–40% in cases of recurrent UTIs. High-grade VUR has been shown to be more strongly associated with renal scarring; however, scarring may also occur in the absence of VUR. In addition, ureteropelvic junction (UPJ) obstruction and other congenital urinary tract anomalies are among the frequently encountered structural pathologies in childhood (20-22). In our study, the most common anomaly was VUR (7.6%), followed by UPJ obstruction (6.9%). Furthermore, the significantly higher rate of urinary system anomalies in patients with upper UTI supports the importance of evaluating underlying structural abnormalities, particularly in cases with upper urinary tract involvement.

Inflammatory markers are important adjunct parameters in the diagnosis of urinary tract infections (UTIs) and in determining disease localization. Indicators such as leukocyte count, CRP, ANC, and platelet count are supportive in the diagnosis of UTI; however, they are non-specific and not diagnostic on their own. Nevertheless, they may assist clinical evaluation, particularly in differentiating lower from upper UTI. Although studies in the literature have suggested that elevated CRP and leukocyte levels may be associated with acute pyelonephritis, the sensitivity and specificity of these markers vary across studies. Data regarding immature granulocyte (IG) percentage in UTIs are limited; however, some studies have demonstrated higher IG levels in febrile UTIs (5-7). In our study, when upper and lower UTI groups were compared, IG percentage, SII, and CRP levels were found to be significantly higher in the upper UTI group. Similarly, ANC, WBC count, and NLR were also significantly elevated in patients with upper UTI. In logistic regression analysis, IG percentage, SII, CRP, and ANC were identified as significant predictors of upper UTI. According to the determined cut-off values, IG percentage and SII demonstrated high sensitivity and specificity in predicting upper UTI. In contrast, no significant difference in inflammatory markers was found between patients with and without urinary system anomalies. These findings suggest that IG percentage and SII may be useful and easily accessible biomarkers for predicting upper UTI in children.

The effectiveness of antibiotic prophylaxis in recurrent UTIs remains controversial, and some meta-analyses have failed to demonstrate a significant benefit in preventing recurrence or renal damage (23,24). Nevertheless, prophylaxis is recommended in children with high-grade VUR or a history of frequent febrile UTIs (7,24). In our study, 37.3% of patients received prophylactic antibiotics, and the use of prophylaxis was significantly higher in patients with urinary system anomalies. In addition, both the frequency of anomalies and the need for prophylaxis were higher in the upper UTI group.

UTIs constitute an important cause of preventable chronic kidney disease (CKD) in childhood (3,4). Renal function should be monitored more closely, particularly in patients with urinary system anomalies. With early diagnosis, appropriate treatment, and regular follow-up, long-term renal damage can largely be prevented. In our study, although renal function was generally preserved during a mean follow-up of 11.7 months, patients with urinary system anomalies had significantly higher creatinine levels and lower eGFR values. The CKD rate was 1.5%, and all cases were observed in the group with urinary system anomalies. These findings suggest that early diagnosis and appropriate management of UTIs may help prevent long-term complications such as renal scarring, hypertension, and CKD.

Limitations

This study has several limitations. First, its retrospective, single-center design and relatively small sample size may have introduced selection bias and limited generalizability. Second, VCUG, DMSA, and MAG-3 imaging were not performed in all patients, potentially leading to missed urinary tract abnormalities or renal scarring. Prospective, multicenter studies with larger cohorts and longer follow-up are needed to confirm these findings.

Conclusion

In conclusion, this study demonstrates that the combined evaluation of clinical findings, imaging modalities, and inflammatory markers in children with urinary tract infections

can provide valuable information for disease management. Our findings indicate that urinary system anomalies are more frequently observed in patients with upper UTI, highlighting the clinical importance of investigating underlying structural abnormalities in this patient group. Furthermore, parameters derived from routine hematological indices, such as IG percentage and SII, may serve as useful biomarkers in predicting upper urinary tract infection. The use of these parameters alongside clinical assessment may contribute to earlier diagnosis and the establishment of appropriate treatment strategies. However, these findings should be confirmed in larger patient populations and prospective multicenter studies to better define the clinical utility of these biomarkers.

This study demonstrated that urinary system anomalies are more frequently observed in children with upper urinary tract infection, highlighting the importance of thorough evaluation for underlying structural abnormalities in this group. Inflammatory markers, particularly IG (%) and SII, showed moderate diagnostic performance and may serve as useful, easily accessible biomarkers in differentiating upper from lower urinary tract infections.

The inflammatory biomarkers evaluated in our study demonstrated potential value in the early diagnosis of urinary tract infections. However, the observed AUC values (0.71–0.74) indicate only moderate diagnostic performance. Therefore, these biomarkers should not be considered strong or independent diagnostic indicators when used alone. Rather, they should be regarded as complementary tools that may improve diagnostic accuracy when interpreted in conjunction with clinical findings and other laboratory parameters. Given that early and accurate identification of upper urinary tract involvement is critical for preventing long-term complications such as renal scarring and chronic kidney disease, the combined use of these inflammatory markers with clinical assessment may facilitate timely diagnosis and appropriate management.

However, given the retrospective design and single-center nature of this study, as well as the potential influence of factors such as patient population characteristics and sample size, further prospective, multicenter studies with larger patient cohorts are warranted to validate these findings and to better define the clinical utility of IG (%) and SII in pediatric urinary tract infections.

Ethics committee approval

This study was conducted in accordance with the Helsinki Declaration Principles. The study was approved by Ankara Etlik City Hospital (26.04.2023, reference number: AEŞH-EK1-2023-106).

Contribution of the authors

Study conception and design: CY, EÇ; data collection: CY, EÇ, TG; analysis and interpretation of results: CY, EÇ, TG; draft manuscript preparation: CY, EÇ. All authors reviewed the results and approved the final version of the article.

Source of funding

The authors declare the study received no funding.

Conflict of interest

The authors declare that there is no conflict of interest.

References

1. Wald ER. Urinary tract infections in infants and children: a comprehensive overview. Curr Opin Pediatr. 2004;16(1):85-8. https://doi.org/10.1097/00008480-200402000-00016
2. Shaikh N, Morone NE, Bost JE, Farrell MH. Prevalence of urinary tract infection in childhood: a meta-analysis. Pediatr Infect Dis J. 2008;27(4):302-8. https://doi.org/10.1097/INF.0b013e31815e4122
3. Yosypiv IV. Congenital anomalies of the kidney and urinary tract: a genetic disorder. Int J Nephrol. 2012;2012:909083. https://doi.org/10.1155/2012/909083
4. Keller G, Zimmer G, Mall G, Ritz E, Amann K. Nephron number in patients with primary hypertension. N Engl J Med. 2003;348(2):101-8. https://doi.org/10.1056/NEJMoa020549
5. García EH, Olavarría F, Araya C, Broussain M, Barrera C, Young L. Diagnostic significance of clinical and laboratory findings to localize the site of urinary infection. Pediatr Nephrol. 2007;22(7):1002-6. https://doi.org/10.1007/s00467-007-0465-7
6. Gervaix A, Galetto-Lacour A, Gueron T, Vadas L, Zamora S, Suter S, et al. Usefulness of procalcitonin and C-reactive protein rapid tests in children with urinary tract infection. Pediatr Infect Dis J. 2001;20(5):507-11. https://doi.org/10.1097/00006454-200105000-00007
7. Karakaya D, Güngör T, Cakıcı EK, Yazılıtaş F, Çelikkaya E, Bülbül M. Determining the effectiveness of the immature granulocyte percentage and systemic immune-inflammation index in predicting acute pyelonephritis. Postgrad Med. 2023;135(2):155-60. https://doi.org/10.1080/00325481.2022.2152970
8. Schwartz GJ, Muñoz A, Schneider MF, et al. New equations to estimate GFR in children with CKD. J Am Soc Nephrol. 2009;20(3):629-37. https://doi.org/10.1681/ASN.2008030287
9. Levey AS, Coresh J, Balk E, et al. National Kidney Foundation practice guidelines for chronic kidney disease: evaluation, classification, and stratification. Ann Intern Med. 2003;139(2):137-47. https://doi.org/10.7326/0003-4819-139-2-200307150-00013
10. Roberts KB; Subcommittee on Urinary Tract Infection. Urinary tract infection: clinical practice guideline for febrile infants and children 2-24 months. Pediatrics. 2011;128(3):595-610. https://doi.org/10.1542/peds.2011-1330
11. de Bessa J Jr, de Carvalho Mrad FC, Mendes EF, et al. Antibiotic prophylaxis for prevention of febrile urinary tract infections in children with vesicoureteral reflux. J Urol. 2015;193(5 Suppl):1772-7. https://doi.org/10.1016/j.juro.2014.10.092
12. Stein R, Dogan HS, Hoebeke P, Kočvara R, Nijman RJ, Radmayr C, Tekgül S. Urinary tract infections in children: EAU/ESPU guidelines. Eur Urol. 2015;67(3):546-58. https://doi.org/10.1016/j.eururo.2014.11.007
13. Becknell B, Schober M, Korbel L, Spencer JD. Diagnosis and management of pediatric urinary tract infections. Expert Rev Anti Infect Ther. 2015;13(1):81-90. https://doi.org/10.1586/14787210.2015.986097
14. Mishra OP, Abhinay A, Prasad R. Urinary infections in children. Indian J Pediatr. 2013;80(10):838-43. https://doi.org/10.1007/s12098-013-1118-4
15. Zorc JJ, Kiddoo DA, Shaw KN. Diagnosis and management of pediatric urinary tract infections. Clin Microbiol Rev. 2005;18(2):417-22. https://doi.org/10.1128/CMR.18.2.417-422.2005
16. Mattoo TK, Shaikh N, Nelson CP. Contemporary management of urinary tract infection in children. Pediatrics. 2021;147(2):e2020012138. https://doi.org/10.1542/peds.2020-012138

17. Brandström P, Hansson S. Urinary tract infection in children. Pediatr Clin North Am. 2022;69(6):1099-114. https://doi.org/10.1016/j.pcl.2022.07.003
18. Uyar Aksu N, Ekinci Z, Dündar D, Baydemir C. Childhood urinary tract infection caused by ESBL-producing bacteria: risk factors and empiric therapy. Pediatr Int. 2017;59(2):176-80. https://doi.org/10.1111/ped.13112
19. Ammenti A, Cataldi L, Chimenz R, et al. Febrile urinary tract infections in young children: recommendations. Acta Paediatr. 2012;101(5):451-7. https://doi.org/10.1111/j.1651-2227.2011.02549.x
20. Murugapoopathy V, Gupta IR. Congenital anomalies of the kidneys and urinary tract (CAKUT). Clin J Am Soc Nephrol. 2020;15(5):723-31. https://doi.org/10.2215/CJN.12581019
21. Stonebrook E, Hoff M, Spencer JD. Congenital anomalies of the kidney and urinary tract: a clinical review. Curr Treat Options Pediatr. 2019;5(3):223-35. https://doi.org/10.1007/s40746-019-00166-3
22. Kohno M, Ogawa T, Kojima Y, et al. Pediatric congenital hydronephrosis. Int J Urol. 2020;27(5):369-76. https://doi.org/10.1111/iju.14207
23. Delbet JD, Lorrot M, Ulinski T. Antibiotic prophylaxis and treatment for urinary tract infections in children. Expert Opin Pharmacother. 2017;18(15):1619-25. https://doi.org/10.1080/14656566.2017.1383383
24. Okarska-Napierała M, Wasilewska A, Kuchar E. Urinary tract infection in children: comparison of guidelines. J Pediatr Urol. 2017;13(6):567-73. https://doi.org/10.1016/j.jpurol.2017.07.018