

Role of Imaging in the Evaluation of Pediatric Urinary Tract Infections and Anomalies

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Abstract

Background: Pediatric urinary tract infections (UTIs) are common and may be associated with underlying urinary tract anomalies and long-term renal complications. Imaging is essential for identifying structural and functional abnormalities that influence management and prognosis. This study aimed to evaluate the role of imaging modalities in detecting urinary tract abnormalities among children with UTIs.

Methods: This cross-sectional study was conducted in the Department of Radiology and Imaging, Bangladesh Shishu Hospital & Institute, Dhaka, Bangladesh, from January to December 2024. Sixty-five children with suspected or confirmed UTIs underwent imaging evaluation using ultrasonography, DMSA renal scintigraphy, MCU/VCUG and selective CT or MRI. Demographic data and imaging findings were analyzed descriptively using SPSS version 25.0.

Results: Most children were aged between 1–5 years (43.1%) and females predominated (56.9%). Fever was the most common presenting symptom (80.0%). Hydronephrosis was the most frequent imaging finding (43.1%), followed by vesicoureteral reflux (36.9%) and renal scarring (24.6%). Posterior urethral valves were identified in 4.6% of patients. Hydronephrosis and Vesicoureteral reflux (VUR) were more prevalent in younger age groups, while renal scarring was most common among children aged 1–5 years.

Conclusion: Imaging reveals a high prevalence of urinary tract abnormalities in children with UTIs. A multimodality, risk-based imaging approach is essential for accurate diagnosis and optimal management.

Keywords: Pediatric urinary tract infection, Imaging, Ultrasonography, Renal scarring.

1. INTRODUCTION

Urinary tract infection (UTI) is among the most common bacterial infections encountered in pediatric practice and represents a significant cause of morbidity in infants and young children. Early childhood UTIs are clinically important due to their association with underlying congenital anomalies of the kidney and urinary tract (CAKUT), recurrent infections and the potential for long-term renal damage [1,2]. The risk of renal scarring following febrile UTIs has been well documented, particularly in younger children and those with delayed diagnosis or structural abnormalities [3].

Imaging plays a central role in the evaluation of pediatric UTIs, providing critical information regarding renal morphology, urinary tract anatomy and functional integrity.

Ultrasonography is widely recommended as the first-line imaging modality due to its non-invasive nature, lack of ionizing radiation and accessibility [4,5]. It allows detection of hydronephrosis, renal size discrepancies and gross anatomical anomalies. However, ultrasound alone may be insufficient to identify vesicoureteral reflux or subtle parenchymal damage [6].

Radionuclide imaging, particularly dimercaptosuccinic acid (DMSA) scintigraphy, is considered the reference standard for detecting renal cortical defects and scarring in children with UTIs [7, 8]. Several studies have demonstrated a strong association between abnormal DMSA findings and recurrent febrile UTIs, as well as long-term renal sequelae [9]. Nevertheless, the routine use of DMSA remains

controversial due to radiation exposure and resource constraints, especially in low- and middle-income settings.

Micturating cystourethrography (MCU/VCUG) remains the gold standard for diagnosing vesicoureteral reflux and posterior urethral valves, conditions that significantly influence clinical management and prognosis [10, 11]. Despite its diagnostic value, MCU is invasive and often distressing for children, leading to ongoing debate regarding appropriate indications and timing [12].

Advanced imaging modalities such as CT and MRI are generally reserved for complicated or atypical cases, including suspected renal abscesses or inconclusive findings on conventional imaging [13]. Recent advances in imaging techniques have improved diagnostic accuracy while emphasizing radiation safety in pediatric populations [14].

Current international guidelines propose selective imaging strategies based on age, clinical severity and recurrence of infection; however, adherence and applicability vary across regions [15, 16]. In Bangladesh and similar resource-limited settings, data on imaging patterns and detected anomalies among pediatric UTI patients remain scarce. Understanding the local burden of imaging-detectable abnormalities is essential for optimizing diagnostic pathways and resource utilization.

This study was undertaken to evaluate the role of imaging modalities in detecting urinary tract abnormalities among children with UTIs in a tertiary care pediatric hospital in Bangladesh. By analyzing imaging findings across age groups, the study aims to contribute evidence relevant to clinical decision-making and guideline adaptation in comparable healthcare settings.

2. MATERIALS & METHODS

This hospital-based cross-sectional study was conducted in the Department of Radiology and Imaging, Bangladesh Shishu Hospital & Institute, Dhaka, Bangladesh. The study was carried out over a one-year period from January 2024 to December 2024. The study population comprised pediatric patients referred for imaging evaluation due to clinically suspected or confirmed urinary tract infections. A total of 65 children were included in the study.

2.1. Sample Selection

Inclusion Criteria

- Children aged ≤ 12 years
- Clinically suspected or laboratory-confirmed urinary tract infection
- Referred for radiological evaluation of the urinary tract
- Availability of at least one imaging modality report

Exclusion Criteria

- History of prior urological surgery
- Known chronic kidney disease unrelated to urinary tract infection
- Critically ill patients are unable to undergo imaging procedures

2.2. Data Collection Procedure

Data were collected prospectively using a structured data collection form designed specifically for the study. Clinical information, including age, sex and presenting symptoms was obtained from patient records and caregiver interviews. Imaging evaluations were performed according to standard departmental protocols. Ultrasonography of the kidneys, ureters and bladder was conducted using high-frequency transducers by experienced radiologists. DMSA renal scintigraphy was performed to assess cortical defects and renal scarring in selected patients based on clinical indications.

MCU/VCUG was undertaken to evaluate vesicoureteral reflux and urethral anomalies, particularly in children with recurrent febrile UTIs or abnormal ultrasound findings. CT or MRI was reserved for complicated cases requiring further anatomical clarification. Imaging findings were documented systematically and cross-checked to ensure accuracy and consistency. Informed consent was secured from parents or legal guardians before enrollment. Patient confidentiality was properly maintained.

2.3. Statistical Analysis

Data were analyzed using Statistical Package for Social Sciences (SPSS) version 25.0. Descriptive statistics were used to summarize demographic variables, imaging modalities and findings. Categorical variables were expressed as frequencies and percentages. Age-wise distributions of imaging findings were analyzed using cross-tabulation.

3. RESULTS

Table 1. Baseline Characteristics of the Study Population (N=65)

Characteristic	Number of children (n)	Percentage (%)	
Age group	<1 year	24	36.9
	1–5 years	28	43.1
	>5 years	13	20
Sex	Male	28	43.1
	Female	37	56.9
Presenting symptoms	Fever	52	80
	Dysuria	18	27.7
	Poor appetite	15	23.1
	Abdominal pain	12	18.5

Table 1 presents the demographic profile and presenting symptoms of the study population. The majority of children were aged between 1 and 5 years (43.1%), followed by infants younger than 1 year (36.9%) and children older than 5 years (20.0%). Female children constituted

56.9% of the cohort, while males accounted for 43.1%. Fever was the most common presenting symptom, reported in 80.0% of cases. Other reported symptoms included dysuria (27.7%), poor appetite (23.1%) and abdominal pain (18.5%).

Table 2. Distribution of Imaging Modalities Performed in the Study Population (N=65)

Modality	Number of children (n)	Percentage (%)
Ultrasonography (USG)	65	100
DMSA scan	42	64.6
MCU/VCUG	35	53.8
CT/MRI	4	6.2

Table 2 describes the imaging modalities used for diagnostic evaluation. Ultrasonography was performed in all patients (100%). Dimercaptosuccinic acid (DMSA) renal scans were conducted in 64.6% of children, while

micturating cystourethrography/voiding cystourethrography (MCU/VCUG) was performed in 53.8%. Advanced cross-sectional imaging with CT or MRI was used in a small proportion of cases (6.2%).

Table 3. Imaging Findings and Detected Urinary Tract Anomalies (N=65)

Finding/Anomaly	Number of children (n)	Percentage (%)
Hydronephrosis	28	43.1
Vesicoureteral reflux (VUR)	24	36.9
Renal scarring	16	24.6
Posterior urethral valves	3	4.6
Normal findings	18	27.7

Table 3 summarizes the abnormalities detected on imaging. Hydronephrosis was the most frequently identified finding, observed in 43.1% of children. Vesicoureteral reflux was detected in 36.9%, while renal scarring was present in 24.6%. Posterior urethral valves were identified in 4.6% of cases. Normal imaging findings were reported in 27.7% of the study population.

among infants younger than 1 year (n=12, 50.0%) and decreased with increasing age. Vesicoureteral reflux was also more frequently observed in infants (n=11, 45.8%) compared with children aged 1–5 years (n=10, 35.7%) and those older than 5 years (n=3, 23.1%).

Figure 1 presents imaging findings stratified by age group. Hydronephrosis was most prevalent

Renal scarring was most common in the 1–5-year age group (n=9, 32.1%). Posterior urethral valves were identified exclusively in children younger than 5 years.

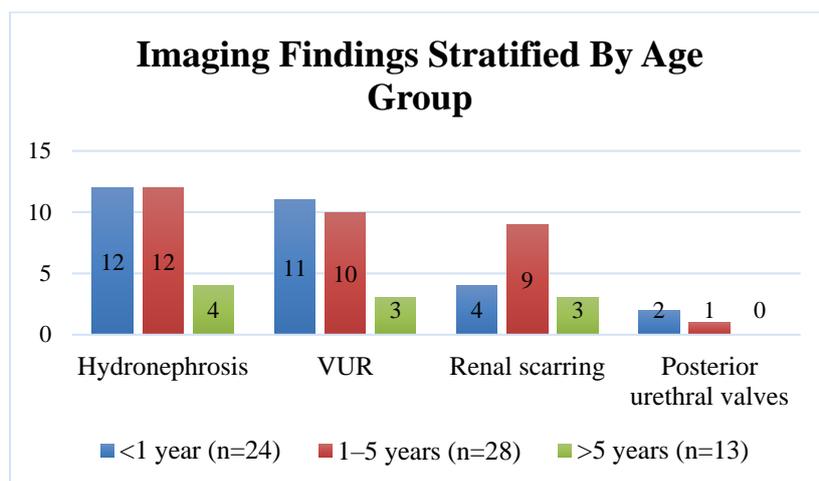


Figure 1. Age-Wise Distribution of Imaging Findings among the Study Population

4. DISCUSSION

The present study highlights the pivotal role of imaging in the evaluation of pediatric urinary tract infections (UTIs), demonstrating a substantial burden of structural and functional urinary tract abnormalities among affected children. The predominance of UTIs among children aged 1–5 years and infants align with established epidemiological patterns, where immature immune defenses and congenital abnormalities contribute to increased susceptibility [1,2]. The higher proportion of female patients observed in this study is consistent with prior reports attributing increased risk to anatomical and periurethral factors [17].

Ultrasonography was universally employed, reflecting its established position as the first-line imaging modality in pediatric UTI assessment due to its safety, availability and diagnostic performance [4,5]. In this study, hydronephrosis emerged as the most frequently detected abnormality, particularly among infants, which aligns with previous reports identifying obstructive uropathies and antenatally detected hydronephrosis as common contributors to early-life UTIs [18,19].

Vesicoureteral reflux (VUR) was identified in more than one-third of patients, with a higher prevalence in younger age groups. This finding is consistent with epidemiological data indicating that VUR is more common in infants and young children presenting with febrile UTIs [10].

The age-related decline in VUR prevalence observed in this study parallels spontaneous resolution patterns reported in longitudinal studies [12]. The reliance on MCU/VCUG for VUR detection in this study reinforces its diagnostic indispensability, despite recognized

concerns regarding invasiveness and patient discomfort [11].

Renal scarring was detected in nearly one-quarter of the study population, with the highest frequency among children aged 1–5 years. This observation supports evidence suggesting that recurrent or inadequately treated febrile UTIs during early childhood are strongly associated with permanent renal parenchymal damage [3]. DMSA scintigraphy proved valuable in identifying cortical defects not evident on ultrasonography, corroborating findings by Finkelstein et al., who demonstrated superior sensitivity of DMSA scans for renal scarring compared to ultrasound alone [8].

Posterior urethral valves were identified exclusively in children under five years of age, reflecting known epidemiological patterns of this congenital anomaly [20]. Early detection through imaging is crucial, as delayed diagnosis is associated with progressive renal deterioration and long-term morbidity. The low proportion of CT or MRI utilization in this study is consistent with current recommendations advocating selective use of cross-sectional imaging for complicated or atypical UTIs [13].

The substantial proportion of children with normal imaging findings underscores the importance of judicious imaging selection, particularly in resource-limited settings. While ultrasonography effectively excluded major structural abnormalities in many cases, its limited sensitivity for detecting VUR and renal scarring supports a tailored, risk-based imaging approach as advocated in recent guideline reviews [16]. The findings of this study reinforce the concept that no single imaging modality is sufficient for comprehensive evaluation; rather, a complementary multimodality strategy is

required based on age, clinical presentation and recurrence risk.

Overall, the findings underscore the complementary roles of different imaging modalities in pediatric UTI evaluation. While ultrasonography remains indispensable for initial assessment, adjunctive imaging such as DMSA and MCU provides critical functional and anatomical insights that directly influence clinical management. In settings similar to Bangladesh, where resource optimization is essential, these results support a targeted, stepwise imaging approach guided by clinical presentation and initial findings.

5. LIMITATIONS OF THE STUDY

The study was conducted in a single hospital with a small sample size. So, the results may not represent the whole community.

6. CONCLUSION

Imaging plays a critical role in the evaluation of pediatric urinary tract infections by enabling early detection of congenital and acquired urinary tract abnormalities. Ultrasonography serves as an effective initial screening tool, while DMSA scintigraphy and MCU/VCUG provide essential complementary information. A structured, age-appropriate imaging approach facilitates timely diagnosis and supports improved clinical outcomes.

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CONFLICTS OF INTEREST

There are no conflicts of interest.

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