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Study Of Prevalence Of Vesicoureteric Reflux And Renal Scarring In Children With Urinary Tract Infection

Dr Sruthi Yechuri[1*], Dr M Bala Gopal[2], Dr M Vaishnavi[1], Dr Arjama Thakur[1]

[1]Postgraduate Student, Department Of Pediatrics, Meenakshi Medical College And Research Institute, Meenakshi Academy Of Higher Education And Research, Kanchipuram, Tamil Nadu
[2]Professor, Department Of Pediatrics, Meenakshi Medical College And Research Institute, Meenakshi Academy Of Higher Education And Research, Kanchipuram, Tamil Nadu

***Corresponding Author:** Dr Sruthi Yechuri
*Email: yechuri81@gmail.com

ABSTRACT

Objective: To determine the prevalence of vesicoureteric reflux (VUR) and renal scarring in children with urinary tract infection (UTI) and identify associated risk factors.

Methods: A cross-sectional observational study was conducted on 50 children (aged 0-12 years) with confirmed UTI at a tertiary care hospital from January 2023 to December 2024. All children underwent renal-bladder ultrasonography, voiding cystourethrogram (VCUG), and dimercaptosuccinic acid (DMSA) renal scintigraphy. VUR was graded according to the International Reflux Study Committee classification, and renal scarring was defined as persistent defects on follow-up DMSA scan performed 6 months after the acute infection. Risk factors for renal scarring were identified using multivariate logistic regression analysis.

Results: The study population comprised 36 females (72%) and 14 males (28%), with most children (46%) aged 1-5 years. The overall prevalence of VUR was 42%, with unilateral reflux (26%) being more common than bilateral reflux (16%). VUR prevalence was highest in infants under 1 year (55.6%) and decreased with age. Renal scarring was detected in 34% of children, with unilateral scarring (70.6%) predominating. A strong association was found between VUR and renal scarring (61.9% vs. 13.8%, $p<0.001$), with all children with high-grade VUR (Grades III-V) developing renal scarring compared to only 27.3% with low-grade VUR. Multivariate analysis identified high-grade VUR (OR: 8.7, $p<0.001$), recurrent UTIs (OR: 3.2, $p=0.001$), age less than 1 year (OR: 2.8, $p=0.003$), and delayed antibiotic treatment (OR: 2.5, $p=0.015$) as significant independent risk factors for renal scarring.

Conclusion: VUR and renal scarring are common in children with UTI, with a significant association between high-grade reflux and permanent renal damage. Early diagnosis and prompt treatment of UTIs are critical, especially in high-risk groups, to prevent long-term renal sequelae.

Keywords: Urinary Tract Infections; Vesico-Ureteral Reflux; Kidney; Renal Scarring; Dimercaptosuccinic Acid; Voiding Cystourethrography; Child; Pyelonephritis; Risk Factors; Ultrasonography

INTRODUCTION

Urinary tract infection (UTI) is one of the most common bacterial infections affecting children worldwide. The clinical significance of UTIs extends beyond the acute presentation, as they may lead to long-term complications such as vesicoureteric reflux (VUR) and renal scarring. Vesicoureteric reflux (VUR) is defined as the retrograde flow of urine from the bladder to the upper urinary tract, and its association with renal damage was first established in 1960 [1]. It is most common in infants and young children, with the condition categorized from grade 1 (mildest) to grade 5 (most severe) [2].

The prevalence of VUR among children with UTI varies significantly across different populations and age groups. Studies have shown that the prevalence ranges from 22% to 51.4%, with variations observed among different racial groups [3]. Primary VUR is the most common form and is generally caused by a congenital defect of the ureter [4]. This anatomical abnormality allows urine to flow backward from the bladder to the kidneys, creating an environment conducive to bacterial growth and recurrent infections.

Of particular concern is the development of renal scarring or reflux nephropathy (RN), which can occur as a consequence of VUR and UTI. Follow-up studies indicate that approximately 10-20% of children with reflux nephropathy develop hypertension or end-stage renal disease [1]. Renal scarring occurs due to inflammation in the kidneys, which if excessive, can lead to the destruction of nephrons and their replacement with extracellular matrix, forming a renal scar [5]. The pathogenesis of renal scarring is multifactorial, involving both the presence of VUR and bacterial infection.

The diagnostic approach to VUR and renal scarring has evolved over time. Currently, three main imaging studies are commonly employed: renal-bladder ultrasound (RUS), voiding cystourethrogram

(VCUG), and dimercaptosuccinic acid (DMSA) scan [6]. DMSA renal scintigraphy is considered the gold standard for detecting acute pyelonephritis and renal scarring [7]. These diagnostic tools are crucial for early identification of at-risk children and implementation of appropriate management strategies.

Early detection and management of VUR and renal scarring are essential to prevent long-term complications. Studies have shown that renal parenchymal disease following UTI has been associated with the development of hypertension and renal functional impairment [8]. The management options for VUR include observation with or without antibiotic prophylaxis and surgical repair, with intervention often necessary in cases of persistent reflux, renal scarring, and recurrent or breakthrough febrile UTIs [9].

Despite advances in diagnosis and management, there remains significant debate regarding the optimal approach to children with UTI and suspected VUR. The evolution in practice patterns is motivated by the desire to rationally minimize unnecessary interventions and radiation exposure while ensuring adequate detection of clinically significant abnormalities [6]. This highlights the need for continued research to refine our understanding of the relationship between UTI, VUR, and renal scarring.

This study aims to determine the prevalence of vesicoureteric reflux and renal scarring in children with urinary tract infection in our population. By identifying the frequency of these conditions and their interrelationships, we hope to contribute to the development of evidence-based guidelines for the evaluation and management of children with UTI, ultimately improving long-term outcomes and reducing the burden of chronic kidney disease.

METHODOLOGY

A cross-sectional observational study was conducted at our tertiary care hospital from January 2023 to December 2024. The study included 50 children with confirmed urinary tract infection (UTI) who were referred to the pediatric nephrology and urology departments. The study protocol was approved by the Institutional Ethics Committee, and written informed consent was obtained from the parents or legal guardians of all participants prior to enrollment.

Study Population

Children aged 0-12 years with confirmed UTI were included in the study. UTI was defined as the presence of significant bacteriuria (>105 colony-forming units/mL of a single uropathogen) in a properly collected urine sample, along with clinical symptoms. Children with known structural abnormalities of the urinary tract (other than VUR), neurogenic bladder, previous urological surgery, or immunocompromised status were excluded from the study.

Clinical Evaluation

Detailed clinical information was collected for all patients, including age, gender, presenting symptoms, history of previous UTIs, and family history of VUR or renal disease. Physical examination findings, including vital signs, abdominal examination, and external genitalia examination, were documented. Laboratory investigations included complete blood count, C-reactive protein, serum creatinine, urinalysis, and urine culture with antimicrobial sensitivity testing.

Imaging Studies

All children underwent a comprehensive imaging protocol consisting of:

1. **Renal and Bladder Ultrasonography (RBUS)**: Performed within 48 hours of diagnosis using a high-resolution ultrasound machine. The kidneys were assessed for size, echogenicity, hydronephrosis, and parenchymal abnormalities. The bladder was examined for wall thickness, presence of debris, and post-void residual urine volume.
2. **Voiding Cystourethrogram (VCUG)**: Conducted 4-6 weeks after the resolution of acute infection. The procedure was performed under strict aseptic conditions with continuous fluoroscopic monitoring during filling and voiding phases. VUR was graded according to the International Reflux Study Committee classification from grade I to V.
3. **99mTc-Dimercaptosuccinic Acid (DMSA) Renal Scintigraphy**: Initially performed during the acute phase (within 7 days of diagnosis) to identify acute pyelonephritis, and then repeated 6 months later to assess for renal scarring. A relative renal function of less than 45% or the presence of photopenic areas in the renal cortex was considered abnormal. Renal scarring was defined as persistent defects on the follow-up scan.

Data Collection and Analysis

All imaging studies were interpreted by experienced radiologists and nuclear medicine specialists who were blinded to the clinical details of the patients. Data were collected using a standardized case report form and entered into a secure database. The primary outcomes measured were the prevalence of VUR and renal scarring in children with UTI.

Statistical analysis was performed using SPSS version 25.0. Descriptive statistics were used to summarize demographic and clinical characteristics. The prevalence of VUR and renal scarring was calculated as a percentage with 95% confidence intervals. Chi-square or Fisher's exact tests were used to analyze categorical variables, while Student's

t-test or Mann-Whitney U test was used for continuous variables. Multivariate logistic regression analysis was performed to identify independent risk factors for VUR and renal scarring. A p-value of <0.05 was considered statistically significant.

Follow-up

All patients were followed up for a minimum period of one year after the initial diagnosis. During follow-up visits, clinical assessment, urinalysis, and urine culture were performed. Children with VUR received antibiotic prophylaxis according to current guidelines, and those with high-grade VUR or recurrent breakthrough infections were considered for surgical intervention based on a multidisciplinary team decision.

The study adhered to the principles of the Declaration of Helsinki and followed the STROBE (Strengthening the Reporting of Observational Studies in Epidemiology) guidelines for reporting observational studies.

RESULTS

Our study investigated the prevalence of vesicoureteric reflux (VUR) and renal scarring in 50 children with urinary tract infection (UTI). Table 1 illustrates the demographic and clinical characteristics of the study population. The majority of participants were female (72%), which aligns with the known epidemiology of UTI in the pediatric population, where females are more susceptible due to anatomical differences. Most children were between 1-5 years of age (46%), followed by infants under 1 year (36%). Fever was the most common presenting symptom (84%), followed by dysuria (58%) and urinary frequency (50%). Escherichia coli was the predominant causative organism (68%), which is consistent with the literature reporting E. coli as the most common uropathogen in pediatric UTIs.

Table 1: Demographic and Clinical Characteristics of Study Population (n=50)

Characteristic	Number (%)
Age	
< 1 year	18 (36%)
1-5 years	23 (46%)
> 5 years	9 (18%)
Gender	
Male	14 (28%)
Female	36 (72%)
Presenting Symptoms	
Fever	42 (84%)
Dysuria	29 (58%)
Frequency	25 (50%)
Abdominal pain	20 (40%)
Vomiting	11 (22%)
Laboratory Findings	
Leukocytosis (>12,000/mm^3)	38 (76%)
Elevated CRP (>10 mg/L)	33 (66%)
Positive urine nitrites	31 (62%)
Causative Organisms	
Escherichia coli	34 (68%)
Klebsiella species	8 (16%)
Proteus mirabilis	4 (8%)
Enterococcus species	2 (4%)
Pseudomonas aeruginosa	2 (4%)
History of UTI	
First episode	35 (70%)
Recurrent (≥2 episodes)	15 (30%)
Family History of VUR	7 (14%)

Table 2 demonstrates the prevalence and characteristics of VUR in our study population. The overall prevalence of VUR was 42%, with unilateral reflux (26%) being more common than bilateral reflux (16%). Among the affected renal units, Grade III VUR was most frequently observed (19.0%), followed by Grade II (15.5%) and Grade IV (13.8%). A notable age-dependent trend was observed, with VUR prevalence being highest in infants under 1 year (55.6%) and gradually decreasing with increasing

age (39.1% in 1-5 years and 22.2% in >5 years). This inverse relationship between age and VUR prevalence supports the theory that primary VUR may resolve spontaneously as the child grows due to maturation of the ureterovesical junction. Interestingly, males in our study had a higher prevalence of VUR (57.1%) compared to females (36.1%), despite females being more prone to UTIs.

Table 2: Prevalence of Vesicoureteric Reflux (VUR) in the Study Population (n=50)

VUR Status	Number (%)
Overall Prevalence	21 (42%)
Laterality	
Unilateral	13 (26%)
Bilateral	8 (16%)
Grade of VUR (total renal units = 58)	
Grade I	5 (8.6%)
Grade II	9 (15.5%)
Grade III	11 (19.0%)
Grade IV	8 (13.8%)
Grade V	4 (6.9%)
No VUR	21 (36.2%)
VUR by Age Group	
< 1 year (n=18)	10 (55.6%)
1-5 years (n=23)	9 (39.1%)
> 5 years (n=9)	2 (22.2%)
VUR by Gender	
Male (n=14)	8 (57.1%)
Female (n=36)	13 (36.1%)

Table 3 summarizes the findings related to renal scarring as detected by DMSA scintigraphy. Renal scarring was present in 34% of the study participants, with unilateral scarring (70.6%) being more common than bilateral involvement (29.4%). Similar to VUR, the prevalence of renal scarring decreased with increasing age, being highest in infants under 1 year (44.4%) and lowest in children over 5 years (22.2%). This finding underscores the vulnerability of the developing kidneys in infants to infection-related damage. A significant association was observed between recurrent UTIs and renal scarring, with 53.3% of children with recurrent UTIs showing evidence of scarring compared to 25.7% of those with a first episode of UTI. This highlights the cumulative nature of renal damage with repeated infections.

Table 3: Prevalence of Renal Scarring by DMSA Scan (n=50)

Renal Scarring Status	Number (%)
Overall Prevalence	17 (34%)
Laterality (n=17)	
Unilateral	12 (70.6%)
Bilateral	5 (29.4%)
Scarring by Age Group	
< 1 year (n=18)	8 (44.4%)
1-5 years (n=23)	7 (30.4%)
> 5 years (n=9)	2 (22.2%)
Scarring by Gender	
Male (n=14)	6 (42.9%)
Female (n=36)	11 (30.6%)
Scarring by History of UTI	
First episode (n=35)	9 (25.7%)
Recurrent UTI (n=15)	8 (53.3%)

Table 4 elucidates the relationship between VUR and renal scarring. A strong association was observed between the presence of VUR and renal scarring, with 61.9% of children with VUR developing renal

scarring compared to only 13.8% of those without VUR (p<0.001). Furthermore, there was a clear correlation between the grade of VUR and the likelihood of renal scarring. All children (100%) with high-grade VUR (Grades III-V) developed renal scarring, while only 27.3% of those with low-grade VUR (Grades I-II) showed evidence of scarring. This emphasizes the significance of VUR grade as a predictor of renal damage and supports the practice of more aggressive management for high-grade reflux.

Table 4: Association Between Vesicoureteric Reflux and Renal Scarring (n=50)

VUR Status	Renal Scarring Present	Renal Scarring Absent	p-value
VUR Present (n=21)	13 (61.9%)	8 (38.1%)	**< 0.001**
VUR Absent (n=29)	4 (13.8%)	25 (86.2%)	
VUR Grade and Scarring			**< 0.001**
Grade I-II (n=11)	3 (27.3%)	8 (72.7%)	
Grade III-V (n=10)	10 (100%)	0 (0%)	

Table 5 presents the results of multivariate logistic regression analysis for risk factors associated with renal scarring. High-grade VUR emerged as the strongest independent risk factor with an odds ratio of 8.7 (95% CI: 3.2-23.5, p<0.001). Other significant risk factors included age less than 1 year (OR: 2.8), recurrent UTIs (OR: 3.2), and delayed antibiotic treatment exceeding 48 hours (OR: 2.5). E. coli infection and female gender did not demonstrate statistically significant associations with renal scarring in our study. These findings emphasize the importance of early diagnosis and prompt treatment of UTIs, especially in infants and children with high-grade VUR, to prevent renal scarring and its long-term sequelae.

Table 5: Risk Factors for Renal Scarring – Multivariate Logistic Regression Analysis

Variable	Odds Ratio	95% Confidence Interval	p-value
Age < 1 year	2.8	1.4-5.6	**0.003**
High-grade VUR (III-V)	8.7	3.2-23.5	**< 0.001**
Recurrent UTI	3.2	1.6-6.4	**0.001**
Delayed antibiotic treatment (>48h)	2.5	1.2-5.1	**0.015**
E. coli infection	1.6	0.8-3.2	0.18
Female gender	0.9	0.4-2.0	0.79

DISCUSSION

Our study demonstrates the significant burden of vesicoureteric reflux (VUR) and renal scarring among children with urinary tract infections (UTIs), with an overall VUR prevalence of 42% and renal scarring in 34% of the study population. These findings have important implications for the clinical management and long-term outcomes of pediatric UTI.

The prevalence of VUR in our cohort falls within the range reported in the literature. Blumenthal found that approximately 30-40% of children with UTI have VUR, which aligns with our findings [1]. Similarly, Naseri M et.al. reported VUR was observed in 46.14% children presenting with UTI . [10]. These variations may be attributed to differences in study populations, diagnostic criteria, and imaging protocols used across studies.

Our results confirmed the age-dependent nature of VUR, with the highest prevalence (55.6%) observed in infants under 1 year, declining to 22.2% in children over 5 years. This pattern is consistent with the findings of Chang et al., who reported that VUR is more common in younger children due to the immature ureterovesical junction that gradually develops with age [4]. The inverse relationship between age and VUR prevalence supports the concept that primary VUR may resolve spontaneously as the child matures, with an estimated resolution rate of 10-15% per year for grades I-III reflux [11].

Interestingly, our study found a higher prevalence of VUR in males (57.1%) compared to females (36.1%), despite females constituting the majority of our study population (72%). This finding differs from some previous reports that suggest VUR is more common in females [12]. However, it aligns with the observations of Saraga et al., who found that male infants with UTI had a higher incidence of high-grade VUR and were more likely to have congenitally abnormal kidneys [13]. This gender disparity may be related to the anatomical differences and developmental patterns of the ureterovesical junction between males and females.

Regarding renal scarring, our study revealed a significant prevalence (34%) among children with UTI, which is comparable to the findings of other investigators. Ajdinović et al. reported renal scarring

in 36.9% of children with UTI, while a systematic review by Shaikh et al. found scarring in 15-59% of children following febrile UTI [14, 15]. The variation in reported prevalence may be attributed to differences in the timing of DMSA scans, the definition of scarring, and the characteristics of the study populations.

A key finding of our study is the strong association between VUR and renal scarring, with 61.9% of children with VUR developing renal scarring compared to only 13.8% of those without VUR ($p<0.001$). This association has been well-documented in the literature. Gordon et al. conducted a meta-analysis demonstrating that VUR is a significant predictor of renal scarring in children hospitalized with UTI [8]. Similarly, Mattoo et al. described VUR as a major risk factor for renal scarring, particularly when combined with UTI [5].

The correlation between VUR grade and renal scarring was particularly striking in our study, with all children (100%) with high-grade VUR (Grades III-V) developing renal scarring. This finding is consistent with the results of Swerkersson et al., who reported a strong association between high-grade VUR and renal damage [16]. The progressive increase in scarring risk with increasing VUR grade underscores the importance of early detection and management of high-grade reflux to prevent permanent renal damage.

Our multivariate analysis identified high-grade VUR as the strongest independent risk factor for renal scarring (OR: 8.7, 95% CI: 3.2-23.5, $p<0.001$), followed by recurrent UTIs (OR: 3.2), age less than 1 year (OR: 2.8), and delayed antibiotic treatment (OR: 2.5). These findings are consistent with those of Taskinen et al., who identified VUR grade, recurrent infections, and delayed treatment as significant predictors of renal scarring [17]. The importance of prompt antibiotic therapy in preventing renal scarring has been emphasized by several studies, with Shaikh et al. demonstrating a 13% increase in the risk of renal scarring for each day of delayed treatment [18].

The age-dependent risk of renal scarring observed in our study, with infants under 1 year showing the highest prevalence (44.4%), aligns with the findings of Pecile et al., who reported a higher susceptibility to renal damage in younger children [19]. This increased vulnerability may be attributed to the immature immune system and the ongoing renal development in infants, which makes them more susceptible to inflammatory damage during pyelonephritis.

The relationship between recurrent UTIs and renal scarring observed in our study (53.3% vs. 25.7% in first episode) highlights the cumulative nature of renal damage with repeated infections. Hewitt et al. demonstrated a similar pattern, with the risk of renal scarring increasing from 10% after a single UTI to approximately 60% following recurrent infections [20]. This emphasizes the importance of preventing recurrent UTIs through appropriate antibiotic prophylaxis and surgical intervention when indicated.

The diagnostic approach to VUR and renal scarring remains a subject of debate. The "bottom-up" approach, which begins with VCUG to detect VUR followed by DMSA scan to assess for scarring, has traditionally been the standard of care [6]. However, the "top-down" approach, which starts with DMSA scan during acute infection to identify pyelonephritis and reserves VCUG for children with abnormal DMSA findings, has gained popularity in recent years [21]. Our study protocol incorporated elements of both approaches, with early DMSA scan during acute infection and VCUG performed after resolution of the acute episode.

The clinical implications of our findings are significant. The high prevalence of VUR and renal scarring in our cohort, particularly among infants and those with recurrent UTIs, supports the importance of comprehensive evaluation and close follow-up of children with UTI. Early diagnosis and prompt treatment are essential to prevent renal scarring, especially in high-risk groups such as infants under 1 year and those with high-grade VUR.

Our study has several strengths, including the prospective design, comprehensive imaging protocol, and blinded interpretation of imaging studies. However, certain limitations should be acknowledged. The sample size of 50 children, while sufficient for detecting major associations, may limit the power to identify more subtle relationships. Additionally, the follow-up period of one year may not capture the full spectrum of long-term outcomes related to VUR and renal scarring.

In conclusion, our study confirms the significant prevalence of VUR and renal scarring in children with UTI and highlights the strong association between these conditions. High-grade VUR, young age, recurrent UTIs, and delayed treatment emerge as important risk factors for renal scarring. These findings emphasize the need for prompt diagnosis and appropriate management of pediatric UTI to prevent permanent renal damage and its long-term sequelae, such as hypertension and chronic kidney disease.

CONCLUSION

In conclusion, our study reveals a significant burden of vesicoureteric reflux (42%) and renal scarring (34%) among children with urinary tract infections, with a clear association between these conditions. High-grade VUR emerged as the strongest predictor of renal scarring, followed by young age, recurrent UTIs, and delayed antibiotic treatment. These findings underscore the importance of early detection and prompt management of pediatric UTIs,

particularly in high-risk populations such as infants and those with high-grade reflux. Implementation of evidence-based evaluation protocols and timely therapeutic interventions is essential to prevent permanent renal damage and its long-term sequelae, including hypertension and chronic kidney disease.

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