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Original Article

Role of Imaging Modalities in the Management of Urinary Tract Infection in Children

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Abstract

Background: Urinary tract infections (UTIs) are a common clinical condition in pediatric practice requiring special attention as congenital anomalies of kidneys and collecting system is usually the causes of recurrence. American Academy of Pediatrics recommends children with UTI should be investigated with voiding cystourethrogram (VCUG), ultrasonogram of urinary tract (renal ultrasound [RUS]), and radionuclide imaging of kidney (dimercaptosuccinic acid renal scan) for diagnosing underlying urinary tract abnormalities.

Aim of the study: The aim of the study was to assess the role of routine RUS in the management of young children hospitalized with uncomplicated febrile UTI.

Materials and Methods: A total of 120 children between 1 month and 12 years of age with the first episode of a confirmed diagnosis of UTI were included in this prospective cross-sectional study. All the children were thoroughly investigated after elicitation of history. Culture of urine, ultrasonogram (RUS) and radionuclide renal scan were obtained at the time of admission. VCUG was performed after 6 weeks to look for vesicoureteric reflux. These tests are in addition to routine investigations before and during follow-up of treatment.

Observations and Results: RUS was done in 120 cases, and 14 (11.66%) cases had abnormal findings. Hydroureteronephrosis is seen in 8 cases (7%), cystitis in 4 cases (3%), pelvic-ureteric junction obstruction in 2 cases (1.8%). VCUG was done in 40 cases (31 males and 9 females) and was abnormal in 12 (30%) cases. 4 (10%) and 2 (5%) of 40 cases had Grades 1–2 vesicoureteral reflux (VUR) and Grades 3–4 VUR, respectively. 4 (13%) of 31 males and 2(22%) of 9 females who underwent VCUG had evidence of VUR; this female to male ratio of 1.7:1 found was not significant statistically (P = 0.49). The sensitivity, specificity, positive predictive value, and negative predictive value of RUS for detecting VUR were 20.7%, 87.33%, 26.33%, and 83.33%, respectively [Table 1]. For the purpose of further analysis, the children were divided into three age groups: <1 year (28 children and 20/08 male/female), 1–5 years (60 children and 44/16 male/female), and 5–12 years (32 children and 12/20 male/female).

Conclusions: The present study question the yield of routine RUS in the management of young children with simple UTI. The study concludes that RUS should only be performed in children in whom complications such as renal obstruction or abscess are suspected based on an unfavorable clinical course, or in children in whom VUR has been found, to look for renal structure abnormalities.

Key words: Bacteriuria and children, Renal ultrasound, Urinary tract infection, Voiding cystourethrography

INTRODUCTION

The main goals of imaging studies in children with episodes of urinary tract infection (UTI) are to identify urinary tract anatomic abnormalities. Unless the existences of such abnormalities are investigated, therapeutic measures even though executed would not prevent future infections and possible long-term damage to the kidneys. Renal ultrasound (RUS) remains currently the most recommended imaging study which mainly detects abnormalities in the upper urinary tract such as hydronephrosis or pelvic-ureteric obstruction. This is followed by voiding cystourethrography (VCUG) or radionuclide cryptography (RNC) to detect anomalies of the lower urinary tract, mainly vesicoureteral reflux (VUR).[1,2] RUS remains an ideal tool of investigation in the hands of the pediatrician

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due to its non-invasive nature, the lack of radiation, and the low cost of the procedure for the children with UTI.[3,4] RUS, when performed during the hospitalization may also detect pathologies such as obstructive uropathy or an abscess that directly influences the management of the child. Review of literature shows that the RUS data have low sensitivity and specificity for predicting VUR. Also especially, when the mothers have undergone repeated ultrasound examination during their pregnancy, the major anomalies would have been diagnosed in the children with UTI. These data question the importance of routine RUS in the management children with acute uncomplicated UTI.[5-8] In this study an attempt is made to assess the role of routine RUS in the management of young children hospitalized with uncomplicated febrile UTI.

MATERIALS AND METHODS

Study Design

This was a cross-sectional prospective and analytical study.

Institute of Study

This study was conducted at the Department of Paediatrics, IMCH, Government Medical College, Kozhikode.

Period of Study

This study was from March 2014 to August 2015.

The present study was a prospective, cross-sectional and analytical study conducted in the Department of Pediatrics of a tertiary teaching hospital of Kerala. An ethical committee clearance was obtained to conduct the study. 120 children on the study group were chosen according to the following criteria:

Inclusion criteria

1. Children between 1 month and 12 years of age, who presented with uncomplicated febrile UTI were included.
2. Children with UTI; presenting with a combination of a positive urine culture (growth of >100 bacteria/ml in a midstream sample or any growth in suprapubic bladder aspiration or in/out bladder catheterization) and fever >38.0°C were included.

Exclusion criteria

1. Children with uncomplicated UTI determined as a child with febrile UTI who clinically responded and became afebrile within 48 h of initiation of therapy were excluded.
2. Children with known urinary tract anomalies, and/or who had been treated with antibacterial agents within 7 days before the admission were excluded.
3. Children below 1 year and above 12 years were excluded.

The sample of the study was calculated based on the prevalence rate VUR in 20% of young children with first diagnosed UTI. A study sample of 200 children was included in the study satisfying the criteria of inclusion and exclusion. The urine was obtained for culture and sensitivity by suprapubic aspiration or in and out bladder catheterization in children younger than 2 years and by the midstream techniques in older children. All the children were initially treated with intravenous antibacterial agents (ampicillin + gentamicin or cefuroxime). Intravenous therapy was continued until fever had subsided, but for at least 96 h in neonates or 48 h in older infants and children. Later followed by oral therapy with appropriate agents was continued for a total duration of 10–14 days. Preventive therapy was given thereafter until results of the VCUG were available. RUS was performed in all patients during the hospitalization using an ultras sound machine with sector or linear 7 and 7.5 MHz transducers. It consisted of an examination of the kidneys to show the kidney size, renal outlet obstruction (such as pelvic-ureteric junction stenosis), collecting system dilatation, parenchymal structure, and parenchymal lesions such as an abscess. Furthermore, examination of the bladder was done to identify dilatation of the distal ureters, hypertrophy of the bladder wall, and presence of ureteroceles. Renal pelvis dilatation was defined as suggestive of VUR and graded as mild, moderate, or severe (hydronephrosis).[9] A VCUG was performed within 2–6 months after the infection, and VUR was classified according to the international VUR classification.[10] The impact on management was defined as a change of therapy, investigations, or follow-up based on RUS results, that would not have been done otherwise. All the data collected were analyzed using standard statistical methods.

OBSERVATIONS AND RESULTS

Age and Gender Distribution

Of 120 cases studied, 28 (23.3%) cases were below 1 year, 60 (50%) cases were between 1 and 5 years, and 32 (26.6%) cases were between 5 and 12 years [Figure 1].

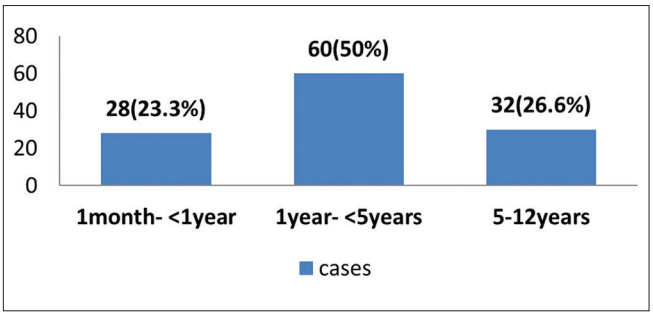


Figure 1: Age incidence in the study group (*n*-120)

Gender Distribution

In the study population, 76 (63.4%) were males and 44 (36.6%) were females. Males outnumber females in children <5 years (71.4% in children between 1 and 12 months and 73.3% in children between 12 and 59 months). Females (62.5%) outnumber males >5 years [Figure 2].

Spectrum of Isolated Organisms

88 (73.3%) *Escherichia coli*, 21 (17.5%) *Klebsiella*, 3 each of CONS, *Enterobacter*, *Staphylococcal aureus,* and 2 of *Acinetobacter* species were isolated. Most common organism isolated was *E. coli* followed by *Klebsiella* [Figure 3].

RUS

RUS was done in 120 cases, and 14 (11.66%) cases had abnormal findings. Hydroureteronephrosis is seen in 8 cases (7%), cystitis in 4 cases (3%), and pelvic-ureteric junction obstruction in 2 cases (1.8%) [Figure 4].

All the hydroureteronephrosis (8 cases) was detected in children <5 years. Of 8 cases with hydroureteronephrosis 7 (87.5%) were males and 5 (71.4%) of these 7 males with hydroureteronephrosis had posterior urethral valve (PUV) [Figure 5].

VCUG

VCUG was done in 40 cases (31 males and 9 females) and was abnormal in 12 (30%) cases. 4 (10%) and 2 (5%) of 40 cases had Grades 1-2 VUR and Grades 3–4 VUR, respectively. 4 (13%) of 31 males and 2 (22%) of 9 females who underwent VCUG had evidence of VUR; this female to male ratio of 1.7:1 found was not significant statistically ($P = 0.49$). In 31 males who underwent VCUG 6 (19.35%) had PUV. Of 6 PUV cases, 4 cases (66.7%) were detected before 12 months of age; 2 (33.3%) cases of PUV were detected after the age of 12 months [Figure 6].

Dimercaptosuccinic Acid (DMSA) Renal Scan

DMSA was done in 57 cases and detected abnormality in 21 cases (37%). All children with abnormal DMSA renal scan (21 cases) had renal scarring at 2–3 months after 1st episode UTI. None of the children had renal function impairment which was assessed by split renal function on DMSA renal scan [Figure 7].

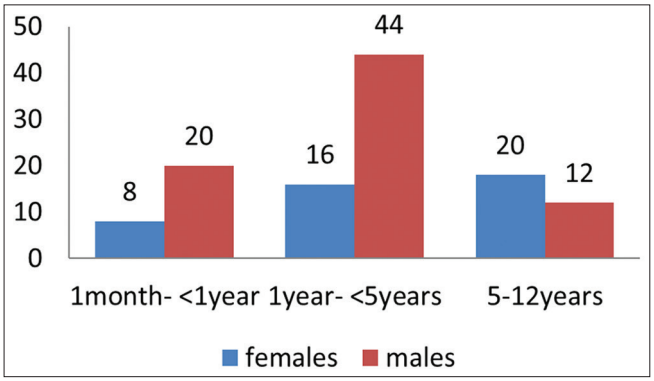


Figure 2: Gender incidence in the study (*n*-120)

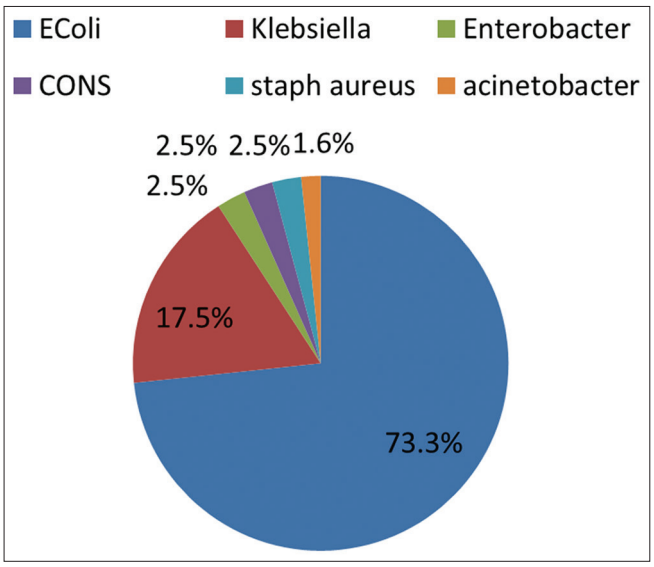


Figure 3: Distribution of organism cultured in the study (*n*-120)

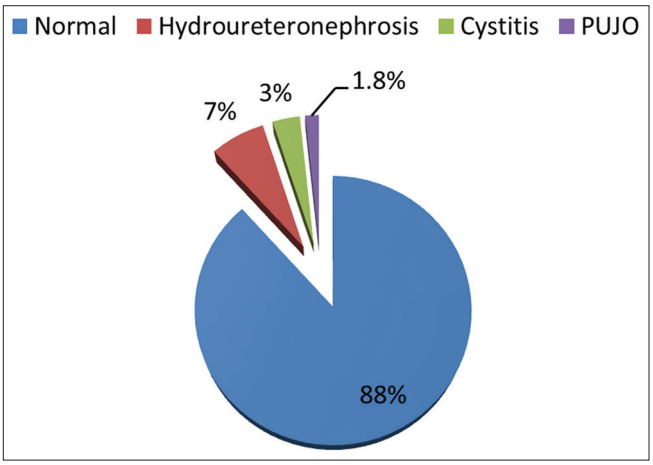
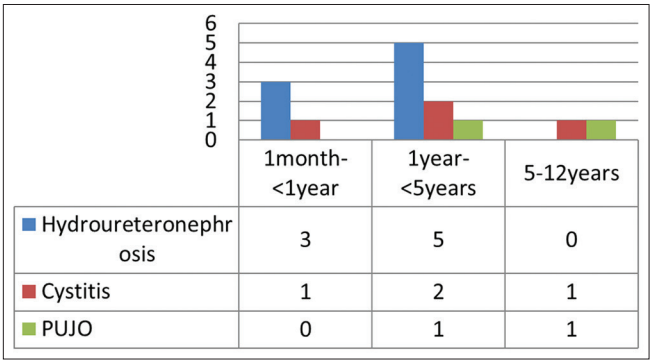


Figure 4: Incidence of abnormal ultrasonography findings (*n*-120)



	1month-<1year	1year-<5years	5-12years
Hydroureteronephrosis	3	5	0
Cystitis	1	2	1
PUJO	0	1	1

Figure 5: Age incidence of the abnormalities diagnosed on ultrasonography (*n*-14)

Treatment Outcome

Of 120 cases, 48 (40%) cases responded (became non-toxic and devoid of urinary symptoms) within 5–7 days of antibiotics. 47 cases needed antibiotics for 7–10 days and 25 cases needed antibiotics for 10–14 days for complete clinical recovery [Figure 8].

Surgical interventions: 6 (7.9%) of 76 males studied had PUV. All children with PUV had undergone cystoscopic fulguration, and 4 of these 6 children had undergone pyeloplasty after fulguration [Figure 9].

The sensitivity, specificity, positive predictive value (PPV), and negative predictive value of RUS for detecting VUR were 20.7%, 87.33%, 26.33%, and 83.33%, respectively [Table 1]. For the purpose of further analysis, the children were divided into three age groups: <1 year (28 children and 20/08 male/female), 1–5 years (60 children and 44/16 male/female), and 5–12 years (32 children and 12/20 male/female). The sensitivity, specificity, PPV, and negative predictive value of abnormal RUS for detecting VUR were 29%, 81%, 21%, and 87%, respectively, in the <1 year group, 25%, 87%, 26%, and 88%, respectively, in the 5 years group, and 9%, 94%, 32%, and 75%, respectively, in the 5–12 years group. The differences in sensitivity and specificity between these groups had no statistical significance [Table 1].

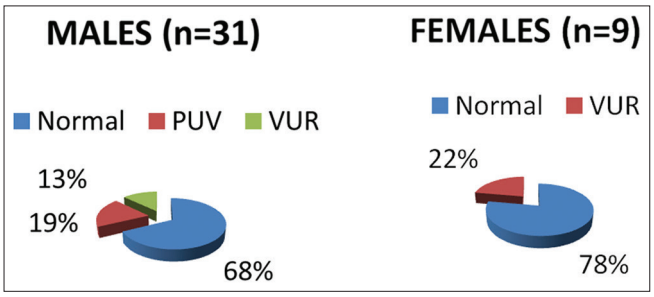


Figure 6: Incidence of micturating cystourethrogram findings (*n*-12)

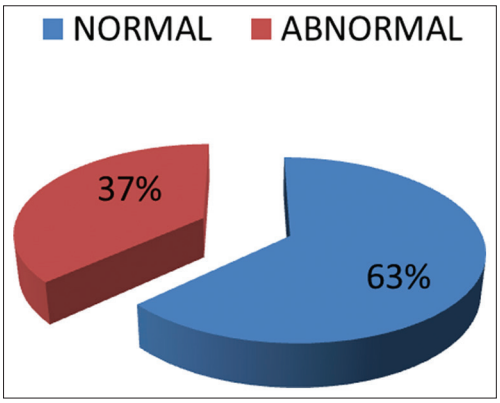


Figure 7: Incidence of abnormal dimercaptosuccinic acid results (*n*-120).

DISCUSSION

UTI is one of the most frequently encountered clinical entities in pediatrics practice. It has been estimated that 8% of girls and 2% of boys will have a UTI during childhood.[11] UTI serves as a marker of underlying anatomic and functional abnormalities. Infants and young children are at higher risk than older children for incurring acute renal injury. The present study it was observed that RUS findings in children younger than 5 years admitted to hospital with an uncomplicated febrile UTI are of little diagnostic value and have no influence on their management. Review of literature also shows similar results regarding the usefulness of RUS as a screening tool for VUR in children younger than 5 years. Mahant *et al.*[12] in their retrospective study of 162 children aged below 5 years with UTI, who had undergone investigations RUS and VCUG: RUS was suggestive of VUR if dilatation of the pelvi-calyces, dilatation of the ureters, or dilatation of the collecting system of one or both kidneys were reported. The overall prevalence of VUR was 22%. RUS findings were suggestive of VUR in only 14 of 35 children with confirmed VUR, and in 30 of 127 children without

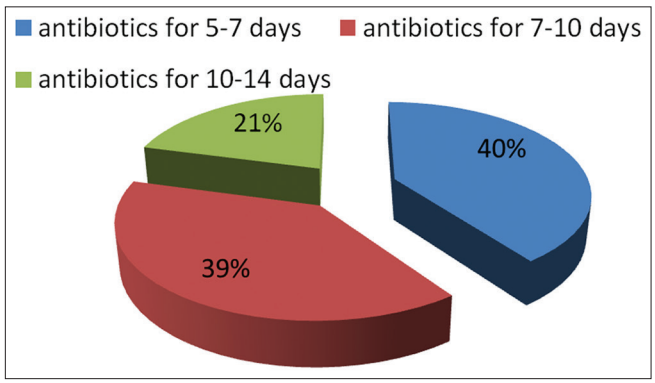


Figure 8: Treatment outcome in the study (*n*-120)

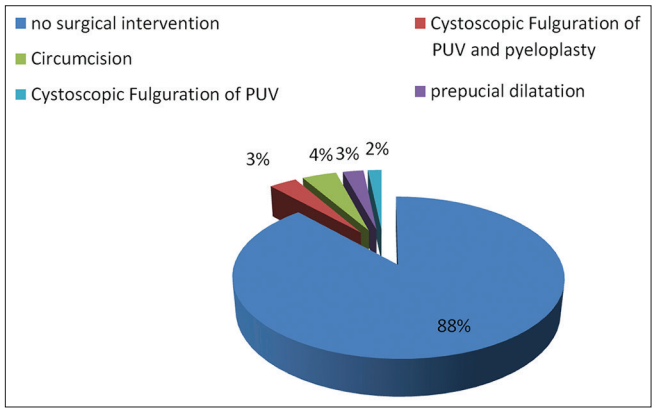


Figure 9: Types of surgical interventions undertake in the study (*n*-120)

Table 1: Sensitivity, specificity, PPV, and negative predictive value of RUS for detecting VUR by VCUG (*n*-120)

Age group (years)	*n*- M/F	RUS suggestive of VUR	VUR on MCU	VUR in patients with abnormal RUS	Sensitivity (%)	Specificity (%)	PPV (%)	NPV (%)
<1	28-20/8	4	4	3	29	81	21	87
2–5	60-44/16	8	6	2	25	87	26	88
5–12	32-12/20	2	2	3	9	94	32	75
Overall	120	14	12	8	20.7	87.33	26.33	83.33

RUS: Renal ultrasound, VUR: Vesicoureteral reflux, MCU: Micturating cystourethrogram, VCUG: Voiding cystourethrogram, PPV: Positive predictive value, NPV: Negative predictive value

VUR. The sensitivity, specificity, and positive and negative predictive values of ultrasound for VUR were 40%, 76%, 32%, and 82%, respectively. Kass *et al*.[13] evaluated 453 children with RUS, VCUG, and DMSA renal scan. They showed that of 101 children who had a normal RUS and normal DMSA, 23% had VUR using VCUG. Alon and Ganapathy[7] studied 124 patients with UTI, of whom RUS showed hydronephrosis and/or hydroureter in 10 patients (8.1%); however, by VCUG, 38 patients (38%) were found to have VUR. Di Pietro *et al*.[14] reported 70 children under the age of 5 years, who were studied using both RUS and VCUG. Five children (7%) had abnormal RUS, of whom two had VUR on VCUG. Of the other 65 children with normal RUS, 19 (29%) had VUR on VCUG. Smellie *et al*.[15] evaluated four methods of investigation in 58 children following UTI. 36 patients (62%) were found to have VUR by VCUG, but only 8 (13%) had abnormal RUS, giving a sensitivity, specificity, and false negative rate of 42%, 91%, and 78%, of RUS for predicting VUR. She concluded that "ultrasonography is unreliable in detecting VUR, renal scarring, or inflammatory change and, alone, is inadequate for investigating UTI in children." These studies show that RUS is an unreliable screening tool for VUR. The contribution of RUS to the management of the hospitalized child with UTI has been studied. Both Mucci and Maguire[5] and Alon and Ganapathy[7] found that routine RUS had a negligible effect on the clinical management of children with simple UTI. Our findings are in accordance with these results. In none of the children did the RUS finding change the management of the patients. Goldman *et al*.[16] reported similar findings in 45 neonates with UTI. Of 12 patients with abnormal RUS, 4 (33%) had normal VCUG, while of 33 patients with normal RUS, 13 (40%) had VUR on VCUG. However, he found urinary tract abnormalities in 22 of 45 (48%) neonates compared to only 18% in our findings (13 of 71). This discrepancy in results can be partly explained by the patient selection methods, as Goldman *et al*. included children who were suspected of urinary tract abnormalities by intrauterine ultrasound, while we excluded any child with known urinary tract anomalies. In a recently published paper, Hoberman *et al*.[17] studied 309 children, aged 1–24 months, using RUS, DMSA, and VCUG. They found that the sensitivity of RUS for detecting VUR on VCUG was 10%, and PPV was 40%. They also reported that the identified abnormalities did not modify management, and concluded that RUS and renal scanning at the time of the acute illness were of limited value. These results are generally in accordance with ours, and we concur with his conclusions. Several issues still remain to be clarified: What is the role of intrauterine ultrasound and does the imaging workup need to be changed according to its findings? Another point in question is the role of DMSA as a screening tool. Since we do not perform DMSA routinely, we cannot address the issue of VCUG versus DMSA based on our own data; however, in light of the growing amount of evidence against DMSA as a screening tool, further studies addressing this issue are needed.

CONCLUSIONS

The present study question the yield of routine RUS in the management of young children with simple UTI. The study concludes that RUS should only be performed in children in whom complications such as renal obstruction or abscess are suspected based on an unfavorable clinical course, or in children in whom VUR has been found, to look for renal structure abnormalities.

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