

Original Article

The results of different diagnostic imaging studies used in children with urinary tract infection

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ABSTRACT

Urinary tract infections (UTI) can cause significant renal scarring, which can be complicated by hypertension and renal impairment. This study describes the outcome of different imaging modalities in children with UTI and its relation to age, sex and type of UTI.

Our objective was to describe the frequencies of different imaging studies, which were used to investigate children with UTI at King Fahad Hospital (KFH) between the years 2003 and 2008. This is a descriptive study of all children presenting with UTI at KFH from 2003 to 2008. The study population, 100 children, were divided into 3 age groups; first group (> 1 month to 2 years); second group (> 2 to 5 years), third group (> 5 to 12 years). All enrolled children were confirmed to have had UTI via urinary cultures. Ninety seven (97%) patients underwent renal ultrasonography (US), 77 (77%) had a ^{99m}Tc-dimercaptosuccinic acid (DMSA) scan within 2

months of presentation, and 60 (60%) patients underwent micturating cystourethrogram (MCUG), mainly those with an abnormal DMSA scan. A total of 100 patients screened, 10 (10%) were males and 90 (90%) were females, first age group constituted 10%, second age group was 25%, third age groups was 65%. E-coli was isolated in 84% of patients, 60% had recurrent UTI, 45% had pyelonephritis, 48.4% had abnormal renal US, 61% had an abnormal DMSA scan, and 26.6% had abnormal MCUG. UTI can cause significant morbidity in children if not managed properly. Imaging studies are useful in identifying children who require advanced medical intervention; however, such studies should be performed only when indicated.

Keywords:

Urinary tract infection; Children; Renal ultrasonography; Dimercaptosuccinic acid scans; Micturating cystourethrogram.

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INTRODUCTION

Urinary tract infections (UTI) are common bacterial infections in childhood [1-3]. They can cause significant renal damage due to renal scarring, especially if they are recurrent and bilateral, if occur in younger children, and are associated with congenital anomalies of the urinary tract, and occur in the presence of vesicouretric reflux (VUR) [4-6]. Renal scarring is worse in children who developed a first infection at a young age [7], had recurrent UTI, had VUR, and where there was a delay in diagnosis and treatment [8]. Guidelines from the Royal College of physicians and American Academy of Pediatrics recommend that all cases of UTI should merit medical investigation at least by non-invasive imaging studies such as renal ultrasonography (US), particularly to detect any renal dilatation, anatomical anomalies, and bladder wall thickness, and to document the presence of renal scarring via the static ^{99m}Tc -Dimercaptosuccinic acid (DMSA) [9,10]. Such recommendations were aimed at preventing renal insufficiency and hypertension on the long term, especially among children ≤ 5 years old, those with pyelonephritis or recurrent UTI. Furthermore, invasive investigations are warranted when the renal US or DMSA scans display any abnormalities, such as VUR. Over 30 years ago imaging studies carried out on children with UTI showed that renal scarring was present in 10–25%, and VUR was present in 30% [6]. Later studies using the DMSA scan have suggested that scarring may often occur in the absence of VUR, and it has been claimed that renal scarring may be independent of the presence or absence of VUR [11,12]. We therefore need to re-assess our knowledge in this field. This is a descriptive study attempting to describe the outcome of different imaging techniques, particularly renal US, DMSA scanning, and cystography in children with UTI and the association of this outcome with the age, sex, different types of UTI in pediatric patients.

METHODS

This is a descriptive study of all patients presenting with UTI to the pediatric nephrology clinic at King Fahd Hospital, 400 inpatient beds from 2003 to 2008. A total of 107 pediatric patients complaining of UTI were screened, 7 of them were excluded due to negative urinary cultures on separate occasions. Inclusion criteria were patients ages between ≥ 1 month and ≤ 12 years, with positive urinary cultures, whether first time or in recurrent occasions. The chart review consisted of patient age, gender, microbiological findings of urine culture, urine analysis findings, and radiological investigations; particularly, renal ultrasonography, DMSA scan and MCUG if used. All imaging investigations were done with the assistance of the radiology department in the same hospital. Furthermore, blood count and acute inflammatory markers, C-reactive protein (CRP) and erythrocyte sedimentation rate (ESR), were reviewed for patients presenting with pyrexia. The study population were divided into three groups with respect to their age; first group > 1 month to 2 years old; second group > 2 to 5 years old; third group > 5 to 12 years old. All patients were followed up for 2 months. UTI defined when a urine culture showing a pure growth of a single bacteria $> 100,000$ (colony forming unit) CFU/ml. Recurrent UTI was defined as 3 UTI that occurred in one year. Acute pyelonephritis was defined as positive urine culture accompanied by fever $> 38.5^\circ\text{C}$ in a patient who looks toxic. Cystitis was defined as positive urine culture accompanied by dysuria, frequency, with or without low grade fever. Renal US was considered abnormal if there was either hydronephrosis, uretric-pelvic dilatation, structural abnormalities, increase bladder wall thickness > 5 mm and renal or bladder calculi. DMSA scans were performed to identify any uptake defects, both focal and generalized, within 1-2 months of presentation. MCUG was done to detect VUR and estimate its grades. It was done after the urine had become sterile,

particularly in patients with an abnormal DMSA scan. The ethical committee in King Fahd Hospital in Al-Baha approved this study.

Statistical analysis

Data was gathered on a previously designed access program prospectively with the patient clinic visit. Then the data was transferred to Statistical Package for the Social Sciences (SPSS, V-16) software for analysis. Continuous variables are presented as means and standard deviations and categorical variables as percentages. This is primarily a descriptive study of the entire population of pediatric patients presenting with UTI to KFH between periods from 2003 to 2008.

RESULTS

In this study, only 10 patients (10%) were males and mean age was 7.16 ± 1.8 years. First age group constituted 10 patients (10%) of all enrolled patients, while the second and third age groups represented 25 patients (25%) and 65 patients (65%), respectively (Figure 1). The prevalence of cystitis was highest among the second and third age group (Figure 2) and mainly in females (Figure 3). Recurrent UTI infections are also highest in the 3rd age group (Figure 4). Results of urinary cultures showed 84 patients (84 %) with E-coli growth.

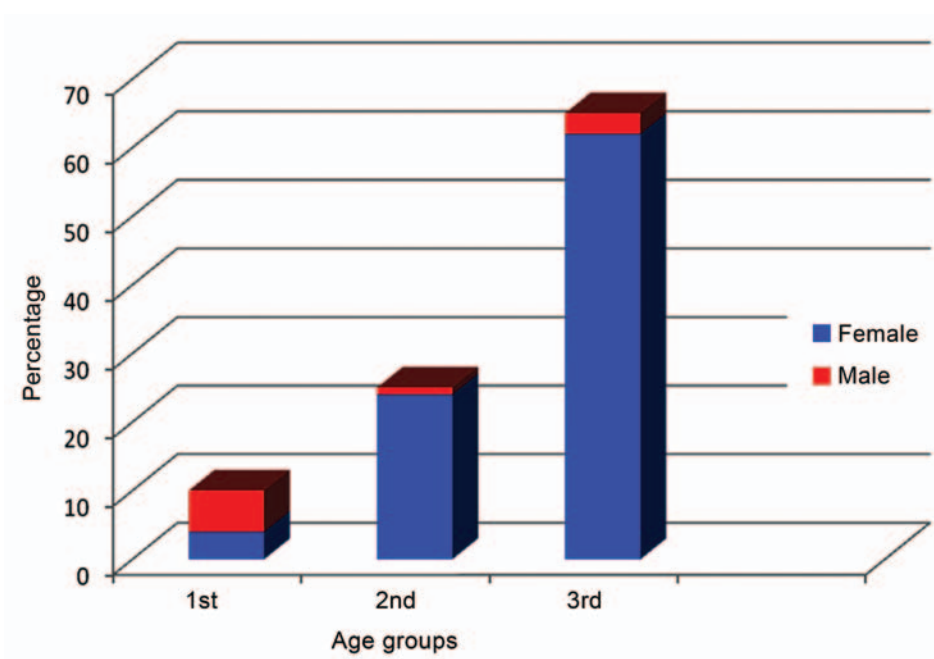


Figure 1 – Percentage of urinary tract infection according to gender in different age groups*

*10 % of all enrolled patients in 1st age group, 25% in 2nd, and 65% in 3rd with females predominant in 2nd and 3rd age groups, constituting almost 96 % of all cases in these age groups.

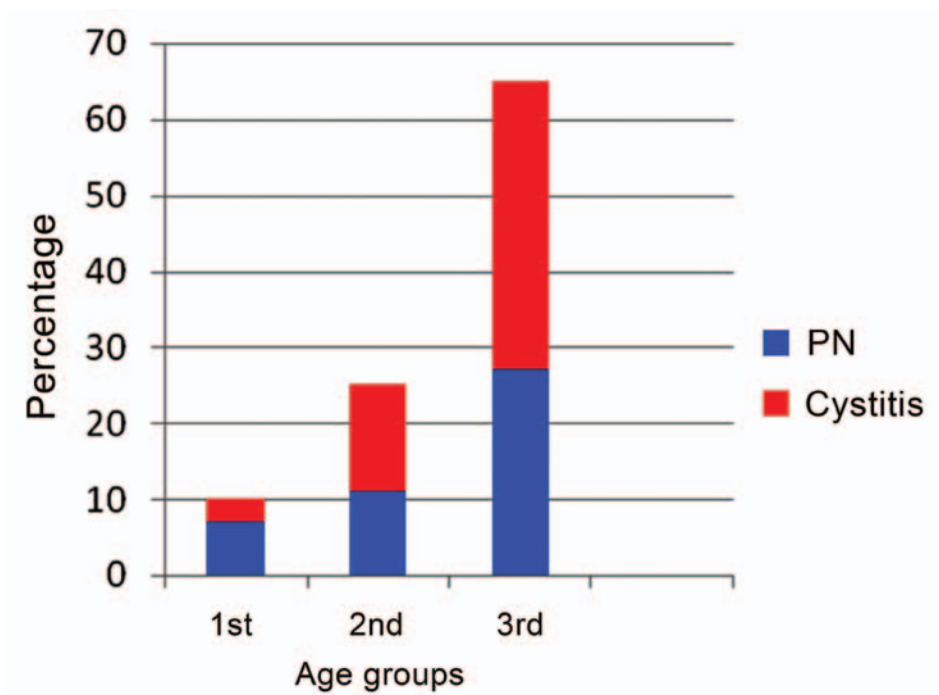


Figure 2 – Site of urinary tract infection in different age groups (pyelonephritis versus cystitis)*

PN – Pyelonephritis

*Cystitis was highest in 2nd and 3rd age groups and constituted 56% and 58.5% of all cases in these age groups, respectively.

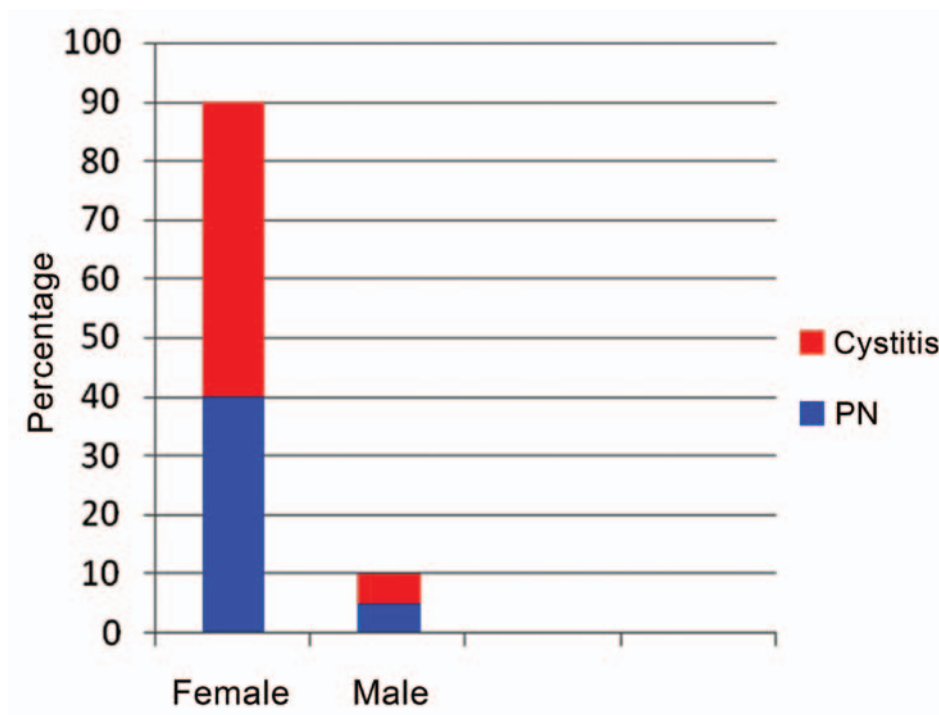


Figure 3 – Site of urinary tract infection according to gender*

PN – Pyelonephritis

*Females had the highest percentage of cystitis and PN and constituted 50% and 40 %, respectively.

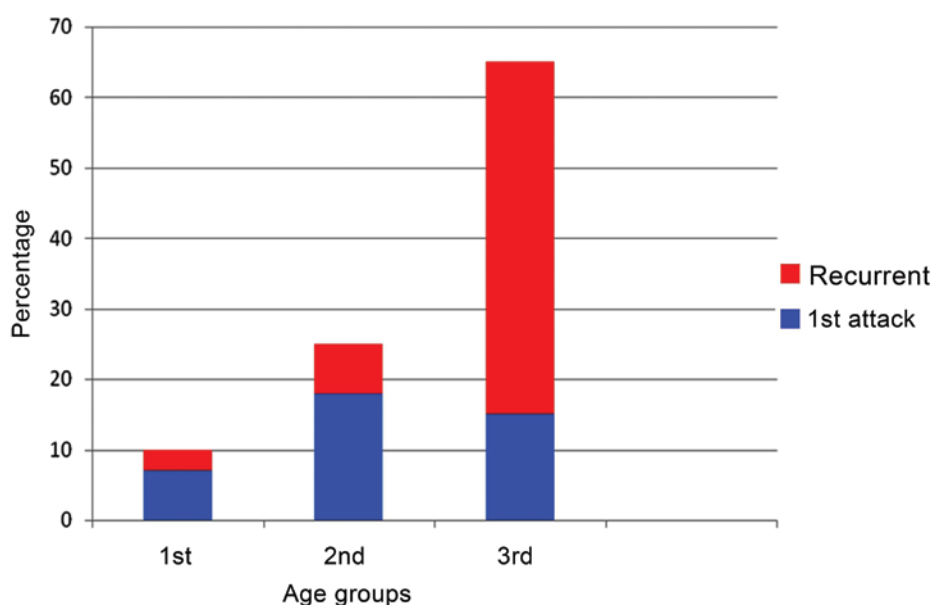


Figure 4 – Number of urinary tract infections (UTI) in different age groups*

*Recurrent UTI was highest in 3rd age group while 1st attack was more prevalent in 1st age group and constituted almost 80% of all cases in this age group. The 1st attack was prevalent in 1st and 2nd age groups and constituted 70% and 72%, respectively.

Renal US was done for 97 patients (97%) at the time of presentation, while 77 patients (77%) underwent DMSA scans and in 60 patients (60%) MCUG was done. Positive results of different imaging studies were higher in females mainly the third age group, while it is mainly positive in the first age group in males. A total of 47/97 patients (48.4%), had an abnormal renal US (Table 1), among them 35/47 patients (74.4%) had recurrent UTI, 20/47 patients (57.5%) had cystitis, and 38/47 patients (80%) had altered urine analysis (Table 2).

A total of 47/77 (61%) had an abnormal DMSA scan;

among them 34/47 patients (72.3%) had recurrent UTI, 26/47 patients (55.3%) had pyelonephritis. Of these patients, 19/47 (40.4%) had an abnormal renal US, and 39/47 (82.9%) had an altered urinary analysis (Table 3). Sixteen patients (26.6% of 60 patients who had MCUG) had an abnormal MCUG; among them 10/16 (62.5%) patients had recurrent UTI and pyelonephritis (Figure 5). Fourteen patients (87.5% of the sixteen patients) had an abnormal DMSA scan, 9/16 (56.2%) patients had an abnormal renal US, only 5 patients (31.2%) were younger than 5 years of age, and all of them had grade 3 or higher VUR (Table 4).

Table 1 – Abnormal imaging studies in different age groups

Type of imaging study	Males			Females			Total
	Age group 1	Age group 2	Age group 3	Age group 1	Age group 2	Age group 3	
Abnormal renal US	5	2	4	2	7	27	47/97 (48.7%)
Abnormal DMSA	3	0	2	1	9	32	47/77 (61%)
Abnormal MCUG	3	0	1	0	4	8	16/60 (26.6%)
Total	11	2	7	3	20	67	

DMSA- Dimercaptosuccinic acid scans; MCUG- Micturating cystourethrogram; US- Ultrasonography

Table 2 – Abnormal ultrasound according to urinary tract infection episodes, site and urine analysis*

Age and Sex		Abnormal ultrasound								
		UTI episodes frequency			UTI site			Urine analysis		
		Recurrent	First	Total	Cystitis	Pyelonephritis	Total	Abnormal	Normal	Total
1 Mo – 2 Yr	F	1	1	2	1	1	2	1	1	2
	M	3	2	5	2	3	5	4	1	5
> 2 Yr-5 Yr	F	4	3	7	3	4	7	6	1	7
	M	1	1	2	1	1	2	1	1	2
> 5 Yr-12 Yr	F	23	4	27	17	10	27	23	4	27
	M	3	1	4	3	1	4	3	1	4
Total		35 (74.4%)	12 (25.6%)	47	26 (57.5%)	20 (42.5%)	47 (57.5%)	38 (80%)	9 (20%)	47

UTI – Urinary tract infection

*Percentage of abnormal renal US are higher in recurrent UTI, cystitis and abnormal urine analysis.

Table 3 - Abnormal DMSA according to urinary tract infection episodes and site, urine analysis and ultrasound findings*

Age and Sex		Abnormal DMSA											
		UTI episodes frequency			UTI Site			Urine analysis			Ultrasound		
		Recurrent	First	Total	Cystitis	PN	Abnormal	Normal	Total	Normal	Abnormal	Total	
1 Mo – 2 Yr	F	1	1	2	1	1	2	1	1	2	1	1	2
	M	2	1	3	1	2	3	2	1	3	1	2	3
>2 Yr - 5 Yr	F	5	4	9	2	7	9	8	1	9	5	4	9
	M	---	---	---	---	---	---	---	---	---	---	---	---
>5 Yr - 12 Yr	F	24	6	30	16	14	30	26	4	30	20	10	30
	M	2	1	3	1	2	3	2	1	3	1	2	3
Total		34 (72.3%)	13 (27.7%)	47	21 (44.7%)	26 (55.3%)	47	39 (83%)	8 (17%)	47	28 (59.6%)	19 (40.4%)	47

DMSA- Dimercaptosuccinic acid scans, PN - Pyelonephritis, UTI – Urinary tract infection

*Percentage of abnormal DMSA is higher in recurrent UTI, PN, abnormal urine analysis and normal renal ultrasound.

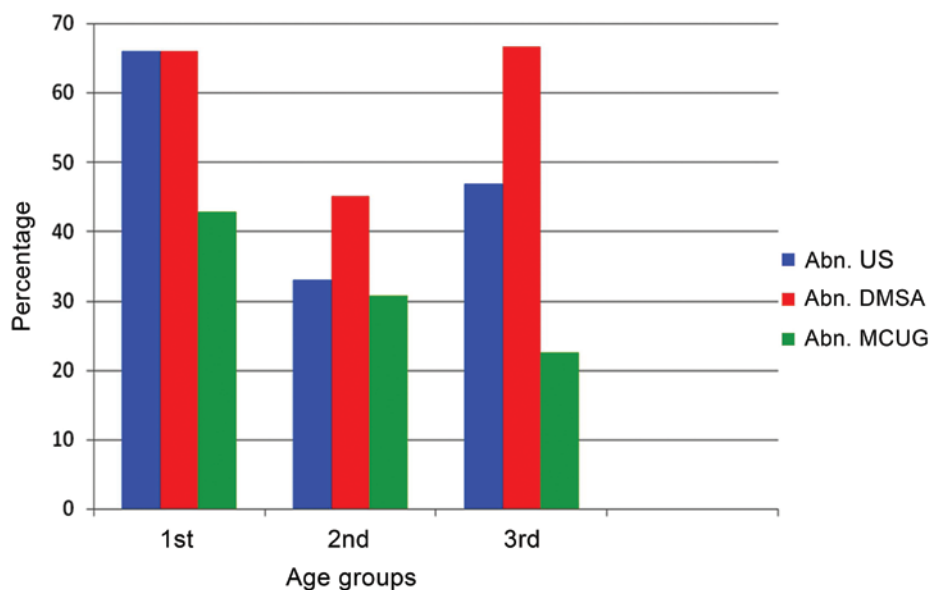


Figure 5 – Number of abnormal imaging studies in different age groups*

Abn. – Abnormal, DMSA - Dimercaptosuccinic acid, MCUG - Micturating cystourethrogram, U/S – Ultrasonography.

*DMSA positivity was highest in all age groups except in 1st age group where it was equal to the abnormal ultrasound. DMSA was highest in 1st and 3rd age groups.

Table 4 - Abnormal MCUG according to urinary tract infection episodes and site, urine analysis and ultrasound and DMSA results*

Age & Sex		Abnormal MCUG			Abnormal MCUG			Abnormal MCUG			Abnormal MCUG		
		First	Recurrent	Total	Pyelonephritis	Cystitis	Total	DMSA			Ultrasound		
								Normal	Abnormal	Total	Normal	Abnormal	Total
1 Mo – 2 Yr	F	---	---	---	---	---	---	---	---	---	---	---	---
	M	2	1	3	1	2	3	1	2	3	---	3	3
>2 Yr - 5 Yr	F	2	2	4	4		4	---	4	4	2	2	4
	M	---	---	---	---	---	---	---	---	---	---	---	---
>5 Yr – 12 Yr	F	2	6	8	4	4	8	1	7	8	5	3	8
	M	---	1	1	1	---	1	---	1	1	---	1	1
TOTAL		6 (37.5%)	10 (62.5%)	16	10 (62.5%)	6 (37.5%)	16	2 (12.5%)	14 (87.5%)	16	7 (43.8%)	9 (56.2%)	16

DMSA- Dimercaptosuccinic acid scans; MCUG- Micturating cystourethrogram; UTI- Urinary tract infection

*Percentage of abnormal MCUG is higher in recurrent UTI, PN, abnormal urine analysis and abnormal DMSA and renal ultrasound.

DISCUSSION

In this study, all pediatric patients presenting with UTI to the pediatric nephrology clinic at King Fahd Hospital during the period from 2003 to 2008 were included. It was found that renal US alone is not adequate for almost half of patients for investigating children with UTI [13]. Zamir et al also reported similar findings [14].

In pediatric patients, renal damage and pyelonephritis can be superimposed by recurrent UTI [15]. Imaging investigations of children's urinary tract post infection are performed in order to discover any risk factor, which can predispose to recurrent UTI, such as urinary obstruction, presence of renal scarring and/or VUR [16]. Two third of children underwent MCUG study, those who had abnormal results were diagnosed to had pyelonephritis, and recurrent UTI. In the present study, the UTI was common among children ≥ 5 years of age; it also had female gender preponderance (91.6%). It has been reported that the incidence of UTI was higher among females with a ratio of 1:1.5 [15,17], Supavekin et al, however, reported otherwise [18]. The most commonly isolated bacteria in urinary cultures were reported to be *Escherichia coli* [15], as well as in this study.

Among the types of UTI affecting pediatric patients, it's been reported that pyelonephritis was the commonest among children under 5, while cystitis was the more prevalent variant among older children [17], this study revealed similar results. While this study reported that recurrent UTI occurred more commonly in children older than 5 years; Smellie et al reported otherwise [16]. Furthermore, cystitis was less prevalent than pyelonephritis among those with recurrent UTI, particularly in the first and third age groups in this study.

Both renal US and DMSA scans revealed a higher percentage of abnormalities in males when compared to their findings in females, particularly among the first and third age groups. We have observed a

correlation between the DMSA scan and MCUG in the first age group and another correlation between the US and DMSA scans in the third age groups. The unequal distribution of genders in this study precludes precise comparison between the radiological findings of their investigations. Renal US is a safe and cost effective method for assessing the anatomic features of the renal tract [19].

DMSA scans were done within the first two months of presentation in patients with pyelonephritis and cystitis. This might be the reason behind the high percentage of radiological abnormalities observed when comparing the results of this study to others [15,20,21]. Ideally, DMSA scans should be performed 3 months after presentation with recurrent UTI. We observed the highest incidence of abnormal DMSA scans among the third age group (64%); others reported similar findings [22,23]. There is great disparity between the abnormalities seen in renal US, with respect to age groups, and MCUG. This is also true to a lesser extent regarding the DMSA scans [16]. In some cases performing MCUG was postponed after revealing an abnormal DMSA scan in order to repeat the DMSA scan, 3 months later and confirm the previous findings. Nine patients refused to undergo a repeated DMSA scan or MCUG. When comparing the abnormal results of the renal US and DMSA scans, also, there was a large discrepancy between the percentages of abnormal renal US and abnormal DMSA scans among those presenting with pyelonephritis and UTI for the first time. However, there was only a slight difference between the percentages of abnormal renal US and abnormal DMSA scans among those with recurrent UTI, which differs from the conclusions of Christian et al [17].

We found no significant difference between normal and abnormal US with respect to an abnormal DMSA scan. However, we did observe a significant correlation between abnormal DMSA scans and abnormal MCUG, both Ajdinovic et al [24] and

Giampiero et al [25] had similar findings. All 9 patients with Vesicoureteric reflux (VUR) observed on MCUG had an abnormal DMSA scan. They constituted 37.5% of all patients with abnormal DMSA scans. All patients with VUR in this study had an abnormal DMSA scan, both Clarrissa et al [26] and Mena et al [27] had similar conclusion. Thus, we recommend performing a DMSA scan among other radiological investigation in the medical evaluation of pediatric patients presenting with VUR. Clarrissa et al [26] and Mena et al [27] had similar findings and conclusions.

A limitation in this study is that there was no specification in the present study about the types of the abnormalities observed in different imaging studies, which might have revealed more correlations between these radiological investigations, especially between DMSA scans and MCUG.

CONCLUSION

Urinary tract infections can cause significant morbidity in children if not managed properly. Imaging studies are useful in identifying children who would require advanced medical intervention; however such imaging studies should be performed only when indicated. Indeed, pediatricians should adhere to available international guidelines and local policy and procedure manuals. These protocols should include the proper timing of performing these investigations after UTI, particularly the DMSA scanning, all in light of early identification and prevention, so they should have more focused protocols when considering the request of invasive imaging studies and also have certain selection criteria in the use of different imaging investigations in specific group of children, renal US, is a safe and cost effective method for assessing the anatomic features of the renal tract. We recommend performing DMSA scan in patients presenting with VUR, especially in a higher grade.

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