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Role of Imaging in Identifying Various Renal Lesions in Children Less Than 5 Years Presenting with First Febrile Urinary Tract Infections

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Abstract

Febrile Urinary Tract Infections (UTI) is one of the common causes of infections in children. Unrecognized and untreated UTIs may lead to renal scarring of the growing kidneys with subsequent renal failure. Objectives: To compare the effectiveness of USG to detect vesicoureteric reflex confirmed by micturating cystourethrogram (MCU) and renal parenchymal abnormalities confirmed by dimercaptosuccinic acid scan (DMSA) between 1 month to 59 months of age. Methods: A prospective observational study was done at a tertiary care centre to study the imaging correlation in children with the first episode of febrile UTI. Ultrasonography Kidney-Urinary-Bladder (USG-KUB), MCU, and DMSA were done according to the Indian Academy of Paediatrics protocol after getting informed consent from parents. Results: USG showed a perfect concordance with MCU in detecting VUR (100% sensitivity and specificity) and had a high sensitivity (94.1%) and specificity (100%) in detecting renal parenchymal abnormalities when compared to DMSA in less than 1 year old. It also showed a sensitivity of 85.4% and specificity of 100% in detecting renal parenchymal abnormalities when compared to DMSA in children aged 1-5 years. Conclusion: Overall, the results of this research article indicate that USG shows promising diagnostic accuracy as a non-invasive imaging modality in detecting VUR and renal parenchymal abnormalities across different age groups presenting with febrile UTI.To study the effectiveness of USG in detecting vesicoureteric reflex confirmed by micturating cystourethrogram and renal parenchymal abnormalities confirmed by dimercaptosuccinic acid scan (DMSA) in children with first episode febrile UTI. ***Short title****: Role of imaging in children with first episode febrile UTI.*

Keywords: *Febrile UTI, Imaging techniques, Vesico-ureteric reflux, MCU, DMSA.*

1. Introduction

UTI is one of the most common bacterial infections in childhood. Approximately 7-8% of girls and 2% of boys have a urinary tract infection during the first 8 years of life with highest incidence during the first year of life in both sexes [1]. Prompt identification of Vesicoureteral reflex [VUR] is important as it is one of the predisposing factors for recurrent UTI and ongoing renal parenchymal damage with subsequent infection [2]. If such abnormalities are detected, steps can be taken to modify the risk of subsequent renal damage, such as surgical intervention or antibiotic prophylaxis to prevent recurrent UTIs. The risk of having a UTI before the age of 14 years is approximately 1-3% in boys and 3-10% in girls [3,4]. VUR is estimated to occur in 1-2% of children, more common in females except in infancy when most studies show not only a male preponderance but a more severe VUR [2,3]. The Indian Academy of Paediatrics (IAP), American Academy of Paediatrics (AAP), and the National Institute of Health Care and Wellness (NICE) have come out with different guidelines on the protocol to be followed in imaging of renal system following the first episode of febrile UTI. (5,6,7). Majority of these protocols recommend the complete functional and morphological evaluation of the child's urinary tract.

A child with UTI is subjected to undergo imaging studies such as USG, MCU and DMSA based on age as per IAP protocol. The advantages of USG over the other two imaging modality include its non-invasiveness, absence of ionizing radiation, and wide availability. It also allows visualization of the renal parenchyma, pelvicalyceal system, and ureters, thereby enabling the detection of VUR. Furthermore, USG can also provide additional information about the urinary tract and detect other associated anomalies. Hence this study will be useful to find out the role of imaging in identifying VUR and renal scarring in children below 5 years of age with first episode febrile UTI.

2. Materials And Methods

In the current study, the children were divided into two groups for the purpose of planning various imaging studies-1month to 12 months of age and 13 months to 59 months of age respectively after getting informed consent from the parents. Diagnosis of UTI was made with isolation of a single species of microorganism in significant number (>10^5) in a properly collected midstream void prior to starting antimicrobial therapy and tested for urine culture. For children aged between 1 month to 12 months USG was done at the time of fever, MCU was done 2-3 weeks later and DMSA scan after 2-3months of the first episode, whereas for children above 1 year, USG was done at the time of admission and DMSA was done after 2-3 months while MCU was done only if DMSA was abnormal. Dilated ureters were considered suggestive of VUR as per USG. MCU was also done age wise as per IAP protocol to look for VUR. Renal scarring was studied using DMSA. All the imaging techniques were compared among the two age groups. Software used: Data were entered and analyzed with Microsoft Excel. Validity of USG vs MCU and DMSA were computed using sensitivity, specificity, positive predictive value and negative predictive value.

3. Results and Discussion

Demographic and population characteristics A total of 100 children ,44 [44%] less than 1 year and 56 [56%] children between 1 year to 5 years of age were included in this study. The female/male ratio was 1.2:1 and 0.4:1 in the less than one year and 1 year to 5 years age groups respectively.

Table 1: Assessment of Ultrasound and MCU in Detecting Vesicoureteral Reflux (VUR) in less than 1 year old: A Comparative Analysis

	MCU positive	**MCU negative**	**Total**
USG positive	32	0	32
USG negative	0	12	12
Total	32	12	
Sensitivity: 100%			
Specificity: 100%			
Positive predictive value: 100%			
Negative predictive value: 100%			

Out of 44 patients less than 1 year old, 32 were MCU positive and 12 were MCU negative. The diagnostic performance of ultrasound (USG) and micturating cystourethrography (MCU) in detecting VUR was analysed. The study results demonstrate a perfect concordance between USD and MCU findings, with both modalities exhibiting 100% sensitivity, specificity, positive predictive value, and negative predictive value.

Table 2: Comparative Analysis of Ultrasound and DMSA Scintigraphy in Detecting Renal Parenchymal Abnormalities in <1 year old

	DMSA positive	**DMSA negative**	**Total**
USD positive	32	0	32
USD negative	2	10	12
Total	34	10	44
Sensitivity: 94.1%			
Specificity: 100%			
Positive predictive value: 100%			
Negative predictive value: 83.3%			

The findings from this study indicate that USD has a high sensitivity of 94.1% and specificity of 100% in detecting renal parenchymal abnormalities when compared to DMSA. The positive predictive value was 100%, indicating that when USD identified abnormalities, they were confirmed

by DMSA. The negative predictive value of 83.3% suggests that USD has a small risk of false-negative results compared to DMSA.

Table 3: Comparative Analysis of Ultrasound and DMSA Scintigraphy for Detecting Renal Parenchymal Abnormalities in Children Aged 1-5 Years

	DMSA positive	**DMSA negative**	**Total**
USD positive	41	0	41
USD negative	7	8	15
Total	48	8	56
Sensitivity: 85.4%			
Specificity: 100%			
Positive predictive value: 100%			
Negative predictive value: 53.3%			

The findings from this study indicate that USD has a sensitivity of 85.4% and specificity of 100% in detecting renal parenchymal abnormalities when compared to DMSA in children aged 1-5 years. The positive predictive value of 100% suggests that when USD identifies abnormalities, they are confirmed by DMSA. However, the negative predictive value of 53.3% indicates a relatively high rate of false-negative results for USD.

Table 4: Comparative Analysis of Ultrasound and DMSA Scintigraphy in Detecting Renal Parenchymal Abnormalities in Children aged 0-5 Years

	DMSA positive	**DMSA negative**	**Total**
USD positive	73	0	73
USD negative	9	18	27
Total	82	18	100
Sensitivity: 89%			
Specificity: 100%			
Positive predictive value: 100%			
Negative predictive value: 66.7%			

The findings from this study indicate that USD has a sensitivity of 89% and specificity of 100% in detecting renal parenchymal abnormalities when compared to DMSA. The positive predictive value was 100%, suggesting that when USD identified abnormalities, they were confirmed by DMSA. However, the negative predictive value of 66.7% highlights that relying solely on a negative USD result may miss a considerable number of renal parenchymal abnormalities in this age group.

Among 100 confirmed cases of UTI, most common organism was E. coli (83%) which was seen in 83 patients, similar to other studies [8,9]. The selection of an imaging method for VUR depends mainly on the patient population (age and gender). However, individual experience, the equipment available locally, as well as health care costs may influence the decision of the selected imaging method for the diagnosis of VUR. VUR has been traditionally detected by VCUG. VCUG provides images with fine anatomical detail, including the bladder and the urethra. The most important limitation of VCUG is the radiation exposure, particularly to the gonads[10]. According to the updated 2013 NICE guidelines[7], a DMSA study in the acute stage cannot identify the risk of VUR in children with first febrile UTI. Therefore, the trend of these guidelines attempted to minimize the use of invasive imaging studies to identify the risk of possible renal problems such as VUR in children with febrile UTI.

Although Ultrasonography can disclose variety of abnormalities, it only indirectly detects VUR with signs such as thickening of renal pelvic, ureteric or bladder wall with a detection rate as high as 85%[10]. Published studies report that USG performed at the time of acute illness is of limited value [11]. But it has been suggested to perform a non-invasive and lower radiation exposure tool such as USG and DMSA before performing MCU study [12]. Our study included a total of 44 patients, out of which 32 were MCU positive and 12 were MCU negative. The USD findings were compared with MCU as the reference standard. The diagnostic performance of ultrasound and micturating cystourethrography (MCU) in detecting VUR was analysed. The study results demonstrate a perfect concordance between USD and MCU findings, with both modalities exhibiting 100% sensitivity, specificity, positive predictive value, and negative predictive value. (Table 1) These findings suggest that USD can be a reliable non-invasive alternative to MCU for the initial evaluation of VUR in children of this age group and could potentially replace MCU as the initial screening tool.

MCU is no longer routinely suggested for the first febrile UTI, unless RBUS shows abnormal findings such as hydronephrosis or hydroureter, renal scar formation, and obstructive uropathies. For children younger than 6 months old, RBUS is also routinely suggested instead of a routine VCUG study in the first febrile UTI, based on NICE guidelines[7]. The updated 2013 NICE guidelines also suggest that USG alone may be sufficient and should be the first-line evaluation in children with a first UTI; VCUG should not be used unless a child has atypical UTI or recurrent UTI[7.] A study conducted by Wallace et al.,[13] focused on infants younger than 2 months old with febrile urinary tract infection (UTI) and utilized renal and bladder ultrasound (RBUS) as a diagnostic tool. The findings from their study demonstrated that RBUS exhibited higher sensitivity and specificity for detecting grades IV and V vesicoureteral reflux (VUR). However, USG was unable to accurately predict lower grades of VUR.

In a survey conducted by Stein et al.,[14] it was found that relying solely on renal and bladder ultrasound (RBUS) may result in the omission of one-third of patients who are at risk. As a result, the authors recommended additional imaging studies such as dimercaptosuccinic acid (DMSA) scintigraphy and voiding cystourethrography (VCUG) in the evaluation of children with febrile urinary tract infection (UTI). USG can serve as a valuable diagnostic tool for identifying renal structural anomalies, including vesicoureteral reflux (VUR). Abnormal USG findings have been associated with a higher incidence of VUR, particularly in children with higher grades of VUR, compared to those with normal USG results[15]. Renal parenchymal abnormalities in paediatric patients can have significant implications for long-term renal health. Radiation exposure is an important limitation of DMSA, especially when it is repeated several times. The diagnostic performance of ultrasound and dimercaptosuccinic acid scintigraphy (DMSA) in detecting such abnormalities was compared in <1 year old. In this study, 44 children less than 1 year age group underwent both USG and DMSA. 34 children were DMSA positive and 10 were DMSA negative.

While DMSA remains the gold standard for evaluating renal parenchymal abnormalities, these findings suggest that USD can serve as an effective screening tool. Its high sensitivity and specificity make it valuable in identifying significant renal abnormalities. However, DMSA can be reserved for confirmatory purposes and for a more detailed evaluation of the extent and severity of the abnormalities detected by USD. In a systematic review by R G Howard.,[16] the sensitivity of USG for scarring compared to DMSA ranged from 37% to 100%, and the specificity from 65% to 99%[17]. We compared the diagnostic performance of ultrasound (USD) and dimercaptosuccinic acid scintigraphy (DMSA) in detecting renal parenchymal abnormalities in children aged 1-5 years. The high specificity observed in this study suggests that USD is effective in identifying true negative cases. However, caution should be exercised when relying solely on USD negative results to rule out renal parenchymal abnormalities in children aged 1-5 years, as the negative predictive value of 53.3% indicates a significant risk of false-negative results. In such cases, DMSA scintigraphy may be necessary to confirm or further evaluate suspected abnormalities. In a study done by Maryse et al[17], USG was found to be not sensitive enough to give reliable information about renal parenchymal defects. But they suggest that DMSA could be optional if the USG indicates parenchymal defects. These findings indicate that while USD shows promise as a non-invasive imaging modality, caution should be exercised in relying solely on its negative results to rule out renal parenchymal abnormalities in this age group. Comparison between USD and MCU for 1-5 years was not done in this study, since only 7 children underwent MCU.

4. Conclusion

Considering its ability to detect high-grade vesicoureteral reflux (VUR) and renal scarring, renal and bladder ultrasound can be considered as the primary imaging modality for evaluating potential

structural anomalies in children with febrile urinary tract infection. Detecting high-grade VUR holds significant importance, and USG can aid in identifying such cases, as well as assessing renal scarring, particularly in children experiencing their first febrile UTI.

Declaration
Research records available with the corresponding author. All the data generated in the study available in the article.

Competing interest
The authors declare that they have no competing interests relevant to this study and the publication thereof.

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Authors Contribution
Dr. Pinnaka Subbarao conceived and planned the work that led to the paper

Dr. Subramani Palaniyandi and Dr. Litha Francis wrote the paper and reviewed successive versions and took part in the revision process

Dr. Anitha Palaniyandi took part in the revision process and approved the final version.

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