Recurrent urinary tract infections in young children: Role of DMSA scan for detecting vesicoureteric reflux

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Aims and objectives

OBJECTIVE:

Previous studies have shown that a normal dimercaptosuccinic acid (DMSA) scan may avoid the need of performing MCUG for detecting VUR in children with first febrile UTI. However, the role of DMSA for ruling out VUR in children with recurrent UTI has not previously been studied.

INTRODUCTION:

Urinary tract infections (UTI) are one of the most common infections in pediatric patients, especially under the age of 5 years. [1] These infections can result in serious complications, such as permanent renal damage and renal failure. [2] Recurrent UTI in children are frequently associated with high-grade vesicoureteric reflux (VUR), which requires antibiotic prophylaxis to limit infection and prevent further sequelae. [3]

Ultrasonography, dimercaptosuccinic acid (DMSA) scan and micturiting cystourethrography (MCUG) are frequently employed for the evaluation of pediatric patients with UTI and detecting the presence of urinary tract abnormalities, such as hydronephrosis, VUR and renal scarring. However, a disparity exists among various guidelines in terms of the imaging modality to be performed and the exact protocol to be followed. The American Academy of Pediatrics (AAP) recommends the use of MCUG in all patients with recurrent UTI between the age of 2 to 24 months, whereas the National Institute for Health and Clinical Excellence (NICE) guidelines do not recommend the routine use of MCUG in children older than 3 months of age with recurrent UTI. [4, 5] Moreover, the exact time to perform the MCUG after the initial presentation has not been specified. Both the guidelines nevertheless recommend the routine use of DMSA for evaluation of patients with recurrent UTI.

Some literature from the developed world suggests that the absence of abnormalities on DMSA scanning may obviate the need for a subsequent MCUG examination in patients with a first febrile UTI. [6] However, no study has been performed in young children with recurrent UTI to assess the association of abnormalities detected on DMSA scan with presence of VUR on MCUG. In the present study, we aim to assess the association of abnormalities detected on DMSA scan with the presence of VUR on MCUG in children with recurrent UTI.

Methods and materials
Ethical exemption was acquired from ethics review committee of our institution and the requirement for informed consent was waived for this retrospective study. Data was retrieved using Radiology Information System for all children of age 10 years or less who underwent DMSA scan for evaluation of recurrent UTI. From January 2011 to September 2012, a total of 50 children with recurrent UTI underwent MCUG examination within 3 months of DMSA scanning. For the purposes of this study, recurrent UTI was defined as children having more than two episodes of UTI as per the NICE guidelines. 

UTI was diagnosed if a child had positive nitrite and leukocyte esterase on urine Detailed Report (DR) in the presence of typical symptoms including fever, loin tenderness, frequency, dysuria, cloudy urine or hematuria. All the children, in addition to these criteria, also had at least one positive urine culture during the course of illness. DMSA scan performed after first episode of UTI and follow-up DMSA scans of children with recurrent UTI were excluded from the study. Moreover, patients with incomplete MCUG examination were also excluded from the study.

Technetium-99-m-DMSA renal scan was performed according to the standard departmental protocol. Low-energy, high-resolution, parallel-hole collimator was used and adequate zoom, according to the child's size was employed. Multiple static images in posterior, right anterior oblique and left anterior oblique projections were acquired under dual-head digital gamma camera 3 hours after the intravenous administration of 60-100 MBq of 99m-Tc-DMSA. Scarring, hydronephrosis and abnormal differential function constituted a positive DMSA scan. Hydronephrosis was defined as the presence diffuse or focal areas of reduced uptake of radionuclide within functioning renal parenchyma. Renal scarring was defined as the presence of photon deficient areas along with deformation of renal outline or the presence of cortical thinning with reduced volume. Differential renal function was considered abnormal if renal uptake of a kidney was less than 45%.

MCUG was performed under aseptic measures by introducing a 4-Fr multipurpose feeding tube into the bladder through the urethra. The urinary bladder was filled with non-ionic water-soluble contrast media injected via the feeding tube. Multiple images were acquired during micturition to demonstrate any reflux of contrast material into the ureters. A final image was obtained after the patient had voided completely to ascertain emptying of bladder. VUR was graded I to V on the basis of the criteria established by the International Re#ux Study in Children. [8] Grade I was considered when the reflux was limited to the ureter without any dilatation. If the reflux reached up to renal pelvis or the calyceal system without dilatation, it was considered grade II. Grade III, IV and V was labeled when reflux into the pelvicalyceal system was associated with mild, moderate or severe dilatation, respectively. Grade I and II were regarded as low grade VUR, while grade III and above were considered high grade VUR.

STATISTICAL ANALYSIS:
Statistical analysis for this study was performed using Statistical Package for Social Sciences (IBM, Chicago, Illinois) version 20. Sensitivity, specificity, positive and negative predictive values were calculated with 95% confidence intervals for abnormalities detected on DMSA scan with the presence of VUR on MCUG. Positive and negative likelihood ratios were also calculated.

Results

We searched the Radiology Information System of our institution to retrieve records of all pediatric patients aged under 10 years who had undergone DMSA scanning for the evaluation of recurrent UTI at our institution from 1st January, 2011 to 31st September, 2012. Out of these, 50 patients had undergone MCUG procedure within 3 months of radionuclide imaging. The mean age of the children included was 4.24 years [Standard deviation(SD): ± 3.06 years]. Eleven patients were male with a mean age of 1.95 years [SD: 2.19 years] and the mean age of the 39 female children was 4.89 years [SD: 2.98 years].

Abnormalities on imaging

The various abnormalities detected on DMSA scan were compared for the presence of VUR on MCUG examination. Abnormalities on radionuclide imaging were noted in 37 (74%) patients. Among these, 25 (50%) patients had scars, 25 (50%) patients had hydronephrosis and 26 (52%) patients had reduced renal functioning. Vesicoureteric reflux was reported on MCUG in 32 (64%) patients. Out of these, 10 (20%) had low-grade VUR, while high-grade VUR was identified in 22 (44%) cases.

Comparison of findings on DMSA and MCUG

Table 1 gives the comparison of abnormalities detected on DMSA scan with the presence of VUR on MCUG.
Table 1: Abnormal findings on DMSA scan in comparison with findings on MCUG among 50 young children included in our study

References: Aga Khan University, Aga Khan University Hospital - Karachi/PK

The sensitivity and specificity of DMSA scan for detecting VUR on MCUG was 87.5% (82.82% - 92.18%) and 38.89% (32% - 45.79%) respectively. The positive predictive value, negative predictive value, positive likelihood ratio and negative likelihood ratio were 71.79% (65.44% - 78.16%), 63.64% (56.79% - 70.41%), 1.43 (1.02 - 2.12) and 0.32 (0.11 - 0.95) respectively.

The comparison of abnormalities noted on DMSA scan with the presence of high-grade VUR on MCUG is also provided in Table 3. The sensitivity and specificity of DMSA scan for the detection of high-grade VUR on MCUG was 95.45% (89.59% - 100%) and 35.71% (28.92% - 42.48%) respectively. The positive predictive value and negative predictive value were 53.85% (46.75% - 60.85%) and 90.91% (86.83% - 94.97%) respectively. The positive likelihood ratio and negative likelihood ratio for the applicability of DMSA to rule out high-grade VUR on MCUG were 1.48 (1.11 - 1.99) and 0.13 (0.02 - 0.92) respectively.

The results of our study are in accord with findings reported from earlier studies who evaluated the role of DMSA in ruling out VUR in children with first episode of UTI as given in Table 4.
Table 2: Sensitivity, specificity, PPV, NPV, positive and negative LR of DMSA scan for detecting grade III and above VUR on MCUG as reported in various studies.  
*References:* Aga Khan Univeristy, Aga Khan Univeristy Hopsital - Karachi/PK

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<tr>
<td>Sensitivity</td>
<td>80.55%</td>
<td>100%</td>
<td>96%</td>
<td>76.0%</td>
<td>95.45%</td>
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<tr>
<td>Specificity</td>
<td>80.90%</td>
<td>34%</td>
<td>57.6%</td>
<td>63.5%</td>
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<td>PPV</td>
<td>36.25%</td>
<td>21%</td>
<td>17%</td>
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<td>NPV</td>
<td>96.86%</td>
<td>100%</td>
<td>99%</td>
<td>96.6%</td>
<td>90.91%</td>
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<td>Positive LR</td>
<td>4.21</td>
<td>1.51</td>
<td>2.06</td>
<td>2.10</td>
<td>1.48</td>
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<tr>
<td>Negative LR</td>
<td>0.24</td>
<td>0</td>
<td>0.07</td>
<td>0.38</td>
<td>0.13</td>
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**Fig. 1:** Right sided grade IV VUR with trabeculated urinary bladder in a child.
Conclusion

DMSA scan had high overall sensitivity and negative predictive value for ruling out high-grade VUR on MCUG in children with recurrent UTI. These findings suggest that a normal DMSA may obviate the need of invasive MCUG examination in children with recurrent UTI.

LIMITATIONS:

First and foremost, our study has a small sample size of 50, which makes it vulnerable to the effect of outliers. Moreover, our analysis was performed on a highly selective sample of children, who were being evaluated for recurrent UTI at our institution. Lastly, our study possesses all the limitations that are inherent to any retrospective charts review.

Nevertheless, the findings reported by our study are novel in that we explored the role of DMSA scan as a rule out test in children with recurrent UTIs. Further prospective studies may shed more light on the role of DMSA scan in obviating the need of invasive MCUG examination in children with recurrent UTI.

Personal information

Dr. Muhammad Awais is working as an year II Resident in the Department of Radiology, Aga Khan University Hospital Karachi, Pakistan. Dr. Awais did his MBBS from Khyber Medical College, Peshawar and did his internships in Medicine at Khyber Teaching Hospital and in Radiology at Lady Reading Hospital, Peshawar.

References