Accuracy of ultrasonic detection of renal scarring in different centres using DMSA as the gold standard

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Abstract

Background. There is an ongoing debate over the radiological investigations of children with urinary tract infections (UTIs) with some authorities suggesting that ultrasound scan (USS) alone is an accurate tool to diagnose renal parenchymal scarring post-pyelonephritis. All studies on this subject have been performed at paediatric teaching centres whereas most children with UTIs are managed by General Paediatricians in District General Hospitals (DGHs) in the United Kingdom. We wished to identify whether results of scans in DGHs differed from those in teaching centres.

Methods. We looked at all children with a clinical history of UTIs having a DMSA and USS over a one year period in two DGHs and one teaching centre. A total of 476 children’s results were reviewed, 297 from the DGHs and 179 from the teaching centre.

Results. The cohort had a total of 949 renal units. There were 79 scarred renal units (kidneys) on DMSA (8%) in 72 patients (15%). Just 18 renal units were detected as being scarred on USS (22.8%). Nine of 32 scarred renal units in the teaching centre were detected compared with nine of 47 in the DGHs (P = 0.40). Thirty-nine (49%) of the scarred renal units were in patients >5-years old. Of these 12 (30.7%) were detected on USS, nine of 17 within the teaching centre compared with just three of 22 at the DGHs (P = 0.01).

Conclusion. Overall only a small percentage of scars are detected on USS. In the over 5-year old group, where USS alone might be preferred, DGHs were significantly worse at detecting scarred kidneys. We conclude that if the detection of renal scars is a prime reason for imaging in children with UTIs, ultrasonography alone is inappropriate at any age and DMSA ought to be the primary investigation.

Keywords: children; dimercaptosuccinic acid scan; investigation; ultrasound scan; urinary tract infection

Introduction

Urinary tract infections (UTIs) cause significant morbidity amongst children. It is estimated that at least 2% of all boys and 8% of girls are likely to encounter at least one urinary tract infection during their childhood [1].

UTIs are investigated as a secondary screening procedure, investigations being based on the recommendations of the working Group of the Royal College of Physicians in 1991 [2]. These recommendations are based on observations from a number of studies that have shown a high incidence of vesico-ureteric reflux (VUR) and renal scarring [3,4]. All these studies have been performed at teaching centres however, whilst most children with UTIs were investigated at their local district hospital.

It has been shown that renal scarring is most likely in the younger patients with pyelonephritis [5]. Under the age of one year, most clinicians in the United Kingdom agree that investigation with a 99mTc dimercaptosuccinic acid scanning (DMSA) scan, ultrasound scan (USS) and micturating cystourethrography (MCUG) is indicated for children with UTIs. Over one year of age most omit MCUG. Some suggest that over the age of five or seven years USS can detect renal scarring with sufficient accuracy to negate the need for DMSA. DMSA, though, is the gold standard with the greatest sensitivity and specificity for detecting renal parenchymal damage (RPD) [6].

The aim of the present study was to test the hypothesis that detection of renal scars on USS in
District General Hospitals (DGHs) is different from that in teaching centres.

**Subjects and methods**

This is a retrospective observation analysis of DMSA and USS reports at three hospitals: two DGHs and one tertiary paediatric teaching hospital performed over a 12-month period. The indication for investigations was a clinical history of UTI followed by an USS and DMSA scan within 3 months of each other. Both investigations were performed at least 8 weeks after the initial diagnosis. The source for referral for investigations included both inpatients and outpatients. Exclusion criteria included investigations done more than three months apart and imaging undertaken for reasons other than an UTI.

Imaging reports were retrieved from the radiology patient information management system. MDS compared the USS reports and findings with reports of DMSA study. As far as we are aware the radiologist reporting on the DMSA scan was unaware of the findings of the renal USS.

Planar DMSA imaging studies were performed as per a standardized examination protocol at all three centres. Views in the posterior and both posterior oblique projections were performed. The DMSA studies were performed by fully trained nuclear medicine technicians at the two DGHs and by paediatric nuclear medicine technicians at the tertiary centre. All DMSA studies were reported by consultant radiologist and consultant paediatric radiologist at DGHs and tertiary centre, respectively.

The USS machines at the two DGH centres were ATL HDI 3000 using either curved linear array 2–5 MHz or phased array 4–7 MHz probes (latter for small children) and Acuson Aspen curved array probe 4–7 MHz or ATL Laboratories Ultramark 9 with general purpose 3.5–5 MHz curved array probe. The USS machine used at the teaching centre was an ATL Ultramark 9, with a 5 MHz annular array probe.

At the tertiary centre, USS examinations were supervised by a consultant paediatric radiologist and undertaken by either the consultant or the trainee radiologist or fully trained paediatric sonographers. At the two DGHs, USS examinations were supervised by a consultant radiologist and undertaken by the consultant or the trainee radiologist. At all three centres, the USS examination was as per a standardized examination protocol. These included both transverse and longitudinal grey-scale images of both kidneys. As described by Moorthy et al. [7], kidneys were routinely assessed for hydronephrosis, echogenicity, corticomedullary differentiation, renal lengths and regularity of cortical outline. Doppler studies of the kidneys were not performed.

Focal scarring on DMSA was defined according to the criteria described by Patel et al. [8], Renal scarring was recorded on the database only if abnormalities as described above on DMSA scanning were associated with an abnormal differential function. Normal differential function was defined as a disparity of up to 45–55% between the two kidneys [9]. Diffuse scarring on DMSA was defined as a differential function of <45% with homogenous uptake on the posterior view, as proposed by the consensus group on renal cortical scintigraphy in children with UTI [10]. Scarring on USS was defined according to the criteria of ‘Scarring, manifested by an irregular renal outline, loss of cortical depth or a focal altered echo pattern in the renal cortex’ [11,12].

Mean, median and SD were calculated. Groups were compared for differences using Fisher’s exact test. Differences were considered significant when \( P < 0.05 \).

**Results**

A total of 476 patients’ reports were reviewed. Of those, 179 were from the teaching centre and 297 from the DGH centres. Median [interquartile range] age at time of USS was 4.3 years [2.2–7.0 years] and the male : female ratio was 1 : 3. The total numbers of renal units (kidneys) studied were 949 with three children having only one kidney each. The three children with single kidneys included one <1-year-old and two in the 1–5-year-old age group. All three were investigated at the DGHs. There were 72 children of age <1 year (54 at DGH). The proportion of patients under 1 year of age was significantly greater in the DGH group (\( P = 0.02 \)). There were 206 1–5 years of age (128 at DGH) and 198 >5 years of age (115 at DGH) patients. The proportions of under/over 5 years of age were similar for the two groups.

Seventy-two (15%) children had 79 renal units with scars. Sixty-five patients had unilateral and seven had bilateral scars. Forty-seven renal scars were diagnosed at the DGH’s and 32 at the teaching centre. The rate of renal scarring (in terms of number of kidneys studied) in our study was 8.3% overall, with 8.0% at the DGH’s and 8.9% at the teaching centre. In the teaching centre, patient scarring was most prevalent in the infants and older children. Amongst the DGH patients the proportion with scarring remained similar across age groups (Figure 1).

Eighteen scars found on DMSA were detected on USS (22.8%). Nine of 32 scars at the teaching centres were detected on USS as opposed to nine of 47 scars at the DGHs (\( P = 0.40 \)). The number of scars seen on DMSA but also detected on USS for <1-year-old patients was one of 11 (detected at DGH) and 1–5 years of age was five of 29 (all detected at DGH). Thirty-nine (49%) of the scarred renal units were in

![Fig. 1. Percentage of patients in each age band with scarring as detected on DMSA.](image-url)
patients >5 years of age. Of these, 12 (30.7%) were detected on USS, nine of 17 within the teaching centre compared with just three of 22 at the DGHs \( (P = 0.01) \). Detection of scars increased with the increasing age of the child but never exceeded 31%. There were 73 focal (45 at DGHs) and six diffuse (two at DGHs) renal scars. Nine of 45 (20%) focal scars at DGHs and six of 28 (21.4%) at teaching centres were detected on USS. Three of the four diffuse scars at teaching centres and none of two at DGHs were detected on USS. Nine of 870 normal renal units on DMSA were suggested to be scarred on USS (1%).

**Discussion**

In this retrospective review, the attention and time dedicated to each scan would have been that of the ‘normal working day’ compared with prospective studies where ‘special attention’ will have been paid. To our knowledge this study is the first study that has looked at the sensitivity of renal ultrasound scan at detecting renal parenchymal defects (RPD) in the ‘real world’ of radiology departments in DGHs as compared with teaching centres.

Christian et al. [13] have previously highlighted the relatively little data available that quantifies the accepted low sensitivity of renal USS for the detection of renal scarring. In their study they have calculated the sensitivity for the detection of renal cortical scarring at 22%. A more recent study by Moorthey et al. [7] concluded that ultrasonography had sensitivity for focal scarring of 5.2 and 47.2% for diffuse scarring. They concluded that ultrasonography alone cannot be substituted for DMSA scan in the evaluation of renal scarring. Both these studies were reporting data from teaching centres. Indeed, a review of the literature by Roebuck et al. concluded that the sensitivity of ultrasonography ranged from 37–100% when compared with DMSA as the gold standard. All the papers reviewed were again from teaching centres [14].

We hypothesized that there is better expertise at a teaching centre when compared with a DGH radiology department. This hypothesis has proved to be false in our study. If teaching hospitals had the expertise then they should have detected a higher proportion of RPD by renal ultrasound scan across all age groups. A previous study by Stokland et al. [15], has previously tried to quantify sensitivity and specificity including inter-observer variation. They found considerable differences between examiners with sensitivities ranging between 30–80%. They looked for improvement at detection by including renal size and/or renal scarring to identify renal parenchymal disease but found a persisting wide range of sensitivities ranging between 40% and 90%. We decided not to look at renal sizes because it has previously been shown that renal length is a poor indicator of reflux nephropathy as it often remains within normal limits despite considerable renal scarring [16].

We have found, like others, that the sensitivity of renal ultrasound scan at detecting RPD across all age groups was very poor [17,18]. In these circumstances the overall detection rate of scars is poor with a maximum sensitivity for USS of 31% in those over the age of five years. This sensitivity falls to 17% in those between the ages of one and five years. There was no significant difference in the rate or type of scar detection by USS between the teaching centre and DGHs. Detection of scars increased with the increasing age of the child but never exceeded 31%.

‘In the real world’ of paediatrics outside teaching centres in DGHs, where most children with UTI are managed, there remains a widely held belief that USS are good at detecting renal scarring, especially so in the older child (>5-year-old). This study presents data to contradict this belief.

We conclude that if the detection of renal scars is a prime reason for imaging in children with UTI’s, ultrasonography alone is inappropriate at any age and DMSA ought to be the primary investigation.

**References**

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