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Original Article

The role of renal contour change in the diagnosis of cortical scarring after urinary tract infection

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Abstract: Urinary tract infections in children can lead to permanent renal scarring in approximately 15% of cases. Technetium-99m (^{99m}Tc)-dimercaptosuccinic acid (DMSA) scintigraphy is the gold standard for identifying renal scarring. Using data and scans from children enrolled at our center in a 2-year prospective clinical trial (RIVUR study), we included children with radiologically confirmed pyelonephritis who exhibited renal scarring on their 1 and/or 2-year follow-up scans and asked 3 blinded pediatric nuclear medicine physicians to reexamine the renal contours in these scans. Five girls met all eligibility criteria (each had two late ^{99m}Tc-DMSA scans 1 and 2 years after index UTI). Of the 20 kidneys imaged, 10 exhibited renal scarring and of these, 7 exhibited renal contour abnormalities. These findings suggest that the presence of abnormalities of the renal contour is not necessary for diagnosis of renal scarring.

Keywords: Renal scarring, nuclear medicine, scintigraphy, infectious disease, imaging

Introduction

One of the most common causes for serious bacterial infections in children are urinary tract infections (UTI), leading to permanent renal scarring in approximately 10-15% of cases [1]. Technetium-99m (^{99m}Tc)-dimercaptosuccinic acid (DMSA) scintigraphy is the most accurate test currently being used to identify renal parenchymal defects; scans obtained soon after a febrile UTI can accurately identify pyelonephritis and scans obtained at least 4 months after a febrile UTIs (hereinafter referred to as late scans) can accurately identify those with permanent scarring [2]. Published guidelines [3] suggest that, for both early and late scans, photopenia without contour abnormalities indicates pyelonephritis whereas photopenia with contour abnormalities (**Figure 1**) indicates scarring. This definition presupposes that (1) scans can be used to accurately differentiate pyelonephritis and scarring and (2) the same definition should be used for early and late scans. In this manuscript we focus on the second question. Namely, we examine how expert pediatric nuclear medicine physicians interpret late ^{99m}Tc-DMSA scans in which photopenia is present but renal contour changes are absent; is an abnormal renal contour necessary in this context for the diagnosis of renal scarring?

Materials and methods

We used data and scans from the Randomized Intervention for children with Vesicoureteral Reflux (RIVUR) trial. The RIVUR [4] trial was a 2-year multisite, randomized, placebo control trial that evaluated the efficacy of antibiotic prophylaxis in children 2 to 71 months, diagnosed with VUR after a UTI. Catheterization or suprapubic aspiration was used for children who were not toilet trained. Clean, voided specimens were collected from toilet-trained children; use of perineal bags was not allowed. Renal scarring was evaluated by baseline and follow-up ^{99m}Tc-DMSA renal scans that were reviewed independently by two blinded reference pediatric nuclear medicine physicians; disagreements were resolved by consensus [5]. Planar ^{99m}Tc-DMSA renal scans were obtained

Figure 1. DMSA left and right posterior oblique (LPO and RPO) projections. Large cortical defect on right upper pole moiety (arrow). The left kidney is normal.

Table 1. Association between renal contour and renal scarring in 10 kidneys

Renal Contour	Renal scarring[a]	No renal scarring[a]
Abnormal[b]	7	0
Normal[b]	3	10

[a]As per consensus of 2 reference pediatric nuclear medicine physicians in the RIVUR trial; [b]As per majority of 3 readers examining scans for this study.

1.5-3 hours after intravenous administration of a weight-appropriate dose of ^{99m}Tc-DMSA (111-185 MBq/1.73 m^2 body surface area) using a parallel hole collimator for planar images and a pinhole collimator for posterior and posterior oblique images (3- to 4-mm pinhole insert; 150,000 counts or 10 minutes).

We limited our investigation to children enrolled in Pittsburgh without history of prior UTIs who had pyelonephritis on a ^{99m}Tc-DMSA scan performed within 16 weeks of their first febrile UTI (latest scan in included patients 47 days after UTI) who were subsequently found to have renal scarring (not pyelonephritis or atrophy) on follow-up ^{99m}Tc-DMSA scans performed roughly 12 months after their index UTI. All included children also had a second scan at 24 months after their index UTI. The study was approved by the University of Pittsburgh Institutional Review Board.

Because no specific data about renal contour change was recorded in the RIVUR study, we asked 3 experienced pediatric nuclear medicine physicians who were blinded to outcomes, symptoms, treatment group, and site, to evaluate the renal contours on the ^{99m}Tc-DMSA scans. Each pediatric nuclear medicine physician was given access to de-identified digital images obtained in the studies and rated each renal contour as "normal" or "abnormal"; the majority reading was used to define kidneys with an abnormal contour. Renal scarring in the RIVUR study was assessed by dividing the kidney into 12 segments and rating the level of scarring on a 5-point scale (0 for no scarring to 4 for global atrophy).

Results

From 188 children included, 5 girls with clinical and radiological evidence of pyelonephritis met all eligibility criteria. All children had *E. Coli* at counts of ≥100,000 colony forming unity per mL on urine culture; 3 were between 12 and 35 months of age, 4 were white, 2 were toilet trained, and all but 1 subject were in the RIVUR placebo group.

Each of the 5 included children had two late ^{99m}Tc-DMSA scans (1 and 2 years after index UTI); the 20 images from these two late DMSA scans (5 children, 2 kidneys per child, each kidney imaged at 1- and 2-years post UTI) are the subject of this report. The mean (SD) time between the two scans was 323 (80) days. Of the 20 kidney images, (**Table 1**) 10 were interpreted as having localized scarring and 10 as being normal. All 10 non-scarred kidneys had normal renal contours. However, of the 10 kidneys with renal scarring per the consensus of reference pediatric nuclear medicine physicians in the RIVUR study, only 7 had abnormal renal contours per the consensus of the three pediatric nuclear medicine physicians in this study. All children with scarring at 12 months had scarring at 24 months. One child with renal scarring appeared to have abnormal contour on the 12-month scan but normal contour on the 24-month scan; this may have been due to the mild nature of the defects in this child.

Discussion

^{99m}Tc-DMSA scintigraphy performed soon after a UTI is often used as the gold standard for the diagnosis of pyelonephritis [3, 5]. In contrast, abnormalities on a late scan are used as the gold standard for diagnosis of renal scarring. In this paper we concerned ourselves with the question of what abnormalities should be considered when interpreting late scans, chiefly because nuclear medicine physicians disagree regarding whether abnormalities in renal contour are necessary for the diagnosis of acquired renal scarring. We found that, although frequently present, contour abnormalities are not necessary for diagnosis of renal scarring. Conceptually, visualizing abnormalities in renal contours requires that the angle at which the kidney is imaged perfectly aligns with the defect reveling a wedge-shaped defect or focal concavity in the renal outline. In the absence of such alignment, only photopenia will be observed. Accordingly, because detecting contour abnormalities seems to be a function of the angle at which the kidney is imaged, requiring abnormalities in the renal contour to diagnose renal scarring would only serve to increase the false negative rates for this test. While the use of single photon emission computerized tomography (SPECT) on ^{99m}Tc-DMSA scans reportedly enhances detection of scarring [6, 7], and may to some extent overcome the issues related to the angle of the scan, the longer time needed for imaging (requiring sedation or general anesthesia in young children) have limited its widespread use.

We propose that, on late planar ^{99m}Tc-DMSA scans (obtained approximately 6 months after a febrile UTI or later), where detection of scarring is of primary importance, an abnormal scan can be defined by the presence of photopenia regardless of renal contour abnormalities. In contrast, for early scans, the presence of abnormalities in the renal contour would likely indicate prior scarring from previously diagnosed or undiagnosed UTIs. It seems therefore that two different definitions should be used depending on the timing of the scan. On early scans, the presence of localized contour change should be recorded, and a follow-up late scan would be recommended for the detection of renal scarring. For a late scan, absence of renal contour abnormality in the presence of a photopenic defect should not influence diagnosis of renal scarring.

This study is limited due to its small sample size and retrospective methodology. More comparative studies are needed.

Disclosure of conflict of interest

None.

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