Inter-and intra-reader reliability of ^{99m}Tc- DMSA planar vs. SPECT/CT scintigraphy in the detection of renal cortical defects

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Abstract:

Aim: The aim of this study was to detect inter- and intra-reader reliability of ^{99m}Tc-DMSA planar vs. SPECT/CT scintigraphy in patients with suspected renal cortical scarring.

Patients and methods: Patients with clinically suspected renal scarring were prospectively included. The ^{99m}Tc-DMSA planar scintigraphy was obtained 2-4 hours after I.V injection of 185 MBq of the tracer. The SPECT/CT images were obtained immediately after the planar one. The images were independently and blindly interpreted by two experienced nuclear medicine physicians (R1; first reader and R2; second reader). Both planar and SPECT/CT images were scored as 0; normal, 1; equivocal, and 2; positive defects. The readings of both readers were compared.

Results: A total of 186 kidneys were eligible for analysis. In planar imaging, R1 identified 113 normal kidneys, 27 equivocal lesions, and 46 positive defects, while R2 identified 92 normal kidneys, 13 equivocal lesions, and 81 positive defects. The two readers agreed on the readings of 133 kidneys and disagreed on the readings of 53 lesions, with a Kappa value of 0.510.

The second planar reading for R1 detected 117 normal, 27 equivocal lesions, and 42 positive defects. The first and second planar readings for R1 agreed on the readings of 168 kidneys and disagreed on the readings of 18 lesions, with a Kappa value of 0.831.

SPECT/CT readings of R1 identified 126 normal kidneys and 60 positive defects, while R2 identified 101 normal kidneys and 85 positive defects. The two readers agreed on the readings of 149 kidneys and disagreed on the readings of 37 lesions, with a Kappa value of 0.590. The second SPECT/CT reading for R1 detected 129 normal and 57 positive defects. The first and second SPECT/CT readings for R1 agreed on the readings of 173 kidneys and disagreed on the readings of 13 others, with a Kappa value of 0.840.

Conclusion: ^{99m}Tc-DMSA SPECT/CT scanning had superior inter-reader yet similar intra-reader reliability to traditional planar imaging for detecting renal cortical scarring.

Keywords: Planar scintigraphy, ^{99m}Tc - DMSA, SPECT/CT, Cortical scar.

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Introduction:

Urinary tract infections (UTI) are among the most common causes of serious bacterial infections in children. They cause permanent scarring of the kidneys in about 10–15 percent of cases. [1]

Cortical scarring can be evaluated using various imaging modalities, including intravenous urography, ultrasonography, computed tomography (CT), magnetic resonance imaging (MRI), and renal scintigraphy. [2] CT has a similar sensitivity and specificity to cortical scanning, but it has the risk of contrast reaction and high radiation exposure. MRI is a promising non-ionizing way, yet it is costly. [3]

The most accurate test for identifying renal parenchymal abnormalities is ^{99m}Tc-DMSA scintigraphy. [4]

Conventionally, the ^{99m}Tc-DMSA renal scan has been performed as a planar image to reveal cortical abnormalities. However, this planar image has inadequate resolution and can miss small defects. Additionally, any hypoactive area behind the normal renal parenchyma may not be detected because planar imaging is a projection image. [5] On the contrary, renal SPECT imaging is a useful diagnostic technique that can detect relatively small photon-deficient areas with its three-dimensional information. Despite the fact that SPECT imaging demonstrating superiority over planar imaging in various studies, recent investigations have shown that ^{99m}Tc-DMSA renal SPECT scanning offers no diagnostic advantage over the planar imaging for the detection of cortical abnormalities. [6,7]

The aim of the present study was to assess the inter- and intra-reader reliability of ^{99m}Tc-DMSA planar vs. SPECT/CT scintigraphy in the detection of renal cortical scarring.

Patients and Methods:

Study population

We got informed consent from all the study participants (parents in the case of children) after our Institutional Review Board approved this prospective study. This study included patients with possible renal cortical scarring. Patients with extensive pyelonephritic changes in the US or atrophic kidney, patients who couldn't lie comfortably without moving during the imaging time, and pregnant women were excluded.

Scanning Protocols and Reconstruction Methods:

1-Planar imaging: anterior, posterior, 45° anterior oblique and 45° posterior oblique views of the abdomen were obtained 2 to 3 hours after intravenous injection of 185 MBq of the tracer (pediatric activity was modified according to a recently published dose card in Eur J Nucl Med Mol Imaging). [8,9] Using a Siemens Symbia T 2-slices dual-head gamma camera equipped with a low-energy, high-resolution collimator and a 20% energy window adjusted at 140 KeV. Patients were scanned in the supine position, and every effort was made to prevent them from moving. Matrix: 256 x 256 pixels with magnification adjusted to provide a pixel size between 2 and 4 mm. A total count of 200,000/view was used.

2-SPECT and SPECT/CT imaging: is performed immediately after planar imaging using the same camera and patient's position. A total of 32 frames, each for 25 seconds, and a matrix size of 128x128 in a non-circular 360-degree arc. Care was taken to avoid patient movement. A low dose CT without contrast media was acquired for anatomical localization and attenuation correction. The used CT parameters were: tube voltage of 130 kV, tube current of 80 mA, and slice thickness of 5 mm. The total acquisition time was approximately 25 minutes. For the best image display, SPECT, CT, and fused images (made in the three standard projections, axial, coronal, and sagittal) were used.

Image analysis

Two independent nuclear medicine physicians (13 and 3 years of nuclear medicine reading experience for reader 1 (R1) and reader 2 (R2), respectively) blindly interpreted the tracer accumulation in the kidneys. Only R1 repeated the readings 6 months later to test the intra-reader reliability.

Tracer accumulation in each kidney was graded using the following scoring system: score 0 for normal (uniform tracer distribution), score 1 for equivocal defect, and score 2 for positive defect (hypoactive area).

Statistical tests:

For data analysis, SPSS 26.0 software was used. Qualitative data were expressed as frequencies and percentages, whereas quantitative data were summarized and expressed as mean ± SD. A Chi-Square test was used to compare the imaging results of each technique. Inter and intra-reader agreements were measured using the Cohen's Kappa test, where the strength of agreement was considered poor (Kappa: <0.00), slight (Kappa: 0.00-0.20), fair (Kappa: 0.20-0.40), moderate (Kappa: 0.41-0.60), substantial (Kappa: 0.61-0.80) and almost perfect (Kappa: 0.81-1.0). P-Value <0.05 was considered significant.

Results:

A total of ninety-three ^{99m}Tc-DMSA scans from 93 patients were eligible for analysis (55 males and 38 females with a mean age of 31.9 ± 18.5 years). In most cases with positive cortical defects (81.25%), the lesions were found in the upper and/or lower pole of the kidney, while only 3 defects were found in the middle zone (Figures 1 and 2).

Agreement analysis

Regarding the planar imaging, R1 identified 113 normal kidneys, 27 equivocal lesions, and 46 positive defects, while R2 identified 92 normal kidneys, 13 equivocal lesions, and 81 positive defects. The two readers agreed on the readings of 133 kidneys (88 normal kidneys, 6 equivocal lesions, and 39 positive defects). They disagreed on the readings of 53 lesions with a moderate degree of inter-reader agreement (Cohen's Kappa value of 0.510, P-Value < 0.01).

The second planar reading for R1 detected 117 normal, 27 equivocal lesions, and 42 positive defects. The first and second planar readings for R1 agreed on the readings of 112 normal, 20 equivocal lesions, and 37 positive defects. They disagreed on the readings of 18 lesions with almost perfect intra-reader agreement (Cohen's Kappa value of 0.831, P-Value < 0.01).

Considering the SPECT/CT imaging, R1 identified 126 normal kidneys and 60 positive defects, while R2 identified 101 normal kidneys and 85 positive defects. The two readers agreed on the readings of 149 kidneys (95 normal kidneys and 54 positive defects). They disagreed on the readings of 37 lesions with a moderate inter-reader agreement (Cohen's Kappa value of 0.590, P-Value < 0.01).

The second SPECT/CT reading for R1 detected 129 normal and 57 positive defects. The first and second SPECT/CT readings for R1 agreed on the readings of 121 normal and 52 positive defects. They disagreed on the readings of 13 lesions with almost perfect intra-reader agreement (Cohen's Kappa value of 0.840, P-Value 0.01).

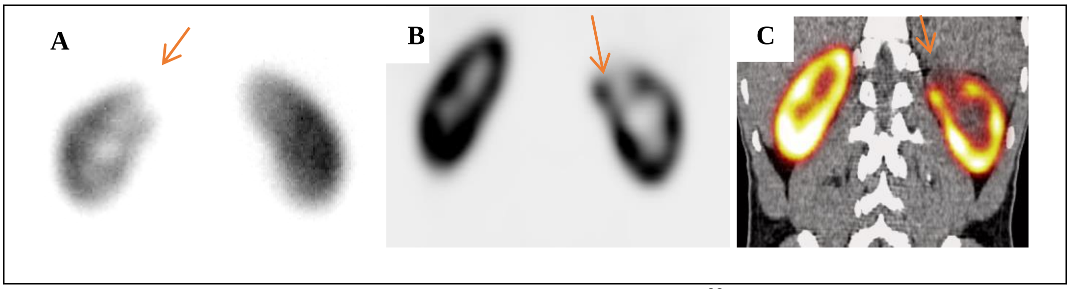

Figure 1: A male patient, 20 years old, presented with left loin pain. (A) ^{99m}Tc-DMSA planar image (posterior view) demonstrating uniform tracer uptake over the right kidney while the left showed equivocal area at the upper (arrow). (B) Coronal SPECT and (C) the corresponding fused SPECT/CT image show uniform tracer uptake over the right kidney with a single defect at the upper pole of the left kidney that was corresponding to a small cortical cyst.

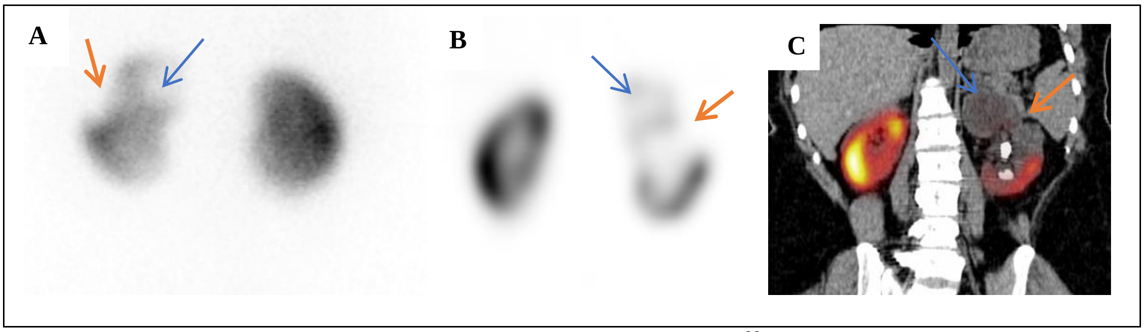

Figure 2: Female patient, 36 years old, presented with left loin pain. (A) ^{99m}Tc-DMSA planar image (posterior view) demonstrating uniform tracer uptake over the right kidney, while the left showed two photopenic areas at the upper and middle zones (arrows). (B) coronal SPECT and (C) the corresponding fused SPECT/CT image shows a normal right kidney with two defects at the left; the red arrow corresponds to a scar while the blue arrow corresponds to hydro-nephrotic changes.

Discussion:

Being the gold standard for the detection of renal cortical abnormalities [10], Various acquisition techniques have been used for ^{99m}Tc-DMSA scanning, including planar high-resolution parallel-hole collimator imaging, planar parallel-hole collimator imaging, pinhole collimator imaging, SPECT, and pinhole SPECT. [11]

DMSA Planar imaging is the most widely used technology. DMSA-SPECT is used in certain nuclear medicine centers as it is thought to be more sensitive and specific. Although it suffers from a lack of accuracy in diagnosis due to the absence of anatomical information, the use of hybrid imaging techniques with SPECT/CT may improve the diagnostic accuracy and patient management. [12]

Piepsz et al. concluded that the use of SPECT/CT added further to the reader's confidence and increased the specificity by delineating renal structures and providing diagnostic clues to lesions that do not represent a scar, including hydro-nephrosis and cortical cyst. [13] Similarly, Shah et al. reported that the use of DMSA SPECT/CT can help to identify the aetiology of the photopenic defect, for example, due to foetal lobulation, scarring, cyst or renal tumors. [14]

The aim of the current study was to detect inter-and intra-reader reliability of ^{99m}Tc-DMSA planar vs. SPECT/CT scintigraphy in the detection of renal cortical scarring.

We found that inter-reader reliability of DMSA scintigraphy for diagnosing renal cortical scarring is higher for SPECT/CT imaging with a Cohen's Kappa value of 0.590 compared to a value of 0.510 for planar imaging; these values come similar to those of Beslic et al. who found overall Cohen's kappa values of 0.59 and 0.57 respectively. [15] In contrast to our results, Einarsdóttir et al. reported a higher value of 0.79 for SPECT and a lower value of 0.38 for planar imaging. [16], the discrepancy in the values might be attributed to different sample sizes and varying degrees of readers experience.

To the best of our knowledge, it is the first study to conduct intra-reader reliability of DMSA renal scintigraphy; we found that intra-reader reliability of SPECT/CT scintigraphy had almost perfect agreement similar to that of conventional planar scintigraphy in the detection of renal cortical scarring with Kappa value of 0.84 vs. 0.831 respectively.

The number of discordant results was higher when interpreting planar scans than that of the SPECT; 53 vs. 37 discordant lesions, respectively; this was similar to previous studies. [16,17]

Limitations and recommendation

The small sample size of the study population was the current limitation of our study. On the other side, the advantage of this study was the use of hybrid SPECT/CT imaging which helped in increased the reader confidence. We recommend further prospective study with a larger sample size to validate our findings; additionally, we recommend using SPECT/CT in cases with equivocal readings in planar images.

Conclusion:

In conclusion, we found that ^{99m}Tc-DMSA SPECT/CT scintigraphy had superior inter-reader yet similar intra-reader reliability compared to conventional planar scintigraphy in the detection of renal cortical scarring.

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