The Value of Filtered Planar Images in Pediatric DMSA Scans

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Abstract

The study was designed to demonstrate the value of filtered planar images in paediatric DMSA scanning. One hundred and seventy three patients ranged in age from 15 days to 12 years (mean: 4.3 years) with urinary tract infection (UTI) and clinical and/or laboratory suspicion of acute pyelonephritis (APN) were retrospectively studied. Planar images were filtered using Butterworth filter. The scan findings were reported as positive, negative or equivocal for cortical defects. Each scan was read in a double-blind fashion by two nuclear medicine physicians to evaluate inter-observer variations. Each kidney was divided into three zones, upper, middle and lower, and each zone was graded as positive, negative or equivocal for the presence of renal defects. Renal cortical defects were found in 66 patients (91 kidneys and 186 zones) with filtered images, 58 patients (81 kidneys and 175 zones) with planar images, and 69 patients (87 kidneys and 180 zones) with SPECT images. McNemar's test revealed statistically significant difference between filtered and planar images (p=0.038 for patients, 0.021 for kidneys and 0.034 for number of zones). Inter-observer agreement was 0.877 for filtered images, 0.915 for planar images and 0.915 for SPECT images. It was concluded that filtered planar images of renal cortex are comparable to SPECT images and can be used effectively in place of SPECT, when required, to shorten imaging time and eliminate motion artifacts, especially in the paediatric population.

Key Words: Tc-99m DMSA, SPECT, Filtered planar images.

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Introduction

Renal cortical imaging in children using Technetium-99m dimercaptosuccinic acid (Tc-99m DMSA) is one of the most widely used techniques in nuclear medicine. It provides an image of the functional renal parenchyma that is helpful in the evaluation of patients with urinary tract infection, detection of renal scars, assessment of function and morphology of small kidneys, confirmation of absent kidney(s), detection of congenital anomalies (ectopic kidney, horse shoe kidney etc.), evaluation of certain renal masses and evaluation of systemic hypertension or suspected vasculitis (1).

Normally three views are obtained while doing a Tc-99m DMSA scan, e.g., posterior, right posterior oblique and left posterior oblique views. An additional anterior view is usually acquired in the case of ectopic kidneys. An anterior view is also required in most instances for the calculation of differential renal function using the geometric mean of anterior and posterior counts over the kidneys. The oblique views are used for better localization and detection of focal defects located in the anterior or posterior surfaces of the kidney. The views are acquired preferably using a high-resolution collimator for a minimum of 200,000 counts. The acquisition time in paediatric imaging is frequently extended to about 10 min to acquire an image of good quality in cases with poor renal function where the count rates obtained over the kidneys are low.

In a few centers single photon emission computed tomography (SPECT) is added to the planar imaging to increase the level of certainty and provide the best image quality and localization of cortical abnormalities (2,3). It has even been recommended that Tc-99m DMSA renal SPECT, rather than planar scintigraphy be routinely used in children with clinical suspicion of acute pyelonephritis (APN) to detect renal scars (4,5). SPECT imaging is however technically more demanding at every step of the process starting from positioning of the patient to longer acquisition time and image reconstruction. Besides, due to long acquisition time relative to planar imaging, results of SPECT studies may also be affected by motion artifacts (6,7).

SPECT imaging is performed technically to enhance image contrast by eliminating over- and underlying activities from the activity in the organ of interest. In cases of renal cortical imaging, however, Tc-99m DMSA concentrates in negligible amounts in the organs surrounding the kidneys. Furthermore, image interpretation is made by finding cortical defects that are in the periphery, which are easily appreciated on planar images, whereas areas of reduced uptake without deformity of the contours are likely to become normal when followed up (8,9). Alternatively, enhancing image contrast can be achieved by filtering planar images with low-pass filters including Butterworth and Hanning filters. Hence, the objective of this study was to assess the value of filtered planar images in pediatric Tc-99m DMSA scans.

Materials and Methods

One hundred and seventy three patients (68 males and 105 females) with urinary tract infection (UTI) and clinical and/or laboratory suspicion of APN were retrospectively studied. The patients ranged in age from 15 days to 12 years with a mean age of 4.3 years.

The patients were injected with Tc-99m DMSA prepared from a commercially available kit. The paediatric dose was adjusted according to the patient's body weight by the formula, dose = [Adult dose (185 MBq or 5 mCi) x weight of the child in kg] /70. The minimum dose injected was 18.5 MBq (0.5 mCi) (10). Two hours after injection, planar images were obtained using a dual-head gamma camera in anterior, posterior and left and right posterior oblique projections. The images were acquired with 1.67-2.00 zoom mode for a total of 300,000 to 500,000 counts in a 256 x 256 matrix using a low-energy, high resolution collimator. The posterior images were filtered using Butterworth filter with an order of 6 and a cut-off frequency of 0.8.

Immediately following planar imaging, a SPECT study was performed using the same camera used in planar imaging. Sixty four views were acquired around a noncircular orbit of 360^{o} for 20 s each using a 128 x 128 matrix and the same zoom of 1.67-2.00. After completion of the study, the raw images were viewed in a cinematic mode to detect patient motion. If patient motion occurred, either a software for motion correction was applied or a repeat acquisition was performed. The data were then processed using Butterworth filter with an order of 7 and a cut-off frequency of 0.4 to reconstruct transverse, sagittal and coronal slices. The patients were imaged in supine position. Sedation was occasionally induced in paediatric patients with chloral hydrate (oral, 40 mg/kg).

Each kidney was divided into three zones; upper, middle and lower, and each zone was graded as positive, negative or equivocal for the presence of renal defects. Planar images were evaluated according to the criteria of Majd et al. (5) and Patel et al. (11). SPECT images were evaluated according to the criteria of Monsour et al. (12).

Cortical defects were compared according to the patient, kidney and zone identified by planar and filtered images or filtered and SPECT images, using the two-tailed McNemar's test for matched pairs (13). Equivocal results (9 patients) were excluded from the test. P values of <0.05 were considered significant. To evaluate inter-observer variation, each imaging technique was read independently by two qualified nuclear medicine physicians, who were blinded to the results of the other imaging technique. Measures of agreement (kappa) and 95% confidence intervals were calculated for the independent readings for each renal zone. Good agreement is indicated by a measure of agreement of greater than 0.80.

Results

Using matched consensus opinion of two readers, 56 patients (78 kidneys and 169 zones) were found positive and 96 patients (234 kidneys and 792 zones) were found negative on filtered and planar images (Figure 1 & 2). Sixty four patients (82 kidneys and 173 zones) were found positive and 93 patients (232 kidneys and 791 zones) were found negative on filtered and SPECT images. Renal cortical defects were found in 66 patients (91 kidneys and 186 zones) with filtered images, 58 patients (81 kidneys and 175 zones) with planar images, and 69 patients (87 kidneys and 180 zones) with SPECT images (Table 1).

Filtered images detected more defects than planar or SPECT images. However, filtered images were statistically different from planar images (p=0.038 for patients, 0.021 for kidneys and 0.034 for zones) but not from SPECT images (p=0.453 for patients, 0.424 for kidneys and 0.263 for zones).

The inter-observer comparison of the zone findings is

		Filtered					
		Patients		**Kidneys**		**Zones**	
		-ve	**+ve**	**-ve**	**+ve**	**-ve**	**+ve**
Planar	**-ve**	96	10	234	13	792	17
	+ve	2	56	3	78	6	169
SPECT	**-ve**	93	2	232	9	791	13
	+ve	5	64	5	82	7	173

Table 1: Matched consensus findings of filtered against planar and SPECT images.

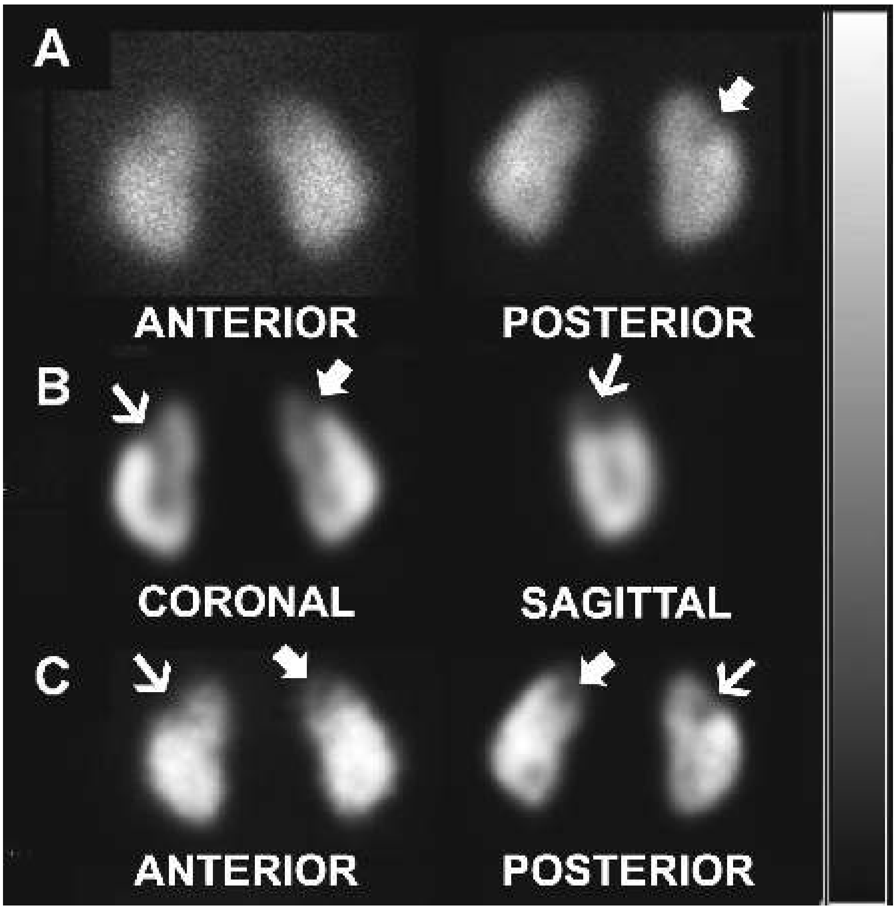

Figure 1. Tc-99m DMSA planar (Top row), SPECT (Middle row) and planar filtered (Bottom row) scans. A cortical defect in the right kidney (Thick arrow in top row) is faintly visualized on the posterior view of the planar images (A). The defect is more clearly visualized on SPECT (B) and filtered (C) images (Thin arrow in middle and bottom rows). Another defect in the left kidney (Thick arrow in middle and bottom rows) is seen only on SPECT and filtered images.

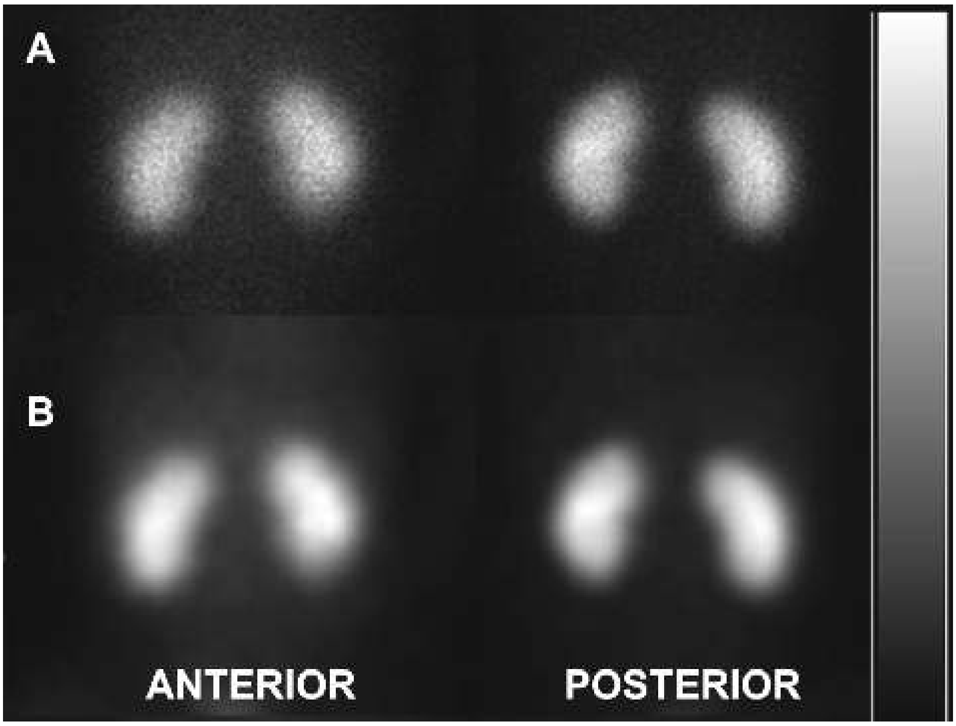

Figure 2: Normal DMSA scan as seen on the planar (A) and filtered (B) images.

Reader - 2		Reader - 1 -ve	Reader - 1 +ve	Reader - 1 Equivocal
Filtered	**-ve**	798	10	5
	+ve	8	185	3
	Equivocal	4	3	2
Planar	**-ve**	809	9	4
	+ve	7	175	2
	Equivocal	2	3	4
SPECT	**-ve**	804	11	2
	+ve	9	180	1
	Equivocal	1	3	1

Table 2: Inter-observer agreement of renal zones in filtered, planar and SPECT images.

shown in Table 2. The measure of agreement was 0.877 (95% CI=0.865-0.932) for filtered images, 0.915 (95% CI=0.881-0.949) for planar images and 0.915 (95% CI=0.881-0.949) for SPECT images. The measures of agreement as well as the value and width of confidence intervals are comparable.

Discussion

Planar renal cortical scintigraphy is considered as an accepted standard for detection of renal scars (14,15). Addition of SPECT to planar imaging has been reported to significantly improve the test sensitivity. The statistically significant difference between filtered and planar images and the insignificant difference between filtered and SPECT images, along with the three techniques being comparable in measures of inter-observer agreement may suggest imaging with filters to be an alternative to SPECT studies.

Filtered images possess some advantages over SPECT studies including avoiding technically demanding SPECT studies, shortening of imaging time with subsequent reduction in motion artifacts (especially in paediatric population) and superior spatial resolution.

Some of the lesions identified by SPECT were found to be false positives (6,7). In this study and similar to SPECT, false positives may, in part, account for the increase in lesion detectability in filtered images when compared to planar images. However, some lesions being true positives cannot be excluded in absence of any correlative histopathological findings (16).

Conclusion

Smooth filtered planar images of paediatric DMSA scans are comparable to SPECT images and can be used to replace SPECT, if required, to significantly shorten imaging time and eliminate motion artifacts, especially when a multi-detector gamma camera is not available.

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