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FULL PAPER

Single-photon emission CT using ^{99m}Tc -dimercaptosuccinic acid (DMSA) for characterization of suspected renal masses

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Objective: A retrospective analysis of the clinical utility of ^{99m}Tc -dimercaptosuccinic acid (DMSA) single photon emission CT (SPECT) for characterization of suspected renal masses.

Methods: 15 patients who had undergone ^{99m}Tc -DMSA SPECT were identified, and 13 patients also had SPECT/CT. ^{99m}Tc -DMSA uptake in the renal lesion was characterized semiquantitatively. Other imaging tests, histology and clinical data were available for correlation.

Results: ^{99m}Tc -DMSA was not taken up in all five renal masses with histological confirmation of malignancy (uptake 7–19% of normal renal tissue); in two further masses, which were clinically likely to be malignant; and in one indeterminate

mass (lack of sufficiently long follow-up). No renal malignancy was identified in any of the seven patients whose renal masses had normal ^{99m}Tc -DMSA uptake (41–130%).

Conclusion: Although caution with regard to applying those results in clinical practice must be advised, owing to the retrospective nature of this report and the small number of patients included, it seems that ^{99m}Tc -DMSA SPECT shows a clinically useful diagnostic accuracy for distinguishing true renal masses (which in many cases require surgery) from pseudomasses.

Advances in knowledge: ^{99m}Tc -DMSA SPECT is a clinically useful adjunct test for characterization of suspected renal masses.

^{99m}Tc -labelled 2,3-dimercaptosuccinic acid (DMSA) has been the standard radiopharmaceutical for static renal scintigraphy for many years.¹ It has a high degree of plasma protein binding (76%). Its main metabolic pathway first involves glomerular filtration, followed by tubular reabsorption, with minimal urinary excretion (5%).² In adults, its foremost clinical use is to determine differential renal function, but also to image ectopic renal tissue.³

We have occasionally used ^{99m}Tc -DMSA scans to establish whether a suspected renal mass or pseudomass contains functioning renal tissue or not. Such use is acknowledged in a respected textbook,⁴ stating that “for many years ^{99m}Tc -DMSA with or without single-photon emission CT (SPECT) was used as a problem-solving technique to differentiate a space-occupying solid mass from a column of Bertin...”. However, we were surprised to be able to identify only a small number of publications reporting the use of ^{99m}Tc -DMSA SPECT for this purpose in a series of patients.^{5,6}

This article reports the results of ^{99m}Tc -DMSA SPECT in 15 patients referred for evaluation of a suspected renal mass from our case archive.

METHODS AND MATERIAL

Patients

Reports of all ^{99m}Tc -DMSA renograms were retrieved from our radiology information system and filtered for those containing the words “mass”, “lesion”, “tumour”, “column” or “Bertin”. Remaining reports were manually analysed for clinical details, and if the referral was made for assessment of a known renal lesion, the patient was included in this retrospective analysis. In this manner, we acquired a group of 15 patients (6 males and 9 females; mean age, 69 ± 14 years) who had a ^{99m}Tc -DMSA renogram between 2003 and 2012. This was requested for functional assessment of a presumed true renal mass in 10 patients and for a likely pseudomass (hypertrophied column of Bertin, splenic hump, pseudomass owing to adjacent renal scarring) in 5 patients.

^{99m}Tc -dimercaptosuccinic acid renogram

150 MBq of ^{99m}Tc -DMSA was injected intravenously, and imaging was performed 4 h later. SPECT was performed in all patients for correlation with CT, and SPECT/CT is available for 12 patients (3 on GE Millennium VG with Hawkeye, GE Healthcare, Chalfont St Giles, UK, and 9 on

Siemens Symbia™ T, Siemens Healthcare, Erlangen, Germany). Acquisition parameters were as follows: low-energy high-resolution collimator, 128×128 matrix, zoom 1.23, 360° rotation and 60 views of 25 s each. Studies were reconstructed iteratively, mostly using Siemens Flash® 3D software with four iterations, eight subsets and a Gaussian filter of four. This resulted in a typical spatial resolution of 6.5-mm full-width half-maximum. ^{99m}Tc -DMSA uptake in the lesion was retrospectively characterized semiquantitatively by comparison with neighbouring normal renal tissue, using 15-mm circular regions of interest without

background subtraction. Results were expressed as a percentage of the uptake in normal renal tissue.

Other data

Patients' clinical history and further clinical course were obtained from hospital notes and the radiology information system. The pathology database was searched for relevant entries for all patients. All imaging was available for comparison, but we paid particular attention to CT (performed with intravenous contrast in all but two patients). The last available reading prior

Table 1. Key characteristics of patients grouped by clinical outcome.

Group	Lesion size ^a (cm)	^{99m}Tc -DMSA uptake ^b (%)	Renal function ^c		Clinical outcome
			Creatinine ($\mu\text{mol l}^{-1}$)	Estimated glomerular filtration rate (ml min^{-1} per 1.73 m^{-2})	
I	2.3	19	62	86	Nephrectomy
	3.1	9	102	65	Nephrectomy following surveillance (Figure 1)
	3.3	10	93	75	Nephrectomy
	2.5 ^d	^e	86	Not done	Nephrectomy
	3.5	7	118	55	Radiofrequency ablation, now considered for nephrectomy (Figure 2)
II	4.6	5	136	33	Patient declined surgery, treated with sunitinib, no change for 12 months
	2.6	11	99	48	On surveillance, no change for 12 months (Figure 3)
III	3.2	2	75	69	No change for 6 months, unfit for surgery
IV	^f	130	90	Not done	Surveillance for 20 months, alive at 83 months (Figure 5)
	1.2	41	88	Not done	No further imaging, alive at 82 months
	1.4	84	96	73	No further imaging, alive at 29 months (Figure 4)
	^f	84	229	26	No further imaging, died of unrelated cause at 32 months
	2.5	^e	Not done	Not done	No further imaging, died of unrelated cause at 28 months
	2.2	130	85	62	No further imaging, alive at 29 months
	^f	82	75	Not done	No further imaging, alive at 107 months

DMSA, dimercaptosuccinic acid; SPECT, single-photon emission CT.

Group I: patients with histologically proven renal cell carcinoma ($n = 5$). Group II: patients with clinically likely renal cell carcinoma ($n = 2$). Group III: patient with indeterminate renal lesion ($n = 1$). Group IV: patients with normal ^{99m}Tc -DMSA uptake and no further imaging follow-up ($n = 7$).

^aMeasured on CT.

^bMeasured on SPECT, compared with normal renal tissue.

^cLast available reading before ^{99m}Tc -DMSA scan.

^dCT images lost, measured on surgical specimen.

^eSPECT not performed.

^fNo mass lesion seen on CT (either column of Bertin or bifid system).

Figure 1. A 79-year-old male presented with haematuria. A renal mass was seen on ultrasound. CT showed a 31-mm right lower pole renal mass with hypoenhancement (arrow). ^{99m}Tc -dimercaptosuccinic acid single-photon emission CT showed very little tracer uptake in the lesion (approximately 9% of normal renal parenchyma). The patient remained on CT surveillance for 9 months, but then underwent a nephrectomy and a 28-mm clear-cell carcinoma was found.

to the ^{99m}Tc -DMSA scan of patients' serum creatinine and estimated glomerular filtration rate were retrieved.

RESULTS

Key characteristics of patients grouped by their clinical outcome are given in Table 1.

Four patients had renal cell carcinoma confirmed at nephrectomy (an example is shown in Figure 1), and one further patient

had it confirmed by biopsy prior to radiofrequency ablation (Figure 2). Visually, none of the lesions showed ^{99m}Tc -DMSA uptake, and semiquantitatively, uptake was 7–19% of that in normal renal parenchyma.

In two patients, a diagnosis of renal malignancy was felt likely, although this was not confirmed by biopsy. One of these patients proceeded to chemotherapy, the other is on surveillance (Figure 3). Visually, none of the lesions showed ^{99m}Tc -DMSA

Figure 2. A 66-year-old male had a history of prostate cancer and transitional cell cancer of the bladder and presented with haematuria. CT showed a 30-mm isoenhancing renal mass in the right kidney centrally (top row, arrow), which had increased in size from 3 years ago, as well as a 15-mm cystic right upper pole lesion (bottom row, arrow) with heterogeneous enhancement. ^{99m}Tc -dimercaptosuccinic acid single-photon emission CT showed very little tracer uptake in either lesion (approximately 7% of normal renal parenchyma). Biopsy of the central lesion revealed clear-cell carcinoma. As the patient was unfit for surgery, he underwent radiofrequency ablation (RFA) treatment of the larger lesion. The upper pole lesion was in an unfavourable position for RFA and continues to grow. The patient is now being reconsidered for nephrectomy.

Figure 3. An 84-year-old male had a history of melanoma 3 years ago and presented with right abdominal pain. Ultrasound examination showed a focal solid mass extending into the renal sinus fat of the left kidney with appearances consistent with a hypertrophied column of Bertin. However, this was of an unusually large size and therefore was further evaluated with a renal mass protocol CT scan. This showed inhomogeneous enhancement within the mass consistent with a central renal tumour (arrow). ^{99m}Tc -dimercaptosuccinic acid single-photon emission CT showed very little tracer uptake in the lesion (approximately 11% of normal renal parenchyma). The overall interpretation was of a likely renal cell cancer, but it was considered unsuitable for radiofrequency ablation, and the patient opted for surveillance. There was no change on CT after 6 and 12 months.

uptake, and semiquantitatively, uptake was 5–11% of that in normal renal tissue.

One patient with very low ^{99m}Tc -DMSA uptake (2%) has completed 6 months of ultrasound follow-up with no change in the size of the renal lesion. This lesion is regarded as indeterminate, but the patient has significant comorbidities and has elected for continued surveillance rather than biopsy or surgery.

In six patients, whose renal lesions showed ^{99m}Tc -DMSA uptake comparable to normal renal parenchyma (41–130%), no further imaging was undertaken (an example is shown in Figure 4), and in one additional patient, imaging follow-up was stopped after 20 months (Figure 5). Two of these patients have since died; one of an unrelated cause and the other with lung and liver metastases at autopsy, but unremarkable kidneys. The five patients alive in this group have not had any hospital care related to renal

Figure 4. A 61-year-old male had a history of transitional cell carcinoma of the bladder. An ultrasound scan of the kidneys was normal 4 years ago. A 14-mm lesion at the lower pole of the right kidney had been noted on a CT scan a year ago and was felt to represent a pseudomass of spared renal parenchyma with adjacent renal scarring (arrow), but a solid renal mass was difficult to exclude on both ultrasound and CT evaluation. Laparoscopic approach for nephrectomy was felt to be difficult. ^{99m}Tc -dimercaptosuccinic acid (DMSA) single-photon emission CT showed that the lesion had uptake similar to normal renal parenchyma (approximately 84%). No further follow-up was undertaken, and the patient is alive 29 months after his ^{99m}Tc -DMSA scan.

Figure 5. A 62-year-old female had a history of right nephrectomy for Stage I renal cancer 4 years ago. An ultrasound scan 9 months ago showed a focal solid projection into the renal sinus thought likely to represent a hypertrophied column of Bertin (left image, arrow). In view of the previous history of renal malignancy, a CT scan and ^{99m}Tc -dimercaptosuccinic acid (DMSA) scan were performed for confirmation of normal renal parenchyma. The CT scan is consistent with a column of Bertin (centre image, arrow). The ^{99m}Tc -DMSA single-photon emission CT/CT was performed on the GE Millenium VG with Hawkeye (GE Healthcare, Chalfont St Giles, UK), giving comparably low CT image quality, but the corresponding sections confirm uptake similar to normal renal parenchyma consistent with a column of Bertin (right images). A repeat ultrasound scan 20 months later was unchanged, and no further imaging has been undertaken. The patient is alive 7 years after the DMSA scan.

pathology for an average of 44 months (median, 30 months; range 3–107 months). All of the patients referred for assessment of a likely pseudomass were in this group, including two patients with a suspected hypertrophied column of Bertin (Figure 5), two patients in whom a pseudomass owing to adjacent renal scarring could not be reliably distinguished from a true renal mass and one patient in whom a duplex system was suspected, but a renal mass could not be excluded.

DISCUSSION

Renal masses are a common incidental finding on ultrasound, CT or MRI. The majority are simple renal cysts that do not require follow-up or treatment. However, solid and complex cystic renal masses may require surgical removal, so their correct characterization is essential to guide patient care. Although ultrasound and contrast-enhanced CT are able to correctly characterize the majority of lesions, their results may occasionally be discrepant,⁷ and some lesions remain indeterminate based on conventional imaging studies. ^{99m}Tc -DMSA scintigraphy will show whether a renal mass contains functioning renal tissue and may provide clinically helpful additional information.⁴

Williams et al⁵ reported the use of ^{99m}Tc -DMSA scintigraphy in 60 patients with suspected renal masses (mainly on intravenous urography) in 1986, and specifically looked at whether SPECT offered additional information over planar imaging. This included 19 patients with a renal tumour, 17 patients with renal cysts, 7 patients with pseudotumours (column of Bertin, cortical nodule) and 17 patients in whom no renal lesion was found on either ^{99m}Tc -DMSA or ultrasound. They found that SPECT slightly improved lesion detectability and localization, although there was no significant difference between receiver operating characteristic curves. The relationship between ^{99m}Tc -DMSA imaging findings and clinical outcome (e.g. histology and clinical follow-up) was not directly reported by Williams et al,⁵ although

it is implied that solid renal tumours do not normally show ^{99m}Tc -DMSA uptake.

Cook et al¹⁶ included five patients with space-occupying lesions within a larger group of 68 patients who had ^{99m}Tc -DMSA planar imaging and SPECT in 1995, but results for this small subgroup are not reported separately.

There are also case reports of decreased ^{99m}Tc -DMSA uptake in patients with mesoblastic nephroma^{8,9} and renin-secreting juxtaglomerular cell tumour.¹⁰ Normal ^{99m}Tc -DMSA uptake has been reported in cases of hypertrophied column of Bertin^{11–13} and compensatory renal parenchymal hypertrophy mimicking a mass lesion.¹⁴

Our study shows that ^{99m}Tc -DMSA was not taken up in all five renal masses with histological confirmation of malignancy, in two further masses, which were clinically likely to be malignant, and in one indeterminate mass (lack of sufficiently long follow-up). No renal malignancy was identified in any of the seven patients whose renal masses had normal ^{99m}Tc -DMSA uptake, but the ^{99m}Tc -DMSA scan was felt to be helpful in differentiating pseudomasses (hypertrophied column of Bertin, splenic hump, pseudomass owing to adjacent renal scarring) from true renal masses.

Caution with regard to applying these results in clinical practice must be advised, owing to the retrospective nature of this report and the small number of patients included.

CONCLUSION

^{99m}Tc -DMSA SPECT shows a clinically useful diagnostic accuracy for distinguishing true renal masses (which in many cases require surgery) from pseudomasses.

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