Prediction of Residual Total Renal Function before Nephron-Sparing Surgery Using $^{99m}$Tc-DMSA Renal Scintigraphy

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Background: Although radical nephrectomy is the standard treatment for renal cell carcinoma, nephron-sparing surgery is the preferred treatment in patients with a single functioning kidney. It is important before surgery to evaluate the level of residual renal function likely after the operation. In this study, we investigated the prediction of residual renal function, using technetium Tc 99m dimercaptosuccinic acid ($^{99m}$Tc-DMSA) renal scintigraphy, before nephron-sparing surgery for renal tumors.

Methods: Preoperative and postoperative evaluation of renal function was done in 11 patients with renal cell carcinoma or renal angiomyolipoma, using $^{99m}$Tc-DMSA scintigraphy. Nine patients had renal cell carcinoma and 2 had renal angiomyolipoma. Partial nephrectomy was performed in 4 patients and surgical enucleation in 7 patients. Both the predicted total DMSA renal uptake rate prior to surgery and the actual postoperative total $^{99m}$Tc-DMSA renal uptake rate were obtained. Endogenous creatinine clearance and serum creatinine levels were also obtained.

Results: There was a good relationship between the predicted and postoperative total $^{99m}$Tc-DMSA renal uptake rates. The ratio of the postoperative total DMSA renal uptake rate to the predicted total $^{99m}$Tc-DMSA renal uptake rate was 85% after partial nephrectomy, and 101% after surgical enucleation. There was also a significant correlation between the postoperative total $^{99m}$Tc-DMSA renal uptake rate and creatinine clearance, and postoperative total $^{99m}$Tc-DMSA renal uptake rate levels above 11.4% coincided with serum creatinine levels below 2.0 mg/dL.

Conclusion: Preoperative assessment with $^{99m}$Tc-DMSA renal scintigraphy is clinically useful for predicting residual renal function after nephron-sparing surgery.

Clin Exper Nephrol 1998;2:245-248

Key words: residual renal function, $^{99m}$Tc-DMSA renal scintigraphy, nephron-sparing surgery

In general, radical nephrectomy is the standard treatment for renal cell carcinoma. Nephron-sparing surgery, however, such as partial nephrectomy or surgical enucleation, is the preferred treatment in patients with a single functioning kidney as a means of improving the quality of life after surgery.

Determination of the probable level of residual renal function is important for predicting postoperative changes in renal function. This kind of assessment is done using renal scintigraphic techniques. Technetium Tc 99m dimercaptosuccinic acid ($^{99m}$Tc-DMSA) preferentially accumulates in the renal cortex in a manner that depends on cortical blood flow. $^{99m}$Tc-DMSA renal scintigrams show static renal cortical images, and the renal uptake rate in each kidney indicates the level of function. We previously reported that the average $^{99m}$Tc-DMSA uptake in healthy control subjects was 22.1% ± 2.8% per kidney (mean ± SD).1

The amount and distribution of the functioning nephron area after nephron-sparing surgery can be shown on $^{99m}$Tc-DMSA scintigrams. In this study, $^{99m}$Tc-DMSA renal scintigraphy was used for preoperative prediction of residual renal function before nephron-sparing surgery for renal tumors.

PATIENTS AND METHODS

Residual renal function was predicted in 11 patients with renal cell carcinoma or renal angiomyolipoma, using $^{99m}$Tc-DMSA renal scintigraphy before nephron-sparing surgery. Scintigraphy was repeated 1 month after surgery. Partial nephrectomy was done
by a guillotine or wedge method that removed the
tumor with the surrounding normal parenchyma.
The enucleation method was limited primarily to
cortical tumors, which are usually surrounded by a
fibrous pseudocapsule. This technique causes less
damage to the normal parenchyma than does partial
nephrectomy. Table 1 shows a clinical profile of the
patients. There were 5 men and 6 women, with a
median age of 69.4 years. Nine patients had renal cell
carcinoma, and 2 had renal angiomyolipoma. Partial
nephrectomy was performed in 4 patients and surgi-
cal enucleation in 7 patients. Patient 4 had bilateral
renal cell carcinomas, so radical nephrectomy was
performed for the right kidney and surgical enucle-
ation for the left kidney. Patients numbers 6 to 9
underwent nephron-sparing surgery, although they
had normal function of the contralateral kidney.
A total of 80 MBq of $^{99m}$Tc-DMSA (Mediphysics,
Takarazuka, Japan) was injected intravenously. Two-
hour images were obtained, using a gamma camera
(GCA70AS; Toshiba, Tokyo, Japan) connected to a
GCA-90 computer (Toshiba). The $^{99m}$Tc-DMSA up-
take rate was measured by Kawamura's method.2
Residual renal function was predicted prior to nephr-
on-sparing surgery by measuring the $^{99m}$Tc-DMSA
renal uptake rate in the region of interest (Fig. 1B),
which corresponded to the residual renal area after
surgery. The predicted total $^{99m}$Tc-DMSA uptake
rate was expressed as the predicted $^{99m}$Tc-DMSA
renal uptake rate in the operated kidney plus the
$^{99m}$Tc-DMSA renal uptake rate in the contralateral
kidney. The postoperative total $^{99m}$Tc-DMSA uptake
rate was estimated 1 month after surgery. Endog-
enous creatinine clearance and serum creatinine
levels were determined simultaneously.

Statistical Analysis
Statistical analysis was done with Spearman's cor-
relation test. Data are presented as mean ± SD.

Table 1. Clinical profile of 11 patients with renal cell carcinoma or renal angiomyolipoma.

<table>
<thead>
<tr>
<th>Patient no.</th>
<th>Age (y)</th>
<th>Sex</th>
<th>Kidney disease</th>
<th>Contralateral kidney disease</th>
<th>Other disease</th>
<th>Operation</th>
<th>WIT (min)</th>
<th>Tumor size (mm)</th>
<th>Tumor position</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>77</td>
<td>F</td>
<td>rt-RCC</td>
<td>lt-hypoplastic kidney</td>
<td></td>
<td>partial</td>
<td>20</td>
<td>65 × 65 × 65</td>
<td>rt-upper</td>
</tr>
<tr>
<td>2</td>
<td>65</td>
<td>F</td>
<td>lt-RCC</td>
<td>rt-hydronephrosis</td>
<td>bladder cancer</td>
<td>partial</td>
<td>30</td>
<td>20 × 20 × 20</td>
<td>lt-upper</td>
</tr>
<tr>
<td>3</td>
<td>54</td>
<td>F</td>
<td>rt-RCC</td>
<td>lt-hypofunction</td>
<td></td>
<td>enucleation</td>
<td>0</td>
<td>35 × 35 × 35</td>
<td>lt-lateral middle</td>
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<tr>
<td>4</td>
<td>60</td>
<td>M</td>
<td>bil-RCC</td>
<td></td>
<td></td>
<td>enucleation</td>
<td>28</td>
<td>10 × 10 × 10</td>
<td>lt-lateral middle</td>
</tr>
<tr>
<td>5</td>
<td>70</td>
<td>M</td>
<td>lt-RCC</td>
<td>rt-hypoplastic kidney</td>
<td>skin cancer</td>
<td>partial</td>
<td>36</td>
<td>80 × 70 × 70</td>
<td>lt-upper</td>
</tr>
<tr>
<td>6</td>
<td>69</td>
<td>F</td>
<td>lt-RCC</td>
<td></td>
<td>prostate cancer</td>
<td>enucleation</td>
<td>26</td>
<td>15 × 15 × 15</td>
<td>lt-lateral middle</td>
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<tr>
<td>7</td>
<td>79</td>
<td>M</td>
<td>lt-RCC</td>
<td></td>
<td></td>
<td>enucleation</td>
<td>0</td>
<td>20 × 20 × 20</td>
<td>lt-upper</td>
</tr>
<tr>
<td>8</td>
<td>69</td>
<td>M</td>
<td>lt-RCC</td>
<td></td>
<td>bladder cancer</td>
<td>enucleation</td>
<td>22</td>
<td>30 × 30 × 30</td>
<td>lt-inner middle</td>
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<td>9</td>
<td>82</td>
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<td>rt-RCC</td>
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<td>enucleation</td>
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<tr>
<td>10</td>
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<td>bil-AML</td>
<td></td>
<td></td>
<td>enucleation</td>
<td>35</td>
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<tr>
<td>11</td>
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<td>enucleation</td>
<td>22</td>
<td>20 × 20 × 18</td>
<td>rt-lateral middle</td>
</tr>
</tbody>
</table>

WIT, warm ischemic time in surgery; RCC, renal cell carcinoma; AML, angiomyolipoma; rt, right; lt, left; bil, bilateral; partial, partial nephrectomy.

Fig. 1. Technetium Tc 99m dimercaptosuccinic acid ($^{99m}$Tc-DMSA) scintigraphy images of a single left kidney
with renal cell carcinoma in the upper pole before (A) and after (C) enucleation. The center of the renal image
(B) indicates the residual renal parenchymal area after surgery (white dotted line) in which the predictive $^{99m}$Tc-
DMSA renal uptake rate was obtained.