Radioisotope Renography and Dynamic Function Studies with the PHO/III Gamma Camera in Renal Transplants

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Since 1964 (Loken et al, 1964) radioisotope renography with $^{131}$I Hippuran has been increasingly used for evaluation of kidney function in patients with renal transplants. Recently results of scintiphotography by means of a Gamma camera have been published. (Weiss et al, 1970; Confortini et al, 1971)

The purpose of the present study has been to investigate the use of renography in the diagnosis of acute rejection and the possibility of diagnosing urinary outflow obstruction immediately after cessation of graft anuria, and in patients where ureteric obstruction reduced the function of an otherwise normal kidney transplant. By means of the Gamma camera we have investigated vascularisation patterns in normal and anuric kidneys using $^{99m}$TcO$_4^-$, and dynamic kidney function studies were performed using $^{131}$I Hippuran.

MATERIAL

Fifty patients were studied. In the Tables are included 65 investigations from these patients.

Twenty three patients had received renal transplants from a closely related family member and are included in group 1, 4 and 6.

Twenty seven patients received cadaver kidney transplants with post-operative anuria or oliguria of 4 - 33 days duration. In six of these 27 patients bilateral nephrectomy was carried out before or in connection with transplantation. The remaining 21 patients were characterised by the fact that kidney function prior to transplantation was reduced with creatinine clearances less than 2 ml/min and 24 hour urine volumes less than 500 ml.

RENOGRAPHIC STUDIES

Renography apparatus, test substances and the study technique were as described previously. (Hansen & Sell, 1970)
The following calculations were performed:

\[
\text{UR (2.5)} = \frac{2.5 \text{ min value (\% of administered dose)}}{1.0 \text{ min value (\% of administered dose)}}
\]

\[
\text{ER (15)} = \frac{15 \text{ min value (\% of administered dose)}}{25 \text{ min value (\% of administered dose)}}
\]

Transit time: measured on the isotope cystogram and represents the time from injection to the appearance of activity over the bladder.

RESULTS

Group 1 (Table I)

Nine patients with stable renal function 68 to 720 days after transplantation. UR (2.5) varied between 1.55 and 1.86 with the mean of 1.66 ER (15) varied from 1.27 to 1.71 with a mean of 1.45. Transit time varied from 2.5 to 5.1 min.

| Table I. Kidney transplants: stable kidney function |
| Investigation: isotope renography |
| Test substance: 131I Hippuran |

<table>
<thead>
<tr>
<th>Group I</th>
<th>No of Investigations</th>
<th>Urine flow ml/min</th>
<th>UR (2.5)</th>
<th>ER (15)</th>
<th>Transit time min</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average</td>
<td>9</td>
<td>77.0</td>
<td>2.89</td>
<td>1.66</td>
<td>1.45</td>
</tr>
<tr>
<td>SD</td>
<td>-</td>
<td>-</td>
<td>0.10</td>
<td>0.15</td>
<td>0.87</td>
</tr>
</tbody>
</table>

Group 2 (Table II)

Seven patients with oliguria or anuria after renal transplantation with a cadaver kidney in whom renography was carried out 4 to 19 days after transplantation. All patients had acute renal insufficiency caused by acute tubulointerstitial nephropathy.

The UR (2.5) averaged 1.28. ER (15) averaged 0.96. In all patients transit time was greater than 30 min.

| Table II. Kidney transplants |
| Investigation: isotope renography |
| Test substance: 131I Hippuran |

<table>
<thead>
<tr>
<th>Group</th>
<th>No of Investigations</th>
<th>Urine flow ml/min</th>
<th>UR (2.5)</th>
<th>ER (15)</th>
<th>Transit time min</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean</td>
<td>Mean SD</td>
<td>Mean SD</td>
<td>Mean SD</td>
<td>Mean SD</td>
<td>Mean SD</td>
</tr>
<tr>
<td>2. Acute anuria caused by ischaemia</td>
<td>7</td>
<td>0.04</td>
<td>0.07</td>
<td>1.28</td>
<td>0.07</td>
</tr>
<tr>
<td>3. Ureter obstruction immediately after cessation of graft anuria</td>
<td>9</td>
<td>5.47</td>
<td>0.97</td>
<td>1.55</td>
<td>0.13</td>
</tr>
</tbody>
</table>
Group 3 (Table II)

Seven patients with cadaver renal transplants in whom isotope renography was done five to ten days after transplantation. In this group ureteral stenosis and acute allograft rejection caused ureteral leakage in four patients and in three rupture of the graft. In four patients rejection in the ureter was histologically verified. UR (2.5) averaged 1.55, ER (15) was on the average 0.95 and transit time exceeded 30 min in all patients except one.

Group 4 (Table III)

Thirteen patients with well functioning renal transplants from closely related family donors in whom clinical and biochemical studies suggested acute rejection 7 to 225 days after transplantation. Renography was performed zero to four days after first sign of rejection was observed. UR (2.5) averaged 1.73 a low ER (15) averaging 1.06 was seen, the transit time was normal with a mean value of 3.87 at a urine flow averaging 1.11 ml/min.

| Table III. Kidney transplants  
Investigation: isotope renography  
Test substance: $^{131}$I Hippuran |
<table>
<thead>
<tr>
<th></th>
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<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Group</td>
<td>No of Investigations</td>
<td>$C_{CR}$ ml/min</td>
<td>Urine flow ml/min</td>
<td>UR (2.5)</td>
<td>ER (15)</td>
<td>Transit time min</td>
<td></td>
</tr>
<tr>
<td>Mean</td>
<td>Mean</td>
<td>SD</td>
<td>Mean</td>
<td>SD</td>
<td>Mean</td>
<td>SD</td>
<td>Mean</td>
</tr>
<tr>
<td>4. Moderate acute rejection</td>
<td>13</td>
<td>37.7</td>
<td>1.11</td>
<td>0.39</td>
<td>1.73</td>
<td>0.34</td>
<td>1.06</td>
</tr>
<tr>
<td>5. Severe acute rejection</td>
<td>5</td>
<td>15.2</td>
<td>0.87</td>
<td>-</td>
<td>1.67</td>
<td>0.10</td>
<td>0.97</td>
</tr>
<tr>
<td>6. Chronic rejection</td>
<td>14</td>
<td>14.2</td>
<td>1.29</td>
<td>0.44</td>
<td>1.46</td>
<td>0.15</td>
<td>1.02</td>
</tr>
<tr>
<td>7. Ureter obstruction after stable kidney function</td>
<td>5</td>
<td>38.0</td>
<td>1.3</td>
<td>0.53</td>
<td>1.64</td>
<td>0.13</td>
<td>0.93</td>
</tr>
</tbody>
</table>

Group 5 (Table III)

Five patients with severe acute rejection 15 to 62 days after renal transplantation. In all patients renal function was retained as evidenced by creatinine clearance averaging 15.2 ml/min. UR (2.5) had a mean value of 1.67. ER (15) averaged 0.97. A prolonged transit time varying from 7 - 15 min was seen. The urine flow was on the average 0.87 ml/min varying from 0.2 to 1.8 ml/min.

Group 6 (Table III)

Includes five patients with chronic rejection characterised by a low ER (15), a decreasing UR (2.5) and a normal transit time.

Group 7 (Table III)

Five patients who developed symptoms of urinary outflow obstruction after
stable renal function had been achieved. UR (2.5) was normal with an average of 1.64. ER (15) averaged 0.93 and transit time varied from 14.5 to greater than 30 min, depending on the severity of the obstruction.

In patients with acute and chronic rejection, ureteric obstruction and ischaemic damage to the transplanted kidney due to long cold ischaemic periods in connection with transplantation a low ER (15) was seen. In patients with creatinine clearances greater than 7 ml/min and a urine flow of more than 0.3 ml/min the transit time normally did not exceed 10 min. A prolonged transit time (12 min) was seen in a patient with severe acute rejection with retained urine production and urine flow at 1.8 ml/min. In such situations it is difficult to differentiate between acute rejection and a slight to moderate ureter obstruction by means of the renogram.

In group 2 and 3 transit time in all patients except one exceeded 30 min and a low ER (15) was found. In five of seven patients the suspicion of ureter obstruction was achieved by a high UR (2.5). In four of these five patients evidence of rejection in the ureter causing obstruction was histologically verified.

INVESTIGATIONS WITH THE PHO III/GAMMA CAMERA

METHODS

A Pho III/Gamma camera combined with an analog digital converter connected to an Ampex tape-recorder and a PDP8 computer was used. The patient was lying in the supine position usually on an examining table with the camera one to two cm over the skin covering the kidney transplant and the bladder. 10 mCi of $^{99m}$TcO$_4$ was given as a bolus into a cubital vein in five to 10 ml of saline, and recordings were done every sec for two min. 'Arrays of interest' were chosen from a cumulated picture of the graft and the vessels. Curves over activity in the upper and lower part of the kidney, the renal and iliac vessels were performed. After injection of 300 µCi $^{131}$I Hippuran counts were taken at 10 sec intervals for 26 min and arrays from the upper and lower half of the kidney and the bladder chosen and curves over activity performed.

RESULTS

$^{99m}$TcO$_4$ studies

In three patients with stable kidney function peak activity in the kidneys was observed after 24 to 26 sec. No peak activity was seen in the renal or iliac vessels (Figure 1). In an anuric patient investigated eight days after transplantation with a cadaver kidney peak activity was seen in the renal and iliac vessels after 18 sec and maximum activity in the kidney after 22 sec. No peak activity in the kidney was observed (Figure 2). In Figure 3 the clinical
Figure 1. $^{99m}$TcO$_4$ studies in a patient with a well functioning renal transplant.

Figure 2. $^{99m}$TcO$_4$ studies in a patient with an anuric cadaver renal transplant eight days after transplantation.
course of a patient for 25 days after renal transplantation is seen. Cessation of graft anuria was observed 10 to 12 days after transplantation and a normalisation of the kidney function and renographic parameters took place. No signs of acute rejection or ureter obstruction were observed.

131I Hippuran studies

In three patients with stable kidney function (Table IV), creatinine clearances averaging 78.5 ml/min, calculations obtained by Gamma camera investigations were done. UR (2.5), ER (15) and transit time were closely related to results obtained by conventional renographic technique. In Figure 4a, b and c tracings obtained with a Gamma camera in a patient with stable kidney

<table>
<thead>
<tr>
<th>T No</th>
<th>C\text{CR}</th>
<th>UR (2.5)</th>
<th>ER (15)</th>
<th>Transit time</th>
</tr>
</thead>
<tbody>
<tr>
<td>56</td>
<td>70.0</td>
<td>1.65</td>
<td>1.61</td>
<td>5.0</td>
</tr>
<tr>
<td>80</td>
<td>65.0</td>
<td>1.62</td>
<td>1.52</td>
<td>6.3</td>
</tr>
<tr>
<td>148</td>
<td>105.0</td>
<td>1.80</td>
<td>1.70</td>
<td>5.0</td>
</tr>
<tr>
<td>Average</td>
<td>78.5</td>
<td>1.69</td>
<td>1.61</td>
<td>5.4</td>
</tr>
</tbody>
</table>
Figure 4. ¹³¹I Hippuran studies on the Pho III/Gamma camera in a patient with stable kidney function after renal transplantation. (a) shows cumulated activity over the kidney and the bladder after background subtraction. (b) shows the kidney curve - a normal renogram. (c) illustrates the bladder curve - a normal cystogram.
function is shown (No 80, Table IV). In Figure 4a a cumulated activity in the kidney and the bladder after background subtraction is shown. Figure 4b illustrates the kidney curve – a normal renogram. Figure 4c shows the bladder curve – a normal cystogram.

In patients with acute rejection renograms obtained by means of the Gamma camera did not differ from those obtained by conventional renographic technique.

CONCLUSION

Radioisotope renography with recording of a radioisotope cystogram is a valuable supplement to other studies which are used to evaluate graft function in kidney transplantation. The study is easy and rapid to perform and not tiring to the patient. It must however be stressed that it is not possible on the basis of radioisotope renography alone to evaluate graft function and urine outflow especially when graft function is slight and urinary volumes small.

By means of the Gamma camera vascularisation patterns in normal and amuric kidneys can be evaluated, studies using $^{131}$I Hippuran did not add essential information to that obtained by conventional renographic technique in patients with stable kidney function and acute rejection.

ACKNOWLEDGMENT

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REFERENCES


OPEN DISCUSSION

M C LEGRAN (Paris): I am sorry if I missed the beginning. I just want to ask a question on using isotope renography to assess kidney function after transplantation. One of the main problems is to detect rejection in an anuric patient. In our experience, using the scintillation camera and other isotopic techniques we have been unable to make a proper diagnosis in such a difficult situation. Do you think that your technique allows you to make a proper diagnosis?

HANSEN: Yes, I agree with you. In the anuric patient I do not think you can make a diagnosis of rejection using radio isotopes.