Doppler Ultrasonography for the Detection of Renal Artery Stenosis in Transplanted Kidneys

Carlos Roberto Maia, Antonio Eduardo Bittar, João Carlos Goldani, Elizete Keitel, Luciane Mônica Deboni, and Valter Duro Garcia

The objective of this study was to evaluate the importance of Doppler ultrasonography in diagnosing renal artery stenosis in transplanted kidneys using angiography as the accepted gold standard. Fourteen kidney graft recipients with clinical severe hypertension, impaired renal function, or both had their renal artery blood flow studied by Doppler ultrasonography before angiography. Seven patients had renal artery stenosis diagnosed by angiography. In six of them, the same diagnosis was achieved by Doppler ultrasonography, and in one patient, Doppler ultrasonography and angiography showed total occlusion of the renal artery. In six patients, both exams were normal. The only false-negative result was in an 8-year-old patient whose graft was placed in the left flank. The Doppler ultrasonography specificity was 100% and its sensitivity was 87.5%. The predictive value of a positive test was 100%; the predictive value of a negative test was 85.7%. Doppler ultrasonography of the renal artery in transplanted kidneys showed an accuracy of 92.86% in diagnosing renal artery stenosis. Because the technique is noninvasive, it should be considered as a first-line screening test.

Renal artery stenosis is one of the most important complications in kidney transplantation, with an incidence ranging from 1.6% to 16.0% of all transplanted patients. The diagnosis of renal transplant artery stenosis (RTAS) must be considered in patients with refractory hypertension or in patients who have impaired renal function not explained by biopsy or ultrasonography. Angiography is the definitive diagnostic investigation modality for this complication, but Doppler ultrasonography, a noninvasive method, has been reported to hold promise as a tool in the detection of RTAS. The purpose of this study was to evaluate the importance of Doppler ultrasonography as a first-line screening test for the detection of RTAS, using renal angiography as the gold standard, in 14 patients with clinical suspicion.

Methods

Thirteen patients with renal allografts and one who had a self-transplant as a consequence of normotopic renal artery stenosis in a single kidney, all of them with clinical suspicion of RTAS, were studied by Doppler ultrasonography and angiography. All patients had severe hypertension, despite treatment with at least two antihypertensive agents, and 11 patients had serum creatinine levels higher than 1.5 mg/dl.

The clinical characteristics of the patients are shown in Table 1. One patient (patient 1) had received a pediatric donor kidney. Thirteen patients received a graft with one renal artery. The anastomosis was performed end-to-end with the hypogastric artery in 11 cases and end-to-side with the external iliac artery in two cases. One patient (patient 3) received a graft with three renal arteries: two arteries were anastomosed in "shotgun barrel" end-to-end with the hypogastric artery, and the other one, end-to-side with the external iliac artery.

Doppler ultrasonography was performed with a Siemens Sonoline A in all patients. In seven cases in which there were doubts about the results, exams were also performed with a Toshiba 65-A (color Doppler). A 3.5- or 5-MHz Doppler transducer was used. Arterial velocities and waves were obtained in the course of the renal artery that was suspicious of stenosis.

Doppler criteria for RTAS included increased velocity (greater than 7.5 kHz) through the stenotic...
TABLE 1. Clinical Characteristics of Patients

<table>
<thead>
<tr>
<th>Patient</th>
<th>Sex</th>
<th>Age (yr)</th>
<th>Etiology of ESRD</th>
<th>Time after transplant (months)</th>
<th>Serum creatinine (mg%)</th>
<th>Donor</th>
<th>Immunosuppression</th>
<th>No. of antihypertensive drugs</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>M</td>
<td>36</td>
<td>Unknown</td>
<td>30</td>
<td>2.2</td>
<td>CD</td>
<td>A+P</td>
<td>2</td>
</tr>
<tr>
<td>2</td>
<td>F</td>
<td>40</td>
<td>HTN</td>
<td>18</td>
<td>1.7</td>
<td>LRD</td>
<td>A+P</td>
<td>3</td>
</tr>
<tr>
<td>3</td>
<td>M</td>
<td>41</td>
<td>HTN</td>
<td>17</td>
<td>1.1</td>
<td>LRD</td>
<td>A+P</td>
<td>3</td>
</tr>
<tr>
<td>4</td>
<td>M</td>
<td>41</td>
<td>PCKD</td>
<td>8</td>
<td>2.6</td>
<td>CD</td>
<td>A+P+C</td>
<td>3</td>
</tr>
<tr>
<td>5</td>
<td>F</td>
<td>32</td>
<td>HTN</td>
<td>8</td>
<td>2.0</td>
<td>LRD</td>
<td>A+P</td>
<td>3</td>
</tr>
<tr>
<td>6</td>
<td>F</td>
<td>8</td>
<td>RN</td>
<td>3</td>
<td>2.2</td>
<td>LRD</td>
<td>A+P+C</td>
<td>3</td>
</tr>
<tr>
<td>7</td>
<td>M</td>
<td>35</td>
<td>HTN</td>
<td>3</td>
<td>3.9</td>
<td>LRD</td>
<td>A+P+C</td>
<td>3</td>
</tr>
<tr>
<td>8</td>
<td>M</td>
<td>45</td>
<td>PCKD</td>
<td>17</td>
<td>2.1</td>
<td>CD</td>
<td>A+P+C</td>
<td>3</td>
</tr>
<tr>
<td>9</td>
<td>M</td>
<td>63</td>
<td>Unknown</td>
<td>15</td>
<td>1.2</td>
<td>CD</td>
<td>A+P+C</td>
<td>2</td>
</tr>
<tr>
<td>10</td>
<td>F</td>
<td>27</td>
<td>DM</td>
<td>11</td>
<td>2.5</td>
<td>LRD</td>
<td>A+P+C</td>
<td>3</td>
</tr>
<tr>
<td>11</td>
<td>M</td>
<td>44</td>
<td>HTN</td>
<td>9</td>
<td>2.0</td>
<td>CD</td>
<td>A+P+C</td>
<td>3</td>
</tr>
<tr>
<td>12</td>
<td>M</td>
<td>46</td>
<td>HTN</td>
<td>9</td>
<td>1.4</td>
<td>CD</td>
<td>A+P+C</td>
<td>2</td>
</tr>
<tr>
<td>13</td>
<td>F</td>
<td>33</td>
<td>BG</td>
<td>2</td>
<td>4.4</td>
<td>LRD</td>
<td>A+P</td>
<td>2</td>
</tr>
<tr>
<td>14</td>
<td>F</td>
<td>42</td>
<td>RVH</td>
<td>6</td>
<td>2.1</td>
<td>Self</td>
<td>None</td>
<td>2</td>
</tr>
</tbody>
</table>

ESRD, end-stage renal disease; M, male; CD, cadaveric donor; A, azathioprine; P, prednisone; F, female; HTN, hypertensive nephrosclerosis; LRD, living related donor; PCKD, polycystic kidney disease; C, cyclosporine; RN, reflux nephropathy; DM, diabetes mellitus; BG, IgA nephropathy (Berger disease); RVH, renovascular hypertension.

Results

Results are shown in Table 2. In six of the 14 cases analyzed, the Doppler ultrasonogram showed a velocity greater than 2.0 m/sec or a frequency greater than 7.5 kHz, which were values suggestive of significant RTAS. In all six cases, stenosis was confirmed by angiography.

In seven patients, the Doppler ultrasonography criteria for RTAS were not fulfilled. Six of these patients had a normal angiography, and one had stenosis at the site of anastomosis. This patient was a child who received the kidney from her father; the kidney was placed in the left flank.

In one case (patient 7), the Doppler echogram showed absence of blood flow through the renal artery, suggesting total occlusion, which was confirmed by angiography.

The Doppler ultrasonography specificity was 100% and its sensitivity was 87.5%. The predictive value of a positive test was 100%; the predictive value of a negative test was 85.7%. The accuracy of Doppler ultrasonography was 92.8%.

Table 2. Results of Doppler Ultrasonography and Angiography

<table>
<thead>
<tr>
<th>Patient</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
<th>10</th>
<th>11</th>
<th>12</th>
<th>13</th>
<th>14</th>
</tr>
</thead>
<tbody>
<tr>
<td>Doppler ultrasonography</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Velocity (m/sec)</td>
<td>1.34</td>
<td>0.85</td>
<td>0.85</td>
<td>2.20</td>
<td>2.20</td>
<td>1.10</td>
<td>0.00</td>
<td>1.02</td>
<td>3.80</td>
<td>2.10</td>
<td>2.40</td>
<td>0.98</td>
<td>1.42</td>
<td>2.20</td>
</tr>
<tr>
<td>Frequency (kHz)</td>
<td>&gt;7.5</td>
<td>&gt;7.5</td>
<td>&gt;7.5</td>
<td>&gt;7.5</td>
<td>&gt;7.5</td>
<td>&gt;7.5</td>
<td>&gt;7.5</td>
<td>&gt;7.5</td>
<td>&gt;7.5</td>
<td>&gt;7.5</td>
<td>&gt;7.5</td>
<td>&gt;7.5</td>
<td>&gt;7.5</td>
<td>&gt;7.5</td>
</tr>
<tr>
<td>Angiography</td>
<td>N</td>
<td>N</td>
<td>N</td>
<td>RTAS</td>
<td>RTAS</td>
<td>RTAS</td>
<td>TO</td>
<td>N</td>
<td>RTAS</td>
<td>RTAS</td>
<td>RTAS</td>
<td>N</td>
<td>N</td>
<td>RTAS</td>
</tr>
</tbody>
</table>

N, normal; RTAS, renal transplant artery stenosis; TO, total occlusion.

Discussion

Renal artery stenosis is an important complication of renal transplantation, which until recently was diagnosed only by angiography. Noninvasive methods to identify patients with such complications have been evaluated, and Doppler ultrasonography has been reported as a highly sensitive method in the diagnosis of RTAS. However, certain technical difficulties may preclude a correct evaluation of the blood velocity in the renal artery: 1) Sometimes one cannot visualize the vessel in all of its extension because of obesity, the presence of air in the bowel, or irregularity of the arteries. 2) The presence of kinking can make it difficult to determine a precise angle between the artery and the ultrasonic beam. This can lead to a false blood flow velocity increase without real stenosis. 3) A renal artery stenosis can be missed in kidneys that have two or more arteries.

In our pediatric recipient, an adult's kidney was placed in the left flank, and this might have affected our ability to properly visualize the artery and might explain the false-negative result.

Diagnostic criteria for RTAS used by our group were the same as established by other investigators. Doppler ultrasonography velocimetry using angiography as the gold standard showed an 87.5% sensitivity...
and a 100% specificity. Our results are comparable to the series of Malfi et al\(^3\) and Deane et al.\(^6\) The heterotopic site of the grafted kidney seems to justify the high sensitivity and specificity reported, because it allows a good visualization of the organ, the vascular pedicle, the anastomosis, and the connected arteries due to the proximity of the renal transplant artery to the Doppler probe, as opposed to the normally positioned kidney.

Angiography is the currently accepted gold standard for diagnosing RTAS. It is known that angiography imposes several risks due to the potential toxicity of radiopaque contrast material, the invasiveness of the technique, and exposure to ionizing radiations. The captopril test has been used in the diagnosis of RTAS but has the disadvantage of the acute hemodynamic effects produced by captopril and the risk of shutting off the glomerular filtration rate.\(^14,15\)

Because Doppler ultrasonography is an innocuous, noninvasive exam and can be repeated without risks, we believe it should be used regularly as a screening test in the diagnosis of RTAS. Furthermore, patients submitted to endoluminal angioplasty can be routinely followed up by this method.

In conclusion, this study presents Doppler ultrasonography as a powerful noninvasive test in the diagnosis of RTAS. It does not have the risks or disadvantages of other methods currently available for the same purpose and should be used as a screening test when RTAS is suspected.

References


KEY WORDS • renal artery stenosis • kidney • transplantation, homologous • ultrasonics
Doppler ultrasonography for the detection of renal artery stenosis in transplanted kidneys.

C R Maia, A E Bittar, J C Goldani, E Keitel, L M Deboni and V D Garcia

*Hypertension*. 1992;19:II207
doi: 10.1161/01.HYP.19.2_Suppl.II207

*Hypertension* is published by the American Heart Association, 7272 Greenville Avenue, Dallas, TX 75231
Copyright © 1992 American Heart Association, Inc. All rights reserved.
Print ISSN: 0194-911X. Online ISSN: 1524-4563

The online version of this article, along with updated information and services, is located on the World Wide Web at:
http://hyper.ahajournals.org/content/19/2_Suppl/II207

Permissions: Requests for permissions to reproduce figures, tables, or portions of articles originally published in *Hypertension* can be obtained via RightsLink, a service of the Copyright Clearance Center, not the Editorial Office. Once the online version of the published article for which permission is being requested is located, click Request Permissions in the middle column of the Web page under Services. Further information about this process is available in the Permissions and Rights Question and Answer document.

Reprints: Information about reprints can be found online at:
http://www.lww.com/reprints

Subscriptions: Information about subscribing to *Hypertension* is online at:
http://hyper.ahajournals.org//subscriptions/