Selective Renal Arteriography in the Diagnosis of Renal Hypertension

By Thomas F. Meaney, M.D., and Harriet P. Dustan, M.D.

RECOGNITION of renal arterial disease as a cause of hypertension has been made possible by the development of renal arteriography. Much of the earlier experience in diagnosis of these lesions was gained with translumbar aortography. As helpful as this technic has been in opening up an important area for clinical study, its usefulness is often limited because it does not always give sufficient detail of the renal arterial supply. The contrast material may be so diluted by aortic blood that it fails to outline adequately the main renal arteries and branches; also, the renal arteries may be obscured by opacified overlying arteries, such as the superior mesenteric, hepatic, and splenic.

Hypertension can be associated not only with lesions of main renal arteries and their interlobar (primary) branches but also with segmental or diffuse renal parenchymal diseases. Adequate differential diagnosis of these renal diseases requires an arteriographic technic that gives good detail of the entire renal arterial supply. At the present time, the procedure of choice is selective renal arteriography. This report describes experience with this technic in 100 hypertensive patients.

Technical Considerations

Method

Renal arteriography was performed by the Seldinger\textsuperscript{1} technic, as modified by Odman\textsuperscript{2-4} with use of the Seldinger needle, (fig. 1) flexible guide wire, and Odman-Ledin catheters.\textsuperscript{5} The catheters were radiopaque polyethylene, with tapered distal ends molded into a terminal curve of about 2.5-cm. diameter. These catheters are provided in three sizes; for the most part, we used the medium-sized (green) catheter, of inside diameter 1.3 mm. and outside diameter 2.4 mm., with three to four side holes punched within 1.5 cm. of the tip.

Before arteriography, most patients received 100 mg. each of pentobarbital (Nembutal) and meperidine (Demerol). Two per cent procaine was used for local anesthesia at the puncture site. The Seldinger needle was inserted into the common femoral artery, just proximal to its deep and superficial branches, at an angle of about 30\textdegree. Following arterial puncture, the longer, inner needle was removed, and the guide wire was passed into the femoral artery and advanced at least 18 inches. When its position had been determined by fluoroscopy to be appropriate, the outer needle was removed from the femoral artery and the catheter was introduced by passing it over the guide wire. Under fluoroscopic observation, the catheter was advanced while the wire was very slowly withdrawn. By the time the catheter tip had reached the level of the second lumbar body the guide wire had been withdrawn into the catheter. At this point the guide wire was removed, and the first radiograph was made to determine the location and number of the renal arteries as well as to visualize orifical lesions. Ten to 20 ml. of 50 per cent diatrizoate (Hypaque) sodium\textsuperscript{†} was injected with an automatic pressure injector at a pressure of 75 lb./sq. in. Following this radiograph, the catheter was manipulated into each renal artery and additional radiographs were obtained with 4 to 6 ml. of contrast material injected manually.

Radiographs were obtained in the anteroposterior position with injections into the aorta and each renal artery. Since this position provides visualization of the renal arterial supply in only the frontal plane an additional position was used that provided a sagittal view of the kidney and exposed the posterior segments. By rotation of the patient 45\textdegree to 60\textdegree in the anteroposterior oblique position a "vascular lateral" projection was obtained that showed the anterior and posterior distribution of renal arterial branches (fig. 2).

Comment

The choice of arterial puncture site is important. Puncture too close to the inguinal ligament carries

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The Seldinger needle consists of an outer blunt cannula (1), through which an inner sharp beveled needle inserts (2). The lumen is closed by a solid stylet (3). The syringe is connected to the catheter through 3 stopcocks and a rotating swivel adaptor. Flasks containing contrast material and flushing solution are connected to two stopcocks and to the third, a Statham strain-gage for recording arterial pressure.

Risk of retroperitoneal hemorrhage, since manual compression may be ineffective following withdrawal of the catheter; too distal a puncture may enter a branch of the femoral artery. Thus, the ideal site seems the common femoral artery just proximal to its deep and superficial branches. In our studies the needle was inserted at an angle of about 30° which is a lower angle than that suggested by Seldinger. It seems useful, since there is less bend to the catheter as it passes into the femoral artery and manipulation is thereby facilitated.

Advancing the guide wire alone without the catheter close to its tip is contrary to previous methods, but seems safe and advantageous. As the wire is advanced, it assumes the configuration of vessels (iliac artery and aorta) in which it lies. This is observed fluoroscopically and with such information the possibility of introducing the guide wire and catheter extra-arterially or into a small artery is minimized.

The contrast material, 50 per cent Hypaque sodium was chosen because of its relatively low viscosity, low incidence of side reactions, and negligible nephrotoxicity. It has provided adequate density for both aortography and renal arteriography.

To give maximum detail of the renal arterial supply, single radiographs were obtained in all patients. In addition, cineradiography was used in 15 patients with use of an 8-inch image intensifier, 35-mm. camera, and 75-mm. f 1.5 lens. While such a technic may be more helpful than single films in defining some lesions of the main renal arteries, it cannot give sufficient detail of small parenchymal branches because of technical limitations. In our experience, a rapid film changer has also been found to give radiographs of insufficient parenchymal detail.

Results

Abnormalities of the Renal Arterial System

One-hundred three consecutive renal arteriograms were performed in 100 hypertensive patients; duplicate studies were performed in three of these. Fifty-eight of the patients were male and 42 female. They ranged in age from 17 to 69 years but more than half were between 40 and 60 years of age (table 1). Eight patients had solitary kidneys.

A total of 239 renal arteries were demonstrated by arteriography and of these 202 (84 per cent) were catheterized. Multiple renal arteries supplied 42 kidneys. Abnormalities of the arterial system were found in

Table 1

<table>
<thead>
<tr>
<th>Age in years</th>
<th>Number of patients</th>
</tr>
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<tbody>
<tr>
<td>10-19</td>
<td>3</td>
</tr>
<tr>
<td>20-29</td>
<td>7</td>
</tr>
<tr>
<td>30-39</td>
<td>19</td>
</tr>
<tr>
<td>40-49</td>
<td>34</td>
</tr>
<tr>
<td>50-59</td>
<td>23</td>
</tr>
<tr>
<td>60-69</td>
<td>14</td>
</tr>
<tr>
<td>Total</td>
<td>100</td>
</tr>
</tbody>
</table>

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52 patients, in 48 there was disease of the main renal arteries or their primary branches, and in 4 avascular or poorly vascularized renal segments (table 2). Thirty-one patients (60 per cent) had unilateral and 21 (40 per cent) had bilateral disease.

Contrary to previous reports, the bulk of main renal arterial lesions was not found primarily within the first centimeter from the aortic origin, since in only 11 (21 per cent) of the patients was this the only location of disease. In this series, lesions of primary arterial branches were common and were found in 30 (58 per cent) patients either alone or in combination with disease of the main renal artery (figs. 3 and 4). Often the arteriogram presented a complicated picture of main renal arterial disease on one side and lesions of primary branches on the other. Aneurysms of the branches of the renal artery were demonstrated in five patients (fig. 5); in two they were very small, measuring less than 4 mm. in diameter. Oblique arteriograms, in addition to the usual anteroposterior films, permit visualization of the vascularity of all renal segments. In four patients, avascular or poorly vascularized areas were found (figs. 6 and 7). In one, surgical exploration showed this to be due to renal infarction; in the others, the segmental changes were thought to represent either pyelonephritic scars or localized vascular disease.

Poutasse has shown that the arteriographic features of atherosclerosis are different from those of fibrous or fibromuscular lesions. By his diagnostic criteria, 32 patients were considered to have atherosclerosis (fig. 4), and 11 had fibrous lesions (fig. 8) or fibromuscular hyperplasia (table 3). Of the remaining nine patients, five had aneurysms and four had poorly vascularized parenchymal segments.

With appropriate timing of exposure, cortical thickness can be demonstrated in both the frontal and oblique arteriograms and is represented by the distance from the arcuate arteries to the edge of the renal mass (fig. 9). Such radiographs demonstrated severe generalized cortical atrophy in a uremic patient with chronic glomerulonephritis (fig. 9). Prior to arteriography, the differential diagnosis between glomerulonephritis and pyelonephritis had been impossible. The arteriographic diagnosis was corroborated by autopsy findings.

**Problems of Technic**

Only 84 per cent of the renal arteries found by aortic opacification were catheterized. The

<table>
<thead>
<tr>
<th>Location of Renal Arterial Lesions</th>
<th>Unilateral</th>
<th>Bilateral</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Disease of main renal arteries only</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>First cm. only</td>
<td>6</td>
<td>5</td>
<td>11</td>
</tr>
<tr>
<td>Midportion</td>
<td>3</td>
<td>3</td>
<td>6</td>
</tr>
<tr>
<td>Entire main trunk</td>
<td>1</td>
<td></td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>10</td>
<td>8</td>
<td>18</td>
</tr>
<tr>
<td>Disease of main renal arteries and branches</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>First cm. and branches</td>
<td>4</td>
<td>4</td>
<td>8</td>
</tr>
<tr>
<td>Distal to first cm. with branches affected</td>
<td>3</td>
<td>4</td>
<td>7</td>
</tr>
<tr>
<td>Entire main trunk and branches</td>
<td>4</td>
<td>3</td>
<td>7</td>
</tr>
<tr>
<td></td>
<td>11</td>
<td>11</td>
<td>22</td>
</tr>
<tr>
<td>Disease of branches only</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Stenosis</td>
<td>2</td>
<td>1</td>
<td>3</td>
</tr>
<tr>
<td>Aneurysm</td>
<td>4</td>
<td>1</td>
<td>5</td>
</tr>
<tr>
<td></td>
<td>6</td>
<td>2</td>
<td>8</td>
</tr>
<tr>
<td>Avascular parenchymal segments</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Infarction</td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Unknown cause</td>
<td>3</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>4</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Totals</td>
<td>31</td>
<td>21</td>
<td>52</td>
</tr>
</tbody>
</table>

*Circulation, Volume XXVIII, December 1962*
Aneurysm involving the origins of all the primary branches of the right renal artery. The oblique projection (right) shows a relative deficiency of the smaller parenchymal arteries in the posterior middle and upper pole regions of the kidney.

Area of relative avascularity demonstrated in the oblique projection (right, between arrows). The presence of such an area is not apparent from the frontal projection alone, (left).

remainder could not be catheterized because some accessory arteries were too small to admit a catheter, orificial lesions occasionally obstructed the arterial lumen, or manipulation of the catheter was limited by marked tortuosity of the aorta and iliac arteries.

Percutaneous femoral artery catheterization was unsuccessful in two patients. In one, a 65-year-old man, the femoral artery was punctured and the guide wire was introduced into the aorta, but the catheter would not pass into the femoral artery. In the second patient, an 8-year-old girl, femoral artery puncture was unsuccessful and catheteriza-
tion was performed following open arteriotomy.

No serious complications occurred. In a patient receiving anticoagulant therapy, external compression for 1½ hours after withdrawal of the catheter was necessary to control bleeding. Delayed bleeding occurred in two patients 6 and 48 hours after arteriography, also easily controlled by pressure over the artery. In another two, who had severe aortic atherosclerosis, the catheter tip entered the aortic wall and contrast material was injected intramurally without incident.

**Discussion**

At the present time, selective arteriography seems the procedure of choice for investigating the renal arterial system, because injecting contrast material into the aorta at or near the origin of the renal arteries fails to give sufficient arteriographic detail consistently. This is so, regardless of whether the injection is made through a translumbar needle or a catheter passed from a peripheral artery. Aortic catheterization, however, has some technical advantage over the translumbar approach. In his original article Seldinger\(^1\) noted that it allows injection of contrast material at any level, reduces risk of extravasation, and permits flexibility in positioning the patient. Although the catheter can be passed into the aorta through a peripheral arteriotomy, Seldinger’s technic via percutaneous femoral puncture is safe and convenient.

**Table 3**

<table>
<thead>
<tr>
<th>Type of Renal Arterial Disease Based on Arteriographic Appearance in 48 Patients with Lesions of Main Arterial Trunks or Primary Branches</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Atherosclerosis</td>
<td>32</td>
</tr>
<tr>
<td>Fibrous disease or fibromuscular hyperplasia</td>
<td>11</td>
</tr>
<tr>
<td>Aneurysm</td>
<td>5</td>
</tr>
<tr>
<td></td>
<td>48</td>
</tr>
</tbody>
</table>
Selective renal arteriography adds many advantages. One of these is ability to opacify only the renal artery, eliminating the confusion contributed by overlying extrarenal arteries, especially the superior mesenteric and splenic. Another is improvement in demonstrating orificial lesions when the origin of the renal artery is not on the lateral aspect of the aorta. When the orifice is anterior or posterior, injection of contrast material into the aorta can obscure it (fig. 10). To visualize the origin, the catheter tip is placed just barely within the renal artery. When the injection is made, medium refluxes into the aorta, outlining the orifice but not obscuring it. If this injection fails to visualize the arterial origin satisfactorily, another radiograph can be made after repositioning the patient. Selective catheterization also permits detailed visualization of the parenchymal arteries. The addition of oblique films allows examination of the anterior and posterior distribution of the interlobar arteries and their finer branches.

Although percutaneous femoral catheterization is the usual approach to selective renal arteriography, it cannot be used in the patient with severe occlusive aorto-iliae disease.

In our experience with hypertensive patients such severe disease is infrequent but, when it is encountered, renal arteriography is performed either by translumbar injection or passing the catheter into the aorta from a brachial arteriotomy.

The incidence of 52 per cent of renal arterial disease in this group of 100 hypertensive patients is higher than that previously reported from this institution. In 1959\(^7\) and again in 1961\(^8\) 28 per cent of patients in whom translumbar arteriograms were done were reported to have arterial stenosis. This difference in incidence is not due to a more careful patient selection, since arteriography was performed in all of a small group of patients regardless of presence or absence of signs suggestive of renal arterial stenosis.\(^9\) Another distinguishing feature in this group as compared with earlier studies was the greater frequency of branch arterial disease. Lesions of primary renal arterial branches were found in 58 per cent of the patients—either alone or in combination with disease of main arterial trunks. Main renal arterial lesions, without branch disease, occurred in only 21 per cent. These findings contrast with those of a recent report\(^9\) in which 84 per cent of patients were considered to have main renal arterial disease and 16 per cent branch arterial disease.

**Figure 9**

*On the left the late arterial phase demonstrates the arcuate arteries which locate the inner border of the renal cortex. The cortical width is easily seen and is in sharp contrast to the arteriogram on the right, which shows extreme narrowing of the renal cortex in a patient with chronic glomerulonephritis. The arcuate arteries lie just beneath the surface of the kidney.*

**Figure 10**

*A diagrammatic sketch showing how the anterior origin of a renal artery, point A, appears from the anteroposterior radiograph (inset) to be located on the lateral wall of the aorta, point B.*
lesions. Presumably this difference is due to improved visualization of branches of the renal arteries and, also, an increased awareness of the frequency with which lesions occur at these sites.

Advances in diagnostic technics for various types of renal lesions associated with hypertension depend, in large measure, on improvements in visualizing the renal parenchyma and its vascular supply. For the first purpose, laminography combined with intravenous urography can give details of renal outline and demonstrate areas of segmental cortical atrophy. The second purpose is served by selective renal arteriography, which permits a detailed study of the peripheral renal arterial circulation. With this technic it is possible to demonstrate avascular, or relatively avascular renal segments, such as were found in four of our patients. In three of these it is not yet known whether these areas represent pyelonephritis or primary vascular disease. Hypertension associated with pyelonephritis has been attributed to vascular disease in the areas of scarring. Radiographic visualization of the parenchymal branches may prove helpful in determining the validity of this suggestion. In one patient (fig. 9) severe atrophy, due to glomerulonephritis, was easily demonstrated by selective renal arteriograms. Accordingly, it seems likely that further experience with selective renal arteriography will aid in establishing diagnostic criteria for a variety of renal lesions associated with hypertension.

Summary
Renal arteriography following percutaneous femoral arterial catheterization (Seldinger technic) was performed in 100 selected hypertensive patients. Eighty-four per cent of the renal arteries encountered were individually catheterized. This procedure permitted a more detailed study of arterial branches than previously possible with aortic injection of contrast material. No serious complications occurred.

Fifty-two patients were found to have disease of renal arteries or their branches. Eleven or 21 per cent of these patients, had lesions of main arterial trunks. Thirty (58 per cent) had disease of primary branches either alone or in combination with main renal arterial lesions. Aneurysms of primary arterial branches were found in five patients, and avascular segments of renal parenchyma in four. The frequency of primary branch arterial disease was greater in this group of patients than in others previously reported. This difference may be due to improved visualization of the renal arterial system obtained with selective arteriography.

References
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THOMAS F. MEANEY and HARRIET P. DUSTAN

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