Percutaneous Transluminal Renal Angioplasty in Nonatherosclerotic Renovascular Hypertension

Long-term Results

VICTOR G. MILLAN, JERRY McCAULEY, RICHARD I. KOPELMAN, and NICOLAOS E. MADIAS

SUMMARY Nineteen stenotic arteries in 16 patients with severe renovascular hypertension of nonatherosclerotic nature (fibromuscular dysplasia in 13, neurofibromatosis in 3) were treated with percutaneous transluminal renal angioplasty. The procedure was technically successful in 12 of 14 (86%) stenoses in the fibromuscular dysplasia subgroup but in only one of five (20%) lesions in the neurofibromatosis subgroup. Hypertension was abated (3 patients) or disappeared (8 patients) in 11 of the 12 (92%) patients with fibromuscular dysplasia who had a technically successful angioplasty, an effect that was sustained at latest follow-up (avg, 37 mo; range, 10–73 mo). The only complication encountered was a retroperitoneal hematoma that resolved uneventfully. Coupled with those from other centers, the results of the present study indicate that angioplasty offers a strong potential for curability in patients with renovascular hypertension caused by fibromuscular dysplasia and that percutaneous transluminal renal angioplasty should be considered the treatment of choice for the initial management of all patients with fibromuscular renovascular hypertension.

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KEY WORDS • fibromuscular dysplasia • neurofibromatosis • interventional radiology • balloon dilatation • renal hypertension • renal artery stenosis

PREVIOUS reports have demonstrated that percutaneous transluminal renal angioplasty (PTRA) may effect dilation of nonatherosclerotic renovascular stenoses and thus remission of the associated secondary hypertension over a short-term follow-up period.1-10 More recently, limited data on small numbers of patients with renovascular hypertension secondary to fibromuscular dysplasia who underwent technically successful PTRA have suggested that the initially beneficial clinical outcome may persist beyond 1 year of observation.11-18 In an effort to ascertain this long-term beneficial outcome, we studied 16 patients with nonatherosclerotic renovascular hypertension who were treated with PTRA and followed up for an average of 37 months (range, 10–73 mo).

Subjects and Methods

Between June 1978 and June 1983 PTRA was attempted in 19 stenotic arteries in 16 patients. On the basis of arteriographic criteria and clinical characteristics all stenoses were considered to be nonatherosclerotic in nature and were classified as being due to fibromuscular dysplasia in 13 patients and neurofibromatosis in three patients. Patients were referred to us either because of difficulty in achieving blood pressure control or following angiography if PTRA was under consideration. The decision to recommend PTRA was based on the presence of an accessible, high-grade (i.e., at least 75% of the arterial lumen) renal artery stenosis in a hypertensive patient, and no other patient selection methods were used. The 16 patients in this study represent all the subjects with nonatherosclerotic renovascular stenosis we saw during the reporting interval.

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Clinical and angiographic data on the 16 patients are presented in Table 1. In the fibromuscular dysplasia subgroup (Patients 1–13), the patients' age ranged from 15 months to 44 years. There were 11 white female subjects and two white male subjects. The neurofibromatosis subgroup (Patients 14–16) included three white male subjects, aged 13, 15, and 20 years. The known duration of hypertension ranged from 1 month to 7 years; nine patients had a history of recent exacerbation of their hypertension. Table 1 depicts the average level of the patients' blood pressure while receiving medication as well as the highest blood pressure values recorded at the time of referral. Seven of the 16 patients had recently required hospitalization for hypertensive crisis. Serum creatinine concentration ranged from 0.3 to 1.9 mg/dl.

As shown in Table 1, 12 patients had single lesions, two patients had two unilateral lesions, and two patients had bilateral stenoses, for a total of 20 stenosing lesions. All lesions involved the main renal artery with the exception of the right-sided lesion of Patient 3, which involved the bifurcation of the lower primary branch. In the fibromuscular dysplasia subgroup, six patients had stenosis of the right renal artery, five patients had stenosis of the left renal artery, and two patients had bilateral involvement. Of the fibromuscular dysplasia lesions, two were classified as intimal and the remainder as medial. The short-term outcome of Patients 1 and 2 has been previously reported.1–2

The PTRA protocol and technique have been previously described.19,20 The balloons of the angioplasty catheters used (Medi-Tech Division of Cooper Scientific Corporation, Watertown, MA, USA, or Cook Inc., Bloomington, IN, USA) had maximal outer diameters ranging from 3.7 to 6.0 mm.

The outcome of the PTRA procedure was judged in both technical and therapeutic terms according to the following arbitrary criteria recently employed by others.18 Complete technical success was defined by the presence of a residual stenosis of 50% or less in the postprocedural angiogram. Partial technical success was defined by the presence of a residual stenosis of 50 to 70% in the postprocedural angiogram. Technical failure was defined by the inability to position the angioplasty catheter across the lesion or by the inadequate dilation of the lesion such that a residual stenosis greater than 70% remained in the postprocedural angiogram. Partial technical success was defined by the presence of a residual stenosis of 50 to 70% in the postprocedural angiogram. Technical failure was defined by the inability to position the angioplasty catheter across the lesion or by the inadequate dilation of the lesion such that a residual stenosis greater than 70% remained in the postprocedural angiogram. The blood pressure response to a technically successful PTRA was defined as cure by a diastolic pressure of 90 mm Hg or less in the absence of antihypertensive medication. Patients were considered improved if a reduction in diastolic pressure of at least 15% had been achieved while they were taking the same or a reduced dose of antihypertensive medication as compared to regimens before PTRA. All other blood pressure responses were considered failures. Statistical significance was determined by Student's t test. Values presented are means ± SD.

### Table 1. Profile of 16 Subjects Undergoing Percutaneous Transluminal Renal Angioplasty

<table>
<thead>
<tr>
<th>Patient no., age (yr), sex</th>
<th>Renal artery stenosis</th>
<th>Type</th>
<th>Location</th>
<th>Severity (%)</th>
<th>Known duration</th>
<th>Avg level (mm Hg)</th>
<th>Highest value (mm Hg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1, 37, F</td>
<td>Intimal FMD</td>
<td>Left main</td>
<td>Left main</td>
<td>90</td>
<td>3 mo</td>
<td>190/110</td>
<td>215/120</td>
</tr>
<tr>
<td>2, 43, F</td>
<td>Medial FMD</td>
<td>Right main</td>
<td>Right main</td>
<td>90</td>
<td>2 yr</td>
<td>170/105</td>
<td>200/130</td>
</tr>
<tr>
<td>3, 19, F</td>
<td>Medial FMD</td>
<td>Left main</td>
<td>Right lower</td>
<td>95</td>
<td>1 mo</td>
<td>180/110</td>
<td>260/160</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>primary branch</td>
<td>60</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4, 10, M</td>
<td>Medial FMD</td>
<td>Right lower</td>
<td>Right lower</td>
<td>95</td>
<td>7 mo</td>
<td>160/125</td>
<td>180/140</td>
</tr>
<tr>
<td>5, 42, F</td>
<td>Medial FMD</td>
<td>Right main</td>
<td>Right main</td>
<td>90</td>
<td>6 mo</td>
<td>140/80</td>
<td>288/180</td>
</tr>
<tr>
<td>6, 24, F</td>
<td>Medial FMD</td>
<td>Left main</td>
<td>Left main</td>
<td>95</td>
<td>6 mo</td>
<td>160/110</td>
<td>210/140</td>
</tr>
<tr>
<td>7, 12, F</td>
<td>Intimal FMD</td>
<td>Right main</td>
<td>Right main</td>
<td>90</td>
<td>Unknown</td>
<td>140/90</td>
<td>160/110</td>
</tr>
<tr>
<td>8, 42, F</td>
<td>Medial FMD</td>
<td>Left main</td>
<td>Left main</td>
<td>95</td>
<td>1 mo</td>
<td>175/95</td>
<td>240/140</td>
</tr>
<tr>
<td>9, 23, F</td>
<td>Medial FMD</td>
<td>Left main</td>
<td>Left main</td>
<td>95</td>
<td>5 mo</td>
<td>200/100</td>
<td>200/120</td>
</tr>
<tr>
<td>10, 41, F</td>
<td>Medial FMD</td>
<td>Right main</td>
<td>Right main</td>
<td>90</td>
<td>5 mo</td>
<td>150/100</td>
<td>225/125</td>
</tr>
<tr>
<td>11, 29, M</td>
<td>Medial FMD</td>
<td>Left main</td>
<td>Left main</td>
<td>99</td>
<td>7 yr</td>
<td>165/105</td>
<td>210/140</td>
</tr>
<tr>
<td>12, 15 mo, F</td>
<td>Medial FMD</td>
<td>Right main</td>
<td>Right main</td>
<td>90</td>
<td>7 mo</td>
<td>130/90</td>
<td>180/130</td>
</tr>
<tr>
<td>13, 44, F</td>
<td>Medial FMD</td>
<td>Right main</td>
<td>Left main</td>
<td>90</td>
<td>5 yr</td>
<td>170/110</td>
<td>230/130</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Right lower</td>
<td>90</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>14, 13, M</td>
<td>NF</td>
<td>Left upper</td>
<td>Left lower</td>
<td>90</td>
<td>3 mo</td>
<td>140/90</td>
<td>160/110</td>
</tr>
<tr>
<td>15, 20, M</td>
<td>NF</td>
<td>Right upper</td>
<td>Right lower</td>
<td>90</td>
<td>3 yr</td>
<td>200/115</td>
<td>200/130</td>
</tr>
<tr>
<td>16, 15, M</td>
<td>NF</td>
<td>Left main</td>
<td>Left main</td>
<td>95</td>
<td>15 mo</td>
<td>150/125</td>
<td>160/140</td>
</tr>
</tbody>
</table>

FMD = fibromuscular dysplasia; NF = neurofibromatosis.
Results

Technical Outcome

In the fibromuscular dysplasia subgroup (Patients 1–13; see Table 1), PTRA was completely successful in nine (64%) and partially successful in three (21%; Patients 5, 7, and 11) of 14 arterial stenoses, which yielded an overall technical success rate of 86%. (As described in the following section, the second lesion of Patient 3 involving the bifurcation of the right lower primary branch was successfully dilated at another center.) Neither lesion in Patient 13 could be crossed by the angiographic catheter. The PTRA reduced the magnitude of the stenosis by $81 \pm 11\%$ (from 93 to 12%; $p < 0.001$) in the completely successful procedures and by $31 \pm 8\%$ (from 93 to 62%; $p < 0.025$) in the three partial successes. No apparent angiographic characteristics separated the lesions in which only partial technical success was achieved. Figure 1 depicts the technical outcome of PTRA in Patient 2, as revealed by the angiogram taken immediately after the procedure and an angiogram taken at 34 months of follow-up. As can be seen, the small irregularities along the arterial wall that were evident on the initial postprocedural angiogram (see Figure 1B), which were presumably the result of flattening of the collagenous ridges of the medial fibroplasia lesion, underwent remarkable repair over the ensuing 34 months (see Figure 1C).

Patient 1 experienced mild restenosis of the involved arterial segment 41 and 20 months after the original dilation; each instance was heralded by relapse of the hypertension and reappearance of the abdominal bruit (see Blood Pressure Response). Completely successful dilation was achieved with ease on both occasions. Patient 12, a 15-month-old girl, was treated with a Dotter procedure using a 6F angiographic catheter. Patients 5 and 11, who had only partially successful outcomes of the original dilation, were subjected to a second angioplasty at 6 and 7 months of follow-up respectively. The residual stenoses of 50 and 75% were further reduced to 20 and 60% respectively.

Of the five arterial stenoses in the neurofibromatosis subgroup (Patients 14–16; see Table 1), angioplasty was completely successful in only one (20%, right upper lesion of Patient 15) and failed in the remaining four (80%). All four patients in whom PTRA was a technical failure (Patients 13–16) were subsequently treated with renovascular surgery.

Blood Pressure Response

Hypertension improved or disappeared in 11 of 12 (92%) patients with fibromuscular dysplasia who had a technically successful PTRA. The only failure was Patient 12, a 15-month-old girl whose extensively stenosed renal artery (80% of the entire length) was successfully dilated with a Dotter procedure (the small caliber of the iliac artery did not allow passage of the balloon catheter). This patient initially was seen with malignant hypertension, but her blood pressure had stabilized at 130/90 mm Hg through a daily regimen of 150 mg of chlorothiazide, 48 mg of propranolol, and 40 mg of hydralazine. Her blood pressure remained virtually unchanged after angioplasty, and she subsequently underwent right nephrectomy with complete resolution of her hypertension.

In the 11 patients with a beneficial clinical response to PTRA, the blood pressure lowering effect of the procedure generally was apparent within hours from its completion and led to a discontinuation or reduction of previously prescribed antihypertensive regimens. All patients were normotensive at the time of discharge, and only two required medication to sustain normoten-

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**Figure 1.** Outcome of percutaneous transluminal renal angioplasty in Patient 2. A. Selective right renal arteriogram taken during Valsalva maneuver shows multiple stenosing rings and intervening aneurysms typical of medial fibroplasia. B. Selective right renal arteriogram taken immediately after angioplasty. C. Selective right renal arteriogram taken 34 months after angioplasty. Note the substantial repair of the arterial wall irregularities as compared with the initial postprocedural study (B). A and B are reprinted from Millan and Madias,2 with permission.
sion (Patients 6 and 11). This result contrasts sharply with the severity of the hypertension and the antihypertensive medication requirements of the patients before PTRA (see Tables 1 and 2).

As can be seen in Table 2, five of the 11 patients (Patients 2, 4, 7, 9, and 10) have remained consistently normotensive since discharge in the absence of any antihypertensive medication during the 17 to 69 months of follow-up. Patient 1 has had mild relapses of hypertension accompanied by reappearance of the abdominal bruit 4 and 20 months after the original dilatation. On both occasions, mild restenosis of the originally dilated arterial segment was demonstrated and was successfully dilated. She has remained consistently normotensive, and at latest follow-up (73 and 53 mo from the original and the last angioplasty, respectively) her blood pressure was 120/80 mm Hg.

Patient 3 had only the left-sided lesion dilated at our institution, which initially stabilized her blood pressure at 135/95 mm Hg without medication. Mild to moderate hypertension recurred in the follow-up period, but the patient refused reevaluation. Four years after PTRA, she was seen with a blood pressure of 210/130 mm Hg at another center. At angiography, the originally dilated left-sided lesion was patent but a 50 mm Hg peak systolic pressure gradient was present across the 60% stenosed right-sided lesion. The patient underwent successful angioplasty and has remained normotensive during the subsequent 14 months of follow-up.

### Table 2. Blood Pressure and Renal Function Before and After Successful Balloon Angioplasty in 11 Subjects with Fibromuscular Dysplasia

<table>
<thead>
<tr>
<th>Patient no., age (yr), sex</th>
<th>BP (mm Hg)</th>
<th>Medication</th>
<th>Time (mo)</th>
<th>BP (mm Hg)</th>
<th>Medication</th>
<th>SCr (mg/dl)</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>1, 37, F</td>
<td>190/110</td>
<td>Methyloma, 750 mg Chlorthalidone, 100 mg</td>
<td>0.7</td>
<td>73</td>
<td>120/80</td>
<td>None</td>
<td>0.9</td>
</tr>
<tr>
<td>2, 43, F</td>
<td>170/105</td>
<td>Methyloma, 1250 mg Hydralazine, 150 mg Chlorthalidone, 100 mg</td>
<td>0.8</td>
<td>69</td>
<td>120/80</td>
<td>None</td>
<td>0.8</td>
</tr>
<tr>
<td>3, 19, F</td>
<td>180/110</td>
<td>Metoprolol, 300 mg Hydralazine, 100 mg Furosemide, 40 mg</td>
<td>1.4</td>
<td>62</td>
<td>130/90</td>
<td>None</td>
<td>1.3</td>
</tr>
<tr>
<td>4, 10, M</td>
<td>160/125</td>
<td>Propranolol, 40 mg Hydralazine, 80 mg Furosemide, 40 mg</td>
<td>0.4</td>
<td>44</td>
<td>118/68</td>
<td>None</td>
<td>0.7</td>
</tr>
<tr>
<td>5, 42, F</td>
<td>140/80</td>
<td>Propranolol, 480 mg Hydralazine, 100 mg Hydrochlorothiazide, 25 mg Triamterene, 50 mg</td>
<td>0.8</td>
<td>37</td>
<td>115/70</td>
<td>Clonidine, 0.2 mg</td>
<td>1.1</td>
</tr>
<tr>
<td>6, 24, F</td>
<td>160/110</td>
<td>Propranolol, 480 mg Captopril, 75 mg Hydrochlorothiazide, 100 mg</td>
<td>1.2</td>
<td>26</td>
<td>130/90</td>
<td>None</td>
<td>—</td>
</tr>
<tr>
<td>7, 12, F</td>
<td>140/90</td>
<td>Captopril, 200 mg</td>
<td>0.8</td>
<td>25</td>
<td>100/70</td>
<td>None</td>
<td>0.7</td>
</tr>
<tr>
<td>8, 42, F</td>
<td>175/95</td>
<td>Atenolol, 50 mg Hydrochlorothiazide, 25 mg Triamterene, 50 mg</td>
<td>0.9</td>
<td>20</td>
<td>120/80</td>
<td>Atenolol, 50 mg Hydrochlorothiazide, 25 mg Triamterene, 50 mg</td>
<td>0.9</td>
</tr>
<tr>
<td>9, 23, F</td>
<td>200/100</td>
<td>Metoprolol, 200 mg Hydralazine, 100 mg Methylclozhatide, 7.5 mg</td>
<td>1.1</td>
<td>19</td>
<td>115/65</td>
<td>None</td>
<td>1.0</td>
</tr>
<tr>
<td>10, 41, F</td>
<td>150/100</td>
<td>Nadolol, 80 mg</td>
<td>0.7</td>
<td>17</td>
<td>140/84</td>
<td>None</td>
<td>—</td>
</tr>
<tr>
<td>11, 29, M</td>
<td>165/105</td>
<td>Propranolol, 320 mg Minoxidil, 20 mg Furosemide, 80 mg</td>
<td>1.9</td>
<td>10</td>
<td>110/80</td>
<td>Atenolol, 100 mg Hydralazine, 200 mg</td>
<td>1.4</td>
</tr>
</tbody>
</table>

BP = blood pressure; PTRA = percutaneous transluminal renal angioplasty; SCr = serum creatinine.
The PTRA in Patients 5 and 11 was judged only partially successful, and their hypertension recurred within a few weeks after the procedure. Repeat angiography showed that the incompletely dilated lesions had not progressed appreciably, and additional dilation was provided (see preceding section). After an initial, short-lived response, however, hypertension recurred and both patients have required medication (although substantially less than that needed before PTRA) to sustain normotension.

Following the attainment of normotension, mild hypertension was noted in Patient 8 two months after PTRA. The patient declined reevaluation because she has been consistently normotensive on a regimen of modest antihypertensive medication. Finally, Patient 6, who was normotensive at discharge while receiving 80 mg of propranolol and 100 mg of hydrochlorothiazide per day, was subsequently weaned from her medication and has remained consistently normotensive.

In summary, as depicted in Table 2, all 11 patients who underwent technically successful balloon angioplasty were normotensive at latest follow-up, averaging 37 months (range, 10–73 mo). Eight of the 11 (73%) have required no antihypertensive medication, and two of the remaining three patients are receiving substantially less medication than that necessary before PTRA.

**Effect on Renal Function and Complications**

As can be seen in Table 2, basal serum creatinine levels averaged 1.0 mg/dl (range, 0.4–1.9 mg/dl). At latest follow-up, serum creatinine levels had not changed significantly and averaged 1.0 mg/dl (range, 0.7–1.4 mg/dl). There were no instances of procedure-related deterioration in renal function, as defined by an increase in serum creatinine levels of 0.5 mg/dl or more after PTRA.

A total of 23 angioplasty procedures were attempted. The only complication encountered was a retroperitoneal hematoma (Patient 5, first PTRA), which probably resulted from passage of the straight-tipped guidewire through the renal artery wall. Hematocrit decreased from 44% to 32%, and the patient experienced mild flank discomfort. No transfusions were administered, and the hematoma resolved uneventfully.

**Discussion**

The results of the present study strongly indicate that PTRA is an effective modality in the management of renovascular hypertension caused by fibromuscular dysplasia. The procedure was technically successful in 86% (12 of 14) of the lesions in which it was attempted. Moreover, 11 of the 12 (92%) patients who had a technically successful PTRA experienced blood pressure lowering effects that were sustained during a mean follow-up of 37 months (range, 10–73 mo).

The degree of technical success achieved in the present study is comparable to that obtained at other centers.4-9, 11-18, 20 The collective experience indicates that the vast majority of stenotic lesions caused by fibromuscular dysplasia are amenable to dilation. Moreover, the sustained functional outcome of the dilation coupled with our and other limited follow-up angiographic data strongly suggest that the morphological-structural effect of a successful PTRA is long lasting.4, 5, 12, 13, 16, 18, 20 Note the morphological appearance of the dilated renal artery of Patient 2 immediately following the procedure (see Figure 1B) compared with that obtained 34 months later (see Figure 1C); far from displaying any tendency toward restenosis, the follow-up angiogram suggests considerable repair and remodeling of the dilated arterial wall during the ensuing healing phase. It is probable that this process contributes a substantial component to the overall dilation effect of PTRA.20 It is unclear whether the two episodes of restenosis experienced by Patient 1 reflect suboptimal dilation by an overcautious operator exploring a then novel technique or the particular nature of the dysplastic lesion (intimal fibroplasia). Nonetheless, it is gratifying to note that, just like the original angioplasty, the two follow-up procedures achieved dilation with ease and no clinical evidence of restenosis has emerged during the subsequent 53 months. The feasibility of lasting dilation of restenosed lesions is corroborated by the experience of others.4, 5, 8, 15, 17, 18, 20

In contrast to the successful technical outcome of angioplasty in patients with fibromuscular dysplasia, the procedure was disappointingly unsuccessful in patients with neurofibromatosis. Angioplasty was technically successful in only one of five (20%) arterial stenoses. As far as we could determine, only three unsuccessful7, 11, 21 and one successful10 attempts at dilation of renovascular lesions in association with neurofibromatosis have been previously reported. It might well be that the variable extent of proliferation of both nonnervous and nervous tissues in the layers of the arterial wall renders the stenotic lesions variably responsive to dilation.22 Additionally, the frequent localization of the lesions at the origin of the main renal artery (as was the case in all 3 of our patients), often in association with coarctation of the abdominal aorta,7, 22 appears to lead to a poor technical result. Certainly, the currently available experience is too limited to allow conclusions regarding the role of PTRA in the management of renovascular hypertension in patients with neurofibromatosis.

As noted, 92% (11 of 12) of the patients with fibromuscular dysplasia who underwent technically successful angioplasty experienced a dramatic and lasting decrease in blood pressure. The only failure was Patient 12, a 15-month-old girl who was seen with malignant hypertension and underwent a Dotter procedure for an extensively and severely stenosed main renal artery. It is unclear whether the lack of response to an apparently successful procedure reflected residual stenosis, prompt restenosis, or maintenance of hypertension by an element of nephrosclerosis. Eight of the 11 responders (73%) have required no antihypertensive medication; the remaining three patients are also nor-
motensive, with two receiving substantially less medication than needed before PTRA (see Table 2). Our data confirm the relatively short-term results of previous studies1-9, 11-18 and also enforce the growing perception of long-term durability of the beneficial response of hypertension to a technically successful PTRA.14, 15 Indeed, the collective data indicate that angioplasty offers a strong curative potential in patients with renovascular hypertension due to fibromuscular dysplasia. Furthermore, the favorable blood pressure response of the two pediatric patients (Patients 4 and 7) in our study who underwent techni-
cally successful PTRA expands the limited experience with angioplasty in pediatric renovascular hyper-
tension.21, 22-25

The only complication encountered in the present study was a retroperitoneal hematoma that resolved unevenly. There were no instances of procedure-related renal dysfunction. This low complication rate (4.3%; 1 in 23 procedures) adds support to the emerging consensus that PTRA, when carried out by experienced interventional angiographers, is a relatively low-risk procedure.

We believe that our and other results justify the conclusion that PTRA in experienced hands should be considered the treatment of choice for the initial management of all patients with renovascular hypertension secondary to fibromuscular dysplasia.4-9, 11-18, 20 We consider the presence of an accessible, high-grade renal artery stenosis in a hypertensive patient sufficient indication for recommending PTRA. Given the well-established evidence that some 30 to 50% of patients with renovascular stenosis and a negative renal vein/renin ratio have responded to reparative surgery and the relative benignity of PTRA, we do not view renal vein renin lateralization as a prerequisite to the procedure.29-30 We favor PTRA over renovascular surgery as the initial therapeutic approach on grounds of substantially lower mortality and morbidity, decreased rate of nephrectomy, and markedly lower expense.4, 8, 9, 13, 15-18, 20 Additional advantages of PTRA include its suitability for the management of branch stenoses and its easy repeatability, a particularly attractive feature in view of the progressive nature and the frequently bilateral occurrence of renovascular disease.30 Certainly, failure of PTRA does not preclude operation. In our opinion, PTRA constitutes the most exciting recent advance in the treatment of renovascular hypertension.

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