Endovascular revascularization of renal artery stenosis: Technical and clinical results

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Purpose: The natural history of renal artery stenosis is progression with subsequent deterioration of kidney function and development of renovascular hypertension. Percutaneous transluminal renal angioplasty is effective in the treatment of nonostial lesions but less effective for ostial stenoses. Because of the poor technical success experienced with percutaneous transluminal renal angioplasty, stenting of ostial stenoses is becoming the standard of endovascular care. In this retrospective study we analyzed the technical and clinical outcomes after renal artery stenting in 73 consecutive patients.

Patients and Methods: From July 1992 to January 1999, 88 Palmaz stents were deployed in 85 renal artery stenoses in 73 patients, with a mean age of 67.9 ± 9.4 years. Twelve patients (16%) underwent bilateral stent placement. Atheromatus lesions were the most prevalent (99%; 82% ostial, 16% nonostial). Most stents were implanted for suboptimal balloon dilation (52%) or dissection (24%). Mean percent stenosis was 86% ± 12%. Renal insufficiency (creatinine level ≥ 1.5 mg/dL) was present in 50 (68%) patients, and uncontrolled hypertension (systolic ≥ 160 mm Hg or diastolic ≥ 90 mm Hg with more than two medications) was present in 57 (78%).

Results: Primary technical success was achieved in 89%. At the initial procedure, three additional stents were placed for residual stenoses, and urokinase was used to treat one intraprocedural stent thrombosis, resulting in an assisted primary technical success rate of 94%. Major complications occurred in 9.1% of stents placed: access artery thrombosis (n = 4), renal artery extravasation (n = 1), renal artery thrombosis (n = 1), and hematoma requiring operation (n = 2). Long-term clinical data were available on 69 (95%) patients at 20 ± 17 months. Overall, a significant decrease in systolic and diastolic pressures (P < .001) and reduction of medication (P < .01) were noted without a change in renal function (P = NS). Angiography was performed on 22 patients at 11.3 ± 10.3 months for persistent or worsening renal function or hypertension or for other reasons; 10 patients had significant restenoses in 14 renal arteries.

Conclusion: Our retrospective analysis demonstrates that endovascular stenting of renal artery stenosis in patients with poorly controlled hypertension or deteriorating renal function is a safe and effective alternative treatment to surgical management. (J Vasc Surg 2001;33:1041-9.)

Renal artery stenoses are clinically significant lesions because of their potential to compromise renal function and lead to or exacerbate hypertension. Recent data have been accumulated on the progressive natural history of renal artery stenoses and deterioration of renal function.\(^1\) A more liberal approach to percutaneous transluminal renal angioplasty (PTRA) has been advocated for the treatment of renal artery stenosis.\(^2\) Complicating the decision to intervene is the fact that some lesions appear to have no clinical sequelae.

Although there are numerous surgical options available for the treatment of renal artery stenoses, the durability of which has been clearly demonstrated, there is increasing interest in a minimally invasive approach (ie, PTRA) by both physicians and patients alike. With the increasing involvement of cardiologists in the percutaneous management of peripheral vascular problems, it is incumbent on vascular surgeons to evaluate the efficacy of these interventions.

The first PTRA was reported in 1978 by Grüntzig et al.\(^3\) There have been numerous studies of renal angioplasty, including a large series from our institution.\(^2\) In 1992 we reported the long-term clinical results of 110 patients after balloon angioplasty alone of atherosclerotic renal ostial lesions. After comparing our outcomes with a control cohort of 94 patients with nonostial stenoses and finding no differences, we concluded that PTRA is beneficial in the control of renovascular hypertension when used to treat both ostial and nonostial lesions. Our conclusion that ostial renal artery stenoses are not a contraindication to angioplasty differed from earlier reports from our institution and from others.\(^4\)\(^-\)\(^9\) As experience has increased with treatment of these lesions, as well as patient selection bias, so will results improve.\(^10\)\(^-\)\(^13\) The position that physicians should take a more aggressive approach to the treatment of renal artery stenoses can be supported only if the interventions are safe, effective, and durable. Compared with conventional surgery, PTRA is a simple procedure associated with a low morbidity rate and has

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Competition of interest: nil.


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MATERIAL AND METHODS

renal artery stenoses. Patients with hemodynamically significant atherosclerotic disease were considered preocclusive, or renal insufficiency (serum creatinine level ≥ 1.5 mg/dL; Emory University Hospital laboratory standard). Fifty patients (68%) had abnormal baseline serum creatinine levels. Serum creatinine levels were 1.5 to 2 mg/dL in 23 patients (32%), 2.1 to 3.0 mg/dL in 13 (18%), 3.1 to 4.0 mg/dL in 8 (11%), and greater than 4.0 mg/dL in 6 (8%). All patients referred with renal insufficiency who were found to have renal artery stenosis amenable to an endovascular approach underwent PTRA with stent placement when appropriate. Follow-up data collected included blood pressure (BP), oral antihypertensive therapy, serum creatinine levels, restenoses, other interventions, need for dialysis, and

Of these 12, eight had bilateral ostial stenoses. Stents were deployed in two patients with a congenital solitary kidney and in three patients who had had a previous nephrectomy. In four patients the contralateral renal artery was occluded (bilateral occlusion in one patient). Only one patient underwent hemodialysis before stent placement. Patient demographics are shown in Table I. Seventy-one lesions (84%) were ostial; the remaining 14 (16%) were nonostial. A stenosis was considered hemodynamically significant if there was greater than 50% luminal stenosis or greater than 15% peak systolic pressure gradient (percent peak systolic pressure gradient = renal artery peak systolic pressure/aortic peak systolic pressure × 100) measured across the stenosis.24 The lesion was considered ostial if it involved the proximal 5 mm of the renal artery. After PTRA indications for stenting were a peak systolic pressure gradient greater than 10% remaining across the lesion or a residual stenosis greater than 30%. Primary stenting was not performed in this group of patients.

Reasons for renal evaluation were uncontrolled hypertension in 27 patients (37%) or worsening renal function in 19 patients (26%). Twelve patients (16%) had a combination of the two symptoms. All patients in this series had some degree of hypertension, and many were considered high-risk surgical candidates because of multiple comorbid illnesses (Table I). Evidence of systemic manifestations of atherosclerotic disease was present in 58 patients (79%). Renal artery stenosis was diagnosed as an incidental finding in 15 patients (21%) who were being evaluated primarily for peripheral vascular disease, cerebrovascular disease, or coronary artery disease. In this subset of patients, the decision to treat the renal artery lesion was a clinical judgment on the basis of the high degree of stenosis (85% ± 12%) present in the setting of hypertension requiring 2.8 ± 1 drugs for control. These 15 patients had a mean serum creatinine level of 1.5 ± 0.7 mg/dL. Two of the 15 had development of intrastent restenosis at 3 months and 17 months requiring repeat angioplasty. No patients in this subset required dialysis; indeed, all had either improvement or no change in their creatinine level. The treatment of renal artery stenosis with PTRA and stenting was considered for patients with poorly controlled hypertension (systolic blood pressure ≥ 160 mm Hg or diastolic blood pressure ≥ 90 mm Hg) with two or more medications, renal artery stenosis that was considered preocclusive, or renal insufficiency (serum creatinine level ≥ 1.5 mg/dL; Emory University Hospital laboratory standard). Fifty patients (68%) had abnormal baseline serum creatinine levels. Serum creatinine levels were 1.5 to 2 mg/dL in 23 patients (32%), 2.1 to 3.0 mg/dL in 13 (18%), 3.1 to 4.0 mg/dL in 8 (11%), and greater than 4.0 mg/dL in 6 (8%). All patients referred with renal insufficiency who were found to have renal artery stenosis amenable to an endovascular approach underwent PTRA with stent placement when appropriate. Follow-up data collected included blood pressure (BP), oral antihypertensive therapy, serum creatinine levels, restenoses, other interventions, need for dialysis, and

Table I. Patient profile

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Men/women (%)</td>
<td>33/40 (45/55)</td>
</tr>
<tr>
<td>Age (y)</td>
<td>67.8 ± 9.5 (range, 40-86)</td>
</tr>
<tr>
<td>Risk factors</td>
<td></td>
</tr>
<tr>
<td>Tobacco use</td>
<td>25 (34)</td>
</tr>
<tr>
<td>Ischemic heart disease*</td>
<td>43 (59)</td>
</tr>
<tr>
<td>Diabetes mellitus†</td>
<td>12 (16)</td>
</tr>
<tr>
<td>Peripheral vascular disease‡</td>
<td>49 (67)</td>
</tr>
<tr>
<td>BP (mm Hg)</td>
<td></td>
</tr>
<tr>
<td>Systolic</td>
<td>166 ± 29</td>
</tr>
<tr>
<td>Patients with systolic ≥ 160 and/or diastolic ≥ 90 mm Hg</td>
<td>57 (78)</td>
</tr>
<tr>
<td>No. of antihypersensitive drugs</td>
<td>2.8 ± 1.1</td>
</tr>
<tr>
<td>Three or more antihypersensitive drugs</td>
<td>39 (53)</td>
</tr>
<tr>
<td>Serum creatinine level (mg/dL)</td>
<td>2.2 ± 1.4</td>
</tr>
<tr>
<td>Patients with Cr ≥ 1.5 mg/dL</td>
<td>50 (68)</td>
</tr>
</tbody>
</table>

Cr, Serum creatinine level.
Mean ± SD.
*Ischemic heart disease—evidence in medical record of documented angina pectoris, coronary artery bypass or angioplasty, congestive heart failure, myocardial infarction.
†Diabetes mellitus—either insulin-dependent or non–insulin-dependent on oral hypoglycemic therapy.
‡Peripheral vascular disease—history of prior medically treated peripheral arterial occlusive disease, or a history of surgery for correction of atherosclerotic disease.

been shown to have a high immediate technical success rate2,5,14,15; however, the restenosis rate has been unsatisfactory. In a review by Martin et al,14 the incidence of restenosis after a technically successful PTRA was 30%. Furthermore, this same incidence was demonstrated in a prospective trial by Weibull et al.15 High restenosis rates occur after the treatment of atherosclerotic ostial lesions because they, in fact, represent an extension of severe aortic atheromatous disease. In 1987 Palmaz et al10 introduced stenting of the renal arteries in animal models. Not thereafter, the use of stents was reported as an adjunct to PTRA.11-13 The placement of intravascular stents in renal arteries has been recommended after PTRA that has failed as a result of elastic recoil and resistance of the aortic plaque, dissection, or restenosis, or as a primary procedure itself.7,16-23 In this study, we evaluated the technical and clinical results of stent placement in 73 patients with hemodynamically significant atherosclerotic renal artery stenoses.

MATERIAL AND METHODS

Patient population. Medical records were retrospectively reviewed for this study. Patients undergoing PTRA and stenting between July 1992 and January 1999 at our institution were identified with physician billing codes. During this time frame, 88 Palmaz (Johnson & Johnson Interventional Systems, Warren, NJ) stents were deployed into 85 renal artery stenoses (left 43, right 45) in 73 patients. Twelve patients (16%) received bilateral stents.
performing with either nonionic low osmolar iodinated arterial access, a selective digital renal arteriogram was experienced vascular radiologists. After gaining percutaneous procedures were performed in an interventional suite by experienced physicians. It was our policy to repeat angiography in patients in whom improvement in hypertension control or renal function initially occurred and then later deteriorated. Routine imaging was not systematically performed.

**Endovascular techniques.** All endovascular procedures were performed in an interventional suite by experienced vascular radiologists. After gaining percutaneous arterial access, a selective digital renal arteriogram was performed with either nonionic low osmolar iodinated contrast or CO₂. The lesion(s) was localized by use of a 5F catheter, and a road map image was created. Pressure gradients and percent stenosis were determined. An 8F renal artery guiding catheter was positioned at the renal artery orifice, through which an appropriately sized balloon was passed and angioplasty was performed. When the decision to place a stent was made, Palmaz stents were mounted on the delivery balloon, and the balloon and guiding catheter were placed across the stenosis. The guiding catheter was then retracted, and the stent was deployed. Patients were given systemic anticoagulants during the interventions and received 50- to 100-µg aliquots of nitroglycerin directly into the renal artery before each catheter or guide wire exchange as prophylactic treatment against vasospasm. Technical success was defined as safely crossing and dilating the stenosis with no major morbidity, a residual stenosis of less than 30%, or a peak systolic pressure gradient of less than 10%, all in compliance with the Society for Cardiovascular and Interventional Radiology Standards of Practice guidelines.²⁴

**Statistical analysis.** Descriptive data are expressed as mean ± 1 SD. Differences between groups were calculated by the Student t test for continuous variables. Probability values less than .05 were considered statistically significant. Kaplan-Meier survival analysis was performed. An SAS statistical package was used for analysis (version 5.0; Abacus Concepts, Berkeley, Calif).

## RESULTS

**Technical results.** Initial stent insertion was successful in 76 of 85 renal arteries, for an immediate technical success rate of 89% as indicated by little or no residual pressure gradient and negligible postprocedural residual stenoses. The preprocedural mean diameter stenosis was 86% ± 12%. Failure to completely cover an ostial lesion occurred in three patients because of distal placement of the stent. This misplacement was seen at the time of stenting; consequently a second overlapping stent was placed successfully over the lesion or arterial ostium. In one patient, small filling defects within the stent were seen on completion angiography. Urokinase (250,000 units administered over 10 minutes) was infused with complete resolution of the defects, thus indicating the presence of intrastent thrombus. With these four corrective measures, the postprocedure technical success rate was 94% (80 of 85 arteries).

Problems during the procedure were encountered in five patients. In one failed procedure, an unsuccessfully dilated 90% stenosis was complicated by subintimal guide wire dissection and subsequent renal artery occlusion. The patient underwent successful immediate operative revascularization. In another patient, after dilation and stenting of an occluded proximal renal artery lesion, urokinase was infused overnight in an attempt to increase the poor arterial flow after stent placement. Arteriography performed after the overnight thrombolytic infusion demonstrated persistent sluggish flow because of more distal renal arterial and parenchymal disease. No further intervention was considered appropriate in this case. In two failed procedures, attempts to stent a residual stenosis after PTRA were unsuccessful because the stents slipped off the balloons on which they were mounted. In both cases the

### Table II. Clinical variables before and after intervention (short-term)

<table>
<thead>
<tr>
<th>Variable</th>
<th>Before PTRA/stent</th>
<th>After PTRA/stent</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Systolic blood pressure (mm Hg)</td>
<td>166 ± 29</td>
<td>141 ± 19</td>
<td>&lt; .001</td>
</tr>
<tr>
<td>Diastolic blood pressure (mm Hg)</td>
<td>85 ± 16</td>
<td>76 ± 12</td>
<td>&lt; .001</td>
</tr>
<tr>
<td>No. of antihypertensive medications</td>
<td>2.8 ± 1.1</td>
<td>2.3 ± 1.2</td>
<td>.01</td>
</tr>
<tr>
<td>Serum creatinine level (mg/dL)</td>
<td>2.2 ± 1.4</td>
<td>2.0 ± 1.3</td>
<td>NS</td>
</tr>
<tr>
<td>Serum creatinine level (mg/dL) in patients with renal insufficiency (Cr ≥ 1.5 mg/dL)</td>
<td>2.7 ± 1.4</td>
<td>2.4 ± 1.3</td>
<td>NS</td>
</tr>
</tbody>
</table>

Cr, Serum creatinine level; NS, no significant between-group difference.

Mean ± SD.

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stents were recaptured and deliberately deployed in the external iliac artery. The patients were observed with no compromise in iliac artery blood flow; no further renal therapy was attempted. The fifth technical failure took place after inadvertent subintimal guide wire placement. A renal artery dissection was noted with compromised flow to the kidney. The contralateral kidney had already been successfully stented and the guide wire removed; therefore no further treatment was performed.

**Treatment of restenosis.** Routine follow-up imaging was not routinely performed in this population. Angiography was performed for worsening hypertension or recurring renal insufficiency in 15 patients (20.5%) who had initially responded favorably to renal artery stenting. There were 14 intrastent restenoses in 14 renal arteries of 10 patients occurring at 11.3 ± 10.3 months. Eleven (79%) of the restenotic lesions were ostial. Fifty percent of the lesions were successfully treated by angioplasty alone (n = 4), with stent implantation (n = 3), and surgical revascularization (n = 2). No further treatment was recommended in five patients who had only moderate degrees of restenosis. Figs 1 through 7 illustrate one such complicated case in a patient who had undergone previous bilateral PTRA alone and presented with recurrent disease, eventually requiring a bilateral aortorenal artery bypass graft.

**Clinical results.** After renal artery stenting, there was a statistically significant overall improvement in both systolic and diastolic arterial pressures and in the reduction of the number of antihypertensive medications (Table II). At latest follow-up, 61 patients (84%) had a systolic BP less than or equal to 160 mm Hg, and 65 (89%) had a diastolic BP less than or equal to 90 mm Hg. Four patients (5.5%) were eventually allowed to discontinue taking medications altogether. Overall, postoperative renal function measured by mean serum creatinine level did not change. Likewise, in the subset of 50 patients with renal insufficiency (creatinine level ≥ 1.5 mg/dL), the mean postoperative creatinine level was also not significantly changed. Table III demonstrates the clinical results of the patients with preoperative renal insufficiency by incremental baseline serum creatinine level. At serum creatinine levels less than 4.0 mg/dL, most patients either had levels that improved or remained unchanged. Only those in the patient cohort with extreme renal dysfunction (> 4.0 mg/dL) did not have any benefit from endovascular intervention.

Long-term follow-up of renal function was available on 69 patients (95%) at 20 ± 17 months. Serum creatinine level decreased by more than 20% in 16 patients (22%). Renal function was unchanged (positive or negative change ≤ 20%) in 35 patients (48%) and deteriorated (increase of > 20%) in 18 patients (25%). Nine patients (12%) required dialysis after the procedure, five of whom had preoperative serum creatinine levels of more than 4.0 mg/dL. Two (3%) of those with deterioration in renal
function eventually underwent successful surgical renal revascularization after the endovascular procedure. In the group of nine patients requiring dialysis, the serum creatinine level before PTRA and stent placement was 4.5 ± 1.6 mg/dL (range, 2.3-6.8 mg/dL). Dialysis was initiated at 17.4 ± 13.0 months (range, 0.8-39.1 months). Cumulative survival (dialysis-free) is presented in Fig 8.

Complications. One perioperative death occurred because of the renal intervention (30-day mortality rate of 1.4%). This patient was diagnosed with anuria (serum creatinine level 7.5 mg/dL) after nephrectomy. At angiography she was found to have an occluded renal artery. After angioplasty there was persistent sluggish flow through the renal artery. Urokinase was infused in an attempt to increase the flow, but the result was unsatisfactory because of more distal and diffuse atherosclerotic disease of the renal artery. The patient had a cerebral hemorrhage after thrombolytic therapy and subsequently died. This was considered a technical failure for the purposes of this study. In the first 12 months, records show that four patients (5.5%) died, two as a result of complications of systemic atherosclerotic disease.

The incidence of major complications in this study was 9.4%. One patient had renal artery thrombosis necessitating an urgent, albeit successful, surgical revascularization. In another patient, the renal artery developed a pinhole-sized leak secondary to a balloon rupture. Contrast extravasation was noted from the renal artery, and the leakage ceased after balloon tamponade and stent deployment. The artery remained patent with no surgical procedure or blood transfusion required. In addition, there were six complications associated with arterial access. Three patients had development of acutely ischemic limbs after the intervention necessitating operative repair or revascularization. One femorofemoral bypass graft thrombosed and was successfully treated with urokinase. Hematomas requiring surgical evacuation developed at two puncture sites.

DISCUSSION

After the first renal artery angioplasty by Grüntzig et al in 1978, catheter-based revascularization has become widely accepted for the treatment of atherosclerotic renovascular disease. The morbidity of a major surgical procedure is avoided in a population of patients who are often elderly, have azotemia, and are debilitated because of other manifestations of systemic atherosclerotic disease. The concomitant use of stents has been claimed to be superior to angioplasty alone in maintaining luminal diameter and decreasing the translesion pressure gradient. Nonetheless, the incidence of restenosis is of concern, ranging from 11% to 44% at 2 years. Although one can be crit-
ical of the disappointing restenosis rates and technical success rates that are inferior to surgery, it is important to remember the low overall survival rate in patients with severe atherosclerotic disease. Therapeutic goals and result expectations cannot be the same as in patients who are younger, have recent onset of hypertension, and have normal renal function. Open surgical renal revascularization is a proven standard, albeit not one without significant risk, with morbidity and mortality rates ranging from 7% to 44%.25-27 During the time frame of this study, Palmaz stents were the only type of balloon-expandable stents obtainable. Currently, there is a wider variety of stents available for use, although to date, none have demonstrated superior efficacy. Most renal artery lesions meeting the indications for stenting in this report were ostial (84%) because of the high prevalence of systemic atherosclerotic disease and the inferior results of PTRA in this location. Additionally, with the advent of stent deployment for ostial renal artery lesions, most of our patients do receive stents because of the higher technical success achievable. With stenting of mainly ostial renal artery lesions we have enjoyed a higher procedural success rate (94% compared with 35%), however, there has been no increase in long-term clinical benefit when the cohort presented here is compared with prior work.2 Critical ostial lesions have presented a challenge to the interventionalist because of the recoil and resistance of the aortic plaque. All patients underwent predilation of their stenosis with an appropriately sized 4- to 8-mm diameter balloon. Results previously reported from our institution showed no additional benefit to increasing the balloon size in relation to the normal vessel diameter.2 Stents were positioned to protrude 1 to 2 mm into the aortic lumen. In three patients a second stent was placed proximal to the first stent to ensure complete coverage of the aortic plaque. Because the misplacement of the stent was recognized immediately and corrected with the more proximal stent, these three patients were considered technical successes. Thus, our technical success rate for this procedure was high.

Table III. Relationship of clinical results and serum creatinine levels before endovascular revascularization in 50 patients with renal insufficiency

<table>
<thead>
<tr>
<th>Serum creatinine level before PTRA/stent (mg/dL)</th>
<th>Improved</th>
<th>Unchanged</th>
<th>Worse</th>
<th>Follow-up (mo)</th>
<th>No. requiring dialysis</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.5-2.0 (n = 23)*</td>
<td>6</td>
<td>13</td>
<td>3</td>
<td>19.6 ± 19.6</td>
<td>1</td>
</tr>
<tr>
<td>2.1-3.0 (n = 13)</td>
<td>3</td>
<td>7</td>
<td>3</td>
<td>15.5 ± 15.0</td>
<td>1</td>
</tr>
<tr>
<td>3.1-4.0 (n = 8)*</td>
<td>6</td>
<td>0</td>
<td>1</td>
<td>17.9 ± 15.4</td>
<td>1</td>
</tr>
<tr>
<td>&gt; 4.0 (n = 6)*</td>
<td>0</td>
<td>0</td>
<td>5</td>
<td>12.1 ± 12.6</td>
<td>5</td>
</tr>
</tbody>
</table>

Mean ± SD
*No follow-up data available on one patient.
reaching 94%. This is consistent with the high success rates reported by others.*

Myointimal hyperplasia or progression of atherosclerotic disease may cause intrastent stenosis. True restenosis rates are impossible to calculate from our data because only 22 patients underwent repeat renal angiography. Angiography was not performed systematically but only in patients whose hypertension or renal function initially improved but later deteriorated or who were restudied during evaluation for other peripheral vascular symptoms or heart disease. With these criteria, restenosis was present in 14 of the 22 patients evaluated. This high incidence of restenosis was to be expected because the patients underwent repeat imaging out of concern for possible restenosis. Patients with asymptomatic renal artery restenoses would not have otherwise been detected, unless the restenosis was discovered as an incidental finding during angiography performed for other reasons.

The clinical benefit in hypertension control in a noncontrolled, retrospective study such as ours also needs to be interpreted with caution. The preprocedural and postprocedural blood pressures were monitored for changes, as were the number of medications the patient was taking for control, with statistically significant reductions seen in both. Although other investigators have reported a similar clinical benefit after stenting,7,15,16,20,29,30 it is unclear in our patients whether this benefit is due to more appropriate medical control or to the intervention. As we stated in a prior study, it is theoretically possible that clinical benefit occurred in spite of restenosis.2 Furthermore, patients were not considered for renal angioplasty or stenting if they required surgery for aortoiliac occlusive disease or abdominal aortic aneurysm. What is also lost in a retrospective study is the number of patients who had a hemodynamically significant renal artery stenosis but were not considered candidates for PTRA/stenting. This was because the interventionalist considered either the procedure too difficult or the risk to the patient excessive, or patients were eliminated from consideration by the referring physician, the patient, or the patient’s family.

In a similar study, White et al7 reported 6-month outcomes in a cohort of 100 patients with stents and observed continued lowering of the BP. Blum et al6 reported that 16% of their patients had long-term (27 month) normalization of BP. As nonprimary care specialists working in a tertiary referral environment, we do not often have the benefit of long-term patient follow-up. It is assumed, however, that each patient continues

*References 7, 13, 16, 18-20, 23, 24, and 28.
to be treated by the same primary care physician after the intervention. A statistically significant reduction in the number of medications being used for BP control was observed, which is clinically significant as well, given the reduction in both systolic and diastolic blood pressures. Changes in the dose of each medication were not consistently documented and thus not included in analysis. It was also impossible in this study to determine whether an improvement in blood pressure was due to the interventional procedure, better drug compliance by the patient, a better drug regimen by the prescribing physician, or a combination. Although other studies have observed higher rates of unchanged (36%-67%)13,16,17 or improved (29%-36%)13,16,17 renal function (defined as a 20% improvement in serum creatinine value after stent placement), the baseline renal function in these reports is usually better than that present in our patients. Indeed, the mean serum creatinine level reported by Henry et al16 before stent placement in 210 patients was 1.39 ± 0.70 mg/dL, compared with a level of 2.2 ± 1.4 mg/dL in our series.

Because the natural history of atherosclerotic renal vascular disease is progression to occlusion with imminent kidney failure, a slowing of the rate of deterioration and preservation of the remaining renal function are realistic goals of renal revascularization in patients with this disease. As previously stated, it is unclear whether a lack of change in serum creatinine level truly represents stabilization of renal function or a retardation of the rate of progression. Indeed, Harden et al17 demonstrated that in patients with two functioning kidneys and unilateral renal artery stenosis, the rate of decline in renal function was decreased after stent deployment. This was indicated by analysis of the slope of reciprocal creatinine plotted against time. Longitudinal analysis, based on work by Rowe et al10 on the rate of change of renal function, requires analysis of at least five preprocedural data points, detailed postprocedural data collection, and the use of a computer program. The method fits two intersecting lines to data by computing a least-squares estimate of the position of the slope change and its 95% confidence limits. The work of Harden et al17 supports those who argue that stabilization of renal function or delay in the progression of functional impairment is indicative of successful treatment in the azotemic population. Additionally, improvement of BP control and lowering the number of medications needed may lead to an improvement in renal function. As demonstrated in a recent large series by Rodriguez-Lopez et al,31 a high procedural success rate (97.6%) was combined with an improvement in hypertension without any significant change in serum creatinine levels. However, the mean serum creatinine level in their study was 2.0 mg/dL, with 67% of the patients having a level of 1.5 mg/dL or less. Their study had excellent follow-up, including clinical examination in 100% of patients and renal artery duplex scanning and angiography in 76%. Of the 50 patients in our series with preoperative baseline renal insufficiency, the condition of most remained unchanged (43%) or improved (32%) after treatment. More specifically, 86% with a baseline serum creatinine level of 1.5 to 2.0 mg/dL, 77% with a level of 2.1 to 3.0 mg/dL, and 86% with a level of 3.1 to 4.0 mg/dL had improved or unchanged renal function. All patients with severe baseline renal dysfunction (creatinine level ≥ 4.0 mg/dL) went on to require hemodialysis.

This retrospective study demonstrates that experienced interventionalists can successfully perform the stenting of renal artery stenoses. Although morbidity, and even death, can occur, percutaneous methods can play an important role in hypertension control in this patient population. Although the authors recognize that surgical revascularization or transaortic endarterectomy is beneficial in the treatment of renal artery stenosis, these procedures are not without significant morbidity and mortality rates. Many patients, such as the ones presented in this series, may not tolerate a major open surgical revascularization. In patients who undergo intervention for the control of hypertension, results are encouraging. In patients for whom the primary reason for intervention is worsening renal function, the conditions of 70% will improve or their renal function will not change as measured by serum creatinine levels. However, in the patients who have unchanged creatinine levels after PTRA and stent placement, our data do not necessarily support any treatment benefit toward renal salvage in this group. Indeed, the patients in this series with extreme renal excretory dysfunction did not benefit from endovascular treatment, emphasizing the need for a high clinical suspicion of renal artery stenosis and earlier diagnosis. A prospective, randomized trial would be necessary to determine any benefit of endovascular intervention on either survival or dialysis-independence. In this manner the natural history of untreated renovascular insufficiency may be realized. The survival of patients with renovascular disease and renal insufficiency is poor, with 2-year survival reported as low as 50%. Renal dysfunction can be improved or stabilized in most patients, and dialysis-free survival may be prolonged in those with incipient end-stage renal disease by intervening in patients with significant renal artery stenosis.

CONCLUSION

This retrospective study demonstrates that the endovascular treatment of renal arteries is a safe and effective alternative to surgical management of renal artery stenosis in patients with poorly controlled hypertension or deteriorating renal function. High restenoses rates continue to be the Achilles’ heel of ostial renal artery stenting. However, most of these patients can be successfully treated percutaneously. Should strategies for the control of restenosis become reality, stenting will then become the primary mode of intervention.
REFERENCES


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