Renal Artery Intervention: Origins and New Technical Advances

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Origins. In their first paper in 1964, Dotter and Judkins envisioned the application of catheter recanalization to coronary, renal, and even cerebral vessels. The first percutaneous transluminal renal artery angioplasty (PTRA) using the Gruentzig balloon catheter was performed December 7, 1977 in Bern, Switzerland by our group. Before I moved from Zurich to Bern, I had the chance to work with Andreas Gruentzig on the PTA of peripheral arteries. While Andreas was primarily working on 3 mm balloons for coronary angioplasty, we initiated the manufacture of a larger coaxial 5 mm balloon catheter by the Schneider Company (Zurich, Switzerland). The balloon catheter could be advanced to the renal artery by a special guiding catheter (this first balloon catheter came without an endhole at that time). Following pre-clinical experiments in swines, we offered the catheter treatment to a 50-year-old woman with severe hypertension due to an isolated renal artery stenosis on the left side. The patient agreed, underwent PTRA, and became normotensive. The immediate and 4 month angiograms after PTRA demonstrated a patent, widely dilated lumen of the renal artery (Figure 1), as shown in our first publication.

Upon hearing my happy message from Bern, Andreas also performed a successful PTRA and had his case published in the Lancet, being the faster journal than the Annals of Internal Medicine (where mine was submitted). In a way, the credit not only for coronaries but also for renal arteries does belong to him, since his system made angioplasty possible in both circulatory beds.

Worldwide use of catheter angioplasty in renal artery stenosis did not take a long time. Subsequent important publications were on the first application in a patient with fibromuscular dysplasia (FMD), on the over-the-wire approach, on transplant kidney arteries, on application in azotemic patients with solitary functioning kidney, and later on azotemic patients with bilateral renal artery stenosis, PTRA in children, and the first long term follow-up series.

Follow up. Our first patient illustrates a long-term angiographic follow-up. We had the opportunity to check for a patent renal artery at the time of an iliac artery angioplasty and in combination with a coronary angiography 6 and 7 years after the initial PTRA, respectively. Nevertheless, hypertension aggravated 18 years later. Interestingly, the renal artery stenosis seen (and successfully dilated at this occasion) was further distal than the site of initial dilatation, representing not a recurrent but a de novo stenosis.

In the earlier papers, follow-up relied more upon clinical data such as blood pressure or renal function than on verified renal artery patency. It has been shown that blood pressure response depends on the nature and severity of the disease causing the stenotic lesions. In the long run, an atherosclerosis cure (normotensive...
without medication) is to be expected in about 10%, improvement (blood pressure lower by at least 15 mmHg with unchanged or reduced medication) in about 55%, and no benefit in about 35%. An FMD cure is seen in 40%, improvement in 35%, and no benefit in 25% (mostly due to progression of disease or complicated distal lesions). Patients with generalized atherosclerotic disease and/or renal dysfunction

Figure 1. Angiographic follow-up from the first patient (50-year-old woman) undergoing PTRA by the Gruentzig balloon catheter in 1977. (A) Stenosis on the left side before; (B) 4 months after PTRA; (C) 6 years after PTRA at the occasion of iliac artery PTA for intermittent claudication; (D) 7 years after PTRA at the occasion of coronarography; (E) 18 years after PTRA of a de novo stenosis distal to the original site of PTRA with recurrent hypertension; (F) after repeated PTRA.
respond less favorably than patients with unilateral isolated stenoses. Although selective renal vein renin ratios were determined to predict efficacy of PTRA in earlier years, this is not done today by most interventionists. Renal artery stenosis of more than 60% may be dilated in the presence of hypertension, renal insufficiency, or both. If stenoses of 50% are included, the effect of PTRA becomes doubtful.

Whether or not these clinical results corresponded to renal artery patency was studied in more recent years. While some studies with incomplete follow-up showed optimistically low restenosis rates between 10 and 20%, later studies based on either angiographic or sonographic follow-up tend to show restenosis rates around 30% within the first year and almost 50% within 4 years in atherosclerotic patients. Accordingly, we have shown that clinical findings such as recurrence of hypertension do not correspond well to angiographic restenoses. While almost one third of the hypertensive patients showed no restenosis, 20% of the normotensive patients presented with an unexpected restenosis.

Differences of restenosis rates are certainly dependent on the nature of disease, but rely even more upon the site of the lesion with regard to the origin from the aorta. Clinical results made it clear that the so-called ostial stenosis had a success rate markedly lower than that of non-ostial stenoses in the pre-stent era. Table 1 indicates long-term results of follow-up studies.

**Stenting.** Follow-up of the patient shown in Figure 2 illustrates the usefulness of stents in ostial stenosis. After an unsuccessful PTRA 18 years ago, we saw the

![Figure 2](https://example.com/figure2.jpg)

**Figure 2.** Angiographic follow-up of a patient treated unsuccessfully by PTRA alone 18 years ago, and re-treated by PTRA and stent insertion. (A) Stenosis in the left renal artery after attempted PTRA 1979; (B) almost unchanged stenosis in 1997; (C) result after PTRA and Palmaz-Schatz stent (6/10 mm) insertion; (D) native radiography showing the Palmaz-Schatz stent in a heavily calcified renal artery orifice.

<table>
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<th>Author</th>
<th>Year</th>
<th>Patients (n)</th>
<th>Restenosis Rate</th>
<th>Follow-up (months)</th>
<th>Ostial Stenosis (%)</th>
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a = sonographic follow-up; b = non-consecutive patient selection; c = angiographic follow-up in only 67%.
patient because of an aggravation of the hypertension, and found — surprisingly — an almost unchanged renal artery stenosis originating from a highly calcified aorta. After re-PTRA with Palmaz-Schatz (Cordis Corp., Miami, Florida) stent insertion, a satisfactory technical and durable clinical result was achieved.

Stents have been used since 1986 in renal arteries, but it was not until the systematic sonographic follow-up evaluation of Blum et al. that short, balloon-expandable stents have become widely recognized as a valuable means to treat ostial stenoses successfully by catheter intervention. Indeed, a primary 2 year patency rate of 80% and a secondary patency rate of over 90% was also shown, placing the result of this presumably unfavorable type of lesion well into the range of renal artery stem stenosis.

Stents may also be useful in other situations when balloon PTRA does not suffice. Figure 3 shows an example of a balloon-resistant stenosis in a transplanted kidney artery with difficult access. There is no doubt that stents are indicated in cases with recoiling arteries or dissections where balloon dilatation alone would fail.

Renal insufficiency. The transplanted kidney with flow-dependent dysfunction is the classical situation in which improvement by PTRA may be assumed. The first paper dealing with this problem was on azotemic patients with unilateral kidneys in whom renal insufficiency was improved by PTRA. We confirmed this observation in a similar model, mainly using patients with stenosed transplant kidney arteries. In the pre-stent era, we believed that renal function could not be impaired by a one-sided stenosis in the presence of two kidneys unless a renal parenchymal defect was involved, and therefore may not be improved by PTRA. Until recent years, the results on PTRA with regard to renal insufficiency were considered to be controversial. While some studies did not find a change, others documented beneficial results, as it is known from the surgical series. Our own recent results, however, show that renal function may be stabilized or improved in about 40% of the patients by PTRA and/or stenting of one or two-sided renal artery stenoses. Figure 4 illustrates the serum creatinine of 24 patients before and after PTRA in our institution.

Figure 3. PTRA and stent insertion in a transplanted kidney artery (A) before intervention; (B) PTRA of a distal stenosis; (C) result after PTRA of a proximal stenosis; and (D) final angiographic result after stenting of the proximal stenosis (5/10 mm).

Figure 4. Average serum creatinine of patients with renal insufficiency (creatinine > 120 mol/l) before and after stenting of renal arteries: A significant and persistent decrease after PTRA in serum creatinine has been shown after intervention.
About 40% of the group of patients with serum creatinine greater than 160 ug/l benefited, and as a whole this group showed significant improvement.

**Embolization therapy.** While the primary goal of catheter interventional therapy is the reopening of renal vessels, in some cases the closure may be more beneficial. We treated a series of 5 hypertensive patients with shrinking kidneys and patent or stenosed renal arteries. We made sure that the shrunken kidney produced excess renin by selective renal vein renin evaluation but contributed less than 15% to the global clearance as measured by isotope scintigraphy.

Figure 5 shows the example of a young woman in whom an arterio-venous fistula from an aneurysm of a polar branch was excluded by coil embolization. In these cases, closure of the vessel was successfully achieved by catheter embolization using coils and/or injection of 70% alcohol. Although this procedure is certainly not the first option in treating renovascular diseases, embolization should be available in special cases for exclusion of the kidney or intrarenal vascular aneurysms.

**REFERENCES**

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**PANEL DISCUSSION**

RICHARD STACK: We often find ourselves with patients suffering from advanced hypertension who clearly have very small kidneys; we see a critical stenosis, but the kidneys are so small, blood flow is so poor, or distal vessels are so small and diseased that we do not feel a stent would be appropriate for the management of those patients. These patients are therefore candidates for nephrectomy. Although this operation is generally well tolerated, one matter of concern is that some of these patients may have serious coronary disease and are therefore not great surgical candidates. I wonder about this very promising technique; I believe alcohol injection followed by chloral embolization could frequently be an alternative to nephrectomy. However, my practice still uses nephrectomy a fair amount. In your opinion, which procedure should be the treatment of choice?

FELIX MAHLER: I think catheter ablation is the better solution. That is why I chose to present this case here even though this technique has been recognized for many years. Patients are almost always cured after one week, although one must take care to dose patients with analgesics for about 3 days because they suffer pain and a little bit of fever. This procedure is only indicated for patients with very small kidneys — those not contributing more than 15% of the global clearance. We usually inject alcohol and coils. An occluding stent might simplify the technique, but we do not yet have one on the market.