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Percutaneous transluminal angioplasty alone versus stent placement for the treatment of transplant renal artery stenosis



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KEYWORDS

Renal artery obstruction;
Kidney transplantation;
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Angioplasty;
Stent

Abstract

Purpose: The purposes of this retrospective study were to assess the efficacy of endovascular techniques for the treatment of transplant renal artery stenosis (TRAS) by analyzing technical and clinical success and to compare the results of percutaneous transluminal angioplasty (PTA) alone to those of stenting.

Materials and methods: A retrospective analysis was conducted on 31 patients who underwent endovascular treatment for TRAS between January 2012 and December 2017. There were 23 men and 8 women with a mean age of 60.5 ± 14 (SD) years (range: 24–81 years). Ten patients (10/31; 32%; 8 men, 2 women; median age, 63 years) were treated with PTA alone and 21/31 (68%; 15 men, 6 women; median age, 65 years) with metallic stent placement. Several variables including serum creatinine level, glomerular filtration rate, arterial blood pressure value, antihypertensive medication obtained before and after treatment were compared. Technical success was assessed for each procedure. Clinical success was defined as a 15% drop in serum creatinine level, a decrease greater than 15% in mean blood pressure values or a decrease greater than 10% in mean blood pressure values with a reduction in the number of antihypertensive drugs needed for hypertension control.

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Results: Technical success was obtained in all patients [31/31; 100%; 95% confidence interval (CI): 89–100%] and clinical success in 27/31 patients (87%; 95%CI: 71–95%). Four patients (4/31; 13%; 95%CI: 5–29%) underwent repeat endovascular intervention. Mean serum creatinine level and mean arterial blood pressure values were significantly lower after treatment (177.4 and 93.8 $\mu\text{mol/l}$, respectively) compared to before treatment (319.4 and 106.7 $\mu\text{mol/l}$, respectively) in the stent group but not in the group treated with PTA alone ($P=0.0012$ and $P=0.002$, respectively).

Conclusion: The endovascular approach is safe and effective in the management of TRAS and stenting, depending on the morphology of the stenosis, should be the treatment of choice when possible.

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Transplant renal artery stenosis (TRAS) is the most frequent vascular complication in renal transplant recipients with an incidence varying from 1% to 23% [1,2]. TRAS may develop early or late after renal transplantation [3]. TRAS can induce arterial hypertension with an either sudden or insidious onset, which may become refractory to therapy and gradual worsening of renal function [4]. The presence of a bruit over the transplant on auscultation is non-specific and may be observed in healthy renal transplant recipients. Many factors can contribute to TRAS, such as surgical suture technique, renal artery trauma during transplantation, kinking or twisting of the renal artery, atherosclerosis in donor or recipient vessels, cytomegalovirus infection and rejection [5]. However, in the majority of patients, early-onset TRAS is believed to be due to traumatic intimal injury during surgery (trauma to recipient or donor vessels during surgical manipulation or problems on vascular sutures) [3].

Diagnostic confirmation of TRAS is essential and is currently based on non-invasive imaging. Color-Doppler ultrasound and magnetic resonance imaging (MRI) are the primary imaging methods for the diagnosis of TRAS because of potential changes in renal function associated with this condition. Computed tomography (CT) is performed as a second-line approach. Finally, angiography provides definitive diagnosis of TRAS and allows treatment of stenosis in the same session [6,7].

Since the first report of percutaneous transluminal angioplasty (PTA) in renal transplant arterial stenosis, numerous studies have described the superiority of percutaneous treatments over surgery for TRAS [4,8]. Endovascular management of TRAS is now considered as the treatment of choice and does not preclude further surgical management [3,9–12]. Nowadays, the surgical approach is undertaken as a rescue therapy due to high complication rates and its use is restricted to patients in whom the percutaneous approach has failed. Studies describing the use of PTA alone or in conjunction with stent placement, and primary stenting, have reported high technical success rates and good clinical outcomes with minimal complications [9–11]. The benefits of endovascular treatments include a decrease in arterial blood pressure and serum creatinine level, usually within the 3 to

5 days following endovascular treatment [5]. Several studies have showed the effectiveness of endovascular techniques for the treatment of TRAS [1,3,8,9,13] but very few have compared PTA alone with stenting [14].

The purpose of this retrospective study was to assess the efficacy of endovascular techniques for the treatment of TRAS by analyzing technical and clinical success and compare the results of PTA alone to those of stenting.

Materials and methods

Patients

A retrospective analysis of patients who underwent endovascular TRAS treatment from January 2012 to December 2017 was conducted. This study was performed with the approval of our institutional review board. Standard kidney transplantation procedures were performed based on individual surgical experience and the structure of the graft. The kidney artery was anastomosed end-to-side to the external iliac artery. All patients received triple immunosuppressant therapy after transplantation: a triple regimen of calcineurin inhibitors and steroids, with the addition of either azathioprine or mycophenolate mofetil. The patient list was obtained by querying the picture archiving and communication system of our institution (McKesson Radiology Station 11; McKesson Medical Imaging Group). Clinical data were then retrieved from electronic medical records (Orbis v: 3.5.7; Agfa HealthCare N.V.). One radiologist (O.M.) with 8 years of experience in vascular imaging and a last year resident in radiology (M.M.) gathered all angiography examinations of the renal arteries performed during the study period. Inclusion criteria included a renal artery angiography from transplanted kidney and PTA and/or stenting performed for TRAS. Exclusion criteria included incomplete initial clinical data, incomplete initial imaging data and lack of follow-up information. The initial search retrieved a total of 89 patients. Of these, we included only the 40 patients who underwent angiography of transplanted kidney. Nine patients were further excluded because of missing clinical

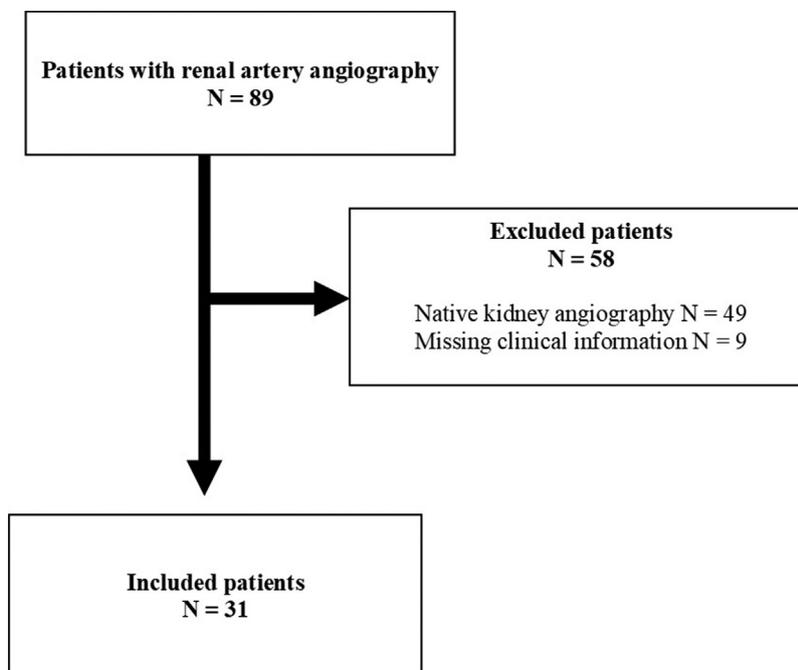


Figure 1. Study flowchart of patient selection.

information after treatment. **Fig. 1** is a flow chart of patients who were considered for this study. A total of 31 patients with TRAS who had undergone endovascular treatment were ultimately included. There were 23 men and 8 women with a mean age of 60.5 ± 14 [standard deviation (SD)] years (range: 24–81 years). Thirty (30/31; 97%) patients received kidneys from cadaveric donors and one (1/31; 3%) from a living donor.

Diagnosis of TRAS

TRAS was suspected in patients with refractory hypertension (arterial blood pressure $> 130/80$ mmHg) [15] or increased serum creatinine level ($> 137 \mu\text{mol/l}$ for men and $104 \mu\text{mol/l}$ for women) [16]. TRAS was further confirmed by imaging using ultrasound, MRI or CT. An ultrasound examination was initially performed for suspicion of TRAS. Ultrasound criteria included peak systolic velocities (PSV) in the renal artery > 200 cm/s, acceleration time or time to peak (TTP) > 0.2 ms and intrarenal resistive index (RI) < 0.6 .

Clinical data

For each patient, clinical presentation of TRAS, time and type of transplantation, date of intervention, technical data (diameter and length of stents and balloons), technical success, serum creatinine levels, glomerular filtration rate (GFR), arterial blood pressure (systolic, diastolic, mean), number of antihypertensive medicinal products and ultrasound examination parameters (PSV, TTP, RI) were recorded. GFR was calculated using the MDRD equation [17] and mean arterial blood pressure (MAP) using the conventional equation [18]. Regarding post-treatment follow-up, we recorded serum creatinine levels and GFR at patient discharge as well as creatinine serum level, GFR, arterial blood pressure values (systolic, diastolic, mean) and the number of

antihypertensive drugs at least one month after treatment. Ultrasound examinations were performed post-procedure, and relevant parameters were recorded.

Endovascular procedure

All endovascular treatment was performed in a hybrid angiography room (Discovery[®] IGS 730—GE Healthcare). The choice of initial strategy (PTA or direct stenting) was based on the location and severity of the stenosis and the angle of TRAS. PTA was first performed when the anastomosis angle was too acute to avoid the risk of stent dislocation. Moreover, for patients with contraindication to antiplatelet therapy, we preferred to avoid stenting. One operator with 30 years of experience in interventional radiology performed all the procedures. Percutaneous ultrasound-guided retrograde femoral access was performed under local anesthesia using a 6-Fr long sheath using an ipsi or contralateral approach. Angiography was performed after crossing the iliac bifurcation when using a contralateral approach. Non-selective angiogram was always obtained to confirm the location of the TRAS and rule out obstructive iliac artery disease. Under fluoroscopy, the stenosis was crossed with a 0.035- or 0.018-In guidewire using an appropriate catheter. Depending on the initially selected strategy, a preselected angioplasty balloon with a diameter ranging from 3–6 mm was centered and inflated on the stenosis (**Fig. 2**). When results were suboptimal (i.e., residual stenosis or evidence of a flow-limiting dissection), a stent was placed after initial PTA. In other cases, we utilized direct stenting without preliminary PTA. The Tsunami[®] peripheral balloon-expandable stent (Terumo) was the most used type of stent. In a few cases, despite the lack of recommended indication for renal arteries, the Pulsar[®]-18—self-expanding stent (Biotronik) was used because of

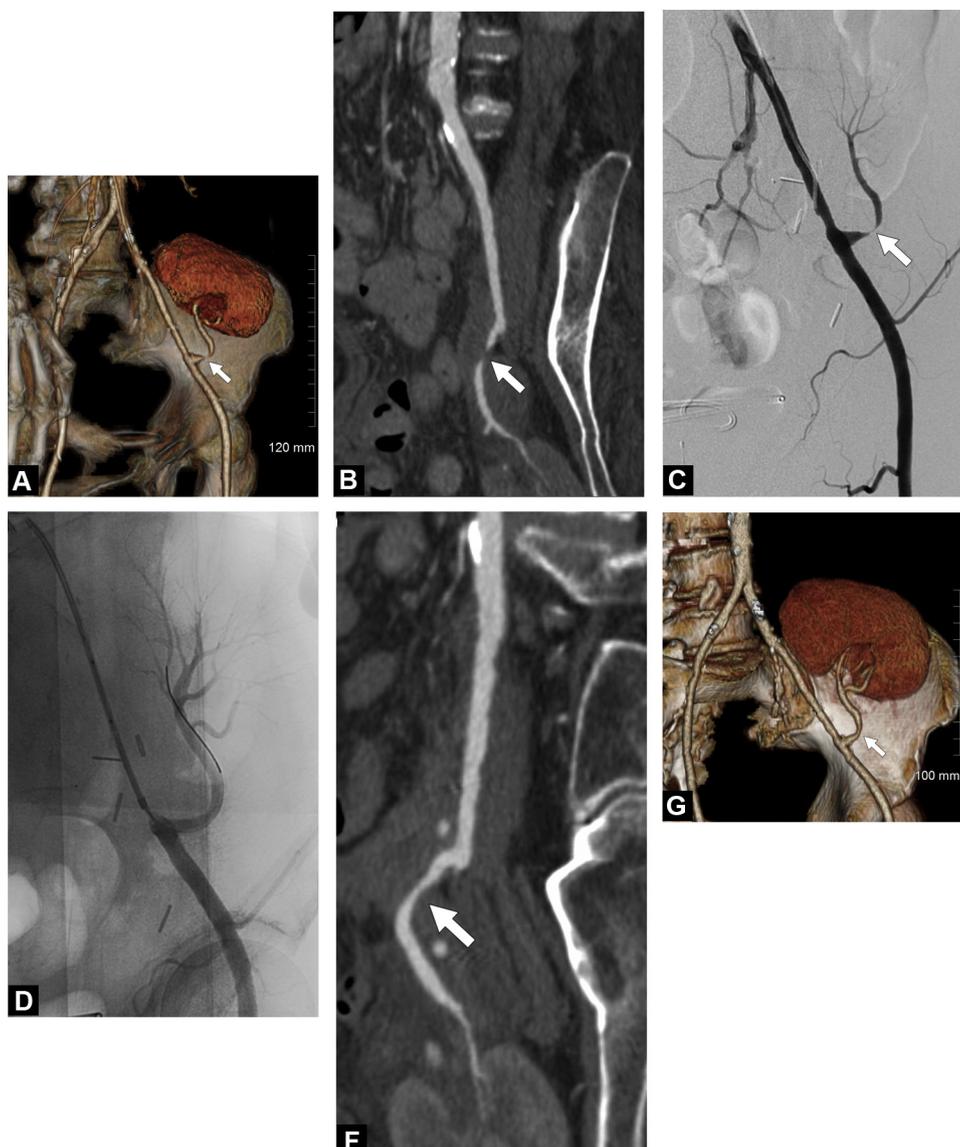


Figure 2. 75-year-old woman with renal artery stenosis after transplantation. A, B: Three-dimensional CT image (A) and curved planar reformation (B) show a very tight stenosis (arrow) of the post-anastomotic segment of the renal artery; C: Angiography confirms tight stenosis (arrow) of the post-anastomotic segment of the renal artery; D: Control angiogram after percutaneous transluminal angioplasty shows no residual stenosis; E, F: CT curved planar reformation and three-dimensional CT image reveal minor residual stenosis at 3 months.

its flexibility and the extreme tortuosity of the vessel. The choice of balloon or self-expandable stent was based on the tortuous nature and location of the lesion (proximal or distal). Balloon and stent sizes were chosen with a slight 5 to 10% oversizing compared to the non-stenosed segment of the renal artery. After deployment, a completion angiography was performed. Hemostasis was obtained by manual compression or using a Perclose ProGlide® 6 F Suture-Mediated Closure System (Abbott). During treatment, a bolus injection of sodium heparin (50 IU/kg) was given and anticoagulant treatments were administered for 24 h. Iomeprol at a concentration of 250 mg of iodine per mL (Iomeron®, Bracco) was used for all angiographic examinations. Antiplatelet therapy (aspirin 50–150 mg/d, or

clopidogrel 75 mg/d) were used for a minimum of 6 weeks post-intervention.

Endpoints

Technical success was defined on final angiography as a residual stenosis < 30%, no flow-limiting dissection and restoration of renal perfusion (i.e. a better visualization of the renal vascularization and the parenchyma). As reported elsewhere, clinical success was assessed at least 1 month after endovascular treatment and confirmed if one or more of the following were present: a reduction in serum creatinine levels of over 15% (stabilization of serum creatinine was also considered a success), a decrease of more than 15%

in mean blood pressure with the number of antihypertensive medicinal products equal to that prior to angioplasty, or a decrease in mean blood pressure of over 10% with a reduction in the number of antihypertensive medicinal products [9].

Complications were classified as major or minor based on the Society of Interventional Radiology (SIR) standard [19]. They were considered to be procedure-related if they occurred within 30 days of percutaneous intervention. Recurrence was suspected when serum creatinine levels and/or blood pressure values increased despite treatment. Following confirmation by ultrasound or MRI, a second endovascular procedure was performed.

Statistical analysis

Tabulation of cohort data was performed using an Excel database. Statistical analysis was performed using MedCalc 12.2.1 (MedCalc). Quantitative data were expressed as means, medians, SD and ranges. Qualitative data were expressed as raw numbers, proportions and percentages. The group of patients treated with PTA alone was compared to the group of patients treated with stents (with or without preliminary PTA) in terms of clinical success, repeat procedure rate, serum creatinine level, MAP and number of antihypertensive medicinal products before and after treatment. Statistical comparisons were performed using the χ^2 test, Fisher exact test and Wilcoxon rank sum test, as appropriate. Statistical significance was set at a $P < 0.05$. Because data were characterized by non-Gaussian distribution, values were expressed as median and range; mean and SD were also reported.

Results

TRAS was suspected because of recurrence of refractory hypertension in 22/31 patients (71%), a worsening in renal function in 22/31 patients (71%) or both in 14/31 patients (45%). Ultrasound examination showed a mean PSV of 338 ± 182 (SD) cm/s (range: 80–950 cm/s); a mean RI of 0.6 ± 0.11 (SD) (range: 0.38–0.8). An increase in TTP (> 20 ms) was observed in 21/31 patients (68%). Renal artery stenosis was also visible on MRI in 16/31 patients (52%) and on CT examination in 3/31 patients (10%). In the other patients, only ultrasound was performed. Clinical parameters before and after treatment are summarized in Tables 1 and 2.

Regarding endovascular treatment, the ipsilateral approach was chosen in 24/31 patients (77%) and the contralateral approach in 6/31 (19%). In one patient with left-side transplanted kidney with two renal arteries, a bilateral approach was needed because one of the renal arteries was too difficult to catheterize using an ipsilateral approach. The arterial anastomosis was the location of TRAS in 14/31 patients (45%). In 13/31 patients (42%), TRAS developed in the post-anastomotic segment of the artery and in 4/31 patients (13%), the stenosis involved both anastomotic and post-anastomotic segments. PTA was performed in 24/31 patients (77%) and a stent was placed in 21/31 patients (68%). An additional stent was used in two patients: one for the presence of two renal arteries,

both of which had recurrent stenosis (Fig. 3), and the other one because of the presence of focal dissection after PTA, which was not sufficiently covered by the first stent (Fig. 4). PTA alone was performed in 10/31 patients (32%).

The technical success rate was 100% (31/31; 100%; 95%CI: 89–100%) as shown by angiography after PTA or stenting. The clinical success rate was 87% (27/31; 95%CI: 71–95%). Complications occurred in 3/31 patients (10%; 95%CI: 3–25%). Two complications, in two different patients, were minor complications consisting in puncture site hematoma that resolved with conservative treatment. The remaining complication was a major complication consisting in one arterial pseudoaneurysm in one patient that was successfully treated with ultrasound-guided compression.

Four patients (4/31; 13%; 95%CI: 5–29%) had stenosis recurrence and underwent reintervention after a period of 3–9 months. Three were treated with PTA alone and one with stent placement. The procedure was repeated for the following reasons: in one patient, restenosis was evidenced at follow-up ultrasound examination. No change in renal function or hypertension. In another patient, an increase in the arterial blood pressure and the appearance of a bruit in the right iliac fossa were indicative of restenosis. This was subsequently confirmed by ultrasound. In the other two patients, renal function deteriorated and was then confirmed on ultrasound. Two patients were retreated with PTA (balloon diameter 6 mm) and the other two with a stent (6×12 mm and 6×18 mm). Arterial blood pressure and serum creatinine levels returned to normal values following this second endovascular procedure in all four patients.

No differences in clinical success rate were found between the stent group (20/21; 95%; 95%CI: 77–99%) and the PTA alone group (7/10; 70%; 95%CI: 40–89%) ($P=0.086$). Similarly, no differences in re-intervention rate were found between the stent group (1/21; 5%; 95%CI: 1–23%) and the PTA alone group (3/10; 30%; 95%CI: 11–60%) ($P=0.086$). Significant differences were found in the stent group between serum creatinine levels after treatment at one month [median, $156 \mu\text{mol/l}$; mean 177.4 ± 64 (SD) $\mu\text{mol/l}$; range 97–355 $\mu\text{mol/l}$] and those before treatment [median $214 \mu\text{mol/l}$; mean 319.4 ± 231 (SD) $\mu\text{mol/l}$; range 108–993 $\mu\text{mol/l}$] ($P=0.0012$). Moreover, there was a significant difference ($P=0.002$) in the same group between MAP after treatment [median 97 mmHg; mean 93.8 ± 10 (SD) mmHg; range 65–110 mmHg] and MAP before treatment [median 107 mmHg; mean 106.7 ± 9.8 (SD) mmHg; range 73–120 mmHg]. No differences in the number of antihypertensive drugs were found between before (median 1) and after treatment (median 2) in the stent group. Conversely, in the group treated with PTA alone no significant differences in serum creatinine levels, MAP values and number of antihypertensive drugs were found between before and after PTA (Table 3).

Discussion

Our study shows that endovascular treatment of TRAS results in 100% technical success and excellent clinical outcomes. Restoration of renal function was achieved in the majority of the patients with a clinical success of 87%. We also observed

Table 1 Demographics of 31 patients with transplant renal artery stenosis.

<i>Patient characteristics</i>	
Age (y)	60.5 ± 14 [24–81]
Men/Women	23/80
Transplant from cadaver	30/31 (97%)
Transplantation-treatment interval(days)*	155 (246 ± 291) [59–1305]
<i>Clinical presentation</i>	
Hypertension	22/31 (71%)
Worsening in renal function	22/31 (71%)
Both	14/31 (45%)
<i>Ultrasound features</i>	
PSV (cm/s)*	300 (338 ± 182) [80–950]
RI*	0.6 (0.6 ± 0.1) [0.38–0.80]
TTP > 20 ms	21/31 (68%)
<i>Endovascular treatment</i>	
PTA	24/31 (77%)
Balloon diameter (mm)*	5 (5 ± 0.9) [3–6]
PTA alone	10/31 (32%)
Stent placement	21/31 (68%)
Stent diameter (mm)*	5 (5.5 ± 0.7) [5–7]
Stent length (mm)*	18 (16.4 ± 6.5) [12–18]
<i>Stenosis location</i>	
Anastomosis	14/31 (45%)
Post-anastomosis	13/31 (42%)
Both	4/31 (13%)

Note: Unless otherwise indicated, the data refer to proportions of patients followed by percentages (%) in parentheses. *Data are median values. Numbers in parentheses are mean ± standard deviation followed by ranges in brackets. PTA = percutaneous transluminal angioplasty; PSV = peak systolic velocity; RI = resistance index.

Table 2 Clinical parameters before and after treatment in 31 patients with transplant renal artery stenosis.

	Before treatment	On discharge	1 month
Systolic blood pressure (mm Hg)	160 (154 ± 18) [100–190]	–	130 (132 ± 17) [95–190]
Diastolic blood pressure (mm Hg)	80 (82 ± 9) [60–100]	–	80 (76 ± 10) [50–100]
MAP (mm Hg)	107 (106 ± 10) [73–123]	–	97 (95 ± 11) [65–130]
Creatinine (μmol/l)	204 (269 ± 205) [108–993]	175 (192 ± 67) [97–378]	155 (173 ± 62) [97–355]
GFR	28.5 (30 ± 17) [4–66]	31.5 (33 ± 13) [12–67]	39.5 (40 ± 15) [16–77]
Number of antihypertensive drugs	2 (1.7 ± 1.2) [0–3]	–	1 (1.4 ± 1) [0–3]

Note: Data are median values. Numbers in parentheses are means ± standard deviations. Numbers in brackets are ranges. MAP = mean arterial blood pressure; GFR = glomerular filtration rate.

a low re-intervention rate (13%) and a low complication rate (10%).

According to published data, a limited number of studies have compared outcomes of stenting to those of PTA alone in TRAS. Since 2000, technical success rates of endovascular treatment of TRAS ranged between 89% and 100% [2,9,11]. In our study, technical success was achieved in all patients. It may be reasonable to assume that the development of new devices has led to improved success rates. For example, the use of pre-mounted balloon-expandable stents with a reduced profile (e.g., some stents can pass over 0.014–0.021-inch guide wires and through 4-F introducers), results in reduced shortening after expansion and good trackability, which are important benefits [9].

Clinical success of endovascular treatment is generally defined by an improvement in arterial blood pressure and/or renal function. Regarding endovascular treatment, using either PTA and/or stenting, clinical success rates of 63% to 94% have been reported [2,3,9,20]. However, the definition of clinical success varies considerably [21]. By comparison with studies that used the same definition of clinical success, it should be noted that we obtained similar results in our investigations [2,9]. Beecroft et al. reported a clinical success rate of 94% but with fewer patients (18 patients vs. 31 patients in our study) [9]. Patel et al. used only PTA to treat TRAS and reported a clinical success rate of 82% when compared to all of our patients while they recorded better results if compared to our patients treated

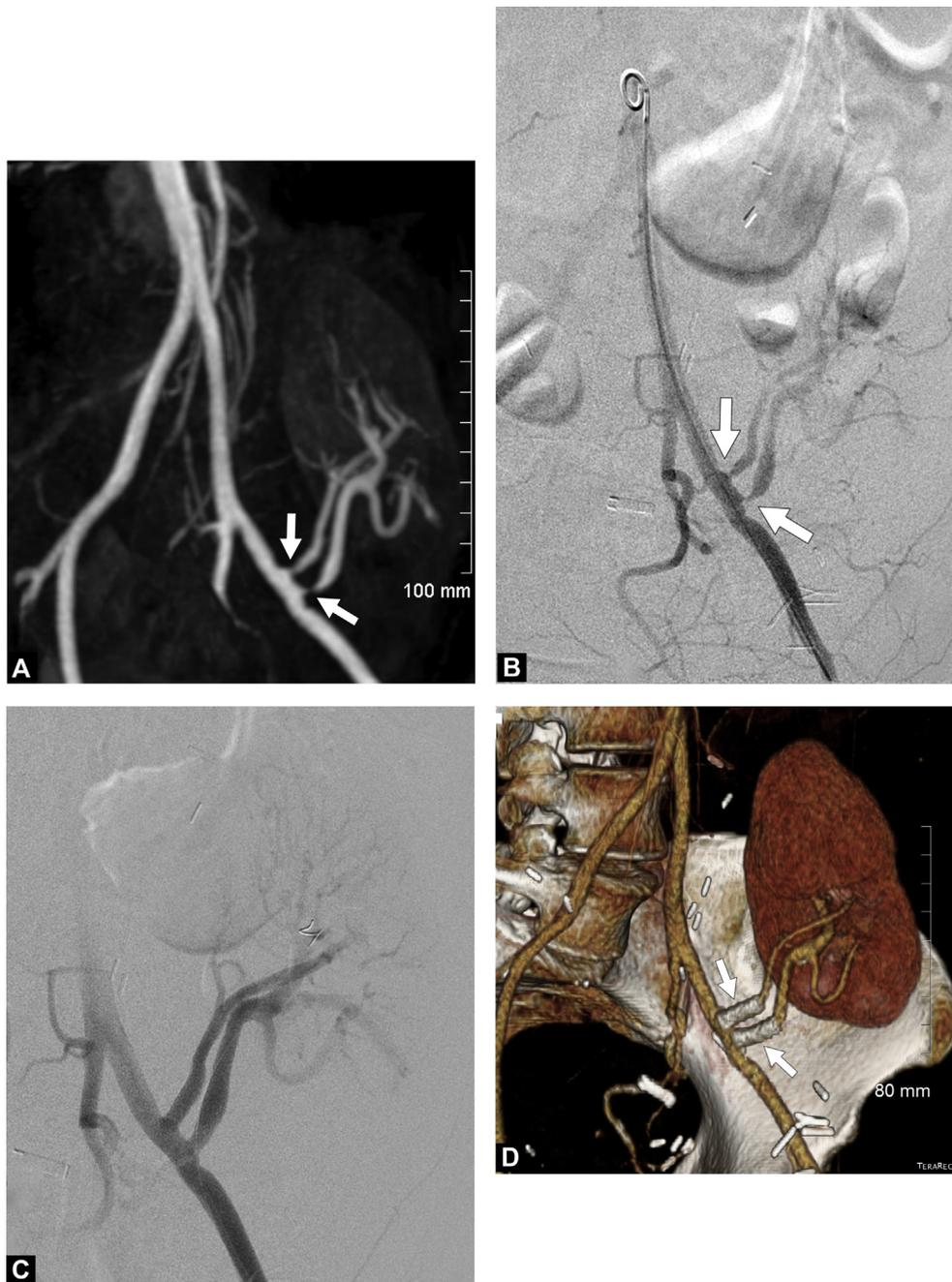


Figure 3. 33-year-old man with renal artery stenosis after transplantation. A: Preliminary MR angiography after intravenous administration of a gadolinium chelate shows two anastomotic stenoses in both renal arteries, B: Angiogram confirms the two stenoses (arrows). C: Angiogram after stent placement shows no residual stenoses. D: Three-dimensional CT image obtained after stent placement confirms stent patency.

with only PTA [2]. These conflicting results confirm the findings of our study in terms of different treatment strategies. We noted no significant differences in clinical success rates with PTA alone (70%) and when using a stent (95%). Further evidence to corroborate the efficacy of stenting is provided by the significant reduction in creatinine values and MAP in the stenting group whereas no significant decrease was found in the PTA only group.

Restenosis is a late complication of the endovascular approach. The reintervention rate is more frequent with PTA alone (19%) compared to stenting (9%) [21].

Furthermore, in our study, re intervention was more common in the group treated with PTA alone (30%) compared to the stent group (5%). Other studies have documented the efficacy of stenting with regard to clinical outcomes, suggesting that this approach is a treatment of choice [9,22–24]. Only a few studies have highlighted the superiority of stenting over PTA alone [3,11,25]. A recent study that compared PTA with stenting for TRAS showed no statistically significant difference in terms of creatinine serum level and blood pressure before and after treatment. However, they did not compare creatinine and blood pressure

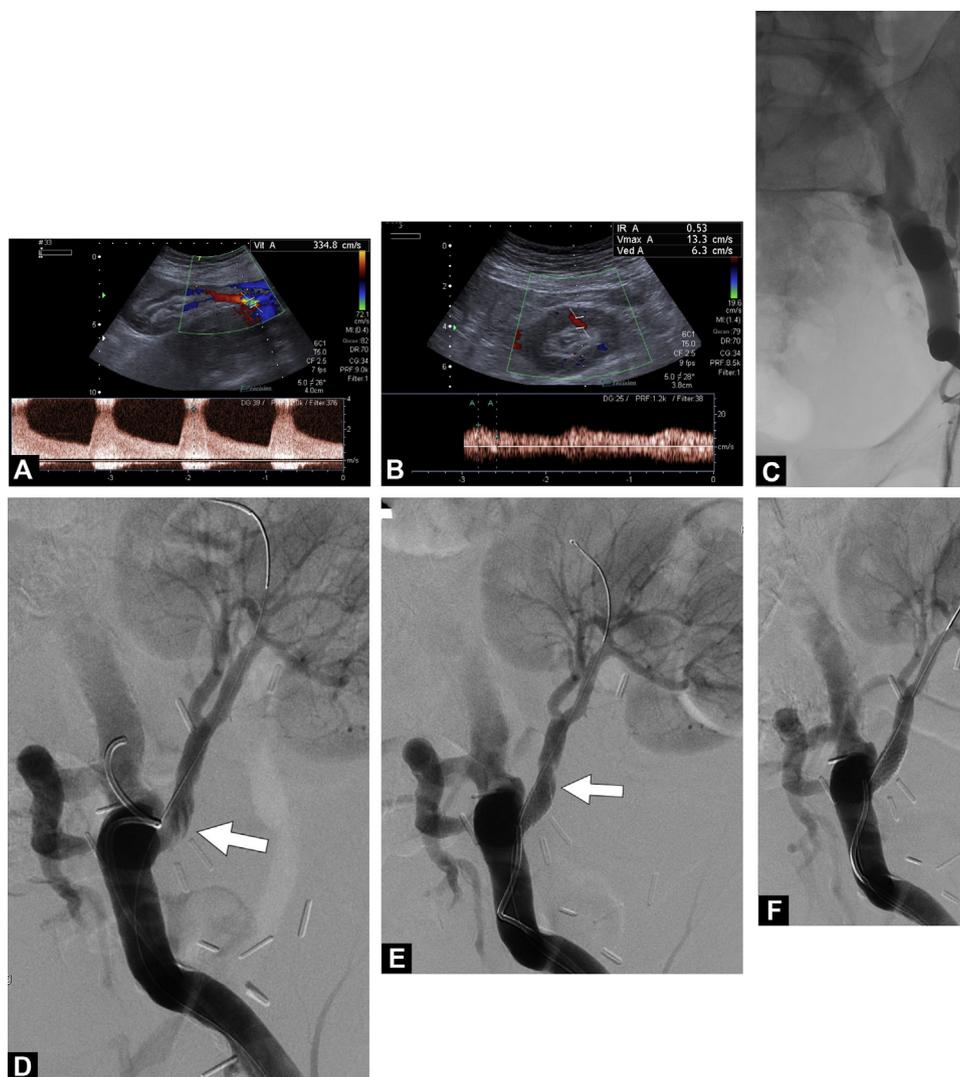


Figure 4. 52-year-old man with renal artery stenosis after renal transplantation presenting with worsening of renal function (creatinine serum level, $210 \mu\text{mol/l}$; GFR, 36 mL/min). A: Ultrasound examination reveals an elevated peak systolic velocity (334 cm/s); B: Ultrasound examination also shows low intraparenchymal resistance index ($\text{RI}=0.53$). These findings suggest the presence of a transplanted renal artery stenosis; C: Angiogram confirms stenosis (arrow) of the transplant renal artery; D: Angiogram obtained immediately after angioplasty reveals focal dissection of the transplant renal artery (arrow); E, D,: Focal dissection was treated with placement of two stents (Tsunami[®] balloon-expandable stent, Terumo).

values before and after intervention within groups. Last, stent placement resulted in fewer cases of restenosis compared with PTA alone [14]. Still, these conclusions should not necessarily limit the use of PTA. This approach should continue to be performed in complex lesions adjacent to bifurcation where stent deployment has to be technically correct with the proximal portion protruding into the iliac vessel. The risk of restenosis increases if the stent protrudes too far [25]. On the other hand, if the stent does not protrude enough, it may not be effective in resolving the stenosis. We also have to understand which stent is better to avoid intimal hyperplasia. Some studies analyzed the differences between bare-metal stents (BMS) and drug-eluting stent (DES) with promising results [25–27]. DES could provide long-term stability in renal function and blood pressure control, thereby reducing the restenosis due to the effects of intimal hyperplasia [26,28].

Endovascular treatment is a low-risk procedure, however some complications including bleeding, arterial rupture, arterial dissection, thrombosis, contrast hypersensitivity, nephropathy, hematoma and pseudo-aneurysm at the puncture site have been reported with the percutaneous approach: [3]. In our study, we had two occurrences of puncture site hematoma which resolved with compression, and one case of a pseudo-aneurysm at the puncture site, which was treated with ultrasound-guided compression. Our complication rate is similar to those reported in prior studies [9,21].

Our study has several limitations. The retrospective design, the limited follow-up period and the limited number of patients are the main limitations of our work. We therefore failed to demonstrate a significant difference in clinical success between PTA alone and stenting. It is difficult to collect extensive data because TRAS is a relatively

Table 3 Comparison between patients treated with PTA alone and those treated with stent (with or without preliminary PTA).

	PTA alone (n = 10)		Stent (n = 21)	
Clinical success <i>P</i> = 0.086	7/10 (70%; 95%CI: 40–89%)		20/21 (95%; 95%CI: 77–99%)	
Reintervention <i>P</i> = 0.086	3/10 (30%; 95%CI: 11–60%)		1/21 (5%; 95%CI: 1–23%)	
	Before	At 1 month	Before	At 1 month
Creatinine serum level (μmol/l)	162.2 ± 44 [113–225] (median, 156) <i>P</i> = 0.76	164.6 ± 60 [103–275] (median, 148)	319.4 ± 231 [108–993] (median, 214) <i>P</i> = 0.0012	177.4 ± 64 [97–355] (median, 156)
MAP (mmHg)	105.2 ± 12 [87–123] (median, 107) <i>P</i> = 0.3	97.5 ± 13 [80–130] (median, 97)	106.7 ± 9.8 [73–120] (median, 107) <i>P</i> = 0.002	93.8 ± 10 [65–0] (median, 97)
Antihypertensive medicinal products*	3 <i>P</i> = 0.062	1	1 <i>P</i> = 0.81	2

Data are expressed as means ± standard deviations (SD) followed by ranges in brackets and median in parentheses. *P* values concerning clinical success and reintervention rate were calculated with Fisher's exact test. *P* values concerning creatinine, MAP and number of antihypertensive medicinal products were calculated with Wilcoxon test. PTA: percutaneous transluminal angioplasty; MAP: mean arterial pressure.

rare condition. Nevertheless, our cohort is still large than those in most recent studies on the subject, and we noted a clear trend in favor of stenting in terms of clinical success and a significant difference in MAP and creatinine levels. A randomized controlled trial should provide answers and help establish when stenting or PTA alone is appropriate in order to further improve the clinical outcome and reduce the reintervention rate.

In conclusion, the endovascular approach is safe and effective in the management of TRAS. Stenting yields better clinical outcomes than PTA alone. Based on our results, it is reasonable to conclude that stenting could be the treatment of choice for TRAS, associated or not with PTA.

Human and animal rights

The authors declare that the work described has been carried out in accordance with the Declaration of Helsinki of the World Medical Association revised in 2013 for experiments involving humans.

Informed consent and patient details

The authors declare that this report does not contain any personal information that could lead to the identification of the patient(s).

The authors declare that they obtained a written informed consent from the patients included in the article. The authors also confirm that the personal details of the patients have been removed.

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Authors contributions

All authors attest that they meet the current International Committee of Medical Journal Editors (ICMJE) criteria for Authorship.

CRedit authorship statement

Marco Macchini: conceptualization, methodology, investigation, writing—original draft preparation. Tema Mokrane supervision. Jean Darcourt: visualization, investigation. Julie Bellière: visualization, investigation. Nassim Kamar: resources. Roberto Candelari: supervision, validation. Hervé Rousseau: supervision, validation. Olivier Meyrignac: methodology, data curation, writing—review & editing.

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Disclosure of interest

The authors declare that they have no known competing financial or personal relationships that could be viewed as influencing the work reported in this paper.

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