Long-term Results of Primary Stent Placement to Treat Infrarenal Aortic Stenosis

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Objective. To determine the safety and the long-term results of primary stent placement for localized distal aortic occlusive disease.

Design. Retrospective observational study.

Patients and Methods. From July 1998 to July 2005 17 patients (14 female and 3 men, mean age 57 years (39–80)) were treated for intermittent claudication. Five of these patients underwent additional endovascular treatment of focal iliac lesions.

Results. Technical success defined as residual stenosis of less than 50% or a trans-stenotic systolic pressure gradient <10% was achieved in 14 of 17 (82%) patients. Major complications included dissection at the puncture site in one patient and thrombosis of additional iliac stents in another patient. Both of these complications were successfully treated. During a mean follow-up of 27 months (range 1–86), four patients had recurrence of symptoms due to in-stent restenoses (n = 2), femoral (n = 1) or iliac occlusion (n = 1), respectively. By Kaplan-Meier analysis, primary aortic hemodynamic patency was 83% at 3 years. Secondary aortic hemodynamic patency was 100%. The primary clinical patency was 68% at 3 years.

Conclusion. Primary stent placement for distal aortic stenoses is an alternative to surgical treatment because of its high patency and relatively low complication rates.

Keywords: Abdominal aorta; Aortic occlusive disease; Endovascular stenting.

Introduction

Focal stenosis of the infrarenal aorta is relatively rare and occurs predominantly in young women who are heavy smokers and have elevated lipid levels.1 Aortic endarterectomy and aortic bypass surgery have been traditional treatment options for these lesions. The long-term results of surgery show excellent patency rates, however, surgery is associated with significant mortality and morbidity rates.2–5 Moreover, in male patients surgical procedures may lead to sexual dysfunction.

Since the 1980s percutaneous transluminal angioplasty (PTA) has been used to treat focal stenosis of the abdominal aorta with encouraging short-term and long-term results.6–16 PTA is less invasive than surgery with less complications and lower costs. Stent implantation may be an efficacious option when PTA fails or is suboptimal.17–26 There are, however, few data on the primary use of stents for treatment of infrarenal aortic stenoses.27–32

The objectives of this study were to evaluate the safety, long-term clinical results and patency rates of primary stent placement for stenosis of the infrarenal aorta.

Patients and Methods

Institutional ethical approval was not required for this study. Seventeen consecutive patients (14 female and three men) with a mean age of 57 (range 39–80) years underwent primary stent placement for focal infrarenal aortic stenosis between July 1998 and July 2005 in two community hospitals, one being a teaching hospital. During the same period no patients were treated surgically for distal aortic stenosis. Patients with involvement of the aortic bifurcation and iliac arteries requiring kissing stents were excluded from this study. Patients’ characteristics are presented in Table 1. All patients presented with moderate or
severe intermittent claudication (category 2 and 3 according to the classification of the Society of Vascular Surgery and International Society for Cardiovascular Surgery (SVS/ISCVS)) and had hemodynamically significant stenosis (>50%) of the infrarenal aorta on color Doppler ultrasound (CDU). All aortic stenoses were caused by obliterating atherosclerosis.

For stent placement a retrograde femoral approach was used under local anesthesia. After placement of an 8 Fr sheath and administration of 5000 IU of heparin intra-arterially, the aortic lesions were transversed with a 0.035 inch hydrophilic guidewire (Terumo, Tokyo, Japan) over which a 5F diagnostic catheter was placed in the abdominal aorta followed by diagnostic digital subtraction angiography of the aorto-iliac tract. Lesion length and types are listed in Table 1. Sixteen patients had a stenosis of the distal aorta and one patient had an occlusion with a length of 2 cm. After pre-dilation of the aortic lesion with an undersized balloon with a diameter of 6–8 mm, a self-expandable nitinol stent (Smart stent, Cordis Johnson and Johnson, Roden, The Netherlands) was placed in 10 patients, and a balloon-expandable stainless steel stent (Palmaz stent n = 6 and a Genesis stent n = 1, Cordis Johnson and Johnson, Roden, The Netherlands) in 7 patients (Fig. 1). There were no strict guidelines for stent selection which was left to the personal choice of the interventional radiologist. The stents had diameters of 9–14 mm and lengths of 20–60 mm. After stent placement the self-expandable stents were post-dilated with a 12–14 mm Opta balloon (Cordis Johnson and Johnson, Roden, The Netherlands). Systolic pressure gradients were measured across the aortic lesion after stent placement and a control angiogram was performed.

Eight patients had an isolated aortic lesion and 9 patients had multi-level disease. In five of these nine patients the aortic intervention was combined with PTA or stenting of stenoses in the iliac arteries and in one patient a femoropopliteal bypass was performed shortly after the aortic stent placement (Table 1). Antiplatelet agents (aspirin 100 mg/day) were continued routinely after the procedure. Patients were also advised to quit smoking and exercise regularly. Other risk factors for atherosclerosis were treated medically.

Follow-up was performed by the vascular surgeon and included assessment of symptoms, physical examination, determination of ankle brachial pressure index (ABPI), treadmill test and CDU of the treated lesions. Assessment was performed at approximately 1, 6 and 12 months after treatment, and with 6–12 months intervals thereafter.

Technical success was defined as a residual stenosis of less than 50% on a post-procedural angiography or a resting trans-stenotic systolic pressure gradient of less than 10%. Clinical patency was defined as either the absence of symptoms or improvement by at least one category according to the SVS/ISCVS classification. Hemodynamic aortic patency was defined as an ABPI greater than 0.90, a minimal increase in ABPI of 0.15, or normal peak systolic velocity (PSV) in the treated lesion (PSV < 200 cm/s, PSV ratio < 2) on CDU after the procedure.

Clinical and hemodynamic patencies of the aortic segments treated with primary stenting were determined with Kaplan-Meier analysis using SPSS statistical software (version 9.0). Primary aortic patency was defined as that achieved after the first stent placement and secondary aortic patency as that achieved after all complementary percutaneous procedures performed during follow-up.

### Results

The characteristics of the patients and treated lesions are presented in Table 1. The majority of patients...
were relatively young women who smoked and had high lipid levels.

According to our definition, stent placement was technically successful in 14 of 17 (82%) patients. Three patients were considered technically unsuccessful. In two patients post procedural angiography showed a residual stenosis of less than 50% but there was a trans-stenotic pressure gradient of 15%. However,
both patients were completely cured of their intermittent claudication and their ABPI returned to >0.9. In the third patient there was a residual stenosis of more than 50% on post procedural angiography and a 15% trans-stenotic systolic pressure gradient after the procedure. She had no improvement of her symptoms and the ABPI increased by only 0.08 in both legs immediately after stent placement. However, at one month follow-up CDU showed a patent aortic stent (maximum PSV of 175 cm/s). In addition, the patients’ iliac arteries were both slightly stenosed and her right superficial femoral artery (SFA) was occluded. Because of severe comorbidity the occluded SFA was treated conservatively.

Major complications occurred in two patients. In one patient post procedural angiography showed a dissection of the common femoral artery at the puncture site which was treated surgically with endarterectomy and Dacron patchplasty. The other patient presented with acute symptoms of her left leg 12 days after she was treated with an aortic stent and bilateral iliac stents. The stents in the left and right common iliac arteries were totally and subtotally occluded, respectively. The patient was successfully treated with intra-arterial thrombolysis with urokinase and subsequent PTA of the residual stenoses in the iliac stents. There were no minor complications in our series.

During a mean follow-up time of 27 months (median 18 months, range 1–86 months) symptoms recurred in four patients. Two of four patients had a restenosis of the aortic stent at 3 and 3.8 years, respectively. One of these patients was successfully treated with in-stent PTA. In the other patient further stent placement was necessary because of residual stenosis accompanied by a pressure gradient of 10% after PTA. In one patient recurrent symptoms were due to occlusion of the superficial femoral artery three months after aortic stent placement, which was treated surgically with a reversed saphenous vein femoro-popliteal bypass. This patient died three months later because of sudden death. The fourth patient, in whom the procedure was complicated by occlusion of the iliac stents 12 days following treatment as described above, developed recurrent symptoms due to restenoses in both iliac stents at 1 year. She has been scheduled for an aortobifemoral bypass operation. These last two patients had deterioration of ABPI of more than 0.15 but their aortic stent was patent at CDU.

Primary aortic patency was 83% at 3 years and 55% at the end of follow-up (86 months) (Fig. 2). Secondary aortic patency was 100% at the end of follow-up. The primary clinical patency was 94%, 88%, 81%, 68% and 45% at 1, 3, 12, 36 and 44 months, respectively (Fig. 3).

PTA of abdominal aortic stenosis is less invasive and less expensive than surgical therapy. Because of encouraging primary (>70%) and secondary (>85%) patency rates, PTA has been advocated as the initial treatment modality for distal aortic stenosis. Stent implantation after failed PTA may increase the success rate. Theoretical disadvantages of PTA alone may be distal embolization, especially in complex stenoses such as eccentric, irregular, ulcerated or...
calcified lesions, as well as the risk of aortic rupture during dilation because of the larger diameter of the abdominal aorta (according to the law of Laplace).34 For these reasons primary stenting may be preferable to balloon angioplasty.

To our knowledge there are only 6 studies in the literature reporting primary stenting of focal distal aortic stenoses27–32 (Table 2). All series including the present study have small patient numbers due to the rare occurrence of the disease. The patient population differs from the usual atherosclerotic cohort. The majority of patients are relatively young females who are heavy smokers and have elevated lipid levels but have less extensive atherosclerotic disease than patients who present with iliofemoral or more distal disease. This explains why the mean pre-treatment ABI is relatively high. Furthermore, aortic stenosis is often associated with the hypoplastic aortoiliac syndrome.35 Early onset of symptoms in these patients is explained by the presence of small diameter vessels with obstruction of the lumen by atherosclerotic plaques.

Reported technical success of primary aortic stenting ranges from 87% to 100%, depending on the definition by the author. We had a slightly lower technical success rate of 82%. However, in the three patients with an unsuccessful technical result of stent placement according to our definition (i.e. trans-stenotic systolic pressure gradient >10%), the aortic stent was patent at CDU and two of three patients were completely cured of their intermittent claudication. Dietrich et al.20 considered complete resolution of the pressure gradient as the only end point for successful angioplasty. However, it should be stressed that the importance of the residual pressure gradient that may be tolerated after stent placement of the infrarenal aorta is unknown, and many patients are reported to be free of symptoms after aortic PTA or stenting despite residual pressure gradients.7,32

The mid- and long-term aortic patency rates in the literature range from 83% to 100% and can be considered as excellent. Furthermore, secondary patency was 100% in all studies. These numbers seem consistent although conclusions still may be difficult to draw because of the relatively small number of patients, differences in patient selection and follow-up periods. The first three studies in Table 2 for example have not determined patency rates with the Kaplan-Meier analyses, i.e. follow-up period are not taken into account. Primary patency rates in these studies are generally higher than in the last three studies, but their follow-up periods are shorter.

The clinical success rate in our study of 68% at 3 years was lower than the stent patency which is explained by stenosis or occlusions not related to the

<table>
<thead>
<tr>
<th>Author and year</th>
<th>No of patients</th>
<th>Mean age (range)</th>
<th>Stenosis/occlusion</th>
<th>Technical success (BT)</th>
<th>Complications (minor/major)</th>
<th>Technical complications</th>
<th>Follow-up months (mean, range)</th>
<th>Kaplan-Meier analyses</th>
<th>SP aorta (%)</th>
<th>PP aorta (%)</th>
<th>Local recurrence symptoms</th>
<th>PP aorta (%)</th>
<th>Secondary patency (with reinterventions)</th>
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Cld = Intermittent claudication, CI = Critical ischemia, BT = Blue toe syndrome, PP = Primary patency, SP = Secondary patency.
aortic segment in three of five patients with clinical deterioration at follow-up. Other studies also report recurrence of symptoms to be higher than recurrence of local aortic stenosis for the same reasons (Table 2).

Two major complications occurred in our study. Dissection of the puncture site was successfully treated with endarterectomy and a Dacron patch. In the other patient the iliac stents trombosed but the aortic stent remained patent. Thus, these complications were indirectly related to the aortic stent placement. Complications such as aortic rupture and distal embolization with limb loss did not occur in our study or in the other studies regarding primary stenting.

In our study there was one patient with a local occlusion of the distal aorta. At the time of diagnosis a severe stenosis was observed on CDU, but angiography immediately before stenting showed an occluded aorta. The occlusion was easily transversed with a guide wire and the stent was successfully deployed. Reports on treating aortic occlusions with endovascular techniques are limited and its role remains to be defined.29,36

In summary, primary stent placement in infrarenal aortic stenosis is a safe and minimal invasive treatment with promising long-term patency. Although there are no randomised trials that compare surgery, PTA and primary stent placement, we believe that the good results in our study and that in other series confirm that endovascular treatment of local distal aortic stenoses should be considered the first line treatment and that primary stenting should be the treatment of choice in a properly selected patient population.

References


28 Stockellhuber BM, Messner O, Stockellhuber M, Wessmann M, Keijfer G. Primary endovascular stent placement for focal


33 Rutherford RB, Becker GJ. Standards for evaluating and reporting the results of surgical and percutaneous therapy for peripheral arterial disease. Radiology 1991;177:277–281.


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