Percutaneous Endovascular Treatment for Stenoses and Occlusions of Infrarenal Aorta and Aortoiliac Bifurcation: Midterm Results

B. J. d’Othée1, S. Haulon2, C. Mounier-Vehier3, J. P. Beregi1*, O. Jabourek3 and S. Willoteaux1

Departments of 1Vascular Radiology, 2Vascular Surgery and 3Hypertension and Vascular Disease, Hôpital Cardiologique, Centre Hospitalier Régional Universitaire (C.H.R.U.) de Lille, Lille, France

Objective: evaluation and comparison of the endovascular treatment of isolated aortic and aortoiliac atherosclerotic lesions (stenoses and occlusions).

Methods: a percutaneous endovascular procedure was performed in 52 patients (38 men and 14 women) with a mean age of 52 years (range, 25–85 years). The baseline angiogram showed 35 aortic lesions (31 stenoses, 4 occlusions) and 17 aortoiliac lesions (14 stenoses, 3 occlusions). Percutaneous techniques used in this series included variable combinations of transluminal angioplasty and stenting. All stents placements were performed over-the-wire using the transfemoral route (most often bilateral approach). Clinical examination and Duplex-scan were performed at discharge, 1 month, 6 months, 12 months, and then yearly.

Results: technical success was 100% for aortic and aortoiliac lesions. Angiographic success rates were comparable for aortic (91%) and aortoiliac (94%) lesions. No death occurred during or early after the endovascular intervention. Duplex-scan confirmed 100% patency rate at discharge. There was no significant difference between the aortic (94%) and aortoiliac (96%) groups regarding immediate clinical improvement. Mean follow-up was 34 ± 31 months (range, 0–130 months). The cumulative primary patency rate at 36 months was 85% in the aortic group and 86% in the aortoiliac group. Clinical success, defined as a symptom-free status at the end of follow-up, was also similar in both groups.

Conclusion: endovascular treatment of isolated aortic lesions of the infra-renal aorta has favorable outcomes comparable to those of aortoiliac lesions.

Key Words: Aorta; Stenosis; Occlusion; Angioplasty; Stent; Iliac.

Introduction

As opposed to the coronary, iliac, and femoral arteries, a more limited literature has focused on percutaneous treatment for stenoses of the infrarenal aorta.1–7 After the first isolated case reports8–11 in the early 1980s, some of the first cohort studies12–16 (1989–93) mixed lesions involving the infrarenal aorta with those located at the aortoiliac bifurcation. Later and larger retrospective cohort reports1,2,4,17–19 (1994–98) excluded appropriately pure iliac lesions. However, all but two1,2 of these studies were based on groups that did not exceed 25 patients and had limited follow-up.17–41 Two articles, published in 19962 and 19981 respectively, have reported larger series of patients having undergone endovascular treatment for aortic stenoses (n = 38 and 102 respectively). In these reports, the endovascular option proved to be safe, efficacious, and less invasive than open surgery,3,18,20,22 with no need for abdominal incision and general anaesthesia, lower morbidity and mortality, shorter procedure time and hospital stay, and lower cost. Preservation or improvement of sexual function in males was also reported with both PTA2 and stent placement.15 More recent investigations have suggested that stent placement in the abdominal aorta was a valuable therapeutic strategy in case of unsuccessful or suboptimal balloon angioplasty.5,15,16,26

To date, the literature on endovascular therapy of the infrarenal aorta has included mostly stenotic lesions, the treatment of aortic occlusions being reported in 29 patients only.15,16,23,30,33,41 To our knowledge, there has not been any report comparing specifically the results of endovascular treatment in aortic versus aortoiliac lesions, and many series have mixed both, sometimes without making any difference between them. The purpose of the present study was to compare the short and midterm outcome of both groups with updated criteria for classifying risk factors,42–44 and the type of aortic lesion.45

* Please address all correspondence to: J.-P. Beregi, Department of Vascular Radiology, Hôpital Cardiologique, CHRU de Lille, 59037 Lille Cedex, France.
Methods

Population

Over a 130 month period, a percutaneous endovascular procedure was performed for the treatment of aortic or aortoiliac obstructive disease in 52 consecutive patients (38 men and 14 women) with a mean age of 52 years (range, 25–85 years). The cardiovascular risk factors (SVS/ISCVS grade ≥ 2), and the clinical status of the patients (SVS/ISCVS classification) before the endovascular procedure, are reported in Table 1. The indications for treatment included moderate or severe claudication according to the SVS/ISCVS classification in most cases, but also a blue toe syndrome in two patients and a Leriche syndrome in two other patients. Patients with critical ischemia were treated by conventional surgery.

Table 1. Cardiovascular risk factors (SVS/ISCVS grade ≥ 2), and clinical status (SVS/ISCVS classification), of the 52 patients before the endovascular procedure.

<table>
<thead>
<tr>
<th>Category</th>
<th>Aortic group (n = 35)</th>
<th>Aortoiliac group (n = 17)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean age (range)</td>
<td>53 (35–85)</td>
<td>51 (25–66)</td>
</tr>
<tr>
<td>Sex (M/F)</td>
<td>23 (66%)/12</td>
<td>15 (88%)/2</td>
</tr>
<tr>
<td>Tobacco use</td>
<td>21 (60%)</td>
<td>12 (71%)</td>
</tr>
<tr>
<td>Diabetes</td>
<td>5 (14%)</td>
<td>4 (24%)</td>
</tr>
<tr>
<td>Hypertension</td>
<td>16 (46%)</td>
<td>5 (29%)</td>
</tr>
<tr>
<td>Hyperlipidemia</td>
<td>15 (43%)</td>
<td>8 (47%)</td>
</tr>
<tr>
<td>Cardiac status</td>
<td>10 (29%)</td>
<td>2 (12%)</td>
</tr>
<tr>
<td>Carotid disease</td>
<td>5 (14%)</td>
<td>2 (12%)</td>
</tr>
<tr>
<td>Renal status</td>
<td>3 (9%)</td>
<td>0</td>
</tr>
<tr>
<td>Respiratory status</td>
<td>1 (3%)</td>
<td>0</td>
</tr>
<tr>
<td>Moderate claudication</td>
<td>15 (43%)</td>
<td>8 (47%)</td>
</tr>
<tr>
<td>Severe claudication</td>
<td>20 (57%)</td>
<td>9 (53%)</td>
</tr>
</tbody>
</table>

Pre-interventional angiographic findings

The baseline angiogram showed 35 aortic lesions (31 stenoses, 4 occlusions) and 17 aortoiliac lesions (14 stenoses, 3 occlusions).

The 35 aortic lesions consisted of class I lesions in 14 patients, class II lesions in 11 patients, class III lesions in 6 patients, and class IV lesions in 4 patients (Fig. 1a). The median length of these aortic lesions was 2 cm (range, 0.5–7 cm) and was poorly correlated to the initial claudication distance (ICD) for either the whole cohort, the aortic group, or the aortoiliac group.

Table 2. Classification of isolated lesions of the infrarenal abdominal aorta on the basis of the classification of the American Heart Association Task Force on Peripheral Percutaneous Transluminal Angioplasty.

<table>
<thead>
<tr>
<th>Category</th>
<th>Short segment stenoses of the infrarenal abdominal aorta (less than 2 cm long) with minimal atherosclerotic disease of the aorta otherwise</th>
</tr>
</thead>
<tbody>
<tr>
<td>Category II</td>
<td>Medium-length stenoses of the infrarenal abdominal aorta (2–4 cm long) with mild atherosclerosis of the aorta otherwise</td>
</tr>
<tr>
<td>Category III</td>
<td>Long segment stenosis of the infrarenal abdominal aorta (&gt; 4 cm long), aortic stenosis with atheroembolic disease (blue toe syndrome), or medium-length stenosis of the infrarenal abdominal aorta (2–4 cm long) with moderate to severe atherosclerosis of the aorta otherwise</td>
</tr>
<tr>
<td>Category IV</td>
<td>Aortic occlusions and aortic stenoses associated with an abdominal aortic aneurysm</td>
</tr>
</tbody>
</table>

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Endovascular procedure

Procedures were performed in the angiosuite, or in the operating room by a combined radiosurgical team. Percutaneous techniques used in this series included variable combinations of PTA and stenting. The sizing of balloons and stents was based on measures provided by arteriography and, when available, CT angiography (Fig. 1b). Angioplasty was performed either by inflation of a single large balloon above the aortic bifurcation or by the kissing balloon technique, depending on the anatomic distribution of the lesions. Primary stent insertion was achieved in two patients who presented with bilateral blue toe syndrome. Secondary placement was performed in the other stented cases, based on the presence of suboptimal PTA results. Suboptimal PTA result was defined as haemodynamic failure (i.e., residual systolic pressure gradient above 20 mmHg and/or residual mean pressure gradient above 10 mmHg without vasodilation pharmacologic test) and/or angiographic failure (i.e., residual stenosis >50%). All stents placemnts were performed over-the-wire using the transfemoral route (most often bilateral approach).

Anticoagulation and antithrombotic treatment

In all cases, acetylsalicylic acid (160 mg/day) was started at least 10 days before the procedure and continued after the procedure. During the procedure, a 2500 IU intravenous or in situ (intraarterially) bolus of heparin was administrated. If a kissing stent implantation was performed, acetylsalicylic acid (160 mg/day) was combined with ticlopidine (250 mg/day) after the procedure during 6 weeks.

Follow-up

Clinical examination and Duplex-scan were performed at discharge, 1 month, 6 months, 12 months, and then yearly. Data from the clinical and imaging follow-up were updated by phone contact and/or by appointment when necessary. A restenosis was considered significant on Duplex-scan when >50%.

Statistical analysis

Statistical analysis was performed to compare either (1) the aortic group (35 patients) versus the aortoiliac group (17 patients), or (2) aortic stenoses (31 patients) versus aortoiliac stenoses (14 patients). Patients with occlusive lesions were not used by themselves as independent samples because of their small number (n = 4 and 3, respectively).

After checking for normal distribution and homogeneity of variance of every variable, bivariate statistical analysis was performed using non-parametric
tests (Student’s *t*-tests). Survival curves were built using the Kaplan–Meier method and differences between the aortic and aortoiliac groups were studied by using the log rank, Breslow, and Tarone–Ware tests. A *p* value < 0.05 was considered significant in all statistical analyses.

**Results**

**Population**

To test for homogeneity of RFs distribution between aortic and aortoiliac groups, comparisons were conducted on all the predictors listed in Table 1. There was no statistically significant difference between both groups in any of these factors. When comparing aortic stenoses versus aortoiliac stenoses for the same variables, the only statistically significant difference was gender: there was a higher (*p* < 0.014) male predominance (14M/0F) in the later group as opposed to a lower male-to-female ratio (21M/10F) in the former.

Comparisons between aortic and aortoiliac groups (all lesions), as well as those between aortic and aortoiliac stenoses, did not show any significant difference in terms of initial presenting symptoms (either SVS/ISCVS classification or initial claudication distance [ICD]).

**Endovascular procedure**

Technical success at the end of the procedure (endovascular treatment performed and mean pressure gradient <15 mmHg at the end of the procedure) was achieved in all patients. Technical success was therefore 100% for aortic and aortoiliac lesions. Angiographic success at the end of the procedure (defined as a residual stenosis <30% in diameter) was achieved in all patients with occlusions (Fig. 1c) (i.e., 4 class IV aortic lesions and 3 aortoiliac occlusions). Among aortic stenoses, one patient in each class had a significant residual endoaortic bud, but the pressure gradient had returned to normal values. In aortoiliac stenoses, one patient also had an imperfect angiographic result but no further treatment was deemed necessary. Overall, there was no significant difference in early angiographic success rates between the aortic (91%) and aortoiliac (94%) groups nor between aortic (90%) and aortoiliac (93%) stenoses.

Early and late complications after the endovascular procedure are summarised in Table 3. No death occurred during or early after the endovascular intervention.

Duplex-scan confirmed 100% patency rate at discharge. The immediate clinical outcome was defined according the SVS/ISCVS criteria on a scale of −1 to +3 for symptoms. There was no significant difference between the aortic (94%) and aortoiliac (96%) groups nor between aortic (95%) and aortoiliac (97%) stenoses regarding immediate clinical improvement.

**Follow-up**

Mean follow-up was 34 ± 31 months (range, 0–130 months). Complete follow-up clinical and duplex-scan data were available in 47 patients (90%). The five other patients were lost to follow-up. Follow-up length was not significantly different between aortic versus aortoiliac groups, nor between aortic and aortoiliac stenoses.

Among class I aortic stenoses patients, one developed an aortic restenosis (>50%) at 37 months of follow-up and was successfully treated by stent placement. In another patient, a focal aortic dissection associated with a 2 cm-diameter pseudoaneurysm was diagnosed at 25 months follow-up.

Class II and class III patients had no complications or events during the follow-up. In one patient with a class IV lesion, intrastent restenosis occurred 11 months after the initial procedure and was treated by PTA with subsequent disappearance of the pressure

<table>
<thead>
<tr>
<th>Table 3. Early and late complications according to the arterial lesion.</th>
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<tbody>
<tr>
<td>Lesion (n)</td>
</tr>
<tr>
<td>Aortic stenoses (31)</td>
</tr>
<tr>
<td>&amp; Aortic dissection</td>
</tr>
<tr>
<td>&amp; Iliac occlusion</td>
</tr>
<tr>
<td>Aortic occlusions (4)</td>
</tr>
<tr>
<td>Aortoiliac stenoses (14)</td>
</tr>
<tr>
<td>Aortoiliac occlusions (3)</td>
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Iliac: Common iliac artery.
gradient. One patient treated for aortoiliac stenoses presented a late thrombosis of the aortoiliac carrefour and was referred to surgery.

The early and late complication rates were similar in the aortic and aortoiliac groups. Delayed mortality was related to a bronchial carcinoma in one patient (death at 54 months), coronary artery disease in two patients (death at 33 and 34 months) and an undetermined cause in one patient (death later than 34 months).

All these four patients had experienced complete relief of their symptoms during the first 2 years of follow-up. The difference in mortality rates was not statistically significant between the aortic and aortoiliac groups (two patients with aortic stenoses, two patients with aortoiliac lesions). Similar conclusions were drawn when comparing aortic and aortoiliac stenoses.

In the aortic group, the cumulative primary patency rate was 93% at 12 and 24 months, and 85% at 36 months. In the aortoiliac group, the cumulative primary patency rate was 94% at 12 and 24 months, and 86% at 36 months.

According to the results of the Kaplan–Meier survival analysis (Fig. 2), the cumulative primary patency rates were similar in the aortic group and in the aortoiliac group. Clinical success, defined as a symptom-free status at the end of follow-up, was also similar in both groups. When including both symptom-free and mild claudicant patients in the definition of clinical success, both groups were also comparable.

Discussion

Obstructive disease of the infrarenal aorta may present as an isolated aortic obstacle and/or an obstructive involvement of the aortoiliac bifurcation. In the first case, isolated stenoses of the distal aorta are believed to involve a special subset of patients. They may consist of a typical endoaortic bud ("coral reef"), either calcified or not, and this presentation seems more frequent in young smoking women. Their exact pathogenesis still remains partially unclear, even if several authors consider it as a particular manifestation of aortic atherosclerosis. In the second and more common case, the involvement of the aortoiliac carrefour by obstructive material is classically considered as a typical manifestation of atherosclerosis with its preferential location at vessel bifurcations. As such, its occurrence is influenced by the same risk factors as other presentations of atherosclerosis, and therefore is more frequent in elderly and male patients.

Plaque ulceration may also present as a blue toe syndrome, which has been previously described as an interesting indication for primary aortic stenting as this technique reportedly reduces the risk of distal embolization from such lesions. In the present study, however, no difference was shown between lesions of the infrarenal aorta alone and lesions of the aortoiliac bifurcation. Also, the class of aortic lesion does not seem to influence the outcome, either in terms of technical success, patency, complication or mortality rates. The relevance of these findings could warrant further prospective studies, as they support the hypothesis that the results of endovascular treatment could be similar at both levels and thus this could lead one to rethink the respective indications for endovascular and open surgical treatment. Whereas the indications of both options are now well codified at the level of the aortic bifurcation, their relative role at the infrarenal level (as well as the relative role of PTA versus stenting) could warrant further prospective studies.

Despite the progressive emergence of appropriate guidelines over more than a decade, cardiovascular risk factors (RFs) have not been used systematically in the literature on endovascular treatment of the aorta to date. In the present series, all but one of the RFs (gender) were similar in both groups. Although most series have reported a female predominance, the male predominance found in both groups of the present series is a feature that had also been reported by others.

Probably the most controversial issue remaining to date is the assessment of the early and late results of the procedure. As agreed on by most authors, we believe that an imperfect cosmetic result on DSA or CT is not an indicator of immediate failure of the intervention. One would intuitively expect that the presence of a heavily calcified endoaortic bud could preclude an appropriate opening of the stent or
impinge a fully unwaisted inflation of the balloon during PTA. However, some cases in our series showed remarkable adaptation over time of the aortic wall contralateral to the bud so that a nearly normal aortic caliber could be obtained. This is in accordance with the presence of a “remodelling” phenomenon, which has also been described after PTA of native coarctations of the aortic isthmus. The lack of correlation between imaging and symptoms was also present in several of our patients treated either by PTA or stent insertion. For example, three of our patients remained completely asymptomatic despite residual reductions in aortic diameter of 20, 30 and 40% respectively.

Like open surgery, the percutaneous approach is by no means restricted to treating the aorta only. In the aortic group, we treated associated renal arterial stenoses in four patients and iliac lesions in five patients by PTA and/or stenting. In the aortoiliac group, five patients were also treated for other concomitant iliac lesions during the initial procedure.

The major complications of endovascular treatment reported in the literature are of three main types: aortic rupture, aortic dissection, and distal emboli. Regarding the first one, many authors have invoked the Laplace’s law to claim that the aorta was at higher risk than smaller arteries (wall stress = \([\text{pressure} \times \text{radius}] / [2 \times \text{wall thickness}]\)). It is commonly assumed that the size of the PTA balloon should be equal or inferior to the diameter of the lumen of the healthy aortic portion immediately upstream. In our series, 20 mm and even 25 mm-wide balloons have been used in some patients; no aortic rupture has occurred, and the two cases of pseudoaneurysms discovered during the follow-up had had balloons of only 14 and 16 mm in diameter, respectively. There might be other factors involved in the rupture mechanism. For instance, Laplace’s law does not explain by itself why, in general, PTA-related ruptures occur more frequently in the external than the common iliac arteries, thus pleading in favor of the existence of other parameters such as vessel wall structure. Calculifications had been suspected by early investigators as a risk factor for aortic rupture. Since then, however, PTA has been performed in calcified aortic stenoses with good technical and clinical outcome. In a literature review, we found 606 reported patients treated percutaneously between 1980 and 2000; among them, only one case of aortic rupture had been reported and it occurred in 1986. In that case, manual pressure was applied to inflate the PTA balloon, as opposed to the use of an inflation device. On the other hand, multivariate analysis suggests that the frequency of symptom recurrence decreases as the dilatation diameter of the PTA balloon increases. Our results and the opinion of others also support the idea that PTA and/or stenting of the infrarenal aorta carries a very low risk of rupture. Secondly, an aortic dissection may also occur as a complication of the procedure. This has been scarcely described during aortic PTA, although minor residual dissections without significant hemodynamic consequences are probably a common occurrence. We have also observed such cases with small and non obstructive dissections after PTA, sometimes persisting and stable for more than 7 years. This “complication” has probably been underreported, as its clinical relevance is probably minor except in the case of pseudoaneurysms developing during the follow-up. The exact risk of developing pseudoaneurysm complications is therefore difficult to determine from the currently available data. Thirdly, there has been some concern that procedures at the level of the infrarenal aorta could be associated with distal embolization and local complications at the femoral puncture site, although this has in fact been reported in two cases only. The risk of distal embolization also exists during surgery. Distal embolization occurred in only one of our patients in whom in situ thrombolysis was performed as an adjuvant therapy and resulted in clinical success with no major bleeding complication. Usually, these emboli do not go farther than the bifurcation of the common femoral artery, as experienced by us as well as by others. There are several potential limitations to our study. First, this is a retrospective cohort study. Second, patients’ symptoms could not be reliably classified according to the SVS–ISCVS system as the Leriche and Fontaine classification remains the prevailing one in everyday clinical practice at our institution, as is the case in most parts of the world. Third, some data were sometimes impossible to obtain in certain cases, such as the ABI and intraarterial pressure measurements and gradients. Fourth, the decision process used by each contributing investigator during the treatment of these lesions was not standardised; however, all methods of treatments were usual and accepted at the time of treatment. Several primary operators were involved in these percutaneous procedures, and technical evolution of the percutaneous materials occurred during the nearly 11-year period encompassed in this study. Thus, because this manuscript encompassed a long time frame, its main aim was to study the overall results of endovascular treatment, not to report the comparative results of each technical variant included in this series. In conclusion, the outcome of endovascular treatment of infrarenal aortic stenoses and thromboses should be assessed as a multidimensional entity. The relative indications of
each therapeutic modality available have yet to be precisely. Therefore, after more than two decades of experience, time has hopefully come to answer that essential question in a multicentre randomised controlled trial comparing angioplasty, stenting, and open surgery.

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