Endovascular Treatment of Penetrating Aortic Ulcers: Mid-term Results

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Objectives. The aim of this study was to evaluate mid-term results of endovascular treatment of penetrating aortic ulcers.

Methods. Between February 2000 and November 2006, 18 consecutive patients underwent endovascular treatment of the descending thoracic aorta (N = 16) and abdominal infrarenal aorta (N = 2) for penetrating aortic ulcer, in a single University Hospital. Data were prospectively collected and retrospectively analyzed. Mean follow-up was 41 months (range 4 to 77 months).

Results. Technical success was achieved in all patients. No perioperative deaths occurred. No conversion to open repair or secondary procedures were required. Two patients died in the follow-up period for reasons not related to penetrating aortic ulcers. One type II endoleak was observed. It was still present, unchanged, twelve months after the procedure.

Conclusion. Endovascular treatment of penetrating aortic ulcers of the descending thoracic and infrarenal aorta were safe and effective in the mid-term in this small series of patients.

Keywords: Penetrating aortic ulcer; Stent-graft; Acute aortic syndrome; Thoracic aorta.

Introduction

Penetrating Aortic Ulcer (PAU), intramural hematoma, and aortic dissection are the three entities of the acute aortic syndrome.1 These three, etiologically different conditions, are closely related due to the similar clinical presentation and eventual catastrophic progression.1 PAU can progress to intramural hematoma, which can progress to aortic dissection. PAU can also directly progress to aortic dissection, or aneurysm/pseudoaneurysm formation, or aortic perforation. Shennan2 first described PAU of the thoracic aorta in 1934. The natural history of the disease remains unclear and little information is available in the literature.3,4 In 1959, Shumacker and King5 reported the first successful surgical repair of a ruptured descending aorta caused by a PAU. Surgical management of PAU is associated with a mortality of 5% to 20%.6 Thoracic and abdominal aortic endografting is routinely performed for aneurysmal and dissection disease in many specialized centers around the world, and is associated with less peri-procedural morbidity and mortality.7,8 The aim of this study was to evaluate mid-term results of endovascular treatment of PAU in a single institution settlement.

Materials and Methods

Patients

From February 2000 to November 2006, 18 consecutive patients underwent endovascular treatment of the descending thoracic aorta (N = 16) and abdominal infrarenal aorta (N = 2) for PAU. All patients were symptomatic for aortic pain at admission. Non-symptomatic patients with accidental findings of aortic lesions were not included in this study.

Initially, medical treatment was offered to 16 patients with PAU by means of aggressive anti-hypertension therapy and analgesic agents with β-blockers, nitroprussate, painkillers, continuous electrocardiogram and continuous non-invasive arterial pressure measurements in a high dependancy unit. Two patients presented with contained ruptures and peri-aortic haematoma of the descending aorta limited to the peri-adventitial space were included in the study and were treated in emergency conditions with stent-grafting. Aortic imaging at admission and every 24 hours for monitoring of eventual progression of the lesion.
was also performed. Intramural haematoma was associated in 4 patients with descending thoracic PAU. The mean longitudinal extension was 2.8 cm. Median time between admission and stent grafting was 2 days (range 1–4 days).

Indications for treatment included chest pain in 4 patients (22.2%), back pain in 8 patients (44.5%), combined chest and back pain in 4 patients (22.2%) and abdominal pain in 2 (11.1%) patients. Patients with intramural hematoma or classic aortic dissection, or predominantly aneurysmal dilatation were excluded for the study. Mean time between admission and treatment in the 16 stable patients was 3 days.

Written informed consent for vascular access and stent-graft placement was obtained from every patient.

Aortic imaging

All patients underwent a pre-interventional trans-thoracic echocardiography for cardiological function evaluation, combined with contrast-enhanced ECG-gated multidetector computed tomography or magnetic resonance angiography. Transesophageal echocardiography was performed intraoperatively in 3 patients (16.6%). Digital subtracted aortography was performed in all patients intraoperatively. Follow-up imaging was obtained with contrast-enhanced computed tomography or magnetic resonance angiography in all patients.

Endografts

Thoracic aortic endografts included ENDOFIT (Endomed, Phoenix, AR) in 6 patients, TALENT (Medtronic, Sunrise, FL) in 4 patients, TAG (W.L. Gore and Associates, Flagstaff, AZ) in 4 patients, and RELAY (Bolton Medical Inc, Sunrise, FL) in 2 patients. The remaining 2 patients with abdominal PAU, were treated with the POWERLINK (Endologix Inc, Irvine, Calif) endograft. The size of the introducer sheath and the delivery system ranged between 20F and 24F. The stent-grafts were available in standard configurations in all patients. A maximum 10% oversizing of the devices was performed.

Procedure

All interventions were performed by endovascular specialists that included vascular surgeons trained in endovascular therapy and interventional cardiologists experienced in aortic endografting. Vascular surgeons performed 5 procedures in the operating theater with a portable C-arm fluoroscopic device with roadmap capability, while interventional cardiologists performed 13 procedures in the cardiac catheterization laboratory.

Patients were prepared in the supine position with the left arm extended to allow access to the brachial artery if needed. Ten patients were treated under general anesthesia and 8 under epidural anesthesia. The operative field was prepared under sterile conditions. Ceftriaxone 2 g intravenous was administered to all patients prior to the procedure. Femoral cut-down was performed in all patients, while in one patient retroperitoneal approach to the right iliac artery, and in another one direct access to the aorta and attachment of a 10 mm Hemashield graft (Boston Scientific, Natick, MA) were necessary for severe iliac arteries calcifications.

Systemic heparinization with 5000 IU was administered. A two projection angiogram was obtained using a 6F pigtail catheter. The devices were advanced over a 0.035” ultra stiff wire Amplatz or Back-up Meir (Boston Scientific, Natick, MA). The devices were deployed under fluoroscopic guidance in all patients, combined with echografic (transesophageal) guidance in 3 patients.

Follow-up

All patients underwent a strict follow-up protocol that combined clinical examination and aortic imaging with contrast enhanced computed tomography or magnetic resonance angiography before discharge, at 3, 6, 12 moths after the procedure, and annually thereafter.

Definitions and statistics

PAU (Fig. 1) was defined as at least one focal contrast material-filled, craterlike outpouching of the endoluminal border of the aortic wall and penetrating the lamina elastica interna localized in an area of significant atheroma. Patients’ clinical health status were evaluated according to the classification of the American Society of Anesthesiologists. Procedural success was defined by successful deployment of the device in the target vessel. Primary success rate was defined as complete exclusion of the lesion without signs of endoleak.

Data were analyzed using the SPSS® software package for windows version 13.0 (SPSS Inc, Chicago, Ill). The Kaplan-Meier non-parametric method was used to estimate survival in time.

Results

Patients’ characteristics are presented in the Table 1. Fourteen patients had a single focal lesion (Fig. 2A),
while 4 patients had multiple PAU (Fig. 2B) (range 1–3). Median crater diameter was 1.2 cm (range 0.5 cm to 2 cm). In all patients a proximal and a distal aortic neck of at least 2 cm of length was present. In two patients the lesion was complicated with pseudoaneurysm formation of 3.6 cm and 4.2 cm, while one patient had contemporary PAU complicated with pseudoaneurysm formation, and an acute coronary syndrome. He was treated with a combined approach excluding the PAU and the pseudoaneurysm with a double TAG device, and stenting the circumflex coronary artery. Aortic pain was persistent in 16 of 18 patients even after medical treatment.

Technical success was achieved in all patients. In 7 of the 16 patients with descending thoracic aorta PAU we deployed two stent-grafts to cover the entire lesion, while in the other 9, a single piece was used. The 2 patients with abdominal PAU receive the one-piece non-modular Endologix stent-graft with no cuff extensions. In three patients iliac angioplasty was performed in order to facilitate the crossing of the device. In the 4 patients with PAU associated with intramural haematoma, the haematoma was completely covered by the stent-graft. There was only one type II endoleak in the patient with angina and aortic pain treated with coronary angioplasty and stenting-grafting. However, he remained asymptomatic for angina or aortic pain after combined treatment, and it was decided to adopt a conservative approach with antipertensive therapy.

In all patients, symptomatic relief from pain was observed after the procedure. There were no perioperative cardiac events, paraplegias, strokes or other major complications. In 7 patients systemic inflammatory reaction was observed with moderate fever in 6 of them (37.5 °C to 38.5 °C) for 24 to 36 hours, and severe fever (39.5 °C to 40.5 °C) in one patient lasting 48 hours. Fever was treated with paracetamol. Median hospital stay was 6 days (range 4 to 11).

Mean follow-up was 41 months (range 4 to 77 months). One death occurred during the follow-up period from myocardial infarction and a second one from neoplastic disease giving a late mortality rate of 11.1% (Fig. 3). No PAU-related deaths were observed. The type II endoleak was persistent at 3 months and 6 months follow-up but asymptomatic and with stable very small diameter. In the other 17 cases the crater of the ulcer remained thrombosed. All 4 intramural haematomas were thrombosed at the 3-month imaging control. There were no treatment failures and no additional interventions required. There was no late pseudoaneurysm formation, nor aorto-bronchial or aorto-esophageal fistulae.

**Discussion**

When Stanson et al.\(^\text{10}\) in 1986 described PAUs, it was thought to have a particularly malignant behavior warranting an aggressive surgical treatment. However, shortly thereafter, Hussain et al.\(^\text{11}\) presented evidence for successful medical treatment in selected cases, whereas other authors supported that PAU has a worse prognosis than classic aortic dissection.\(^\text{12}\) Choe et al.\(^\text{13}\) concluded that many PAU can be managed nonoperatively in the acute setting, but he noticed that at least one third of these patients will undergo an early operation. In the same study,\(^\text{13}\) 85% of the cases with associated intramural haematoma spontaneously thrombosed after one year.

Open surgical repair of the descending aorta requires a large thoracotomy, possible\(^\text{14}\) cardiopulmonary bypass, prolonged mechanical ventilation, and clamping of the aorta. Endovascular surgery in contrast,

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**Table 1. Preoperative patients’ characteristics**

<table>
<thead>
<tr>
<th>Preoperative Characteristics</th>
<th>N (%)</th>
</tr>
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<tbody>
<tr>
<td>Age</td>
<td>68.6 ± 8.2</td>
</tr>
<tr>
<td>Gender (Male)</td>
<td>16 (88.9)</td>
</tr>
<tr>
<td>Hypertension</td>
<td>18 (100)</td>
</tr>
<tr>
<td>Dislipidemia</td>
<td>9 (50)</td>
</tr>
<tr>
<td>Diabetes mellitus</td>
<td>3 (16.7)</td>
</tr>
<tr>
<td>Smoking history</td>
<td>11 (61.1)</td>
</tr>
<tr>
<td>Renal failure</td>
<td>2 (11.1)</td>
</tr>
<tr>
<td>Chronic obstructive</td>
<td>5 (27.8)</td>
</tr>
<tr>
<td>Pulmonary disease</td>
<td>5 (27.8)</td>
</tr>
<tr>
<td>Coronary artery disease</td>
<td>5 (27.8)</td>
</tr>
<tr>
<td>Congestive heart failure</td>
<td>1 (5.6)</td>
</tr>
<tr>
<td>Previous cardiac surgery</td>
<td>1 (5.6)</td>
</tr>
<tr>
<td>Previous carotid surgery</td>
<td>1 (5.6)</td>
</tr>
<tr>
<td>ASA III</td>
<td>4 (22.2)</td>
</tr>
<tr>
<td>ASA IV</td>
<td>14 (77.8)</td>
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Endovascular Treatment of Penetrating Aortic Ulcers

Fig. 2. A. Single penetrating aortic ulcer. The arrow shows the lesion. B. Multiple penetrating aortic ulcers. The arrows are showing the lesions.

Fig. 3. Kaplan-Meier function. Mid-term survival estimation.

generally requires only femoral access and rarely iliac, and no aortic clamping. Operation time is shorter, the procedure is less invasive and has the potential of significantly reducing peri-operative mortality and morbidity. If it is proven to be as effective as surgery it could be the treatment of choice for these lesions.

In patients with PAU the aorta is characterized by a generalized inflammatory process and the vessel is considered to be fragile. Therefore some authors have proposed treating PAU in the subacute phase in order to avoid risks related to fragility, such as aortic perforation from the device and late pseudoaneurysm formation. Moreover, the association with intramural haematoma is considered the main cause of aneurysm formation at the distal stent-graft sites. In sixteen stable patients this strategy was preferred, offering at first aggressive medical treatment, while the two patients with the contained ruptures underwent endografting within 24 hours from admission. For the same reasons endografts with low radial force (6 of the 16 thoracic endografts were Endofit), and with a maximum oversizing of 10% were preferred. This strategy gave no case of aortic perforation or late pseudoaneurysm formation. Despite advanced age and high ASA classification (Table 1) there was zero perioperative mortality, and the two deaths achieved in the follow-up period were non-PAU related. These data compare favourably with many other reports, indicating that endovascular treatment is very suitable for the PAU patients’ population.

PAU occurs predominantly in the descending thoracic aorta and is uncommon in abdominal aorta. To our knowledge, 46 abdominal PAUs have been reported in the literature until now. Twelve of them treated medically, 25 with open surgery and 9 with endografting. In a series of 234 abdominal aortic procedures, 8 were performed for abdominal PAU giving an incidence of 3.4%. In our study two abdominal PAU were observed among 18 total PAUs giving an incidence of 11.1% of all PAUs.

Magnetic resonance angiography is proposed as the method of choice in patients with PAU by some authors. It gives excellent anatomical and functional information. However, it is of little value in identification of intramural haematoma and wall calcification, and it is less practical in the acute setting, and gives
marginal coronary artery imaging. Acute coronary syndromes can be associated in patients with acute aortic syndromes, and this is confirmed in the present study that includes a patient with combined treatment. New generation multidetector computer tomography with ECG-gating capability is more practical in the acute setting because it reduces significantly the time required for image acquisition, and has the advantage of contemporary evaluation of coronary circulation. Artefacts are significantly reduced by ECG-gating software and many authors recommend it as the imaging technique of first choice in patients with PAU.21,22

Transthoracic echocardiography was not routinely used although it can be very useful in the definition and localization of the lesion. It is however an invasive imaging technique and requires general anesthesia. Aortography has a very low sensitivity rate. This study has the limitations of a retrospective analysis, even if data were collected prospectively. The main limitation is the small number of patients that restricts any statistical analysis. PAU is an infrequent disease and therefore large series of patients are lacking in the literature. It is however diagnosed more often nowadays thanks to new refined imaging techniques. Large multicenter registries on PAU could help in better understanding the natural history, epidemiology and best treatment option of these particular lesions.

Conclusions

In these series of patients, endovascular treatment proved safe and effective in treating patients with PAU of the descending thoracic aorta and the abdominal infrarenal aorta in mid-term follow-up. Multicenter prospective registries are required to define the natural history of the disease and validate the long-term durability of endovascular treatment, that in our opinion should be the first-choice option in anatomically suitable patients.

References


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