Endovascular Repair of Infrarenal Abdominal Aorta Penetrating Atherosclerotic Ulcers: Review of Our Experience

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Abstract Penetrating atherosclerotic ulcer (PAU) of infrarenal aorta is a rare but life-threatening entity affecting elderly patients with severe atherosclerotic disease, and potentially complicated with intramural hematoma, adventitial pseudoaneurysm or aortic rupture. Although open surgical repair is an effective therapeutic option, endovascular treatment is emerging as an attractive alternative, especially in high-risk elderly patients.

We report our experience with four cases of endovascular stent-grafting of infrarenal aorta PAU. All patients presented with abdominal or lumbar pain, and two of them with shock. The diagnosis was based on CT scan and angiography that demonstrated infrarenal pseudoaneurysm in two and focal nonaneurysmal infrarenal aortic rupture in the other two patients, secondary to PAU. Endoluminal transfemoral stent-grafting was successfully delivered in all patients. One of them died 5 days after the intervention because of multiple organ failure. During a mean follow-up period of 24 months, no endoleak, aneurysm evolution or stent-graft failure were found in the remaining three patients.

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aortic intima and media, and rupture of the internal elastic lamina.\(^1,2\) Although they were first described as long ago as 1934, they have only recently been recognized as a distinct pathological entity. The disease is typically affecting elderly patients with severe systemic atherosclerosis. Predominantly found in the descending thoracic aorta, PAU are uncommon in the infrarenal abdominal aorta. Their natural history is extremely variable. PAU may be complicated by aortic intramural hematoma, adventitial pseudoaneurysm formation, or aortic rupture.

Early diagnosis and appropriate therapy improves prognosis of patients with PAU. Although open surgical repair with synthetic graft has been the gold standard of treatment, endovascular therapy is emerging as an attractive, less invasive alternative, suitable for high-risk elderly patients.

We report our experience on endovascular repair of infrarenal abdominal PAU, with a review of the relevant literature.

**Materials and Methods**

We analysed retrospectively four patients who were found to have an infrarenal abdominal PAU. All patients were men with a mean age of 67 years (range 47–76 years). All of them were hypertensive, on anti-hypertensive medication. Additional comorbidities and risk factors included hyperlipidemia \((n = 3)\), coronary artery disease \((n = 1)\), chronic obstructive pulmonary disease \((n = 1)\), chronic renal failure \((n = 1)\) and chronic lymphogenous leukemia \((n = 1)\).

All patients were symptomatic, complaining of abdominal or lumbar pain. Two of them were referred because of chronic pain of minor intensity. Ultrasonography had demonstrated an infrarenal aorta enlargement in the first, while a pulsating mass was found in the second. The other two patients were presented on ED because of acute abdominal pain associated with shock.

PAU was initially diagnosed in all cases at computed tomography (CT). PAU was recognized as a contrast-filled, pouch-like aortic protrusion without a dissection flap or false lumen. CT findings included adventitial pseudoaneurysm formation without intramural hematoma in two of the patients (Figs. 1a, 2a), and contained rupture with extra-aortic hematoma in the other two who presented with shock (Figs. 3a–b, 4a). CT also demonstrated extensive aortic calcifications in all patients.

**Figure 1** (a) Contrast-enhanced abdominal CT scan: infrarenal pseudoaneurysm, in addition to extensive aortic calcification. (Note the focal rupture in the left-anterior surface of the infrarenal aorta, which is related to the break in the calcified aortic wall. This area is protruding left-anteriorly to form the pseudoaneurysm). (b) Angiography: infrarenal pseudoaneurysm with very localized extravasation of contrast medium. (c) Follow-up abdominal CT scan 3 months after the intervention: intact stent-graft with no endoleak, migration, twisting or dilation of the diseased aortic segment.
All patients underwent transfemoral endovascular treatment with stent-graft (SG).

The devices used in these patients were:

- patient 1: a 26 × 140 × 14 mm³ aortouni-iliac Endofit SG (Endomed, Arizona, USA)
- patient 2: two excluder tube SGs 3.5 × 23 m² (W.L. Gore and Associates, Flagstaff, AZ, USA)
- patient 3: a bifurcated stent-graft (Excluder 26 × 145 × 14 mm³)
- patient 4: a 26 × 140 × 14 mm³ aortouni-iliac Endofit SG (Endomed, Arizona, USA).

Three repairs were performed under local anesthesia, while one patient underwent general anesthesia with endotracheal intubation because of his poor general condition. Every patient received antibiotic prophylaxis. The common femoral artery was exposed in standard fashion for device access in all patients. Completion digital subtraction angiography (DSA) was routinely performed at the end of the procedure to confirm adequate position of the SG, the complete exclusion of the lesion and detect potential endoleaks.

All patients were followed at 3, 6 and 12 months after the intervention, and yearly thereafter. Primary outcome measures were the exclusion of the PAU, SG patency and patient survival.

Results

Two of the patients underwent elective endovascular repair. SG placement was performed with the patients under local anesthesia in the angiography suite. Angiography demonstrated in both cases the presence of an infrarenal pseudoaneurysm with a localized extravasation of contrast medium. A fresh thrombus was contained into one of the pseudoaneurysms (Figs. 1b, 2b).

The other two patients had an emergency procedure in the operating theatre because of acute abdominal pain and shock. Intraoperative DSA confirmed the presence of a focal nonaneurysmal aortic rupture localized 3 cm above the abdominal aorta bifurcation in the first, and adjacent to the origin of the left common iliac artery in the second one (Fig. 4b).

Insertion and deployment of the SG was technically successful in all patients. A total of five SGs were used. Three patients received one SG and one (patient 2) needed two SGs. Aortograms or CT scans obtained after the procedure demonstrated no endoleak and complete exclusion of PAU or pseudoaneurysm (Fig. 3c). Additional

Figure 2  (a) Contrast-enhanced abdominal CT scan: infrarenal pseudoaneurysm, in addition to extensive aortic calcification. (b) Angiography: aorta of normal caliber with no signs of aneurysm formation. Infrarenal pseudoaneurysm, containing fresh thrombus, with very localized extravasation of contrast medium. (c) Follow-up CT-angiography 3 months after the intervention: intact stent-graft with no endoleak or migration.
procedures included femoro-femoral bypass and occluder placement in the left common iliac artery both delivered in one patient. Intraoperative blood transfusion was needed in the patients with a ruptured PAU. One of these patients — a 76-year-old man with a history of chronic renal failure under hemodialysis — had a complicated postoperative course resulting in multiple organ dysfunction syndrome and finally died after 5 days stay in ICU. The remaining three patients had an uneventful postoperative course and two of them were discharged on the 2nd and one of them on the 4th postoperative day.

Follow-up was performed in all patients 3, 6 and 12 months after the procedure, and yearly thereafter. During a mean follow-up period of 24 months no endoleak, aneurysm evolution or SG failure was recognized in the imaging work-up (CT, CT-angiography or DSA) in any of them (Figs. 1c, 2c, and 3d). All patients are still alive.

Discussion

PAU of the aorta was first identified by Shennan\textsuperscript{3} in 1934, but described as a distinct clinicopathological entity by Stanson et al.\textsuperscript{1} in 1986. Stanson et al.,\textsuperscript{1} in their study, reviewed 684 thoracic aortograms and revealed that 16 patients (2.3\%) met criteria for presence of PAU. In

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Figure 3  (a) Abdominal CT scan without I.V. contrast medium: extensive abdominal aorta calcification. Extensive amount of hemorrhagic fluid in the retroperitoneal space with intense displacement of the left kidney forward, and obscurity of abdominal aortic wall, findings implying abdominal aorta rupture. (b) Contrast-enhanced abdominal CT scan: huge extravasation of contrast medium, confirming aortic rupture. (c) Abdominal CT scan immediately after endovascular repair: stent-graft patency without any evidence of endoleak. (d) Follow-up DSA 12 months after the intervention: stent-graft patency with no evidence of endoleak or migration.

Figure 4  (a) Contrast-enhanced abdominal CT scan: extensive calcification of common iliac arteries. Extensive extravasation of contrast medium. (b) CT-angiography: extensive atherosclerotic disease of abdominal aorta and common iliac arteries. Extensive extravasation of contrast medium at the level of the origin of the left common iliac artery, confirming rupture.
PAU is defined as atherosclerotic lesion with ulceration penetrating the internal elastic lamina and the media of the aortic wall. PAU can be described as a localized “dissection” limited by areas of severe calcification, usually associated with severe atherosclerotic disease, representing a different aortopathy from that of classical aortic dissection.

PAU is typically affecting elderly patients with advanced, severe systemic atherosclerotic disease. It is consequently associated with serious morbidity such as hypertension, coronary disease or other cardiac risk factors, and carotid or peripheral arterial occlusive disease.

The natural history of PAU is not yet fully understood. PAU may be complicated by aortic intramural hematoma, subadventitial pseudoaneurysm (SAP) formation in cases of hematoma extension along the media and subsequent stretching of the weakened aortic adventitia, as well as aortic rupture. All of our patients had complications (SAP: 2, rupture: 2). Batt et al. found 13 cases (28%) of non-complicated PAU and 33 cases (72%) with complications [SAP: 13 cases (28%), transmural rupture: 17 cases (37%), IMH: 4 cases (9%)] after reviewing relevant literature. All three patients with abdominal PAU reported in series of Harris et al. had complicated forms (SAP: 1, distal ischemia caused by embolism from PAU: 2).

PAU is predominantly localized in the distal descending thoracic aorta. It is comparatively uncommon in the infrarenal abdominal aorta. It must be underlined that the most common sites of PAU, the distal thoracic aorta and the abdominal aorta, are the aortic segments most subject to atherosclerotic changes.

The exact incidence of PAU is yet unknown. Thoracic and abdominal PAU have been considered responsible for 2–7% and 1–5% of all aortic ruptures, respectively. The number of patients diagnosed with PAU is expected to increase as improved imaging systems are becoming more commonplace.

An aggressive workup is required in cases of PAU, with urgent diagnostic and therapeutic management because of their tendency to lethal rupture. The diagnosis of PAU is based on its imaging appearance or endovascular treatment, but not confirmed histologically in most cases reported in the literature. Because of lack of histological proof, Quint et al. referred to these lesions as “ulcer-like lesions” of the aorta rather than PAU. Diagnosis can be established by CT scan, magnetic resonance imaging (MRI), conventional aortography or transesophageal echocardiography (TEE). A high degree of clinical suspicion is crucial for diagnosis of PAU.

CT scan is the most commonly used technique with high accuracy. In our series, CT scan was the cornerstone of preoperative diagnosis of PAU in all cases.

On contrast-enhanced CT scan, PAU is recognized as a focal, contrast-filled, pouch-like aortic protrusion without dissection flap or false lumen, in addition to extensive aortic calcification. Intramural hematoma with aortic expansion, adventitial pseudoaneurysm or rupture with extraluminal hematoma may also be seen. Angiographic confirmation of PAU establishes the diagnosis. The three radiological diagnostic criteria for PAU on contrast-enhanced CT scans and aortograms based on the Mayo Clinic Classification include a well-defined ulcer crater in the aortic wall, a subadventitial pseudoaneurysm (SAP) extending beyond the aortic wall, or a transmural rupture with extra-aortic hematoma.

Treatment of PAU remains a subject of considerable controversy. Some authors consider that immediate surgical treatment is not always required because of their usually benign clinical course. However, early intervention is recommended in cases of PAU complicated with aneurysm expansion regardless of size, rupture, peripheral embolization or uncontrolled pain. Open surgical repair with graft interposition is associated with high operative morbidity and mortality because of patients’ advanced age and poor general condition. Endovascular stent-grafting is a less invasive attractive procedure, can be performed under local anesthesia and is, therefore, suitable for high-risk elderly patients. Because of its lower morbidity and mortality, endovascular repair could also be used in patients without symptoms, preventing potential complications. Several reports of endovascular treatment of PAU have been published. However, long-term results are required to fully establish the efficacy of endovascular repair in PAU.

Infrarenal aortic lesions caused by PAU are usually localized and endovascular treatment is considered a safe and feasible alternative to open surgical repair.

Tsju et al. reported successful SG repair in four male hypertensive patients, with uneventful postoperative course and with no endoleak or aneurysm expansion during a mean follow-up period of 14 months. One patient died of non-related disease 7 months after the operation. The remaining three patients are alive without recurrence of disease.

Vasquez et al. reported the first case of endovascular SG placement in treating a non-aneurysmal infrarenal aortic rupture secondary to PAU. Batt et al. reported their experience with eight cases of abdominal PAU, three of whom underwent successful endovascular repair. One patient had two PAU, one in infrarenal aorta and the other in a common iliac artery, and received two SGs. Another patient was managed with a right aorto-uni-iliac SG associated with a femoro-femoral bypass and occlusion of the left common iliac artery, just like one of the patients in our series.

Piffaretti et al. reviewed 13 cases of endovascular repair of abdominal infrarenal PAU. All patients were hypertensive, and 10 of them symptomatic. Primary technical success of SG placement was 100%, while no endoleak, aneurysm evolution or stent-graft failure was recognized in any patient during a mean follow-up period of 26 months. There was one death because of stroke 24 months after the intervention.

Successful deployment of SGs in all cases of infrarenal abdominal PAU reported in the literature, in association with low morbidity and mortality after endovascular repair, could support their extent use in the treatment of PAU, even in cases of rupture.
Conclusions

Endovascular treatment of infrarenal aortic lesions caused by PAU is emerging as an attractive alternative to surgical repair, especially in high-risk patients of advanced age. Use of SG is changing the strategy for treatment of PAU. Mid-term results of endovascular SG are satisfactory suggesting that the procedure is effective and safe. However, further investigation of the long-term results is required to fully establish the efficacy of endovascular repair in the management of PAU.

Conflict of Interest Statement

All authors of this article had not any financial or personal relationships with other people or organisations that could inappropriately influence their work.

References