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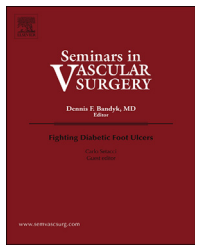

Recommendations for management of infected aortic pathology based on current evidence

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ABSTRACT

The management of infection involving the abdominal aorta requires clinical decisions based on patient factors and the nature of the infectious process. Any infection occurring after endovascular aortic aneurysm repair or open aortic replacement grafting should be treated promptly with appropriate systemic antibiotic therapy. Once a vascular prosthesis becomes infected, surgical treatment is necessary. There should be a low threshold for graft excision and extra-anatomic bypass in the presence of fistula or abscess cavity, when feasible entire graft should be excised. In selected patients, graft excision with in situ aorta reconstruction is an appropriate option using an autogenous femoral vein, cryopreserved allograft, or a prosthetic graft impregnated with antibiotic. The replaced in situ aortic graft should be covered with an omental pedicle. For primary aortic graft infections, endovascular treatment may act as a bridge to more definitive treatment; or, in the absence of gross retroperitoneal infections, endovascular grafting alone with prolonged systemic antibiotic therapy is a viable option, particularly in patients not fit for open surgical procedures.

1. Introduction

While the incidence of aortic graft infection is low (0.2% to 5%), this vascular surgery problem is associated with significant morbidity and mortality [1–4]. Infective complications include infection of the graft material itself; para-anastomotic aneurysm; leak due to anastomotic failure and fistulae; and sepsis, which can result in organ failure, limb loss, and death [5]. Mortality reaches 100% within 2 years in operated cases where the infected aortic graft remains in situ [6,7]. The aim of treating graft infection is patient survival, eradication of infection, and revascularization, which may involve an anatomic or extra-anatomic route. Vascular grafts, whether inserted via an open or endovascular approach, are difficult to remove and, as such, their removal carries a greater risk of morbidity and mortality than the original surgery.

Ideally, measures should be taken to reduce the risk of graft infection, but infective complications will still occur, particularly in the elderly, obese patients, and those undergoing revision surgery. The management of the infected aorta depends largely on the site of disease and the general fitness of the patient (Fig. 1). Clinical results of purely medical treatment, local and systemic antibiotic/antibacterial administration, are poor and

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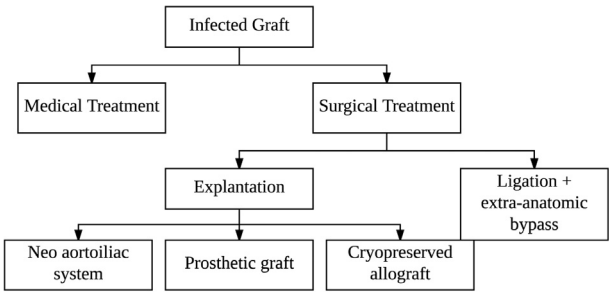

Fig. 1 – Treatment algorithm for an infected aortic graft.

applicable only to patients judged to be prohibitive surgical candidates. Surgical treatment is the standard of care unless the risks are prohibitively high [8]. Traditional surgical treatment involves removal of the infected graft, with ligation of the aorta proximally and distally, and debridement of the surrounding inflammatory tissue, either followed by or preceded by extra-anatomic bypass to maintain perfusion of the lower limbs [9]. In the past 25 years, replacement of the infected segment of aorta with a variety of different grafts has increased in popularity. Grafts may include autogenous superficial femoral vein [10,11], rifampicin-bonded silver grafts [12], and fresh homograft or cryopreserved donor allograft [13]. In the case of revision aortic surgery, particularly the replacement of infected grafts, there is increasing evidence to suggest that in situ reconstruction yields better results than excision and extra-anatomic bypass [14]. Endovascular solutions are available and are associated with significantly lower perioperative risk than open surgery [15]. Endovascular treatment may be used as a bridging procedure to definitive repair, particularly in the presence of systemic sepsis. Treatment outcomes are poorer when patients have fever at the time of operation or when they present with signs of aneurysm rupture [16].

2. Prevention of graft infection

Patients undergoing elective aortic surgery should be admitted as close to the time of surgery as possible, and should be isolated from individuals with known infections. There is no evidence to support the use of preoperative washing or bathing with antiseptic products. Strict aseptic technique should be adhered to in an operating theater with laminar air flow. The use of iodine-impregnated adhesive drapes aid in isolating the operative field. There is no evidence to suggest that the prophylactic soaking of Dacron grafts in rifampicin solution or the used of silver-coated grafts reduces graft infection. Similarly, the use of suction drains in groin wounds has not shown to have a positive or negative impact on the incidence of wound infection. The use of prophylactic systemic antibiotics does reduce the risk of wound and early graft infection, but extending this prophylaxis for more than 24 hours confers no additional benefit.

3. Treatment of infected endografts

Endovascular aneurysm repair (EVAR) is increasingly the treatment of choice for both abdominal and thoracic aortic aneurysms. Infective complications are being increasingly reported as a result and may include disruption of the graft–arterial anastomosis, recurrent hemorrhage, aortoenteric, aortocaval, and aortoesophageal fistulae, sepsis, limb loss, and death [5]. There are no large, multicenter studies at present, but the incidence of endograft infection has been described as between 0.2% and 5% [17–21].

The diagnosis of graft infection should be considered in symptomatic patients who present with a history of chronic infection, infection complicating the index repair, or a need for interval procedures. A recent French multicenter study found that endograft infection occurs early after implantation [22], with a median time of 414 days from the index EVAR to signs of infection. This study assessed the results of 33 patients who underwent explantation of an infected abdominal aortic graft; the patients all presented with one or more of abdominal pain, fever, or hematemesis. More than one-third of these patients had an infectious complication in the perioperative period of their index EVAR, which highlights the potential for secondary infection of an endograft by contaminated blood. An additional one-third of this cohort had undergone reintervention. Recently, there has been advocacy for endograft preservation, aspiration of perigraft collection or debridement, and lifelong antibiotics from the Swedish Mycotic Aneurysm Collaborators [23] and the Malmo group, with reasonable short- and medium-term outcomes. This is probably true in the low virulence infections. However, in the Asian groups [24,25], the organisms had high virulence and endograft explantation, retroperitoneal and aortic debridement and reconstruction was the common trend.

Conversion to open surgery following EVAR is associated with an increased risk of morbidity and mortality, however, some groups have published a 0% mortality rate for elective late conversions. Risks are higher when early conversion is required, ranging from 7% to 25%, these rates may be even higher when associated with rupture [26–28].

The reported rates of infection after revision procedures are 20% after graft explantation and extra-anatomic bypass [29], 10% to 15% after in situ repair with prosthetic material [30], 13% after repair with a neo-aortoiliac system [31], and 4% after reconstruction with cryopreserved allograft [32,33].

4. Graft explantation and extra-anatomic bypass

It is generally considered preferable to undertake extra-anatomic bypass prior to removal of the infected graft, as this avoids a prolonged ischemia time that may be associated with graft removal prior to explantation. This is the case particularly if the procedure is staged, which may be an attractive way of reducing the operative time. The procedures may be undertaken 1 to 5 days apart [34]. The typical reconstruction in this situation is an axillobifemoral bypass using ring-supported polytetrafluoroethylene, which avoids the infected tissue planes.

The approach to the infected aorta is essentially similar to that of primary open aneurysm surgery. The operation itself is considerably more challenging. Dissecting the proximal aortic neck may be more difficult due to the surrounding

inflammation related to the stent graft. Suprarenal or supraceliac clamping is often required, particularly in cases where endografts with suprarenal fixation have been used. Generally, stent-grafts with infrarenal fixation may be removed quite simply once the aneurysm sac has been opened. Ideally, the entire graft should be removed, but in cases where there is suprarenal fixation, especially involving hooks and barbs, the suprarenal component may need to be left in situ. In such situations, the infrarenal section of the stent-graft should be amputated by cutting the metal structure of the suprarenal attachment, which is then incorporated into the proximal anastomosis, utilizing a supraceliac clamp. With standard bifurcated grafts, the iliac arteries must then be dissected and the external and internal iliac arteries clamped individually.

Chaufour et al [22] describe their procedure for graft explantation in their 2017 publication. Access is via a midline laparotomy or occasionally a thoracoabdominal incision for more proximally placed disease. In the absence of suprarenal fixation, a suprarenal clamp is applied to the aorta, otherwise a supraceliac clamp or balloon is deployed. Where possible, the graft is completely excised, although this was found to be technically difficult in the presence of suprarenal hooks. In this series, 30 of 33 patients underwent in situ grafting; 25 of these grafts were aortobiiliac in configuration and 5 were tube grafts. The remaining 3 patients had an aortobifemoral bypass following ligation of the native aorta. Twenty-three of the 30 grafts used were cryopreserved allografts, 5 were rifampicin-bonded silver grafts, and 2 were autogenous common femoral vein grafts. In this multicenter experience, perioperative mortality was 39% and 1-year survival was 44%. In this series, 13 deaths occurred and were due to sepsis leading to multi-organ failure (6 patients), rupture of in situ graft (3 patients), colonic ischemia (3 patients), and irreversible limb ischemia (1 patient). No single form of reconstruction was found to be superior.

A 2017 study has suggested management options for the aortic stump should include harvesting of the deep fascia as a flap to buttress the closure, wrapping an omental pedicle around the stump and the use of sigmoid colectomy and ureteric reconstruction, where necessary [35].

The advantages of this approach are considerably decreased operative time compared with in situ revascularization. Lower rates of infection are seen when the new graft is placed outside the infected field. Potential disadvantages include decreased long-term patency of the extra-anatomic bypass, the requirement of good outflow vessels and non-infected groins, and the risk of aortic stump blowout, estimated to be around 25% [30].

5. In situ reconstruction with prosthetic grafts

Polytetrafluoroethylene or polyester grafts can be used for reconstruction following excision of the infected graft. Once the infected field has been thoroughly debrided, the reconstruction can take place and the new conduit should be wrapped in an omental pedicle. If the groin sites are used, muscle flaps should be used to cover the graft.

In situ reconstruction avoids the risk of aortic stump blowout that may be associated with explantation and ligation of the aorta. However, it is associated with longer operative times. Reinfection rates, conduit failure, mortality, and amputation rates do seem to be lower when in situ reconstruction is undertaken [14]. The 2006 meta-analysis from which these findings come found that rifampicin-bonded prosthetic grafts had the lowest rates of amputation, conduit failure, and early mortality [14]. Infection rates using this form of reconstruction do seem to be higher than for the others. Silver-coated prosthetic grafts showed promising results in the treatment of infected aortic grafts, with an early study reporting just a 3.7% reinfection rate at 16 months [12]; however, a later study suggested the results were similar to those for other conduits [36].

6. Reconstruction using autogenous vein

The great saphenous vein or femoral vein can be used for reconstruction following removal of an aortic graft. There is a risk of substantial size mismatch and, therefore, the vein should have a diameter >6 mm, as demonstrated on preoperative ultrasonography [34]. The size discrepancy can be mitigated by plication of the anterior aorta prior to anastomosis, or by combining two grafts to form a larger one. This approach to reconstruction does have the advantage of a low infection rate (0% to 5%), but it is also associated with long operative time (sometimes in excess of 6 hours) and risk of leg swelling. Thirty-day mortality rates have been reported as 5% to 10%, with a primary patency rate >90% and amputation rates of 0% to 10% [10,37].

A neo-aortoiliac system can be constructed using the femoropopliteal veins [30]. This is an attractive proposition, as it can eliminate the size mismatch inherent in reconstructing the aorta with smaller veins. As such, primary patency rates are good, with reports suggesting 75% to 90% patency at 5 years [38]. Infection rates are very low at 2%, as are rates of amputation (2% to 7%) [37,38]. However, this is a long operation that usually requires two operating teams and should therefore be reserved for those patients who can tolerate such a procedure. Chronic venous hypertension is subsequently seen in up to 15% of patients and approximately 12% will require fasciotomies [39]. Thirty-day mortality has been reported at 10% [38,39].

7. Reconstruction with cryopreserved allograft

Arterial or venous allografts may be used for in situ reconstruction. These grafts are cryopreserved and so require complete thawing prior to implantation. Fresh allograft is generally not used due to its propensity to dilate. Contemporary cryopreservation techniques seem to preserve the collagen matrix, thus leading to fewer graft-related complications and better patency rates [40]. Allografts can match the required anatomy and diameter and are therefore a good option for the treatment of infective disease involving the visceral segment of the aorta. Side branches that are not to be

utilized will need to be ligated, with the avoidance of metal clips. When cryopreserved allografts are used, ABO matching is not required.

Reconstruction with cryopreserved allograft has a low incidence of aneurysmal degeneration, which can be a risk with autogenous reconstruction. Allografts are, however, expensive and not always readily available, although venous grafts have greater availability than arterial grafts [41,42]. Graft rupture (<10%), reinfection (0% to 6%), and amputation (0% to 5%) rates are all relatively low in comparison with other methods of reconstruction. Thirty-day mortality has been reported as 5% to 15% and 3-year primary patency as 80% to 100% [13,43].

8. Endovascular repair

Endovascular treatment may be used as a primary treatment for infected aortic disease in the absence of significant contamination. In fact, it should be seen to play an essential role in the treatment of acute rupture or hemorrhage as a result of the infective process. In the presence of contamination, stent-grafting may be used as a bridging procedure to more traditional surgery, if necessary [23]. A recent Swedish multicenter study analyzing 132 cases has reported higher early survival rates for the use of endovascular treatment of infected aortic pathology compared with open techniques; 96% versus 74% survival at 3 months ($P < .001$) and 84% versus 73% at 1 year ($P = .054$). There is no difference in survival between the two treatment groups at 5-year follow-up (58% *v* 60%; $P = .771$). Infection-related complications are similar (24% *v* 18%; $P = .439$), as are reintervention rates (24% *v* 21%; $P = 0.650$) [44].

A disadvantage to this approach is that there is no possibility to directly sample the aorta and gain samples for microbiological examination, therefore, all patients treated in this way without positive blood cultures should remain on long-term broad-spectrum antimicrobial therapy. Endovascular treatment may therefore be used as a bridging procedure to definitive repair, particularly in the presence of systemic sepsis. Given that treatment for the infected aorta carries such risks of morbidity and mortality, endovascular treatment is a viable option and is associated with lower rates of complications and death in the early stages of follow-up [45].

9. Recommendations

- Any infection occurring at or after EVAR or open aortic surgery should be treated promptly with appropriate antibiotics to minimize the risk of graft contamination by hematogenous spread.
- Surgical treatment should be attempted unless the risks of doing so are prohibitively high.
- There should be a low threshold for extra-anatomic bypass in the presence of fistula or abscess cavity.
- Thorough debridement and irrigation with povidone iodine or hydrogen peroxide is essential.
- Infected aortic grafts should be completely excised, where possible.
- In situ reconstruction should ideally be undertaken using an autograft or allograft, where possible, or with prosthetic graft impregnated with antibiotic, if this is not an option.
- Prosthetic conduits should be impregnated with antibiotic and covered with an omental pedicle.
- Endovascular treatment may act as a bridge to more definitive treatment.
- In the absence of gross contamination, there is growing evidence that endovascular treatment alone is a viable option, particularly in those not fit enough for open surgery.

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