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Is Endovascular Repair of Mycotic Aortic Aneurysms a Durable Treatment Option?

R.E. Clough [a], S.A. Black [a], O.T. Lyons [a], H.A. Zayed [a], R.E. Bell [a], T. Carrell [a], M. Waltham [a], T. Sabharwal [b], P.R. Taylor [a,*]

[a] *Department of Vascular Surgery, Guy's and St Thomas' NHS Foundation Trust, London, UK*
[b] *Department of Radiology, Guy's and St Thomas' NHS Foundation Trust, London, UK*

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Abstract *Objective:* Endovascular repair for degenerative aortic aneurysms is well established, but its role in those with infective pathology remains controversial. This study aims to assess the durability of endovascular repair with a review of our midterm results.
Method: A retrospective analysis of a prospectively maintained endovascular database (1998–2008) was conducted, which identified 673 consecutive patients with aortic aneurysms.
Results: Nineteen patients (2.8%) were identified with infected aortic aneurysms, in which there were a total of 23 separate aneurysms (16 thoracic and seven abdominal). Six patients (32%) presented with rupture. Eleven patients (58%) had received antibiotics preoperatively for a median duration of 11 days (1–54 days). Fifteen of the 19 (79%) had positive blood cultures, with *Staphylococcus aureus* being the most common organism.

All 19 patients underwent endovascular repair. There were three Type I endoleaks (one requiring conversion to open repair) and two Type II endoleaks. One patient developed transient paraplegia, resolved by cerebrovascular fluid (CSF) drainage, and one patient had a stroke.

The 30-day mortality was 11%, and survival at median follow-up of 20 months (0–83 months) was 73%. All eight deaths in the series were related to aneurysm.
Conclusion: Endovascular treatment of infective aortic pathology provides an early survival benefit; however, concerns over on-going graft infection remain.

Mycotic aneurysms have a relative incidence of 1–3% in large aortic series, and represent one of the most challenging clinical problems for the vascular surgeon.[1] The classical symptoms of fever, malaise and leucocytosis are nonspecific, and this often leads to late diagnosis and treatment.[2] In addition, these aneurysms have a relative predilection for the visceral and thoracic segments of the aorta, which further complicates management.

* Corresponding author. P.R. Taylor, MA M.Chir FRCS, Consultant Vascular Surgeon, Department of Vascular Surgery, 1st Floor, North Wing, Guy's and St Thomas' NHS Foundation Trust, Westminster Bridge Road, London SE1 7EH, UK. Tel.: +44 (0)20 74033893; fax: +44 (0)20 74032323.
E-mail address: taylorvasc@aol.com (P.R. Taylor).

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Traditional treatment consisted of open surgical repair with resection of the infected segment, extensive local debridement and *in situ* or extra-anatomical bypass. Despite advances in peri-operative management and antimicrobial therapy, the mortality and morbidity remain high, in the region of 21–36%.[3,18]

Endovascular repair of degenerative thoracic and abdominal aneurysms is well established; however, placing an endovascular graft in an infected field remains counter-intuitive. There are an increasing number of reports in the literature of successful endovascular repair of mycotic aneurysms, but the numbers are small and the follow-up is short.[4–7]

The current study aimed to assess the durability of endovascular repair of mycotic aortic aneurysms with a review of our midterm results.

Methods

A review of a prospectively maintained database of patients undergoing endovascular repair of thoracic and abdominal aneurysms in our institution was conducted. The database covered a 10-year period from 1998 to 2008.

Aortic infection was defined by two or more of the following: clinical evidence of infection (fever, pain, leucocytosis), positive blood culture or characteristic radiological appearance (rapidly growing or saccular aneurysm). Patients with pathology isolated solely within the ascending aorta or visceral segment were excluded from the study. All patients were considered unfit for open surgical repair. There was no change in stent-graft selection or method of device sizing, compared with the treatment of uninfected aortic aneurysms within our practice.

Our follow-up protocol consisted of clinical (fever/pain), imaging (computerised tomography, CT, with intravenous contrast) and haematological (C-reactive protein (CRP)/white cell count (WCC)) analysis at 3, 6 and 12 months and then annually thereafter. Data were obtained from systems within our hospital, from the patient's general practitioner (community doctor) and from the patient's local hospital when applicable. Data were recorded on Microsoft Excel, and statistical analysis was performed with Prism software. Analysis of frequencies and survival was performed.

Results

During the 10-year interval, 673 patients underwent endovascular repair of thoracic or abdominal aneurysms. A total of 19 patients (7 men and 12 women) were identified with infected aortic aneurysms giving an incidence of 2.8%. The median age of these patients was 70 years (range: 39–79 years). The median clinical follow-up was 20 months (range: 0–83 months). The patient demographics are illustrated in Table 1.

Six patients had evidence of rupture (32%). Twelve patients (63%) had fever, pain or leucocytosis (Table 2). Eleven patients (58%) had received antibiotics preoperatively for a mean duration of 11 days (range: 1–54 days). Fifteen patients (79%) had positive blood cultures, with *Staphylococcus aureus* being the most common organism (Fig. 1). Of the 19 patients, seven patients (37%) had one or more co-morbid factors associated with a degree of immuno-compromise and nine had a recent infection or operation (47%).

Table 1 Patient demographics

	$N = 19$	Percentage (%)
Co-morbidities		
Diabetes mellitus	2	11
Smoking	8	42
Chronic renal failure	1	5
Chronic disease	4	21
Recent infection		
Gastrointestinal	3	16
Musculoskeletal	2	11
Urinary	1	5
Respiratory	1	5
Previous aortic surgery	6	32
Recent operation (<6 weeks)	2	11

A total of 23 aneurysms were identified in the 19 patients: 16 thoracic and seven abdominal. Pre-operative imaging (CT with intravenous contrast (17 patients), angiography (patient too unstable for CT/in addition to CT) (four patients) and oesophago-gastro-duodenoscopy (for visualisation of fistula) (three patients)) revealed that all aneurysms were saccular (Fig. 2) and also revealed the presence of six fistulae (aorto-oesophageal (three patients), aorto-cutaneous (one patient) and aorto-bronchial (two patients)).

All patients underwent endovascular repair. The details of devices used and the procedural data are included in Table 3. Cerebrospinal fluid (CSF) drainage was not used preoperatively.

Additional procedures were required in six patients and included: carotid–carotid bypass to extend the proximal landing zone (three patients), femoral–femoral bypass after insertion of an aorto-uni-iliac device (two patients) and left subclavian artery embolisation for a Type II endoleak (one patient).

The median hospital stay was 19 days (range: 2–67 days), with three patients requiring intensive care admission for a median duration of 15 days (range: 2–23 days).

Early outcome (< 30 days post-procedure)

Mortality

The 30-day mortality (Table 4) was 11% (two out of 19). One death was due to rupture of a further mycotic aneurysm,

Table 2 Infective status

	N	Percentage (%)
Fever (>38 °C)	8	42
Leucocytosis ($>11.0 \times 10^9$ cells l^{-1})	9	47
Pain	7	37
C-reactive protein (>5 mg l^{-1})	9	47
Positive blood culture	15	79
Pre-operative antibiotic	11	58
Presentation with rupture	6	32
Saccular aneurysm morphology	23	100

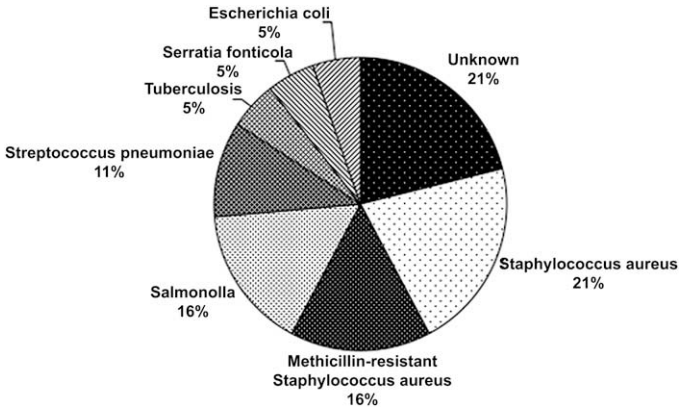

Figure 1 Organisms from blood culture.

the other due to formation of an aorto-oesophageal fistula and multiple organ failure secondary to sepsis. The former was our first case; the primary, symptomatic aneurysm was located within the thoracic aorta and the secondary, initially asymptomatic, aneurysm was located distally just above the aortic bifurcation. Initial imaging did not include the entire aorta, and so the second aneurysm was not foreseen. This death lead to a change in our practice and now all patients undergo imaging of the entire aorta.

Morbidity

Postoperative recovery was complicated by cardiac (acute coronary syndrome (two patients), arrhythmia (one patient)), respiratory (pneumonia (two patients) and pulmonary embolus (one patient)) and neurological complications (stroke (one patient) and paraplegia (one patient)). The single case of paraplegia resolved with immediate CSF drainage.

Table 3 Procedural data and devices

	Median	Range
ASA grade	3	2—4
Procedure duration (min)	85	50—540
Radiation dose (Gy m^{-2})	135	49.8—361.0
Contrast volume (ml)	107	20—240
Blood loss (ml)	322	10—1800
Stent grafts	*n*	
Cook Group Inc. (Bloomington, IN)	**8**	
Tx2	3	
AAA	3	
Aorto-uni-iliac	2	
Medtronic Inc (Santa Rosa, CA)	**4**	
AneuRx	2	
Talent	2	
W.L. Gore & Associates (Sunnyvale, CA)	**11**	
Tag	9	
Excluder	2	

Endoleak

Endoleak occurred in four patients: two proximal Type I endoleaks (one required conversion to open repair and one was sealed with a proximal extension cuff), one distal Type I endoleak (sealed spontaneously by day 6) and two Type II endoleaks arising from the left subclavian artery (one required embolisation and the other sealed spontaneously).

Secondary procedures

Further endovascular grafts were deployed in two patients: one on day 39 for a further mycotic abdominal aortic aneurysm, the other on day 28 for further bleeding from an aorto-oesophageal fistula (Fig. 3).

Late outcome (> 30 days post-procedure)

Mortality (Table 4)

Cumulative survival was 73%, 73% and 29% at 1, 4 and 5 years, respectively.

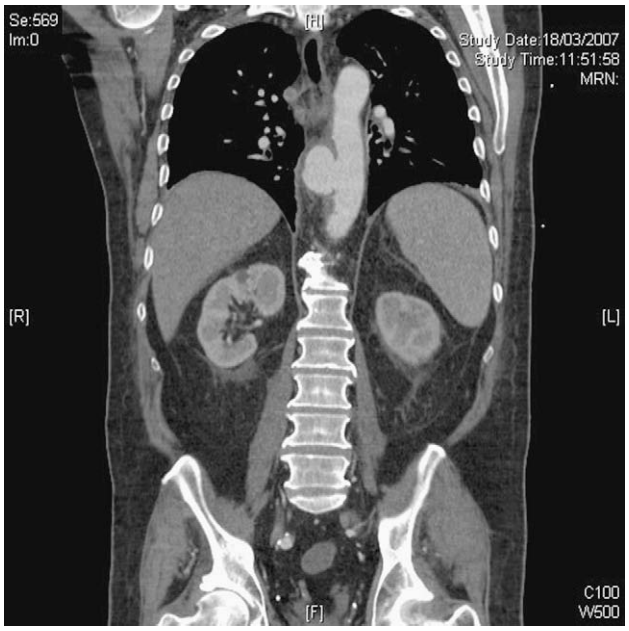

Figure 2 CT angiogram illustrating thoracic saccular aneurysm.

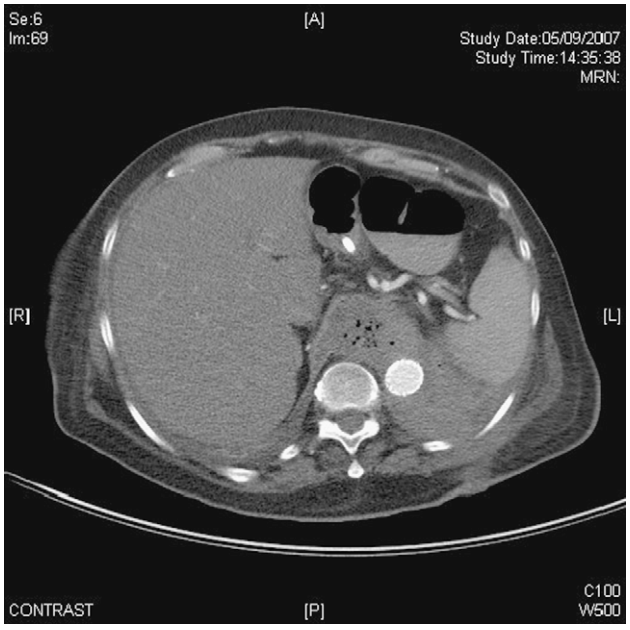

Figure 3 CT angiogram illustrating evidence of on-going infection after endoluminal repair.

There were six late deaths, of which, three occurred in the first year, and all were due to fistulae — one new (aorto-oesophageal) and two recurrent (aorto-oesophageal and aorto-cutaneous) fistulae. A further death occurred after 4 years due to sepsis of unknown origin. The remaining two were in the 6th and 7th year of follow-up and were due to recurrent fistulation (aorto-bronchial and aorto-oesophageal).

Morbidity
There was no reported late morbidity.

Endoleak
No late endoleak was detected.

Secondary procedures
Two patients required further stent grafts: one on day 39 for recurrence of an aorto-oesophageal fistula, the other in the 5th year for recurrence of an aorto-oesophageal fistula.

Antibiotic therapy
The antibiotic regime was devised on a case-by-case basis with close collaboration with the microbiology department. Broadly speaking, if there were positive blood cultures, then the treatment regime was organism-specific; otherwise it was broad spectrum. *Methicillin-resistant Staphylococcus aureus* (MRSA) was not routinely covered, unless there were positive cultures or a high index of suspicion. Patients received initial high-dose intravenous therapy and were then discharged on a course of oral antibiotics. The antibiotics were stopped when clinical markers (fever/pain), haematological (CRP/WCC) and imaging (CT with intravenous contrast), were within normal limits. The median duration of antibiotics was 42 days (range: 28—91 days).

Discussion

Mycotic aneurysms represent a relatively small proportion of our endovascular series, but provide the greatest complexity in terms of diagnosis and clinical management. The classical features of fever, pain and leucocytosis were present in the majority, and resulted in late presentation with a high incidence of aortic rupture. Despite treatment of 11 of 19 patients with antibiotics preoperatively, infections were detected in 79% of our series, with virulent organisms such as *S. aureus* and *Salmonella* forming the greatest proportion. A high number of patients were immuno-compromised with a history of previous aortic surgery and recent systemic infection. Pre-operative imaging revealed classical saccular aneurysms in all, with a relative predilection to the thoracic segment and multiple aneurysms in four of the 19 patients.

Table 4 Deaths

Sex	Age	Primary diagnosis	Complication	Re-intervention	Cause of death	Number of days after initial procedure
M	62	Thoracic aorta aneurysm	Further aortic aneurysm	None	Rupture of further aortic aneurysm	4
F	74	Thoracic aorta aneurysm	Aorto-oesophageal fistula	None	Aorto-oesophageal fistula	23
F	68	Aorto-oesophageal fistula	Recurrence	Further stent-graft, day 28	Aorto-oesophageal fistula	39
M	64	Thoracic aorta aneurysm	Aorto-oesophageal fistula	Further stent-graft, day 39	Aorto-oesophageal fistula	49
F	69	Aorto-cutaneous fistula	Recurrence	None	Aorto-cutaneous fistula	163
F	63	Thoracic and abdominal aorta aneurysms	Sepsis	None	Multiple organ failure secondary to sepsis	1748
F	67	Aorto-bronchial fistula	Recurrence	None	Aorto-bronchial fistula	1944
F	58	Aorto-oesophageal fistula	Recurrence	Further stent-graft, day 1560	Aorto-oesophageal fistula	2289

Of the eight deaths in this series, all were related to aneurysm. Four occurred in the six patients who had initially presented with an aortic fistula, thereby almost doubling the mortality rate in the group compared to that for simple aneurysm. The cohort is too small and heterogeneous to allow meaningful statistical evaluation; however, crude analysis suggests that, in addition to the presence of a fistula, patients presenting with rupture and those in whom a stent graft was deployed in the presence of a fever tended to have problems with persistent infection. Patients who received antibiotics for more than 3 days preoperatively tended to be relatively protected from long-term infection. These findings are similar to those from the recently published systematic review.[8]

Analysis of other patient-related features, including organism type, did not reveal any other associations.

Our survival analysis illustrates promising early and midterm results; however, it is difficult to find a suitable control to which these results can be compared. Within our centre, over this 10-year period, we have not undertaken any open mycotic, thoracic aorta repairs and have performed only four infrarenal extra-anatomical repairs. Of the latter, two have remained well during follow-up and two have died of aneurysm-related causes. Crude comparison with data from the literature would suggest that endovascular repair has the early and midterm advantage but that long-term survival may be better with open surgical repair.

Open repair is a well-established means of treating this pathology, and traditionally consists of aneurysm resection, extensive local debridement and extra-anatomical bypass.[9,10] However, initial survival tends to be poor with high rates of aortic stump rupture, amputation and cardiovascular morbidity.[11,12] *In situ* repair with prosthetic material, or autologous or cryopreserved conduit, have demonstrated promising results, and this suggests that the placement of foreign material within the infected area may be feasible.[9,13,14] This is the case with endovascular repair, and early follow-up from small series have demonstrated promising results. However, patients with a primary or secondary aortic fistula, or infected prosthetic material from a previous open repair, tend to do worse.[15] In this series, results for individuals with previous prosthetic repair were comparable with primary aortic infection, but those with aortic fistulae had evidence of on-going infection and high rates of re-intervention.

It seems likely that aortic fistulae form a distinct subgroup, and methods of open repair vary depending upon the area of the gastrointestinal or respiratory tract involved; treatment focuses on obliteration of the fistula tract, excision of infected material and adequate repair of both lumens.[16] Endovascular repair is not able to address the pathological communication and, therefore, the stent graft is subjected to a continuing source of infection. Acceptable results have been achieved with long-term, organism-specific antibiotics, but many authors conclude that, for this pathology, endovascular repair may only be a temporising method, with definitive open repair once haemodynamic stability and infective control has been gained. [15,17] Within our series, these patients were not fit enough for open repair, and so a staged procedure was not an option. However, on the basis of these results, we would recommend a second-stage procedure, although its timing and patient compliance may be an issue.

Lastly, antibiotic therapy is clearly crucial to the management of this pathology. These patients are complex, and we would, therefore, advocate a regime to be devised on a case-by-case basis. Antibiotic type should be determined by culture results and duration by clinical, imaging and haematological follow-up.

Conclusion

Endovascular repair is feasible and confers promising early and midterm results; however, long-term durability is yet to be established. Patients presenting with an aortic fistula, aortic rupture or with evidence of active infection may be more likely to have problems with infection in the long term. Antibiotic therapy is clearly crucial to the management of this pathology, and pre-operative treatment may be relatively protective against on-going infection. The antibiotic regime should be devised on a case-by-case basis with close collaboration with the microbiology department.

Conflict of Interest

None.

Funding

None.

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