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Outcomes of Open Repair of Mycotic Aortic Aneurysms with *In Situ* Replacement

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Background: Mycotic aortic aneurysms are rare and life-threatening. Unfortunately, no established guidelines exist for the treatment of patients with mycotic aortic aneurysms. The purpose of this study was to evaluate the midterm outcomes of the open repair of mycotic thoracic and thoracoabdominal aneurysms and suggest a therapeutic strategy. **Methods:** From 2006 to 2016, 19 patients underwent open repair for an aortic aneurysm. All infected tissue was extensively debrided and covered with soft tissue. We recorded the clinical findings, anatomic location of the aneurysm, bacteriology results, antibiotic therapy, morbidity, and mortality for these cases. **Results:** The median age was 62±7.2 years (range, 16 to 78 years), 13 patients (68%) were men, and the mean aneurysm size was 44.5±4.9 mm. The mean time from onset of illness to surgery was 14.5±2.4 days. Aortic continuity was restored *in situ* with a Dacron prosthesis (79%), homograft (16%), or Gore-Tex graft (5%). Soft-tissue coverage of the prosthesis was performed in 8 patients. The mean follow-up time was 43.2±11.7 months. The early mortality rate was 10.5%, and the 5-year survival rate was 74.9%±11.5%. **Conclusion:** This study showed acceptable early and midterm outcomes of open repair of mycotic aneurysms. We emphasize that aggressive intraoperative debridement with soft-tissue coverage results in a high rate of success in these high-risk patients.

Key words: 1. Thoracic aortic aneurysm
2. Abdominal aortic aneurysm
3. Infected aneurysm
4. Aorta, surgery

Introduction

Mycotic thoracic abdominal aortic aneurysms are rare, accounting for fewer than 1% of all aortic aneurysms. They are associated with a high incidence of fatal rupture when medical therapy alone is attempted. Although there are no standard guidelines for treatment, the most common practice is to combine antibiotic therapy with surgical resection and graft interposition [1-3]. The purpose of this study was to assess the midterm outcomes of open repair of mycotic aortic aneurysms with soft-tissue coverage during a 10-year period at the Severance Hospital, Yonsei University College of Medicine.

Methods

From January 2006 to December 2016, 19 patients underwent open repair of a mycotic aortic aneurysm. We reviewed prospectively collected data to identify patients who underwent surgical repair for mycotic aortic aneurysms. This study was conducted follow-

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ing approval by the Institutional Review Board of the Yonsei University College of Medicine (IRB number: 4_2011_0173). The individual patient consent was waived. Aneurysms were defined as mycotic if its characteristic appearance was observed in radiologic imaging or during an intraoperative examination, and if positive cultures were obtained from either blood or aortic tissue. Computed tomography (CT) imaging was used to determine whether the aneurysm was rapidly growing, had newly developed, and whether there was air in the aortic wall or a soft-tissue mass surrounding the aneurysmal aorta. The primary endpoints were in-hospital mortality and late death from any cause. The secondary endpoints were early major complications and a composite of late aortic events.

1) Surgical technique

All procedures were performed with sternotomy, left thoracotomy, or left thoracoabdominal or median abdominal incision, depending on the anatomic location of the aneurysm. Infected tissues were completely excised, and aortic continuity was restored with a Dacron prosthesis (Macquet Corp., Oakland, NJ, USA), homograft, or Gore-Tex (W. L. Gore & Associates, Elkton, MD, USA) graft. Cryopreserved arterial homografts were used in infections that were not controlled by antibiotic therapy. Soft-tissue coverage of the prosthesis was performed when permitted by the anatomy and patient condition [1,4,5].

2) Statistics

Data processing and analysis were performed using IBM SPSS ver. 20.0 (IBM Corp., Armonk, NY, USA). Results are expressed as frequency and percentage for categorical variables and as mean and standard deviation for continuous variables. All p-values <0.05 were considered to indicate statistical significance. Survival estimates were generated using the Kaplan-Meier method.

Results

1) Patients and characteristics

Patient characteristics are listed in Table 1. The median age was 62±7.2 years (range, 16 to 78 years). The series of 19 patients consisted of 13 men (68.4%) and 6 women (31.6%). Nine patients (47.4%) had at least 1 comorbid condition associated with some degree of immunosuppression, including 6 (31.6%) with diabetes mellitus, 4 (21.0%) with chronic renal disease, or 2 (10.5%) with benign or malignant tumors.

Table 1. Patient characteristics and early outcomes (N=19)

Characteristic	Value
Age (yr)	62±7.2
Gender	
Men	13 (68)
Women	6 (32)
Underlying disease	
Chronic renal disease	4 (21)
Diabetes mellitus	6 (32)
Hypertension	5 (26)
Tumors	2 (11)
Symptoms and clinical findings	
Pain	10 (53)
Fever	8 (42)
Hematochezia, hemoptysis	4 (21)
Extremities weakness	2 (11)
None	1 (5)
Location of mycotic aneurysm	
Ascending aorta	3 (16)
Descending thoracic aorta	6 (32)
Thoracoabdominal aorta	2 (11)
Abdominal aorta	8 (42)
In-hospital mortality	2 (10.5)
Sepsis	1 (5.2)
Acute myocardial infarction	1 (5.2)
Morbidities	
Stroke	0
Postoperative bleeding	1 (5.2)
Acute renal failure	1 (5.2)
Pulmonary complications	4 (21.1)
Length of stay in intensive care unit (day)	11±19.7
Length of hospital stay (day)	52±44.6
Reinfection	1 (5.2)

Values are presented as mean±standard deviation or number (%).

2) Symptoms and clinical findings

In this study, 95% of patients presented with aneurysm-related symptoms: pain (n=10, 53%), fever (n=8, 42%), or hematochezia or hemoptysis (n=4, 21%). Preoperative CT was performed in all patients; the mean aneurysm size was 44.5±4.9 mm. Six patients (31.5%) had a contained rupture at the time of surgery. The average duration of symptoms before

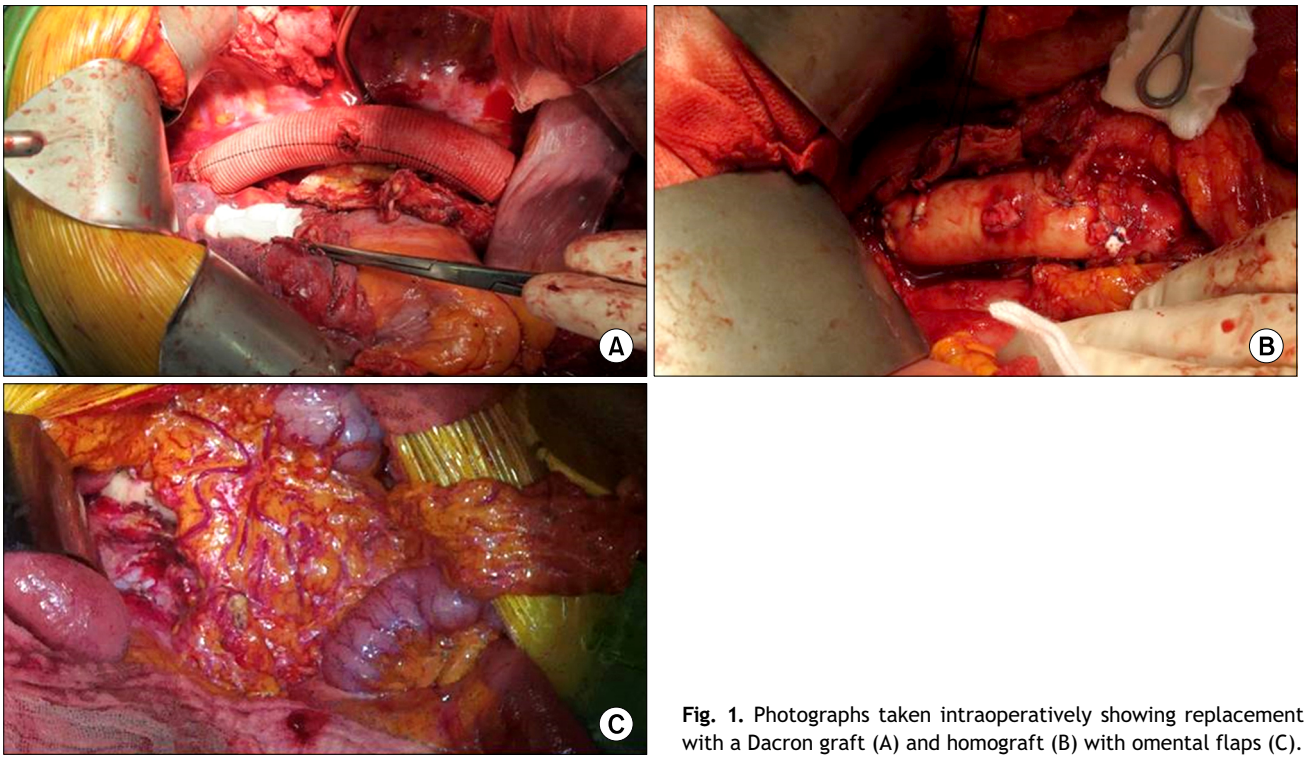

Fig. 1. Photographs taken intraoperatively showing replacement with a Dacron graft (A) and homograft (B) with omental flaps (C).

surgery was 14.5±4.7 days.

3) Anatomic location

Of the 19 mycotic aneurysms, 3 (15.8%) were ascending, 6 (31.6%) were descending thoracic, 2 (10.5%) were thoracoabdominal, and 8 (42.1%) were abdominal.

4) Surgical procedure

Following radical debridement of the infected tissue, Dacron grafts (n=15, 78.9%) (Fig. 1A), cryopreserved arterial homografts (n=3, 15.8%) (Fig. 1B), or a Gore-Tex graft (n=1, 5.3%) was placed *in situ* in the normal anatomic position. Nine patients (47.4%) had additional soft-tissue coverage, including 8 (42.1%) with an omental flap (Fig. 1C) and 1 (5.3%) with a pectoralis major muscle flap (Table 2).

5) Bacteriology and antibiotic treatment

Blood cultures were positive for *Staphylococcus aureus* in 4 patients (21%), while 3 (15.7%) had *Enterobacter* species. Nine (47%) had negative culture results. The remaining results of the bacteriological analysis are outlined in Table 2. Patients were initially administered broad-spectrum antibiotics, followed by targeted antibiotics after the causative organisms were identified and their susceptibility analyzed. Broad-spectrum intravenous antibiotics were administered in the early postoperative period for 4–6 weeks and then replaced by oral therapy based on the results of the bacteriological analysis [6,7].

6) Short-term outcomes

The mean intensive care unit (ICU) stay and in-hospital stay were 11±19.7 and 52±44.6 days, respectively. There were 2 in-hospital deaths (10.5%), secondary to sepsis and acute myocardial infarction.

7) Long-term outcomes

The mean follow-up time of the patients was 43.2±11.7 months. Two patients (10.5%) died of aneurysm-related complications during the follow-up period. One patient presented 32.4 months postoperatively with massive hematemesis due to an aorto-enteric fistula. Another patient died 61.9 months postoperatively due to sepsis from a mediastinal abscess resulting from graft reinfection (Table 1). During follow-up, 1 patient had a prosthetic graft reinfection, as mentioned above. None of the patients had a spinal cord injury or stroke. One patient re-

Table 2. Individual case details

No.	Age (yr)	Gender	Comorbidity	Symptom	Preoperative duration (day)	Bacteriology		Location	Conduit	Soft tissue coverage	Outcome
						Gram stain	Species				
1	71	M	ESRD-peritoneal dialysis	Fever, back pain	75	−	*Enterobacter*	Abdominal	Dacron	No	Died
2	77	M		Abdominal pain	1	+	*S. aureus*	Abdominal	Dacron	No	Discharged
3	78	M	Infrarenal aortic aneurysm s/p graft replacement	Hematochezia, hematemesis	1		None	Abdominal	Gore-Tex	No	Died
4	16	M	Desmoplastic small round cell tumor s/p autologous peripheral blood stem cell transplantation	Fever, cough, hematemesis	1	−	*Klebsiella*	Descending	Dacron	No	Died
5	57	M	DM, military pulmonary tuberculosis	Chest pain, hemoptysis	10	−	*Enterobacter*	Descending	Dacron	Omental	Died
6	72	M	DM, ESRD-hemodialysis	Upper extremity weakness	0		None	Abdominal	Dacron	No	Discharged
7	38	F	Left atrial myxoma s/p excision of cardiac mass	Epigastric pain	7	−	*Pseudomonas*	Ascending	Homograft	Pectoralis	Discharged
8	73	M	HTN, CAOD 3VD, s/p off-pump coronary artery bypass 3 grafts	Chest pain	7	+	*S. aureus*	Thoracoabdominal	Dacron	No	Died
9	72	F	Empyema s/p decortication	Fever	46	−	Nontyphoidal	Descending	Dacron	No	Discharged
10	65	F	DM	Fever, abdominal pain, both flank pain	8	+	*S. aureus*	Descending	Dacron	No	Discharged
11	65	M	HTN, DM, basal cell carcinoma (derma)	Fever, abdominal pain	1		None	Descending	Dacron	Omental	Discharged
12	45	F	SLE, ESRD, CAOD 2VD		9		None	Abdominal	Dacron	Omental	Discharged
13	66	F	HTN, DM, chronic heart failure, ESRD	Abdominal pain	7		None	Thoracoabdominal	Dacron	Omental	Discharged
14	71	M	HTN	Fever, weight loss, cough, sputum, chest discomfort	30	+	None	Abdominal	Homograft	Omental	Discharged
15	76	M	HTN, ESRD, CAOD 3VD s/p multiple percutaneous transluminal coronary angioplasty, rule out SLE	Abdominal pain	30	−	None	Abdominal	Homograft	Omental	Discharged
16	53	M	Ventricular septal defect s/p patch repair	Hemoptysis	7		*S. aureus*	Ascending	Dacron	Omental	Discharged
17	71	M	Infectious spondylitis, endocarditis	Fever, lower extremities weakness	7		*Enterobacter*	Ascending and arch	Dacron	No	Discharged
18	65	F	Ruptured abdominal aorta s/p endovascular aneurysm repair	Back pain	60		None	Descending	Dacron	Omental	Discharged
19	47	M	Rectal cancer s/p radio therapy	Fever, chills	60		None	Abdominal	Dacron	No	Discharged

ESRD, end-stage renal disease; *S. aureus*, *Staphylococcus aureus*; s/p, status post; DM, diabetes mellitus; HTN, hypertension; CAOD, coronary artery occlusive disease; VD, vessel disease; SLE, systemic lupus erythematosus.

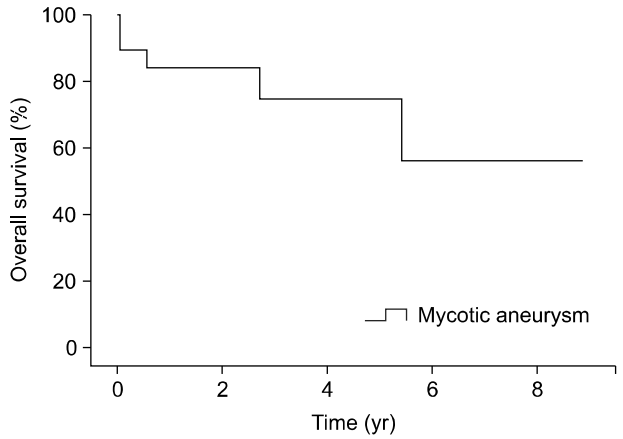

Fig. 2. Kaplan-Meier survival estimates of mycotic aortic aneurysms.

quired new-onset dialysis and developed permanent renal failure. None of the patients underwent reoperation. The 5-year survival rate after surgery was 74.9%±11.5% (Fig. 2).

Discussion

Mycotic aneurysms were first described by Osler in 1885, referring to infected aneurysms secondary to septic embolisms due to endocarditis. The incidence of infected aneurysms is higher when invasive monitoring techniques, angiography, and other percutaneous techniques are performed; it is also higher in patients with immunosuppressive conditions and in intravenous drug users [8,9].

A European multicenter collaboration of 16 centers was conducted to retrospectively evaluate the durability of endovascular aortic repair in patients with mycotic aortic aneurysms, by assessing late infection-related complications and long-term survival. In that study, 5% of patients were converted to open repair during a mean follow-up period of 35 months, and the 5-year survival rate was 55% [10]. In another study, in-hospital mortality was 22.7% in the extra-anatomic reconstruction group and 18.9% in the *in situ* repair group [11]. Our hospital has considerable experience with *in situ* repair; the in-hospital mortality rate was 10.5% and the 5-year survival rate was 74.9%±11.5% during the 43.2-month follow-up period. *In situ* revascularization has gradually become a standard procedure, based on good results reported in the literature [11-13]. Therefore, the use of stent grafts in the setting of infection could be performed just as a bridge procedure to open repair, because the endograft inevitably becomes infected and fails.

The choice of the ideal conduit is still controversial [12]. To reduce the risk of reinfection, rifampicin-impregnated grafts or cryopreserved arterial homografts can be used instead of prosthetic grafts. However, no studies have confirmed the superiority of rifampicin-impregnated grafts. Cryopreserved arterial homografts have lower rates of reinfection (approximately 20%) but higher rates of aneurysmal degeneration and rupture (0%–9%) [7,14,15]. Lau et al. [1] reported that the 5-year survival rate of aortic surgical repair using Dacron prostheses was 71%, with no prosthetic graft infection observed during follow-up. This study also demonstrates that using Dacron prosthetic grafts led to acceptable outcomes in terms of reinfection and surgical outcomes.

To reduce the risk of reinfection, we covered the graft with a pedicle of uninfected tissue, such as the omentum; increased the blood supply; and increased the antibiotic concentration in the area [11]. In our series, we observed only 1 case of reinfection (5.2%) after *in situ* reconstruction. Our data show that favorable results can be obtained by *in situ* revascularization, aggressive debridement, and soft-tissue coverage in cases without an advanced-stage infection.

Although mycotic aneurysms have been reported in all age groups, the typical patient is elderly and has atherosclerosis [5,16,17]. In our study, the mean age of the patients was 62±7.2 years. Compared with noninfected aortic aneurysms, mycotic aneurysms tend to be symptomatic [18]. Almost all of our patients had aneurysm-related symptoms, including fever and pain (Tables 1, 2). Therefore, early operative intervention is indicated in these cases, especially for older patients with symptomatic aortic aneurysms.

In the literature, the most frequently reported microorganisms related to mycotic aneurysms are *Staphylococcus, Streptococcus,* and Gram-negative microorganisms, such as *Klebsiella pneumoniae* and *Salmonella* [5]. Gram-negative microorganisms are thought by many to exhibit a more virulent course, because of their ability to invade the normal intima and cause early aneurysm rupture [3]. In this study, the patient with *Salmonella* presented with a rupture at admission; she also had the longest ICU and hos-

pital stay due to sepsis. Therefore, if a positive culture is found for Gram-negative microorganisms, aggressive surgical treatment and antibiotic suppression therapy are needed to prevent a fatal outcome.

The outcome of surgery depends on several factors, including the type and location of the aneurysm, the form of presentation, the patient's comorbidities, the microorganism that is isolated, the type and duration of antibiotic therapy, and the type of surgery [11]. Our results suggest that uncontrolled fever, rupture, and Gram-negative microorganisms are risk factors for adverse surgical outcomes.

In our series, because of the lack of power in the sample and the retrospective nature of the study, a robust statistical analysis was not possible. Therefore, a much greater number of cases than were available for this series is necessary to demonstrate any influence of the surgical technique on outcomes.

In conclusion, the early and midterm outcomes of the open repair of mycotic aneurysms were favorable. Aggressive intraoperative debridement with *in situ* prosthetic reconstruction and soft-tissue coverage yielded a high rate of success in these very high-risk patients.

Conflict of interest

No potential conflicts of interest relevant to this article are reported.

Acknowledgments

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