Ten-Year Experience with Surgical Repair of Mycotic Aortic Aneurysms

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Background: Mycotic aneurysm remains a lethal pathologic entity, especially when rupture occurs. It may result from primary aortitis, be induced by septic emboli, or be secondary to an adjacent infection, such as pancreatitis or a psoas muscle abscess. Surgical intervention is the only way to treat such disease. Even when successful repair is achieved by insertion of an interposition *in situ* graft or by performance of an extra-anatomic bypass, the prognosis is poor. The aim of this study was to present our experience of managing mycotic aortic aneurysms during the past 10 years.

Methods: From January 1994 to June 2004, a total of 734 patients with aortic aneurysms underwent surgical repair at our institution. Among these cases, 17 (2.3%) were shown to be mycotic aneurysms of the ascending aorta (n = 1), aortic arch (2), thoracic and thoracoabdominal aorta (3), or abdominal aorta (11); 14 patients (mean age, 58.8 years) were male. Preoperative imaging studies were performed in all patients. Mycotic aortic aneurysms were suspected in 12 of the 17 patients (70.6%) preoperatively, and 4 of these 12 patients were found to have ruptures on imaging. At the time of surgery, 9 of the 17 aneurysms (52.9%) were ruptured. Fifteen patients had an interposition graft inserted after meticulous debridement, 1 underwent an aorto-aortic bypass, and 1 underwent an extra-anatomic (axillo-femoral) bypass. An omentum patch was applied to wrap the graft in 8 of 11 mycotic aortic aneurysms of the abdominal aorta. The most common pathogens were *Salmonella* spp. (n = 7) and *Staphylococcus* spp. (4). All patients received antibiotic therapy, according to the culture report, for about 4–6 weeks postoperatively.

Results: In-hospital mortality was 11.8% (n = 2). Another patient died from massive upper gastrointestinal bleeding 6 months after operation because of complications involving an aorto-duodenal fistula, and another died from stomach cancer 6 years after surgery. Long-term follow-up (mean, 37 months; range, 3–111 months) revealed that, at the time of writing, the remaining 13 patients were alive and well, without any recurrence of aneurysm.

Conclusion: Mycotic aneurysm of the aorta is a life-threatening disease, especially when rupture occurs. The high mortality rate is due not only to the high rupture rate, but also to sepsis. When mycotic aortic aneurysm is diagnosed, early surgical intervention is mandatory. [*J Chin Med Assoc* 2005;68(6):265–271]

Key Words: extra-anatomic bypass, *in situ* graft interposition, mycotic aneurysm

Introduction

The term "mycotic aneurysm" was first used by Sir William Osler in 1885 to describe infected aneurysms that had developed as complications of bacterial endocarditis.[1] However, fungal infection was not correlated with the cases presented at that time, and the term "mycotic" was, therefore, misleading. At present, the term "mycotic aneurysm" is used to describe all kinds of "infected" aneurysms, irrespective of the causative pathogen. It is believed that bacteremic emboli may lodge in a diseased or atherosclerotic arterial wall, especially in larger arteries such as the aorta. The septic emboli may then enter the vasa

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vasorum and cause vessel-wall infection. As the arterial infection progresses, the arterial wall may be destroyed and aneurysm forms. With this pathogenesis, the causes include infective endocarditis, primary aortitis, and systemic bacteremia. Conversely, aneurysm may initially form gradually with chronic atherosclerotic change, and a pathogen may enter and infect pre-existing atherosclerotic aneurysm. A mycotic aortic aneurysm may result from an extravascular infectious source, such as pancreatitis, psoas muscle abscess, or vertebral osteomyelitis. In addition, localized infection close to the aorta can gradually erode the aortic wall such that a pseudo-aneurysm develops. Surgical intervention is the only way to eradicate an infected aortic aneurysm. After surgery, antibiotic therapy to which the pathogen is sensitive is needed. Here, we report our experience of managing mycotic aortic aneurysms in our institution during the past 10 years.

Methods

Study participants and follow-up

From January 1994 to June 2004, 734 patients underwent surgical repair of aortic aneurysms at our institution. Seventeen patients (2.3%; Table 1) had mycotic aneurysms, based on the criteria of imaging studies and culture reports; this group comprised 13 men and 4 women of mean age 58.8 years (range, 2–75 years). The diagnostic criteria for mycotic aneurysm were a positive culture report for the aneurysm wall or a pus discharge surrounding the aneurysm noted perioperatively (Figure 1), even if there was a negative culture result for the aneurysm wall. All medical and surgical records and imaging studies were reviewed retrospectively by 2 experienced vascular surgeons.

The mean follow-up period was 37 months (range, 3–111 months) and comprised imaging studies, such as abdominal sonography, computed tomography (CT), magnetic resonance imaging or angiography, and laboratory examinations, including complete blood counts, and measurement of C-reactive protein levels.

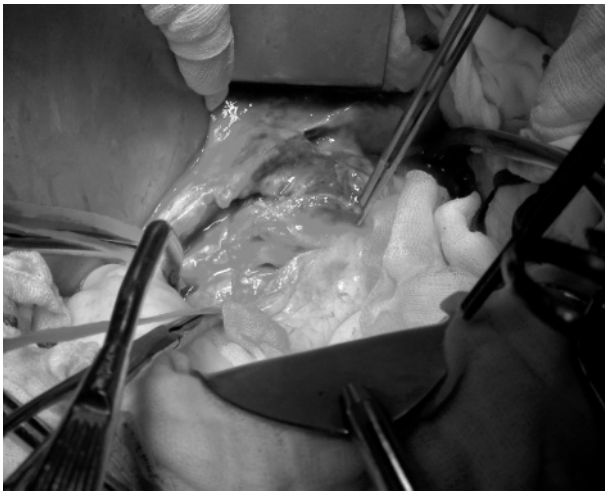

Figure 1. A multiple lobulated retroperitoneal abscess and purulent discharge from the aneurysm wall.

Table 1. Clinical characteristics of 17 patients with mycotic aortic aneurysm

Case	Age (yr)/ Gender	Location	Pathogen	Ruptured	Operative procedure	Outcome
1	71/F	Thoracoabdominal	*Staphylococcus* spp.	Yes	Interposition graft	Death
2	65/M	Infrarenal abdominal	*Salmonella* spp.	Yes	Interposition graft + omentum patch	Good
3	74/M	Aortic arch	Negative	No	Interposition graft	Good
4	46/M	Infrarenal abdominal	*Salmonella* spp.	Yes	Interposition graft + omentum patch	Good
5	67/M	Infrarenal abdominal	*Salmonella* spp.	Yes	Interposition graft + omentum patch	Death*
6	62/M	Thoracic	*Staphylococcus* spp.	Yes	Interposition graft	Death†
7	75/M	Infrarenal abdominal	*Klebsiella* spp.	Yes	Axillo-femoral bypass	Good
8	62/M	Thoracic	*Streptococcus* spp.	Yes	Aorto-aortic bypass	Death
9	2/F	Ascending aorta	*Staphylococcus* spp.	No	Interposition graft	Good
10	22/F	Aortic arch	Negative	No	Interposition graft	Good
11	65/M	Infrarenal abdominal	Negative	No	Interposition graft	Good
12	58/M	Infrarenal abdominal	*Salmonella* spp.	No	Interposition graft + omentum patch	Good
13	75/M	Infrarenal abdominal	*Salmonella* spp.	No	Interposition graft + omentum patch	Good
14	62/M	Infrarenal abdominal	*Staphylococcus* spp.	No	Interposition graft	Good
15	60/M	Infrarenal abdominal	*Salmonella* spp.	Yes	Interposition graft + omentum patch	Good
16	64/M	Infrarenal abdominal	*Salmonella* spp.	Yes	Interposition graft + omentum patch	Good
17	76/M	Infrarenal abdominal	Negative	No	Interposition graft + omentum patch	Good

**Died from gastric cancer 6 years after operation; †died from aorto-duodenal fistula 6 months after operation.*

Etiology and patient status

The definitive causes of mycotic aneurysm remained unclear in all cases, except in 1 patient who had a previous related chronic infection of the biliary tract with necrotizing pancreatitis, and in whom cultures from adjacent tissue and the aneurysm wall were identical. Various accompanying infectious diseases were also found in other patients, including prostatitis (n = 1), epididymitis (1), bronchopneumonia (1), urinary tract infection (1), psoas muscle abscess (1), tuberculous meningitis (1), and perianal abscess (1). Although the infections and aneurysms did not yield identical culture results in these patients, it can be assumed that the patients had inflammation that facilitated infection. Of the 17 patients, 14 had a history of hypertension, which seemed to be a predisposing factor leading to aneurysm formation; 4 had a history of type 2 diabetes mellitus; and 1 had a history of nasopharyngeal cancer, and had completed a course of radiotherapy. Immunocompromised patients are also at high risk of infection.

Clinical findings and imaging studies

Interestingly, all 17 patients with mycotic aneurysms were symptomatic when compared with the other patients with aortic aneurysms. The most common complaint was pain, including that in the chest, abdomen, flank, and lower back, depending on location of the aneurysm. Fever occurred in 8 patients (47.1%). Diarrhea, hemoptysis, productive cough, and body weight loss, were also noted. Most of the symptoms, especially pain and fever, had persisted for more than 7 days. Signs of infection were also found preoperatively. Leukocytosis was found in 9 patients (52.9%), and an elevated level of C-reactive protein was found in 13 (76.5%). Hemorrhagic shock was noted in 2 patients on arrival at our emergency room.

All 17 patients underwent preoperative imaging studies. Mycotic aortic aneurysm was identified preoperatively in 12 patients: CT scans disclosed a free rupture in 4 patients and a concealed rupture in 5; the latter results were compatible with operative findings[2] (Figure 2). The 5 patients whose preoperative imaging studies did not reveal mycotic aortic aneurysm were diagnosed with the condition based on surgical findings of pus discharge from adjacent tissue and the aortic wall.

Anatomic locations and rupture

The most common location for mycotic aortic aneurysm in this series was the infrarenal aorta, which accounted for 11 cases. The ascending aorta was involved in 1 patient, the aortic arch in 2, the thoracic aorta in 2, and the thoracoabdominal aorta in 1. One of the patients developed an infrarenal aneurysm 3 months after surgical repair of a thoracic aneurysm.

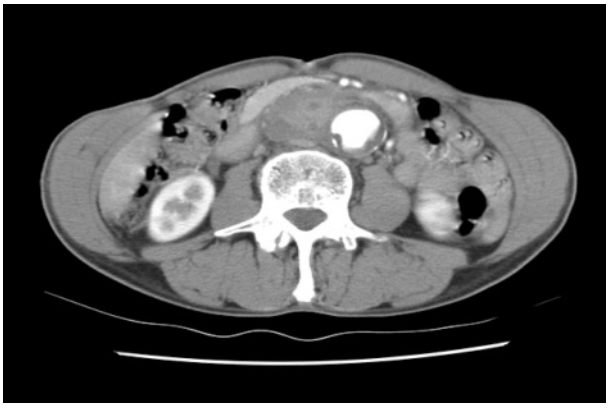

Figure 2. Abdominal computed tomography scan showing a retroperitoneal abscess and formation of an aortic aneurysm.

The aneurysms of 9 patients were ruptured during operation. The thoracic aorta was involved in 2 patients, the thoracoabdominal aorta in 1, and the abdominal aorta in 6. Four of them were found, preoperatively, to be ruptured, and the other 5 patients were found to be ruptured during operation. In these 9 patients with ruptured aneurysms, 2 presented with free ruptures, hemorrhagic shock, and unstable vital signs; 2 seemed to have chronically ruptured aneurysms, with adhesion to the pleural space and lung parenchyma; and the other 5 had ruptures confined to the retroperitoneal space.

Bacteriology

Specimens from all aneurysm walls were sent for culture. The culture results were negative for 4 patients, 3 of whom had been treated with antibiotics for more than 1 week preoperatively. Among the other 13 patients, the causative microorganisms were *Salmonella enteritis* group D (n = 7), *Staphylococcus aureus* (4), *Klebsiella pneumoniae* (1), and *Streptococcus pneumoniae* (1). Blood cultures were also carried out for 12 patients, and 6 of the cultures were positive: the organisms isolated were *S. enteritis* group D (n = 4), *S. aureus* (1), and *K. pneumoniae* (1).

Selection of surgical intervention

The appropriate surgical management for mycotic aortic aneurysm is eradicative debridement and reconstruction of the aorta. The procedure comprises resection of the infected aorta and reconstruction, either by implantation of an interposition *in situ* graft or by extra-anatomic bypass. We reconstructed the aorta with an interposition *in situ* graft in 15 patients; 1 patient underwent an aorto-aortic bypass for a

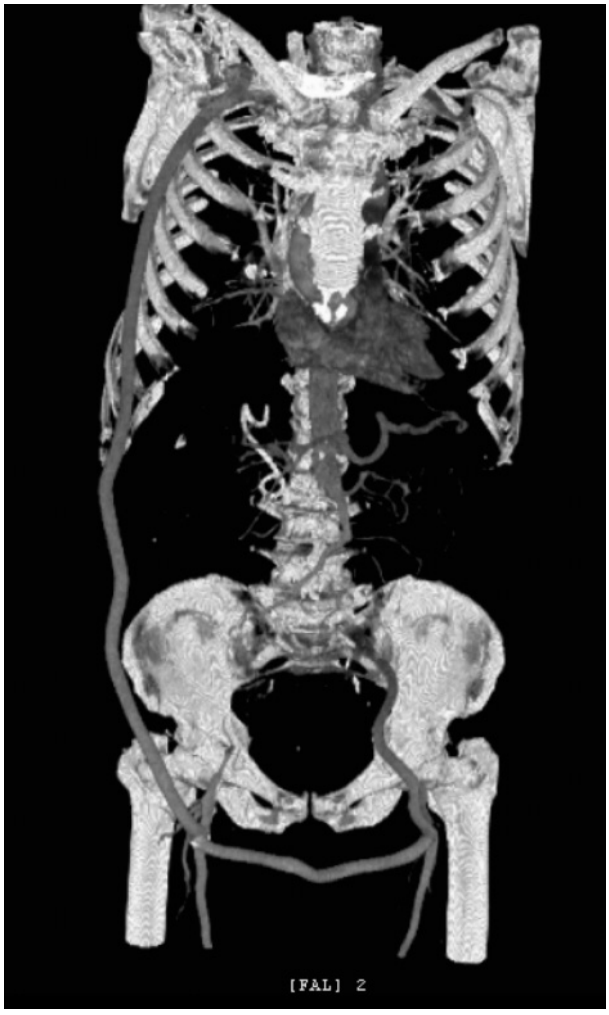

Figure 3. Computed tomographic angiography showing good graft patency and the transected abdominal aorta.

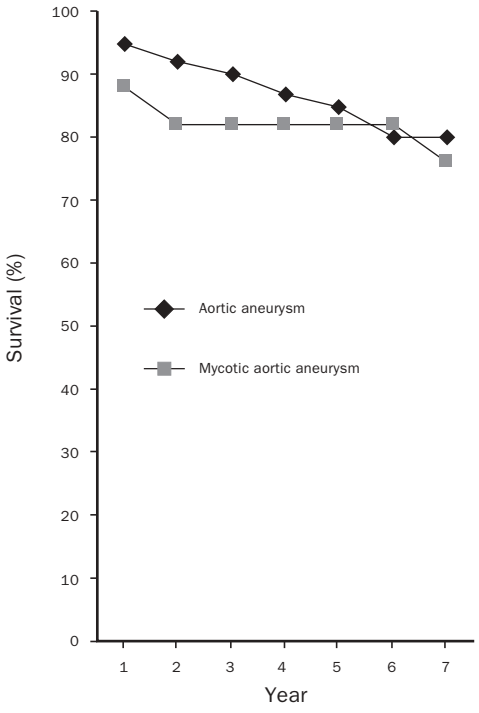

Figure 4. Patient survival rates with life-table analysis.

thoracic mycotic aortic aneurysm with severe infection; and the remaining patient, who had severe bowel and peritoneal adhesion due to chronic biliary tract infection with necrotizing pancreatitis, underwent an extra-anatomic bypass, involving an axillo-femoral bypass and a femoro-femoral crossover bypass (Figure 3). After meticulous debridement and reconstruction of the aorta with graft interposition, an omentum patch was harvested and wrapped around the graft in 8 of the 11 patients with infrarenal mycotic aortic aneurysms. All patients were subsequently treated with appropriate antibiotics for 4–6 weeks postoperatively.

Results

Overall, the in-hospital mortality rates for aortic and mycotic aortic aneurysms were 4.7% and 11.8%, respectively (Figure 4). There were 2 deaths in the mycotic group: 1 patient with aneurysm of the abdominal aorta with free rupture, who initially presented with unstable vital signs and hemorrhagic shock; and 1 patient with aneurysm of the proximal thoracic aorta, who initially presented with fever and hemoptysis, and who was treated for pneumonia and an unknown lung mass. In the first case, unstable hemodynamics and acute renal failure developed postoperatively despite a successful graft, and the patient died 12 hours after the operation. In the second case, the patient's hemoptysis progressed, and chest CT disclosed a ruptured thoracic mycotic aortic aneurysm. Despite successful surgical repair with an aorto-aortic bypass, the patient died 4 days after the operation due to marked sepsis and multiple organ failure.

The mean follow-up time for the remaining 15 patients was 37 months (range, 3–111 months). There were 2 late deaths: 1 patient died from stomach cancer 6 years after the operation; and 1 died from hemorrhagic shock, because of complications with the aorto-duodenal fistula, 6 months after the operation. In the latter patient, a ruptured thoracic mycotic aortic aneurysm was noted initially. Although the operation was successful at first, an infrarenal mycotic aortic aneurysm developed 3 months later. The patient then underwent further aneurysm repair. Unfortunately, massive hematemesis occurred 3 months after the second operation.

Exploratory laparotomy was performed immediately, and an aorto-duodenal fistula was found. The patient eventually died because of hemorrhagic shock. Long-term follow-up of the remaining 13 patients has, at the time of writing, been uneventful without any recurrence of aneurysm formation.

Although our report does not provide any meaningful statistical analysis because of the small sample (n = 17) and the retrospective nature of the investigation, rupture of mycotic aortic aneurysm clearly seems to have a major influence on mortality. Our 3 surgical deaths all correlated with the presence of aneurysm rupture at the initial presentation. We also conducted a life-table analytic comparison of mycotic with non-mycotic aneurysms (Figure 4). Surgical and 1-year mortality rates were higher in the mycotic than non-mycotic group, whereas no difference in 5-year mortality rate was evident.

Discussion

The pathophysiology of mycotic aneurysm can be described in 1 of 3 ways. Firstly, bacteremia exists, and septic emboli subsequently infect the arterial wall and cause aneurysm formation. Secondly, in patients with predisposing factors such as hypertension, hyperlipidemia, and diabetes, an aortic aneurysm forms initially, and subsequently, systemic pathogens may lodge in the existing aortic aneurysm. Thirdly, a mycotic aneurysm may result from an extravascular source or adjacent tissue. Before the introduction of antibiotics in the 1930s (sulfonamides) and their widespread use from the 1940s onwards (penicillin, streptomycin, etc.), mycotic aneurysms of intravascular origin (infection from "within") were generally limited to patients with infective endocarditis. In a series of 217 cases reported in 1923, 86% of the mycotic aneurysms were associated with infective endocarditis.[3] With the introduction of antibiotics during the past 50 years, the incidence of infective endocarditis decreased gradually, and mycotic aortic aneurysms associated with endocarditis became rare.[4] However, the leading etiology of mycotic aortic aneurysms changed. As a Western diet became more popular, the occurrence of risk factors for cardiovascular disease, such as hyperlipidemia, hyperglycemia, and hypertension, increased. Vessels became more atherosclerotic and diseased, and indeed, atherosclerotic mural thrombus deposited on the aortic wall is a source of nutrition for infective organisms. In our report, 14 of the 17 patients (82.4%) had a history of hypertension.

Despite the fact that mycotic aneurysms occur in all age groups, the elderly comprised the largest group in our series. Among the non-elderly patients in our study, 1 was only 2 years old, and another was 22 years old. The remaining 15 patients were all older than 46 years, and had a mean age of 64 years. When patients with mycotic versus non-mycotic aortic aneurysms are compared, the former are more often symptomatic and usually experience pain and fever.[4,5] In our series, all patients were symptomatic, with symptoms having lasted for more than 7 days, and even up to 2 months.

In our report, *Salmonella* spp. (n = 7) and *Staphylococcus* spp. (4) were the most common pathogens, a finding similar to that in previous literature.[6,7] Nontyphoidal S*almonella* spp. are common food-borne pathogens and a major cause of gastroenteritis in humans.[8,9] The most common symptoms after *Salmonella* infection are diarrhea, abdominal cramping pains and fever.[9,10] The first case of mycotic aneurysm due to *Salmonella* spp. was reported in 1909 by Cathcart[11] in a patient with typhoid fever. Cohen et al,[12] in a classic study published in 1978, found that 25% of bacteremic adults aged over 50 years developed endovascular infections due to *Salmonella* spp., and that these infections mainly involved aortic atherosclerotic plaques.

The optimal surgical management of mycotic aortic aneurysms remains controversial, but should include eradication of the source of infection and reconstruction of the aorta. Adequate drainage, administration of organism-specific parenteral antibiotics, and surgical debridement, are the strategies used to resolve infection. The extent to which infection is eradicated may influence further aortic reconstruction, which comprises either interposition graft implantation or extra-anatomic bypass.[13–16] In a review of 150 patients with aortitis due to nontyphoidal *Salmonella* spp., Soravia-Dunand et al[17] reported that patients with an extra-anatomic bypass had fewer early postoperative complications and a better survival rate (71% vs 51%) than patients with an interposition *in situ* graft. Conversely, long-term results for extra-anatomic bypass (graft stenosis, inadequate blood supply to the viscera) were worse than for *in situ* graft implantation.[16,17] In this series, for the 8 patients who had infrarenal abdominal mycotic aneurysms, we applied an omentum patch to cover the interposition graft. Regarding long-term follow-up, all 8 patients had a good clinical condition, without any recurrent aneurysm formation. Follow-up angiography for the 1 patient who received an extra-anatomic bypass showed good graft patency (Figure 5).

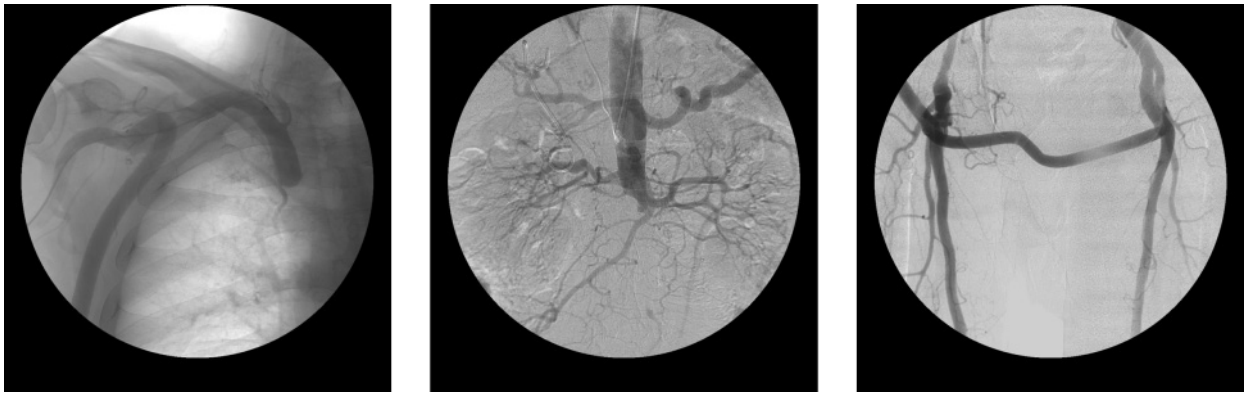

Figure 5. Follow-up angiography for a patient who underwent extra-anatomic bypass: good graft patency can be seen in the axillo-femoral and femoro-femoral crossover bypass; the transected abdominal aorta can also be seen.

Although a period of antimicrobial therapy before surgery is advised, immediate surgery is indicated, irrespective of bacteriologic status, when there are signs of rupture or impending rupture.[18] Antibiotic administration according to postoperative sensitivity testing is crucial: although the optimum duration of postoperative antibiotic therapy remains unclear, recommendations have ranged from 6 weeks to lifelong.[4,13–15] Generally, there is little doubt about the need for postoperative parenteral antibiotic therapy for 4–6 weeks, whereas controversy still exists about the appropriate duration of oral antibiotic therapy.[4,13–15] Here, we suggest the use of antibiotic therapy for 6 weeks after defervescence; antibiotic therapy should be stopped only when all infectious signs and blood cultures are negative.

Our results are similar to reports from other centers (Table 2). An interesting feature is that *Salmonella* spp., rather than *Staphylococcus* spp., seem to cause most mycotic aortic aneurysms in Eastern countries, but no definitive reason for this can be offered at present. It may be plausible that people in Eastern countries like to eat sashimi (raw fish) and seafood, and that salmonellosis is common after the ingestion of contaminated foods.[19] Indeed, both sashimi and seafood in general have a greater than average risk of contamination with *Salmonella* spp.

After rupture of a mycotic aneurysm in the aorta, surgery is often too late, and septic emboli from the aneurysm may spread to peripheral tissues. Therefore, surgical intervention, as soon as possible after confirmation of the diagnosis, is mandatory. We conclude that surgical repair with an interposition graft, and omentum patch coverage in the absence of severe purulent infection, can achieve good long-term results.

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Table 2. Comparison of the present series of 17 patients with mycotic aortic aneurysm with recent literature about the condition

	Chen et al (2005) [present series]	Hsu et al[15] (2004)	Kyriakides et al[14] (2004)	Muller et al[13] (2001)
Number of cases	17	46	33	15
Location	IR/SR: 11/6	IR/SR: 26/20	IR/SR: 16/17	IR/SR: 4/11
Principal pathogen	SE/SA: 7/4	SE/SA: 35/3	SE/SA: 6/8	SE/SA: 3/3
Treatment	IS/EAB: 15/2	IS/MTA: 35/11	IS/EAB: 25/8	IS/EAB: 13/2
In-hospital surgical mortality rate (% of patients)	12	11	36	26

EAB = extra-anatomic bypass; IR = infrarenal; IS = in situ interposition graft; MTA = medical treatment alone; SA = Staphylococcus aureus; SE = Salmonella enteritis; SR = suprarenal.

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