Acute and contained rupture of the descending thoracic aorta: Treatment with endovascular stent grafts

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Purpose: **The purpose of this study was to evaluate feasibility and safety of endovascular stent grafting for the treatment of patients with rupture of the descending thoracic aorta.**
Methods: **Thirteen patients with rupture of the descending thoracic aorta were treated with endovascular stent grafting. Six patients were treated on the day of diagnosis because their vital signs were unstable, and the other seven patients were treated electively. Five patients had infection or potential infection, and the other eight patients did not. Expanded polytetrafluoroethylene-covered or polyester-covered Z stents were used in all patients.**
Results: **Stent grafts were successfully placed in all patients. No endoleaks were observed at the end of the procedure. However, rebleeding was observed within 2 weeks of the procedure in two patients with infection. Six patients (46%) died within 5 months of the procedure (mean survival period, 61 ± 60 days). All five patients with infection (100%) died, and only one of eight patients without infection (13%) died ($P < .01$). The remaining seven patients are alive during the mean follow-up period of 21 months (overall survival rate, 54%), although additional surgical interventions, including surgical conversion in one case and upper extremity extraanatomic bypass in the other, were necessary in two of these patients.**
Conclusion: **Endovascular stent grafting may be a safe and feasible method for the treatment of rupture of the descending thoracic aorta in selected patients without infection. However, its usefulness in terms of long-term prognosis appears to be extremely limited, especially in patients with infection. (J Vasc Surg 2003;37:100-5.)**

Endoluminal stent graft placement has now become widespread in the treatment of almost all aortic diseases after its initial clinical application in the early 1990s.[1,2] One of the advantages of interventional procedures over conventional open surgery is that the lesion can be accessed with less risk of further bleeding. Since the initial introduction of this technology in the clinical setting, aortic rupture has been one of the most reasonable and potentially beneficial indications of endovascular technology because of this advantage.[3] Recently, several investigators have reported the effectiveness of stent grafting for the treatment of aortic rupture. However, the numbers of treated patients have been small and no consensus can be reached on whether this technology is superior to conventional surgical repair in terms of long-term outcome.[4-8] In this report, we describe our experience in the use of endovascular stent grafting in the treatment of patients with rupture of the descending thoracic aorta and discuss the prognosis of patients after such therapy.

METHODS

Patients. Between July 1997 and February 2002, 71 patients with descending aortic diseases were treated with endovascular stent graft placement. Among them, 13 patients (18%) had rupture of the descending thoracic aorta. There were 10 men and three women. The ages ranged from 16 years to 82 years (mean, 65 ± 17 years). Conventional surgical repair was judged inadvisable because of various coexisting problems in all patients (Table I).

Three patients were hypotensive (systolic blood pressure < 90 mm Hg at any given preoperative point). Two of these patients with hypotension received blood transfusion (15 units and 36 units, respectively) since hypotension was sustained. Six patients, including three with hypotension, underwent stent graft repair on the day of diagnosis. The other seven patients underwent repair after a mean period of 44 ± 45 days (range, 1 to 110 days). Five of the 13 patients (38%) had infection or potential infection at the rupture site (ie, active mycotic aneurysm in two patients and fistulous communication with surrounding structures in two patients). In one patient with ruptured thoracic aortic aneurysm, potential fistulous communication between the aneurysm and the airway system was suspected because of hemoptysis.

Approval was obtained from the Institutional Review Board of the hospital. Informed consent was obtained from each patient or from the family when the patient was unconscious or was under age 20 years.

Preoperative imaging. Computed tomographic (CT) scan imaging was performed before surgery in 11 patients for diagnosis, and the remaining two patients did not undergo CT scanning but were examined with angiography immediately after the diagnosis of rupture on the basis of clinical findings. Calibrated angiography with a catheter with graduations (Merit Medical Systems, South

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Table I. Patient characteristics

No.	*Age/ gender*	*Symptoms and signs*	*Disease*	*Coexisting problems*	*(Potential) Infection*	*Hypo-tension*	*Blood transfusion before/ during stent grafting*	*Hemo-globin (g/Dl)*	*ASA score*	*Interval between rupture and treatment (d)*
1	75/Male	Back pain	Type B aortic dissection with rupture	Chronic renal failure, aortic regurgitation	No	No	N/A	7.5	III	0
2	64/Female	None	Traumatic pseudo-aneurysm of thoracic aorta	Multiple fracture, hemothorax	No	No	N/A	12.1	II	30
3	59/Male	Massive he-matemesis	Fistula between thoracic aorta and esophagus	Esophageal carcinoma	Yes	Yes	36 units	5.3	IV	0
4	82/Female	Chest pain, hemoptysis	Rupture of my-cotic aneurysm of thoracic aorta	Bacteremia	Yes	No	N/A	8	III	0
5	63/Male	Hemoptysis	Rupture of true aneurysm of thoracic aorta	History of left up-per lobectomy and radiation therapy	Yes	No	N/A	8.8	III	71
6	75/Male	Back pain	Type B aortic dis-section with rupture	Hemothorax	No	Yes	N/A	6.8	III	0
7	16/Male	None	Traumatic pseudo-aneurysm of thoracic aorta	Multiple fracture, urethral rup-ture, contusion of small bowel mensentery	No	No	N/A	11	III	115
8	59/Male	Massive he-matemesis	Fistula between thoracic aorta and ileum	History of esopha-geal resection	Yes	Yes	18 units	6.7	IV	0
9	79/Male	Hoarseness, left shoulder pain	Rupture of true aneurysm of thoracic aorta	History of left thoracoplasty	No	No	N/A	11.1	III	88
10	70/Male	Back pain	Type A aortic dissection with rupture	Hemomediastinum	No	No	N/A	9.4	III	0
11	64/Male	None	Traumatic pseudo-aneurysm of thoracic aorta	Multiple fracture, hemothorax, liver laceration, asthma	No	No	N/A	9.2	III	1
12	70/Female	Back pain	Rupture of my-cotic aneurysm of thoracic aorta	Liver cirrhosis	Yes	No	N/A	6.4	III	7
13	77/Male	Back pain	Rupture of true aneurysm of thoracic aorta	History of left thoracoplasty	No	No	N/A	9.8	III	3

N/A, Not applicable; *ASA*, American Society of Anesthesiologists.

Jordan, Utah) was performed to determine the access routes and landing zones in all patients. Blood flow to aortic branches was also checked with angiography in cases of aortic dissection. CT scan images obtained previously were used to determine the design of the stent grafts in patients who did not undergo preoperative CT scan.

Stent grafts. Homemade stent grafts were used in all patients. Stent grafts were fabricated from Z stents (Cook, Bloomington, Ind) covered with thin wall woven polyester (UBE, Tokyo, Japan), which expanded polytetrafluoroethylene (Impra, Tempe, Ariz) and were dilated with a balloon catheter until the desired diameter was obtained. When thinner delivery systems were necessary, expanded polytetrafluoroethylene–covered stents were preferred. Graft materials were attached to the Z stents with 5-0 polypropylene sutures (Ethicon, Somerville, NJ). The diameters of the stent grafts were selected to be 10% to 20% larger than those of both the proximal and distal landing zones, which were measured on CT scan or angiography. An 18F, 20F, or 22F delivery system (Cook) was used for deployment. For patients whose hemodynamics were unstable, back-up stent grafts were used. At our institution, we keep back-up stent grafts of the tubular type in four sizes (25, 32, 36, and 40 mm in diameter and 7.5 cm in length) for the treatment of aortic diseases.

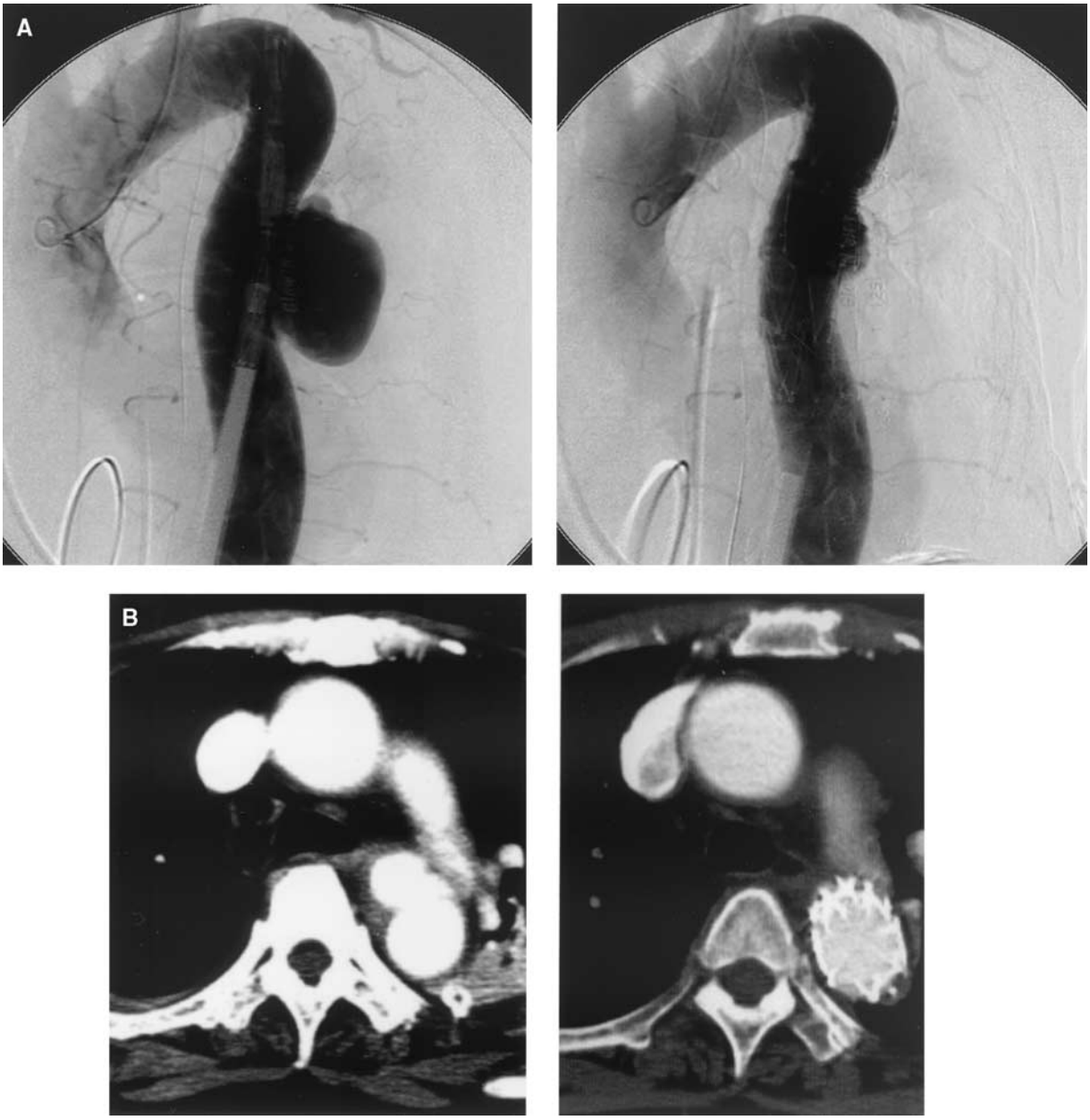

Fig 1. A 77-year-old man with contained rupture of middle descending thoracic aorta. Because patient had history of left thoracoplasty, stent graft repair was chosen. After stent graft repair, patient followed favorable clinical course without any complications. **A,** Angiography before *(left)* and after *(right)* stent graft placement. Aneurysm was completely excluded after stent grafting. **B,** CT scan before *(left)* and at 1 week after *(right)* stent grafting. Aneurysm has completely excluded after stent grafting.

Procedures. Stent graft placement was performed with general anesthesia. After femoral arteriotomy, the delivery system was advanced until its tip reached the proximal landing zone. The stent graft was inserted and advanced into the delivery system. Stent grafts were deployed by quickly withdrawing the outer sheath while firmly grasping the pusher mandrel. The blood pressure was reduced with a vasodilator, or transient cardiac arrest with adenosine was used to avoid misplacement. In one patient (patient 5), extraanatomic bypass surgery was necessary between the ascending aorta and the cervical branches under side clamping of the ascending aorta to create a sufficiently long proximal landing zone before stent graft placement. Antibiotics were administered from the time of initial diagnosis and were continued indefinitely in all patients with infection or potential infection.

Follow-up. Follow-up examination was performed with CT scan at 1 week, 1 month, 3 months, 6 months, and

Table II. Outcomes

No.	*Alive/dead*	*Stent graft–related death*	*Postprocedural problems and management*	*Stent graft–related postoperative problems*	*Follow-up (d)*
1	Dead	No	Pneumonia	None	9
2	Alive	N/A	None	None	1410
3	Dead	Yes	Sepsis	Sepsis	90
4	Dead	Yes	Rebleeding, resection of aneurysm and extraanatomic bypass, multiple organ failure	Rebleeding	3
5	Dead	Yes	Pneumonia, sepsis	Sepsis	106
6	Alive	N/A	Aneurysm development, surgical conversion	Aneurysmal degeneration	750
7	Alive	N/A	None	None	750
8	Dead	Yes	Rebleeding	Rebleeding	14
9	Alive	N/A	None	None	570
10	Alive	N/A	Left arm ischemia, bypass surgery	Left arm ischemia	540
11	Alive	N/A	Respiratory failure	None	360
12	Dead	No	Fistulous communication between aorta and esophagus, brain stem infarction	Fistulous communication between aorta and esophagus	150
13	Alive	N/A	None	None	120

N/A, Not applicable.

1 year and yearly thereafter. Endoscopic examination was performed in a patient with rebleeding (patients 4 and 8).

Statistical analysis. Comparison of survival and complication rates was performed with the χ^2 test. A P value of less than .05 was considered statistically significant.

RESULTS

Technical outcomes. Stent grafts were successfully placed in all patients (Fig 1). Seven patients needed one stent graft for successful repair, and six patients needed two stent grafts for successful repair. The diameter and the length of the stent grafts were 3.2 ± 0.3 cm (range, 2.7 to 3.6 cm) and 8.2 ± 1.2 cm (range, 7.5 to 10.0 cm), respectively. Complete exclusion of the aneurysm or complete sealing of the rupture site or entry tear, as confirmed with angiography at the end of the procedure, was achieved in all patients. All patients with hypotension became normotensive after stent graft placement. Disruption of the femoral artery at the access site occurred in one patient being treated for traumatic pseudoaneurysm of the proximal descending aorta (patient 7). Interposition of a vascular graft was necessary after stent graft placement in this patient. There were no other intraoperative complications.

Immediate clinical outcomes. Five of the 13 patients (38%) died before discharge, with a mean survival rate of 52 ± 62 days (range, 3 to 142 days; Table II). The causes of death were related to infection in three patients who had infection or potential infection at the rupture site before stent graft placement. These included rebleeding in two patients from infectious degeneration of the landing zones (patients 4 and 8) and sepsis in the remaining patient (patient 3). The cause of death in one patient with infection was brain stem infarction (patient 12). In this patient, fistulous communication between the descending thoracic aorta and the esophagus was observed during the follow-up period and was finally healed before death (Fig 2). The other patient, who had no infection, died of pneumonia (patient 1).

Late clinical outcomes. Eight (57%) of 13 patients could be discharged from the hospital. Only five of the 13 patients (38%) are doing well and did not have any late complications during the mean follow-up period of 21 ± 16 months (range, 4 to 47 months). However, one patient who had a thoracic aortic aneurysm with contained rupture and hemoptysis died of sepsis on the 106th day after stent grafting (patient 5). The cause of sepsis was thought to be related to infection through the communication between the airways and the ruptured aneurysm. The remaining two patients underwent additional interventions after discharge. Aneurysmal degeneration developed at the top end of the stent graft in the proximal descending thoracic aorta on the 41st postoperative day in one patient who had acute type B aortic dissection with rupture. Because the proximal neck was not sufficiently long, this patient underwent open surgery (patient 6). The other patient, who had acute type A aortic dissection with rupture, had left arm numbness after discharge (patient 10). Because the cause of this symptom was thought to be related to occlusion of the left subclavian artery by the stent graft, the patient underwent bypass surgery between the two subclavian arteries.

In summary, the overall survival rate in all patients with rupture of the descending thoracic aorta who were treated with endovascular stent grafting was 54% (7/13). In terms of the disease at the rupture site, all the five patients who had infection or potential infection died, and only one of eight patients (13%) without infection died ($P < .01$). Aorta-related complications, including infection, were observed in all the five patients (100%) who had infection or potential infection, and such complications were observed in only two of eight patients (25%) without infection ($P < .01$).

The general condition became stable after stent grafting in three of five patients with infection (patients 3, 5, and 12) for 3 months or more. Open surgery was not indicated for them because of their coexisting problems, including advanced esophageal carcinoma, history of upper lobec-

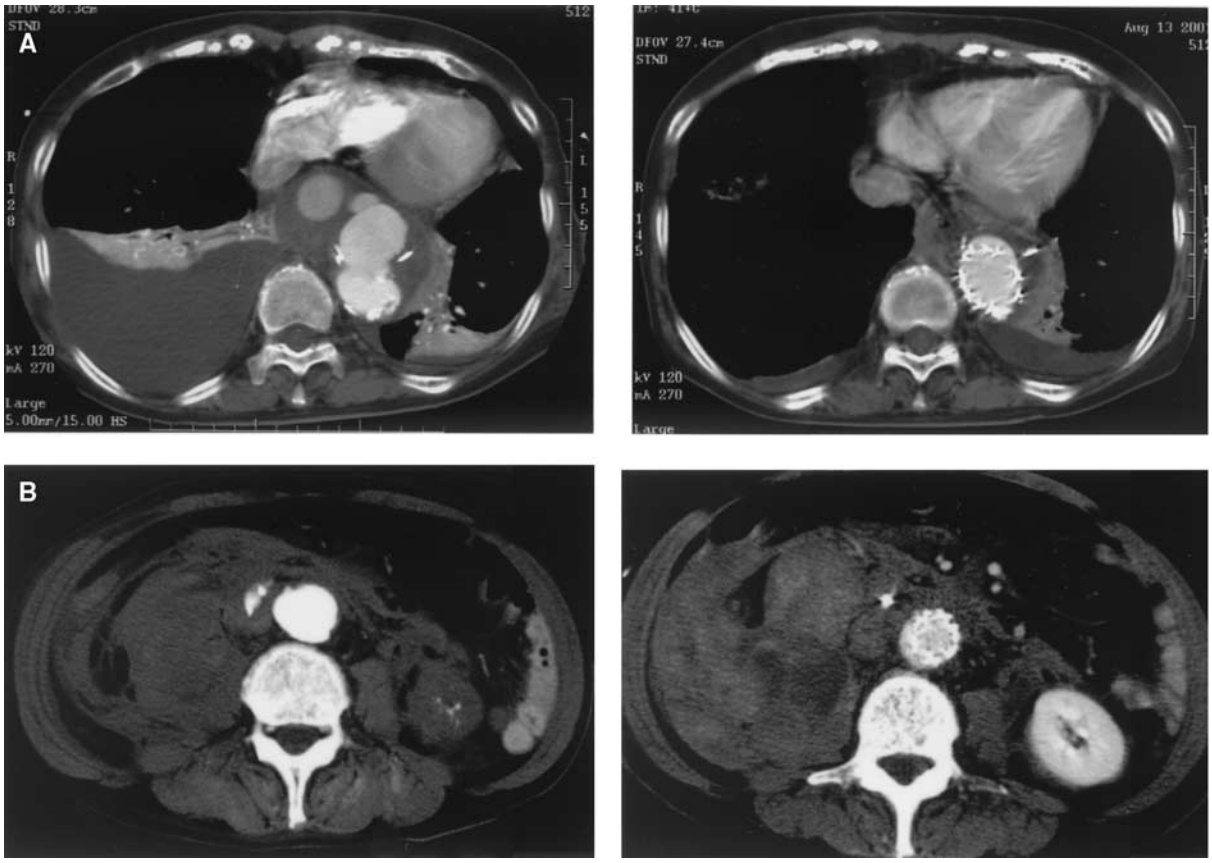

Fig 2. A 70-year-old woman with mycotic aneurysm in middle descending thoracic aorta. Although fistulous communication between aorta and esophagus developed after stent grafting, which was finally healed, patient was doing well until sudden death from brain stem infarction 5 months later. **A,** CT scan before *(left)* and after *(right)* stent graft placement. Pseudoaneurysm was completely excluded after stent grafting. **B,** Esophagogram obtained 1 month after stent grafting. Contrast medium can be seen in aneurysmal sac.

tomy of the left lung and radiation therapy, and severe liver cirrhosis. However, they might have undergone definitive surgery if they had not had such serious problems.

DISCUSSION

Semba et al[4] treated 11 patients with contained rupture of the descending thoracic aorta. Complete exclusion of the rupture was achieved in all patients without any procedure-related complications. In addition, they achieved an overall survival rate of 80%, which is much higher than that for surgical intervention, although it was not clarified whether there was infection at the rupture site in their series. Several investigators have reported similar results for the endovascular treatment of traumatic aortic pseudoaneurysms.[5,6] Similar to their rates, the overall survival rate of patients without infection, including traumatic pseudoaneurysm and aortic dissection with rupture, was 88% in our series. This fact is not surprising because stent graft repair is much less invasive than open surgery.

Controversy still exists concerning the appropriate treatment of mycotic aneurysms (ie, extraanatomic bypass with aneurysm excision versus in situ graft replacement).[9,10] However, the latter seems to have gained favor because mortality and morbidity rates for the two methods are similar but the former suffers from several limitations. Taylor et al[9] treated five patients with infected abdominal aortic aneurysms with extraanatomic bypass, aneurysm excision, and drainage. There were no operative deaths or complications except for wound dehiscence in one patient in their series.[9] Chan et al[10] treated 22 patients with mycotic aortic aneurysms, including mycotic thoracic aortic aneurysms, with in situ prosthetic graft replacement and showed an early survival rate of 86%.

As an alternative, Semba et al[11] have adopted endovascular stent grafting for the treatment of mycotic aneurysms. Although only three patients underwent such treatment and the follow-up period was short, exclusion of the aneurysm was achieved without any complications. In our series, five patients had infection or potential infection. In contrast to the previous report, all the five patients died within 5 months of stent graft repair. The causes of death were related to the infection at the rupture site in all patients except for one. In addition, rebleeding was observed from

the ends of the stent grafts in one patient, where the stent grafts were exposed from infectious degeneration of the aortic walls in the landing zone. This should be the result of the remaining infected tissue after stent grafting, unlike the case for in situ graft replacement, in which debridement is performed simultaneously, even though antibiotics are administered in both methods.[10]

Taking our results into consideration and comparing them with those of surgical interventions,[9,10] we may not be able to expect too much for the endovascular treatment of diseases in patients with infection. Instead, stent grafting could be used as a temporizing measure before definitive surgery. As described previously, three patients with infection would have had a chance to undergo definitive surgery after stent grafting stabilized their general condition if they had not had such serious coexisting problems.

There are several disadvantages in the endovascular repair of aortic rupture. First, it is not an uncommon situation for no stent grafts of appropriate size to be available when a patient with free rupture needs treatment. As mentioned previously, we keep several back-up stent grafts of the tubular type for the treatment of aortic diseases. This is why we are able to treat free ruptures in the emergent setting. However, it may not be possible for all institutions to store a sufficiently wide range of back-up stent grafts. Second, the hoop strength of stent grafts may have adverse effects on the walls of the landing zone. The walls of the landing zone may be fragile in cases with infection or potential infection, and excessive hoop strength may prove to be another factor responsible for degeneration of the walls, leading to rebleeding. In our series, rebleeding was observed in two patients. The main cause of rebleeding appeared to be infectious degeneration of the walls of the landing zone. However, the hoop strength of the stent grafts used may also have contributed to wall degeneration. Third, the stent grafts we use are semirigid designs that make it difficult to achieve complete apposition to the aortic curvature. Late surgical repair was necessary in one patient with acute type B aortic dissection to treat aneurysmal degeneration, which developed at the proximal end of the stent graft. In this case, the cause of aneurysmal degeneration was thought to be related to mechanical interference between the fragile intimal flap and the edge of the stent graft.[12]

Endovascular stent grafting for the treatment of the ruptured descending thoracic aorta appears to be feasible in some patients and may prove to be useful because of its reduced invasiveness in carefully selected patients (ie, those without infection). However, its efficacy in the treatment of ruptures with infection or potential infection appears to be extremely limited, and it may not contribute to long-term survival. Secondary definitive intervention, including combined resection of the rupture site and extraanatomic bypass surgery or debridement and in situ graft replacement, may be necessary after stabilization of the patient's condition to improve long-term survival.

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