Descending Thoracic Aortic Rupture: Role of Endovascular Stent-Grafting

Kiyofumi Morishita, Yoshihiko Kurimoto, Nobuyoshi Kawaharada, Johji Fukada, Yoshikazu Hachiro, Yasuaki Fujisawa and Tomio Abe

Ann Thorac Surg 2004;78:1630-1634

Descending Thoracic Aortic Rupture: Role of Endovascular Stent-Grafting

Kiyofumi Morishita, MD, PhD, Yoshihiko Kurimoto, MD, PhD, Nobuyoshi Kawaharada, MD, PhD, Johji Fukada, MD, PhD, Yoshikazu Hachiro, MD, PhD, Yasuaki Fujisawa, MD, and Tomio Abe, MD, PhD

Department of Thoracic and Cardiovascular Surgery, Sapporo Medical University School of Medicine, Sapporo, Japan

Background. **The mortality of patients with descending thoracic aortic rupture who are treated by conventional surgery is high. Our current strategy for the management of descending thoracic aortic rupture is to treat seriously ill patients with endovascular stent-grafting using handmade grafts, and to treat other patients with traditional open repair. The aim of this study was to assess the early results of our strategy.**

Methods. **Twenty-nine consecutive patients with descending thoracic aortic rupture were referred to Sapporo Medical University Hospital from June 2001 to January 2004. Eighteen of these 29 patients were selected for endovascular stent-grafting because of polytrauma (n = 7), comorbidities (n = 6), advanced age (n = 2), past history of left thoracotomy (n = 2), and patient's preference (n = 1). The remaining 11 patients underwent traditional graft replacement of the diseased aorta. Their outcomes and follow-up data were collected and analyzed retrospectively.**

Results. **The in-hospital mortality rate was 14% (4/29). The mortality rate for surgical patients and stent-grafting patients was 9% (1/11) and 17% (3/18), respectively. The survival rate of patients at 2 years was 63% ± 10%. In the follow-up period, 2 of the 18 patients who underwent endovascular stent-grafting required open repair, and 1 patient underwent a redo endovascular stent-grafting procedure because of stent failure. One of these 3 patients died of an intraoperative retrograde type A aortic dissection.**

Conclusions. **The early results of endovascular stent-grafting for the treatment of high-risk patients with descending thoracic aortic rupture are promising. Early results of open repair can also be improved by the selection of stabilized patients. However, the requirement of reintervention indicates that detailed follow-up examinations in patients who have undergone endovascular stent-grafting with handmade stent-grafts should be performed.**

(Ann Thorac Surg 2004;78:1630–4)

The rates of mortality and morbidity after the surgical repair of descending thoracic aortic rupture are higher than those after elective operations, despite improvements in anesthetic management, surgical skills, and postoperative patient care [1–3]. Many patients with descending thoracic aortic rupture have comorbidities and are of advanced age [3]. When surgical invasion is added to such unfavorable conditions, the high mortality and morbidity rates are inevitable. Ideally, less invasive therapy is suitable for the treatment of acute thoracic aortic rupture.

Endovascular stent-grafting has emerged as a less invasive alternative to traditional open repairs. There have been a few reports of endovascular therapy having been performed in patients with ruptured thoracic aortic aneurysms or acute dissections [4–6]. The authors reported excellent early results of endovascular stent-grafting for acute thoracic aortic syndromes. However, the long-term durability of stent-grafts, particularly that of handmade stent-grafts, may be disappointing [7]. Because grafts are not commercially available in Japan, it therefore appears that endovascular stent-grafting for the management of acute thoracic rupture should be limited to high-risk patients. Our current strategy for the management of acute thoracic rupture is to treat seriously ill patients with endovascular stent-grafting and to treat other patients by traditional open repair. The aim of this study was to assess early results of our strategy.

Material and Methods

Twenty-nine consecutive patients (20 men, 9 women) with descending thoracic aortic rupture were referred to Sapporo Medical University School of Medicine between June 2001 and January 2004. The ages of the patients ranged from 19 to 86 years (mean age, 61 ± 17 years). Patients who had an episode of hypotension (< 80 mm Hg) and for whom computed tomographic (CT) scans showed hemothorax (n = 15) or periaortic hematoma (n = 12) were considered to have a rupture. Patients who

Accepted for publication May 4, 2004.

Presented at the Poster Session of the Fortieth Annual Meeting of The Society of Thoracic Surgeons, San Antonio, TX, Jan 26–28, 2004.

Address reprint requests to Dr Morishita, Department of Thoracic and Cardiovascular Surgery, Sapporo Medical University School of Medicine, South 1 West 16, Chuou-ku, Sapporo 060–8543 Japan; e-mail: kmori@sapmed.ac.jp.

Published by Elsevier Inc

0003-4975/04/$30.00
doi:10.1016/j.athoracsur.2004.05.014

presented with massive hemoptysis were also considered to have rupture if they had descending aortic aneurysms (n = 2). Acute rupture occurred because of trauma in 11 patients (38%), expansive degenerative aneurysm in 11 patients (38%), and acute dissection in 5 patients (17%). Two patients (7%) had anastomotic false aneurysms. Hypotension was found in 12 patients (41%) on admission.

Twenty-three patients received CT scans in referring hospitals. These patients were transported immediately to an operating room or a cardiac catheterization laboratory. No or little information on CT images was available for the other 6 patients, 2 of whom needed intensive inotropic and volume resuscitation because of hypotension. Because they responded to our resuscitation therapy, all patients underwent CT scans by which a diagnosis and the information necessary for treatment were obtained. The mean interval from onset to treatment was 10 ± 8 hours.

Patient selection for endovascular stent-grafting was performed according to clinical as well as anatomic characteristics. Endovascular stent-grafting was considered to be an appropriate initial procedure for patients who were 80 years of age or older, those who had a past history of left thoracotomy, and those who had comorbidities including chronic renal failure (serum creatinine level > 3.0 mg/dL), chronic obstructive pulmonary disease, and severe ischemic heart disease. Patients with head injuries and multiple fractures were also considered primary candidates for endovascular stent-grafting because their conditions would have been exacerbated by the use of extracorporeal circulation and anticoagulants. Anatomic inclusion criteria for stent-grafting included 15 mm or more of proximal and distal lengths of the fixation site, landing zone diameters of less than 40 mm, and mild or moderate kinking of the thoracic aorta (>60 degrees). Patients underwent traditional open repairs if they did not meet the above clinical or anatomic criteria.

Seventeen of the 29 patients (7 with trauma, 6 with degenerative aneurysms, 2 with type B dissection, and 2 with false aneurysms) were selected for endovascular stent-grafting because of polytrauma (n = 7), comorbidities (n = 6), advanced age (n = 2), or a past history of left thoracotomy (n = 2). The main reason for placement of a stent-graft in the 7 trauma patients was brain injury. One patient with a type B dissection underwent endovascular stent-grafting at his request. Comorbidities that were considered to preclude traditional open repair included chronic obstructive pulmonary disease (n = 3), chronic hemodialysis (n = 2), and brain tumor (n = 1). An 84-year-old woman who was considered to be a high-risk patient for traditional surgery underwent open repair because the diameter of her landing zone was too large to be suitable for endovascular stent-grafting. Thirteen patients were American Society of Anesthesiologists (ASA) classification IV, 3 patients were ASA V, and 2 patients were ASA III.

The 11 patients (5 with degenerative aneurysms, 4 with trauma and 2 with type B dissection) who were ASA III underwent graft replacement of the descending thoracic aorta. One patient had a history of stroke. Three of these patients received a central cannulation technique to prevent neurologic injury because of anticipated clamping on the atherosclerotic arch [8].

Stent-Graft Placement

Vascular and cardiothoracic surgeons performed endovascular stent-graft placement with at least one perfusionist on standby. Patients were placed in the supine position under general anesthesia. A 400-cm guidewire was passed through the right brachial artery through the aortic arch to the femoral artery. This brachial guidewire technique facilitates endovascular stent-grafting [9]. It is often difficult to advance a rigid stent-graft to a target lesion when the aorta or the iliac artery is unfavorably tortuous. To overcome this difficulty, the guidewire is straightened by applying tension to both of its ends, whereby the stent-graft can be advanced easily, even through unfavorable anatomy.

The stent-graft was custom-made. It was reconstructed by the suturing of graft material (Ube Corp, Ube, Japan) to an endoskeleton of Gianturco Z stents (Cook Inc, Bloomington, IN) in the operating room, which takes 20 minutes. There are various types of endoskeleton (6 cm, 9 cm, 12 cm, and 16 cm in length, and 3 cm and 4 cm in diameter) consisting of 2.5-cm-long Z-stents. Z-stents are attached to each other with solder, leaving spaces of 8 mm between stents (Fig 1). Endoskeletons were gas-sterilized and stored in our hospital so as to be available immediately if required.

Axial CT images were used to determine the diameter of the landing zone and the length of the endoskeleton. Graft diameter was oversized by 10% to 20%. If there was little information from CT images, digital subtracted angiography (DSA) was initially performed during the procedures.

The stent-graft was manually loaded into a proximal end of an 18F to 22F sheath (Cook Inc), depending on the dimensions of the stent-graft. The delivery system was advanced to the target region over the guidewire. The sheath was withdrawn after DSA confirmed the exact localization in relation to the head vessels, primary entry tear, and the diseased aortic segment. For patients with dissection, positioning of the guidewire into the true lumen was verified with intravascular ultrasonography. Systolic arterial blood pressure was lowered to 80 mm Hg during deployment.

When a postprocedural DSA demonstrated endoleak, balloon dilatation was performed; however, expansion by excessive balloon force was not done in an acute dissection. Two patients required stent-graft extension because of persistent endoleak. The average diameter of the deployed stent-graft was 33 ± 3 mm and the mean length of the endoskeleton was 14 ± 2 cm. A tapered graft (34-mm proximal diameter, 24-mm distal diameter, and 16-cm length) was made for a patient with a perforated type B dissection. The iliac artery was used as the access route in 3 patients because of the small sizes of femoral

Ann Thorac Surg
2004;78:1630–4

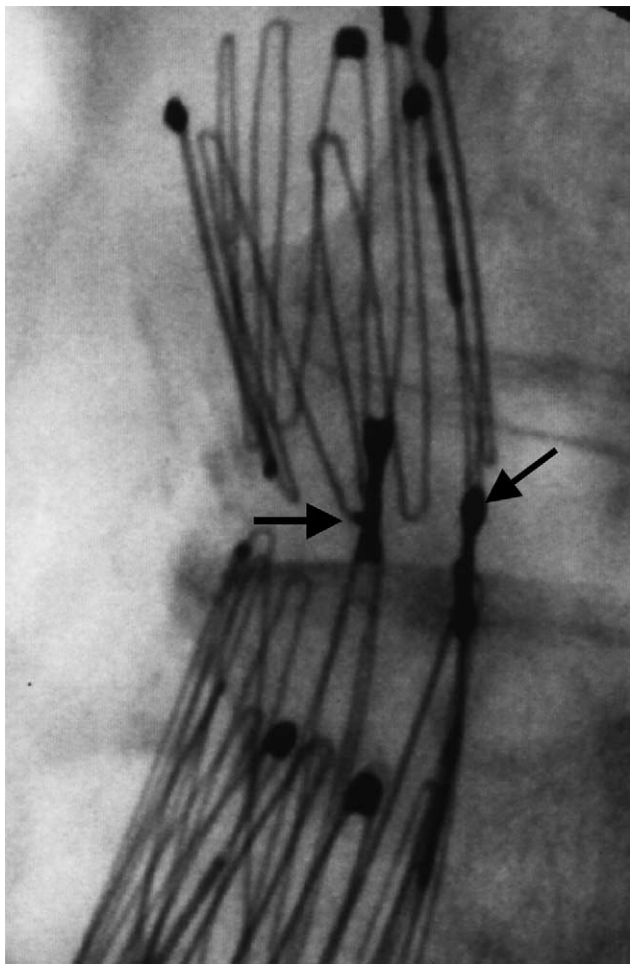

Figure 1. Roentgenogram of endoskeleton. Partial attachment of stents (arrows) *increases flexibility for the endoskeleton to fit aortic tortuosity.*

vessels (diameter less than 7 mm). Initially, 4 patients underwent the procedure in a cardiac catheterization laboratory, but endovascular stent-graft deployment has been performed in an operating room with a portable C-arm unit (OEC Digital Mobile Imaging System, GE OEC Medical Systems, Inc, Salt Lake City, UT) in the remaining 14 patients.

Postoperative Care

All patients were transferred to the intensive care unit for postoperative care after the open repair or stent-graft placement was completed. The surviving patients received postoperative follow-up examinations, including CT scans, at 1, 3, 6, and 12 months and every 6 months thereafter. The survival of patients who did not visit our outpatient clinic was confirmed by telephone contact to the patients, their families, or the referring physicians. The mean follow-up period was 12 months (range, 1 to 34 months).

Statistical Analysis

Data were expressed as mean ± standard deviation. Survival rates were calculated using the Kaplan-Meier method. StatView statistical software (SAS Institute Inc, Cary, NC) was used to analyze statistical data.

Results

Stent-grafts were successfully placed in all patients, and bleeding was controlled in 16 patients. The remaining 2 patients (11%) suffered rebleeding. The 11 patients who underwent open repairs survived the procedures.

Mortality

The in-hospital mortality rate was 14% (4/29). Three patients who had undergone endovascular stent-grafting died (17%, 3/18). One suffered from simultaneous brain injury, lung injury, rib fractures, and renal injury. During deployment of the stent-graft, severe hypoxemia developed despite ventilatory support with high fraction of inspired oxygen and positive end-expiratory pressure. The patient eventually underwent endovascular stent-grafting with the aid of extracorporeal membrane oxygenation; however, the patient died of acute respiratory distress syndrome immediately after stent-grafting.

Another patient had a past history of pyothorax as a postoperative complication of a descending thoracic aorta repair. He was successfully treated with antibiotics and irrigation. The patient presented with mild hemoptysis 17 months later. CT images demonstrated a proximal anastomotic aneurysm. He was admitted to our institution urgently because of massive hemoptysis. Endovascular stent-grafting was selected because of technical difficulties in redoing the thoracotomy. After the placement of an endovascular stent-graft, the hemoptysis stopped. Though postprocedural CT documented the exclusion of the pseudoaneurysm, the patient suddenly suffered a massive pulmonary hemorrhage and died 2 weeks after the stent-grafting. An autopsy was not allowed.

Hemoptysis reoccurred in the third patient who received chronic hemodialysis. Its origin could not be detected, though CT scans showed a false aneurysm proximal to the previously placed descending aortic graft. Because that patient developed massive hemoptysis, physicians suspected a ruptured false aneurysm. The patient was referred to our department for endovascular stent-grafting. Despite successful stent-grafting, the patient died of recurrent hemoptysis 20 days after the stenting. The autopsy confirmed complete thrombosis of the false aneurysm. However, disrupted collateral circulation from the bronchial artery had caused recurrent hemorrhage.

One patient (9%) of the 11 patients who underwent open surgery died of respiratory failure 10 days after the surgery.

Morbidity

Eight (44%) of the 18 patients who underwent stent-grafting required prolonged mechanical ventilation (> 72 hours), 2 patients (9%) required postoperative dialysis for chronic renal dysfunction, and 1 patient needed extracorporeal membrane oxygenation as previously described.

Three (27%) of the 11 patients who underwent open repair received prolonged mechanical ventilation (> 72 hours), and 1 patient (9%) suffered from renal failure that required dialysis. None of the patients had cerebral embolism, although 1 patient (9%) who underwent open repair suffered from paraplegia. No patients in this series received cerebral spinal fluid drainage.

Follow-Up

Five patients died during the follow-up period. One patient suffered from a rupture of a remote (arch) aneurysm 8 months after the successful open repair of a ruptured descending thoracic aortic aneurysm. The patient died of shock despite emergency total arch graft replacement.

One patient, a 64-year-old man, had endovascular stent-grafting for a ruptured aortic dissection. CT images demonstrated thrombosis of the false lumen of the thoracic aorta. However, there was retrograde filling of the false lumen in the abdominal part through reentries. Four months later, the diameter of the proximal descending thoracic aorta had expanded to 7 cm. He underwent graft replacement of the descending thoracic aorta. During the operation, a retrograde type A aortic dissection occurred that caused dissection of the left coronary artery. Emergency coronary artery bypass grafting was added; however, he died of low cardiac output syndrome.

The other 3 deaths were unrelated to aneurysms (hepatoma, apoplexy, and chronic pancreatitis). Actuarial 2-year survival rates were 63% ± 10% (Fig 2).

Three patients who underwent stent-grafting required reintervention in the form of open repair (n = 2) or endovascular stent-grafting (n = 1) because of stent-grafting failure. In addition to the 64-year-old patient previously discussed, distal migration of the stent-graft occurred 2 weeks after the procedure in another patient, a 29-year-old man, causing headache and hypertension (> 180 mm Hg). His stent-graft was successfully retrieved, and traditional graft replacement of the descending thoracic aorta was performed under hypothermic circulatory arrest. In another patient, the size of the aneurysm increased because of proximal endoleak. Proximal stent-grafting extension was performed in that patient 4 months after stent-grafting.

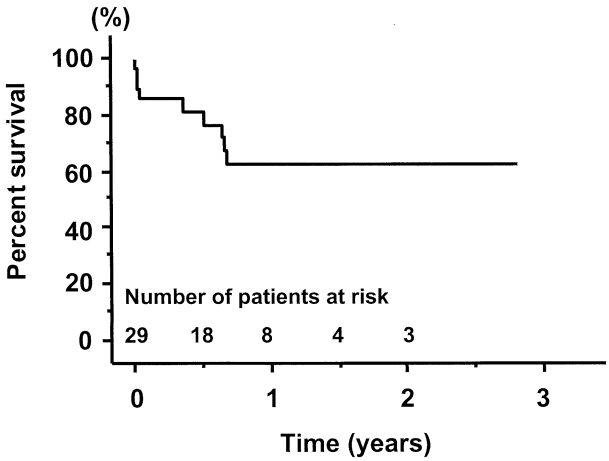

Figure 2. Actuarial survival rates of patients.

Comment

The results of this study showed that the use of endoluminal stent-grafting to treat ruptured descending thoracic aorta in high-risk patients yielded acceptable early results. Some previous studies have also indicated that patients with ruptured thoracic aorta benefit from endovascular stent-grafting, at least in the early term [6, 10, 11]. It appears that stent-grafting guarantees early results because of its small degree of invasiveness. To take advantage of this merit, we have used stent-grafting in patients in whom the risk of death was highly expected. As a consequence, early results of open repair in this series were also satisfied by the selection of stabilized patients.

Some authors [5, 6] reported no mortality of stent-grafting for the treatment of acute thoracic aortic syndromes. In contrast, the mortality rate of stent-grafting in this study was 17%. A partial explanation for this is that only high-risk patients underwent endovascular stent-grafting. If those patients had undergone conventional open repair, the mortality would likely have been higher. The cause of death in our patients who underwent stent-grafting was associated with recurrent bleeding. Kato and associates [12] reported that rebleeding resulted from infection. They speculated that infection led to degeneration of the aorta. One of 2 patients with persistent hemoptysis in our study also had infection. Endotension must have caused the infectious aneurysmal wall to rupture, resulting in recurrent hemoptysis.

Stent-grafting appears to be the first choice in the treatment of thoracic aortic rupture. However, whether stent-grafting is durable has not been determined. A clinical study of a large series showed a high frequency of late complications occurred with the placement of handmade grafts [7]. Our patients also suffered from late complications related to stent-grafting that required reintervention. Some authors [6, 10] have emphasized that further intervention is not needed when commercially available stent-grafts are used. Commercially manufactured, standardized stent-grafts could have improved late postoperative results in our series if they had been readily available in appropriate sizes.

In addition to the lack of commercially available devices, some other explanations for the higher incidence of reintervention in our series are possible. One is that the wall of the ruptured aorta is so fragile that the aortic wall may be vulnerable to even a small force generated by

endotension or endoleak. Another possible explanation is that the emergency situation did not allow for an accurate evaluation of the anatomic pathology. Stent-graft migration occurred in one patient because the graft size was determined inappropriately on the basis of insufficient data.

Considering the high rate of reintervention, close follow-up examinations should be performed for surveillance of late complications of handmade grafts. However, we believe that late stent-graft failures do not offset early satisfactory survival rates obtained by endovascular stent-grafting. Even if a high mortality of open repair is expected at the time of rupture, patients are likely to undergo a secondary operation with an acceptable mortality because their conditions are stabilized.

One patient in our series who had undergone stent-grafting suffered from a retrograde type A aortic dissection during secondary surgery. The proximal clamp was placed between the left carotid artery and the left subclavian artery together with the proximal part of the stent-graft. After resecting the proximal descending thoracic aorta, the stent-graft was retrieved easily by releasing the clamp temporarily; however, the proximal clamping likely caused a tear in the arch that resulted in aortic dissection. The force of a proximal Z-stent on the arch might have led to wall degeneration. That patient died immediately after the operation. We have subsequently stopped applying a clamp near a previously deployed stent-graft and have used open proximal anastomosis with hypothermic circulatory arrest.

In conclusion, early results of endoluminal stent-grafting for high-risk patients, such as those with polytrauma and comorbidities and those of advanced age, in the treatment of ruptured descending thoracic aorta are promising. Early results of open repair can also be improved by the selection of stabilized patients. However, the requirement of reintervention in some patients indicated that detailed follow-up examinations in patients who have undergone stent-grafting with handmade stent-grafts should be performed.

References

1. Crawford ES, Hess KR, Cohen ES, Coselli JS, Safi HJ. Ruptured aneurysm of the descending thoracic and thoracoabdominal aorta. Ann Surg 1991;213:417–26.
2. von Segesser LK, Genoni M, Kunzli A, et al. Surgery for ruptured thoracic and thoracoabdominal aortic aneurysms. Eur J Cardiothorac Surg 1996;10:996–1002.
3. Girardi LN, Krieger KH, Altorki NK, Mark CA, Lee LY, Isom OW. Ruptured descending and thoracoabdominal aneurysms. Ann Thorac Surg 2002;74:1066–70.
4. Iannelli G, Piscione F, Tommaso LD, Monaco M, Chiariello M, Spampinato N. Thoracic aortic emergencies: impact of endovascular surgery. Ann Thorac Surg 2004;77:591–6.
5. Doss M, Balzer J, Martens S, et al. Emergent endovascular stent grafting for perforated acute type B dissections and ruptured thoracic aortic aneurysms. Ann Thorac Surg 2003; 76:493–8.
6. Nienaber CA, Ince H, Weber F, et al. Emergency stent-graft placement in thoracic aortic dissection and evolving rupture. J Card Surg 2003;18:464–70.
7. Demers P, Miller DC, Mitchell RS, et al. Midterm results of endovascular repair of descending thoracic aortic aneurysms with first-generation stent grafts. J Thorac Cardiovasc Surg 2004;127:664–73.
8. Westaby S, Katsumata T, Vaccari G. Arch and descending aortic aneurysms: influence of perfusion technique on neurological outcome. Eur J Cardiothorac Surg 1999;15:180–5.
9. Ohki T, Veith FJ. Technical adjuncts to facilitate endovascular repair of various thoracic pathology. J Card Surg 2003;18: 334–50.
10. Doss M, Balzer J, Martens S, et al. Surgical versus endovascular treatment of acute thoracic aortic rupture: a single-center experience. Ann Thorac Surg 2003;76:1465–70.
11. Grabenaoger M, Fleck T, Czerny M, et al. Endovascular stent graft placement in patients with acute thoracic aortic syndromes. Eur J Cardiothorac Surg 2003;23:788–93.
12. Kato N, Hirano T, Ishida M, et al. Acute and contained rupture of the descending thoracic aorta: treatment with endovascular stent grafts. J Vasc Surg 2003;37:100–5.

Descending Thoracic Aortic Rupture: Role of Endovascular Stent-Grafting

Kiyofumi Morishita, Yoshihiko Kurimoto, Nobuyoshi Kawaharada, Johji Fukada, Yoshikazu Hachiro, Yasuaki Fujisawa and Tomio Abe

Ann Thorac Surg 2004;78:1630-1634