Emergency Endovascular Stent-Grafting for Life-Threatening Acute Type B Aortic Dissections

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Background. **There is still a considerable controversy regarding optimal treatment for patients with acute type B aortic dissection. Patients with complicated disease are particularly challenging for cardiovascular treatment. Early surgery for acute dissections of the descending aorta with life-threatening complications is known to carry a high mortality. Endovascular stent grafting is developing as an alternative treatment mainly for chronic stages of type B aortic dissection. It is not clear whether endovascular stent grafting is safe and effective in emergency treatment of acute type B aortic dissection.**

Methods. **In 10 patients (7 men, 3 women; mean age, 59.2 years; range, 46 to 65 years), endovascular stent grafting was performed within 11.0 ± 5.9 hours (range, 4 to 24 hours) of diagnosis of complications. Indications for acute intervention included contained rupture, hematothorax, life-threatening malperfusion, and refractory pain. Using a retrograde endovascular route after surgical exposure of the femoral artery, self-expanding stent prostheses consisting of polyester-covered Nitinol (Talent, World Medical; mean diameter, 40 ± 4 mm; length, 10 cm) were placed into the descending aorta distal to the subclavian artery. Before discharge and on follow-up visits, imaging of the aorta was performed using computed tomography.**

Results. **In 9 of 10 patients (90%), the primary entry could be completely occluded with the endovascular stent. Early mortality was 20% (2 of 10): 1 patient died after disruption of the intimal layer distal to the stent, and 1 patient died in hemorrhagic shock after surgical fenestration of the abdominal aorta for persistent malperfusion. Three patients (30%) required consecutive surgical treatment: indications included acute development of retrograde type A aortic dissection, acute stent dislocation by fractured wires and secondary leakage, and late formation of an aneurysm of the descending aorta 6 months after endovascular stent grafting. There were no surgical or late deaths.**

Conclusions. **Our experience provides some evidence that early mortality of life-threatening acute type B aortic dissection may be reduced by emergency endovascular stent grafting and that this form of treatment is a promising therapeutic option. Refinements, especially in stent design and application, may further improve the prognosis of patients in the life-threatening situation of complicated acute type B aortic dissection.**

(Ann Thorac Surg 2004;78:1261–7)

The optimal therapy for acute type B aortic dissection has not yet been clearly defined [1, 2]. Two groups of patients with dissection of the descending aorta have been differentiated: patients with uncomplicated disease and patients with life-threatening complications [3].

There is consensus that in patients with uncomplicated acute type B aortic dissection, medical therapy is preferred to open surgical treatment, although there are ongoing prospective randomized trials to define the role of endovascular stent grafting (EVSG) in this setting.

Patients with life-threatening complications of acute dissection of the descending aorta are therapeutically more challenging. The definition of life-threatening complications is still a matter of debate, but usually includes contained rupture, malperfusion of visceral organs or extremities, rapid increase of aortic diameter, and refractory pain.

So far the only effective treatment option was open emergency surgical intervention with replacement of the descending aorta. Early mortality in this group used to be very high (more than 50%) [4]. Although it could be reduced in recent years to 21% to 40% [5, 6], there is still a significant morbidity and mortality after surgical repair of complicated acute type B aortic dissections. For this high-risk group of patients, a safer and equally effective form of treatment is desirable.

Recently EVSG has become an alternative form of treatment with promising midterm results for patients with aneurysms and chronic dissections of the descending aorta [7, 8]. Endovascular stent grafting might be a potential option because of its less invasive character. It

Accepted for publication March 16, 2004.

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Published by Elsevier Inc

0003-4975/04/$30.00
doi:10.1016/j.athoracsur.2004.03.107

Table 1. Demographic Data, Indications for Emergency Stent Grafting, and Stent Diameter

Patient No.	Age (y)	Sex	Complication of Aortic Dissection	Interval of Complication to Stent Grafting (h)	Proximal Diameter of Stent (mm)
1	57	Male	Refractory pain	12	46
2	64	Male	Extension of dissection, obstruction of branch vessels	6	42
3	65	Male	Obstruction of branch vessels (left kidney, left leg)	13	42
4	64	Female	Obstruction of branch vessels (left kidney, right leg)	4	42
5	63	Male	Acute aortic rupture, hematothorax	8	46
6	46	Male	Refractory pain	6	38
7	55	Female	Contained rupture	12	30
8	64	Female	Rapid increase of aortic diameter	24	38
9	56	Male	Dysathria, neurologic deficit lower extremities, loss of bladder control	9	42
10	53	Male	Obstruction of branch vessels (right kidney)	16	42

is effective because it closes the entry and reroutes the blood into the true lumen, thereby ameliorating life-threatening malperfusion. The endoluminal approach can avoid the major trauma of surgical therapy. This should help to bring the patients out of the acute life-threatening phase of this devastating disease.

Nevertheless, this presumably less-invasive method has its inherent risks. Rupture of the aorta might occur during the stent implantation. Perivascular leakage is reported in up to 25% of patients with type B aortic dissection after EVSG [9]. Dislocation of stents, leading to side branch occlusion and subsequent ischemia, is another potential complication [10]. Because of embolization of emboli from the atherosclerotic aorta or malperfusion of the spinal cord, neurologic complications may occur in up to 8% of patients [11]. The incidence of these adverse effects of stent grafting might be higher in the acute stage of complicated type B aortic dissections because the intima is weaker in these patients.

Little experience exists with acute endoluminal therapy in this high-risk group of patients within a few hours after diagnosis. We report the experience of emergency stent grafting in patients with acute life-threatening complications of type B aortic dissection at our institution.

Patients and Methods

Patients

Between October 2000 and October 2003, 10 patients (7 men, 3 women) with a mean age of 59.2 years (range, 46 to 65 years) underwent emergency EVSG for complicated acute type B aortic dissection within 11 ± 6 hours of diagnosis of complications. Spiral computed tomography of the chest and abdomen in combination with transesophageal echocardiography was used to confirm the diagnosis. All patients were admitted to the emergency room because of persistent chest pain despite prior strong analgesic and multidrug antihypertensive medication.

Indications for acute intervention besides refractory pain included rapid progression of aortic dilatation (2 cm in 8 hours), contained rupture, hematothorax, and life-threatening malperfusion. Exclusion criteria for endovascular stent treatment were a distance of less than 0.5 cm between the subclavian artery and the entry and disease of the femoral or iliac arteries that precluded the introduction of the stent delivery system.

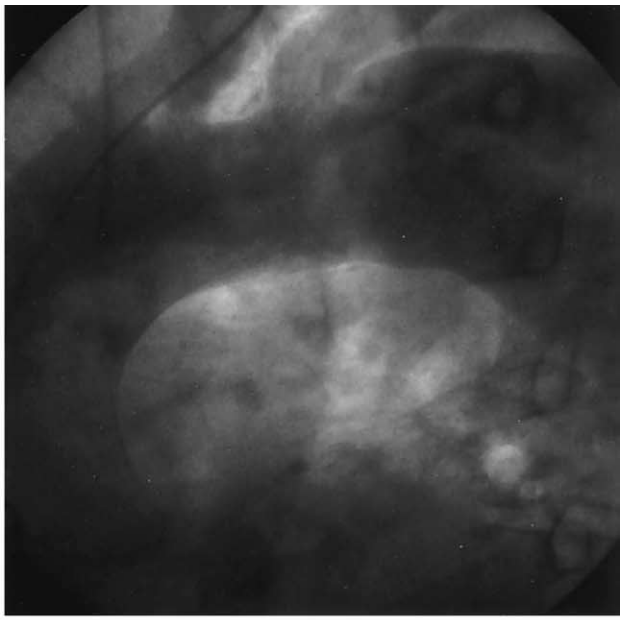
None of the patients had Marfan's syndrome or a known history of aortic disease. Arterial hypertension as a cardiovascular risk factor was found in all patients.

In all patients the entry of the type B dissection was found in a typical location just distal to the left subclavian artery. A cardiac catheterization was performed in all patients to rule out concomitant coronary artery disease. Demographic data and the intervals between the diagnosis of complications and stent grafting, as well as indications for acute endoluminal stent placement, are listed in Table 1.

Stent Placement

The mean time between diagnosis of complications and stent grafting was 11.0 ± 5.9 hours (range, 4 to 24 hours).

The in-hospital availability of a variety of endovascular stents in different diameters made an emergency approach feasible. Using a retrograde endovascular route after surgical exposure of the femoral artery, self-expanding stent prostheses consisting of polyester-covered Nitinol (Talent; Medtronics, Sunrise, FL; mean diameter, 40 ± 4 mm; covered length, 100 mm) were placed into the descending aorta at the entry of dissection distal of the left subclavian artery. Only a short stent was used to avoid unnecessary side branch (eg, intercostal artery) occlusion. A pigtail catheter was advanced through the left brachial artery into the ascending aorta for angiography during the procedure and visualization of the true lumen. Emergency stent grafting was performed under general anesthesia in the cardiac catheterization laboratory by a team of interventional cardiolo-



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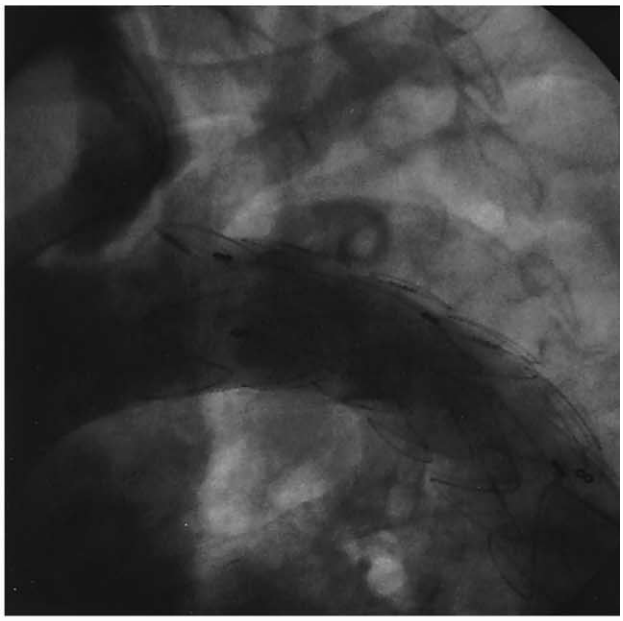

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Fig 1. (A) Aortic angiogram depicts contrast media filling of false lumen through an entry site distal to the left subclavian artery. (B) Closure of the entry site by the stent graft resulted in redirection of flow into the true aortic lumen.

gists and cardiac surgeons. During the release of the stent, the systolic arterial pressure was lowered to 60 mm Hg. The stents were expanded at the proximal end by balloon dilatation to anchor the stents in the aortic wall.

At the end of the procedure in all patients, angiography was used to demonstrate the location of the stent and perfusion of the aorta and its branches (eg, left subclavian, mesenteric, renal arteries; Fig 1). Before discharge and on follow-up visits, imaging of the aorta was performed using computed tomography.

Results

In all patients the stent grafts were successfully deployed in the intended position. With the exception of patient number 5, the primary entry could be occluded with the endovascular stent in all patients. Only one stent was used per patient. None of the patients had vascular problems at the arterial site of access for EVSG.

Early mortality was 20% (2 of 10 patients). In patient number 3, the proximal entry of the dissection was successfully occluded by placement of an endovascular stent. However, renal ischemia persisted, and 1 day after EVSG surgical fenestration of the abdominal aorta was performed. Two days postoperatively the patient died in hemorrhagic shock as a result of massive intraabdominal bleeding after surgical fenestration of the abdominal aorta for persistent malperfusion.

Patient number 6 had symptoms of mesenteric and lower extremity ischemia the morning after the intervention. With the exception of the right renal artery, no flow could be demonstrated in any of the visceral arteries of the infradiaphragmatic aorta by angiography. There was a complete disruption of the intimal layer distal to the stent. Surgical fenestration of the abdominal aorta did not lead to reperfusion. After resection of the ascending and transverse colon for complete necrosis, the postoperative course was complicated by renal failure, abdominal hematoma, necrosis of the pancreas, and retroperitoneal infection. The patient expired in multiorgan failure 5 weeks after EVSG.

Three patients (30%) required consecutive surgical treatment: indications included in patient number 4 acute development of retrograde type A aortic dissection, in patient number 5 persistent leakage and late formation of an aneurysm of the descending aorta 6 months after EVSG, and in patient number 8 acute stent dislocation by fractured wires and a distal aneurysm. Surgical mortality was zero.

Patient number 4 experienced hemiplegia with left-sided symptoms 12 hours after initially uneventful EVSG. Echocardiography showed an acute type A aortic dissection with involvement of the aortic arch and occlusion of the right internal carotid artery. In addition, there was severe aortic regurgitation. Intraoperatively a fresh entry tear was detected between the brachiocephalic trunk and the left internal carotid artery. The former entry in the descending aorta was found to be sealed by the stent. An aortic valve reconstruction was performed; the ascending aorta and partial aortic arch were replaced. The right internal carotid artery was revascularized by direct anastomosis of the dissected layers. Postoperatively symptoms of the hemiplegia were resolving. The patient was discharged on postoperative day 29 in stable condition.

In patient number 5 emergency stent grafting was performed for aortic rupture with hematothorax. After EVSG only minimal flow into the false lumen could be demonstrated. The postinterventional course was com-

Table 2. Morbidity and Mortality of Acute Stent Grafting in Life-Threatening Type B Aortic Dissection

Patient No.	Complication of Stent Placement	Secondary Surgery	Outcome	Duration of Follow-up (mo)
1	None	None	Good long-term result	38
2	None	None	Good long-term result	34
3	Persistent visceral ischemia	Surgical fenestration of abdominal aorta, fatal bleeding	Death	1 day (died)
4	Acute retrograde type A dissection, carotid artery occlusion, aortic valve regurgitation	Surgical replacement of ascending aorta and arch, carotid revascularization, aortic valve repair	Good long-term result	33
5	Only partial occlusion of entry-tear, persistent leakage	6 mo postinterventional surgical replacement of descending aorta	Good long-term result	33
6	Intima disruption at distal end of stent, complete occlusion of distal aorta	Unsuccessful surgical revascularization, bowel resection	Death	35 days (died)
7	None	None	Good long-term result	30
8	Stent dislocation caused by fractured wires, secondary leakage	6 mo postinterventional distal descending aortic aneurysm, surgical replacement	Good long-term result	27
9	Cerebral infarction (left middle cerebral artery)	None	Slow recovery from neurologic morbidity	5
10	None	None	Good short-term result	1

plicated by renal failure and pneumonia necessitating tracheotomy. The patient was discharged 1 month after EVSG. Follow-up computed tomographic scans revealed persistent flow in the false lumen and an aneurysm of the descending aorta of 8 cm. An uneventful elective surgical replacement of the descending aorta was performed 6 months after stent grafting.

In patient number 8 the primary entry was initially successfully occluded by the stent. However, fracture of the distal stent wires caused a dislocation of the endovascular stent with secondary leakage. An aneurysm was the indication for replacement of the descending aorta and later the infrarenal abdominal aorta.

Two patients suffered from neurologic morbidity perinterventionally. In patient number 4, left-sided hemiplegia was caused by occlusion of the internal carotid artery secondary to retrograde type A aortic dissection after stent grafting. It resolved completely after surgical revascularization as described earlier.

Patient number 9 had emergency stent grafting for acute type B aortic dissection with motor deficit of the lower extremities and loss of bladder control. In addition the patient suffered from marked dysarthria before EVSG. The stent placement was uneventful. The primary entry tear could be successfully occluded. Postinterventionally the patient demonstrated right-sided hemiplegia. Computed tomographic scans showed ischemia in the area of the left middle cerebral artery. Neurologic deficits resolved slowly, and on postinterventional day 27 the patient was transferred to a neurologic rehabilitation center. No neurologic deficits or sequelae were detectable periinterventionally or during follow-up in any of the other patients.

Table 2 summarizes the stent-related complications, secondary operation, and outcomes of all patients.

Mean follow-up was 25.0 ± 13.9 months (range, 1 to 38 months) and was complete. None of the patients died during the follow-up period.

Comment

Endovascular stent grafting was developed in the early 1990s, and the initial clinical use was in patients with abdominal aortic aneurysms [12, 13]. Shortly after, endoluminal stent placement was applied to patients with aneurysms of the thoracic aorta [7, 14]. Later this new approach was used in patients with aortic dissections as well [8, 15, 16]. During the last several years, evidence has accumulated that the outcome after EVSG in patients with chronic dissections of the descending aorta has favorable midterm results [16]. This is especially true for the elderly patient population with relevant comorbidities including hypertension, diabetes mellitus, renal disease, coronary artery disease, and obstructive lung disease.

However, similar to any treatment option, endovascular stenting has its potential side effects. The risks of the endoluminal approach include a secondary intimal tear as a result of the stent wires, stent dislocation, perivascular leakage, branch occlusion, vascular problems at the arterial site of access, and, rarely, rupture of the aorta.

Although endovascular stent placement for acute aor-

tic dissections with complications (eg, ischemic) has been performed before [15, 17], it is not a well-established procedure yet. In the majority of theses cases the interval between diagnosis and stent grafting was longer than 24 hours, usually several days. Thus, there is little information available about the safety and effectiveness of endovascular stent grafting for complicated, life-threatening acute type B aortic dissection within 24 hours or less of diagnosis. Previously, the open surgical approach resulted in a high morbidity and mortality (more than 50%) in patients with life-threatening type B aortic dissections [4].

In our institution a total of 13 patients underwent surgery for acute complicated type B aortic dissection between 2000 and 2003. Seven of these patients died (in-hospital mortality of 54%): 2 died intraoperatively, and 5 died during the postoperative course. Causes of death included multiorgan failure, pulmonary complications, and cardiac low output syndrome. Because of the very high surgical mortality and the promising early results with stent grafting, in 2001 emergency stent placement became the procedure of choice for complicated acute type B aortic dissection in our institution.

Recently surgical mortality could be reduced to 21% to 40% in some centers [5, 6], but there is still a significant morbidity and mortality after emergency surgical repair of complicated type B aortic dissection.

Our study indicates that stent placement is a feasible and effective approach even in the emergency treatment (within 24 hours) of patients with complicated acute type B dissection. This is in keeping with a recent literature report [18] about emergent EVSG for perforated acute type B dissections (n = 4) and ruptured thoracic aortic aneurysms (n = 7). They concluded that emergency EVSG is technically feasible with less morbidity and mortality than conventional open surgery in high-risk patients.

Stent grafting is effective by occlusion of the primary entry tear, which could be achieved in a majority of patients even in this acute setting.

Our results also indicate that the mortality in this high-risk group may be reduced when compared with surgical series; however, it remains high (20%) in this EVSG series.

Nienaber and colleagues [8] reported in 1999 an early mortality of 0 in 12 patients with descending aortic aneurysm. However, in their series patient profiles and selection were different. Endovascular stent grafting was not performed as an emergency treatment in a life-threatening situation. This might in part explain the difference in mortality.

However, according to a more recent report by the same group, emergency stent graft placement was successful without any periprocedural mortality and morbidity in 11 patients with acute type B aortic dissection with leakage and evolving rupture [19]. This shows that with a lot of expertise there is a potential for very low mortality after emergency stent grafting even in patients with complicated acute type B aortic dissections.

In our series the cause of death in 1 patient was a presumably procedure-related distal disruption of the intimal layer leading to a complete abdominal ischemia. In these high-risk patients the creation of a secondary intimal tear by emergency EVSG is particularly of concern because the intima in patients with acute dissections tends to be weak. The bare spring wires at the distal end of the stent were thought to be responsible for the damage of the intima. Thereafter the protocol was changed, and only stents without distal bare springs were applied.

One patient died in hemorrhagic shock after surgical fenestration for persistent mesenteric malperfusion. The malperfusion might have been caused by a so-called static flap of the dissection membrane that occluded mesenteric branches. This type of malperfusion is not easily reversible by the increase of flow in the true lumen and decline of flow in the false lumen. This problem has also been described after surgical repair of acute type B aortic dissection [4].

The problem of persistent malperfusion is an important issue in the care of patients with acute type B aortic dissections. Early diagnosis by selective angiography is crucial. Treatment remains difficult. As demonstrated by our experience, stent grafting of the descending aorta is not always sufficient to improve malperfusion of vital abdominal organs caused by local branch vessel obstruction. Newer treatment options include additional selective endoluminal stenting of important aortic branch vessels (such as the mesenteric or renal arteries).

Three patients (30%) required consecutive surgical treatment: indications included acute development of retrograde type A aortic dissection, acute stent dislocation by fractured wires and secondary leakage, and late formation of an aneurysm of the descending aorta 6 months after EVSG. There were no surgical deaths, indicating that surgery in more chronic (nonemergency) stages provides more predictable results.

In the patient with retrograde type A aortic dissection after emergency EVSG of the descending aorta, the cause of this complication might have been a secondary tear at the proximal end of the stent [20]. This was possibly the result of the rigidity of the stent graft [21].

Fracture of stent wires leading to dislocation of the stent and secondary leakage is a device-related complication. Refinements in stent design and application may prevent this complication. This should further improve the prognosis of patients with acute type B aortic dissections.

Our experience provides some evidence that early mortality of life-threatening acute type B aortic dissection may be reduced by emergency EVSG. Complications after stent grafting were primarily caused by stent-related factors potentially amendable by improved stent design. Nevertheless, the principle of this therapeutic approach seems promising and warrants further careful evaluation.

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INVITED COMMENTARY

During the second half of the last century, all areas of thoracic aorta became accessible to the thoracic surgeon for repair. Despite tremendous advances in surgical techniques and care, surgical repair of an acute aortic dissection remains a high-risk procedure. Acute aortic dissection is a complicated manifestation of aortic wall pathology. The prognosis of acute aortic dissection rests mainly on the anatomic location of the dissection and patient specific characteristics. At the Methodist DeBakey Heart Center, we continue to follow the teachings of Drs Michael E. DeBakey and E. Stanley Crawford, who developed our thoracic aortic program, operating acutely on DeBakey type I and II (Stanford type A) aortic dissections, and treating DeBakey type III (Stanford type B) acute dissections medically unless they are complicated. Our definition of complicated descending thoracic aortic dissection matches that of the author, including contained rupture, hemothorax, life-threatening malperfusion, and refractory pain. We agree with the Stanford group that the prognosis in uncomplicated descending thoracic aortic dissection is similar for medically and successfully surgically treated patients [1]. The problematic point is the difficulty in achieving a successful surgical outcome in cases of acute descending thoracic aortic dissection.

The current paper by Duebener and colleagues describes their experience with 10 patients undergoing emergency stent graft placement for complicated descending thoracic aortic dissection within 24 hours of diagnosis. This represents an extremely high-risk group and a very rapid turnaround time for stent placement. They have an early mortality rate of 2 of 10 patients (20%) compared with 7 of 13 patients (54%) treated with open surgical repair at their institution during the same time frame.

Although the mortality rate associated with open surgical repair of complicated acute dissection continues to decline, and there is even a series reporting zero mortality [2], it remains a substantial surgical challenge, and a 50% mortality is closer to what most surgical groups are likely to achieve with open repair. Three patients did require consecutive surgical repair for complications of the stent or stent placement.

There are currently three thoracic stent graft clinical trials in the United States, and no commercially available thoracic stent grafts. At the Methodist DeBakey Heart Center, we are participating in one of these trials. All surgeons who have operated on patients with a complicated acute descending thoracic aortic dissection know

0003-4975/04/$30.00
doi:10.1016/j.athoracsur.2004.03.108