Thoracic aortic emergencies: impact of endovascular surgery

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Background. **Conventional surgery for thoracic aortic emergencies, such as contained or free rupture of thoracic aortic aneurysms, acute type B dissections, and traumatic rupture of the thoracic aorta, is frequently associated with a high rate of mortality and morbidity. To obviate this risk, endovascular surgery is considered to be a valid alternative procedure.**

Methods. **From March 2001 to July 2002, 15 of 22 patients with acute thoracic aortic syndromes were submitted to endovascular surgery: 3 patients (20%) for traumatic rupture, 4 patients (26.7%) for contained or free rupture of thoracic aortic aneurysm, and 8 patients (53.3%) for acute type B dissection evolving to rupture. Computed tomographic scan was diagnostic in all patients. The stent grafts were introduced through the femoral artery.**

Results. **In the endovascular group there were no perioperative deaths or open conversions. The intraoperative angiography and computed tomographic scan performed on discharge showed no significant endoleaks and successful sealing of the aortic dissection. Average intensive care unit and hospital stay was 1.7 ± 0.8 and 5.9 ± 3.0 days. Follow-up ranged between 4 and 23 months and included clinical examinations and serial computed tomographic scan at 3, 6, and 12 months, and every 6 months thereafter. One 84-year-old patient with thoracic aortic aneurysm died of pneumonia 78 days after endovascular surgery. Only one type 1 endoleak was noted in the first patient with traumatic rupture, 3 months after the procedure.**

Conclusions. **Endovascular surgery is a safe technique, showing encouraging early and midterm results and allowing for prompt treatment of associated lesions in complex multitrauma patients.**

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Despite gradual improvements, conventional surgery of the descending thoracic aorta is still associated with a significant risk of mortality and morbidity that increases in emergency cases [1, 2]. Thoracic aortic emergencies, such as contained or free rupture of thoracic aortic aneurysm, acute type B dissection, and traumatic rupture of the aorta, have been always considered a surgical challenge [3]. The association of acute aortic syndrome with older age and comorbidities has shown such a high mortality rate as to justify nonoperative medical management or delayed treatment for these basically surgical conditions [3, 4].

Since the initial reports from Stanford [5], endovascular surgery to treat diseases of the thoracic aorta has been used with growing enthusiasm, encouraging many centers to investigate the feasibility of this approach [6]. After our initial experience with endovascular surgery for abdominal aortic aneurysm, in March 2001 we started an endovascular program only for emergency disorders of the thoracic aorta in high-risk patients.

The purpose of this study is to evaluate short-term and midterm results of endovascular surgery restricted to thoracic aortic emergencies.

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Material and Methods

From March 2001 to July 2002, 22 consecutive patients with acute thoracic aortic syndrome were admitted to our department. Indications for conventional or endovascular surgery were as follows: contained or free rupture of the thoracic aorta complicating blunt chest trauma or aneurysm, lack of response to medical therapy, pain, or increasing false lumen of acute type B aortic dissection. Medical treatment remained the primary option for uncomplicated acute type B aortic dissection. Seven of the 22 patients (31.8%) received conventional treatment: medical for 5 patients with uncomplicated acute type B aortic dissection and surgical for 2 patients with thoracic aortic aneurysm. In the 2 patients treated by conventional surgery, the aorta was cross-clamped and a femorofemoral bypass was instituted. The dilated descending aorta segment was resected and replaced with woven polyester graft (Intervascular S.A., La Ciotat Cedex, France). During this same period, the remaining 15 patients (68.2%), 13 male and 2 female, underwent emergency endovascular surgery. The criteria for selecting these particular patients for endoluminal grafting were type of disease and anatomic suitability for device implantation. Three patients (20%) had traumatic rupture of the aorta at the isthmus, 4 patients (26.7%) had free or contained rupture of thoracic aortic aneurysm, and 8 patients (53.3%) had acute type B aortic dissection evolving to rupture. Ages

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Table 1. Demographics and Patient Characteristics

Patients	Traumatic Rupture (n = 3)	Thoracic Aortic Aneurysm (n = 4)	Acute Type B Dissection (n = 8)	Total (n = 15)
Age (y)	26.3 ± 11.0	77.0 ± 7.6	63.5 ± 6.0	58.3 ± 19.1
Sex (M/F)	2/1	4/0	7/1	13/2
Thoracic pain		4 (100%)	7 (87.5%)	11 (73.3%)
Increasing diameter		4 (100%)	8 (100%)	12 (80.0%)
Shock		3 (75.0%)	2 (25.0%)	5 (33.3%)
Hemothorax	2 (66.6%)	1 (25.0%)	1 (12.5%)	4 (26.7%)
Dysphonia	1 (33.3%)			1 (6.6%)
COPD		3 (75.0%)	2 (25.0%)	5 (33.3%)
CAD		2 (50.0%)	2 (25.0%)	4 (26.7%)
Aortobifemoral bypass		2 (50.0%)		2 (13.3%)
Chronic renal failure		3 (75.0%)	3 (37.5%)	6 (40.0%)
Hemodialysis			1 (12.5%)	1 (6.6%)
ASA class				
III	1 (33.3%)	1 (25.0%)	2 (25.0%)	4 (26.7%)
IV	2 (66.6%)	2 (50.0%)	6 (75.0%)	10 (66.7%)
V		1 (25.0%)		1 (6.6%)

ASA = American Society of Anesthesiologists; CAD = coronary artery disease; COPD = chronic obstructive pulmonary disease.

ranged from 19 to 84 years at the time of procedure (mean, 58.3 ± 19.1 years). All patients were enrolled in accordance with the American Society of Anesthesiologists classification, on the basis of their comorbidity (Table 1); they underwent endovascular surgery within 6 to 8 hours from admission. Comorbidities were chronic renal failure (serum creatinine level > 2.0 mg/dL) in 6 patients (40%); 1 patient (6.6%) from the acute type B group was receiving hemodialysis; 2 patients with traumatic aortic rupture had an associated severe multitrauma (head injuries and multiple fractures); 2 patients with thoracic aortic aneurysm had previous history of surgery (aortobifemoral bypass), 1 patient for abdominal aortic aneurysm and 1 patient for symptomatic obstruction of the aortic bifurcation.

A spiral computed tomographic scan and digital subtraction angiography of the thoracic and abdominal aorta (with a calibrated catheter) were performed for measuring and localizing purposes.

In the group with traumatic rupture, 2 patients showed hemothorax and 1 an increasing pseudoaneurysm with dysphonia caused by compression of the laryngeal nerve. In the group with acute type B dissection, all patients suffered from thoracic pain not responsive to morphine and antihypertensive therapy and from increasing false lumen diameter: antegrade in 7 patients and retrograde in 1. In the group with thoracic aortic aneurysm, 3 patients suffered from shock and one of them had a massive left hemothorax; the aneurismal diameter for all patients ranged from 7.5 cm to more than 9.0 cm.

The diameter of the selected stent graft exceeded the diameter of the aorta by a minimum of 10% for traumatic rupture to a maximum of 20% for aortic aneurysm and acute type B dissection. The excess diameter was required to increase the radial force of the device as a result of self-expansion of the endoprosthesis, thus allowing for improved sealing of the graft in the aorta. The criteria to assess anatomic suitability for device implantation were vascular access larger than 8 mm and an aortic arch angulated at less than 60 degrees.

Stent graft placement was performed in the catheterization laboratory or in the operating room. Patients received general anesthesia and mechanical ventilation. The surgical team included 2 cardiovascular surgeons, an interventional cardiologist, an anesthesiologist, a scrub nurse, and a standby bioengineer. The procedure began by introducing a 6F pigtail catheter (Cordis, Hamburg, Germany) through the radial artery for precise localization of the subclavian artery, intraprocedural aortography, and direct monitoring of invasive arterial pressure. Antibiotic prophylaxis with cefotaxime and heparin (5,000 U) was given intravenously. In all cases femoral access was achieved by surgical dissection of one of the femoral or iliac arteries chosen after contrast injection of the distal abdominal aorta to select the best side for access and the onset of the celiac axis (landing zone). In the 2 patients with previous aortobifemoral bypass, access was obtained through a prosthetic branch. A Keller-Tillerman introducer sheath (Cook Inc, Bloomington, IN) was inserted through the femoral or iliac artery over a 300-cm-long 0.035-inch Back-up Meier wire (Boston Scientific, Boston, MA). The delivery system was loaded onto the wire (through the sheath) to the level of the thoracic aorta. Hypotension (mean arterial pressure approximately 60 mm Hg) was induced by sodium nitroprusside just before the placement of the stent(s). Subsequent aortography confirmed the adequacy of treatment.

The endovascular criteria for a successful procedure are as follows: (1) absence of death or surgical conversion; (2) exclusion of aneurysm or transected tract; and (3) occlusion of thoracic tears. The persistence of a double

Table 2. Results

Patients	Traumatic Rupture (n = 3)	Thoracic Aortic Aneurysm (n = 4)	Acute Type B Dissection (n = 8)	Total (n = 15)
Early mortality				
Midterm mortality (>2 mo)		1		1 (6.6%)
Endovascular stent grafts/patient	1	2.2 ± 1.0	2.7 ± 0.9	
Diameter (mm)	28.0 ± 5.2	38.2 ± 2.9	36.7 ± 2.1	
Paraplegia				
Endoleak[a] (type I)	1 (33.3%)			1 (6.6%)
Vascular complications				
Rescue bypass	1 (33.3%)			1 (6.6%)
Left subclavian artery occlusion		1 (12.5%)	2 (25.0%)	3 (20.0%)
Celiac axis occlusion			1 (12.5%)	1 (6.6%)
Postimplantation syndrome		1 (25.0%)	3 (37.5%)	4 (26.7%)
Hybrid treatment		1 (25.0%)		
Transfusion		1 (25.0%)		1 (6.6%)
Grafts/patient	1	2.3 ± 0.5	2.7 ± 1.3	2.2 ± 1.2
ICU stay (d)	2.6 ± 0.5	1.3 ± 0.5	1.5 ± 0.7	1.7 ± 0.8
Hospital stay (d)	4.3 ± 1.5	7.7 ± 5.5	5.6 ± 1.2	5.9 ± 3.0

[a] White classification.

ICU = intensive care unit.

lumen in the abdominal aorta was not considered as an indication of failure if the thoracic intimal tears were covered and there was no blood flow in the false lumen. To evaluate the presence of endoleaks, in accordance with the White classification [7], all patients underwent a spiral computed tomography before discharge and at 3, 6, and 12 months after treatment. The number of stent grafts implanted ranged from one to four: one graft in patients with traumatic rupture, 2.2 ± 1.0 grafts/patient in patients with aortic aneurysm and 2.7 ± 0.9 grafts/patient in patients with acute type B dissection. The "telescope technique" was used to cover the descending thoracic aorta with multiple stent grafts of increasing diameters, from the proximal to the distal aorta. The size and number of implanted stent grafts is illustrated in Table 2. The endovascular device used in our first patient with traumatic rupture was a Gore Excluder thoracic stent graft (WL Gore, Flagstaff, AZ), a self-expandable endoprosthesis with an inner polytetrafluoroethylene tube and outer nitinol exoskeleton wire support structure designed for the thoracic aorta. For all the other patients we used the endovascular Talent stent graft (Medtronic AVE, Santa Rosa, CA), a self-expandable endoprosthesis consisting of circumferential nitinol stent springs covered with a Dacron graft, compressed into a 22F to 25F Teflon delivery system.

It was possible to perform the procedures under emergency conditions because a complete inventory of standardized 130-mm-long Talent stent grafts is available in Europe, although this device is currently still in Phase II of the U.S. Food and Drug Administration evaluation procedure.

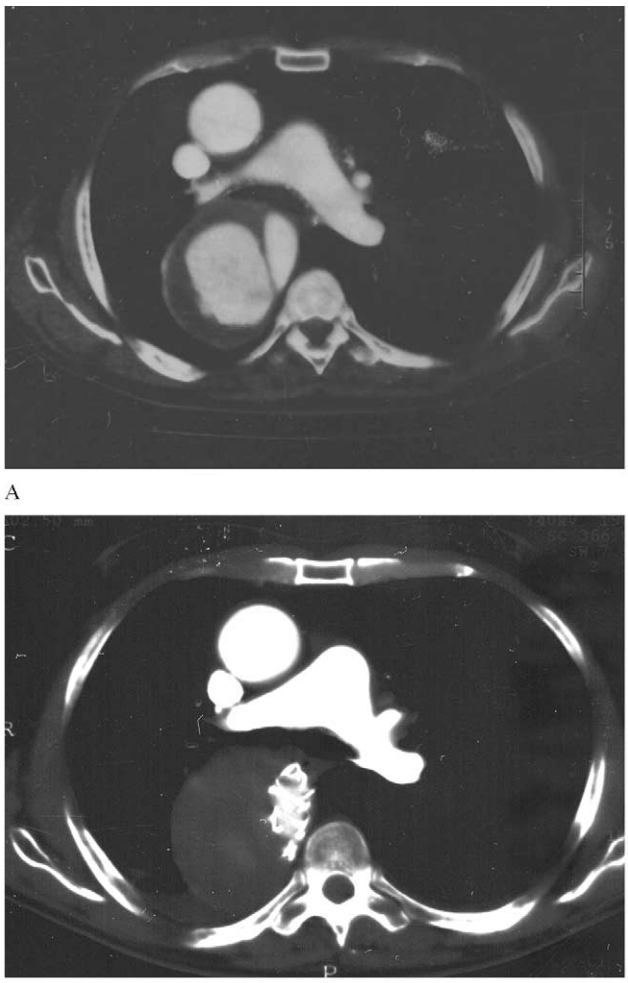
Results

Early Results

There were no major complications or deaths in the group treated by conventional methods. There were no perioperative deaths in the endovascular group and no paraplegia, despite extensive repair of the entire descending thoracic aorta from the left subclavian artery to the celiac axis in 9 (60%) of the patients. Open surgical conversion for thoracic aortic emergency was not required. An asymptomatic obstruction of the celiac axis caused by progressive thrombosis of the false lumen was unexpectedly detected by the computed tomographic scan performed before discharge in an acute type B patient. The left subclavian artery was intentionally occluded in 3 patients (20%), 2 with acute type B dissection (1 with retrograde dissection involving the arch of a right-sided thoracic aorta as shown in Fig 1) and 1 with thoracic aortic aneurysm, without steal phenomena. The patient with thoracic aortic aneurysm and obstruction of the aortic bifurcation required an associated aorto-bifemoral bypass to use as main vascular access: the hybrid procedure was performed in the operating room (Table 2).

Laceration of the right iliac artery occurred during the endovascular procedure performed on a 19-year-old woman with traumatic rupture of the aorta and multitrauma (head injury and leg fractures) requiring an emergency rescue iliac-femoral artery bypass (Fig 2). This complication was the result of a discrepancy between the diameter of the artery (less than 8 mm) and the size of the device (25F).

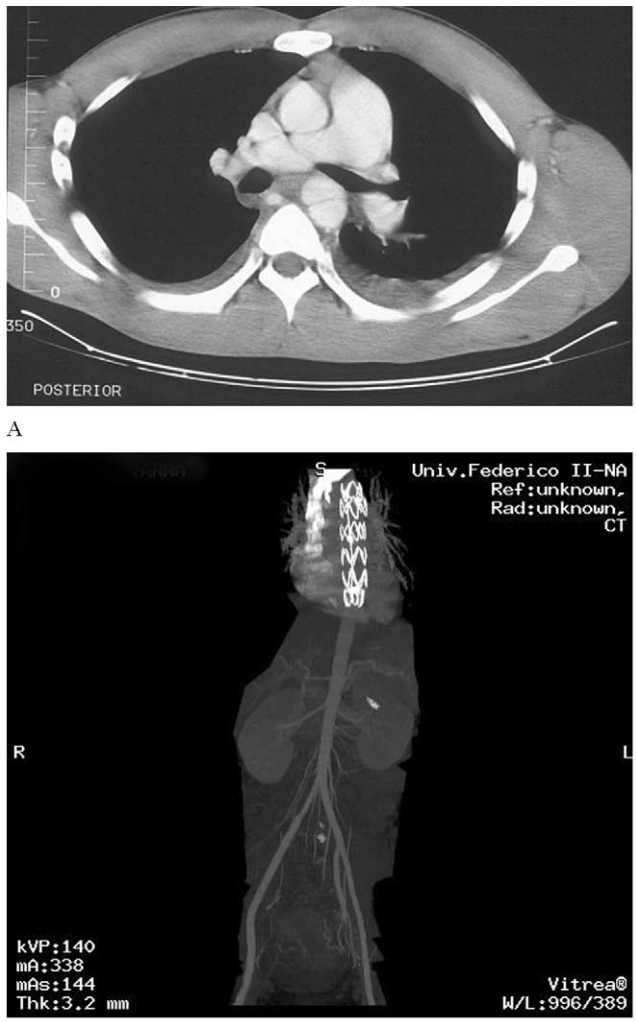
In an 84-year-old moribund patient with free ruptured thoracic aortic aneurysm (American Society of Anesthe-



A

B

Fig 1. (A) Angiographic computed tomographic scan showing an acute type B dissection with retrograde involvement of the aortic arch in patient with right-sided descending aorta. (B) Three months' follow-up angiographic computed tomographic scan showing no endoleak and complete thrombosis of the false lumen.



A

B

Fig 2. (A) Preoperative angiographic computed tomographic scan of 19-year-old woman showing posttraumatic acute aortic transection. (B) Six months' follow-up angiographic computed tomographic scan showing the Talent stent graft in descending thoracic aorta and the right iliac-femoral bypass.

siologists class 5), a left chest tube was used to drain 2,350 mL of blood, and massive transfusions with prolonged intubation and tracheotomy were required. Transient renal failure occurred in 4 patients (26.7%), complicated by hematuria, leukocytosis, and fever, as documented in the "postimplantation syndrome" [8], but they responded quickly to steroid therapy.

The average length of intensive care unit and hospital stay was 1.7 ± 0.8 and 5.9 ± 3.0 days, respectively.

The intraoperative angiography and computed tomographic scan on discharge showed no significant endoleaks in any of the patients, confirming successful sealing of dissected layers.

Midterm Results

The follow-up ranged between 4 and 23 months (average 12.8 ± 5.8 months) and included a clinical examination and a serial computed tomographic scan at 3, 6, and 12 months, and every 6 months thereafter. Two patients with traumatic rupture of the aorta required orthopedic surgery (leg and arm fractures), performed in a trauma center 5 and 7 days after endovascular treatment. Both patients were discharged home 2 weeks after the complex multitrauma. Four older patients, who had a major comorbidity, were transferred to a rehabilitation center 7.1 ± 4.7 days after treatment. One of these, an 84-year-old with thoracic aortic aneurysm, died of septic shock from pneumonia 78 days after endovascular surgery.

Only one type 1 endoleak was noted 3 months after the endovascular procedure in the first patient treated for traumatic rupture by implantation of a Gore-Excluder. The patient refused surgical treatment and is still doing well, with no evidence of increasing endoleak at 23 months' follow-up.

Comment

The natural history of untreated acute thoracic aortic syndrome is sudden progression of the disease, leading to rupture and usually death [3, 9]. Old age and comorbidities, more frequent in patients with aortic aneurysms and acute type B dissections, increase the surgical risk with consequent higher mortality rates, in excess of 50%, in emergency cases [1, 2, 10]. Delayed surgical treatment of patients with traumatic rupture of the aorta has recently been suggested, as this shows a certain improvement in the mortality rate compared with emergency procedures (10% versus 38%) [4]. The risks of high mortality and morbidity are mainly because of associated lesions often present in multitrauma patients [4, 11], exacerbated by extracorporeal circulation and anticoagulation.

Postoperative complications include pulmonary failure requiring prolonged ventilation, myocardial infarction, renal failure, coagulopathy requiring massive blood transfusions, and neurologic complications such as paraplegia [3, 9]. This latter possibility is a catastrophic event, especially when occurring in younger patients with traumatic rupture of the aorta, as demonstrated by extensive meta-analysis resulting in 19.2% incidence of paraplegia [11]. Prolonged convalescence is also expected in these cases, along with increased costs for hospitalization [12, 13]. The surgical option must always take into consideration the complexity of the procedure and the unsatisfactory results often attained in emergency situations and with older patients [3, 9, 14]. Reluctance related to conventional surgery has encouraged many centers to consider alternative strategies involving less-invasive techniques [6, 12–14].

Endovascular surgery is a promising therapy for disease of the descending aorta and has rapidly evolved as a valuable alternative to conventional surgery [5, 6, 12–14]. More recently, an attempt was made to identify the ideal candidate for endovascular surgery by using a numerical score chart, in accordance with the clinical and anatomic criteria proposed by Alves and colleagues [15].

In our initial experience, with candidates not considered to be ideal according to the American Society of Anesthesiologists class distribution, we treated high-risk patients in emergency conditions with no resulting hospital mortality and only one late death in an elderly patient in whom the surgical risk was considered prohibitive (American Society of Anesthesiologists class 5).

Open conversion was not required, and no endoleaks were present in any of the 15 patients on discharge. At 3 months' follow-up the first patient in our series—with a Gore-Excluder stent graft implanted for posttraumatic pseudoaneurysm—showed a significant type 1 endoleak, currently stable 23 months from treatment. This failure could be ascribed to our learning curve and to a progressive reduction of the device's radial force, considered essential for successful sealing.

In the other 2 patients with traumatic rupture of the aorta—19 and 22 years old—the result was more encouraging, requiring only a short hospital stay and early orthopedic treatment of the fractures, resulting in prompt recovery and absence of endoleaks, confirmed at the 14-month and 19-month follow-up.

No paraplegia occurred in our series, despite extensive covering of the entire descending aorta in 9 patients (60%) and of two thirds of the aorta in 3 patients (20%): the critical region between T9 and T12 was stented in all 12 patients. Although some authors [16] recommend evaluating the spinal cord supply, the preoperative angiography was never taken into consideration and no particular strategies were adopted. Anatomic occlusion of all intercostal arteries is not a prognostic discriminant for paraplegia, according to surgical reports on complete replacement of the descending aorta when safe clamping time (less than 30 minutes) was achieved [17].

One major vascular complication occurred in the 19-year-old woman because of the discrepancy between the diameter of the iliac artery and the size of the device. We highly recommend using a vascular access larger than 8 mm to avoid unfortunate complications during the introduction of the device and advise great care in the presence of an exceedingly angulated aortic arch (in excess of 60°) as this is dangerous to cross and increases the risk of dislocation of the device as a result of inadequate sealing. The rigidity of the stent graft might also cause difficulties as it would not sufficiently hug the aortic arch and might lead to an endoleak. The Talent endovascular graft used in our series improves proximal adherence, maneuverability, and conformation and is considered suitable for this procedure.

Endovascular stent graft surgery is a promising and less-invasive alternative to exclude aneurysms, transection, and dissection of the aorta from blood flow and makes it possible to treat patients considered otherwise unsuitable for conventional surgery. Although a long-term follow-up is mandatory to detect late failures related to the prosthetic device, we can conclude that endovascular surgery (1) is safer than conventional surgery for emergency or high-risk patients, (2) allows for prompt treatment of associated lesions in complex multitrauma patients in which heparinization and extracorporeal support are not indicated and delayed treatment may be life-threatening, and (3) may be considered as an hypothetical bridge to conventional surgery for younger patients, if some unforeseeable device failure should occur.

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