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Emergent Endovascular Interventions for Contained Rupture of Thoracic Aortic Aneurysms

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ABSTRACT

Background: The purpose of our study was to assess in an emergency setting the feasibility of endovascular stent graft treatment of contained ruptures of thoracic aortic aneurysms.

Methods: Seven patients with contained ruptures of thoracic aortic aneurysms from a series of 54 endovascular interventions were treated by the deployment of an aortic stent graft. In all cases, hemothorax was present. Acute deployment was performed with the patient under general anesthesia, and access was gained via the common femoral or iliac arteries. After a follow-up of 12 months, the patients were evaluated by computed tomography.

Results: One patient died perioperatively. The procedure was technically successful in 5 patients. Perioperatively and at follow-up, there were no cases of paraplegia, stent graft migration, or endoleaks. There were, however, 2 cases of access failure, 1 case of temporary renal failure, and 2 patients who required prolonged mechanical ventilation.

Conclusion: The acute treatment of contained ruptures of thoracic aortic aneurysms is feasible. This form of treatment seems to be a promising option in the treatment of these high-risk patients.

INTRODUCTION

Previous studies have already demonstrated the feasibility of endovascular stent graft placement with promising preliminary results [White 1997, Dake 1999, Greenberg 2000, Temudom 2000]; however, only a few reports exist that describe the use of stent graft implantation in an urgent setting, as in cases of acute aneurysm formation or perforation [Greenberg 2000, Temudom 2000]. Overall, the clinical experience with this new method of treatment still is limited.

Conventionally, the preferred treatment for chronic dissecting aneurysms of the descending aorta is medical therapy consisting of antihypertensive therapy. Surgical treatment is reserved for those cases that are complicated by the progression of disease, impending rupture, formation of a pseudoaneurysm, persistent thoracic pain, drug-resistant hypertension, or end-organ ischemia [Schepens 1994, Safi 1998]. With conservative treatment, the mortality rate is 20%, whereas the mortality rate is 35% to 50% after surgical repair, depending on the complexity of the perfusion changes caused by the dissection. Thus, both conservative treatment and surgery in patients with lesions of the descending thoracic aorta are associated with high mortality rates [Safi 1998, Griepp 1999].

Patients with leaking thoracic aortic aneurysms require immediate surgical repair. Surgery usually consists of the replacement of the proximal part of the descending aorta. Despite recent advances in perioperative and postoperative care for such patients, surgical repair remains associated with a high rate of mortality and morbidity [Svensson 1993, Coady 1999].

We report our experience of 7 patients with contained ruptures of thoracic aortic aneurysms that were acutely treated with endovascular stent graft deployment.

MATERIALS AND METHODS

From January 2001 to November 2001, 26 patients with contained ruptures of aortic aneurysms were referred to our department. Nineteen patients were not suitable for stent graft implantation owing to anatomical considerations. Seven patients were treated with an endovascular stent graft within a mean of 28.5 hours (range, 12-38.5 hours) after the onset of symptoms.

The patient population consisted of 3 women and 4 men with a mean age of 66.4 ± 17.4 years. All 7 patients showed aneurysms of the descending thoracic aorta (Figures 1 and 2). Acute leakage was caused by trauma after a road traffic accident in 2 patients, and it occurred after spontaneous rupture in 5 patients. All patients demonstrated a perforation with periaortic hematoma, hemothorax (n = 7), or evidence of bleeding into the lung parenchyma. The lesions were predominantly located in the proximal part (61.5%) and the middle part (26.9%) of the descending aorta; only a few occurred in the distal part (11.5%).

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Figure 1. Intra-aortic digital subtraction angiogram of a contained rupture of the descending thoracic aorta of a 71-year-old woman with an acute aneurysm prior to the deployment of a stent graft.

Inclusion criteria for stent graft implantation were impending rupture, complications (eg, periaortic hematoma, hemothorax, patent aortal bleeding), formation of a pseudoaneurysm, persistent thoracic pain, drug-resistant hypertension, or end-organ ischemia. Exclusion criteria for stent graft implantation were a diameter of the thoracic aorta proximal and distal to the lesion of ≥44 mm, lesions originating from the ascending aorta, lesions too close (≤5 mm) to the orifice of the left common carotid artery, and diameters of the common iliac arteries of ≤7 mm, as well as a heavily tortuous course of the abdominal or thoracic aorta.

Concomitant diseases in the patients that increased the risk for surgical repair were arterial hypertension (84.6%), chronic obstructive pulmonary disease (30.8%), stroke (7.7%), cardiac insufficiency (11.5%) with a low ejection fraction (<30%), and renal insufficiency (11.5%).

Two different commercially available thoracic stent graft systems were implanted in this study, the Talent LPS (n = 5; Medtronic World Medical, Sunrise, FL, USA) and the Excluder (n = 2; W. L. Gore and Associates, Sunnyvale, CA, USA). The stent graft consisted of a self-expanding nitinol stent covered externally with polyethylene terephthalate fiber (Dacron) graft (Talent LPS) or internally with polytetrafluoroethylene graft (Excluder). All Talent stent grafts had a bare spring design 15 mm in length at the proximal end. The mean length of the implanted stent grafts was 113.8 ± 21.9 mm (range, 94-153 mm). The stent diameter (mean ± SD, 34.3 ± 5.9 mm) was 4 to 6 mm greater than the diameter of the aortic neck to allow the appropriate fixation of the stent graft.

All stent graft implantations were performed in a digital subtraction angiography (DSA) suite (Multistar Plus, Siemens, Erlangen, Germany) by a team of cardiovascular surgeons and interventional radiologists with the patient under general anesthesia. The DSA unit is equipped with double C-arm construction allowing rotation of the entire C-arm (X-ray tube and image intensifier) at speeds of up to 25°/s. Additionally, the system is road map capable and offers the fading in of DSA images during fluoroscopy. No external skin markers were used to locate the orifices of the large supra-aortic branches.

The patients were placed in a supine position. In all cases, percutaneous access through the brachial artery (left, 9 cases; right, 2 cases) was obtained. After the placement of a 5F Introducer sheath (Radiofocus; Terumo, Tokyo, Japan) a 5F pigtail catheter (Nylex; Cordis Endovascular, Waterloo, Belgium) was positioned in the ascending thoracic aorta, thus allowing contrast medium application throughout the entire process of stent graft deployment. Arterial access for stent graft insertion was achieved via surgical cutdown in all cases (left groin, 3 cases; right groin, 8 cases). The technique of stent graft insertion and deployment has previously been described in detail. In short, after successful surgical exposure of the femoral artery and a transverse arteriotomy, a pigtail catheter was positioned in the ascending thoracic aorta over a soft, angled guidewire (Radiofocus standard guidewire M; Terumo). The guidewire was exchanged for a superstiff guidewire (Lunderquist extra stiff; Cook, Bloomington, IN, USA) for stent graft insertion. After an initial angulated DSA examination of the thoracic aorta with 30 mL of contrast material (Visipaque 320; Nycomed Amersham Buchler,

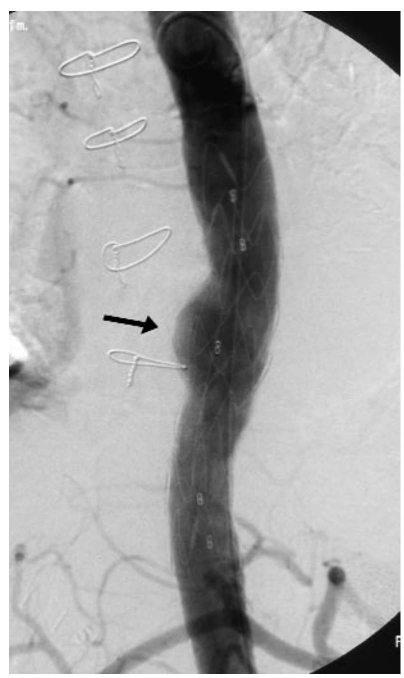

Figure 2. Intra-aortic digital subtraction angiogram of the patient after stent graft deployment (Talent tube graft; 28-mm diameter, 102-mm length). In the final angiogram, a downsizing of the aneurysm with slight protrusion of the stent graft into the aneurysm (arrow) was seen.

Ismaning, Germany) and a flow rate of 15 mL/s was established, 5000 IU heparin was administered intra-arterially. The stent graft system was then advanced into the desired position, and the correct location was verified by an additional DSA examination immediately before stent graft deployment. Downstream migration of the device during deployment was avoided by lowering the mean arterial blood pressure to 70 mm Hg with sodium nitroprusside (n = 4) just before device release. In 5 patients, a short period of cardiac arrest was achieved by the intravenous injection of adenosine (6-12 mg) to ease device deployment and to allow exact device positioning at the orifice of the left subclavian or carotid artery. In all cases, postdilation was performed with a polymeric balloon to obtain the optimal shape and sealing of the implanted stent graft.

A final DSA procedure was performed to verify appropriate stent graft localization and to demonstrate the free perfusion of the supra-aortic vessels as well as the stent graft. All interventional materials were removed, and the arteriotomy was closed with a continuous 5-0 polypropylene (Prolene) suture. All patients were transferred to the intensive care unit for at least 4 hours for postoperative surveillance. All patients had single-shot broad-spectrum antibiotic prophylaxis (third-generation cephalosporins) just before the initial incision. Follow-up examinations were performed with multidetector row computed tomographic angiography scans before patient discharge and at 3, 6, and 12 months after implantation.

RESULTS

Successful stent graft deployment was achieved in 5 patients. One patient with acute perforation died from cardiac failure before device positioning and sealing could be achieved. In 1 patient with a type B dissection, the Talent LPS device could be advanced up to the level of the renal arteries but not any farther because of the tortuous course of the vessel and calcification at the level of the bifurcation. The patient in this case was then treated conservatively. Insertion was difficult in another 2 patients because of pelvic vessel diameters not exceeding 8 mm and a 25F device size. After dilatation with 8-mm and 9-mm endoballoons and subsequent careful advancement of the device, stent graft delivery to the appropriate position was possible in both patients.

In 2 patients, 2 stent grafts had to be inserted in an overlapping manner to seal off the primary lesion. In one of these patients, angiographic results showed that the aneurysm was excluded after the first stent graft implantation, but the 1-month follow-up computed tomography scan revealed a reperfusion. After the successful placement of a second stent graft, this endoleak was successfully sealed.

The distance from the proximal part of the lesion to the origin of the left subclavian artery ranged from 8 to 85 mm (mean, 30.5 ± 25.8 mm). The mean length of the lesions was 129.7 ± 74.3 mm.

On conclusion of the procedure, no antegrade perfusion of the false aortic lumen in the thoracic segment or in the aneurysm could be documented angiographically. The mean procedure time was 93 ± 15.8 minutes, and the mean fluoroscopy time was 14.9 ± 9.2 minutes. A mean of 216.5 ± 75.5 mL of contrast medium was administered.

Postinterventional Course

All patients were observed in the intensive care unit for at least 4 hours. Severe alteration of arterial blood pressure in the form of arterial hypertension was observed in all patients during the immediate postinterventional course. No neurologic deficits were observed. However, 2 patients experienced groin infection that was successfully treated with intravenous antibiotics. One patient with extensive pleural hematoma and another with multiple bone injuries after a road traffic accident required prolonged intubation and intensive care unit observation for 3 weeks and 4 weeks, respectively, because of concomitant diseases or injuries. In all other patients, the immediate postinterventional course was uneventful.

One-Year Follow-up

Five patients completed 12 months of follow-up as of this writing. All patients were free of symptoms with regard to the lesions of the descending aorta. In addition, no stent migration or stent fractures were observed. No endoleaks were observed in any of the patients. In 4 patients, the size of the aneurysm had already decreased.

DISCUSSION

Because the surgical treatment of acute ruptures of the descending thoracic aorta is still associated with significant mortality and morbidity rates, our group has sought alternative means of managing these patients. Endovascular stent grafting has been shown to be an interesting option in the elective setting. Considerable experience has been accumulated with stent graft procedures for the endoluminal repair of infrarenal aortic aneurysms [White 1997]. Experience with the endoluminal repair of thoracic aortic aneurysms is less extensive. Dake and colleagues [Dake 1999] have reported their experience with 100 patients; however, experience in most other centers is more limited. Dake and colleagues [Dake 1994] were also one of the first groups to publish on the feasibility of using endovascular stent grafting for treating aneurysms of the descending thoracic aorta. Since then, several published studies have reported the benefits of using several prototype endovascular prostheses for the endovascular treatment of aneurysms and dissections of the descending aorta [Kato 1997, Nienaber 1999, Greenberg 2000, Temudom 2000, Heijmen 2002]. With further improvements in stent graft systems, the technique has become safer, and today even branched stent grafts have been developed for reconstruction of the aortic arch and the thoracoabdominal aorta [Inoue 1999, Sueda 2001].

Reports in the literature of the acute, emergency treatment of descending thoracic aortic aneurysms with stent grafts are scarce, however. Nienaber and colleagues [Nienaber 1999] reported on 12 patients with subacute dissecting aneurysms of the thoracic aorta treated with stent grafts. The procedure was successful in all patients, and no complications were observed. Dake and colleagues [Dake 1999] reported on

19 patients with acute aortic dissecting aneurysms treated with stent grafts. These workers demonstrated that emergency endovascular stent grafting is feasible with good clinical results when carried out by experienced hands.

The results of our series support these findings. Conversion to open surgical repair was not necessary, and there was only one case of reintervention. In our experience, it is essential that patients respond to resuscitation treatment before the induction of anesthesia so that they are in a fairly stable hemodynamic condition for the procedure. In the case of a free rupture, endovascular stent grafting should not be attempted, and if the patient is to have a chance of survival, immediate open surgical control of the bleeding and subsequent repair should be performed.

Furthermore, for patients to become eligible for successful deployment of stent grafts in the emergency setting, the same anatomical prerequisites as in elective stent grafting have to be met. Therefore, a precise and quick preoperative workup is essential. We use a high-resolution, 16-array, volume computed tomography scan, extending from the apex of the patient down to the groin. This scan is performed in approximately 45 seconds. This method provides us with all the necessary information regarding the lesions of the thoracic aorta and provides the measurements necessary for stent graft planning. Furthermore, it gives us knowledge of a possible tortuous vessel course, any calcifications, and the sizes of the entire aorta and pelvic arteries, which allow the assessment of safe stent graft access and delivery [Heijmen 2002]. Most studies published in the literature have used thoracic helical computed tomography and calibrated intra-arterial DSA to evaluate the lesion of the thoracic descending aorta as well as the pelvic and groin vessels [Grabenwö 2000, Bortone 2001, Heijmen 2002]. In using these techniques, however, White et al [White 2001] reported a 27% frequency of access complications (eg, femoral artery reconstruction or iliac artery grafts). In our patient population, we had only 1 patient (3.8%) with access failure and a slight difficulty with another 2 patients (7.7%) in advancing the system, and we had no severe vascular complications.

For adequate fixation and safe deployment of the stent graft, a normal aorta of sufficient length is necessary. Several investigators have reported on a transposition operation of the left subclavian artery on the left common carotid artery to lengthen the proximal fixation zone. This procedure was performed as a separate operation either before or after the stent graft implantation. Although some investigators also have found that overstenting the origin of the left subclavian artery can be performed without any complications [Inoue 1999, Sueda 2001], others have stated that overstenting the left subclavian artery may result in occlusive thrombosis with left upper extremity ischemia despite an unimpeded blood flow and the absence of a pressure gradient at the completion of angiography [Temudom 2000, Heijmen 2002]. Additionally, subclavian artery obstruction may lead to cerebral vascular insufficiency in compromised patients due to a reversal of flow in the ipsilateral vertebral artery. The latter artery also contributes to the anterior spinal artery, and it is conceivable that its flow reversal may increase the risk of spinal ischemia. Furthermore, persistent flow in the left subclavian artery may result in a retrograde endoleak (type II endoleak) [White 2001]. Alternatively, the origin of the left subclavian artery can be overstented with an uncovered proximal design of the stent graft. Recently, a fenestrated stent graft with a U-shaped window at the greater curvature of the graft has been devised to prevent obstruction of the subclavian artery [Sueda 2001]. Both techniques, however, jeopardize the adequacy of proximal fixation.

We know that associated paraplegia rates can be significantly reduced compared with conventional surgery by performing elective endovascular aortic stent grafting. We have found this reduction in rates to be true for our limited cohort of acute patients as well. Because of the absence of aortic cross-clamping and reperfusion, endovascular stent graft repair of the descending thoracic aorta may lower the incidence of spinal cord ischemia [Grabenwö 2000, Greenberg 2000, Bortone 2001]. Concurrent or previous abdominal aortic repair, however, has been associated with an increased risk of paraplegia [Bortone 2001]. In our series, there were no neurologic deficits and no paraplegia or paraparesis, even though the middle and distal thoracic aorta was stented. Because most of the operations were performed immediately after patient referral to our hospital, spinal vessel blood supply was not investigated preoperatively. Nevertheless, in the case of immediate or delayed onset of paraplegia, the current design of stent grafts does not allow an endoluminal removal of the endoprosthesis once it has been completely deployed. Successful reversal of paraplegia has been reported by both emergent conversion to open surgery [Reichart 2001] and cerebrospinal fluid drainage [Tiesenhausen 2000]. Monitoring evoked spinal cord potentials during the temporary interruption of the intercostal arteries by a specially designed retrievable occlusive device may aid in identifying the patients at risk for spinal cord ischemia. Conversion to traditional open repair or prophylactic cerebrospinal fluid drainage may be performed in these patients to avoid this complication [Heijmen 2002].

In conclusion, emergent endovascular stent grafting for treating contained ruptures of descending thoracic aortic aneurysms is a feasible alternative to surgical repair. In experienced hands and with a good preoperative workup, a multidisciplinary approach, and a ready supply of stent grafts of various sizes, good clinical results with a low mortality and associated morbidity rate can be achieved. Because experience in this field is still limited, further studies with larger patient populations and longer follow-up periods are essential to allow definitive conclusions.

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