Endovascular stent graft placement in patients with acute thoracic aortic syndromes

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Abstract

Objective: In the present study, the effectiveness of endovascular stent grafts (ESG) in the treatment of acute aortic complications, such as acute dissection type B, penetrating ulcer and traumatic aortic rupture is evaluated. Patients and methods: From June 1997 to February 2002, 66 patients were treated with ESG. Out of this cohort, 19 patients (28.8%) were subjected to stent grafting due to acute aortic syndromes. Acute dissection type B was present in 11 patients (16.6%), a penetrating ulcer was diagnosed in six patients (9%) and in 2 patients (3%) a traumatic aneurysm was the indication for operation. There were 16 male and three female patients with a mean age of 60 years (20–85 years). Excluder™ stent grafts (Gore) were used in 15 patients, the Talent™ device (Medtronic) was implanted in four patients.

Results: Stent graft placement was technically successful in all patients. Hospital mortality was 0%. Paraparesis occurred in one patient (5.2%), which could be managed successfully without remaining neurological deficit after installation of cerebrospinal fluid drainage for 72 h. In another patient, overstenting of the left subclavian artery caused ischemia of the left arm and left subclavian to carotid artery bypass had to be performed. ICU-stay ranged from 1 to 6 days (mean 2.4 days) and the patients could be discharged after an average hospital stay of 8 days. In the follow-up period, one patient died due to myocardial infarction and one patient had to be re-operated due to contained rupture of the thoracic aorta caused by an endoleak. Conclusions: The study suggests that endovascular stent grafting is an excellent and effective treatment modality for the acute aortic accident, which can be recommended for high-risk patients too. However, close follow-up examination is indicated and long-term results have to be awaited to evaluate the real effectiveness of this method.

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1. Introduction

The first successful endovascular stent graft (ESG) treatment of abdominal aortic aneurysms described by Parodi et al. in 1991 prompted the investigation by various groups into the feasibility of endovascular thoracic aortic aneurysm repair [1–4]. The potential advantages of ESG are related to its minimally invasive approach to the thoracic aorta: A femoral or iliac arterial cutdown is performed without thoracotomy or aortic clamping and there is no need for full heparinization, thus eliminating major bleeding complications that may occur after open surgical procedures. This less invasive approach advocates this treatment modality especially for patients, who are unsuitable for conventional surgery due to their chronic comorbidities or acute hemodynamic instability. Thus, in the high risk setting of acute aortic syndromes, endoluminal repair emerged as a new therapeutic strategy which is yielding encouraging results [5–9].

Penetrating aortic ulcers result from progressive erosion of atheromatous plaques perforating the internal elastic lamina. Penetrating ulcers are considered a predisposing condition for aortic dissection and spontaneous rupture. As penetrating ulcers are associated with comorbidities like hypertension, peripheral or coronary artery disease and chronic renal insufficiency, patients are often not eligible for
conventional surgical repair [10]. In the case of traumatic aortic dissections, the patients often present with multiple injuries and therefore open repair is a high risk procedure because of bad overall condition or the need of systemic heparinization [11].

In the present study, we evaluate the feasibility and safety of ESG placement in patients with acute aortic syndromes, such as acute dissection type B, penetrating ulcers and traumatic aneurysms.

2. Patients and methods

Between June 1997 and February 2002, 66 patients were treated with ESG at our department after obtaining informed consent. Out of this cohort, 19 patients (28.8%) were selected into our study group, which focuses on acute aortic syndromes. Acute dissection type B was present in 11 patients (16.6%), a penetrating ulcer was diagnosed in six patients (9%) and in two patients (3%) a traumatic aneurysm was the indication for intervention. The majority of patients with type B dissections (nine out of 11 patients) were regarded as complicated type B dissections due to recurrent chest pain as well as increasing pleural effusion. One patient with the signs of a contained rupture was treated under emergency conditions.

There were three female (15.8%) and 16 male (84.2%) patients with a mean age of 61 years (20–85 years). Time interval between diagnosis and stent grafting ranged from 4 h to 6 days (mean 2 days). At the time of operation, one patient was hemodynamically unstable, the remaining patients were treated under stable conditions.

Significant comorbidities were hypertension in 17 patients (89.4%), coronary artery disease with previous myocardial infarction in three patients (15.8%), chronic renal failure in three patients (15.5%) and COPD in eight patients (42.1%). Three patients had previous cardiac surgery, two CABG and one aortic valve replacement.

Symptoms present at the time of intervention were chest or back pain in all patients, dyspnea in two patients, low output syndrome in one patient and three patients with a penetrating ulcer exhibiting hemoptysis.

The zone of the primary entry tear was localized in the proximal descending aorta in 11 patients, in the isthmic zone in the two patients presenting traumatic dissection and in the mid-portion of the thoracic aorta in the remaining six patients. Procedural success was defined by complete sealing of the primary entry tear followed by obliteration of the false lumen at least in the thoracic region. In the case of penetrating ulcer and localized traumatic dissection, complete coverage of the injured aortic segment was defined as procedural success.

2.1. Endovascular procedure

All endovascular procedures were performed in an angio-suite by a team of cardiovascular surgeons and interventional radiologists. Sixteen patients were operated in general anesthesia, three patients were treated in spinal anesthesia. For vascular access the femoral artery was surgically exposed in 13 patients (68.4%), the iliac artery was used in six patients (31.6%). A six French pig-tail catheter was advanced over the left brachial artery into the ascending aorta to allow intraprocedural angiography. An angiography with an automatic injector was performed to localize precisely the primary entry site in patients with acute type B dissection or traumatic dissection or the site of contained aortic perforation. Thereafter, a pig-tail catheter was introduced from the femoral or iliac artery into the ascending aorta. The catheter was advanced under angiographic control in a stepwise manner to confirm introduction into the true lumen. Over the pig-tail catheter an extra-stiff guidewire (Backup Meier, Boston Scientific, Natick, MA) was placed into the ascending aorta.

Prior to stent graft insertion, 5000 IU of heparin sodium was administered intravenously and antibacterial medication was given routinely. Next, the delivery system was introduced through the true lumen and was carefully advanced into the optimal position under fluoroscopic guidance. After correct positioning of the device, the stent graft was deployed.

Finally, an angiogram was performed to confirm the position of the device relative to the entry tear of perforation site, to evaluate patency of the left subclavian artery and blood flow in the visceral arteries and to verify the effectiveness of the stent grafting. Thereafter the placement system was removed and the arteriotomy was closed in the conventional manner.

Patients were subjected to a strict follow-up protocol that requires a contrast spiral computed tomography (CT) scan and clinical evaluation at 3.6 and 12 months after surgery and then annually thereafter.

2.2. Stent graft systems

Two different stent graft systems are available to our department. The GORE Thoracic Excluder Endoprothesis (W.L. Gore and Associates, Sunnyvale, CA) was used in 15 patients (79%). Exclusion of thoracic aortic aneurysms with the TALENT endoluminal stent graft system (Medtronic, Sunrise, FL) was performed in 4 patients (21%).

The TALENT stent graft consists of a nitinol wire stent shaped in a zigzag formation, which is covered with extra-thin polyester (Dacron). A straight nitinol wire severs the length of the device and avoids twisting or kinking. This self-expandable stent graft is compressed over a placement catheter. Both the stent graft and the catheter are loaded into a polyurethane sheath for insertion. The endoluminal stent graft system is passed over the guidewire and positioned at the desired location as determined by intraoperative angiography. After exact positioning, the stent graft released by removing the sheath.
The GORE Thoracic Excluder stents are constructed differently. The system is placed into the vasculature through an introduction sheath. The stent graft itself is mounted on a placement catheter. Development of the stent graft is achieved by pulling on a string at the end of the placement catheter. GORE stent grafts are available in standard sizes.

3. Results

Stent deployment was technically successful in all patients. No hospital mortality was observed and all patients could be discharged in good overall condition. Duration of the procedure lasted from 89 to 300 min (mean 121 min). Mean ICU stay was 2.4 days (ranging from 1 to 6 days) and overall hospital stay was 8.4 days.

One or two stent grafts per patient were necessary to cover the aortic lesion (mean 1.4 stents/patient). Patients with penetrating ulcers were treated with one stent graft. In the case of type B dissection and traumatic lesions, most of the patients received two stent grafts. The goal of the intervention was not only to cover the primary entry tear, but also to reinforce the dissected aorta. Stent diameters ranged from 26 to 40 mm (mean 35.7 mm) and length varied from 50 to 200 mm (mean 100 mm).

CT scans performed at the time of discharge revealed complete sealing of the aorta at the perforating site or local dissection area in patients with penetrating ulcer or traumatic lesions. Patients treated for acute type B dissection showed closure of the primary entry tear with thrombosis of the false lumen at the height of the stent graft in all patients. Therefore, procedural success was 100%. Complete obliteration of the false lumen could be achieved in 2 patients, whereas the remaining patients exhibit perfusion of the false lumen in the abdominal region via re-entries at the height of the renal arteries.

In the postoperative period, two complications were encountered. One patient treated for acute type B dissection developed incomplete paraplegia within 14 h postoperatively. Cerebrospinal fluid drainage was installed 8 h after onset of symptoms by inserting a lumbar catheter in the height of L3–L4. Initial cerebrospinal fluid pressure was 45 mmHg. To reach the target pressure of 15 mmHg, liquor was drained for 96 h. A total volume of 800 ml was collected and neurologic symptoms decreased continuously. After an uneventful postoperative course, the patient could be discharged with no remaining neurologic deficit. Another patient with type B dissection developed ischemia of the left arm after overstenting of the left subclavian artery. Fourteen days after stent graft placement, subclavian to carotid artery transposition was performed.

Follow-up period ranged from 3 to 63 months (mean 17.2 months) and was 100% complete. Within the follow-up period, one patient treated for penetrating ulcer died due to myocardial infarction (late mortality 5.3%). Another patient was admitted at the emergency room 4 years after stenting due to a penetrating ulcer showing a contained rupture of the severely calcified aorta. CT scans revealed marked dilatation of the thoraco-abdominal aorta and a proximal type I endoleak resulting in a contained aortic rupture. Due to the morphology of the adjacent thoracic aorta, placement of additional stent grafts was not feasible. Therefore, open surgery with replacement of the thoraco-abdominal aorta using the left heart bypass technique had to be performed. After surgery, the patient recovered uneventfully. The remaining patients are doing fine and the completion of CT scans showed complete thrombosis of the false lumen of the entire aorta in two additional patients with type B dissections. The mean diameter of the false lumen of the dissected aorta decreased from 2.3 ± 58 to 0.7 ± 0.44 cm, and the true lumen increased from 1.56 ± 0.5 to 4.10 ± 0.60 cm in the thoracic region.

4. Comment

Our study indicates that stent graft placement is a feasible and effective approach in the treatment of acute aortic complications such as acute type B dissections, traumatic aortic lesions and penetrating ulcers. In the case of type B dissection stent graft placement is effective by closure of the primary entry tear, thereby minimizing the risk of rupture of the thoracic aorta and optimizing distal perfusion by decompression of the true lumen (Fig. 1A, B).

Fig. 1. (A) Aortic angiogram shows contrast media filling of the false lumen via an entry site located at the mid-portion of the descending aorta. (B) Closure of the entry site by the stent graft caused obliteration of the false lumen.
Coverage of local aortic dissections caused by trauma or penetrating ulcers by a stent graft is suggested to be a formidable treatment modality, which can be applied in high-risk patients too.

Due to the promising results obtained in former studies, the field of stent grafting is expanding very fast during the last 4 years [12–16]. So far only few studies are available concerning the usage of ESG in the acute setting of aortic syndromes [4–9]. Especially in these situations stent graft placement could emerge as a valid treatment option, which is equally effective but less invasive as compared to conventional surgical repair. Kato and colleagues already demonstrated the feasibility of ESG for treatment of acute traumatic aortic aneurysms [17]. Development of low-profile and flexible stent grafts, which can be introduced percutaneously, will further facilitate this treatment option [18].

In our series, two patients with acute traumatic aortic aneurysms were treated successfully with ESG (Fig. 2A, B). One of these patients exhibited multiple bone fractures and injuries of liver and spleen. Thus, the patient was not a suitable candidate for total heparinization as required for conventional surgical repair. The traumatic rupture was located just at the offspring of the left subclavian artery. Overstenting of the subclavian artery was performed leading to a pulse deficit of the left arm without clinical symptoms. Based on this initial experience, placement of ESG is suggested to be an excellent treatment modality especially for the polytrauma patient, a high-risk candidate for conventional surgical repair.

The so-called “penetrating ulcer” is another important indication for placement of ESG. Three of the six patients treated at our department presented with hemoptysis indicating aortic rupture with an aorto-bronchial fistula. Although most of the patients with penetrating ulcers have a heavily calcified aorta, the critical aortic lesion is limited to a small area (Fig. 3A, B). Therefore, sealing of the penetrating atherosclerotic plaque using a short stent graft is suggested to be an effective and feasible method, and an excellent alternative to conventional open surgery (Fig. 4A, B). However, one patient developed a thoraco-abdominal aneurysm followed by a proximal perigraft leak resulting in rupture of the distal thoracic aorta 4 years after ESG placement. Replacement of the thoraco-abdominal aorta using the left heart bypass technique was performed. The distal part of the stent was clamped together with adjacent aortic tissue. However, it was possible to pull the stent out of the closed clamp and replace the aorta using a Vascuteck prosthesis. This late complication underlines the importance of a close follow-up of patients after ESG placement by CT scans, since progression of the aortic disease may adversely affect the attachment of the stent graft causing perigraft leakage. At our department, CT controls are performed at discharge, after 3, 6 months and annually thereafter.

Recent publications investigating the natural history of chronic type B dissection showed that 20–28% of patients had to undergo surgery of the descending thoracic aorta due to aneurysm formation in a follow-up period of 40–50 months. Fatal rupture of the aorta occurred in 18% of the study cohort, stressing the importance of a more aggressive surgical management [19,20]. The objective of ESG in patients with acute type B aortic dissection is the closure of the primary entry tear leading to decompression of the true lumen followed by improved distal perfusion. Stabilization of the injured thoracic aorta by ESG placement is an additional goal of the procedure with the intention to prevent late aneurysm formation. Therefore, most patients with type B dissections received two stent grafts. This
stabilization of the thoracic aorta may help to minimize the risk of rupture even in the so-called uncomplicated dissections. All patients of this indication group showed complete thrombosis of the false lumen at the height of the stent graft. In four patients complete obliteration of the false lumen was achieved, the remaining seven patients exhibited retrograde filling of the false lumen in the abdominal region via re-entries at the height of the visceral vessels (Fig. 5A–D). However, in our opinion, the proximal and mid-portions of the thoracic aorta, being the regions most prone for dilation, are protected by ESG placement.

We observed one severe neurologic complication. This patient suffered from bilateral paraparesis with motor and sensory deficits affecting completely the right leg and partially the left leg. Cerebrospinal fluid drainage was initiated 8 h after onset of symptoms via a lumbar catheter. A total volume of 800 ml was drained within 96 h. Subsequently, neurologic symptoms declined and the patient came to full recovery. Due to the location of the primary entry tear in the distal portion of the thoracic aorta in this case, it seems most likely that spinal cord ischemia resulted from closure of essential distal intercostal arteries by ESG placement. Therefore, prophylactic installation of CSF drainage in this particular subgroup of patients seems advisable.

In one patient, left subclavian-to-carotid artery bypass had to be performed, because of intermittent claudication of the left upper extremity caused by closure of the origin of the left subclavian artery. In the acute setting – in contrast to elective cases – it is our policy to overstent the left subclavian artery if necessary. Close monitoring of left upper extremity perfusion is performed. If ischemia develops staged revascularization procedures can be performed.

We therefore conclude that this technique can be considered as a valid treatment option in the emergency setting, especially when standard surgical procedures cannot be carried out due to severe comorbidities. However, close follow-up examination is indicated and long-term results have to be awaited to evaluate the real effectiveness of this method.

References

Appendix A. Conference discussion

**Dr B. Koul (Lund, Sweden):** I didn’t really understand, when you’re talking about acute type B dissection, do you mean you electively go and stent graft these patients or only those who present with a contained rupture?

**Dr Grabenwoeger:** In our opinion, we stent all patients, the complicated and the uncomplicated, the so-called uncomplicated type B dissection. But there are a lot of papers in the literature with a lot of patients that develop a chronic type B dissection and several years later you have to operate on them because of a diameter of 6 or 7 cm. So in our group there are some patients with signs of contained rupture and with a hematohorax, patients with malperfusion of one kidney, but also patients which had a diagnosed acute type B dissection, they had pain, but now they are stable patients. But we also stent the stable patients, not only the complicated cases.

**Dr A. Haverich (Hannover, Germany):** I only have one question, and that is regarding retrograde type A dissection in those patients where you did deploy the descending stent. Because I’m aware now of all unpublished data of 5 patients in Germany that suffered acute type A dissection either immediately at the time of deployment of the descending stent or even like 2 or 4 weeks after that event. The mortality in that situation is 80%, as far as I know. Have you experienced that, and how do you think we could avoid that complication?

**Dr Grabenwoeger:** Fortunately, we’ve never experienced this. I have heard a lot from colleagues that they had this problem. Maybe it is also a problem from the stent graft used. If you use the Talent stent graft system, there are stents available with so-called bare springs. These are metal bare springs, they are not covered by a tissue, by a Dacron. And I don’t know if you are using this stent graft with this special patient, but in my opinion if you use, for example, a Talent stent graft system with bare springs, then you can, after stent deployment, you can induce with the bare springs in the aortic valve a second lesion and the retrograde type A dissection.

And also in type B dissection, we never expand with the balloon the stent. We only expand the stent, but we don’t use the balloon for further expansion of the stent graft, too, because we don’t want to put too much force on the dissected, on the fresh diseased aortic wall.

**Dr H. Ogino (Osaka, Japan):** I think the patients have some risk that might be very small of the spinal cord injury after stent graft. And in type B dissection the patient is quite stable. So in the type A dissection, the risk of the patient is a big aim. So how do you prevent the spinal cord injury?

**Dr Grabenwoeger:** Normally we put the stent graft only in the first third of the descending aorta, because just normally the primary entry tear is in the proximal area of the descending aorta. In the future, if you have a patient which has an uncomplicated type B dissection and he has his entry in the mid portion or distal portion of the descending artery, maybe I refuse to stent this patient because of obliteration of the important distal intercostals. Or you can also say, okay, we install prior to stenting a CSF drainage and afterwards. But I think if we have an uncomplicated type B dissection in the distal area, I would refuse.

**Dr T. Carrel (Bern, Switzerland):** Did you have strong evidence that you were able at least in one patient to reverse acute malperfusion of the visceral arteries with stenting?

**Dr Grabenwoeger:** A lot of patients, if you look perioperatively at the CT scans, you see at least a less perfused kidney. We saw 3 or 4 patients that one kidney was not perfused or less perfused. And after stent graft placement, you see really an increase in the perfusion of the kidney, which was not perfused or less perfused before. There was no patient in the series with a real visceral malperfusion or with a cold leg. But only from the point of the kidneys, I could say that we have good results.