Endovascular stent-graft treatment for diseases of the descending thoracic aorta

A.S. Bortone a,*, S. Schena a, G. Mannatrizio a, V. Paradiso a, G. Ferlan a, G. Dialetto b, M. Cotrufo b, L. de Luca Tuppiti Schinosa a

a Division of Cardiovascular Surgery, Department of Emergency and Transplantation, University of Bari, Bari, Italy
b Department of Cardiac Surgery, Second University of Naples, Naples, Italy

Objective: Assessment of endovascular stent-graft treatment for diseases of the descending thoracic aorta as a valid and effective alternative to surgery.

Methods: From March 1999 to August 2000, a total of 16 patients underwent deployment of endovascular stent-grafts in the descending thoracic aorta. Patients were divided into three groups according to the type of lesion. Group A (n = 8) included five patients with atherosclerotic aneurysm and three with chronic post-traumatic pseudoaneurysm. Patients with acute post-traumatic pseudoaneurysm (n = 3) and type B aortic dissection (n = 5) were included in Groups B and C, respectively. All patients underwent 5-mm chest spiral angio-computerized tomography (CT) scan and angiography as preoperative assessment. The deployed stent-graft systems were Talent™-Medtronic and Excluder™-Gore.

Results: A total of 20 stent-grafts were placed. Two patients required deployment of two grafts, while three grafts were juxtaposed in a third patient in order to treat larger lesions. There was no mortality related to the procedure, although one patient (6.2%) died because of multiorgan failure 24 h post-operatively. The placement of the graft was successful in all cases except one affected with type B dissection and characterized by a very large intimal flap, which was eventually fenestrated by graft guidewire. Therefore, an optimal sealing of the grafts was achieved in 15 patients. However, in one patient the descending aorta had to be surgically replaced because of the calcified pseudoaneurysm still compressing the trachea and left bronchus. Two patients required a left carotid-subclavian bypass in order to achieve a sufficient neck for the proximal placement of the graft. No spinal cord injuries were observed. At the follow-up, performed with chest spiral angio-CT scan within 72 h and scheduled at 6 and 12 months and once a year, no stent-graft related complications have been detected.

Conclusions: Endoluminal stent-graft treatment may represent a valid option in well-selected cases of descending thoracic aorta diseases. A longer follow-up in a larger series of patients is desirable to confirm these initial positive results. © 2001 Elsevier Science B.V. All rights reserved.

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1. Introduction

Aneurysms, traumatic ruptures and dissections of the descending thoracic aorta represent life-threatening conditions. Aortic resection and replacement with graft interposition is the preferred method of treatment in the first two situations [1]. Although great strides have been made during the past years in the management of patients with thoracic aortic aneurysm by new surgical techniques, post-operative mortality and morbidity rates still remain high [1–4]. In contrast, the preferred treatment for most patients with Stanford type B dissection is medical therapy. Nonetheless, the current mortality rate among patients who received medical therapy for type B dissection remains about 20% [1,5,6].

The technique of endoluminal aortic stent-graft placement has recently been introduced for repair of abdominal and thoracic aneurysms [2,4,7]. In the high-risk setting of aortic dissection, endoluminal repair is a new therapeutic strategy which is yielding encouraging results [5,6] while very few reports have appeared on stent-graft repair of post-traumatic pseudoaneurysms [8,9].

The aim of the present study is to report our experience in a series of patients presenting with one type of the following diseases of the descending thoracic aorta: (1) aneurysm, (2) acute or chronic post-traumatic pseudoaneurysm, and (3) dissection.
2. Materials and methods

From March 1999 to August 2000, a total of 16 patients received endovascular stent-graft placement at our institutions. Patient characteristics are presented in Table 1. For descriptive purposes the 16 patients were divided into three groups according to the type of aortic lesion. Group A consisted of a total of eight patients: five were diagnosed with atherosclerotic aneurysm of the descending thoracic aorta and three patients presented with chronic post-traumatic pseudoaneurysm. Group B was made up of three patients with acute post-traumatic pseudoaneurysm. Finally, Group C included five patients with type B aortic dissection.

In the first five patients with atherosclerotic aneurysm of Group A, the aortic lesion was localized in the proximal part of the descending thoracic aorta in three cases and, in the middle part in two cases. The maximal diameter of the aneurysm ranged from 60 to 80 mm. All patients had a history of smoking, hypertension and back pain. In detail, patient 1 presented with a sacciform aneurysm, coronary artery disease, chronic obstructive pulmonary disease and previous surgical replacement of an aneurysm of the abdominal aorta. Patient 2 had a ruptured aneurysm, left haemothorax and liver damage with intraparenchimal haematoma.

Four out of five patients included in Group C had a primary entry tear in the proximal third of the descending aorta with the intimal flap extending down to the abdominal aorta. The fifth patient underwent replacement of the descending thoracic aorta because of a type B dissection. However, he presented 3 months later with a new dissection of a pseudoaneurysm localized at the isthmic tract of the aorta. All patients underwent stent-grafting within a few hours from the traumatic event. In particular, patient 2 presented with signs of aortic rupture (Fig. 1), left haemothorax and liver damage with intraparenchimal haematoma.

Fig. 1. Preoperative aortic angiography: large acute post-traumatic pseudoaneurysm localized at the isthmic level of the descending thoracic aorta.
further down from the site of the distal anastomosis, acute renal failure, intermittent visceral and right limb ischaemia.

For preoperative assessment, all patients underwent chest X-ray, 5-mm contrast-enhanced spiral computerized tomography (CT) scan of the chest, abdomen and pelvis and arteriography.

2.1. Endovascular procedure

All procedures were carried out in the angiography suite under general anaesthesia. An operative room equipped with a cardiopulmonary by-pass machine was on standby in every case. The common femoral artery was surgically exposed and controlled proximally and distally. If the femoral artery appeared too small, the iliac artery was used for vascular access. Whenever those vascular accesses were considered inappropriate, the right subclavian artery was exposed in order to avoid thoracotomy. One hundred IU/kg of heparin were administered intravenously in order to get ACT values of 250–350 s. According to each case, a percutaneous left and/or right brachial artery approach was selected, allowing a catheter to be inserted over a guidewire in order to localize the subclavian artery and celiac axis and to be used for aortograms.

Two different stent-graft devices are available at our department: Talent™ (Medtronic, World Medical Manufacturing Corp, Sunrise, FL, USA) and Excluder® (Gore, Sunnyvale, CA, USA). Both devices have been described already [4,7].

With the Talent™ system, a guidewire is inserted and passed above the site of deployment through a transverse femoral arteriotomy. The endovascular stent is passed over the ultrastiff guidewire (Meyer Extra Back-up 0.035 inches × 300 cm) and positioned at the desired location. The placement catheter is held still, while the sheath is withdrawn to deploy the stent-graft. A mean arterial pressure of 70 mmHg is maintained during implantation in order to avoid the dislodgement of the graft. At this stage, the stent-graft expands and conforms to the size of the normal aorta. A polymeric balloon is occasionally inflated to maintain sufficient pressure against the aortic wall.

The Excluder® graft is introduced over the ultrastiff guidewire, with or without a dedicated sheath, through the vessel and, once the desired location is reached, it is opened by pulling a string attached to the graft. In this case, the device opens from the middle portion to the extremities. In most cases, the Excluder® remains open without any additional manoeuvre although, even with this device, an ad hoc polymeric balloon may be inflated to obtain the optimal sealing.

Finally, an arteriogram is made to verify a complete exclusion of the aneurysm or dissection and to verify the correct perfusion through the graft without perigraft leakage (Fig. 2). The placement system is then removed and the arteriotomy is closed in the usual manner.

In all patients, a transesophageal colour-Doppler echocardiogram was carried out as a guidance to the site of interluminal communication.

2.2. Follow-up

The follow-up protocol included a 5-mm spiral angio-CT scan of the chest and abdomen that was performed within 72 h from the procedure, in order to assess the position of the graft, the optimal sealing with complete exclusion of aneurysm and, in patients with dissection, the extent of thrombosis of the false lumen with perfusion of the branch vessels. Chest CT-scans were then obtained after 6 and 12 months from procedure and scheduled once a year, as planned in the follow-up, with the goal to monitor changes in the aorta and the graft.

Early mortality and morbidity included events occurring within 30 days after stent-graft deployment, either in hospital or after discharge. Information about patients was obtained both from retrospective chart review and by contacting patients or their treating physicians. The follow-up was 100% complete and its mean duration was 6.2 ± 4.2 months.

3. Results

Of the 16 patients being treated, the deployment of the stent-grafts at the intended position was successfully performed in 15 cases. There was one post-operative death resulting in an overall operative mortality of 6.2%.

In Group A, patient 4 received two stent-grafts. After deployment of the first graft there was still a certain degree of perigraft leakage. Therefore, a second stent-graft was positioned proximally to and within the first one in a ‘telescope’

![Fig. 2. Postoperative aortic angiography: Excluder® stent-graft in place. Total exclusion of the pseudoaneurysm from bloodstream is evident.](image-url)
fashion, during the same procedure. He also required a left carotid-subclavian by-pass upon completion of the procedure, due to the graft position, which covered the origin of the left subclavian artery. Unfortunately, the patient died 24 h later due to multiorgan failure. In patients 1 and 5 the stent-graft was introduced through the right subclavian artery because of a previously performed aorto-bifemoral by-pass and a sharply calcified kinking of the iliac arteries, respectively. In patient 3, despite the optimal deployment and perfect sealing of the graft, the original giant aneurysm was still compressing the left main bronchus and trachea. The respiratory mainstem was stented with little improvement; therefore, the patient underwent surgical replacement of the aneurysm with a Dacron tubular prosthesis. As in the case previously described for patient 4, patient 8 required deployment of three subsequent stent-grafts in the ‘telescope’ fashion because of persistent perigraft leakage.

In Group B, the post-traumatic pseudoaneurysm was repaired successfully in all cases. In Group C, patient 1 presented with extensive aortic redissection following a partial surgical replacement of the descending thoracic aorta and causing intermittent ischaemia of the abdominal viscera and the right leg. He underwent stenting of both renal arteries the day before receiving the stent-graft. His renal failure improved and the stent-graft was deployed with its proximal end anchored within the Dacron graft surgically interposed. At the end of the procedure, the intimal flap persisting in the right iliac artery was fenestrated. Thus, intermittent bowel and right leg ischaemia abated. Patient 2 required ‘telescope’ placement of a second stent-graft because, despite the positioning of the first graft, blood flow was still detected through the false lumen. He eventually underwent left carotid-subclavian by-pass. In patient 3 the graft could not be placed because the intimal flap was unintentionally fenestrated with the graft guidewire, so it became impossible to distinguish the true from the false lumen. Because this new haemodynamic balance resulted in satisfactory perfusion of abdominal viscera, the deployment of the stent-graft was not performed. The patient was treated medically with betablockers and discharged.

None of the patients died during the follow-up. No cases of perigraft leakage were detected and, in patients with aortic dissection, a shrinkage of the false lumen was observed as a result of its thrombosis. In addition, no cases of aneurysm or aortic rupture were detected, and no further interventions on the aorta were necessary in any of the cases. No changes in the position or configuration of the graft were observed.

4. Discussion

Our findings suggest that non-surgical repair may be an effective therapeutic option for patients with descending thoracic aortic diseases such as aneurysms, pseudoaneurysms or dissections.

Stent-grafting of descending thoracic aneurysms was the first endoluminal repair to be performed on the thoracic aorta; therefore, it has longer and more established long-term results [2–4,7,10]. Despite one particular case characterized by a giant chronic aneurysm, our experience is overall satisfactory since each patient with an aneurysm received endoluminal treatment avoiding replacement of the aorta, which has higher morbidity and mortality [1–4,7,10,11].

In the past, our management of descending thoracic aortic aneurysm was medical unless clinical and instrumental signs of rupture were evident and required immediate surgery. At present, indications for stent-graft treatment are: presence of an uncomplicated aneurysm and history of hypertension with chest discomfort or signs of compression on surrounding organs. However, if a patient is considered to be a candidate for stent-graft placement, several major factors have to be taken into account. The most important are location and morphology of the aneurysm; a distal vascular access of sufficient size; and, last but not least, a limited tortuosity of the abdominal and thoracic aorta. During preoperative assessment, the determination of the proximal and distal ‘landing’ zones of the stent-graft is essential, as they serve as a friction anchor at each end. The grafts are generally oversized in diameter by 3–4 mm to allow sufficient radial force for fixation. In the case of a short proximal neck close to the left subclavian artery, we favour the coverage of the artery itself and the performance of left carotid-subclavian by-pass in order to treat larger lesions also involving part of the aortic arch.

With the Talent™ system, subclavian grafting can sometimes be avoided because the proximal end of the graft has polyurethane uncovered nitinol spring bars that can be safely placed across the origin of the left subclavian artery.

In case of persistent perigraft leakage, a second endoluminal stent-graft can be inserted within the first graft in a ‘telescope’ fashion with the aim of ‘patching’ the leaking site during the same procedure. This is a feasible and handy solution when some persistent leakage is observed and has already been described [11]. The only post-operative death of our series occurred in this group despite optimal stent-graft deployment because of extremely poor preoperative overall conditions.

After performing an in-depth literature review, our series would appear to be the first one to report results of endoluminal stent repair of acute and chronic post-traumatic pseudoaneurysms [1–10]. The outcome in this group of patients was satisfactory; therefore, this technique can be considered a valid option, especially when standard surgical procedure cannot be carried out for other reasons as in patient 2 of group B. In that case, the replacement of the ruptured tract of the aorta was not feasible because the patient had rupture of the liver with intraparenchimal hematoma and, thus, was not suitable for total heparinization.

We tend to prefer the Excluder™ system when repairing a pseudoaneurysm, especially in an acute situation, because its spring system exerts a lighter pressure on the aortic wall.
thus reducing the risk of perforation. In patient 6 of group A, the aortic pseudoaneurysm had to be surgically removed despite good sealing of the stent-graft. The main reason was suboptimal candidate selection because although the graft had sealed off the false aneurysm from the blood stream, its walls were heavily calcified, resulting in further compression of the left main bronchus and trachea, not solved even after their own stenting.

As in the previous two groups, also in patients with type B aortic dissection endoluminal stent-grafting has yielded encouraging results. In the past, our management of patients with type B aortic dissection was medical unless clinical and instrumental signs of aortic rupture were found. This policy was dictated by the very high mortality and morbidity observed in our patients after this kind of surgery. As a matter of fact, in the last 5 years seven patients have undergone surgery for type B aortic dissection in our institution, with 43% (three out of seven) mortality and 28.5% (two out of seven) spinal cord injury rates.

Deployment of an endoluminal stent-graft in a dissected descending thoracic aorta is much more challenging and potentially hazardous than repairing an aneurysm or a pseudoaneurysm. Most of the problems derive from the anatomical variability with which the dissection flap can propagate distally. As a result, the true and false lumens may appear in any of numerous complex configurations and the branch vessel origins may be distributed in unpredictable patterns, occasionally in association with life-threatening ischaemia of the viscera and extremities. One of the main problems a physician may encounter when stenting a type B dissection is perforation of the flap, as occurred in patient 3 of Group C. The passage of the stiff guidewire created a large fenestration of the intimal flap, so that the true lumen could not be distinguished from the false one. As a result, the procedure had to be abandoned and the patient was kept on a hypertensive drug regimen.

It is imperative to locate the primary entry tear as aortic rupture is by far the most frequent cause of death in patients with type B aortic dissection [5,6]. Our experience, as well as those of others [5,6], suggests that stent-graft placement over the primary entry tear in patients with type B dissections may be an effective alternative to open surgery. The result is similar to surgical obliteration of the entry tear because it can exclude the blood flow through the initial tear in the intima and redirect it exclusively into the true lumen.

With stent-graft implantation, aortic stability is induced both by thrombosis of the false lumen and by the endoprosthesis itself; a relatively short stent-graft can cover the proximal entry and induce false lumen thrombosis over the entire length of the dissected aorta within 3 months [5,6]. Even if only partial thrombosis of the false lumen is achieved, an endovascular stenting procedure can still be advantageous: it may protect the false lumen from enlarging over time, since systemic blood pressure is no longer directly transmitted from the aorta through a large primary tear in the intima [5,6].

With regard to visceral and peripheral vascular ischaemia there is a complication rate of about 30–50% in type B aortic dissection. Stent-graft placement across the primary entry tear is an effective treatment for this complication. As in a patient of our series, adjunctive deployment of a stent within the true lumen of a dissected aortic branch or intimal flap fenestration may still be necessary to effectively treat the obstruction caused by direct extension of the flap into the branch.

It has to be noted that no cases of paraplegia were encountered in our series. In the case of aneurysms many intercostal branches are already occluded and the spinal cord is perfused by collaterals. Furthermore, the sudden deployment of the stent followed by the occlusion of the intercostal branches does not produce a steal syndrome in the perfusion of the spinal cord [7]. In patients with type B dissection, the use of short stent-grafts and deployment far from vertebrae T8 to L2 further minimizes the risk of paraplegia, as compared with the risk of surgical aortic replacement and graft interposition [5,6]. Most important, endoluminal stenting is a much shorter procedure than surgery. Therefore, stenting circumvented the need for circulatory arrest and cross-clamping of the aorta, and the associated ischaemia and reperfusion injury. Moreover, it averted post-operative respiratory failure and prolonged hypotension and the delayed risk of paraplegia. Even successful reimplantation of the intercostal arteries and cross-clamping for less than 30 min have not totally eliminated the risk of paraplegia after surgery [1,6].

In our series we observed a failure rate of 18.5% (three out of 16). In detail, we had one death for multiorgan failure due to poor preoperative conditions, one conversion to surgery because of suboptimal candidate selection and one abandonment following the involuntary large fenestration of the intimal flap caused by the stiff guidewire. In two cases a left carotid-subclavian by-pass represented an ideal concordant procedure allowing a more proximal treatment of larger aortic lesions.

With regard to follow-up, no deaths or complications were observed in our patients and all have resumed their daily life activities. It is likely that future indications to endovascular stent-grafting may be broadened when more flexible prostheses with arms for aortic branches stenting will be available for clinical use.

In conclusion, endoluminal stent-graft is a satisfactory alternative technique for the treatment of most lesions of the descending thoracic aorta. Nonetheless, prospective randomized trials with larger series of patients and longer follow-up are highly desirable to confirm these initial positive findings in order to establish indications to this kind of treatment and assess its real advantages over conventional surgical treatment.

References

Appendix A. Conference discussion

Dr L. von Segesser (Lausanne, Switzerland): We have a similar experience, but part of our experience is that some of the problems we had in the chest before we have now in the groin. You didn’t tell us anything about access problems, endarterectomies, infections.  

Dr Vitale: No, as shown in my presentation, we did not encounter any of these problems in our experience.  

Dr J. Bachet (Paris, France): Your conclusion was rather positive, and you indicated a 100% survival, but I saw on your slides that there was one death.  

Dr Vitale: No. One patient died, as I said. As shown in my presentation our operative mortality was 6.2%. The patient died of renal failure.  

Dr Bachet: You have two failures; one death and one conversion to open surgery.

Dr Vitale: Yes.  

Dr Bachet: Out of 16 patients, it’s between 10% and 15% treatment failure.  

Dr Vitale: Yes.  

Dr Bachet: Could you really say that this is a real improvement in comparison to open surgery?  

Dr Vitale: We consider it an improvement compared to open surgery. With regard to the case of conversion to open surgery, it was due to poor candidate selection. It occurred at the beginning of our experience and at the time we did not take into consideration that the aneurysm was heavily calcified; therefore, it was still compressing the airways despite successful aortic graft stenting. Only surgical removal of the aneurysm terminated the compression. Our experience is still at an early stage and we are learning from our mistakes.  

Dr Bachet: Keeping on this matter, what are your guidelines to select patients who should undergo this and patients who should undergo traditional surgery?  

Dr Vitale: With regard to dissection, the first line of treatment is medical. We then assess if graft stenting is feasible in terms of vascular access and anatomy of the lesion. If so, we go ahead with stenting. In the presence of an atherosclerotic aneurysm we place indication to surgery if technically feasible, especially if the patient experienced chest pain.

In case of acute false aneurysms endovascular stenting is a valid option because most patients have other traumatic lesions that do not allow total reparation. For example, if you consider one case in the series: a young patient with acute aortic false aneurysm, liver hematoma and brain haematoma. Endovascular grafting did solve the problem.  

Dr M. Turina (Zurich, Switzerland): How do you intend to prevent paraplegia if you have to cross the lower thoracic segment?  

Dr Vitale: That’s a very good question. At the moment we don’t have an answer.  

Dr Turina: Because we have one patient who developed paraplegia after placement of the graft, and strangely enough, this patient is walking now 3 months after the graft placement.  

Dr Vitale: Was it for an aneurysm?  

Dr Turina: It was for an aneurysm in the lower descending aorta, and paraplegia rarely happens in surgical repair.  

Dr Vitale: I must say in our series we didn’t see any paraplegia, and I’ve read other papers reporting no paraplegia at all also in larger series.  

Dr Turina: How many of them crossed the critical segment of the thoracic 10 to 12 in your experience?  

Dr Vitale: I would say 2 probably.  

Dr M. Sarsam (Belfast, Northern Ireland, UK): Could you please tell us about the subclavian artery occlusion? I think you had three cases.  

Dr Vitale: Two cases. Sorry. There is a mistake in the abstract. We had two cases.  

Dr Sarsam: How soon after placement of the stent did you do the bypass?  

Dr Vitale: Immediately after placing the graft.  

Dr Sarsam: Under general anaesthetic?  

Dr Vitale: Yes.