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Endovascular treatment of type B aortic dissections

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The purpose is to describe our experience with endovascular treatment of type B aortic dissections. Five patients were treated for complications following type B dissections like, false channel aneurysm formation, rupture and arterial obstruction. They were treated in general anaesthesia using a 'homemade' endoprosthesis or a commercially available endoprosthesis (Excluder®) deployed during fluoroscopy.

The patients have been followed at regular intervals with a median observation time of 18 months (range 12–36). One patient needed a secondary intervention due to dislodgement of the proximal stentgraft with haemorrhage into both the false and the true lumen. Otherwise there have been no early or late mortality or major complications in this series.

Even if our experience with endovascular treatment of type B dissections is rather limited, the results so far are promising. Open surgery in many of these cases is complicated with high morbidity and mortality rate and the endovascular technique offers great advantages. A longer follow-up period is necessary to define the place of endovascular treatment.

Keywords: dissection, complications, endovascular repair

Introduction

Although dissections can occur in any part of the arterial system, the condition is most commonly observed in the thoracic aorta [1–5]. Patients with type A aortic dissections should be operated on while those with type B dissections are primarily treated conservatively [5–8]. In type B dissections open surgery is usually performed if complications occur [9]. Such complications are false channel aneurysms that may lead to rupture, or progression of the dissection with occlusion of arteries to organs or tissues like the bowel, kidneys or the lower extremities. Formation of false channel aneurysms may be observed in 30–40% of these patients during the follow-up period [10]. Aneurysm formation as a complication of aortic dissection has at least the same tendency to rupture as regular atherosclerotic aneurysms. They should therefore be treated along similar guidelines, or perhaps even more aggressively. Open surgery for complications of aortic dissection is associated with a high morbidity and mortality [11–17]. Recently endovascular treatment has been used for thoracic aneurysms [18–20], and for type B dissections of the thoracic aorta as well as dissections in other parts of the arterial system with promising intermediate-term results [21,22]. The purpose is to review our experience with endovascular treatment of complications of type B dissections.

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Material

The material includes altogether five patients treated for complications following type B dissection during the period February 1998–May 2000 (*Table 1*). One was treated for rupture, one for impending rupture, two for false channel aneurysm formation, and finally one for occlusion of the right common iliac artery. The false channel aneurysms had diameters of 72 and 79 mm respectively. The median age of the total series was 64 yr (range 50–71) and all patients were male.

Methods

Thoracic aorta

Endovascular treatment has been performed in general anaesthesia under fluoroscopic guidance in a fully equipped operating theatre except for one patient who was treated in the radiologic department for iliac artery obstruction. The patients were prepared as for open surgery in case conversion should become necessary. In four cases we applied a 'homemade' endoprosthesis, consisting of woven uncrimped thin-walled polyester (Cooley Verisoft® Meadox Medicals Inc. Oakland NJ, USA) where Gianturco Z-stents® (Cook Inc. Bloomington IN, USA) had been sutured on the inside. These grafts were tailored after careful preoperative measurement of the descending thoracic aorta including both the false and the true lumen. In one patient, an Excluder® endograft (WL Gore and Associates, Flagstaff, AZ, USA) was applied in addition to homemade stentgrafts. In general we prefer 4–5 mm oversizing of the transverse diameter. This means that we used an endograft which was 4–5 mm wider than the aorta at the landing points. Stentgrafts of 15 cm length were applied, and for longer defects a second or third graft could be applied with 3–4 cm of overlapping. Transoesophageal echocardiography (TEE) was used during the procedure to investigate whether the diseased part of the aorta had been excluded from the circulation as well as monitoring the heart (*Figures 1 and 2*).

Through a transverse arteriotomy of the femoral artery a 20–24 F Cook® introducer was advanced into the thoracic aorta over a superstiff guidewire (AMPLATZ®, Boston Scientific/Medi-Tech, Watertown, MA, USA). A catheter was introduced from the left brachial artery to define the position of the orifice of the left subclavian artery and make deployment of the endograft easier. The inner dilator was removed from the introducer, the endograft placed within the introducer and advanced to a proper position. During deployment of the prosthesis the systolic blood pressure was decreased to about 80 mmHg for a couple of min. While the pusher is kept in place and the introducer retracted, the endograft expanded. Both TEE and post-deployment angiography were used to control the position of the endoprosthesis.

In the following, two patients with complications following type B dissections are described. A 50-yr

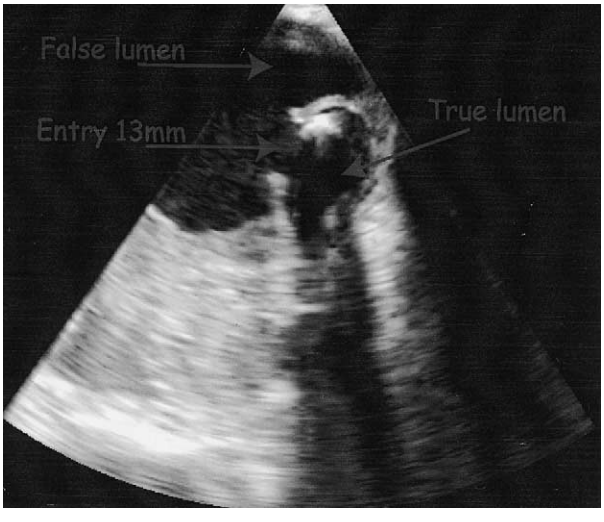

Figure 1 Transoesophageal echocardiography (TEE) showing the entry between the true and false lumen of the thoracic aorta in a patient with type B-dissection

Table 1 Patients treated for type B dissection during the period 1998–2000

Patient no	Sex	Age	Disease	Treatment	Follow-up (months)	Complications
1	M	71	B-dissection, acute	Stents	14	None
2	M	71	B-dissection, impending rupture	Stentgraft	36	None
3	M	70	B-dissection, rupture	Stentgraft	24	None
4	M	50	B-dissection, aneurysm (79 mm)	Stentgrafts	18	Proximal dislocation of endograft. Repair
5	M	60	B-dissection, aneurysm (72 mm)	Stentgrafts	12	None

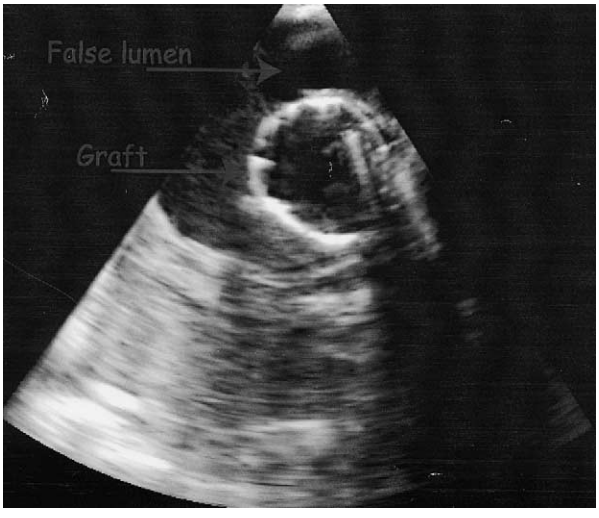

Figure 2 Transoesophageal echocardiography (TEE) following endovascular treatment with endografts, showing closure of the entry

old male patient was admitted for false channel aneurysm of the descending thoracic aorta following a type B dissection (*Figure 3*). The aneurysm was 79 mm in diameter. During the first procedure three stentgrafts were placed from the orifice of the subclavian artery, excluding the first and middle part of the descending thoracic aorta from the circulation. On table aortography revealed that there was an entry distal to the reconstruction and an additional stentgraft was therefore inserted excluding the aorta to the coeliac trunk (*Figure 4*). During follow-up investigations it became evident that there were more entries in the infrarenal abdominal aorta, and they were treated by a modular bifurcated endoprosthesis (Vanguard® Boston Scientific Corp. Nattick Ma USA). An extension of the right limb of this pros-

Figure 3 CT-reconstruction showing type B dissection in a 50-yr old male patient with a 79 mm aneurysm filling most of the left part of the mediastinum. The dissection started immediately distal to the left subclavian artery and also included the infrarenal abdominal aorta

Figure 4 The dissection shown in *Figure 1* was treated by homemade stentgrafts. CT-reconstruction 18 months following the procedure is showing the thrombosed false channel of the thoracic aorta

thesis to the external iliac artery became necessary, and the right internal iliac artery therefore had to be coiled. At follow-up the entries and most of the false channel aneurysm had been excluded from the circulation except one entry close to the right renal artery. One and a half year later the proximal part of the endograft dislodged permitting blood flow both into the false and true lumen of the previously excluded false channel aneurysm. The patient also had blood in the left pleura. Three Excluder® stentgrafts were placed from the former endoprosthesis in the proximal direction sealing the leak and covering the left subclavian artery. In this emergency situation, the aorta was covered all the way from the left common carotid artery. The postoperative course was uneventful and the patient was discharged without having any complications.

A 70-yr old male patient was admitted with rupture of an acute type B-dissection. He had chest pain, and CT-scans revealed haemorrhage outside the descending thoracic aorta, the left carotid and subclavian arteries (*Figure 5*). An intimal tear was shown by TEE about 2 cm distal to the left subclavian artery. A 'homemade' stentgraft was used to exclude the proximal part of the descending thoracic aorta (*Figure 6*). At one year follow-up, the hematoma had resorbed and the graft was in excellent position.

All patients have been followed with regular intervals at the outpatient clinic (*Table 1*). CT-scans have been performed routinely while arteriography has been carried out on a selective basis.

Results

In all cases successful deployment of the stentgrafts was obtained. There have been no mortality or conversions to open surgery. One patient required a sec-

Figure 5 CT-reconstruction showing rupture of a type-B dissection with hematoma along the aorta and the brachiocephalic vessels

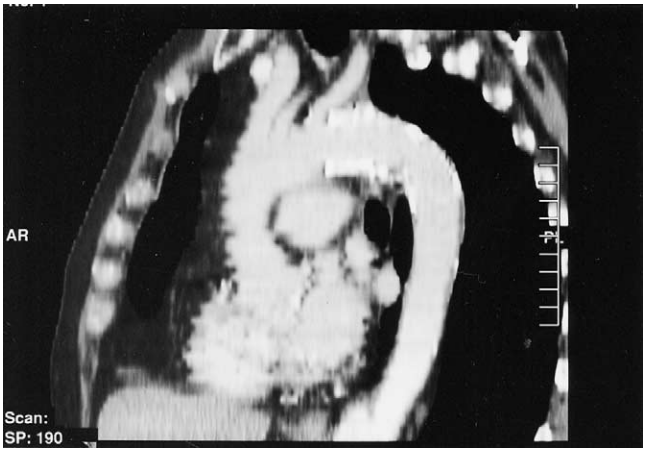

Figure 6 CT-reconstruction of the same patient as shown in *Figure 5*. The endoprosthesis is shown in the proximal part of the descending thoracic aorta sealing the entry and the rupture site

ondary intervention after one and a half years due to dislodgement of the proximal part of the stentgraft. The condition was successfully treated with endovascular technique (*Table 1*). Further, we have not observed any complications like embolism or paraparesis/paraplegia. However, in one of the patient with false channel aneurysm there is a minor pocket of contrast medium in the false channel at the level of the viceral arteries.

Discussion

Although our experience is limited and with a relatively short follow-up period, we feel that this initial experience with endovascular treatment of arterial dissection is promising. Open operation for complications following acute dissection is usually a major procedure with a significant morbidity and mortality [2,10,12–16]. A concern howeever, is whether endovascular treatment could lead to further dilation of the aorta at the landing zones of the prosthesis.

An advantage with endovascular treatment for dissection compared with atherosclerotic aneurysms is that there is usually no aneurysmal sack which volume and form could change in the postoperative course leading to disfigurement of the prosthesis. The false lumen may shrink if the entry of the dissection and the proximal part of the diseased aorta is excluded by an endoprosthesis [23]. Further, the high blood flow in the thoracic aorta will prevent occlusion of the prosthesis. Finally, there are few side-branches with a relatively small risk of endoleak or retrograde filling of the space between the endograft and the aortic wall. An interesting question is whether endovascular treatment should be preferred as the primary treatment for type B dissection. Initial conservative treatment is used in most centres, but additional primary closure of the entry may be a promising alternative. Juvonen [24] reports a high mortality in patients even with small false channel aneurysms following type B dissections and advocates for a more aggressive approach towards treatment of patients with chronic B-dissections. A prospective randomised study comparing endovascular closure of the entry with medical treatment would be interesting to explore whether it is possible to reduce the incidence of complications in the long run.

A thorough preoperative diagnostic work-up is essential in cases of dissection. Both the entry and the re-entries should be defined and the diameter of the true lumen at various levels must be estimated. It is impossible to dilate the true lumen of the aorta and therefore conical grafts may have to be introduced. There are indications that even if visceral arteries are supplied from the false lumen, stent-grafting of the descending thoracic aorta can be performed, provided there is a reentry distal to the end of the stentgrafts. It is assumed that soon after the procedure a remodelling of the false lumen may take place and there will be shrinking of the aneurysm around the stentgraft. Even if there is some retrograde flow into the false lumen in the early postoperative period, this may decrease or even disappear later.

Aortic dissection may be complicated by peripheral and visceral ischaemia. This can be due to stenosis or occlusion of branches from the aorta, or obstruction of the true aortic lumen by the false lumen. Some of these complications can also be induced by closure of the proximal entry using a stentgraft. The endovascular treatment for these complications should be fenestration of the intimal flap and/or stenting of aortic true lumen or the side branches from the aorta. These techniques must be known to endovascular centres treating aortic dissections with stentgrafts [21,25–32]. Whenever the orifice of the left subclavian artery is covered by the endoprosthesis, it is recommended that this artery

is revascularised for instance by a carotid subclavian bypass. In extensive aortic dissections with complications an open thoracoabdominal repair is a major undertaking with a high morbidity and mortality. An alternative option in such cases is to close the entry and reentries of the dissection by an endoprosthesis, supplemented with extra-anatomic bypass to the visceral arteries. In the future it is likely that endoprosthesis with side branches fitting to the subclavian, renal or even the intestinal arteries will be available [33]. At present there is no substitute for open operation in patients with type A dissections with the primary tear in the ascending aorta. However, it seems logical to supplement an open operation with the implantation of a distal stent graft whenever the dissection is continuing into the descending thoracic aorta.

The local anatomy of the aortic arch differs from one patient to another. In many elderly patients there is a more pronounced curvature of the aorta distal to the left subclavian artery. In those cases it may be difficult to deploy the graft in a proper position. One possibility is to alternate the advancement of the dilator and introducer until the orifice of the subclavian artery is reached. Thereafter the dilator is removed and the endoprosthesis is deployed. So far we have felt it advantageous to make 'homemade' prosthesis according to individual anatomical conditions. Flexible stentgrafts are advantageous in case of pronounced angulation of the aorta. In the future it is unlikely that 'homemade' prosthesis will be our preference since flexible endografts have become available. (Excluder® WL Gore and Associates, Flagstaff, AZ, USA). For the application of these prosthesis, the introducer needs to be advanced only a short distance into the aorta, while the endoprostheses is further introduced on a stiff guidewire and then rapidly expanded. Thus, it may be easier to place these prosthesis in the proximal part of the descending thoracic aorta, especially when its curvature is pronounced.

References

1. DeBakey, M.E., McCollum, C.H., Crawford, S. *et al.*, Dissection and dissecting aneurysms of the aorta: Twenty-year follow-up of five hundred twenty-seven patients treated surgically. *Surgery*, 1982, **92**, 1118–1134.
2. Svensson, L.G. and Crawford, E.S., Aortic dissection and aortic aneurysm surgery: clinical observations, experimental investigations, and statistical analyses part II. *Current Problems in Surgery Mosby* 1992, 913–1057.
3. Weiss, V.J. and Smith, R.B., Peripheral vascular manifestations of aortic dissection: recognition and management. *Perspectives in Vascular Surgery*, 1999, **10**, 27–45.
4. Ferko, A., Kranjina, A., Jon, B. *et al.*, Dissection of the infrarenal aorta treated by stent graft placement. *Cardiology*, 1998, **8**, 298–300.
5. Masuda, Y., Yamada, Z., Morooka, N. *et al.*, Prognosis of patients with medically treated aortic dissections. *Circulation*, 1991, **84**(Suppl. III), III7–III13.
6. Glower, D.D. *et al.*, Comparison of Medical and surgical therapy for uncomplicated descending aortic dissection. *Circulation*, 1990, **82**, IV39–IV46.
7. Wheat, M.W., Current status of medical therapy of acute dissecting aneurysms of the aorta. *World Journal of Surgery*, 1980, **4**, 563–569.
8. Miller, D.C., The continuing dilemma concerning medical versus surgical management of patients with acute type B dissections. *Seminars in Thoracic and Cardiovascular Surgery*, 1993, **5**(1), 33–46.
9. Schor, J.S., Yerlioglu, M.E., Galla, J.D. *et al.*, Selective management of acute type B aortic dissection: long-term follow-up. *Annals of Thoracic Surgery*, 1996, **61**, 1339–1341.
10. Neya, K., Omoto, R., Kyo, S. *et al.*, Outcome of Stanford type B acute aortic dissection. *Circulation*, 1992, **86**(Suppl. II), II1–II7.
11. Svensson, L.G., Crawford, S., Hess, K.R. *et al.*, Experience with 1509 patients undergoing thoracoabdominal aortic operations. *Journal of Vascular Surgery*, 1993, **17**, 357–370.
12. Svensson, L.G., Crawford, S., Hess, K.R. *et al.*, Dissection of the aorta and dissecting aortic aneurysms. Improving early and long-term surgical results. *Circulation*, 1990, **82**(Suppl. IV), IV24–IV38.
13. Fann, J.I., Smith, J.A., Miller, C. *et al.*, Surgical management of aortic dissection during a 30-year period. *Circulation*, 1995, **82**(Suppl. II), II113–II121.
14. Da Gama, A.D., The surgical management of aortic dissection: form uniformity to diversity, a continuous challenge. *Journal of Cardiovascular Surgery*, 1991, **32**, 141–153.
15. Svensson, L.G., Crawford, E.S., Hess, K.R. *et al.*, Variables predictive of outcome in 832 patients undergoing repairs of the descending thoracic aorta. *Chest*, 1993, **104**(4), 1248–1253.
16. Borst, H.G., Jurmann, M., Bühner, B. *et al.*, Risk of replacement of descending aorta with a standardized left heart bypass technique. *Journal of Thoracic and Cardiovascular Surgery*, 1994, **107**, 126–133.
17. Coselli, J.S., LeMaire, S.A., de Figueiredo, L.P. *et al.*, Paraplegia after thoracoabdominal aortic aneurysm repair: Is dissection a risk factor? *Annals of Thoracic Surgery*, 1997, **63**, 28–36.
18. Mitchell, R.S., Dake, M.D., Semba, C.P. *et al.*, Endovascular stent-graft repair of thoracic aortic aneurysms. *Journal of Thoracic and Cardiovascular Surgery*, 1996, **111**, 1054–1062.
19. Dake, M.D., Noriyuki, K., Mitchell, R.S. *et al.*, Endovascular stent-graft placement for the treatment of acute aortic dissection. *New England Journal of Medicine*, 1999, **340**, 1542–1546.
20. Ehrlich, M., Grabenwoeger, M., Cartes-Zumeluzu, F. *et al.*, Endovascular stent graft repair for aneurysms on the descending thoracic aorta. *Annals of Thoracic Surgery*, 1998, **66**, 19–25.
21. Walker, P.J., Dake, M.D., Mitchell, S. *et al.*, The use of endovascular techniques for the treatment of complications of aortic dissection. *Journal of Vascular Surgery*, 1993, **18**, 1042–1051.
22. Nienaber, C.A., Fattori, R., Lund, G. *et al.*, Nonsurgical reconstruction of thoracic aortic dissection by stent-graft placement. *New England Journal of Medicine*, 1999, **340**, 1539–1545.
23. Kato, M., Tatsuda, T., Kaneko, M. *et al.*, Outcomes of stent-graft treatment of false lumen in aortic dissection. *Circulation*, 1998, **98**, II305–II312.
24. Juvonen, T., Ergin, M.A., Galla, J.D. *et al.*, Risk factors for rupture of chronic type B dissections. *Journal of Thoracic and Cardiovascular Surgery*, 1999, **117**, 776–786.
25. Slonim, S.M., Miller, D.C., Mitchell, R.S. *et al.*, Percutaneous balloon fenestration and stenting for life-threatening ischemic complications in patients with acute aortic dissection. *Journal of Thoracic and Cardiovascular Surgery*, 1999, **117**, 1118–1127.
26. Faykus, M.H., Hiette, P. and Koopot, R., Percutaneous fenestration of a type I aortic dissection for relief of lower extremity ischemia. *Cardiovascular and Intervention Radiology*, 1992, **15**, 183–185.
27. Williams, D.M., Brothers, T.E. and Messine, L.M., Relief of a mesenteric ischemia in type III aortic dissection with percu-

taneous fenestration of the aortic septum. *Radiology*, 1990, **174**, 450–452.
28. Chavan, A., Hausmann, D., Dresler, C. *et al*., Intravascular ultrasound-guided percutaneous fenestration of the intimal flap in the dissected aorta. *Circulation*, 1997, **96**, 2124–2127.
29. Marty-Ané, C. -H., Alric, P., Prudhomme, M. *et al*., Intravascular stenting of traumatic abdominal aortic dissection. *Journal of Vascular Surgery*, 1996, **23**, 156–161.
30. Saito, S., Arai, H., Kim, A. *et al*., Percutaneous fenestration of dissecting intima with a transseptal needle: a new therapeutic technique for visceral ischemia complicationg acute aortic dissection. *Catheter Cardiovascular Diagnosis*, 1992, **26**, 130–135.
31. Lacombe, P., Mulot, R., Labedan, F. *et al*., Percutaneous recanalization of a renal artery in aortic dissection. *Radiology*, 1992, **185**, 829–831.
32. Williams, D.M., Lee, D.Y., Hamilton, B.H. *et al*., The dissected aorta: percutaneous treatment of ischemic complications — principles and results. *JVIR*, 1997, **8**, 605–625.
33. Inoue, K., Sato, M., Iwase, T. *et al*., Clinical endovascular placement of branched graft for type B aortic dissection. *Journal of Thoracic and Cardiovascular Surgery*, 1996, **112**, 1111–1113.

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