Atherosclerotic Descending Thoracic Aneurysms and Dissections – Endovascular Options

a report by

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Introduction

Conventional repair of thoracic aortic aneurysms involve extensive surgical trauma and consequent complications. Centres with experience continue to report good results with conventional surgery on selected patients. However, the best results are not reproduced widely and open surgery is associated with a high risk of mortality and morbidity. It is therefore compelling to adapt the endovascular approach to this segment of the aorta as well as for the benefits of reducing the magnitude of surgical invasion.[1] Results of stent-graft treatment of thoracic type-B dissections appear to be superior to those of conventional surgery and in most centres endovascular therapy has become the modality of choice.

Feasibility

Several reports, including a registry series (the combined analysis of EUROSTAR Thoracic Registry and United Kingdom Thoracic Endograft Registry) allude to early results of endovascular repair of thoracic aneurysms – they appear comparable with, or better than, open surgery.[1–7] However, it is difficult to evaluate these reports in comparison with conventional surgery for a combination of reasons. Most series of endovascular repair consisted of a sizeable proportion of patients considered to be of high risk or unfit for conventional surgery. Most series also included elective and emergent procedures and a variety of pathologies such as dissection, trauma and penetrating ulcer made it difficult to assess the outcome in different groups of patients. Follow-up had been of limited duration. Experience from infrarenal aortic aneurysms suggest that late follow-up is crucial. For all these reasons it is not currently possible to objectively compare all aspects of the endovascular repair of thoracic aneurysms with those of conventional surgery. The feasibility of the procedure is beyond question and overall, early results are encouraging.

Benefits and Limitations of the Endovascular Approach

Endovascular repair avoids thoracotomy, aortic cross-clamping and left-sided heart bypass that are employed during an open operation with consequent reduction in operative risk. Advantages with endovascular repair in terms of post-operative morbidity, requirement of intensive care beds, speed of recovery and rehabilitation have been demonstrated. It has been suggested that endovascular repair is associated with a lower incidence of spinal cord ischaemia and consequent paraplegia. Endovascular repair is generally associated with increased cardiovascular (CV) stability during the operation compared with an open repair, resulting in a consistent and better perfusion pressure to the spinal cord – a possible mechanism of this benefit.[8]

1. *Leurs L J, Bell R, Degrieck Y, Thomas S, Hobo R, Lundbom J, "Endovascular treatment of thoracic aortic diseases: combined experience from the EUROSTAR and United Kingdom Thoracic Endograft registries",* J. Vasc. Surg. *(2004);40(4): pp. 670–679; discussion.*
2. *Cambria R P, Brewster D C, Lauterbach S R et al., "Evolving experience with thoracic aortic stent graft repair",* J. Vasc. Surg. *(2002);35(6): pp. 1,129–1,136.*
3. *Ellozy S H, Carroccio A, Minor M et al., "Challenges of endovascular tube graft repair of thoracic aortic aneurysm: midterm follow-up and lessons learned",* J. Vasc. Surg. *(2003);38(4): pp. 676–683.*
4. *Gowda R M, Misra D, Tranbaugh R F, Ohki T, Khan I A, "Endovascular stent grafting of descending thoracic aortic aneurysms",* Chest *(2003);124(2): pp. 714–719.*
5. *Greenberg R, Resch T, Nyman U et al., "Endovascular repair of descending thoracic aortic aneurysms: an early experience with intermediate-term follow-up",* J. Vasc. Surg. *(2000);31(1 pt 1): pp. 147–156.*
6. *Lambrechts D, Casselman F, Schroeyers P, De Geest R, D'Haenens P, Degrieck I, "Endovascular treatment of the descending thoracic aorta",* Eur. J. Vasc. Endovasc. Surg. *(2003);26(4): pp. 437–444.*
7. *Orend K H, Scharrer-Pamler R, Kapfer X, Kotsis T, Gorich J, Sunder-Plassmann L, "Endovascular treatment in diseases of the descending thoracic aorta: 6-year results of a single center",* J. Vasc. Surg. *(2003);37(1): pp. 91–99.*

Most endovascular aneurysm repair experience is based upon the treatment of infrarenal aortic aneurysms. Thoracic aorta and its aneurysms are of a larger size in comparison with abdominal aortic aneurysms with a greater degree of pathological change and anatomical distortion. This process has a propensity to continue even after apparent exclusion of the aneurysm from circulation. The ability of a stent-graft to maintain its function over a prolonged period of time depends upon its ability to maintain seal and fixation while remaining structurally intact. The thoracic aorta is unique in several ways that render these issues more complex, compared with an infrarenal aortic aneurysm.

Deployment Issues

Thoracic stent-grafts generally require a larger profile construction and also have to traverse longer and more tortuous anatomy for deployment. Access-related problems are therefore more common. Kink resistance and flexibility of the delivery systems therefore play a vital role in facilitating insertion. Newer generation devices appear to fare better in both of these respects. The use of stiff guidewires within the arch of the aorta and the extensive aneurismal disease create a risk of embolisation to cerebral and systemic circulation. Attention to systemic heparinisation and careful use of catheters and guidewires is therefore necessary to minimise such risk.

For a successful endovascular repair, landing zones of a minimum height of 2cm are required proximally and distally to provide a satisfactory seal. While such landing zones are available with localised aneurysms, extensive disease of the descending thoracic aorta is often seen when such areas are not available. An elongated descending aorta may present a horizontal segment above the diaphragm, which has the propensity to undergo continued dilation and poor long-term fixation. Unless the supra-diaphragmatic aorta is evidently healthy, the stent-graft ought to extend below the diaphragm to the vertical aortic segment right above the celiac trunk. Tortuosity and larger diameter of the aorta in this region make it difficult to accurately estimate the length of stent-graft, even with calibrated angiography.

Accurate deployment is hampered by several factors including difficulties in visualising all the branches of the aortic arch with one fluoroscopic projection, constant movement of the aortic arch throughout the cardiac cycle and respiratory movements. The blood flow tends to push the stent-graft downstream once deployment is commenced. Haemodynamic force in this location is considerable and deliberate hypotension during deployment has therefore been recommended, in order to facilitate accurate deployment.[9]

The routine use of two-component stent-grafts allows the physician to pay exclusive attention to one landing site at a time for accurate deployment both proximally and distally. This also renders accurate pre-operative estimation of the length of the stent-graft less crucial. The distal component is deployed first, which supports a second and proximal extension to complete the repair. Stent-graft components should be planned with a generous overlap so that the final achievable deployed length is widely variable with a stable overlap between the components. A generous overlap also compensates for distractional movement between the components, which is likely to occur during late follow-up due to changing aneurysm morphology or stent-graft distortion. When treating an atherosclerotic aneurysm, exclusion of the entire segment of the aorta between the origin of the left carotid and celiac axis is preferable in all but very localised lesions. This allows utilisation of the aorta closer to the ostia of major branches. These segments of aorta generally resist aneurismal degeneration with increasingly preserved connective tissue and structural elements. Routine overlap of the left subclavian artery is associated with a low incidence of ischaemic complications of the arm, which can usually be managed with relative simplicity. However, covering the subclavian origin increases the risk of spinal cord ischaemia, particularly if the patient had repair of an infrarenal aneurysm in the past or when the distal landing zone extends to the level of T12 vertebra.

Durability Issues

Current stent graft designs largely depend upon columnar strength, radial forces and appendages such as hooks or barbs, to maintain fixation. The cyclical strain on a thoracic stent-graft is greater compared with an infrarenal device due to the natural curvature of the aorta resulting in early mechanical fatigue. The haemodynamic forces acting upon the stent-graft are also greater due to the proximity to the heart, larger diameters, greater blood flow and an almost invariably curved configuration of the stent-graft. These vectors tend to force caudal migration of the top end of the stent-graft and the cephalad displacement of the distal end.

8. *Mitchell R S, "Stent grafts for the thoracic aorta: a new paradigm?"*, Ann. Thorac. Surg. *(2002);74(5): S1818–1820; discussion S1,825–S1,832.*
9. *Marty B, Morales C C, Tozzi P, Ruchat P, Chassot P G, von Segesser L K, "Partial inflow occlusion facilitates accurate deployment of thoracic aortic endografts"*, J. Endovasc. Ther. *(2004);11(2): pp. 175–179.*

Due to the curvature thoracic stent-grafts assume once deployed, there is a need to keep the columnar strength of the device low, otherwise there is a risk of poor alignment between stent-graft and aortic wall leading to excessive cyclical stress. This ultimately leads to mechanical failure of the stent-graft (metal component fracture) or of the aortic wall (erosion of the aortic wall with consequent rupture or formation of a fistula).[3,10] A stent-graft anchored at the apex of the arch is prone to develop pulsatile pivoting motion of the uppermost stent and proximal type I endoleak. It is desirable to avoid anchorage at the apex of a particularly angulated arch even if it means having to cover the origin of the common carotid artery and an antecedent extranatomic bypass.

The incorporation of hooks or barbs at both ends of the device has the potential to improve long-term fixation. The presence of a bare stent with or without hooks or barbs in the proximal aorta is documented to cause erosions, leading to dissection or pseudoaneurysm formation.[11] Such risk should be balanced against the desirability of greater fixation in each patient. When treating a dissection, a device that incorporates a bare stent at the top may only be used when the entire bare stent could be placed within healthy and dissection-free segment. Such bare stents placed across the origin of a left subclavian artery do not seem to cause any significant long-term problems. Stent-graft incorporating bare-stents on the bottom, with or without barbs, should not be used for dissections simply because there is a risk of perforation of the membrane. Devices with a bare metal stent and cranially-directed barbs at the lower end are currently commercially available for use in dissection-free aneurysms. The aortic segment at the level of the visceral arteries is usually healthy and provides a better area to deploy such a bare stent (akin to the proximal end of an infrarenal device), with negligible risk of creating a dissection at this level.

Conclusion

The early experience of thoracic repair has been characterised by a high incidence of early mortality and late device failure reflecting a learning curve and evolution of the technique. In the light of experience and more effective devices, significant improvement in the results is expected in the future. There is currently widespread enthusiasm for the further development and wider application of the endovascular approach to treat thoracic aortic aneurysms since the conventional surgical alternative involves extensive surgical and metabolic trauma. The current commercially available devices fare better in most aspects compared with the earlier generation of stent-grafts. Experience suggests that it is best to exclude generous segments of aorta on either side of a thoracic aneurysm so that the stent-graft spans clearly healthy segments. Worldwide experience suggests that the endovascular technique has evolved sufficiently to become a valid alternative to open surgery. There is optimism that improvements in stent-graft technology will improve the results further in the future. ■

10. *Eggebrecht H, Baumgart D, Radecke K et al., "Aortoesophageal fistula secondary to stent-graft repair of the thoracic aorta",* J. Endovasc. Ther. *(2004);11(2): pp. 161–167.*
11. *Pasic M, Bergs P, Knollmann F, Zipfel B, Muller P, Hofmann M, Hetzer R, "Delayed retrograde aortic dissection after endovascular stenting of the descending thoracic aorta",* J. Vasc. Surg. *(2002);36(1): pp. 184–186.*