Total Endovascular Debranching of the Aortic Arch

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Abstract
Background: Significant morbidity and mortality are related to conventional aortic replacement surgery. Endovascular debranching techniques, fenestrated or branched endografts are time consuming and costly.

Objective: We alternatively propose to use endovascular approach with parallel grafts for debranching of aortic arch.

Methods: Under general anesthesia, 12 F sheaths were inserted in the femoral, axillary and common carotid arteries for vascular accesses. ViaBahn grafts 10 – 15 cm in length were placed into the aortic arch from right common carotid, left common carotid and left axillary arteries, until the tip of each graft reached into the ascending aorta. Through one femoral artery, the aortic stent-graft was positioned and delivered. Soon after, the parallel grafts were sequentially delivered. Self-spanding Wallstents were used for parallel grafts reinforcement. Ballooning was routinely used for parallel grafts and rarely for aortic graft.

Results: This technique was used in 2 cases. The first one was a lady with 72 years old, with an aortic retrograde dissection from left subclavian artery and involving remaining arch branches. Through right common carotid artery a stent-graft was placed in the ascending aorta and through the left common carotid artery a ViaBahn was inserted parallel to the former. A thoracic endograft then covered all the aortic arch dissection extending into the ascending aorta close to the sinotubular junction. The second case was a 82 year old male patient with a 7 cm aortic arch aneurysm. Through both common carotid arteries ViaBahn grafts were introduced and positioned into the ascending aorta. Soon after, the deployment of the thoracic stent graft covered all parallel grafts of the aortic arch, excluding the aneurysm. Both cases did not have neurologic or cardiac complications and were discharged 10 days after the procedure.

Conclusions: This technique may be a good minimal invasive off-the-shelf technical option for aortic arch "debranching". More data and further improvements are required before this promising technique can be widely advocated.

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Introduction

Aortic arch replacement with cardiopulmonary bypass and deep hypothermia is still a demanding cardiac procedure, with significant morbidity and mortality in spite of all technical improvements during the last years. The side effects of deep hypothermia, especially in elderly patients with various co-morbidities, often prolong intensive care unit (ICU) and hospital stay.

Endovascular treatment of aortic arch aneurysms requires extensive debranching procedures to obtain an adequate landing zone. In some cases, there are no patent or sufficiently patent feeding arteries for an extra-thoracic debranching procedure. Alternatively, fenestrated or branched grafts were used in these cases. Most of these options use custom-made devices associated with long manufacturing times and increased costs. Therefore, the use of parallel grafts was advocated for permitting an easy off-the-shelf solution. In this article, we describe two different techniques of total endovascular debranching of the aortic arch, using parallel grafts for supra-aortic vessels extending into the ascending aorta to obtain an extensive sealing zone.

Material and Methods

All procedures were performed under general anaesthesia. Monitoring included transoesophageal ultrasound, in addition to an arterial line and venous catheters. Cut down of the femoral arteries, both common carotid arteries and the axillary arteries, was accomplished first. A diagnostic pigtail catheter was introduced in the aorta, through the left common femoral artery. Under fluoroscopic guidance, 12-F sheaths were introduced through both axillary and common carotid arteries. Hydrophilic stiff guidewires, 0.035 mm, were placed through the sheaths into the ascending aorta and left in situ. ViaBahn® grafts (Gore, Flagstaff, Arizona, USA) with 10–15 cm in length were positioned into the aortic arch until the tip of the graft reached into the ascending aorta. Depending on the extent of the aneurysm, the tip of the ViaBahn® graft was placed in proximity to the sinu-tubular junction and the aortic valve. Repeated angiography and transoesophageal echocardiography were performed to prevent obstruction of the coronary arteries or the aortic valve. Before deployment of the parallel graft, the aortic endograft was advanced transfemorally into the aortic arch. If necessary, the 0.035 Lunderquist® guidewire (Cook Inc., Bloomington, IN, USA) was placed through the aortic valve into the left ventricle. The aortic stent graft was deployed first and subsequently the parallel grafts. Re-enforcement of the parallel grafts with self-expandable Wallstents® (Boston Scientific, Natick, MA, USA) was performed at the crossing of the parallel graft into the aortic arch. Ballooning of the chimney grafts was performed after deployment of the aortic stent graft and the chimney grafts.

Results

Endovascular debranching of the aortic arch was performed in two cases.

In the first patient, a 72-year-old woman, over-stenting of the left subclavian artery as part of exclusion of an aneurysm extending into the aortic arch was performed after subclavian carotid transposition. However, after endograft deployment, control angiography showed retrograde dissection, involving the innominate artery and the left carotid artery. After exposure of both carotid arteries, a 12-mm iliac extension limb Zenith® (Cook, Bloomington, IN, USA) was introduced through the right common carotid artery into the innominate artery and the ascending aorta. A Viabahn® graft was placed through the left common carotid artery into the ascending aorta. Subsequently, a thoracic endograft was deployed (42 mm Cook ProForm, Bloomington, IN, USA), which covered all of the aortic arch, extending into the ascending aorta, close to the sinu–tubular junction (Fig. 1).

The second case, an 82-year-old male patient, with a 7-cm aortic arch aneurysm, chronic obstructive pulmonary disease (COPD), coronary artery disease and impaired left ventricular function, required complete endovascular exclusion of the aortic arch. After exposure of the axillary arteries and both carotid arteries, four ViaBahn® grafts were introduced into the ascending aorta, through each access (Fig. 2).

Both patients were extubated the day of the operation. There was no neurological or follow-up computed tomography (CT) scan of the first case with innominate artery endo-debranching, and left common carotid (LCC) chimney graft was obtained after 17 months postoperatively. All chimney grafts were patent and there was no proximal type I leak. The patient required a distal extension because of an increasing descending aortic aneurysm, which was successfully accomplished after 1 year. Follow-up CT scan of the second case was performed after 10 months. Again, there was no type I leak and chimney grafts of all four supraaortic vessels were fully patent. Yet, the patient had developed an asymptomatic >80% stenosis of the right carotid bifurcation and is still under close surveillance.

Discussion

Endovascular repair of aortic arch aneurysm offers an attractive minimally invasive alternative to open surgery. Hybrid techniques, with surgical debranching, are the most commonly used approach currently. Compared to traditional open surgical repair, hybrid approaches may lessen morbidity and mortality by avoiding hypothermic circulatory arrest and aortic cross-clamping. However, mortality and morbidity, especially for zones 0 and 1, are still significant. Dislodgement of thrombus material can be a major problem in these patients with heavily diseased aortic arch.

The technical difficulty and complexity of branched grafts' positioning and deployment, especially with unibody branched grafts, may result in high rates of embolism. Alignment of fenestrated or branched grafts requires especially skill from the medical team, particularly in patients with a gothic arch and a curved descending aorta, and an excellent manoeuvrability of the materials to get apposition of branches or fenestrations adjacent to the origin of the cerebral vessels. In the future, possibly
new products will develop with smaller profiles and diameters for reducing these limitations.

Chimney grafts in the aortic arch can be combined with all currently available endografts.\(^2,7\) Due to the relatively short follow-up period, we do not have any data about possible side effects, such as corrosion at the site of the interface between the parallel graft and the aortic endograft, migration and leaks.

Experience from chimney grafts used in the abdominal aorta shows that type I endoleaks can be avoided when the chimney grafts run in parallel to the main endoprosthesis over a distance of at least 7 cm.\(^15\) We oversized the endografts by 20% as we usually do. The chimney grafts will adapt or mould close to the aortic stent graft. Larger oversizing carries the risk of infolding or creation of more gutters with a subsequent type I endoleak.

Parallel grafts automatically take a curved position, accommodating (fitting) to the aortic arch curvature. This avoids the ‘gutter effect’ seen when the snorkel grafts go straight upwards like a real chimney, leaving some free space on either side.

Currently, chimney grafts in the thoracic aorta as well as in the abdominal aorta are still experimental and should be reserved for those cases where the surgeon does not have another option. We still do not know what type of grafts is better for combination with chimneys without risking material fatigue. Different stiffness and compliance of some grafts do most probably prevent its combination with a parallel graft.

The technique described can be readily used as an alternative technique to exclude aortic arch aneurysms. Long-term data are still required before a wider use can be advocated.

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**Figure 1** Picture animation and postoperative angiotomography section with 3D reconstruction of 3 arteries total endovascular debranching of the aortic arch for retrograde dissection treatment (18 months follow-up).

**Figure 2** Postoperative angiotomography section and 3D reconstruction of 4 aortic vessels (right subclavian, right common carotid, left subclavian and left common carotid arteries) total endovascular debranching for treatment of aortic arch aneurysm (18 months follow-up).
Conclusion

Total endovascular debranching of the aortic arch, using parallel grafts for all patent supraaortic vessels, may amplify and simplify the application of endovascular techniques for treatment of aneurysms involving the aortic arch. It can be a good minimally invasive technical option for aortic arch ‘debranching’, which carry on cervical transpositions and bypasses, or proximal ascending aorta-based bypass to one or more branches via a median sternotomy. The present technique also can be applied by using standard off-the-shelf stent grafts to instantly treat lesions with inadequate fixation zones in aortic arch and proximal thoracic aneurysms. More data and further improvements are required, before this promising technique can be widely advocated.

Conflict of Interest/Funding

The authors declare there is no financial arrangement or other relationship that could be construed as a conflict of interest in this article.

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