SHORT REPORT

Experiences of Intentional Carotid Stenting in Endovascular Repair of Aortic Arch Aneurysms—Two Case Reports

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Endovascular repair of thoracic aneurysms has emerged as an attractive alternative especially in patients at high risk. However, the left common carotid artery limits the use of stent-grafts in aneurysms located in the aortic arch or close to the left subclavian artery. We report two cases with aneurysms in the distal arch and proximal descending aorta, where we have used a carotid stent in juxtaposition to an aortic stent-graft, to gain a longer proximal neck in the aortic arch in an attempt not to rely only on a by-pass graft feeding the left carotid artery.

Keywords: Thoracic aneurysm; Carotid stenting; Endovascular repair.

Conventional repair of aneurysms and dissections of the aortic arch requires open thoracic surgery and graft replacement, usually with deep hypothermic circulatory arrest, and associated with significant mortality and morbidity.1 Even with brain protection and use of retrograde or antegrade selective cerebral perfusion mortality rates of 10–13% have been reported.2 Emergency surgery and age > 75 years are risk factors for mortality.3 Endovascular repair of thoracic aneurysms has emerged as an attractive alternative especially in patients at high risk.4 However, aneurysms located in the aortic arch or close to the left subclavian artery have often been excluded from stent-graft repair due to a short proximal neck. In 1999 Inoue et al.5 reported a successful deployment of a custom-built, unibody branched stent-graft in the aortic arch. In 2003 Chuter et al.6 described a modular branched stent-graft for use in the aortic arch. Another method to treat aneurysms in the aortic arch is to combine stent-graft repair with extra anatomical bypass from the proximal ascending aorta or the femoral arteries7 to the common carotid artery and/or the subclavian artery. We report two cases in which we used a carotid stent to gain a longer proximal neck in the aortic arch.

Case Reports

Case 1

A 68-year-old man with hypertension was treated for a benign lung tumour 2 years previously. Two aneurysms were demonstrated on a chest X-ray, one located in the distal arch and proximal descending thoracic aorta and the other in the middle and distal one-third. Endovascular exclusion of the distal fusiform aneurysm of the descending aorta of 72 mm diameter was performed, utilizing two stent-grafts. The saccular, 58 mm wide aneurysm located at the origin of the left subclavian artery was deliberately left without treatment. Between the two aneurysms, there was a bridge of a 4 cm normal aorta.

At routine follow-up with CT-scan a proximal type I-endoleak was observed and the patient was planned for another intervention with a proximal extension into the aortic arch in order to exclude also the saccular aneurysm, now measuring 60 mm in diameter.

Preoperative neurological assessment and CT-angiography of the cerebral and cervical arteries was performed. No stenoses of the carotid arteries were revealed and there was no history of cerebral vascular disorder.

Under general anaesthesia the left subclavian artery
and the left common carotid artery were exposed. An 8-mm thin walled spiral supported polyester graft (Sulzer Vascutek, Terumo, Inchinnan, Scotland) was anastomosed end-to-side to both arteries. Before completion of the carotid anastomosis a 7 Fr introducer sheath was inserted in the left common carotid artery and a guidewire advanced in retrograde direction to the ascending aorta. Next a 24 Fr introducer was

![Fig. 1. Line drawings shows stages of the procedure. (a) A carotid-subclavian bypass has been performed with an introducer inserted through the carotid anastomosis. A self-expanding nitinol stent has been placed at the origin of the left carotid artery. A Gore TAG\textsuperscript{\textregistered} has been advanced with its upper end crossing the origin of the left common carotid artery. A guidewire has been inserted through the left subclavian artery into the ascending aorta. (b) The Gore TAG\textsuperscript{\textregistered} and the carotid stent have been deployed. The carotid introducer and its guidewire have been removed and the suture in the carotid anastomosis has been tied. (c) The subclavian guidewire has been pulled back to the central left subclavian artery and coils have been placed close to the subclavian origin.](image-url)
A 78-year-old man with hypertension was admitted because of a saccular, 58 mm wide, aortic aneurysm located in the distal arch and proximal descending thoracic aorta. There was no history of cerebral disorder and a preoperative CT-angiography did not show any stenoses of the carotid arteries.

Under general anaesthesia a by-pass between the left common carotid artery and left subclavian artery was performed with a ring-supported, 8-mm-expanded polytetrafluoroethylene graft (W.L. Gore and Associates Inc., Flagstaff, AZ, USA). An introducer sheath and a guidewire were inserted in the left common carotid artery together with an angiography catheter. Next a 24 Fr introducer was percutaneously inserted through the femoral artery, a Gore TAG® (W.L. Gore and Associates Inc., Flagstaff, AZ, USA) stent-graft was advanced until its upper end crossed the origin of the left common carotid artery. The stent-graft was deployed but migrated centrally. The registered carotid blood flow decreased from 450 to 50 ml/min. Another preloaded self-expanding nitinol stent, Symphony™ (Boston Scientific/Medi-Tech, Watertown, MA, USA) had been placed at the origin of the left carotid artery. The stent-graft was deployed but migrated centrally. The registered carotid blood flow decreased from 450 to 50 ml/min. Another preloaded self-expanding nitinol stent, Zilver® (William Cook Europe, Bjaeverskov, Denmark), of the same size was successfully deployed at the origin of the left common carotid artery. The carotid blood flow immediately recovered to 400 ml/min. The migrated stent was recovered to the iliac artery and, finally, coiling of the central left subclavian artery to avoid backflow in the aneurysm completed the whole procedure. Completion angiography revealed a minor endoleak in the aneurysmal sac.

The patient recovered well and was discharged 2 days postoperatively without any complications. One-month follow-up with CT-angiography showed no leakage and normal carotid- and by-pass graft flow.

**Case 2**

A 78-year-old man with hypertension was admitted because of a saccular, 58 mm wide, aortic aneurysm located in the distal arch and proximal descending thoracic aorta. There was no history of cerebral disorder and a preoperative CT-angiography did not show any stenoses of the carotid arteries.

Under general anaesthesia a by-pass between the left common carotid artery and left subclavian artery was performed with a ring-supported, 8-mm-expanded polytetrafluoroethylene graft (W.L. Gore and Associates Inc., Flagstaff, AZ, USA). An introducer sheath and a guidewire were inserted in the left common carotid artery together with an angiography catheter. Next a 24 Fr introducer was percutaneously inserted through the femoral artery, a Gore TAG® (W.L. Gore and Associates Inc., Flagstaff, AZ, USA) stent-graft was advanced until its upper end crossed the origin of the left common carotid artery. Before deployment of the stent-graft a balloon-expanded stainless steel stent, Palmaz-Genesis™ (Cordis Europe N.V., Roden, The Netherlands), was positioned as in the previous case (Figs. 1(a) and 2). For technical reasons blood flow in the left carotid artery could not be measured. Immediately after deployment of the stent-graft the carotid stent was deployed by inflation of the balloon followed by rapid deflation (Figs. 1(b) and 3). From the beginning a guidewire had been inserted through the left subclavian artery and into the ascending aorta. It was withdrawn and coiling of the central left subclavian artery was performed (Fig. 1(c)) and a completion angiography showed no leakage.

The postoperative course was eventfree and the
patient was discharged on the second postoperative day. A minor type-II endoleak was revealed on a postoperative CT-angiography but on another CT, 3 weeks later, the aneurysm was completely sealed and there were no clinical complications.

**Discussion**

Endovascular repair of aneurysms of the aortic arch with involvement of the branches is still under development. It is indicated that a proximal neck of at least 15–20 mm is required for good fixation of the graft and sealing of the aneurysm. Intentional covering of the left subclavian artery can be done with an acceptable complication rate, but the long-term hemodynamic effects of the vertebrobasilar circulation are not well known. Transposition or by-pass surgery of branches is sometimes required. The aortic arch is large, curved and mobile, subject to high flow rate and related to the cerebral circulation. Therefore, endovascular repair has specific requirements. Fixation of the stent-graft to aortic arch can be problematic and there is an incidence of proximal type-I endoleak. One option to lengthen the proximal neck is to cover the left common carotid in combination with extra-anatomic bypass to this artery. Carotid stenting is now well established as a therapeutic option and we decided to explore this method in combination with proximal arch fixation of the stent-graft.

One advantage with the Gore TAG® is its flexibility and it is the only present system that can be advanced to the target and deployed without a sheath. Another advantage is the instant releasing mechanism, making it unnecessary to pharmacologically induce systemic hypotension or asystole. A disadvantage, however, is the inability to make corrections in positioning of the stent-graft after it is released which given the difficulty in predicting the exact positioning prior to deployment can be a problem (Fig. 4).

One has to consider that a distance on the minor curvature corresponds to a significantly longer distance on the major curvature. If aiming at a landing zone of 2 cm on the minor curvature to get a safe proximal sealing of the aneurysm, a longer distance has to be reached on the major curvature.

Branched stent-grafts may be an ultimate solution to achieving optimal proximal fixation, but at this stage, they are associated with significant complications and need to be custom-made. Using the method we outline in this report there is no need for custom-made devices, however, there may be increased potential for distal migration and endoleak.

In conclusion, intentional carotid stenting may increase the indications for endovascular repair of aortic aneurysms close to the subclavian artery. This technique may also be useful in a Stanford type B dissection. A similar technique could be used for the left subclavian artery. However, this technique is under development and further experience is required.

**Acknowledgements**

The authors thank Peter Grahn, radiologist, for his help in the production of the line drawings.

**References**

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Accepted 24 February 2005
Available online 7 April 2005