ORIGINAL ARTICLE

ANZJSurg.com

Branch thoracic stent graft repair for arch aneurysm

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Key words
aortic arch aneurysm, arch aneurysm, branch thoracic stent graft, thoracic stent graft.

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Accepted for publication 24 January 2012.

doi: 10.1111/j.1445-2197.2012.06024.x

Abstract

Aortic arch aneurysms involving the major vessels of the neck pose great challenges in their repair. Open repair of these aneurysms are associated with a significant morbidity and mortality. The major challenge for endovascular repair of these complex aneurysms is the maintenance of cerebral perfusion during stent implantation and long-term durability. This paper discusses preoperative planning and technical aspects to successful endovascular repair of a large aortic arch aneurysm involving the distal take-off of the left subclavian artery.

Introduction

Stent graft repair of aortic arch aneurysms poses great challenges as maintaining cerebral perfusion is crucial to avoid cerebral ischaemia. With the advances in fenestrated and branch stent graft technology, vascular surgeons are now equipped with greater experience and confidence in tackling complex arch aneurysms. Fenestrated repair of juxtarenal aneurysms is an evolving technique with numerous studies reporting good technical success and mid-term results.[1–3] The initial work with fenestrated grafts progressed to branch graft technology allowing treatment of thoraco-abdominal aneurysms with substantially lower morbidity and mortality compared with open surgery.[4,5] Open repair of arch aneurysms has a significant morbidity and mortality, which has been an impetus for stent graft repair of arch aneurysms.[6,7]

A 70-year-old man presented with haemoptysis due to a 9-cm aneurysm of the aortic arch involving the left subclavian artery (Fig. 1). The working diagnosis was of a mycotic aneurysm. The mortality from open repair of such a large mycotic aneurysm of the arch was deemed too great by the cardiothoracic surgeons and hence the endoluminal option was then considered. However a standard thoracic stent graft or even one with a scallop for the left common carotid artery would not provide an adequate landing zone. So a customized branched thoracic stent graft (Cook Medical, Bloomington, IN, USA) was planned (Fig. 2). Long-term intravenous antibiotics were commenced and the patient was discharged from the hospital when his symptoms settled to await stent graft construction. However, he re-presented with further haemoptysis a week later. Repeat computed tomography (CT) scan showed increase in aneurysm size from 9 cm to 11 cm. He was therefore kept in hospital until his stent graft repair.

The arch stent graft has significant features, which allow accurate placement of the graft and its branches and also aid cannulation and placement of the bridging stents. The pre-curved inner cannula of the delivery system aids the sheath and graft to adapt to the curve of the arch and guide the opening of the branches to align with the vessel origins. This requires precision preoperative planning, which was reliant on accurate imaging with Tera Recon software (Tera Recon Inc, San Mateo, CA, USA) to determine the position of the vessel origins in a clock orientation relevant to the apex of the arch. The graft is fixed to the pre-curved cannula via a running wire to place the branch origins at the correct clock position prior to loading in its sheath. This fixation of the graft prevents the need for rotational manipulation of the graft to align these branches with the targeted supra-aortic vessels (Fig. 3). The rotational orientation is important to simplify the cannulation of branches from above once the graft is deployed.

The branches of the arch device have been designed to be completely within the stent graft as any external branch may not fully open in the arch. The branches are 20 mm long to allow for a good

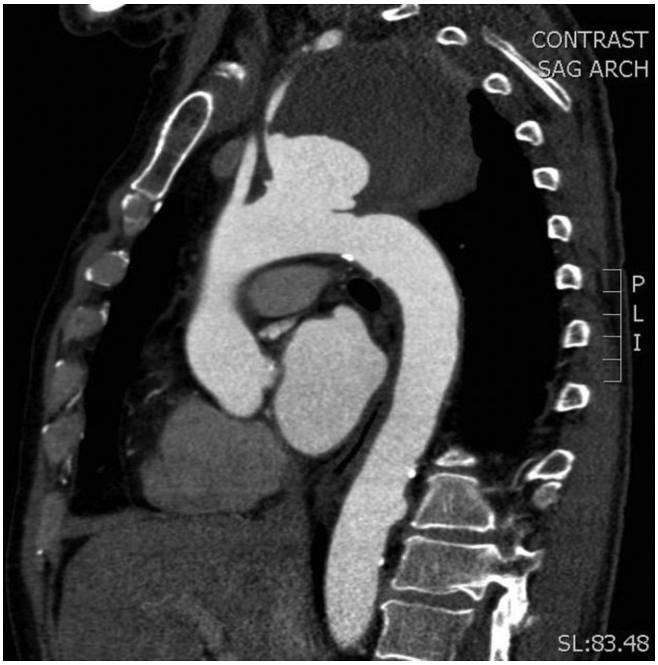

Fig. 1. Pre-op CT scan.

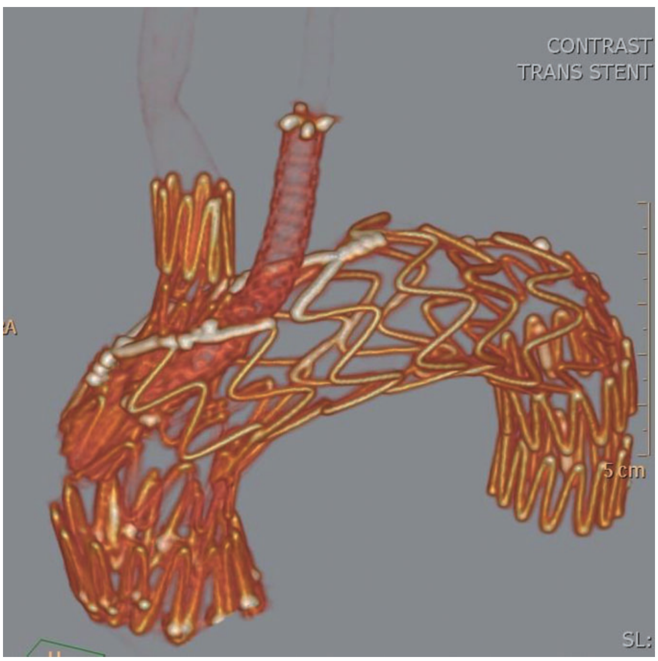

Fig. 2. CT showing arch, stent graft with bridging stents.

sealing zone with the bridging stents. The external opening of each branch sits at the bottom of a wider crater which aids in the cannulation of the branch from above (Fig. 4).

Access vessels for placement of bridging stents were via a right axillary cut down for the brachiocephalic stent and a left brachial cut down for the left carotid stent, which was delivered through a left carotid to left subclavian bypass performed earlier.

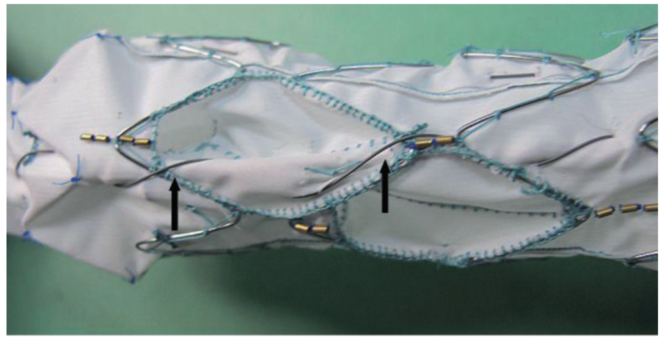

Fig. 3. Spiral wire (arrows) attaches graft to curved inner cannula.

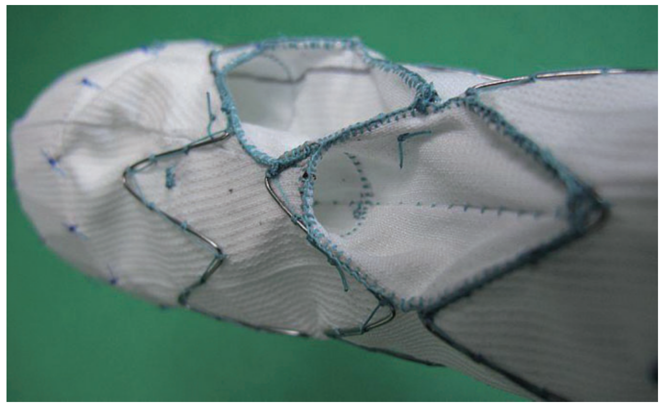

Fig. 4. Arch graft with funnelled openings to the branches.

The main body of the stent graft was introduced via the right femoral artery over a stiff wire placed in the left ventricle. To aid cannulation of the branches, it helps if the crater for the carotid branch sits directly below the left common carotid artery. However, when in this position, it is imperative to ensure that the proximal edge of the graft is clear of the sinotubular junction and left coronary artery ostia. If not, the graft needs to be repositioned distal to the coronary ostia although this may compromise the ease of branch cannulation. Following an angiographic run via the pigtail to confirm positioning, the pigtail was withdrawn to the descending aorta. The sheath in the left common carotid artery was used as reference point for graft position checks thereafter. Rapid pacing was induced to halt cardiac output and the stent was unsheathed completely. At this stage, the exposed device was still attached at its proximal and distal ends, and also throughout its length to the introducer system. Rapid pacing was ceased immediately to allow return to sinus rhythm after a total cardiac pause of 30 s.

With the graft fully opened and in position, the left common carotid branch was cannulated via the left brachial artery and the brachiocephalic branch from the right axillary exposure. The brachiocephalic bridging stent was a custom-made 16 mm × 70 mm TFLE graft (Cook Medical), which was deployed ensuring proximal edge overlap with the branch and the distal edge just short of the right common carotid origin. The left common carotid artery being 6 mm in diameter, a 9 mm × 90 mm Fluency Plus stent (Bard Periph-

Fig. 5. Post-op CT with total exclusion of aneurysm.

eral Vascular Inc., Tempe, AZ, USA) was deployed within the branch and the left common carotid artery to obtain adequate seal. The bridging stents were not balloon moulded. Check angiography revealed good flow through the bridging stent with the aneurysm still in circulation via retrograde flow from the subclavian. A 10-mm Amplatzer vascular plug device (AGA Medical Corporation) was deployed in the left subclavian artery just proximal to the left vertebral origin to seal the aneurysm sac. Completion angiography demonstrated good flow through the brachiocephalic, left common carotid arteries and the carotid-subclavian bypass with complete exclusion of the aneurysm.

Post-operatively, the patient was transferred to intensive care unit and recovered with no neurological or other complications. A check CT angiogram performed a week later prior to discharge from hospital and at 6 weeks follow-up showed good flow through the graft with exclusion of the aneurysm (Fig. 5). The patient will be followed up in our annual endovascular stent graft surveillance programme.

Discussion

Stent grafts have been used to treat descending thoracic aneurysms and dissections for many years with good results.[8] The problem occurs when there is no landing zone distal to the left subclavian artery. Stent grafts have been placed proximally in the arch in zones I and II with techniques incorporating fenestration and scallops to maintain perfusion of the brachiocephalic, left common carotid and left subclavian arteries.[9] However, securing a good alignment of the scallops and fenestrations with these vital supra-aortic vessels is difficult. Arch tortuosity and reduced torquability of the device from the femoral artery access makes aligning pre-cut fenestration against the target vessel origin difficult. *In situ* fenestration of the main graft body after deployment is one possible solution to overcome this problem.[10] However, this technique requires temporary femoral to carotid bypass during the formation of the fenestration and branch placement to maintain cerebral perfusion. Long-term sealing and stability is a major concern with this technique.

The chimney graft technique has been employed for aortic arch branch vessels.[11] It involves cannulating the side branch with a covered stent which is then stented over with the aortic stent. Subsequently, the covered stent in the side branch is expanded and the aortic stent moulds around the side branch stent to provide a proximal seal. One advantage with the chimney graft is that the components being off the shelf allow this technique to be available in the acute setting. However the chimney graft raises complex technical difficulties in sizing the length of the stent graft for the branch vessel, which often takes an unpredictable tortuous route. In addition, it is susceptible to endoleaks from the gutters formed by the chimney graft running along the outer wall of the aortic stent. Hybrid procedures such as debranching of the supra-aortic vessels and stenting of the arch still involve a significant open surgical component.

Early designs of branch stent graft for aortic arch aneurysms used a bifurcated device with one limb perfusing the brachiocephalic trunk and the other remaining within the aortic lumen.[12] This requires a carotid to carotid bypass in addition to left carotid to subclavian bypass. Graft delivery is via the common carotid and this poses concerns of embolization and also compromise to cerebral perfusion as the device is delivered via a 24 French sheath.

The alternative is a multi-branched stent graft to allow perfusion of more than one cerebral vessel. This design also increases the sealing area from overlap of the bridging stent and the side branches and hence provides a more stable configuration. Early reports suggest excellent results for type II and type III thoraco-abdominal aneurysms with branch stent grafts.[13] These are custom-made devices, which preclude use in an acute setting although the modular concept may lend itself to off-the-shelf devices in the future.

The custom-made TFLE (Cook Medical) was the choice for the brachiocephalic bridging stent because of its durability combined with its flexibility to negotiate the curved configuration of the brachiocephalic artery from an axillary approach. A Fluency stent (Bard Nordic) deployed over a wire avoided the need for a large sheath in the left common carotid artery with its potential to compromise cerebral perfusion via the left common carotid artery.

Precision graft deployment in the thoracic aorta is dependent on reducing cardiac output to prevent migration from the windsock effect. Rapid cardiac pacing allows for a prompt and predictable response with complete cardiac standstill and in addition, a test pacing allowed the anaesthetists to prepare in advance. A team approach integrating the cardiologists, interventional radiologists and anaesthetists is critical to the success of such complex cases.

Thoracic stent grafts are managed in intensive care environment post-operatively. Though, spinal ischaemia was not a great concern due to sparing of the descending thoracic aorta, we were prepared for a spinal drain insertion if warranted. For the same reasons, the patient was extubated at the earliest opportunity.

Although in this particular case we were fortunate to have access to a custom-made design, time for graft manufacture remains the limiting factor in endovascular treatment of complex arch aneurysms in acute or semi-acute circumstances. Hence, until there is an off-the-shelf solution, the use of branch stent grafts for complex arch aneurysm will be restricted.

Disclosures

BM Stanley and D Hartley are consultants to Cook Medical, USA.

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