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CASE REPORT

# Successful Endovascular Management of Iatrogenic Aortic Coarctation Following Total Aortic Arch Repair in Type B Dissection: A Case Report

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## INTRODUCTION

Frozen elephant trunk (FET) technique has been commonly used in the management of a wide variety of thoracic aortic pathology. Postoperative kinking of an FET stent graft resulting in clinically significant aortic coarctation is rare. We report a challenging case of a patient with chronic type B aortic dissection who underwent FET repair that was complicated by clinically significant FET graft kinking but successfully treated with endovascular stenting.

## CASE REPORT

A 47-year-old man with a history of chronic type B aortic dissection had a dissection flap starting just distal to the origin of the aberrant right subclavian artery (SCA) and extending down to the aortic bifurcation. Sequential computed tomography angiography (CTA) showed progressive dilatation of an aortic arch dissecting aneurysm (5.8 cm) and narrowing of the true lumen. In May 2021, he underwent ascending and total aortic arch replacement with FET graft (Thoraflex Hybrid; Terumo Aortic, Renfrewshire, United Kingdom), aorto-right axillary artery bypass and embolisation of the aberrant right SCA with Amplatzer vascular plug (Abbott Medical, Plymouth [MN], US).

Following the surgery, he developed persistent hypertension despite multiple antihypertensive medications and progressive respiratory distress. There was significant upper and lower limb blood pressure (BP) discrepancy up to 40 mmHg. Echocardiogram demonstrated preserved left ventricular ejection fraction (60%). CTA on postoperative day 5 revealed kinking of the FET stent graft at the distal aortic arch with marked luminal stenosis (Figure 1a and b). Another finding was an endoleak from the aberrant right SCA, later managed by surgical ligation of the right SCA origin. Aortic angiogram confirmed high-grade stenosis of the FET graft at the distal aortic arch (Figure 1c). Intra-arterial BP measurement revealed a 53-mmHg pressure gradient across the stenosis.

Endovascular stenting of the iatrogenic aortic coarctation was performed with a bare-metal stent (BMS)

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Ethics Approval: The patients were treated in accordance with the Declaration of Helsinki and provided written informed consent for all treatments and procedures and consent for publication.

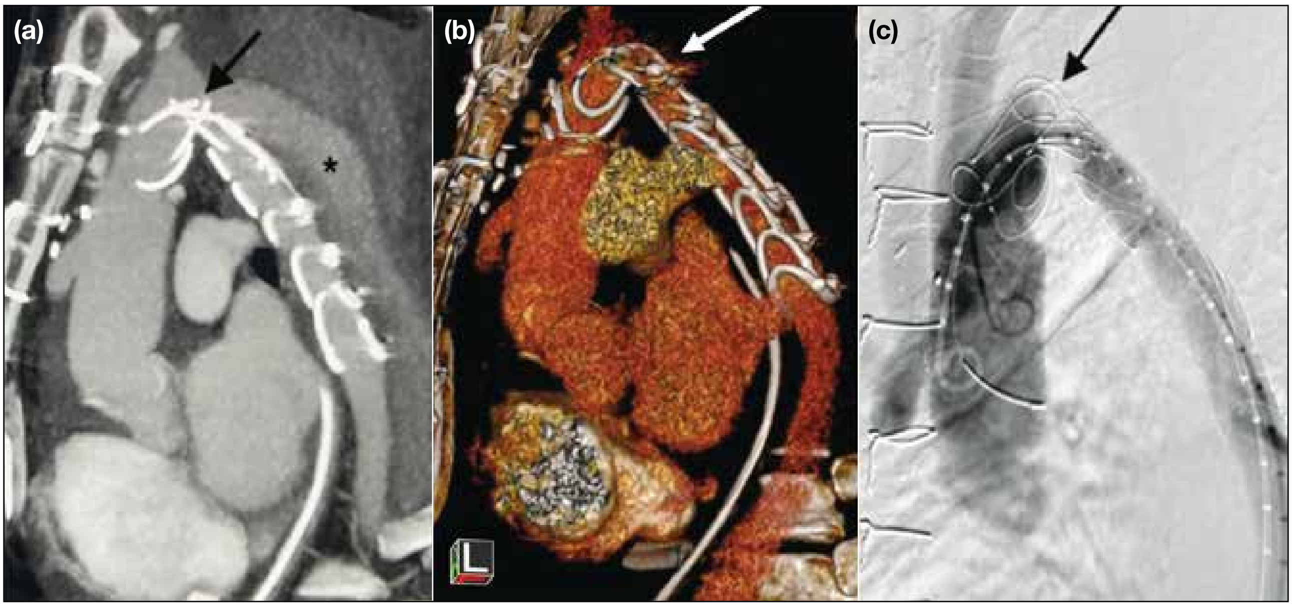


**Figure 1.** (a) Double oblique sagittal view of contrast-enhanced computed tomography angiography maximal intensity projection image and (b) three-dimensional reconstruction showing ascending and total aortic arch replacement with frozen elephant trunk (FET). There was kinking and severe stenosis at the distal aortic arch (arrows in [a] and [b]), as well as presence of endoleak in false lumen along the aortic arch and descending thoracic aorta (asterisk in [a]). (c) Digital subtraction angiogram in left anterior oblique view showing kinking of FET trunk with high-grade stenosis at the distal aortic arch.

[Sinus-XL 34 × 100 mm; OptiMed, Ettlingen, Germany] under local anaesthesia. Due to the acute angulation at the aortic arch and tight stenosis, an attempt to deploy across the stenosis within the FET was particularly challenging. Difficulties were encountered during passage of the delivery system across the stenosis as well as retraction of the outer sheath for stent deployment. To overcome these difficulties, balloon dilatation of the stenosis was first performed. This was followed by partial deployment of two-thirds of the stent within a 12-F sheath (Cook Medical, Bloomington [IN], US) with the sheath tip rested at the non-kinked portion of the FET. The entire complex was then advanced proximally to the desirable zone. The partially opened stent was deployed across the stenosis by unsheathing the 12-F sheath with constant forward pressure on the delivery system to avoid distal migration. Post-stenting dilatation with a 32-mm Coda balloon catheter (Cook Medical, Bloomington [IN], US) achieved satisfactory luminal expansion (Figure 2). Post-stenting BP gradient improved to 20 mmHg.

On day 3 post-stenting, the patient developed haemolytic anaemia and syncope. Urgent CTA revealed no source of bleeding. The BMS across the coarctation was partially collapsed but there was interval luminal gain when compared with preprocedural CTA (Figure 3). The haemolytic anaemia was suspected to be stent-related; a repeat aortic angiogram was performed on postoperative day 14 and demonstrated a small residual pressure gradient (8 mmHg) across the kinking. Since the stent remained partially collapsed, repeat balloon angioplasty was performed with 32-mm Coda balloon (Cook Medical, Bloomington [IN], US) and 26-mm Atlas balloon (Bard Medical, New Providence [NJ], US). Despite the lack of significant stent expansion on fluoroscopy, the pressure gradient disappeared by the end of procedure. The patient made an uneventful recovery and was subsequently discharged.

Follow-up CTA performed 1 month post-stenting revealed no interval collapse of the stent or luminal re-stenosis. The patient was asymptomatic with no upper and lower limb BP discrepancy or haemoglobin drop.

## DISCUSSION

Although the FET technique is now widely used to manage thoracic aortic dissection, postoperative kinking of the stent graft that necessitates secondary intervention has rarely been reported in the literature. FET kinking often occurs at the junction of the distal aortic arch and descending aorta.[1] Risk factors for graft kinking include acute aortic arch angulation, marked true

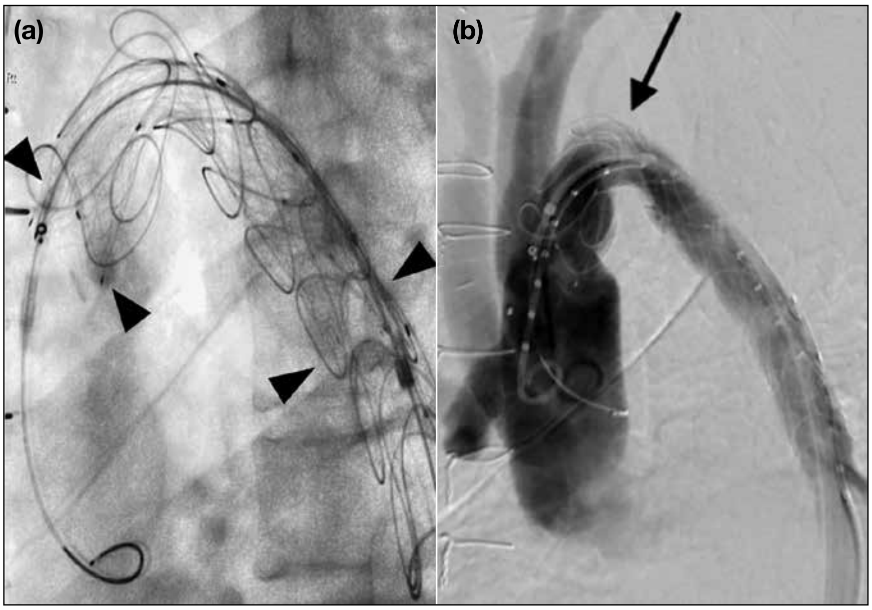


**Figure 2.** (a) Post-stenting and balloon angioplasty radiograph showing successful bare-metal stent deployment (arrowheads) within the frozen elephant trunk. Note the struts of the bare-metal stent are more densely packed than that of the stent graft. (b) Post-stenting and balloon angioplasty digital subtraction angiogram showing satisfactory luminal expansion (arrow).

**Figure 3.** Double oblique sagittal contrast-enhanced computed tomography angiography image showing partial collapse of the bare-metal stent (white arrow) within the frozen elephant trunk (black arrow) at the site of kinking. Note the interval expansion of aortic lumen.

lumen narrowing, a rigid chronic dissection membrane, reperfusion of false lumen, use of a low radial force device or presence of a non-stent part in the FET graft.[2-4] Although rare, kinking can result in coarctation, graft thrombosis, haemolytic anaemia, and heart failure.

Secondary surgery to rectify the kinked graft can be complex and necessitate cardiopulmonary bypass. Endovascular repair offers a minimally invasive option that can be performed under local anaesthesia. Realigning a stent within the kinked graft may provide adequate scaffolding to maintain graft patency. Complications include stent fracture, migration, and collapse.

Graft kinking in this patient was both clinically and radiologically significant, as evidenced by the presence of heart failure, haemolytic anaemia, marked luminal narrowing on imaging, and significant pressure gradient. Possible contributing factors in this case included acute aortic arch angulation, rigid chronic dissection flap, and stenotic true lumen. As angioplasty alone would not have provided adequate scaffolding, alignment of the FET with stent was chosen.

An ideal stent in this scenario would have high radial force without compromised flexibility. Stent grafts are often preferred since they are available in a wide range of sizes, up to 46 mm in diameter, and with tapering property; they also provide additional safety in case of

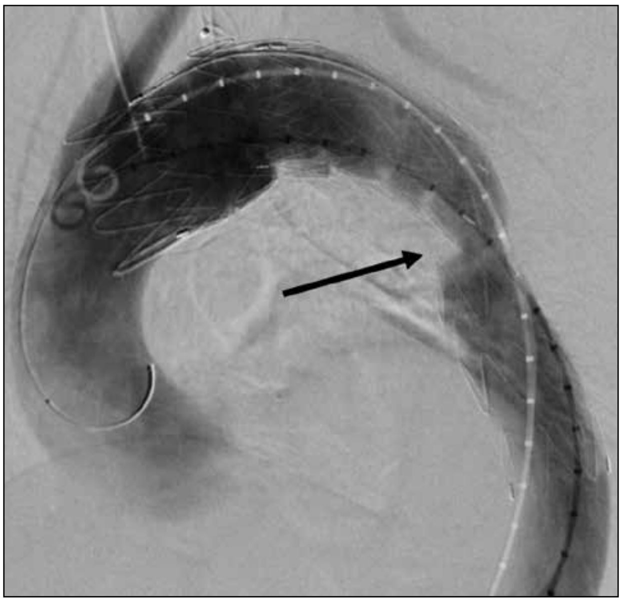

**Figure 4.** Digital subtraction angiogram from a different patient with post–thoracic endovascular aortic repair stent graft–induced new entry (SINE) tear at the distal end of the stent, resulting in significant true lumen narrowing and need for subsequent distal stent graft extension. Post–stent graft extension showed persistent narrowing (arrow) at the site of SINE due to insufficient mechanical support from the fabric between the nitinol rings.

inadvertent aortic rupture during the procedure. In our experience, better support can be achieved by positioning the stent struts at the most stenotic point to maximise mechanical support (Figure 4). This is more achievable with BMS because their stent struts are more densely packed compared with stent grafts where the nitinol rings are typically separated by 10 to 15 mm of fabric.

Sinus-XL is a self-expanding uncovered nitinol stent with a closed-cell design that has been proven to be safe and durable in treating adult aortic coarctation.[5] Despite its low profile and the ability to deliver up to 36 mm stent within a 10-F introducer, we experienced difficulties in traversing the kink and stent deployment because the acute angle prevented outer-sheath retraction by the coaxial pull-back system. This would have been even more challenging if a similarly sized stent graft had been chosen since it would have required 20-F access.

Most stent manufacturers discourage operators from deploying stents across an acute angle due to potential entrapment of the delivery system. Nonetheless stent deployment can be facilitated by methods that straighten the target coverage, as in our patient. Other methods include use of buddy wires or the body flossing technique. These techniques were less appropriate for our patient given the recent surgical anastomosis; overcorrecting the existing anatomy might have increased the risk of anastomosis-related complications. Moreover, degree of stent apposition does not necessarily correlate with the pressure gradient across the kinking, as illustrated in this case. Thus, in cases of tight stenosis, aggressive balloon dilatation to pursue a ‘perfectly’ expanded stent may not be necessary and should be avoided.

In conclusion, FET stent graft kinking is rarely encountered but can result in significant haemodynamic consequences. Endovascular stenting is a safe and effective alternative to surgery. In our patient, we illustrate the advantages of a BMS over a stent graft in offering more focal support to the kinked portion in a low-profile setting. Stenting across the severely kinked graft can be technically challenging and require additional manoeuvres, as demonstrated by our case.

To date, no study has compared BMS with covered stents for treatment of aortic coarctation; head-to-head bench comparison with reference to radial forces is also lacking. Although we believe that endovascular repair can be considered for patients with FET graft kinking to avoid a second major operation, the decision to use a BMS or covered stent should be tailored to the individual and take account of the underlying pathology and anatomy.

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