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Case report of retrograde in situ fenestration of the thoracic stent graft with reentry device in a patient with aortobronchial fistula

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Abstract

Rationale: *In situ* fenestration may be necessary to preserve branch arteries during thoracic endovascular aortic repair (TEVAR) when there is an inadequate landing zone.

Patient concerns: We report the case of a 74-year-old man presenting with recurrent hemoptysis.

Diagnoses: Based on computed tomography (CT) angiogram and bronchoscopy, diagnosis was aorto-bronchial fistula.

Interventions: We performed retrograde *in situ* fenestration with reentry catheter (Pioneer Plus, Volcano Corporation, San Diego, CA) to preserve the left subclavian artery following TEVAR for aorto-bronchial fistula.

Outcomes: Following this procedure, the patient had a patent left subclavian artery and no evidence of endoleak. The patient had no further episodes of hemoptysis.

Lessons: The retrograde *in situ* fenestration with reentry catheter strategy is an option for patients when carotid-subclavian bypass is deemed unsafe.

Abbreviations: CT = computed tomography, EGD = esophagogastroduodenoscopy, EVAR = endovascular aneurysm repair, IVUS = intravascular ultrasound, TEVAR = thoracic endovascular aortic repair.

Keywords: aortobronchial fistula, in situ fenestration, reentry catheter, thoracic endovascular aortic repair

1. Introduction

The Society for Vascular Surgery recommends revascularization of the left subclavian artery when thoracic endovascular aortic repair (TEVAR) proximal seal requires subclavian artery coverage.[1] This recommendation has been promoted since left subclavian artery coverage trends toward an increased risk of paraplegia, anterior circulation stroke, arm ischemia, and vertebrobasilar ischemia.[1] Carotid-subclavian bypass or transposition is the gold standard for revascularization of the left subclavian artery for zone II landing during TEVAR. However, carotid-subclavian bypass or transposition is not without risk. Potential complications of carotid-subclavian bypass include stroke, bleeding, injury to the thoracic duct, phrenic nerve, and brachial plexus. To that end, several groups have explored endovascular alternatives to carotid-subclavian bypass such as chimney or in situ fenestration.[2,3]

In situ fenestration of TEVAR endografts were first described by McWilliams et al[4] in 2004 as a technique to preserve blood flow to the left subclavian artery. Several groups have reported techniques for in situ fenestration using a needle, guidewire, or energy source to create a fenestration in the endograft.[5–7] This report describes a successful retrograde in situ fenestration of the thoracic stent graft using reentry catheter.

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2. Ethical statement

This study was approved by the institutional review board at University of Wisconsin—Madison. Informed consent was obtained from the patient for publication of this report.

3. Case report

A 74-year-old Caucasian man presented with recurrent hemoptysis. He had a history of coronary artery disease, chronic kidney disease stage III, diabetes mellitus type II, and infrarenal abdominal aortic aneurysm status post endovascular aneurysm repair (EVAR). On presentation, he had normal vital signs and an unremarkable physical examination. He had an extensive workup of his hemoptysis with esophagogastroduodenoscopy (EGD), bronchoscopy, and computed tomography (CT) angiogram. His EGD was negative for active bleeding but bronchoscopy showed extrinsic compression of the distal third of the trachea. Endobronchial ultrasound demonstrated aortic diverticulum 3 mm from the trachea at the level of the tracheal compression. CT angiogram demonstrated 6 mm pseudoaneurysm of the thoracic aorta just distal to the takeoff of the subclavian artery (Fig. 1). CT angiogram also demonstrated thickening and signs of vasculitis of the thoracic aorta and great vessels. The imaging findings and patient's symptoms were consistent with aortobronchial fistula.

We proceeded with a planned TEVAR with zone II landing and left carotid-subclavian bypass. The carotid artery was explored

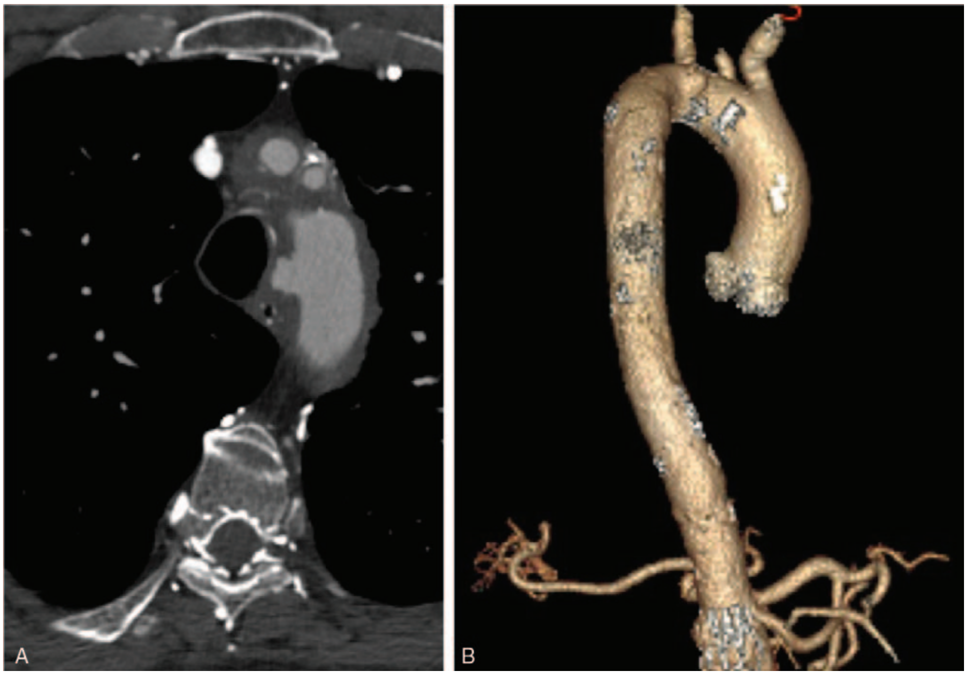

Figure 1. (A) CT angiogram depicting 6 mm penetrating aortic ulcer. (B) Three-dimensional reconstruction of CT angiogram. CT = computed tomography.

for bypass but the artery and surrounding tissue were severely inflamed. Instead, we proceeded with bail out retrograde in situ fenestration of the left subclavian artery with the reentry catheter (Pioneer Plus, Volcano Corporation, San Diego, CA). We exposed the left axillary artery and placed a 7 French Destination sheath (Terumo, Tokyo, Japan) into the ascending aorta. We accessed the right common femoral artery percutaneously and thoracic stent graft (32 mm × 10 cm, RelayPlus, Bolton Medical, Sunrise, FL) was advanced into the thoracic aorta. We deployed the RelayPlus stent graft while the 7 French Destination sheath was in place from the left axillary access. The 7 French Destination sheath was withdrawn, leaving a wire from the left axillary artery into the ascending aorta.

The Pioneer Plus catheter was advanced over the wire from the left axillary artery. Using intravascular ultrasound (IVUS) and fluoroscopy, we directed reentry needle and punctured the stent graft and advanced a 0.014 wire into the ascending aorta (Fig. 2A). We then serially ballooned open the stent graft by first using a 1.5 × 20 mm balloon followed by a 4 × 20 mm balloon. We exchanged the 0.014 wire for an 0.035 wire (Advantage Glide wire, Terumo), and advanced and deployed a 10 mm × 38 mm covered stent graft (iCast, Atrium Medical, Hudson, NH) stent through the fenestration into the inside of stent graft (Fig. 2B). We postdilated the proximal stent with a 20 × 40 mm balloon to flare the stent and also ballooned the distal stent with an 8 × 40 mm balloon. Completion angiogram demonstrated patency of the innominate artery, left carotid artery, and fenestrated left subclavian artery without evidence of endoleak (Fig. 2C).

The patient tolerated the operation well, and he had an unremarkable postoperative course. He had no symptoms of stroke or spinal cord ischemia following the procedure. He was discharged home from the hospital on postoperative day 4.

The patient was seen at 1-month follow-up with CT angiogram that demonstrated patency of the left subclavian artery without

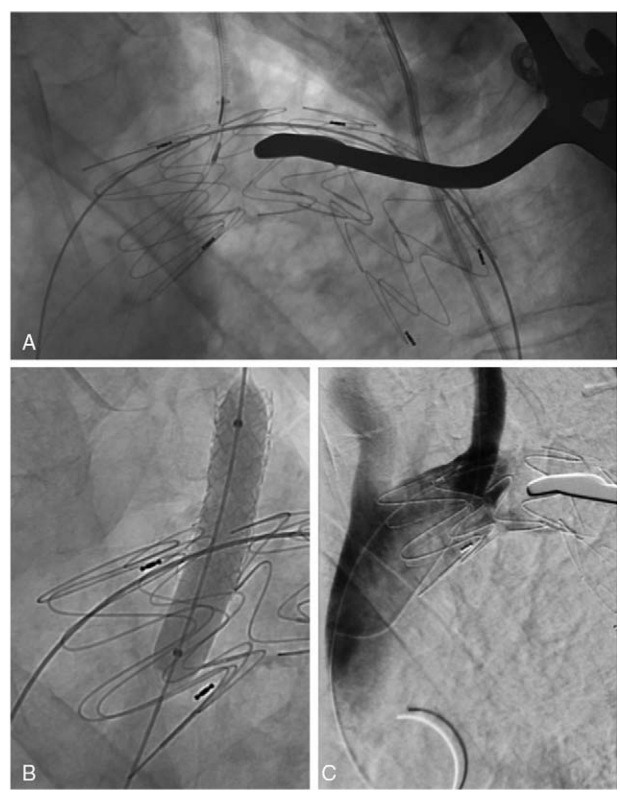

Figure 2. Intraoperative angiogram. (A) Puncture of RelayPlus stent graft (Bolton Medical, Sunrise, FL) with the Pioneer Plus catheter (Volcano Corporation, San Diego, CA). (B) iCast (Atrium Medical, Hudson, NH) stent deployment through RelayPlus fenestration. (C) Completion angiogram depicting patent left subclavian artery without endoleak.

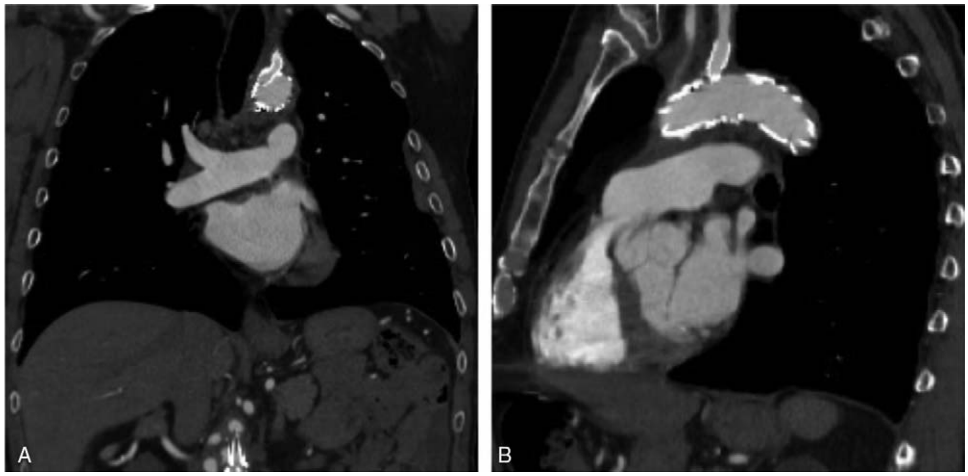

Figure 3. One-month follow-up CT scan depicting patent in situ fenestration of left subclavian artery without endoleak in (A) coronal and (B) sagittal reconstructions. CT = computed tomography.

any stenosis and no evidence of endoleak as depicted in Fig. 3. The patient has not had any further episodes of hemoptysis.

4. Discussion

In this article, we report a case of successful retrograde in situ fenestration of the thoracic stent graft using reentry catheter. Retrograde in situ fenestration offers an alternative to left carotid-subclavian bypass, chimney technique, or fenestrated and branched stent grafts.[8–10] Several techniques for retrograde in situ fenestration have been described by puncturing stent grafts using percutaneous transhepatic cholangiodrainage needles, guidewires, and laser catheters.[11,12] Laser catheters have been favored by some groups to prevent fraying of graft material and more forgiving in tortuous anatomy compared to needle fenestration.[11] The reentry catheter is a good alternative to the needle or laser fenestration.

There are no clinical trials comparing in situ fenestration to carotid-subclavian bypass or chimney technique. A potential benefit compared to carotid-subclavian bypass is the minimally invasive nature of the procedure and not having to clamp the carotid artery, which we hypothesize would result in fewer strokes. Furthermore, in contrast to bypass surgery, retrograde in situ fenestration could potentially be performed with minimally invasive fashion without extensive supraclavicle exposure or neck incision, which may benefit patients with higher risk for invasive procedures.

While there is limited outcomes data on retrograde in situ fenestration of the thoracic stent graft, we believe there is less probability for developing endoleaks compared to the chimney technique. This is supported by Crawford et al's[11] analysis of 46 reported cases of in situ fenestration, which demonstrated 9.1% of reported cases developed endoleak.[11] This is compared to up to 18% rate of endoleak with the chimney technique.[2]

The major challenges of retrograde in situ fenestration include precisely targeting the fenestration site and safely perforating the stent graft. A potential concern for perforating a stent graft with a reentry catheter is creating tears in the fabric, especially after balloon dilation. Riga et al[13] analyzed various stent graft needle puncture and balloon dilation angles and found that the grafts should be punctured and dilated orthogonally to prevent fabric tears. Cutting balloons were also associated with increased fabric tears.[13] Amid concerns of graft or thrombus embolization during in situ fenestration, Sonesson et al performed laser fenestration with an embolic filter in place in animal models. They did not find any embolic debris in the filter after performing laser fenestration.[12] However, no study has evaluated the potential for toxic molecules released when Dacron or Polytetrafluorethylene graft is vaporized or melted during laser or RF in situ fenestration. We favor the use of the reentry catheter with integrated IVUS given the ability to precisely puncture the stent graft under both IVUS and fluoroscopic guidance. An advantage of using the Pioneer Plus catheter in particular over other in situ fenestration methods is in tortuous subclavian arteries where is it difficult to align the catheter in the proper orientation toward the TEVAR stent graft. Furthermore, with the Pioneer Plus strategy, it is possible to convert to the chimney technique since wire access is maintained from the subclavian artery into the ascending aorta.

As in situ fenestration is a new procedure and outside the manufacturer's instructions for use (IFU), there is limited information on the long-term outcomes. A potential complication from in situ fenestration is endoleak, especially given the limited landing zone of the fenestration stent graft into the TEVAR. The risk of this type III endoleak is reduced by flaring the fenestration stent into the TEVAR. There may be unknown consequences of modifying stent grafts that have yet to be reported.

Long-term follow-up of patients who underwent in situ fenestration is needed to determine the safety and durability of this technique. In conclusion, the Pioneer Plus catheter can be successfully used for in situ fenestration, and it is a reasonable bail-out technique when carotid-subclavian bypass is not safe or feasible.

Author contributions

Conceptualization: Alexander Leung, Dai Yamanouchi.
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Project administration: Dai Yamanouchi.
Supervision: Dai Yamanouchi.

Writing – original draft: Alexander Leung.
Writing – review & editing: Alexander Leung, Dai Yamanouchi.

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