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CASE REPORT

Antegrade *In Situ* Fenestration During Thoracic Endovascular Aortic Repair for Preserving Isolated Left Vertebral Artery

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Introduction: An isolated left vertebral artery (ILVA) on the aortic arch with aortic arch pathologies is common, but how to preserve the ILVA blood flow during endovascular repair remains challenging. Several strategies have been reported but there is still no consensus on the best treatment. This case report presents a novel totally endovascular technique for ILVA revascularisation using antegrade *in situ* needle assisted fenestration without neck surgical procedures.
Report: A 72 year old man with an ILVA and an incomplete circle of Willis underwent endovascular repair of an aortic arch dissection aneurysm. A 30—26 x 160 mm polytetrafluoroethylene aortic stent graft (Ankura; Lifetech, Shenzhen, China) was deployed proximally in zone 2 of the aortic arch covering the primary tear together with the ILVA and left subclavian artery (LSA). A 6F steerable sheath was placed in the LSA through brachial access, and another 6F long sheath with an adjustable puncture needle was introduced through the right femoral access and placed against the ILVA ostium with the guidance of LSA angiography. Antegrade ILVA fenestration was successfully performed using a needle, and a 0.018 inch guidewire was introduced through the puncture hole, followed by balloon dilation and implantation of a 4.5 × 12 mm balloon expandable bare stent (Dynamic; Biotronik, Bulach, Switzerland). The LSA was reconstructed using a retrograde *in situ* needle fenestration technique through the steerable sheath from left brachial access, and a 9 × 50 mm Viabahn stent graft was deployed. Post-operatively, the patient recovered uneventfully without neurological deficit. One year follow up imaging confirmed patent ILVA and LSA, and favourable aortic remodelling without any leakage.
Conclusion: This case suggests that the totally endovascular technique of antegrade *in situ* fenestration is feasible and effective for preserving an ILVA.

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INTRODUCTION

The management of aortic arch pathologies involving branch artery variations is difficult, increasing the incidence of adverse events. Approximately 33.5% of patients with thoracic aortic disease have aortic arch branch variations, with the incidence of isolated left vertebral artery (ILVA) being 0.79—6.1%.[1] An ILVA refers to the left vertebral artery directly originating from the aortic arch rather than the left subclavian artery (LSA), and the variation is usually located between the LSA and left common carotid artery. How to preserve the ILVA blood flow during thoracic endovascular aortic repair (TEVAR) is still quite challenging. Current literature has reported several strategies such as the surgical transposition technique, *in vitro* fenestration, and chimney technique to reconstruct the ILVA; these strategies have their advantages and disadvantages but there is still no consensus on the best treatment strategy.[2—6] The current team previously reported the technique of retrograde *in situ* fenestration to reconstruct an ILVA, which needs a neck incision to expose the ILVA to perform the puncture.[7] This case report presents a novel totally endovascular technique for ILVA revascularisation using antegrade *in situ* needle fenestration without any neck surgical procedure. Informed consent was obtained from the participant in this case study. All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional (approved) and with the 1964 Helsinki Declaration and its later amendments or comparable ethical standards.

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CASE REPORT

A 72 year old man with a non-dominant ILVA (Fig. 1A and B) and an incomplete circle of Willis underwent endovascular repair of an aortic arch dissection aneurysm. The diameter of the ILVA was approximately 4 mm. A 30–26 x 160 mm tapered polytetrafluoroethylene aortic stent graft (Ankura; Lifetech, Shenzhen, China), the proximal part of which was bare, was deployed in zone 2 of the aortic arch covering the primary tear together with the ILVA and LSA (Fig. 1C and D). The ILVA and LSA were reconstructed using antegrade and retrograde *in situ* needle fenestration, respectively. A 6F steerable sheath (Fu-star; Lifetech, Shenzhen, China) was placed in the LSA (Fig. 2A and B, white arrow) through brachial access, and another 6F long sheath with an adjustable puncture needle (Fu-through; Lifetech, Shenzhen, China) (Fig. 2A and B, black arrow) was introduced through the right femoral access and placed against the ILVA ostium with the guidance of LSA angiography. After validation of the direction of the puncture device in different projection angles (Fig. 2A and B), antegrade ILVA fenestration was successfully performed using a needle, and a 0.018 inch guidewire was introduced through the puncture hole into the ILVA (Fig. 2C). The position of the guidewire in the ILVA was also confirmed by angiography through the steerable sheath in the LSA (Fig. 2D), which was then followed by gradual dilation of the fenestration using 3 mm and 4 mm balloons. The 0.018 inch wire was then replaced with a 0.014 inch guidewire to deploy a 4.5 x 12 mm balloon expandable bare stent (Dynamic; Biotronik, Bulach, Switzerland) through the fenestration into the ILVA. Subsequently, the LSA was reconstructed using a retrograde *in situ* needle fenestration technique through the steerable sheath from left brachial access and a 9 x 50 mm Viabahn stent graft (Gore & Associates Inc., Flagstaff, AZ, USA) was deployed and post-dilated. Completion angiography showed successful exclusion of aortic dissection and patent aortic arch branches (Fig. 3A). Post-operatively, the patient recovered uneventfully without neurological deficit. One year follow up imaging confirmed patent ILVA and LSA and favourable aortic remodelling without any leakage (Fig. 3B and C).

DISCUSSION

An ILVA on the arch with aortic arch pathologies is common, but few cases have been reported. During TEVAR for aortic arch pathologies with an ILVA, the proximal landing zone, dominance of the vertebral artery, and integrity of the circle of Willis should be thoroughly evaluated. If the landing zone is inadequate, the LSA and ILVA need to be covered. However, ILVA occlusion may lead to posterior craniocerebral circulation ischaemia and even stroke or spinal cord ischaemia, especially in patients with an incomplete circle of Willis. Yang *et al.* recommended that all patent ILVAs should be preserved if possible because the prevalence of complete circle of Willis is 27% in the Chinese population.[8] The current authors also prefer a relatively positive strategy to manage ILVA.

There are several techniques for the reconstruction of the ILVA, most of which need surgical procedures with significant morbidity. Potter *et al.* reported that 17 patients underwent ILVA to carotid transposition as an adjunct for the management of aortic disease.[2] There was no peri-operative stroke, but there were two cases of hoarseness, presumably owing to recurrent laryngeal nerve palsy. The transposition procedure is invasive; thus, endovascular techniques were considered to reconstruct ILVA. Zhang *et al.* reported the *in vitro* fenestration technique and novel chimney technique (the right brachial–left brachial through and through procedure) to reconstruct the ILVA blood flow.[3] No deaths or new neurological symptoms occurred within 30 days, and all patients had unobstructed antegrade flow in the ILVA. However, the rate of early and midterm type Ia endoleak was higher in the *in vitro* fenestration and novel chimney technique groups than in the transposition technique group. Shen *et al.* reported three cases of retrograde *in situ* fenestration technique for ILVA revascularisation via a left neck incision;[7] there was no endoleak or re-intervention during the follow up period.

Based on the previous experience of *in situ* fenestration, the current team tried, for the first time, to perform the antegrade *in situ* fenestration technique to reconstruct ILVA

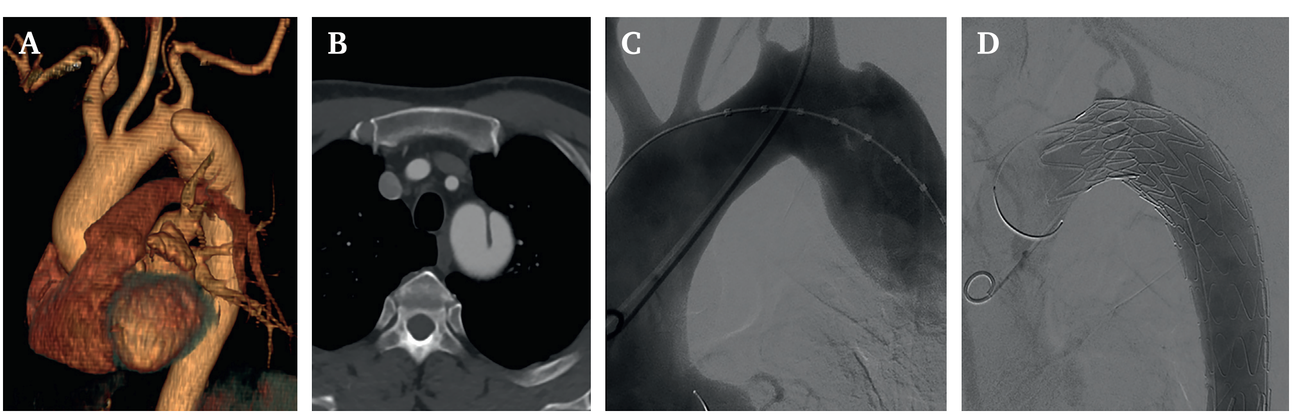

Figure 1. A, B. Pre-operative computed tomography angiography showing an aortic arch dissection aneurysm with an isolated left vertebral artery (ILVA), which arose from the top of the aortic arch with a diverticular orifice. C. Intra-operative angiography confirmed the aortic arch dissection aneurysm with an ILVA. D. A covered stent graft was deployed in the aortic arch covering the primary tear of the dissection, ILVA, and left subclavian artery.

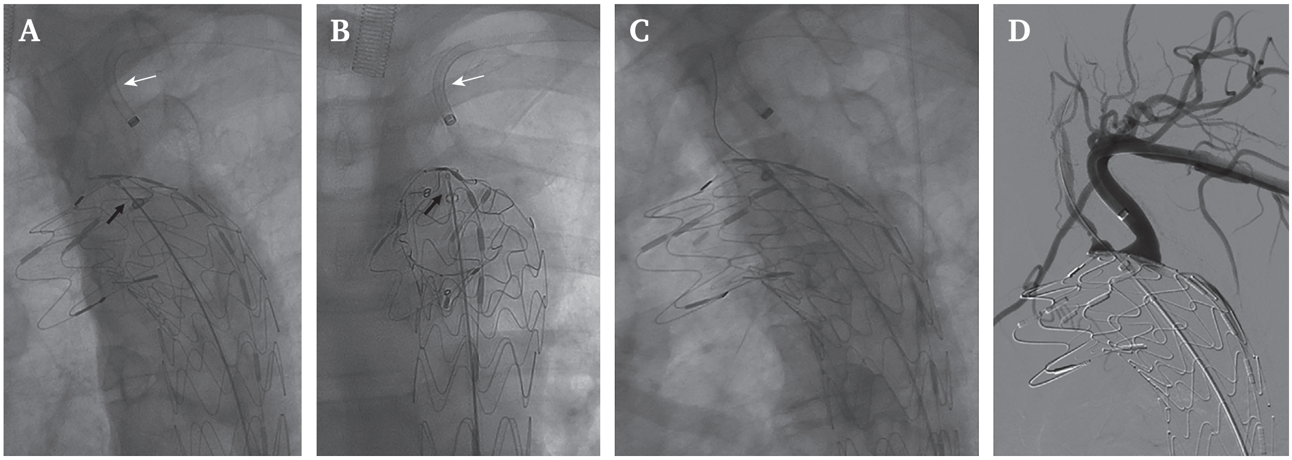

Figure 2. A, B. A 6F steerable sheath (white arrow) was placed in the left subclavian artery through brachial access to perform the angiography to display the isolated left vertebral artery (ILVA) ostium. Another 6F long sheath with an adjustable puncture needle (black arrow) was introduced into the aortic arch through the right femoral access and placed against the ILVA ostium confirmed in different projection angles. C. Antegrade *in situ* fenestration was performed using a needle followed by advancing a 0.018 inch guidewire via the puncture hole into the ILVA. D. The location of the guidewire in the ILVA was confirmed with angiography through the left subclavian artery.

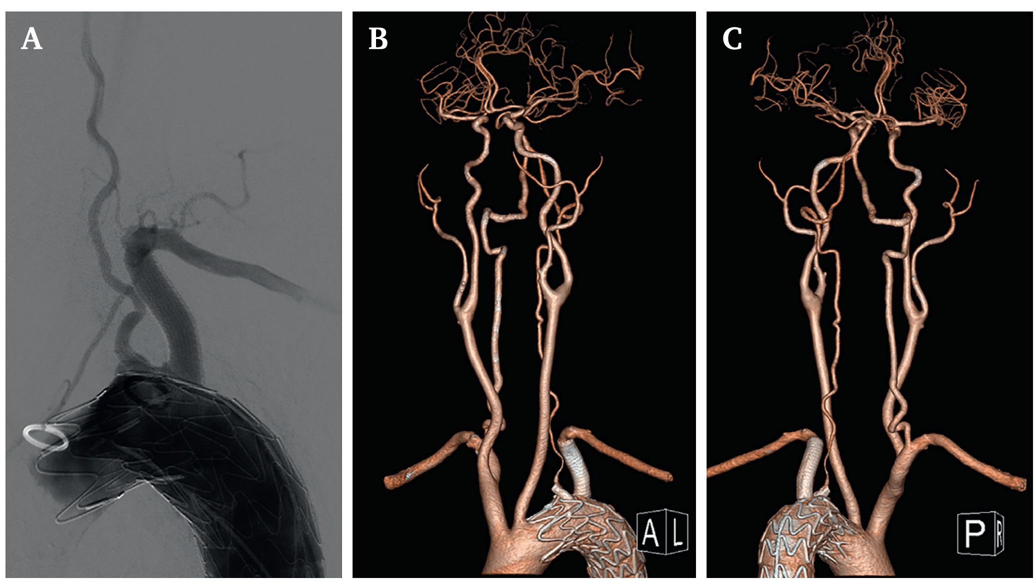

Figure 3. A. Completion angiography showing successful exclusion of aortic dissection and patent isolated left vertebral artery (ILVA) and left subclavian artery (LSA). B, C. Post-operative one year follow up imaging showing patent ILVA and LSA and favourable aortic remodelling.

in a totally endovascular way without any cervical surgical procedure. Although the success of the technique seemed not guaranteed, the team think that it is reproducible in appropriate patients. The direction of the puncture was determined by angiography through the LSA, which can show the image of the ILVA. It was preferred not to pre-stent in such a small target vessel. A suitable morphology of the aortic arch (types 1 and 2) and the relatively large ILVA ostium ($\geq$4 mm) will facilitate the success of the technique.

This case suggests that the totally endovascular technique of antegrade *in situ* fenestration can be considered a viable option with which to preserve an ILVA by an experienced *in situ* fenestration team when the ostium of the ILVA is relatively large.

CONFLICT OF INTEREST

No conflict of interest.

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