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Case Report

Fenestrated Endovascular Repair with Debranching Technique for Blunt Traumatic Isthmus Injury

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Thoracic endovascular repair (TEVAR) is a safe treatment alternative to open repair for blunt traumatic aortic injury (BTAI). A 29 year-old-female had multiple traffic injuries, including BTAI located in lesser curve of the isthmus close to the left common carotid artery with an isolated left vertebral artery. TEVAR with simple covering of the left subclavian artery was not adequate to prevent the endoleak. We considered fenestrated TEVAR with RELAY® PLUS to ensure blood flow to the left common carotid artery and reconstruction of the left isolated vertebral and left subclavian artery. The fenestrated TEVAR with a debranching technique provided good results without device-related complications.

Keywords: blunt traumatic aortic injury, fenestrated thoracic endovascular repair, polytraumatized patient

Introduction

Blunt traumatic aortic injury (BTAI) is the second most lethal traumatic injury. Thoracic endovascular repair (TEVAR), which was recently introduced as the first treatment to improve survival rate, is a safe and attractive alternative to open repair. Recent studies reported that TEVAR resulted in lower mortality and neurological complication rates than open surgery, with low long-term device-related complication rates.[1–3)]

BTAI commonly occurs in the aortic isthmus near the left subclavian artery, which requires covering the left subclavian artery to prevent endoleak in TEVAR. Generally, TEVAR with simple covering of the left subclavian artery provides an appropriate landing, without left upper limb ischemia and paraplegia.[1–4)] However, in BTAI, treatments near the left common carotid artery (CCA) are controversial. We describe a successful case of fenestrated TEVAR with a debranching technique for BTAI, close to the left CCA, with an isolated left vertebral artery (VA) in a polytraumatized patient.

Case Report

A 29-year-old female was transferred to our hospital after being struck by a motor vehicle and was promptly intubated for respiratory failure. Computed tomography (CT) angiography showed a BTAI in the lesser curve of the proximal descending aorta with a hematoma, an extravasation, and a large (35 mm) pseudoaneurysm (**Fig. 1**). Other injuries included left orbital blowout fractures, rib fractures with pneumohemothorax, and stable pelvic fractures. The BTAI was a Grade IV injury, evidenced by extravasation as a rupture, and required emergent surgery although the patient's hemodynamics were stable. We considered immediate fenestrated TEVAR combined with a debranching technique because the BTAI was close (<1 cm) to the left CCA, and the left VA branched from the aortic arch individually.

Under general anesthesia, we first performed a left CCA to left axillary artery bypass and reconstructed the left VA through the left cervical and subclavian incision. A 6-mm GORE PROPATEN (W.L. GORE & Associates Inc., Flagstaff, AZ, USA) graft was passed through a route between the left internal jugular vein and the anterior scalenus muscle under the left clavicle, from the left CCA to the left axillary artery, using a Kelly clamp. After administering heparin (50 units/kg), thiopental, and steroid to prevent brain edema, we anastomosed the left CCA to the graft and left VA under simple clamping of the left

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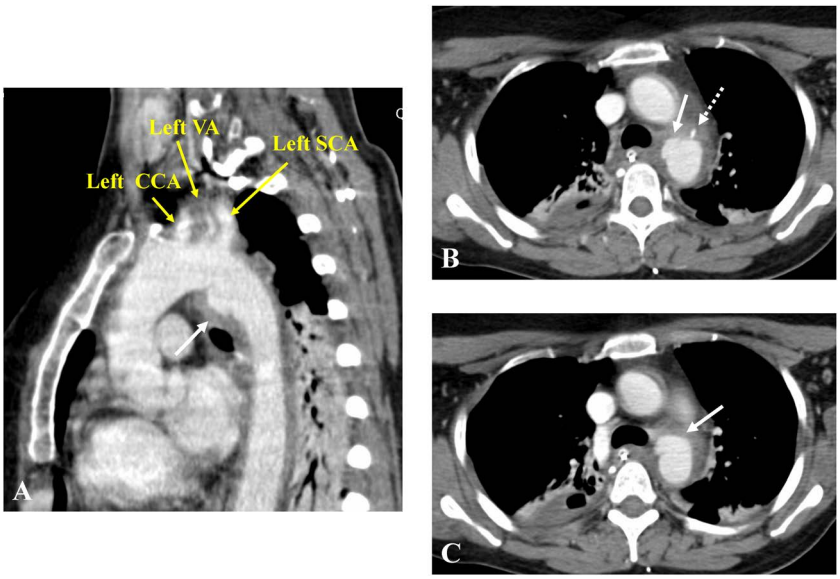

Fig. 1 Computed tomography angiography before surgery.
A: Sagittal plane showed blunt aortic injury at the isthmus (white arrow), close to the left CCA (<1 cm) with an isolated left VA. CCA: common carotid artery; VA: vertebral artery; SCA: subclavian artery
B, **C**: Axial plane revealed extravasation (broken line arrow) and large pseudoaneurysm (white arrow) with hematoma.

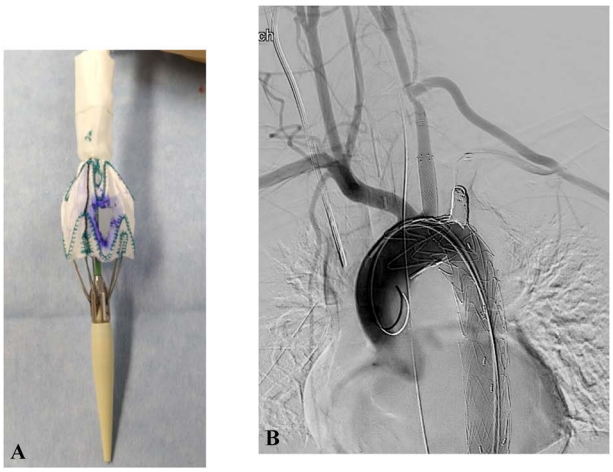

Fig. 2 Intraoperative findings.
A: Fenestrated stent graft between the first and second stents. The hole size was 1.5 cm×1.2 cm cut using a cautery system. **B**: Angiography showed no endoleak with good patency of the left subclavian artery and reconstructed vertebral artery.

CCA. The graft was then anastomosed laterally to the left axillary artery. During bypass grafting, the patient's hemodynamics showed no aggravation. After bypass grafting, we made the fenestrated stent graft with RELAY® PLUS (Bolton Medical Inc., Sunrise, FL, USA) (**Fig. 2a**). Because of the diameter difference between the aortic arch and the descending aorta, we used a stent graft (24-mm diameter, 100-mm length, 15% oversizing) in the descending aorta. Then we placed the fenestrated stent graft (28-mm diameter, 150-mm length, 15% oversizing) from the distal to the brachiocephalic artery to the descending aorta, via the right common femoral artery, under balloon occlusion of the left subclavian artery. The bare metal stent (8 mm×40 mm S.M.A.R.T CONTROL® Self-Expanding Stent: Cardinal Health Inc., Dublin, OH, USA) was deployed in the left CCA orifice to prevent left CCA stenosis or occlusion. Finally, we performed balloon dilatation of the stent graft and coil embolization of the proximal left subclavian artery. Angiography showed no endoleak with good blood flow of the bypass graft (**Fig. 2b**). Heparin was reversed postprocedure using protamine. The operation time was 210 min. There was no significant clinical issue of upper-extremity blood pressure although the left arm blood pressure was slightly lower (about 15 mmHg) than the right arm.

After the TEVAR, the patient was extubated on postoperative day 1 without brain damage or paraplegia. The chest tube was removed with full expansion of the right lung and no air leakage. CT angiography showed adequate covering of the aortic injury by stent graft without endoleak (**Fig. 3**). The patient then underwent fracture reduction and iliac bone transplantation for her left orbital blowout fracture. The stable pelvic fracture was managed conservatively. She was transferred to a rehabilitation hospital on postoperative day 37. After the discharge from rehabilitation hospital, she returned to our hospital for follow-up visit, doing well with no complications associ-

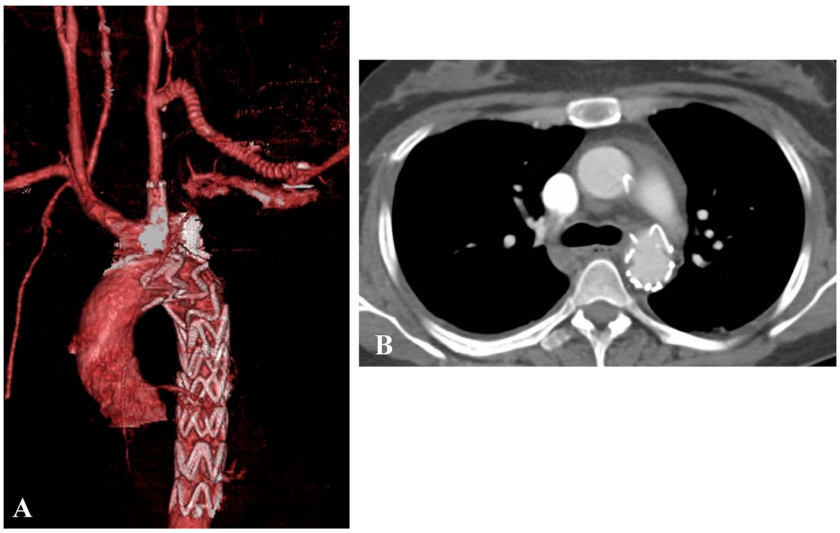

Fig. 3 Computed tomography (CT) angiography after surgery.
A: Three-dimensional-CT. **B**: Axial image.

ated with stent graft for over six months.

Discussion

BTAI is associated with a high mortality rate; up to 30% of patients die within 24 h of admission.[5] We successfully treated a patient with a Grade IV BTAI close to the left CCA using an isolated left VA and fenestrated TEVAR with a debranching technique.

TEVAR for aortic isthmus injury just distal to the origin of left subclavian artery commonly requires covering the left subclavian artery to prevent endoleak. Recent studies showed that almost all TEVAR with simple coverage of the left subclavian artery did not require additional interventions.[1–4] Therefore, simple coverage of the left subclavian artery may not require reconstruction in emergency situations. However, in this patient, who had an isolated left VA, coverage of the left subclavian artery required reconstruction to prevent left upper limb ischemia. Moreover, the distance between the left CCA and aortic isthmus was minimal, which required adequate apposition, just distal to the brachiocephalic artery origin, to prevent endoleak. In this situation, the two-debranching technique secures an adequate proximal landing, but this technique can increase the risk of stroke and requires additional operative time compared with the one-debranching technique.[6] Open repair should also be considered, but it was not possible for this polytraumatized patient with a head injury. Furthermore, BTAI commonly occurs in the aortic arch's lesser curve, on the opposite side of the arch vessels, allowing a fenestrated technique different from an aortic aneurysm. We performed the fenestrated TEVAR with a left CCA–left subclavian artery bypass and reconstructed the left VA without endoleak or neurological complications.

Creating fenestration of a stent graft demands the re-storage stent graft system because the fenestration must be done by hand in emergent situations. The RELAY stent graft with a double sheath delivery system can undergo re-storage in a stent graft sheath, and a unique spiral support strut for longitudinal support at the outer curvature makes it more adaptable to the aortic arch's inner curvature.[7] This stent graft system allows it to advance to the aortic arch by gearing the spiral support strut toward the aortic arch's greater curvature. The fenestrated site of the stent graft naturally fits the arch vessels after advancing the stent graft to the aortic arch. The RELAY stent graft may be suitable for performing the fenestrated TEVAR because of its unique stent graft system.

Stent graft size is an important factor associated with stent graft collapse after TEVAR. A graft that is too large or too small may cause the device to collapse after TEVAR for BTAI.[8,9] Therefore, 10–20% oversizing of aortic diameter at the attachment site is recommended for younger BTAI patients because they may develop a dilated aorta in the future. Hemodynamic collapse is associated with a smaller-sized aorta compared to normal hemodynamics.[2] We also used 15% oversizing in relation to the aortic diameter at the attachment site, which led to a good result without device collapse.

Conclusion

The fenestrated TEVAR with a debranching technique provided good results without procedure-related or neurological complications in patients who had BTAI close to the left CCA.

Disclosure Statement

The authors have no conflict of interest.

Author Contributions

Study conception: AM
Data collection: AM, ES, KY
Analysis: AM, HF, TS
Investigation: AM, ES
Writing: AM
Critical review and revision: all authors
Final approval of the article: all authors
Accountability for all aspects of the work: all authors

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