Trans-sternotomy, snare-assisted thoracic endovascular aortic repair for redirection of a migrated elephant trunk

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ABSTRACT

The two-stage elephant trunk (ET) and thoracic endovascular aortic repair technique for type A and B aortic dissection can result in complications between the two stages. We have presented the case of a patient with an acute-on-chronic type B aortic dissection complicated by ET kinking and migration into the false lumen. We used a hybrid approach consisting of a first stage (retrograde thoracic endovascular aortic repair) and a second stage ("body floss" with antegrade thoracic endovascular aortic repair) to successfully reposition the ET back into the true lumen. (J Vasc Surg Cases Innov Tech 2023;9:1-4.)

Keywords: Ascending aortofemoral through-and-through wire technique; Body floss; False lumen graft deployment; Hybrid prosthesis; Kinked elephant trunk

The two-staged elephant trunk (ET) technique is a hybrid open and endovascular approach to treat aortopathy when ascending and descending aortic surgery is indicated.[1] Although with a lower incidence of morbidity compared with the open approach,[2] lethal complications can arise between the two stages. In the present report, we have described the management of a kinked first-stage ET that had migrated to the false lumen (FL). The case report has been de-identified, and the patient provided written informed consent for the report of her case details and imaging studies.

CASE REPORT

A 51-year-old woman with a history of hypertension, diabetes, obesity, chronic obstructive pulmonary disease, peripheral vascular disease, and dissection (zones 1-9) presented with severe back pain. Three years earlier, she had undergone aberrant right subclavian artery debranching with aorta–subclavian artery bypass and total arch replacement with common carotid artery trunk, left subclavian artery, and vertebral artery island reimplantation and an ET. Computed tomography (CT) angiography demonstrated an acute-on-remnant type B aortic dissection with a 7.5-cm aneurysm in zones 3 and 4. The new and old dissection flaps had created a triple lumen with the 15-cm ET situated in the FL of zone 4 (Fig 1, *A*). Deeming the patient at high risk for open thoracoabdominal surgery, we undertook a staged, hybrid procedure.

Because of the ET's tortuosity and zone 2 and 3 instability, we initially performed a retrograde thoracic endovascular aortic repair (TEVAR) with a 15% oversize 32 × 28 × 150-mm stent graft in zones 4 and 5, augmenting the distal true lumen (TL) and creating a landing zone for the second-stage antegrade TEVAR (Fig 1, *B*). After an uneventful first stage, we began the redo sternotomy but were concerned about a chest reentry injury because the CT scan showed the aortic graft attached to the sternum's posterior table with an unclear dissection plane. In preparation, we initiated cardiopulmonary bypass without deep hypothermic arrest by cannulating the left axillary artery and left common femoral vein.

An end-to-end graft was sewn to the right subclavian artery graft and accessed via a micropuncture technique and an 11F short sheath (Fig 2, *A*). Given the tortuous, long migrated ET, we created a coaxial system with an 11F access sheath, an 8.5F steerable Tourguide sheath (Medtronic, Santa Rosa, CA), a Berenstein catheter (Cook Medical Inc, Bloomington, IN), and an 0.035-in. Glide Advantage wire (Terumo Interventional Systems, Somerset, NJ), traversed the ET, and landed in the zone 3 aneurysmal FL (Fig 2, *B*). We accessed the FL in a retrograde manner through the first-stage TEVAR and introduced an EnSnare system (Merit Medical, South Jordan, UT). An antegrade, trans-sternotomy Lunderquist wire (Cook Medical Inc) was then snared and externalized out the right femoral artery, creating an ascending aortofemoral "body floss" (Fig 2, *C*). This bisectional, body floss-on-tension overcame the tortuous ET and enabled its redirection back into the TL.

We reaffirmed TL access using angiography and intravenous ultrasound before performing the antegrade, trans-sternotomy TEVAR with a 34 × 34 × 150-mm stent graft (Terumo Interventional Systems). This bridged the ET with our first-stage TEVAR

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Author conflict of interest: P.V. serves on the medical advisory board for Terumo Aortic. N.N. serves as speaker or proctor for the medical advisory board for Terumo Aortic and Medtronic Aortic. S.F. and A.A. have no conflicts of interest.

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The editors and reviewers of this article have no relevant financial relationships to disclose per the Journal policy that requires reviewers to decline review of any manuscript for which they may have a conflict of interest.

2468-4287

https://doi.org/10.1016/j.jvscit.2023.101095

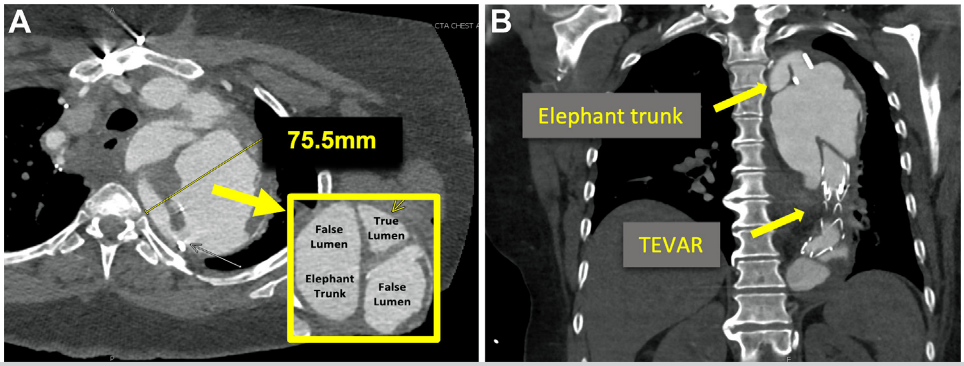

Fig 1. **A,** Preoperative presentation showing three lumens with the elephant trunk (ET) in the false lumen (FL). **B,** First-stage thoracic endovascular aortic repair (TEVAR) in the descending thoracic aorta.

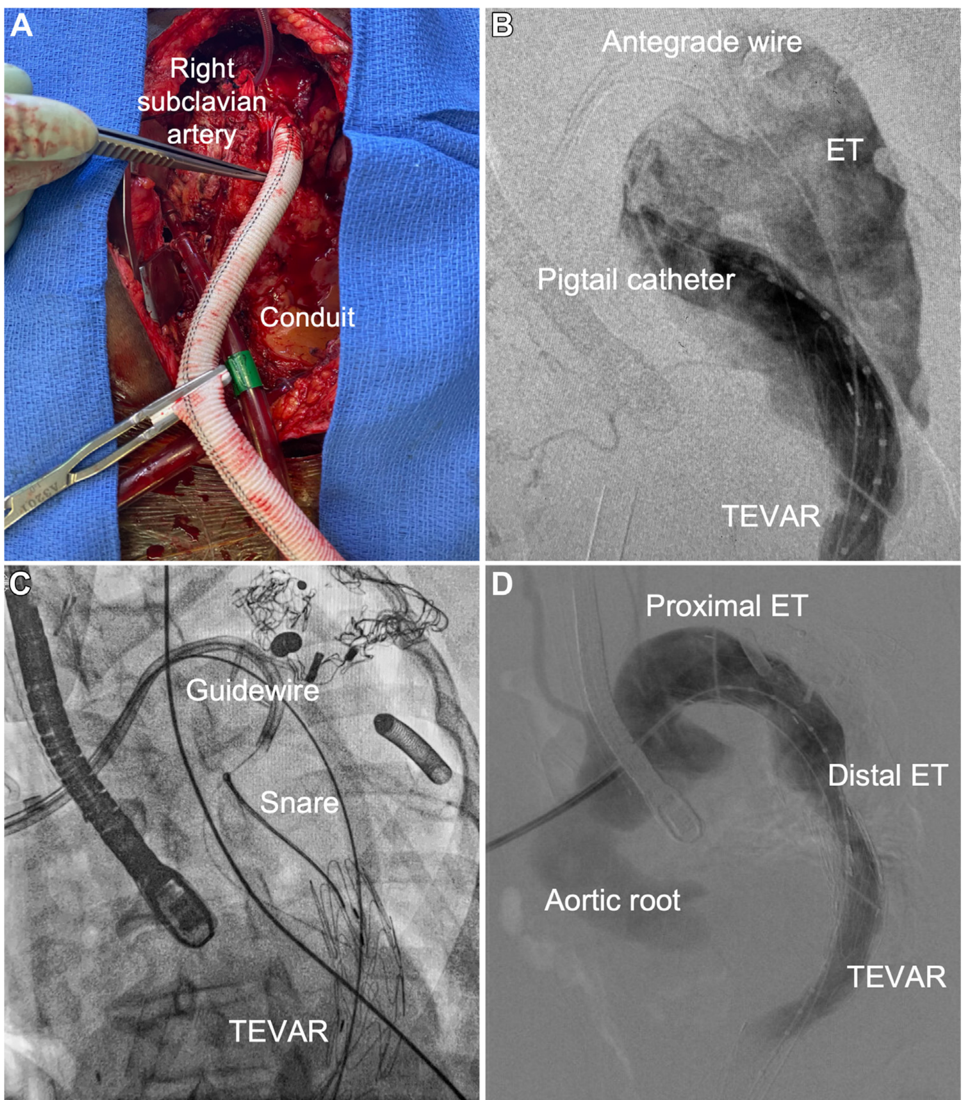

Fig 2. **A,** Transected right subclavian artery bypass graft with an end-to-end Dacron surgical conduit to facilitate antegrade thoracic endovascular repair. **B,** Retrograde transfemoral pigtail catheter advanced through the first stage of thoracic endovascular aortic repair (TEVAR) in the true lumen (TL). Antegrade Guidewire advanced through the elephant trunk (ET) in the false lumen (FL). Angiogram revealed the aortic dissection septum, large fenestrations in the aortic aneurysm, and large anteroposterior distance between the TL and FL lumen to be bridged. **C,** We advanced a Guidewire into the FL using an antegrade steerable sheath in the ET, which was snared back into the TL thoracic endovascular repair. **D,** With the wire snared, on manual bidirectional tension, we performed an antegrade TEVAR through the surgical conduit, bridging the ET with the distal TEVAR. Completion angiogram showed through-and-through TL flow with exclusion of the dissecting aneurysm and no endoleak.

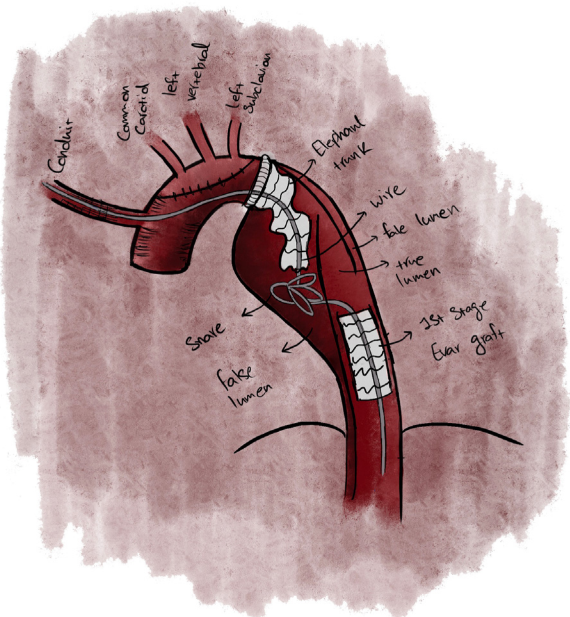

Fig 3. Diagram showing the wires from the surgical conduit passing through the tortuous elephant trunk (ET) and snare from the femoral access passing through the first-stage thoracic endovascular aortic repair (TEVAR) meeting in the false lumen (FL).

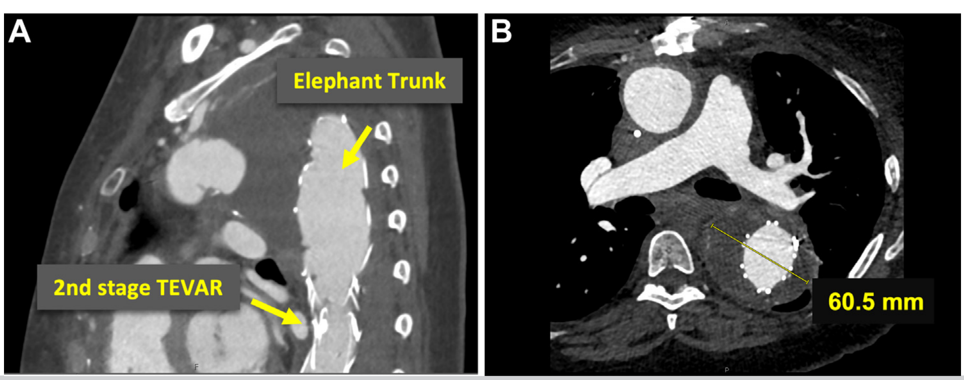

Fig 4. A, Second-stage thoracic endovascular aortic repair (TEVAR) with proximal extension into elephant trunk (ET) showing thrombosis of both false lumens (FLs). **B,** Reduction in aneurysm size, with true lumen (TL) augmentation, and complete FL thrombosis.

and excluded the aneurysm and FL in zones 3 to 5. The completion angiogram revealed no endoleak, device fracture, migration, or malperfusion (Fig 2, *D*). A diagram of the technique is shown in Fig 3. The left axillary artery access site was repaired with a Dacron patch, and the right subclavian artery was revascularized with an anastomosis to the ascending aorta graft.

Although no aortic, hemorrhagic, or surgically related complications had occurred, the patient's postoperative recovery was prolonged by her chronic obstructive pulmonary disease and a requirement for tracheostomy. CT angiography showed positive aortic remodeling, FL thrombosis, and aneurysm sac regression from 7.5 cm to 6.0 cm (Fig 4, *A* and *B*). Genetic testing showed myosin heavy chain 11 mutations, consistent with her aortic aneurysm and dissection presentation.

DISCUSSION

A fatal complication of ET is the development of a FL compressing the TL, causing visceral malperfusion.[3] In such cases, emergent fenestration distal to the endograft can restore flow to the TL and be lifesaving.[4] Endovascular fenestration is preferred over open surgical fenestration or endograft explantation given the lower operative morbidity rates.[4]

To manage this complication nonemergently, the FL and TL should be bridged using existing or new transseptal fenestrations.[5] Fenestrations can be created via a guidewire or an atraumatic radiofrequency wire and serially balloon dilated or using an Outback LTD re-entry catheter (Cordis, Johnson & Johnson, Bridgewater, NJ).[4-8]

For more acute dissections, the thin flap architecture can be perforated or torn down using a micro-guidewire.[9] We used an existing fenestration proximal to the ET and the ascending aorta—femoral snare-assisted technique to bridge the first-stage TEVAR and the ET using a stent. We have previously described a snare-assisted retrograde brachiofemoral body floss technique to redirect a malpositioned ET into the TL and facilitate TEVAR. However, for the present patient, we favored antegrade TEVAR because the redundant, kinked ET did not have enough outer curvature support to facilitate traversing zones 0 to 3 and could not accommodate the endograft delivery system. This technique is indicated if the FL size can accommodate both the snare and wire and the ET is proximal enough to allow for stent deployment without celiac trunk coverage.

The use of antegrade TEVAR is uncommon and typically performed in zone 0 hybrid arch procedures or for patients who lack traditional retrograde TEVAR access.[10,11] Antegrade body floss access will usually be through the right brachial artery, then the left common carotid artery or left subclavian artery.[12] In patients with severe supra-aortic calcification, the ascending aorta can be accessed through a transapical approach, often used for transcatheter aortic valve replacement or with a transseptal sheath and snare-pull down of the delivery system.[4,11] Because these approaches have been associated with valve regurgitation, an alternative is to use a graft conduit. We performed antegrade TEVAR through the patient's existing right subclavian conduit owing to bilateral the axillosubclavian angulation.

Overall, for correct proximal ET deployment, the TL should be identified with direct visualization, intravascular ultrasound, transesophageal echocardiography, or standard angiography.6 However, despite proximal visualization, the wire can perforate the dissection membrane or slide into the FL via a second entry tear.[6] As such, distal visualization of the fenestrations and wire positioning via intravascular ultrasound is also recommended.[6]

Kinking, another underreported ET complication, can be detected on follow-up CT angiography or present as intermittent claudication or decreased lower extremity arterial pressure.[13] Because of the curvature, thoracic wall attachment, and proximity to the heart, the proximal descending aorta will be subjected to greater dynamic forces than the abdominal aorta.[14] Retrograde ET blood flow, placement at the aortic flexure, and the prosthesis architecture and length can kink the distal end of the graft.[13] Our patient's excessively long ET may have increased the risk of kinking. Graft oversizing of 10% to 20% may provide an adequate counteracting radial force to avoid this complication.[14]

The through-and-through wire technique with a stiff wire can be used to straighten kinking and deliver a stent graft.[8] Although the use of a floppy guidewire can reduce vessel trauma, we used an extra stiff wire for stability and to minimize the wire and catheter exchange in a patient with tenuous anatomy. This technique is also indicated for TEVAR placement in a tortuous, elongated thoracic aorta such as rickets and angulated arches.[12] Using a catheter over the wire or EN snare can mitigate trauma to the artery's ostium from the body floss on tension.[15]

CONCLUSIONS

Antegrade TEVAR with the body floss technique can address the complications of stage I ET, specifically kinking and migration to the FL. The long-term safety and efficacy of this technique warrant further investigation.

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Submitted Oct 5, 2022; accepted Dec 15, 2022.