From the Society for Vascular Surgery

Intercostal artery embolization to induce false lumen thrombosis in type B aortic dissection

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ABSTRACT

Persistent false lumen flow is common after thoracic endovascular aortic repair of type B aortic dissection and may contribute to continued aortic aneurysmal degeneration. We report an innovative technique of intercostal artery embolization within the false lumen for a patient who had incomplete false lumen thrombosis and progressive aortic enlargement after thoracic endovascular aortic repair of chronic type B aortic dissection. Technical success was facilitated by use of on-table cone beam computed tomography angiography, virtual vessel marking, and modern endovascular tools. The patient had no complications from the procedure. Postoperative imaging demonstrated complete thoracic false lumen thrombosis and favorable aortic remodeling with reduction in maximal aortic diameter. (J Vasc Surg Cases and Innovative Techniques 2020;6:433-7.)

Keywords: Type B aortic dissection; Intercostal artery; Embolization; False lumen

Thoracic endovascular aortic repair (TEVAR) is commonly performed for treatment of Stanford type B aortic dissection (TBAD) with the goal of preventing rupture by inducing false lumen thrombosis (FLT). However, >30% of patients fail to achieve FLT despite TEVAR.[1] Assuming adequate proximal seal of the entry tear, TEVAR halts antegrade flow into the false lumen around the TEVAR, and if false lumen flow becomes stagnant, FLT ensues. However, false lumen flow often becomes retrograde (type R entry flow), with inflow from distal (usually abdominal) septal fenestrations and outflow through false lumen intercostal arteries.[2] This can lead to persistent false lumen patency around the stented portion of the thoracic aorta, which may correspond to false lumen pressurization and predisposition to aneurysm growth.

Theoretically, eliminating these sources of inflow or outflow should stop type R entry flow and propagate FLT. Embolization of intercostal arteries represents one method of eliminating outflow. We describe a technique for intercostal artery embolization and a case in which we used this technique for thoracic false lumen aneurysmal degeneration around a previously placed TEVAR endograft. The patient provided consent for publication of this case report, which was deemed exempt from Institutional Review Board approval at our institution.

CASE REPORT

A 49-year-old man presented with chronic $TBAD_{4,11}$ and associated aneurysm of the thoracic aorta measuring 6.4 cm (Fig 1). He underwent TEVAR deployment from zone 3 to zone 5, covering 17 cm of aorta including the proximal entry tear. Six months later, surveillance computed tomography angiography (CTA) demonstrated progressive enlargement of the thoracic aorta to 8.2 cm (Figs 1 and 2). The TEVAR demonstrated excellent proximal seal and proximal FLT. However, the false lumen around the distal 9 cm of TEVAR remained patent and in continuity with the false lumen in the unstented thoracoabdominal aorta (zone 5). Six intercostal arteries originated from the patent false lumen, and a distal septal fenestration was noted at the aortic bifurcation (zone 9). A presumptive diagnosis was established of type R entry flow with false lumen intercostal artery outflow contributing to persistent thoracic false lumen pressurization. We elected to embolize intercostal arteries in the hope that occluding outflow into false lumen intercostals would induce complete thoracic FLT.

The patient had several patent intercostal and lumbar arteries arising from the true lumen and patent internal iliac arteries bilaterally; however, a lumbar drain and central line were placed prophylactically to treat any symptoms of spinal cord ischemia without delay. General anesthesia was induced to minimize the patient's movement. Mean arterial pressure was maintained above 90 mm Hg intraoperatively to maximize spinal cord perfusion pressure.

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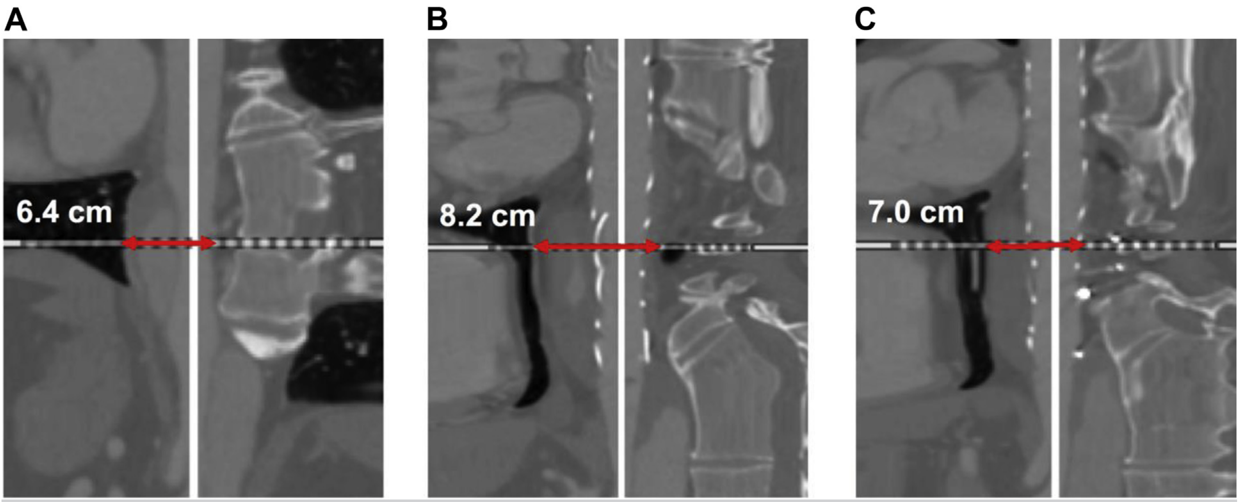

Fig 1. Maximal aortic diameter before **(A)** and 6 months after **(B)** thoracic endovascular aortic repair (TEVAR) and 2 months after coil embolization of false lumen intercostal arteries **(C)**. Images are straightened multiplanar reconstructions of extracted aortic centerlines (Aquarius iNtuition 3D; TeraRecon, Foster City, Calif). Labels denote the widest aortic diameter on cross-sectional slices perpendicular to centerline.

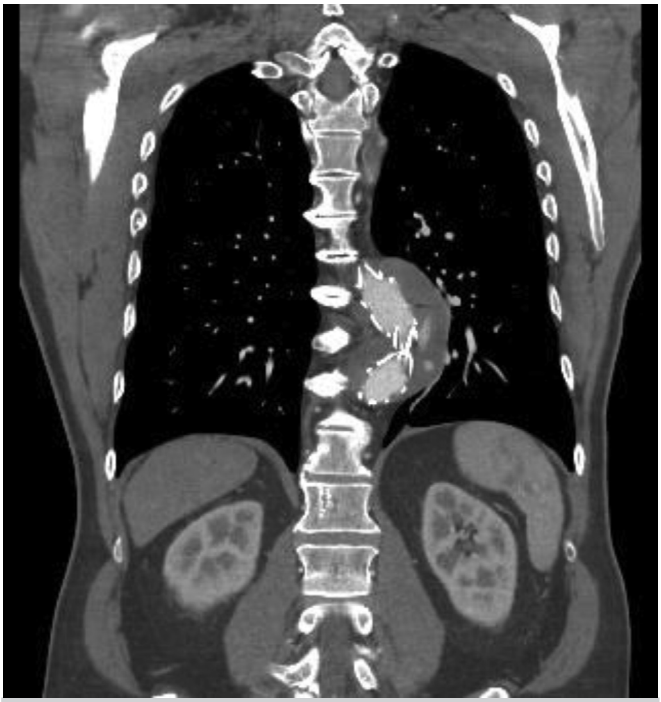

Fig 2. Coronal reconstruction of computed tomography angiography (CTA) image after thoracic endovascular aortic repair (TEVAR) demonstrating partial false lumen thrombosis (FLT) in zone 5.

From a percutaneous femoral approach, wire access to the false lumen was established through the distal aortic septal fenestration. A flush catheter was placed in the false lumen above the celiac artery, and on-table cone beam DynaCTA (Artis zeego Q with PURE; Siemens, Munich, Germany) was performed, maximally opacifying the thoracic false lumen and confirming type R flow.

Cone beam DynaCTA was performed by using a 5-second spin with an injection of 10 mL/s with a 2-second X-ray delay using 50% contrast agent. Three-dimensional-three-dimensional fusion was then performed, and multiplanar reconstruction of the cone beam DynaCTA image was used to identify the false lumen intercostal arteries that we planned to target. Three-dimensional polylines were then drawn to follow the vessel paths for use as an overlay during live fluoroscopy.

Six false lumen intercostal arteries superior or just inferior to the distal seal of the previous TEVAR were identified and targeted for embolization. With use of bedside controls, the courses of these arteries were drawn manually to create three-dimensional polyline overlays (Fig 3). This on-table mapping approach yielded more precise vessel localization than we have been able to achieve with fusion registration of preoperative CTA images.

A 55-cm TourGuide 6.5F deflectable sheath (Medtronic, Minneapolis, Minn), 0.035-inch 135-cm QuickCross catheter (Spectranetics, Colorado Springs, Colo), Renegade STC 0.018-inch 150-cm microcatheter (Boston Scientific, Marlborough, Mass), and Synchro2 0.014-inch 300-cm wire (Stryker, Kalamazoo, Mich) were used to cannulate each intercostal artery. System stability for coil delivery was improved by advancing the QuickCross approximately 1 cm into the intercostal target. Each artery was embolized using two 0.018-inch Interlock coils (Boston Scientific), 3 or 4 mm in diameter. Successful occlusion was confirmed with digital subtraction angiography.

Overall procedural time was 72 minutes; fluoroscopy dose was 398 mGy; and contrast material administered was 62 mL, inclusive of on-table cone beam DynaCTA. Blood loss was minimal.

Postoperatively, the patient remained neurologically intact, without requiring lumbar drainage or blood pressure augmentation. The lumbar drain was removed on postoperative day 1, and he was discharged home on day 3 without complications.

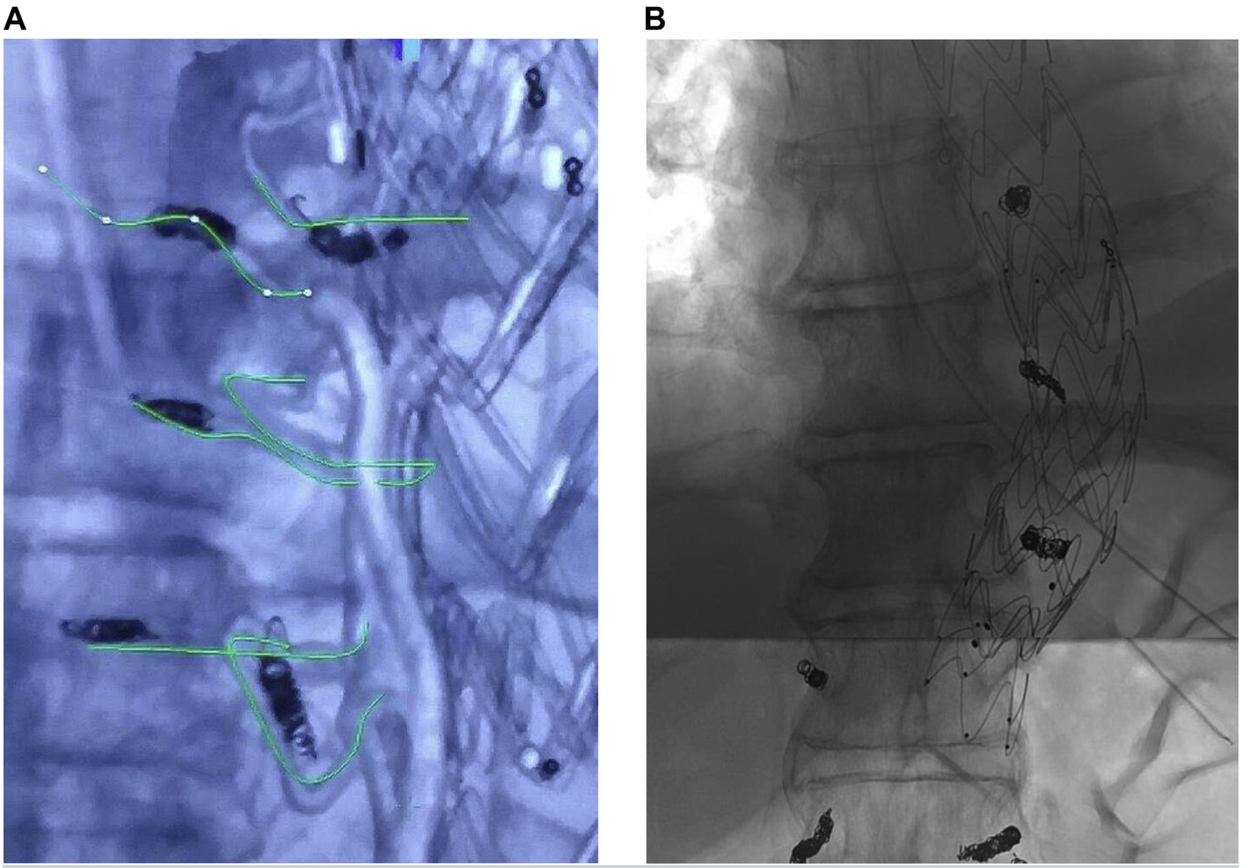

Fig 3. A, Three-dimensional polyline overlays used to demonstrate false lumen intercostal artery trajectory during endovascular intervention to aid in cannulation. **B,** Postoperative fluoroscopy imaging demonstrating successful coil embolization of false lumen intercostal arteries.

Follow-up CTA with arterial and delayed phases performed 2 months later per Society for Vascular Surgery and Society of Thoracic Surgeons reporting standards demonstrated complete thoracic FLT (Fig 4) and a reduction in maximal thoracic aortic diameter from 8.2 cm to 7.0 cm (Fig 1). The false lumen in the paravisceral and abdominal aorta (zones 5-11) remained patent and unchanged in diameter or extent.

DISCUSSION

Coverage of the proximal entry tear with TEVAR alone is frequently insufficient to induce complete FLT in patients with TBAD, especially with chronic dissections that extend into the abdominal aorta.[1] FLT after TEVAR is protective against aortic growth and confers a decreased risk of rupture as well as of other late complications.[3] Conversely, failure to achieve FLT is associated with significant likelihood of reintervention, ranging from simple TEVAR extension to more complex procedures such as fenestrated-branched endovascular aneurysm repair or open thoracoabdominal aortic repair.[4]

Intercostal arteries originating from the false lumen may contribute to inhibition of FLT. Liu et al[5] found that at 24 months after TEVAR, only 40% of patients with eight or more false lumen vessels developed complete FLT vs 87% of patients with fewer. Kitamura et al[6] similarly associated failure to achieve FLT after TEVAR with abdominal aortic branches arising from the false lumen. In addition, computational fluid dynamic modeling suggests that false lumen branches impede FLT by affecting blood flow rate and pattern.[7]

Several adjuncts to TEVAR have been explored to induce FLT. The "knickerbocker" and "candy plug" techniques expand seal at the TEVAR distal landing zone but may not be feasible in the setting of significant supraceliac aneurysmal degeneration. Plugs, coils, and glue have been used to occlude entry tears, type IA entry flow, and anastomotic leaks as well as to fill the patent false lumen.[8] Filling of the false lumen, however, involves placing large quantities of radiodense material into a diseased aorta or thrombus, diminishing interpretability of subsequent imaging while potentially still permitting false lumen perfusion through or around the embolic material.[9] Intercostal embolization to treat type II endoleak after TEVAR has recently been reported by hybrid technique with surgical exposure of the intercostal arteries.[10]

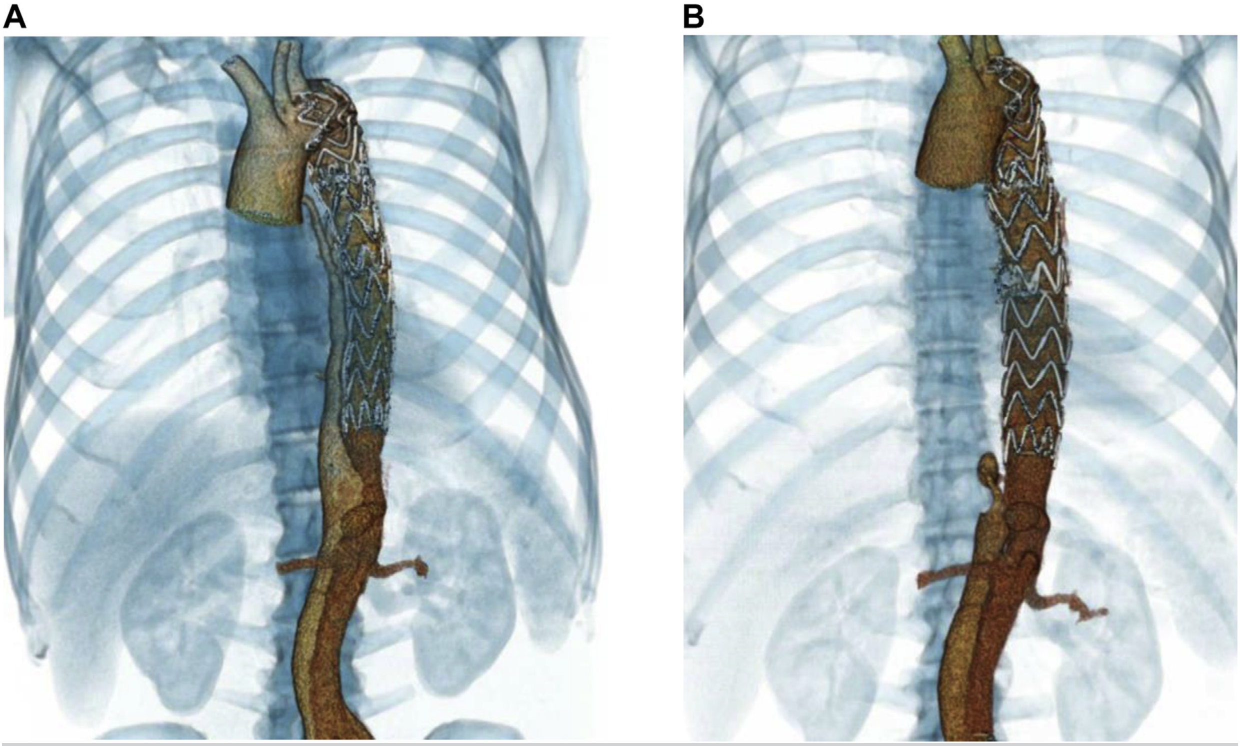

Fig 4. Three-dimensional reconstruction of computed tomography angiography (CTA) image before **(A)** and after **(B)** false lumen intercostal artery embolization demonstrating improved false lumen thrombosis (FLT) around the thoracic aorta and prior thoracic endovascular aortic repair (TEVAR).

Intercostal embolization is a targeted intervention that avoids these drawbacks. Many fewer coils are needed than would be required to fill and to obliterate the entire false lumen, which reduces radiographic artifact on subsequent computed tomography scans. Furthermore, placing coils into the intercostal artery itself allows sealing within a healthy vessel lumen rather than in a diseased, degenerated one. The procedure may have additional benefits before further aortic coverage by aiding in development of protective spinal cord collateralization.[11] Finally, in patients who have continued aortic growth after TEVAR, intercostal embolization can be an adjunct to treat both type II intercostal entry flow and type R entry flow with intercostal outflow.

Despite these theoretical benefits, intercostal coiling has not yet been convincingly demonstrated to be practically feasible, safe, or therapeutically beneficial. Concerns exist about technical difficulty, radiation and contrast material exposure, risk of false lumen rupture, risk of paraplegia, and cost. In this case, we demonstrate that modern imaging techniques including on-table CTA and virtual vessel marking as well as modern endovascular tools including deflectable sheaths and microwires made embolization of false lumen intercostal arteries accomplishable with acceptable levels of operative time, fluoroscopy, and contrast material. In this patient, the procedure had no deleterious effects and was effective in both inducing complete thoracic FLT and promoting early aortic remodeling, with a reduction in aneurysm diameter of 14%.

CONCLUSIONS

We describe a technique for coil embolization of false lumen intercostal arteries around prior TEVAR. Technical success was aided by use of modern imaging techniques and endovascular tools. Further study will be required to determine the practical feasibility, safety, and therapeutic utility of intercostal embolization in management of chronic TBAD.

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