Sandwich thoracic branch endoprosthesis technique for endovascular repair of thoracic aortic aneurysm with aberrant right subclavian artery

Yasmeen Dhindsa, MD, Alexander DiBartolomeo, MD, Gregory A. Magee, MD, MSc, Fernando Fleischman, MD, *and* Sukgu M. Han, MD, MS, *Los Angeles, CA*

ABSTRACT

Subclavian artery coverage is frequently required to achieve an adequate proximal seal during thoracic endovascular aortic repair. The thoracic branch endoprosthesis (TBE; W.L. Gore & Associates) is the first U.S. Food and Drug Administration–approved branched device for thoracic endovascular aortic repair, designed for left subclavian artery incorporation. However, anatomic suitability of the TBE has been shown to be limited. In the present report, we describe a novel technique using the TBE in a sandwich periscope configuration to allow for emergent repair of a ruptured thoracic aortic aneurysm with a highly angulated proximal seal zone and aberrant right subclavian artery. (J Vasc Surg Cases Innov Tech 2023;9:101289.)

Keywords: Ruptured thoracic aortic aneurysm; Thoracic branch endograft; Thoracic endovascular aortic repair

Coverage of the left subclavian artery (SCA) is required in ≤30% of thoracic endovascular aortic repairs (TEVARs) to achieve an adequate proximal seal zone, with inferior outcomes associated with a compromised proximal seal.[1-3] Revascularization of the SCA can be achieved via cervical debranching, including carotid subclavian bypass or subclavian-to-carotid artery transposition. However, this can pose challenges in the setting of concomitant carotid artery stenosis or hostile neck anatomy. Previously described total endovascular incorporation techniques of the SCA include in situ fenestration, fenestrated or branched TEVAR devices, and parallel grafting.[4] The thoracic branched endoprosthesis (TBE; W.L. Gore & Associates) is the first dedicated branched TEVAR device to obtain U.S. Food and Drug Administration approval for commercial use. Although the pivotal trials of zone 2 TBE use have shown excellent short-term and midterm results, the anatomic suitability of TBE appears to be limited by the off-the-shelf design of the device.[5-7] Furthermore, the TBE device does not have angulation control, a key feature of the latest generation conformable TAG with active control (cTAG-AC; W.L. Gore & Associates), which improves orthogonal deployment during TEVAR in an angulated arch. In the present report, we describe a case of a ruptured thoracic aortic aneurysm in the setting of an aberrant right SCA and highly angulated proximal seal zone, repaired with the sandwich TBE technique. Combining the use of the TBE with the previously described sandwich periscope approach as the distal branched component allowed for endovascular incorporation of the aberrant right SCA and accurate orthogonal deployment of the cTAG-AC in a highly angulated arch. The patient provided written informed consent for the report of his case details and imaging studies.

CASE REPORT

A 58-year-old man with a history of hypertension, coronary artery disease, and TEVAR for a descending thoracic aortic aneurysm presented with acute-onset chest pain. Computed tomography angiography (CTA) showed left hemothorax and mediastinal hematoma consistent with a contained rupture of a 9.3-cm descending thoracic aortic aneurysm (Fig 1, *A*). Additionally, CTA revealed complete loss of the proximal seal of the previous TEVAR, an aberrant right SCA originating distally to the left SCA, and high angulated neck distal to the left SCA (Fig 1, *B-D*).

On arrival, the patient was hypotensive, with a systolic blood pressure in the 90s with hemoglobin of 7 g/dL. Also, he was hypoxic and tachypneic with an oxygen saturation of low 90% with supplemental oxygen and a respiratory rate in the high 20s. The patient was taken to the operating room for total endovascular repair within 3 hours of arrival. Percutaneous access was performed at the right femoral and right brachial arteries. First, distal TEVAR was performed using a 31-mm × 200-mm cTAG-AC above the celiac origin, relining the previous TEVAR

From the Division of Vascular Surgery and Endovascular Therapy, Comprehensive Aortic Center, University of Southern California.

Author conflict of interest: G.A.M. is a consultant for W.L. Gore & Associates and Cook Medical. F.F. is a consultant for W.L. Gore & Associates and Terumo Aortic. S.M.H. is a consultant for Cook Medical, W.L. Gore & Associates, and Terumo Aortic and is a member of the scientific advisory board for W.L. Gore & Associates, Terumo Aortic, and Vestek. Y.D. and A.D. have no conflicts of interest.

Correspondence: Sukgu M. Han, MD, MS, Division of Vascular Surgery and Endovascular Therapy, Comprehensive Aortic Center, University of Southern California, 1520 San Pablo St, Ste 4300, Los Angeles, CA 90033 (e-mail: Sukgu.han@med.usc.edu).

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.2023.101289

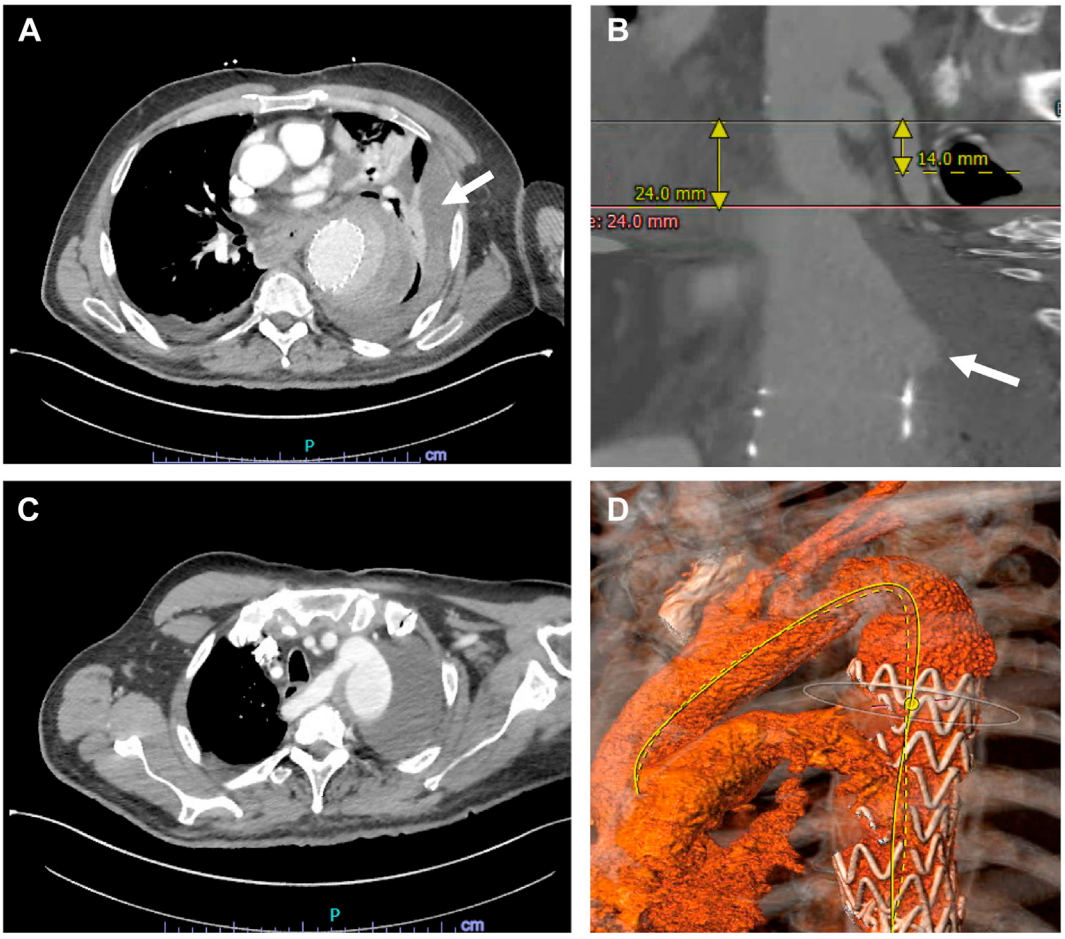

Fig 1. A, Ruptured descending thoracic aortic aneurysm with left hemothorax (*arrow*). **B,** Complete loss of proximal seal. **C,** Aberrant right subclavian artery (SCA) arising from the aneurysm and distal to the left SCA. **D,** Highly angulated proximal seal zone distal to the left SCA with the length of 24 mm.

device (Fig 2, *A*). Second, a 31-mm × 150-mm TBE with an 8-mm portal was deployed distally to the right SCA origin using a right brachial-to-right femoral through-and-through wire (Fig 2, *B*). Third, the right SCA and 8-mm portal were bridged with 13-mm × 10-cm self-expanding Viabahn covered stents (W.L. Gore & Associates), introduced over the through-and-through wire. Additional Viabahn VBX stents (W.L. Gore & Associates) were required to achieve a distal seal into the ectatic right SCA (Fig 2, *C*). Finally, proximal TEVAR was performed using a 31-mm × 150-mm cTAG-AC, achieving a proximal aortic seal in a highly angulated proximal neck (Fig 2, *D*). The time from vascular access to aneurysm seal with the right SCA incorporation was ~45 minutes, with a fluoroscopy time of 21 minutes and contrast usage of 80 mL. The left hemothorax was drained, and the patient had an uneventful recovery. At the 7-month follow-up, the patient remained well without dysphagia symptoms. CTA showed a complete seal with sac regression to 5.6 cm and a patent right SCA branch. Given the emergent presentation, no genetic testing was performed before endovascular repair. However, the patient was referred for genetic testing for heritable thoracic aortic disease.

DISCUSSION

In the present report, we describe the next evolution of the previously reported periscope sandwich TEVAR technique.[4] The advantages of the periscope sandwich technique include preservation of the proximal and distal overlap zones for future proximal and distal extensions and facilitation of left upper extremity access to the visceral and renal arteries using commercially available components. The new sandwich periscope technique provides three additional advantages. First, by incorporating the TBE with its inner branch or portal design as the sandwich component, the inherent limitation of the occurrence of a gutter leak associated with parallel grafting is eliminated. Second, proximal extension with the new cTAG-AC with angulation control features provides greater deployment precision and reduced bird beaking, especially in an angulated proximal seal zone, as illustrated by our patient's case. Third, although in the current case, we used the sandwich TBE technique for preservation of an aberrant right SCA, the technique can be applied for left SCA incorporation. This technique

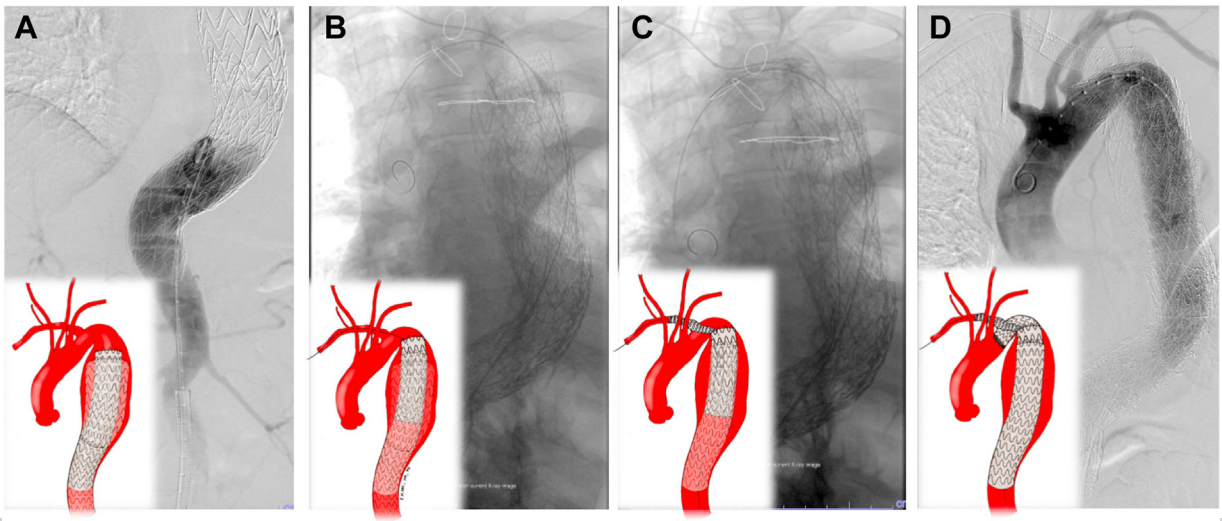

Fig 2. A, Relining thoracic endovascular aortic repair (TEVAR) with deployment of the conformable TAG with active control (cTAG-AC) above the celiac artery origin. **B,** Deployment of thoracic branch endoprosthesis (TBE) device with 8-mm portal distal to the origin of the right subclavian artery (SCA) origin with through-and-through wire access. **C,** Placement of bridging stents to the right SCA. **D,** Deployment of the proximal cTAG-AC to complete repair.

expands the anatomic suitability for TBE, beyond the distance between the arch branch origins to avoid shuttering by the required "covered length" of the off-the-shelf design of the TBE device.

Several treatment options are available for thoracic aortic aneurysm exclusion with SCA revascularization, including TEVAR with cervical debranching, in situ fenestration, parallel grafting, and branched fenestrated TEVAR. This technique combines the last two options to expand the anatomic applicability of the TBE device and leverage the latest generation cTAG-AC features to allow for more precise deployment. Although cervical debranching is a widely accepted "standard" procedure, it carries additional risks of complications specific to cervical dissection such as cranial nerve injury, chyle leak, hematoma, and seroma.[8,9] Our patient had no contraindications for cervical debranching. However, our team has been performing complex TEVARs routinely for the previous decade, including the TBE trials and sandwich periscope technique. The described technique combines the procedural steps our team is accustomed to performing, as indicated by the time to endovascular completion of 45 minutes. Unlike the in situ fenestration technique, sandwich TBE does not require modification of the stent grafts, potentially decreasing the risk of type III endoleaks from fabric tears.

The present technique has several limitations. This configuration results in a longer retrograde branch to the SCA using a ≥10 cm length and, often, multiple covered stents. As such, compared with the dedicated branch component of the TBE, this technique might be more prone to branch instability. At present, the TBE device is not readily available at many centers, limiting its wide applicability in emergent settings. Additionally, familiarity with complex TEVAR procedures, including TBE and parallel grafting, is required before this technique should be applied in emergent settings. However, we believe the ever changing availability of this commercially approved device should not negate the potential advantages of this technique at centers with expertise in complex endovascular aortic repairs. The additional device costs associated with TBE and multiple branch components should be considered, which could be prohibitive at some centers. With any new endovascular techniques, the long-term durability of this off-label technique remains to be determined. Thus, the decision to apply this technique should be carefully made with these limitations in mind.

CONCLUSIONS

The sandwich TBE technique provides an alternative method of endovascular SCA incorporation using off-the-shelf endovascular components. This technique improves on the previously described sandwich periscope technique and expands the applicability of TBE to patients who do not meet the anatomic criteria.

REFERENCES

1. Kuo EC, Veranyan N, Johnson CE, et al. Impact of proximal seal zone length and intramural hematoma on clinical outcomes and aortic remodeling after thoracic endovascular aortic repair for aortic dissections. J Vasc Surg 2018;69:987-95.
2. Yoon W, Mell M. Outcome comparison of thoracic endovascular aortic repair performed outside versus inside proximal landing zone length recommendation. J Vasc Surg 2020;72:1883-90.

3. Lombardi J, Famularo M, Kratzberg J, Roeder B. Effect of proximal fixation length on complications after endovascular repair of type B aortic dissection. J Vasc Surg 2021;73:1189-96.
4. Johnson CE, Zhang L, Magee GA, et al. Periscope sandwich stenting as an alternative to open cervical revascularization of left subclavian artery during zone 2 thoracic endovascular aortic repair. J Vasc Surg 2020;73:466-75.e3.
5. Magee GA, Veranyan N, Kuo EC, et al. Anatomic suitability for "off-the-shelf " thoracic single side-branched endograft in patients with type B aortic dissection. J Vasc Surg 2019;70:1776-81.
6. Dake MD, Brinkman WT, Han SM, et al. Outcomes of endovascular repair of aortic aneurysms with the GORE thoracic branch endoprosthesis for left subclavian artery preservation. J Vasc Surg 2022;76:1141-9.e3.
7. Liang NL, Dake MD, Fischbein MP, et al. Midterm outcomes of endovascular repair of aortic arch aneurysms with the Gore thoracic branch endoprosthesis. Eur J Vasc Endovasc Surg 2022;64:639-45.
8. Oladokun D, Patterson BO, Brownrigg JR, et al. Early outcomes after left subclavian arteyr revascularization in association with thoracic endovascular aortic repair. Vascular 2017;25:74-9.
9. Bianco V, Sultan I, Kilic A, et al. Concomitant left subclavian artery revascularization with carotid-subclavian transposition during zone 2 thoracic endovasular aortic repair. J Thorac Cardiovasc Surg 2020;159:1222-7.

Submitted Jun 15, 2023; accepted Jul 24, 2023.