How Do You Manage Arch Pathologies?

Experts explain their step-by-step approaches to endovascular repair of zone 0 aortic arch pathology using laser in-situ fenestration and the Gore TAG thoracic branch endoprosthesis.

With Jonathan Bath, MD; Brant W. Ullery, MD, MBA; and Christopher J. Smolock, MD, FSVS

Approach Using Laser In-Situ Fenestration

By Jonathan Bath, MD, and Brant W. Ullery, MD, MBA

Laser in-situ fenestrated endograft (LIFE) repair represents a promising alternative to open aortic arch replacement and can be performed alone or in combination with supra-aortic arch debranching procedures to treat lesions spanning all zones of the aortic arch. The LIFE registry recently reported excellent early results of this technique in multiple aortic pathologies and clinical acuities.[1] As the long-term durability of this approach remains ill defined, LIFE is generally reserved for nonelective clinical settings and/or for patients who are either not open surgical candidates, do not meet criteria for off-the-shelf branched stent graft technology, or are deemed high risk for cervical debranching procedures.

CASE EXAMPLE

Patient Presentation

A man in his early 80s with a 6.4-cm postdissection arch aneurysm after previous type A dissection repair presented for zone 0 LIFE repair. He was not a candidate for open repair and was deemed high risk for cervical debranching and thoracic endovascular aortic repair (TEVAR) due to prior neck radiation (Figure 1A).

Operative Exposure and Setup

The technical details of LIFE in the aortic arch expand upon the fundamentals of this approach in the more commonly described zone 2 coverage. Zone 0 LIFE can

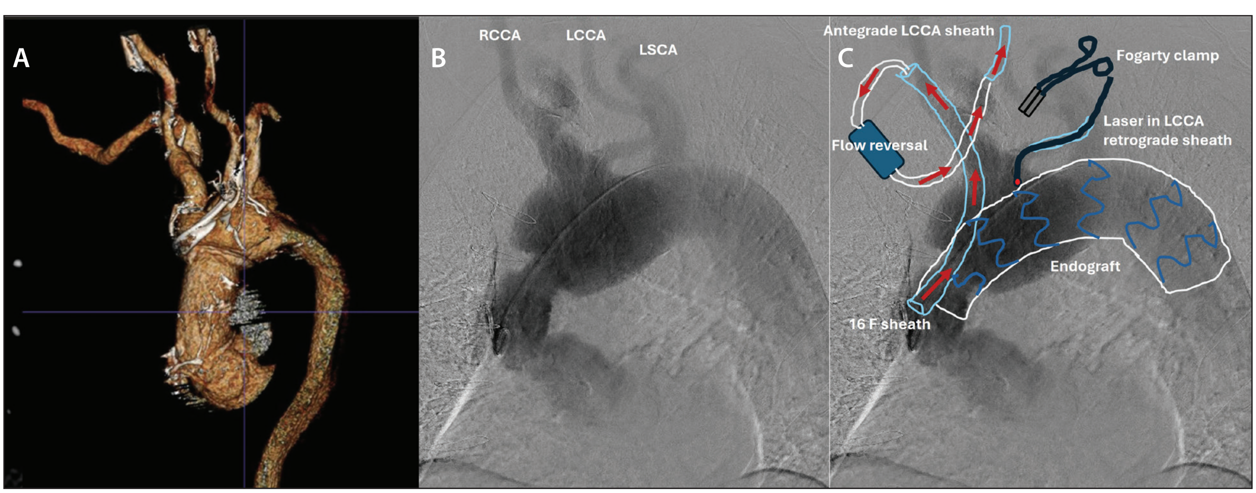


Figure 1. Three-dimensional (3D) reconstruction of postdissection arch aneurysm with previous ascending aortic repair for type A dissection (A). Arch angiogram delineating anatomy of supra-aortic trunk vessels (B). Diagram of flow reversal setup, including a 16-F sheath placed via the RCCA down to the aortic root, a 9-F antegrade LCCA sheath for perfusion via flow reversal, and a 7-F retrograde steerable sheath for LCCA laser fenestration (C).

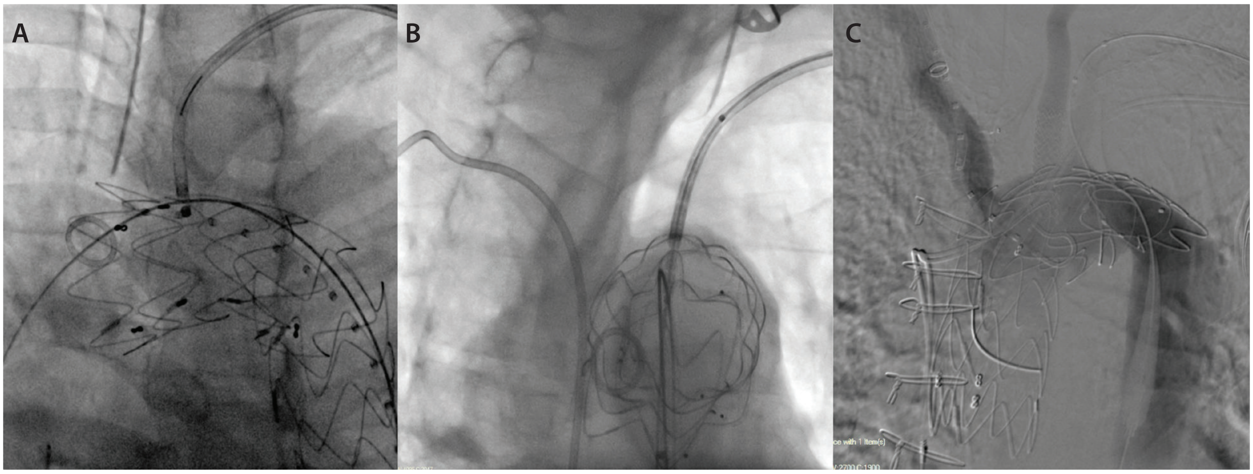


Figure 2. Orthogonal view for laser fenestration (A). "Down the barrel" view for laser fenestration (B). Demonstration of flush catheter placed through innominate fenestration to confirm intraluminal entry with free spinning of the flush catheter. Note that the LCCA fenestration and stenting have been completed (C).

be undertaken with adjunctive maneuvers to preserve antegrade cerebral blood flow. We prefer a flow reversal system to provide flow to the left carotid system during zone 0 LIFE repair. Surgical exposure to the left and right proximal common carotid arteries (CCAs) is obtained at the base of the neck. Left axillobrachial or radial access is also obtained. The left CCA (LCCA) exposure is continued for a length that will allow dual sheath puncture. Figure 1B demonstrates the initial angiographic anatomy. Systemic heparinization is initiated, and a retrograde 7-F steerable sheath and 9-F antegrade flow reversal sheath are introduced through the LCCA. A 16-F sheath is placed into the right CCA (RCCA) and positioned at the aortic root. Through the 16-F sheath, a flow reversal sheath is placed, and the flow reversal system is connected to the 9-F LCCA antegrade sheath. An occlusion balloon is deployed to the left subclavian artery (LSA) at the origin, and a test clamp is placed to the LCCA between the two sheaths. The blood pressure is taken down to around 80 mm Hg, and intraoperative neuromonitoring (IONM) is utilized to detect any cerebral perfusion deficits. If changes are not detected, the procedure continues with deployment of the thoracic endograft into zone 0 alongside the 16-F sheath placed from the RCCA (Figure 1C).

Arch LIFE Technique

A 2.3-mm laser fiber (Turbo-Elite, Philips) is advanced retrograde through the steerable sheath in the LCCA. Although the LCCA is generally a much straighter vessel off the aortic arch compared to the LSA, we still universally use a steerable sheath to obtain perpendicular orientation of the laser fiber to the stent graft fabric within the aortic arch. Two complementary fluoroscopic views are obtained (generally coronal and "down the barrel") to confirm alignment (Figure 2A and 2B). Taking the time to ensure both views are achieved is critically important to the safety and efficacy of the LIFE technique. In addition to fluoroscopic confirmation of appropriate perpendicular orientation, we also rely on tactile feedback to reaffirm our position prior to committing to in-situ fenestration. Gentle but firm downward pressure of the laser catheter against the aortic stent graft often results in subtle movement of a stent strut near the site of proposed laser fenestration. A short burst of energy at 40 to 60 mJ is applied with steady forward pressure, and the laser fiber is then felt penetrating the fabric. Once the laser catheter enters the lumen of the aortic stent graft, a wire is advanced through the catheter to secure intraluminal position. The wire is often directed into the ascending aorta but can be easily redirected into the descending thoracic aorta with a curved catheter, if needed. A flush catheter may also be employed over the wire to confirm intraluminal position within the stent graft. The flush catheter should spin freely if within the graft lumen, in a similar fashion to gate cannulation in endovascular aneurysm repair (Figure 2C). Next, a balloon-expandable covered stent is placed with approximately 5 mm of the stent protruding within the aortic lumen (Figure 3A). Predilation of the fenestration prior to covered stent graft placement is generally not necessary when using a 2.3-mm laser catheter.

After successful LCCA fenestration, the flow reversal system is discontinued and the LCCA is flushed before removing the clamp; purse string sutures are then deployed to close the arteriotomies. The 16-F sheath is

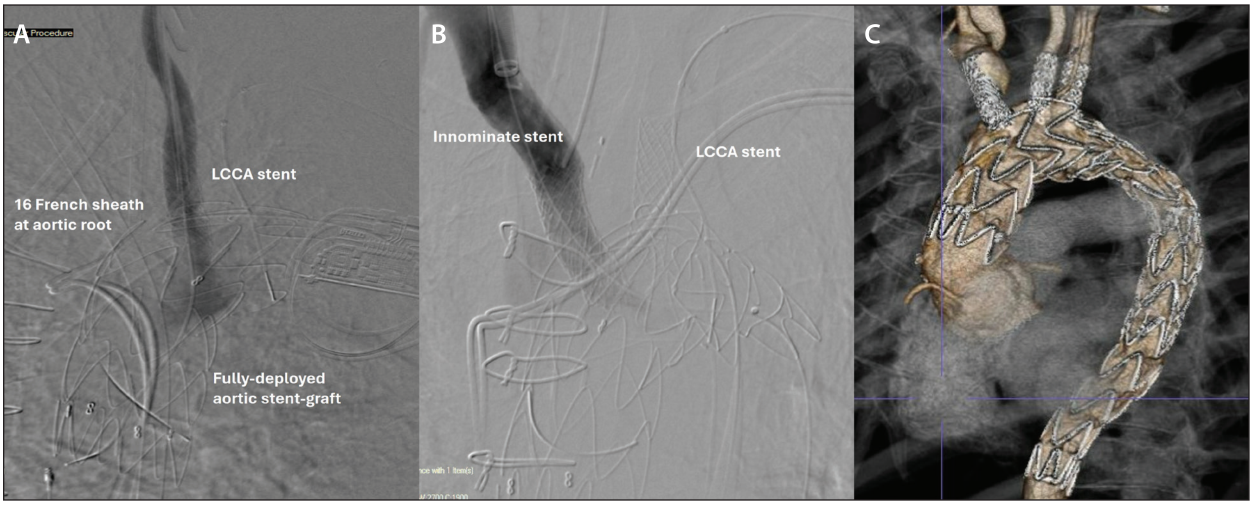


Figure 3. LCCA stenting with ideal 5 mm of stent protrusion into the aortic graft lumen. Note the 16-F sheath placement through the RCCA extends proximally to the aortic root parallel to the fully deployed aortic stent graft (A). LCCA stent and innominate stent (B). 3D reconstruction of three-vessel aortic arch laser fenestration for postdissection arch aneurysm (C).

then withdrawn above the TEVAR, and a 7-F steerable sheath is inserted through this to perform laser fenestration to the innominate artery (Figure 3B). Given the larger size of the innominate artery, options for bridging stent include the use of a large balloon-expandable or self-expanding covered peripheral stent, iliac limb, or commercially available branch stent, such as that used as part of the Gore TAG thoracic branch endoprosthesis (TBE; Gore & Associates). In general, we try to keep the fenestration to no more than 8 mm, and then an appropriate large-diameter balloon is used to flare the stent distally to match the target artery diameter (Figure 2B). The RCCA arteriotomy is repaired, and the 16-F sheath is removed before completing the LSA laser fenestration, in a similar fashion (Figure 3C). At times, the supra-aortic arch vessel origins may be in very close proximity. In such cases, we generally prefer to perform in-situ laser fenestration of the innominate and LSA (to maximize the distance between the two target vessels) in combination with a left carotid-subclavian bypass.

Alternative Arch LIFE Technique

An alternative technique for cerebral perfusion during zone 0 laser fenestration involves the use of a large-diameter balloon introduced through the RCCA or contralateral femoral access. This balloon is directed toward the ascending aorta to create a temporary gutter leak after thoracic endograft deployment to allow perfusion through the right carotid system. Once a gutter has been created, then the laser fenestration can proceed to the LCCA, innominate, then LSA in a similar manner as described previously.

Zones 1 and 2 LIFE Technique

The zones 1 and 2 LIFE technique employs many of the same principles as the more extensive zone 0 repair but carries a lower risk of stroke for patients with appropriate anatomy. In zone 1 cases, IONM can be useful to ensure adequate cerebral perfusion through the right carotid system but generally is not necessary. Left carotid cutdown is still our favored approach, with carotid clamping above the retrograde sheath. Antegrade perfusion is not utilized unless there is an identified IONM perfusion deficit once test clamped. Finally, laser fenestration is performed using the same technique as previous, followed by LSA laser fenestration. Zone 2 LIFE repair does not require IONM and proceeds as described previously. The minimum distance between the proximal fabric edge and the most proximal laser fenestration is not well defined; however, we have felt comfortable with a fenestration-to–proximal edge distance ≥ 5 mm, as long as the seal zone is still adequate from fabric to aortic pathology. Although this minimal distance is likely sufficient in most cases, increased experience and comfort with this technique has led us to be increasingly aggressive with obtaining increased quantitative and qualitative seal zone, even at the expense of needing to incorporate additional supra-aortic arch vessels into the reconstruction. Although our early results have been excellent, we feel this aggressiveness is warranted until long-term durability of this technique is better defined.

CONCLUSION

LIFE enables rapid endovascular treatment of aortic arch pathology with expeditious branch vessel revascularization. Early results of LIFE in the aortic arch demonstrate promising results among high-risk patients and its particular utility for urgent and emergency situations; however, longitudinal data are needed to confirm the durability of this technique. The technique employs limited CCA exposure, provides the opportunity for distal embolic protection via clamping, and utilizes a steerable sheath to facilitate perpendicular orientation of the laser catheter and the aortic stent graft.

1. Ullery B, Magee G, Han SM, et al. Midterm outcomes of laser in-situ fenestrated repair (LIFE) of complex aortic arch pathology: results from the multicenter LIFE registry. J Vasc Surg. Published online October 9, 2025. doi: 10.1016/j.jvs.2025.09.056

Jonathan Bath, MD
Associate Professor of Surgery
Program Director for Vascular Fellowship
University of Missouri
Chief of Vascular Surgery
Harry S. Truman VA
Columbia, Missouri
bathj@health.missouri.edu
Disclosures: Consultant to W.L. Gore and Medtronic.

Brant W. Ullery, MD, MBA
Medical Director, Oregon Vascular Specialists
Wilsonville, Oregon
Medical Director, Vascular and Endovascular Surgery
Providence Heart & Vascular Institute
Portland, Oregon
brant.ullery@providence.org
Disclosures: Consultant to W.L. Gore, Medtronic, and Boston Scientific Corporation.

Using the Gore TAG TBE in Zone 0 With Aortic Arch Debranching

By Christopher J. Smolock, MD, FSVS

Hybrid endovascular/debranching repair to zone 0 of the aortic arch with a commercially available, off-the-shelf, branched thoracic endograft has been an alternative to any of the variety of open cardiac aortic arch repairs, which often require circulatory arrest, since 2022. The Gore TAG TBE only gained an indication for use in zone 0 in June 2025. Such procedures for aortic arch pathologies, aneurysms, and/or dissections, as well as for trauma, are challenging at baseline due to the complex anatomy and need to maintain cerebral perfusions. However, in higher-risk patients less suitable for open repair, employing an endovascular repair can offer a less invasive alternative with high technical success and acceptable perioperative risk.[1-3]

Zone 0 deployment, proximal to the innominate artery/brachiocephalic trunk, requires a secure proximal landing zone in the ascending aorta, necessitating surgical debranching of the arch branch vessels to preserve cerebral and upper extremity blood flow.[2,4,5] The Gore TAG TBE has a single-branch configuration with a retrograde, inner-branch design to allow maintenance of flow to a target branch arch vessel.

PROCEDURAL PLANNING

In a zone 0 proximal landing, that target branch is the innominate artery. The LCCA and LSA need to be revascularized by debranching or surgical bypass, and this is usually supplied by the RCCA in the form of a retropharyngeal right carotid–to-LSA bypass with reimplantation of the left carotid artery end-to-side onto this bypass graft for an effective left carotid–right carotid artery bypass and a left carotid–subclavian artery bypass.

Proper planning and detailed preoperative imaging, ideally a gated CTA with 1.5-mm thin reconstructions, are paramount (Figure 1).[1-4,6] The diameter range of the ascending aorta landing zone that can be treated is 16 to 42 mm. There must be at least 20 mm of seal length proximal to the target branch vessel. The diameter range of the target branch vessel must be between 6 and 18 mm, and its length should be 2.5 to 3 mm, depending on the branch diameter used. Additional anatomic considerations are aortic arch and descending thoracic aortic curvatures, thrombus, calcification, branch vessel angulation, and access vessel diameter, as the sheath sizes range from 20 to 26 F. Neuromonitoring and/or spinal drainage is decided on a case-by-case basis, considering but not limited to length of aortic coverage, prior aortic surgery, and hospital resources. Once the appropriate device and branch endografts are chosen, the surgical debranching is performed ideally during an operative setting separate from that of TBE placement. This endovascular aortic portion of the repair is done in a staged manner at least 1 to 2 days after debranching. This surgical debranching is achieved via bilateral, supraclavicular incisions.

Courtesy of Ezequiel Parodi, MD, with University of North Carolina.

Figure 1. Preoperative CTA 3D reconstruction showing arch anatomy as well as largest diameter of the aneurysmal dilation of a chronically dissected thoracic aorta (type B1-11) not visualized in this reconstructed image.

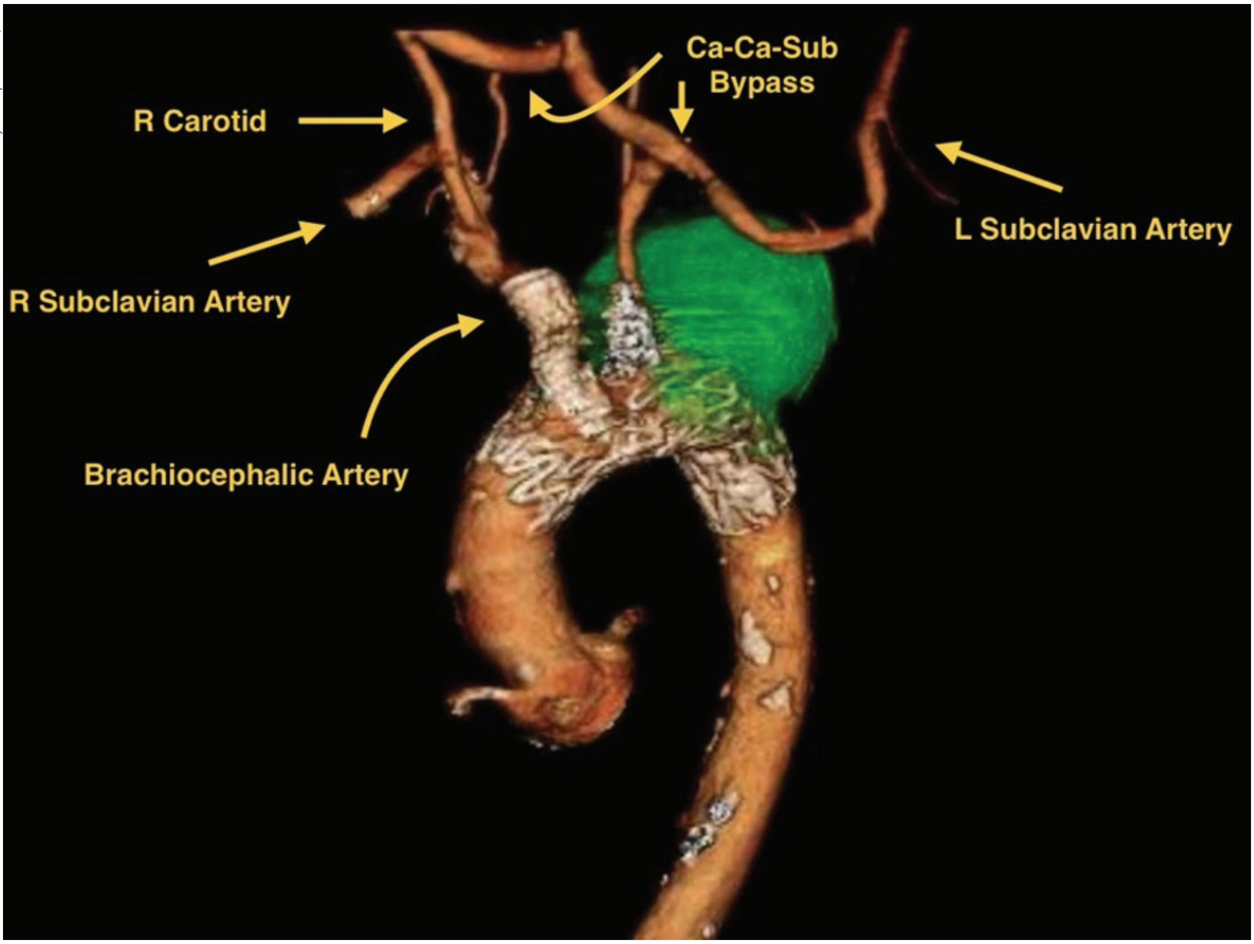
Courtesy of Ezequiel Parodi, MD, with University of North Carolina.

Figure 2. Postoperative CTA 3D reconstruction demonstrating TBE device with innominate artery target branch.

PROCEDURAL TECHNIQUE

On the right neck, a short incision of approximately 3 cm is made parallel and just cranial to the clavicle and between the heads of the sternocleidomastoid muscle. Here, the proximal-mid RCCA is easily dissected free just deep to the muscle and medial to the internal jugular vein. On the left, this incision, again just cranial and parallel to the clavicle, should extend from the medial, sternal head of the sternocleidomastoid muscle to approximately 6 cm laterally. The CCA is dissected free and controlled with loops in the medial aspect of this incision. Next, the scalene fat pad is mobilized laterally while ligating all lymphatics, including the thoracic duct. The phrenic nerve is identified in its path along the anterior scalene muscle and protected. The anterior scalene muscle is then removed from its insertion on the first rib, and the LSA is identified immediately posterior to this and controlled with loops. Medially in each incision, the spinous body is identified posteriorly in the wounds. Blunt finger tunneling medially along the anterior surface of the spinal body is performed until each side reaches the other in a nonconstricted manner. Care is taken to protect the posterior aspect of the pharynx during this process, as the tunneling occurs between it anteriorly and the spine posteriorly. Depending on the carotid and subclavian artery diameters, a 6- or 8-mm woven or knitted Dacron graft is tunneled between the wounds in the retropharyngeal space made. We recommend not using ringed polytetrafluoroethylene behind the pharynx so as not to contribute to dysphasia. The bypass graft is anastomosed in the right neck end-to-side to the RCCA with 6-0 Prolene suture (Ethicon, Inc., a subsidiary of Johnson & Johnson) and in the left neck end-to-side to the LSA. The LCCA is then divided and ligated proximally in the neck. The distal cut end of the carotid artery is then anastomosed end-to-side onto the bypass graft, coursing across the left wound with 6-0 Prolene suture. Upon closure of the wounds, a round drain is placed in the left neck for potential lymphatic leak once postoperative diet is resumed.

When the patient is brought back to the operating room in the following days, percutaneous access is achieved in the femoral artery of choice that can accommodate the needed sheath French size for TBE delivery. Alternatively, if necessary, an iliac artery conduit or direct iliac artery puncture can be used for the TBE delivery. The contralateral femoral artery is accessed percutaneously for flush catheter access, and



Courtesy of Ezequiel Parodi, MD.

Figure 3. Postoperative CTA 3D reconstruction with labeled arch branches and endovascular and open arch debranching reconstructions.

the right radial artery is accessed percutaneously as well. This radial artery wire is snared from the femoral access and is ultimately the target branch vessel wire access. Consider using a 65-cm-long Gore DrySeal sheath (Gore & Associates) from the femoral access best suited for large-diameter access, as this can assist proper rotational orientation of the TBE. The right radial access is snared from the chosen femoral access, and the TBE is loaded onto both of these wires and taken into the arch. Rotation of the device is done to decrease wire wrap. This can be difficult for a zone 0 deployment given the multiple aortic zone curvatures that are traversed. Once the main body is deployed, the branch graft is quickly placed into the target vessel. A second branch graft is kept at the ready in case extension of the first branch is needed. This especially can be the case if the TBE is rotated posteriorly or anteriorly in relation to the target vessel and therefore consuming greater branch graft distance than is initially appreciated. The branch overlap zones are briefly ballooned, and then any additional needed proximal or distal aortic pieces are placed.

The native LSA origin may need to be occluded to prevent back bleeding into the aortic pathology. This can be done at any time between completion of the surgical arch debranching and completion of placement of the TBE and any other aortic endografts. Embolization of this origin must be done proximally to the vertebral artery, ensuring preservation of antegrade flow into it from the debranching bypass graft.

After completion of TBE and aortic endograft placements, the patient is awoken from anesthesia, and a neurologic exam is obtained in the operating room. If this exam is at the patient's baseline, then the patient is transferred to the intensive care unit until at least postoperative day 1 for close monitoring of heart rate, blood pressure, and other cardiovascular events such as retrograde aortic dissection. If a spinal drain was used, often this is capped on postoperative day 1 for 6 hours, and if the neurologic exam remains intact, then the drain is removed. Depending on the patient's presenting pathology and other intraoperative findings, a postoperative gated CTA of the chest, abdomen, and pelvis in three phases with thin reconstructions is sometimes obtained prior to discharge (Figures 2 and 3). Discharge from the hospital on dual antiplatelet therapy can be expected around postoperative day 4 from placement of the TBE, depending on the patient.

Postoperative follow-up occurs at 1 month with a CTA of the chest, abdomen, and pelvis if not already done prior to discharge, and then continued surveillance with CTA is undertaken at 6 months, 12 months, and annually for life. Monitoring for endoleak, target branch instability, endograft integrity, and aortic dilation at proximal and distal landing zones is imperative to prevent long-term complications.

STUDY RESULTS

The early feasibility study of the Gore TAG TBE (United States multicenter study), as well as single-center, postapproval data, showed high technical success (> 90%) in zone 0/1 deployment with branch patency near 100%, a stroke rate of approximately 8%, and mortality up to 11%.[1,2,5-8] Other infrequent, early, and perioperative complications included access site complications, retrograde dissection, and spinal cord ischemia. Compared to open aortic arch repairs, TBE with debranching offers similar or lower morbidity and mortality in high-risk cohorts.[2,5,8,9] In the trial of midterm outcomes, 3-year follow-up showed no device migration, fracture, or aortic rupture reported in zone 0/1 patients; branch patency was 100%, and there were no reinterventions or aneurysm enlargement in this cohort.[10] In other single-center, retrospective data sets, the mid- to long-term outcomes and durability of the Gore TAG TBE in zone 0 repairs with aortic arch debranching are similarly favorable, with high device stability, low rates of migration and fracture, and low reintervention rates over 3 to 5 years. Late complications are infrequent, and persistent endoleak of all types is approximately 7%.[1,5-8,10-13]

SUMMARY

Use of the Gore TAG TBE in zone 0 with aortic arch debranching for the treatment of aortic arch pathologies demonstrates acceptable perioperative risk-benefit ratio, especially in patients who are high risk for open aortic arch repair with circulatory arrest. This procedure also shows excellent mid-term durability with low reintervention rates and minimal late complications. Continued long-term follow-up study is needed to observe long-term results beyond 5 years.[1-4] ■

1. Dake MD, Bavaria JE, Singh MJ, et al. Management of arch aneurysms with a single-branch thoracic endograft in zone 0. JTCVS Tech. 2021;7:1-6. doi: 10.1016/j.xjtc.2021.01.011
2. Sweet MP, Azizzadeh A, Oderich GS, et al. Early outcomes of endovascular repair of aortic arch lesions in zone 0/1 with a thoracic branched endoprosthesis. J Vasc Surg. 2025;82:1591-1600.e4. doi: 10.1016/j.jvs.2025.07.040
3. Nana P, Tyrrell MR, Guihaire J, et al. A review: single and multibranch devices for the treatment of aortic arch pathologies with proximal sealing in Ishimaru zone 0. Ann Vasc Surg. 2023;94:45-55. doi: 10.1016/j.avsg.2022.09.044
4. Clough RE, Spear R, Van Calster K, et al. Case series of aortic arch disease treated with branched stent-grafts. Br J Surg. 2018;105:358-365. doi: 10.1002/bjs.10681
5. Smorenburg SPM, Montesano M, Hoogteijling TJ, et al. Anatomic suitability for branched thoracic endovascular repair in patients with aortic arch pathological features. J Am Heart Assoc. 2020;9:e016695. doi: 10.1161/JAHA.120.016695
6. Kent WD, Appoo JJ, Bavaria JE, et al. Results of type II hybrid arch repair with zone 0 stent graft deployment for complex aortic arch pathology. J Thorac Cardiovasc Surg. 2014;148:2951-2955. doi: 10.1016/j.jtcvs.2014.06.070
7. Kudo T, Kuratani T, Shimamura K, et al. Long-term results of hybrid aortic arch repair using landing zone 0: a single-centre study. Eur J Cardiothorac Surg. 2021;59:1227-1235. doi: 10.1093/ejcts/ezab016
8. Pang HJ, Warren AS, Dansey KD, et al. Early outcomes of endovascular repairs of the aortic arch using thoracic branch endoprosthesis. J Vasc Surg. 2024;80:22-31. doi: 10.1016/j.jvs.2024.02.003
9. Zlatanovic P, Koncar I, Sladojevic M, et al. Hybrid repair of aortic arch with zone zero endografting—case series with review of the literature. J Card Surg. 2021;36:3805-3816. doi: 10.1111/jocs.15811
10. 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;64:639-645. doi: 10.1016/j.ejvs.2022.08.003
11. DiLosa KL, Manesh M, Kanamori LR, et al. Multi-center experience with an off-the-shelf single retrograde thoracic branch endoprosthesis for acute aortic pathology. J Vasc Surg. 2025;81:839-846. doi: 10.1016/j.jvs.2024.12.007
12. Gable DR, Verhoeven E, Trimarchi S, et al. Endovascular treatment for thoracic aortic disease from the Global Registry for Endovascular Aortic Treatment. J Vasc Surg. 2024;79:1044-1056.e1. doi: 10.1016/j.jvs.2023.12.040
13. Patel AJ, Ambani RN, Sarode AL, et al. Outcomes of great vessel debranching to facilitate thoracic endovascular aortic repair. J Vasc Surg. 2022;76:53-60.e1. doi: 10.1016/j.jvs.2022.01.127

Christopher J. Smolock, MD, FSVS
Associate Professor of Surgery
Icahn School of Medicine at Mount Sinai
New York, New York
christopher.smolock@mountsinai.org
Disclosures: Speaker for Cook Medical; research for Gore & Associates and Terumo Aortic.