Optimal Landing Zone for TEVAR

Considerations regarding landing zone length and diameter, angulation, and calcification and thrombus and a review of available devices.

By Kyle Reynolds, MD, and Javairiah Fatima, MD, FACS, RPVI, DFSVS

Thoracic endovascular aortic repair (TEVAR) is a minimally invasive treatment modality that has revolutionized the treatment of thoracic aortic pathologies. Initially developed and indicated for descending thoracic aortic aneurysms, TEVAR has since evolved into the mainstay and preferred treatment option for type B dissections, intramural hematomas, penetrating aortic ulcers, and traumatic aortic transections.[1] With abundant data indicating the efficacy of TEVAR, it has been widely used and accepted as the recommended first-line treatment over open repair for descending thoracic aortic aneurysms due to significantly lower morbidity and mortality rates associated with TEVAR.

The ability to undergo successful TEVAR is highly dependent on favorable anatomy and being within the criteria of an endovascular device's instructions for use (IFU). This makes preoperative imaging and measurements vital to determine the suitability for endovascular repair and subsequent device selection. CTA with thin cuts (≤ 1 mm) examining the entire aorta as well as the iliofemoral arteries remains the most important imaging modality for assessment of anatomic feasibility.[2] Use of three-dimensional software with creation of centerline of flow is critical to obtain accurate and precise measurements for endograft sizing. Imaging review entails assessment of the proximal and distal landing zone length, diameter, morphologic characteristics, aortic angulation, and access vessels. Studies have demonstrated that an adequate landing/seal zone is paramount to achieve long-term device success.[3,4]

LANDING ZONE LENGTH

An ideal landing zone creates the best opportunity for good apposition of the stent graft, allowing a good seal and fixation. A compromised landing zone leads to endoleaks, bird-beaking, retrograde aortic dissection, and device migration. The commercially available thoracic stent grafts vary in their specific requirements to optimize seal at the landing zone, ranging from 15-25 mm proximally and 20-30 mm distally. An ideal segment of healthy aorta has a relatively healthy parallel aorta with a uniform diameter over the straight segment of the vessel designated to be the seal zone; this segment should be nonaneurysmal and free of intraluminal thrombus, calcification, and tortuosity.

LANDING ZONE DIAMETER

The diameter of the aorta within the landing zone segment may vary up to 15% without significant risk of endoleak or failure of a proximal fixation.[5,6] This is likely due to the fact that commercially available stent grafts for TEVAR are oversized, depending on the device's IFU and surgical indication. With stent grafts ranging from 21 to 46 mm for TEVAR, it is feasible to treat aortic diameters from 16 to 42 mm. Patients with aneurysms are recommended for greater oversizing, typically 15% to 20% to maximize the radial force at the seal zones, although the general consensus for aortic dissections/transections is 0% to 10%. In patients with aortas with severe curvature at the arch, even more generous oversizing may be necessary to ensure adequate apposition along the inner curvature to prevent a type Ia endoleak and/or graft migration. Caution must be taken with too much oversizing because it increases the risk of retrograde type A dissection[7] and can lead to stent graft infolding and accelerated aneurysm degeneration. In fact, data have shown that there is a strong correlation between the percentage of oversizing and change in the distal neck diameter after TEVAR in aneurysm patients.[8]

ANGULATION

Stent graft deployment with TEVAR commonly requires a proximal seal zone in the aortic arch. When the proximal landing zone segment has extreme angulation or curvature, it can lead to incomplete endograft apposition to the aortic lumen wall, known as bird-beak configuration. Due to the unsealed portion between the endograft and the lesser curvature of the aorta, severe bird-beaking causes an increased risk of type Ia endoleaks.[9] Unlike EVAR, type I endoleaks are the most common endoleaks after TEVAR and the most common cause of reintervention, observed in 2% to 15% of TEVAR procedures.[10] Earlier endografts were more prone to bird-beaking because the proximal stent grafts did not conform to the aortic anatomy well, with an incidence as high as 40% to 57%.[11,12] Current-generation TEVAR devices have evolved in their design, including staged proximal deployment sequences and material improvements, which have helped improve the conformability of the stent grafts within the aortic arch. This has allowed better sealing of the proximal landing zone and decreased the occurrence and severity of bird-beaking.

CALCIFICATION AND THROMBUS

Extensive circumferential thrombus or calcification of the aortic wall at the desired landing zones is a relative contraindication to TEVAR and leads to type I endoleaks.[13] There is no consensus on how much is too much. A recent study tried to answer this, focusing on the distal landing zone. Compromised distal landing zone was defined as cross-sectional thrombus > 50%, > 25% circumferential mural calcification, or > 3.5-cm diameter. In 55 TEVARs performed for aneurysmal disease falling into one of these compromised distal landing zone categories, 35% of patients had type Ib endoleaks in their intermediate follow-up.[14]

COMMERCIALLY AVAILABLE TEVAR DEVICES

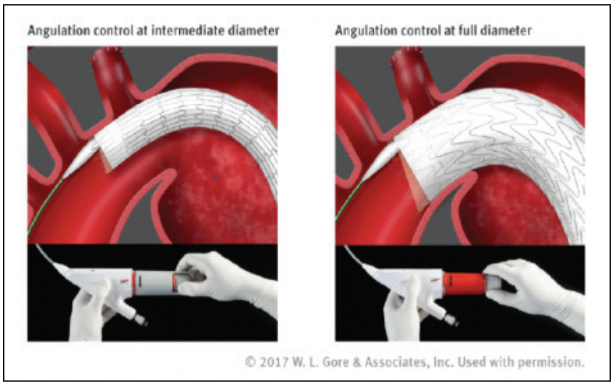
Currently, there are four thoracic aortic stent grafts available for commercial use in the United States, each with unique characteristics that should be considered in operative planning and device choice. Each of these devices has gone through design and material improvements to allow better conformability and seal.

The Valiant Navion stent graft system (Medtronic; Figure 1) is available in the FreeFlo configuration, which is uncovered proximal bare-metal stents requiring > 20 mm of proximal landing zone, and the CoveredSeal configuration, which is a closed-web design without proximal bare-metal stents requiring 25 mm. Pivotal results from a global clinical trial of 30-day outcomes of the Valiant Navion had a 1.2% type Ia endoleak rate and a 2.5% overall endoleak rate.[15]

Courtesy of Medtronic.

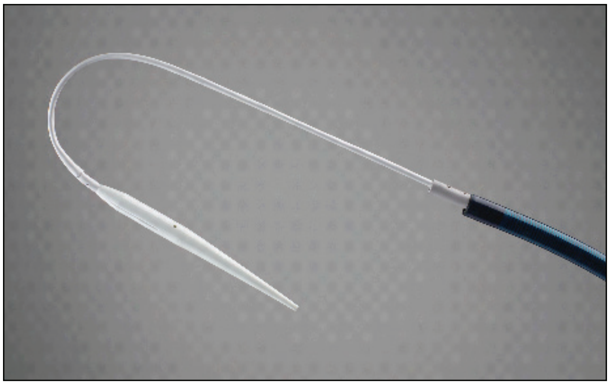
Figure 1. Valiant Navion stent graft system.

The newest-generation Conformable Gore TAG (CTAG; Gore & Associates; Figure 2) with active control offers a multistage controlled release and allows for orthogonal adjustment of the proximal stent graft to the curvature of the proximal landing zone, creating a better seal and decreasing bird-beaking. The SURPASS observational registry of 127 patients demonstrated need for repositioning the graft in two-thirds of the cohort intraoperatively, and half of the cases used the angulation feature to improve wall apposition and orthogonality in the aorta, resulting in type Ia endoleaks in two patients and no bird-beaking at 1 year.[16]



Courtesy of Gore & Associates.

Figure 2. CTAG.



Courtesy of Cook Medical.

Figure 3. Zenith Alpha thoracic endovascular graft.

Figure 4. RelayPlus.

The Zenith Alpha thoracic endovascular graft (Cook Medical; Figure 3) is the newer generation of the Zenith TX2 with a built-in nose cone curvature to improve conformability.

RelayPlus (Terumo Aortic; Figure 4) has a curved self-aligning supportive S-bar engineered into the stent graft that orients to the outer curve of the thoracic aorta and is coupled with staged deployment, allowing for precise positioning. The IFU-required aortic landing zone length varies depending on the diameter of the stent graft, ranging from 15 to 25 mm proximally and 25 to 30 mm distally.

EXTENSION OF LANDING ZONE IN COMPLEX AORTIC ANATOMY

Given the successful incorporation of TEVAR for thoracic aortic pathology with significantly reduced morbidity, landing zone extension has been implemented in higher-risk patients with more complex anatomy. Branch vessels that would have been occluded by the stent grafts can often be bypassed or debranched, and the landing zone can be moved more proximally into zone 0 to 2 to allow for adequate seal (Figure 5).

Additionally, trials are currently underway that are evaluating patients with thoracic aortic pathology encroaching on or involving the arch branch vessels, such as trials involving the Valiant Mona LSA stent graft system (Medtronic), Gore TAG thoracic branch endoprosthesis (Gore & Associates), and most recently the Relay Branch stent graft (Terumo Aortic). These devices are available only to a few select centers participating in these trials. Meanwhile, the parallel stent graft technique (chimneys and snorkels) has also been used, with the advantage of immediate availability using off-the-shelf endograft devices.[17] However, the longevity and durability of these techniques are not known. Laser in situ arch fenestration is a useful adjunct that has been used successfully in expanding the proximal extent of TEVAR to obtain adequate seal.[18]

EndoAnchors (Medtronic) have been used prophylactically and therapeutically to reinforce fixation in proximal seal in challenging or hostile proximal landing zones, augmenting endograft seal and mitigating the risk of stent migration.[19,20] It is important that the area deemed suitable for EndoAnchor placement is devoid of calcification and thrombus to achieve optimal results.

Although the indications for TEVAR continue to expand to treat more challenging aortic diseases, achieving adequate proximal landing zone remains a fundamental requisite for adequate fixation and seal of the endograft. Close and continued postoperative imaging surveillance is therefore an important and necessary aspect of care for these complex patients.

CONCLUSION

Optimal landing zones have long, healthy, parallel (nontorturous) aortic segments free of calcium and mural thrombus. Compromised landing zones lead to stent graft failure, including endoleaks and stent

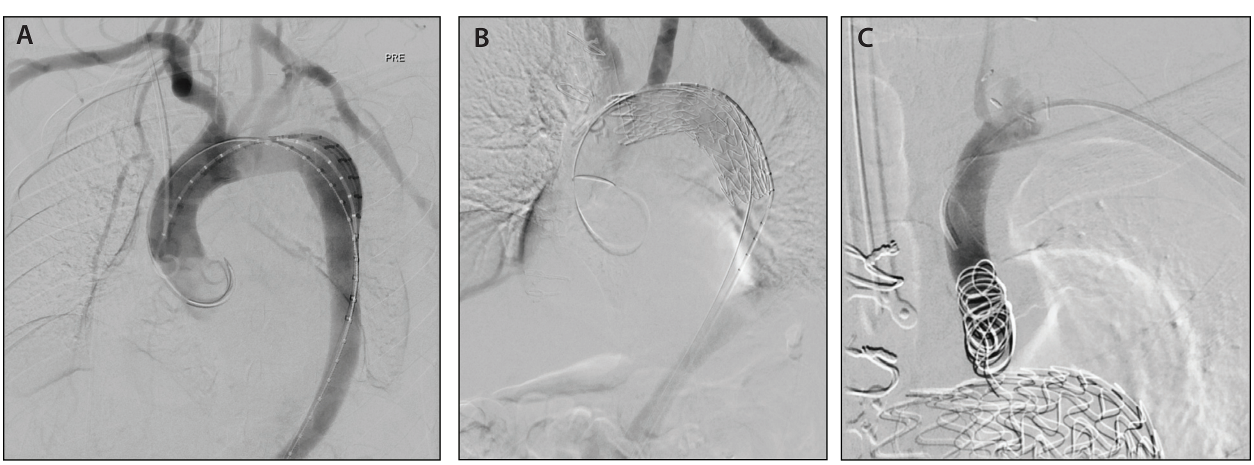


Figure 5. Extension of proximal landing zone into healthy parallel aorta (zone 2) with coverage and coil embolization of left carotid subclavian artery to obtain adequate seal proximal seal zone (A-C).

migration. TEVAR repairs benefit from the evolution and development of modern endovascular stent grafts with improved modifications and designs aimed at increasing precise deployment, conformability, and sealing at landing zones. ■

1. Makaroun MS, Dillavou ED, Kee ST, et al. Endovascular treatment of thoracic aortic aneurysms: results of the phase II multicenter trial of the GORE TAG thoracic endoprosthesis. J Vasc Surg. 2005;41:1-9. doi: 10.1016/j.jvs.2004.10.046
2. Upchurch GR Jr, Escobar GC, Azizzdeh A, et al. The Society for Vascular Surgery clinical practice guidelines for thoracic endovascular aneurysm repair (TEVAR). J Vasc Surg. Published online July 3, 2020. doi: 10.1016/j.jvs.2020.05.076
3. Aburahma AF, Campbell J, Stone PA, et al. The correlation of aortic neck length to early and late outcomes in endovascular aneurysm repair patients. J Vasc Surg. 2009;50:738-748. doi: 10.1016/j.jvs.2009.04.061
4. Schanzer A, Greenberg RK, Hevelone N, et al. Predictors of abdominal aortic aneurysm sac enlargement after endovascular repair. Circulation. 2011;123:2848-2855. doi: 10.1161/CIRCULATIONAHA.110.014902
5. Nation DA, Wang GJ. TEVAR: endovascular repair of the thoracic aorta. Semin Intervent Radiol. 2015;32:265-271. doi: 10.1055/s-0035-1558824
6. Barfield ME, Maldonado TS. Identifying the appropriate thoracic device size. Endovasc Today. 2017;16:51-52, 54-56.
7. Chen Y, Zhang S, Liu L, et al. Retrograde type A aortic dissection after thoracic endovascular aortic repair: a systematic review and meta- analysis. J Am Heart Assoc. 2017;6:e004649. doi: 10.1161/JAHA.116.004649
8. Alberta HB, Secor JL, Smits TC, et al. Comparison of thoracic aortic diameter changes after endograft placement in patients with traumatic and aneurysmal disease. J Vasc Surg. 2014;59:1241-1246. doi: 10.1016/j.jvs.2013.11.075
9. Marrocco-Trischitta, MM, Spampinato, B, Mazzaeo, G, et al. Impact of the bird-beak configuration on postoperative outcome after thoracic endovascular aortic repair: a meta-analysis. J Endovasc Ther. 2019;26:771-778. doi: 10.1177/1526602819865906
10. Ganapathi AM, Andersen ND, Hanna JM, et al. Comparison of attachment site endoleak rates in Dacron versus native aorta landing zones after thoracic endovascular aortic repair. J Vasc Surg. 2014;59:921-929. doi: 10.1016/j.jvs.2013.10.086
11. Ueda T, Fleischmann D, Dake MD, et al. Incomplete endograft apposition to the aortic arch: bird-beak configuration increases risk of endoleak formation after thoracic endovascular aortic repair. Radiology. 2010;255:645-652. doi: 10.1148/radiol.10091468
12. Boufi M, Guivier-Curien C, Deplano V, et al. Risk factor analysis of bird beak occurrence after thoracic endovascular aortic repair. Eur J Vasc Endovasc Surg. 2015;50:37-43. doi: 10.1016/j.ejvs.2015.04.018
13. Bonci G, Steigner ML, Hanley M, et al. American College of Radiology ACR appropriateness criteria® thoracic aorta interventional planning and follow up. Accessed October 10, 2020. https://acsearch.acr.org/docs/3099659/Narrative
14. Dubois BG, Houben IB, Khaja MS, et al. Thoracic endovascular aortic repair in the setting of compromised distal landing zones. Ann Thorac Surg. Published online July 6, 2020. doi: 10.1016/j.athoracsur.2020.05.074
15. Azizzadeh A, Desai N, Arko FR 3rd, et al. Pivotal results for the valiant navion stent graft system in the valiant EVO global clinical trial. J Vasc Surg. 2019;70:1399-1408.e1. doi: 10.1016/j.jvs.2019.01.067
16. Torsello GF, Argyriou A, Stavroulakis K, et al. One-year results from the SURPASS observational registry of the CTAG stent-graft with the active control system. J Endovasc Ther. 2020;27:421-427. doi: 10.1177/1526602820913007
17. Hogendoorn W, Schlösser FJ, Moll FL, et al. Thoracic endovascular aortic repair with the chimney graft technique. J Vasc Surg. 2013;58:502-511. doi: 10.1016/j.jvs.2013.03.043
18. Redlinger RE Jr, Ahanchi SS, Panneton JM. In situ laser fenestration during emergent thoracic endovascular aortic repair is an effective method for left subclavian artery revascularization. J Vasc Surg. 2013;58:1171-1177. doi: 10.1016/j.jvs.2013.04.045
19. Jordan WD Jr, Mehta M, Varnagy D, et al. Results of the ANCHOR prospective, multicenter registry of EndoAnchors for type Ia endoleaks and endograft migration in patients with challenging anatomy. J Vasc Surg. 2014;60:885-892.e2. doi: 10.1016/j.jvs.2014.04.063
20. Ongstad SB, Miller DF, Panneton JM. The use of EndoAnchors to rescue complicated TEVAR procedures. J Cardiovasc Surg (Torino). 2016;57:716-729.

Kyle Reynolds, MD
Clinical Instructor of Surgery
Georgetown University Hospital
MedStar Heart and Vascular Institute
Washington, DC
kyle.b.reynolds@medstar.net
Disclosures: None.

Javairiah Fatima, MD, FACS, RPVI, DFSVS
Associate Professor of Surgery
Georgetown University School of Medicine
Co-Director Complex Aortic Center
MedStar Heart and Vascular Institute
Washington Hospital Center
Site Director, MedStar Montgomery Medical Center
Washington, DC
javairiah.fatima@medstar.net
Disclosures: None.