Endovascular repair of ascending aortic pathologies in patients unfit for open surgery: case series and literature review

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ABSTRACT

The number of vascular centers performing endovascular repair of ascending aortic disease is constantly increasing. Accordingly to the guidelines, open surgical repair remains the gold standard for these pathologies. However, approximately one quarter of patients are deemed unfit for open surgery. In this study, we describe three cases of ascending thoracic endovascular aortic repair (TEVAR) performed at our center. All the patients were deemed unfit for open surgery by the aortic team. Two patients had an ascending aortic pseudoaneurysm, and the third had a focal type A aortic dissection. In two cases, we used two abdominal aortic cuffs deployed from zone 0B to zone 0C, with no need for supra-aortic trunk debranching. In one case, we performed a "reverse" extrathoracic debranching, and we deployed a thoracic endograft from zone 0B to zone 2. Complications included one minor stroke and one inguinal hematoma. In one patient with an infected pseudoaneurysm, we performed ascending TEVAR as a bridge strategy for open repair. This patient developed a type Ia endoleak; however, clinical stabilization and infection control were obtained, and he was able to undergo heart surgery successfully. He underwent a second reintervention to treat superior mesenteric embolic occlusion. At 2 years of follow-up, all three patients were alive. Our preliminary experience demonstrates the technical feasibility and clinical appropriateness of ascending TEVAR using standard, commercially available endografts. However, no consensus has been reached regarding some critical aspects, such as the development of a standardized technique or the efficacy of the currently available devices. The improvements in graft design and the adoption of the "aortic team" approach could help in the near future to standardize the procedure, establish appropriate indications, and ensure good clinical outcomes. (J Vasc Surg Cases Innov Tech 2024;10:101455.)

Keywords: Ascending aorta; Ascending aortic pseudoaneurysm; Ascending TEVAR; Endovascular techniques; Type A aortic dissection

Thoracic endovascular aortic repair (TEVAR) has evolved rapidly and replaced open repair as the standard treatment for descending aortic pathologies, with a significant reduction in early death and complications.[1,2] The continuing development of the technology in the direction of branched and fenestrated endografts and the application of new techniques—such as parallel grafting and physician modifications—has introduced endovascular (both total and hybrid) treatment of the aortic arch for patients who are unfit for open repair, for whom, otherwise, open surgery continues to be the standard of care.[3,4]

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Encouraged by the generally favorable outcomes seen in the aortic arch and the absence of alternative treatments for unfit patients, endovascular repair of the ascending aorta is also emerging.[5] A systematic review identified 119 patients who underwent TEVAR in the ascending aorta; 67% of whom had previously undergone cardiac surgery, and 28% were to be treated for an anastomotic pseudoaneurysm.[6] Some series have shown encouraging results with ascending TEVAR in different aortic pathologies, such as type A aortic dissection (TAAD), ascending aortic pseudoaneurysm (AAP), intramural hematoma (IMH), penetrating atherosclerotic ulcer, and infection.[7-12]

Because there is no standardized technique, different approaches have been used. Currently, no endografts designed for this purpose are commercially available, and nearly 90% of the cases have been performed off-label with standard thoracic endografts or abdominal aortic cuffs.[13,14] The deployment of a single, short endograft cuff is the most commonly used strategy for ascending TEVAR. In ≤30% of the reported cases, the Zenith TX2 Pro-form endograft extension (Cook Medical) has been used.[15,16] Some investigators reported the use of investigational or custom made devices.[17,18] Two dedicated ascending devices, the Zenith Ascend (William

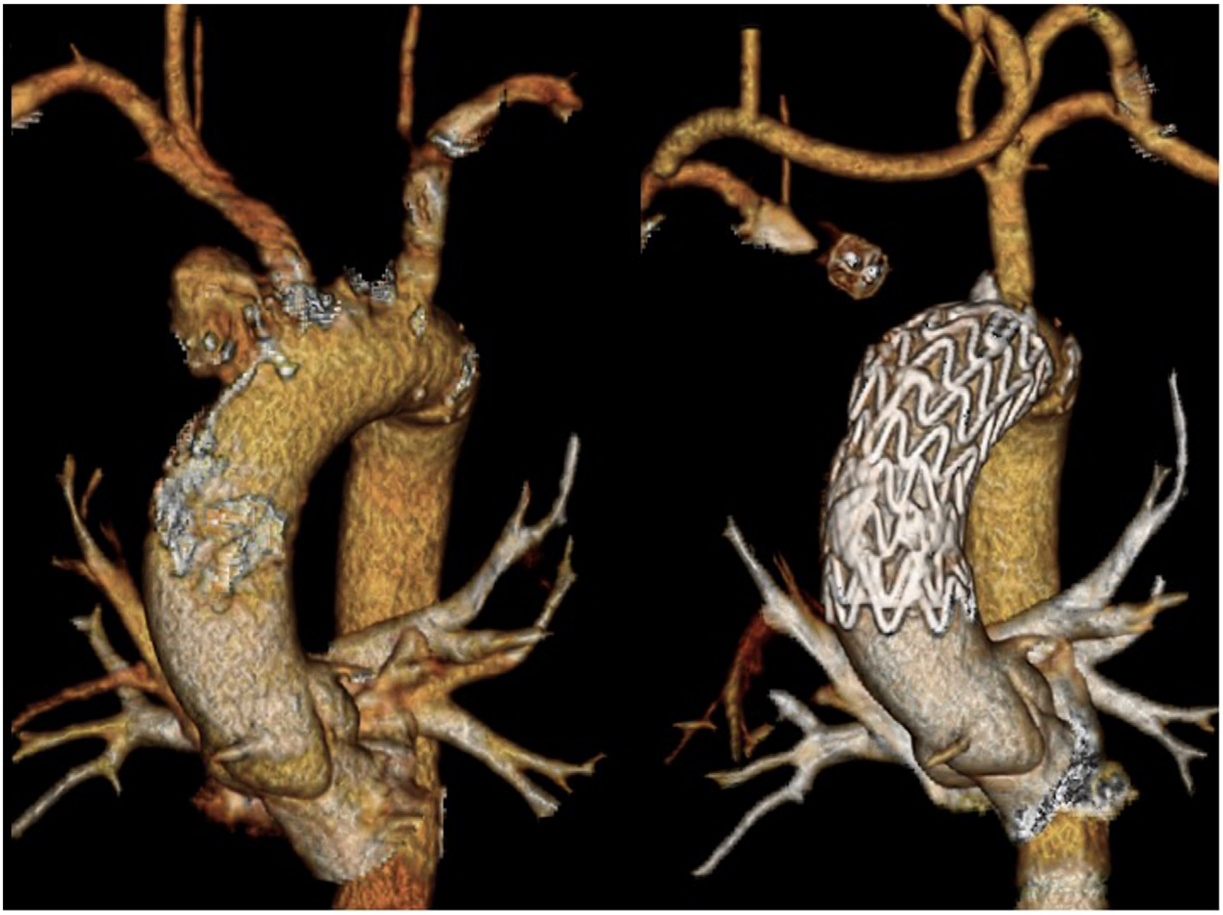

Fig 1. Pre- and postoperative three-dimensional computed tomography (CT) reconstructions showing an aortic pseudoaneurysm (AAP) treated with ascending thoracic endovascular aortic repair (TEVAR) and reverse supra-aortic trunk debranching.

Cook Europe) and Gore Ascending stent graft (W.L. Gore & Associates) have provided encouraging results to date.[11,18-21]

In this case series, we aim to describe our surgical technique and report our experience with three such cases. All three patients provided written informed consent for the procedure and the report of their case details and imaging studies.

CASE SERIES

Patient 1. A 60-year-old man with a history of granulomatosis with polyangiitis and IMH of the ascending aorta (treated conservatively until then) presented to the emergency department with hemoptysis. Computed tomography (CT) revealed a ruptured AAP with a diameter of 52 mm associated with mediastinal hematoma. The aneurysm neck was in the outer curve, just below the innominate artery (zone 0C). The patient was hemodynamically stable but assessed as unfit for open surgery by the cardiac surgery team due to the increased operative risk for a redo sternotomy in a fragile patient. A hybrid approach was proposed, with "reverse" extrathoracic debranching to allow for ascending TEVAR. In the same operation, an axillary—axillary bypass (8-mm Dacron graft) was performed, and both common carotid arteries were reimplanted on it. The graft was tunneled under both pectoralis major muscles and anterior to the sternum before heparinization. From a left femoral surgical access, a 36 × 100-mm conformable TAG endograft (W.L. Gore & Associates) was deployed, with the proximal end in zone 0B and the distal end in zone 2, covering the pseudoaneurysm neck and innominate and left carotid arteries. An 8F introducer was placed in the left subclavian ostium to avoid accidental coverage, and transfemoral rapid pacing was performed during deployment. Finally, the innominate artery was occluded with a 14-mm Amplatzer II vascular plug (Abbott Cardiovascular) inserted through the right axillary artery. The intervention was uneventful. Postoperative CT demonstrated correct positioning of the stent graft with complete AAP exclusion and patency of the bypasses (Fig 1). The perioperative course was complicated by a minor stroke symptomatic for left

Fig 2. Intraoperative angiography with preoperative axial computed tomography (CT) detail and postoperative three-dimensional CT reconstruction of focal type A aortic dissection (TAAD) treated with ascending thoracic endovascular aortic repair (TEVAR) with two abdominal cuffs.

hand hyposthenia, which probably occurred during the procedure. The patient was discharged home after 9 days with only a mild hyposthenia of the left hand, which regressed after a couple of weeks. At 22 months of follow-up, the patient was alive and had regained motility of his left hand.

Patient 2. An 80-year-old man presented to the emergency department with thoracic pain. The electrocardiography findings and cardiac markers were negative. However, CT showed a bovine arch and a focal TAAD. The lesion was 45 mm long and located in the outer curve, 12 mm above the sinotubular junction (zone 0B) and 5 mm before the innominate artery (zone 0C). The entry tear was located in the middle of the lesion. Because the patient was unfit for sternotomy due to his age and comorbidities, a less invasive endovascular approach was preferred. Through a right axillary conduit, two 32 × 45-mm abdominal aortic Excluder cuffs (W.L. Gore & Associates) were implanted during transfemoral rapid pacing. The entire ascending aorta from the sinotubular junction to the innominate artery was covered (Fig 2). Postoperative CT demonstrated correct positioning of the cuffs, with complete exclusion of the TAAD. The patient's in-hospital stay was complicated by an inguinal hematoma, which was treated conservatively. The patient was discharged after 10 days, and the 26 months follow-up was uneventful.

Patient 3. A 67-year-old patient with a recent history of surgical evacuation of intracerebral hemorrhage (ICH) was diagnosed with bacterial endocarditis. At 1 month after ICH evacuation and due to severe worsening of aortic regurgitation, he underwent aortic valve replacement with a biologic valve. During rehabilitation, blood cultures were positive for *Candida tropicalis*, and the patient developed bilateral tibioperoneal trunk pseudoaneurysms, likely caused by septic emboli. Antimycotic therapy was started, and compression bandages were applied to both legs. CT revealed a massive AAP (diameter, 90 mm) with an aortic wall rupture located 7 mm above the coronary ostia (zone 0B). Because of his compromised condition and the high risk of ICH during extracorporeal circulation, the patient was deemed temporarily unfit for an open repair. Thus, ascending TEVAR was chosen as a "bridge" procedure before redo heart surgery to avoid fatal AAP complications and

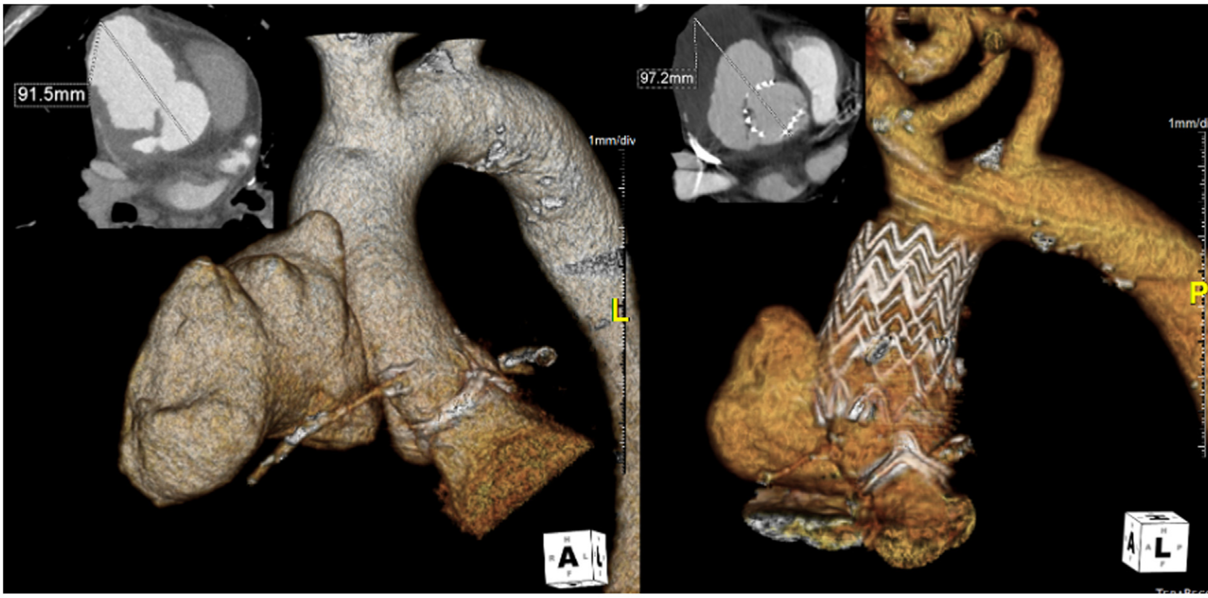

Fig 3. Pre- and postoperative three-dimensional computed tomography (CT) reconstructions showing an aortic pseudoaneurysm (AAP) treated with ascending thoracic endovascular aortic repair (TEVAR) with two abdominal cuffs.

further AAP enlargement. As with patient 2, through a left axillary conduit, two 36 × 44-mm abdominal aortic Excluder cuffs (W.L. Gore & Associates) were implanted, with the proximal end in zone 0B, just above the right coronary ostium. Before deployment, the right coronary artery was cannulated through a right percutaneous radial access to obtain an anatomical landmark. The deployment was performed under transfemoral rapid pacing. Consecutive postoperative CT scans showed progressive regression of the cerebral hemorrhagic lesions and residual AAP perfusion from a type Ia endoleak (Fig 3). The patient was discharged after 39 days with no significant residual neurologic deficit. Given the infectious nature of the disease, lifelong antimycotic treatment was prescribed. Follow-up CT showed endoleak persistence but significant thrombosis of the AAP sac. Because the patient's condition had significantly improved and the cerebral lesions were stable after 2 months, he underwent redo aortic valve and ascending aortic replacement with removal of the two cuffs. Correction of the right and left tibioperoneal trunk pseudoaneurysms was performed 4 and 5 months after ascending TEVAR, respectively. Although echocardiography showed no evidence of new-onset AAP or valvular vegetations and CT-positron emission tomography showed significant uptake reduction, he developed bowel ischemia from superior mesenteric embolic occlusion after 21 months, and underwent embolectomy and bowel resection. He eventually recovered and was alive at 24 months.

These three cases are summarized in the Table with device and procedural details. The ascending aorta landing zones are defined according to Roselli's zone 0 classification.[22]

DISCUSSION

The number of vascular centers performing endovascular repair of ascending aortic diseases is constantly increasing. According to the guidelines, open surgical repair remains the gold standard for these pathologies; however, many patients are deemed unfit for surgery.[23] The operative mortality with TAAD is reported to be 10% to 20%. Furthermore, 10% to 20% of TAAD patients are not candidates for open surgical repair.[18] Some series have reported mortality rates of ≤18% for redo aortic root procedures.[24,25] In this scenario, ascending TEVAR has emerged as the only alternative in selected cases for those patients who might otherwise be treated conservatively.

Endograft design and types of procedures. Ascending TEVAR presents unique anatomical and geometric challenges.[26] First, the proximal and distal landing zones are circumscribed by the positions of the coronary and innominate arteries. Accidental coverage of these vessels could lead to severe or even fatal complications, such as myocardial infarction and cerebrovascular accident. Second, ascending aorta diameters are typically larger than other aortic segments, and there is a significant mismatch in length between the outer and inner curves due to its curved structure. Finally, not all ascending aortas are long enough to accommodate commercially available endografts, which generally have a minimum length of 10 cm.

Table. Patient demographics, intervention, and follow-up specifications

Pt. No.; age, years	Previous cardiac surgery	Lesion (zone)	Device and procedure details	PLZ; DLZ	Complication	Follow-up, months
1; 60	No	AAP (0C)	Urgent; 1 thoracic endograft (36 × 100 mm); SAT debranching; femoral access	0B; 2	Minor stroke	22; no reinterventions
2; 80	No	TAAD (0B-C)	Urgent; 2 abdominal cuffs (32 × 45 mm); no SAT debranching; right axillary access	0B; 0C	Inguinal hematoma	26; no reinterventions
4; 67	Aortic valve repair	AAP (0B)	Urgent; 2 abdominal cuffs (36 × 44 mm); no SAT debranching; right axillary access	0B; 0C	Type Ia EL	24; cardiac surgery, SMA embolectomy, bowel resection

AAP, ascending aortic pseudoaneurysm; *DLZ*, distal landing zone; *EL*, endoleak; *PLZ*, proximal landing zone; *Pt. No.*, patient number; *SAT*, supra-aortic trunk; *SMA*, superior mesenteric artery; *TAAD*, type A aortic dissection.

For patients who are candidates for ascending TEVAR, a total endovascular approach with off-the-shelf devices would be ideal, considering that many must be performed in an emergency setting. However, in the real world, the hybrid approach with partial or total debranching provides an elegant solution.

Extra-anatomic supra-aortic trunk (SAT) debranching is an option to lengthen the aortic segment available for endograft deployment and to create a suitable distal landing zone. This approach allows for the delivery of a single device through a femoral access, reducing the risk of mechanical failure associated with the use of multiple abdominal cuffs. However, hybrid debranching increases the complexity and risks of the procedure, and reconstruction of the cerebral perfusion from a single vessel can raise concerns regarding long-term patency.

We used this technique in one patient to treat a ruptured zone 0C AAP in the context of an IMH (patient 1). We performed ascending TEVAR with the shortest available endograft associated with a total "reverse" debranching with axillary−axillary bypass and carotid artery reimplantation. In our experience, this approach is feasible unless revascularization of a dominant vertebral artery arising from the arch is needed and should be considered a viable option for those patients who present with extension of the disease into the proximal aortic arch.

Chang et al[27] described two cases of TAAD treated endovascularly with subclavian−carotid−carotid bypass. Tsilimparis et al[11] described one case of carotid−carotid bypass with reimplantation on the subclavian artery to achieve distal landing zone for ascending TEVAR. Ronchey et al[21] performed a SAT bypass to ensure a suitable distal landing zone in a patient with residual dissection after ascending replacement.

A few cases of endovascular SAT debranching with a double-barrel technique have been reported. Bernardes et al[8] performed two cases of ascending TEVAR combined with innominate chimney and carotid−carotid bypass to treat a dissecting arch aneurysm and a zone 0C penetrating atherosclerotic ulcer. Preventza et al[28] reported two cases of ascending TEVAR and SAT stenting with the snorkel technique, one performed intentionally due to a length mismatch between the ascending aorta and available thoracic endograft, and the other performed as a bail-out procedure after accidental coverage of the innominate artery.

An alternative strategy to overcome the problem of the ascending aortic length is to use two or more abdominal aortic cuffs. This allows for coverage of a variable length of the aorta, avoiding SAT debranching; however, it carries the risk of dislodgement, migration, and type III endoleak development. Also, it cannot be performed through a femoral access due to the shortness of the delivery shafts. Many investigators have used abdominal aortic cuffs for ascending TEVAR.[29-34] We used this technique in two patients to treat a focal TAAD and a postoperative AAP with good results and no type III endoleak. In both cases, we preferred the Excluder abdominal aortic cuffs (W.L. Gore & Associates) because of their reverse deployment from distally to proximally, which helps reduce the "wind-sock" effect and improves deployment accuracy.

Although we used a standard, commercially available Gore cuff in this series, a specifically designed Gore ascending stent graft (with the objective of being off-the-shelf) is under investigation in 19 patients in the ARISE (first-in-human evaluation of a novel stent graft to treat ascending aortic dissection) study and reported promising early results, including 16% mortality, 5% disabling stroke, and 5% myocardial infarction.[18]

The other options for ascending TEVAR is device customization and physician-modified endografts (PMEGs). These adaptations allow for a reduction of the total covered length, delivery from a femoral access, and adjuncts of fenestrations or branches to extend the distal landing zone into the aortic arch. Manufacturer customization can be used only in elective settings, because time is required to assemble them. PMEGs do not present with this disadvantage; however, they carry the risk of device malfunctions, and results require confirmation. Piffaretti et al[12] successfully treated 9 patients with TAAD, AAP, and aortic rupture using a custom-made Relay Plus (non−bare metal stent; Terumo Aortic), with a total length of 65 mm. Kolvenbach et al[17] reported five cases of intraoperative modification of a standard thoracic endograft that was cut to length after partial deployment to avoid innominate coverage. Chassin-Trubert et al[35] described the use of a double-fenestrated physician-modified Valiant Captivia EG (Medtronic) for total arch repair of zone 0C saccular aneurysm. Experience with in situ fenestration and PMEGs is generally continuously increasing due to the appeal of a total endovascular option that does not require ≥1 month from order to delivery. Many concerns remain about the durability of device components in the proximity of the fenestration.

The heterogeneity of devices and techniques for ascending TEVAR reflects both the lack of approved devices for the treatment of ascending aortic diseases and the adaptability of the available ones. The introduction of dedicated devices would help to standardize ascending TEVAR, expand its indications, and improve its results. The best candidates for ascending TEVAR are patients with focal lesions located in zone 0C and in the distal part of zone 0B. A great technological advance would be the merging of transcatheter aortic valve implantation (TAVI) and TEVAR concepts in an endovascular valve-carrying conduit.[36]

Endograft deployment and vascular access. The deployment of endografts in the ascending aorta has a very restricted margin of error and, therefore, must be extremely accurate. It is mandatory to reduce the hemodynamic displacement forces associated with cardiac output to avoid the “windsock effect.” This can be done with temporary ventricular pacing, drugs, or, even, cardiopulmonary bypass. In all our cases, we performed transvenous temporary rapid pacing to ensure a stable image of the proximal landing zone. For patients 1 and 3, we also cannulated the left subclavian artery and right coronary artery, respectively, to obtain a fixed landmark of the proximal and distal landing zones.

Up to 62% of ascending TEVAR cases have been performed through femoral access.[11] This is not possible when abdominal aortic cuffs are used, because they are designed with short delivery shafts. The carotid, axillary, and subclavian arteries provide an alternative access and have been used in ∼20% of cases. Another viable option is the reverse transapical approach. We preferred the axillary access for abdominal cuff delivery and femoral cutdown for endograft delivery. In our experience, right axillary access is less satisfactory. Thus, when performing axillary access for ascending TEVAR or TAVI, we use a conduit because it provides a site for cannulation in the case of conversion to cardiopulmonary bypass. Although we have no experience with the transapical approach, our heart team uses this approach for TAVI when crossing the iliac arteries is not feasible. Other investigators have suggested that transapical and axillary accesses have the benefit of improving deployment accuracy by shortening the length of delivery and, therefore, reducing extra deployment forces.[37] We believe, in the setting of compassionate surgery, the target is less invasive as a possible approach. Thus, we consider the transapical approach only as a final option when femoral or axillary access cannot be used.

Literature results. The early results of ascending TEVAR are promising, with early mortality and technical success rates ranging from 0% to 14.3% and 85.7% to 100%, respectively.[8,10-12,16,28] Early complications include cerebrovascular events, acute aortic insufficiency, myocardial infarction, pulmonary complications, early open conversion, and type I endoleak. The series by Roselli et al[16] of 22 patients reported three in-hospital deaths (13.6%), two open conversions (9%), two myocardial infarctions (9%), three strokes (13.6%), and two severe respiratory complications (9%). In two patients, ascending TEVAR was a bridge procedure. Li et al[10] treated 15 cases of TAAD with 100% technical success and no early major complications or deaths. Tsilimparis et al[11] reported 90% technical success and two cerebrovascular events (20%) after treating 10 patients with various ascending aortic pathologies.

In our experience, no in-hospital mortality was observed, and one patient experienced a minor stroke. Complete exclusion of the lesions was achieved in two of the three cases. One patient (patient 3), who was treated with two abdominal aortic cuffs to exclude a massive AAP arising from the suture line of an infected biologic valve, developed a postoperative type Ia endoleak with residual perfusion of the AAP. Although achieving only partial AAP exclusion can be considered a failure, it resulted in a bridge cardiac redo procedure after ICH stabilization and infection control. Possible explanations to this technical failure include the infectious nature of the disease and the proximal location of the lesion. Although the rupture in the aortic wall was not very large, it was located a few millimeters above the border between zone 0A and zone 0B. Thus, the proximal landing zone was very short, and the deployment should have been extremely accurate. It has been reported that disease extension into zone 0A is associated with higher mortality, irrespective of the underlying aortic pathology.[7]

Although the early outcomes appear to be acceptable, concerns exist regarding the durability of ascending TEVAR. Roselli et al[16] reported an actual survival at 5 years of 75%. They observed six type I endoleaks (31%) and performed four late reoperations (21%). Li et al[10] reported no mortality during follow-up but reported eight (53%) major morbidities, including new-onset dissection and retrograde dissection. Four patients (27%) underwent reintervention.

CONCLUSIONS

Our preliminary experience with three high-risk patients unfit for open surgical repair demonstrates the technical feasibility and clinical appropriateness of ascending TEVAR for selected ascending aortic pathologies using standard, commercially available endografts. Long-term results must be confirmed. The choice to treat the ascending aorta using endovascular techniques must be discussed in the context of an aortic team and being clear that the gold standard continues to be open surgery. However, the introduction of specifically designed devices will help to standardize the procedure of ascending TEVAR, establish appropriate indications, and ensure good clinical outcomes.

DISCLOSURES

None.

REFERENCES

1. Upchurch GR, Escobar GA, Azizzadeh A, et al. Society for Vascular Surgery clinical practice guidelines of thoracic endovascular aortic repair for descending thoracic aortic aneurysms. *J Vasc Surg*. 2021;73:55S–83S.
2. Riambau V, Böckler D, Brunkwall J, et al. Editor's choice – management of descending thoracic aorta diseases: clinical practice guidelines of the European society for vascular surgery (ESVS). *Eur J Vasc Endovasc Surg*. 2017;53:4–52.
3. Spanos K, Nana P, von Kodolitsch Y, et al. Management of ascending aorta and aortic arch: similarities and differences among cardiovascular guidelines. *J Endovasc Ther*. 2021;29:667–677.
4. Anwar MA, Hamady M. Various endoluminal approaches available for treating pathologies of the aortic arch. *Cardiovasc Intervent Radiol*. 2020;43:1756–1769.
5. Preventza O, Huu AL, Olive J, Cekmecelioglu D, Coselli JS. Endovascular repair of the ascending aorta: the last frontier. *Ann Cardiothorac Surg*. 2022;11:26–30.
6. Baikoussis NG, Antonopoulos CN, Papakonstantinou NA, Argiriou M, Geroulakos G. Endovascular stent grafting for ascending aorta diseases. *J Vasc Surg*. 2017;66:1587–1601.
7. Basu R, Zhang J, Zaheer S, Grimm J, Szeto W, Kalapatapu V. Ascending aorta thoracic endovascular aortic repair for infected pseudoaneurysm. *J Vasc Surg Cases Innov Tech*. 2022;8:244–247.
8. Bernardes RC, Navarro TP, Reis FR, et al. Early experience with off-the-shelf endografts using a zone 0 proximal landing site to treat the ascending aorta and arch. *J Thorac Cardiovasc Surg*. 2014;148:105–112.
9. Quevedo HC, Alonso A. Endovascular therapy for ascending aorta pseudoaneurysm. *Cardiovasc Revasc Med*. 2016;17:586–588.
10. Li Z, Lu Q, Feng R, et al. Outcomes of endovascular repair of ascending aortic dissection in patients unsuitable for direct surgical repair. *J Am Coll Cardiol*. 2016;68:1944–1954.
11. Tsilimparis N, Debus ES, Oderich GS, et al. International experience with endovascular therapy of the ascending aorta with a dedicated endograft. *J Vasc Surg*. 2016;63:1476–1482.
12. Piffaretti G, Czerny M, Riambau V, et al. Endovascular repair of ascending aortic diseases with custom-made endografts. *Eur J Cardiothorac Surg*. 2021;59:471–479.
13. Di Marco L, Lovato L, Murana G, et al. Endovascular repair of ascending aorta pseudoaneurysm. *J Vis Surg*. 2018;4:116.
14. Muetterties CE, Menon R, Wheatley GH. A systematic review of primary endovascular repair of the ascending aorta. *J Vasc Surg*. 2018;67:332–342.
15. Vallabhajosyula P, Gottret JP, Bavaria JE, Desai ND, Szeto WY. Endovascular repair of the ascending aorta in patients at high risk for open repair. *J Thorac Cardiovasc Surg*. 2015;149:S144–S150.
16. Roselli EE, Idrees J, Greenberg RK, Johnston DR, Lytle BW. Endovascular stent grafting for ascending aorta repair in high-risk patients. *J Thorac Cardiovasc Surg*. 2015;149:144–154.
17. Kolvenbach RR, Yoshida R, Pinter L, Zhu Y, Lin F. Urgent endovascular treatment of thoraco-abdominal aneurysms using a sandwich technique and chimney grafts – a technical description. *Eur J Vasc Endovasc Surg*. 2011;41:54–60.
18. Roselli EE, Atkins MD, Brinkman W, Coselli J, Desai N, Estrera A, et al. ARISE: first-in-human evaluation of a novel stent graft to treat ascending aortic dissection. *J Endovasc Ther*. 2023;30:550–560.
19. Kölbel T, Detter C, Carpenter SW, et al. Acute type A aortic dissection treated using a tubular stent-graft in the ascending aorta and a multibranched stent-graft in the aortic arch. *J Endovasc Ther*. 2017;24:75–80.
20. Oderich GS, Pochettino A, Mendes BC, Roeder B, Pulido J, Gloviczki P. Endovascular repair of saccular ascending aortic aneurysm after orthotopic heart transplantation using an investigational Zenith Ascend stent-graft. *J Endovasc Ther*. 2015;22:650–654.
21. Ronchey S, Serrao E, Alberti V, et al. Endovascular stenting of the ascending aorta for type A aortic dissections in patients at high risk for open surgery. *Eur J Vasc Endovasc Surg*. 2013;45:475–480.
22. Roselli EE, Idrees JJ, Johnston DR, Eagleton MJ, Desai MY, Svensson LG. Zone zero thoracic endovascular aortic repair: a proposed modification to the classification of landing zones. *J Thorac Cardiovasc Surg*. 2018;155:1381–1389.
23. Erbel R, Aboyans V, Boileau C, et al. 2014 ESC Guidelines on the diagnosis and treatment of aortic diseasesDocument covering acute and chronic aortic diseases of the thoracic and abdominal aorta of the adult. The Task Force for the Diagnosis and Treatment of Aortic Diseases of the European Society of Cardiology (ESC). *Eur Heart J*. 2014;35:2873–2926.
24. Di Eusanio M, Berretta P, Bissoni L, Petridis FD, Di Marco L, Di Bartolomeo R. Re-operations on the proximal thoracic aorta: results and predictors of short- and long-term mortality in a series of 174 patients. *Eur J Cardiothorac Surg*. 2011;40:1072–1076.
25. Silva J, Maroto LC, Carnero M, et al. Ascending aorta and aortic root reoperations: are outcomes worse than first time surgery? *Ann Thorac Surg*. 2010;90:555–560.
26. Palumbo MC, Redaelli A, Wingo M, et al. Impact of ascending aortic prosthetic grafts on early postoperative descending aortic biomechanics on cardiac magnetic resonance imaging. *Eur J Cardiothorac Surg*. 2022;61:860–868.
27. Chang G, Wang S, Li X, et al. Endovascular stent-graft treatment for DeBakey I aortic dissection. *Zhonghua Wai Ke Za Zhi*. 2007;45:168–171.
28. Preventza O, Henry MJ, Cheong BYC, Coselli JS. Endovascular repair of the ascending aorta: when and how to implement the current technology. *Ann Thorac Surg*. 2014;97:1555–1560.
29. Heye S, Daenens K, Maleux G, Nevelsteen A. Stent-graft repair of a mycotic ascending aortic pseudoaneurysm. *J Vasc Interv Radiol*. 2006;17:1821–1825.
30. Ailawadi G, Lim DS, Peeler BB, Matsumoto AH, Dake MD. Traumatic ascending aortopulmonary window following pulmonary artery stent dilatation: therapy with aortic endovascular stent graft. *Pediatr Cardiol*. 2007;28:305–308.
31. Vaughan-Huxley E, Hamady MS, Metcalfe MJ, et al. Endovascular repair of an acute, mycotic, ascending aortic pseudoaneurysm. *Eur J Vasc Endovasc Surg*. 2011;41:488–491.
32. Veroux P, D'Arrigo G, Giaquinta A, Virgilio C, Cappellani A, Veroux M. Emergency endovascular repair of two ascending aortic pseudoaneurysms. *J Vasc Interv Radiol*. 2011;22:417–419.

33. Gray BH, Langan EM, Manos G, Bair L, Lysak SZ. Technical strategy for the endovascular management of ascending aortic pseudoaneurysm. *Ann Vasc Surg*. 2012;26:734—738.
34. McCallum JC, Limmer KK, Perricone A, Bandyk D, Kansal N. Case report and review of the literature total endovascular repair of acute ascending aortic rupture: a case report and review of the literature. *Vasc Endovascular Surg*. 2013;47:374—378.
35. Chassin-Trubert L, Gandet T, Lounes Y, Ozdemir BA, Alric P, Canaud L. Double fenestrated physician-modified stent-grafts for total aortic arch repair in 50 patients. *J Vasc Surg*. 2021;73:1898—1905.e1.
36. Kreibich M, Rylski B, Beyersdorf F, Siepe M, Czerny M. Endo-Bentall for proximal aortic dissection: from conception to application. *Asian Cardiovasc Thorac Ann*. 2021;29:697—700.
37. D'Onofrio A, Cibin G, Antonello M, Caraffa R, Grego F, Gerosa G. Transapical antegrade ascending aorta stent-grafting: going through the front door. *Innovations (Phila)*. 2021;16:523—528.

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