Concurrent stabilization of “downstream” aorta during acute type A aortic dissection repair

Suvitesh Luthra, MCh, FRCS(CTh),^{a,b} and Geoffrey M. Tsang, MD, FRCS(CTh)^{a,b}

“Primum non nocere—first, do no harm”

Surgical resections for Stanford type A acute aortic dissections (ATAADs) conventionally have involved limited resections (segments of ascending aorta with closed or open distal anastomosis) or extended resections (hemiarch and arch resections). There is a great variability in the operative morbidity and mortality of the initial repair. The extended resection for ATAAD repair was initially modified with the elephant trunk operation.¹ This was later improved to the frozen elephant trunk (FET) operation (Akihiko Usui, Nagoya, Japan) with the use of hybrid stent grafts (Chavan-Haverich, 2003) and other later modifications.²⁻⁴

The FET operation adds a new paradigm for stabilizing both the upstream and the downstream dissected aortas at the time of the initial repair for Stanford type A and non-A/non-B acute aortic dissections extending beyond the proximal arch (Society of Thoracic Surgeons/Society for Vascular Surgery acute aortic dissection types A₁ to A₁₁). Various modifications for the stent graft now include Jotec E-vita Open/Open Plus (Jotec Inc, Hechingen, Germany), Vascutek Thoraflex-Hybrid (Vascutek, Inchinnan, Scotland), Frozenix J graft (Japan LifeLine, Tokyo, Japan), Cronus (MircoPort, Shanghai, China), and various thoracic endovascular aortic repair (TEVAR) hybrid stent devices (GORE TAG [W. L. Gore & Associates, Newark, Del], Valiant [Medtronic, Dublin, Ireland], Medtronic TX2, JSOG, and Gianturco stent/Hemashield Gold graft [Ge-tinge, Gothenburg, Sweden]).

The advantages of FET include better suture line hemostasis due to distal endoluminal false lumen obliteration and concurrent partial to complete stabilization of the downstream aorta. It reduces reintervention rates on distal thoracic aorta and can provide a distal landing zone for future, less morbid endovascular interventions. The technique is technically challenging and involves knowledge and expertise in various aspects of cannulation strategies,

Open stent stabilization of “downstream” dissected aorta.

CENTRAL MESSAGE

There is emerging expert consensus for safe and standard use of hybrid stent devices in acute type A ascending aortic dissection repair by experienced surgeons in high-volume aortic centers.

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neurocerebral, cardiac, and visceral protection using combinations of different antegrade and retrograde cerebral perfusion schemes and deep hypothermic circulatory arrest.

There has been no systematic evaluation of the evidence and a lack of clear guidance on the subject except in the form of isolated expert opinions and a single consensus document.⁵ ATAAD repair is largely governed by principles of “first, do no harm,” which in most instances translates to “a safe, conservative, lifesaving operation” aimed at stabilization of only the upstream aorta. This usually involves limited resections with closed or open distal anastomosis under various strategies of neurocerebral, cardiac, and whole-body protection. Previous editorials and commentaries have assiduously asserted this principle with various arguments and a stern conviction.⁶⁻¹⁰

For an emergency operation with limited surgical skills and expertise in a nonaortic center, the unequivocal answer for ATAAD repair has to be a conservative resection, with as little jeopardy as possible for both the patient and the

From the ^aDivision of Cardiac Surgery, Wessex Cardiothoracic Centre, Southampton University Hospital NHS Trust, Southampton, United Kingdom; and ^bUK Aortic Surgery Group (UKAS), United Kingdom.

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Address for reprints: Suvitesh Luthra, MCh, FRCS(CTh), Division of Cardiac Surgery, Wessex Cardiothoracic Centre, Southampton University Hospital NHS Trust, Southampton, Hampshire SO16 6YD, United Kingdom (E-mail: drs100@gmail.com).

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surgeon. On the other hand, this analysis attempts to build a framework for future guidance for experienced aortic surgeons in supra-regional, aortic super-centers. Would it be considered a callous frivolity to attempt a more extensive unconventional emergency operation aimed at stabilizing both the upstream and the downstream dissected aortas in a patient with a mortality risk of 1% to 2% every passing hour without an operation and 8% to 60% if offered a conventional operation. The justification for an extensive operation with a FET must argue the absolute need for greater intervention, the relative safety, and the short- and long-term benefits compared with conventional ATAAD repairs.

Long-term studies on the fate of the residual type B dissection are lacking after ATAAD repair. Because both Stanford type A and B essentially share the same cause and risk factors for progression (hypertension, atherosclerosis, connective tissue disorders), these insights can be gained indirectly from the natural history and changing management of isolated acute type B aortic dissections (ATBADs).^{11,12} In the presence of these risk factors, the fate of a residual ATBAD even after a limited resection and stabilization of the upstream aorta should be no different after ATAAD repair.

The natural history of ATBAD shows that the majority of patients will fail medical therapy. Intervention-free survival is $55.0\% \pm 3.0\%$ at 3 years and $41.0\% \pm 3.2\%$ at 6 years.¹³ At a mean follow-up of 4.2 years with medical management (range, 0.1-14.7 years), the freedom from intervention was $77.3\% \pm 2.4\%$ at 3 years and $74.2\% \pm 2.5\%$ at 6 years. Likewise, in the INSTEAD-XL trial, the risk of all-cause mortality (11.1% vs 19.3%; $P = .13$), aorta-specific mortality (6.9% vs 19.3%; $P = .04$), and progression (27.0% vs 46.1%; $P = .04$) after 5 years were lower with TEVAR than with optimal medical treatment alone.¹⁴

In a meta-analysis of 6 studies comparing medical management and endovascular repair for uncomplicated ATBAD, Hossack and colleagues¹⁵ found that medical management was associated with a higher risk of late all-cause mortality (hazard ratio [HR], 1.54; 95% confidence interval [CI], 1.27-1.86; $P < .001$) and aorta-related mortality (HR, 2.71; 95% CI, 1.49-4.94; $P = .001$). There were no statistically significant differences between endovascular repair and medical management with regard to inpatient mortality (risk difference [RD], 0.01; 95% CI, -0.01 to 0.02; $P = .46$) and early reintervention by TEVAR (RD, 0.02; 95% CI, -0.01 to 0.04; $P = .19$) or surgery (RD, 0.00; 95% CI, -0.01 to 0.01; $P = 1.0$), attesting to the relative safety of an additional, concurrent endovascular intervention. Both the Society of Thoracic Surgeons/Society for Vascular Surgery and European Society for Vascular Surgery guidelines now regard TEVAR as the standard therapy for uncomplicated and complicated ATBAD (level of evidence 1A).¹⁶

The question then essentially remains of establishing the safety of concurrent stabilization of the downstream aorta at the time of the initial ATAAD repair. Is FET a more morbid procedure compared with isolated resections of the upstream aorta in experienced centers?

FET is a safer operation than conventional arch resection. In the international multicenter ARCH registry, FET was associated with a statistically significantly lower mortality risk (odds ratio, 0.47; $P = .03$) than a conventional arch resection.¹⁷

In a large pioneering European series (Hannover, Bologna) over a decade, 120 patients with ATAAD repairs with FET had a mortality of 17.5% and paraplegia rates of 6% (overall mortality in the entire group of 437 patients was 14.9%).¹⁸ Mortality was lower for elective and urgent chronic dissections (9.9%) but higher for thoracic aortic aneurysm resections (19.3%). Paraplegia rates have been lower in other series, and the UK experience has been more favorable. In a pooled analysis of 15 studies with 1279 patients, the ALICE group reported an early mortality of 9.2% for FET in acute dissections (95% CI, 7.7-11.0), stroke of 4.8% (95% CI, 2.5-9.0), and spinal cord injury of 3.5% (95% CI, 1.9-6.6). The reintervention rate was 9.6% (95% CI, 5.6-15.8), and false lumen thrombosis was seen in 96.8% (95% CI, 90.7-98.9).¹⁹ Likewise, Tian and colleagues²⁰ reported in-hospital mortality of 10.2%, permanent neurologic deficit of 7.7%, and spinal cord injury of 6.5%. Using enhanced secondary analysis of survival data, they reported 1-, 2-, 3-, 5-, and 10-year survivals of 90.7%, 88.3%, 86.1%, 83.9%, and 73.5%, respectively.²⁰

With further technologic advances in the development of hybrid uncovered stents such as the Ascyrus Medical Dissection Stent (Ascyrus Medical, Boca Raton, Fla), morbidity of reimplantation of neck vessels, malperfusion, and spinal cord ischemia can be avoided. The Dissected Aorta Repair Through Stent Implantation trial reported malperfusion-related mortality of 7.7%, malperfusion resolution in 95.5%, paralysis in 0%, new postoperative stroke in 6.5%, and aortic arch remodeling in 100%.²¹ Overall, these results are vastly superior to those reported for isolated upstream resections of ATAAD in databases and registries, although the number of patients is small and follow-up is short.²²

Is there a long-term benefit at all? Freedom from any aortic reintervention at 1, 3, and 5 years after stent grafting for ATAAD was 93.9%, 89.3%, and 86.8%, respectively.²⁰ The historical published figures for late reinterventions are erroneous as even unstable downstream aortas are managed conservatively because of the lack of surgical expertise for most open interventions and absence of endovascular options and referral to appropriate centers. Interventional endovascular facilities and open surgical

expertise for descending thoracic aorta are not widely available.

False lumen patency in the descending aorta is associated with late mortality and increases aortic reinterventions due to aortic expansion.²³ FET leads to false lumen thrombosis universally in 92% to 95% and midterm freedom from reinterventions of 93% at 6 months, 87% at 1 year, 77% at 3 years, and 72% at 5 years.²⁴

Given the complexities of the intervention and the acute emergency nature of the treatment, direct comparisons of modalities in a randomized control trial setting are not possible. It would be difficult to recruit for such a trial. A nonrandomized international multicenter study among aortic centers with established FET programs can be performed to build international consensus and guidelines for practice. This is increasingly necessary now for safeguarding aortic surgeons engaged in these high-risk, intensive procedures for the benefit of the patients in isolated aortic centers.

From limited experience around the world, FET for concurrent stabilization of both upstream and downstream aortas appears to be safe in ATAAD repair with superior short- to midterm results. There is emerging expert consensus for standard use in selected younger low-risk patients with suitable anatomy and expected extended longevity, when performed by experienced aortic surgeons. Contemporary use should be restricted only to aortic centers with significant experience with the technique. Further standardization of techniques and evidence of long-term safety and efficacy are required from large multi-institutional databases and registries before recommendations for widespread use.

Conflict of Interest Statement

The authors reported no conflicts of interest.

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References

- Borst HG, Waltherbusch G, Schaps D. Extensive aortic replacement using "elephant trunk" prosthesis. *Thorac Cardiovasc Surg*. 1983;31:37-40.
- Suto Y, Yasuda K, Shiya N, Murashita T, Kawasaki M, Imamura M, et al. Stented elephant trunk procedure for an extensive aneurysm involving distal aortic arch and descending aorta. *J Thorac Cardiovasc Surg*. 1996;112:1389-90.
- Kato M, Ohnishi K, Kaneko M, Ueda T, Kishi D, Mizushima T, et al. New graft-implanting method for thoracic aortic aneurysm or dissection with a stented graft. *Circulation*. 1996;94(9 Suppl):II188-93.
- Karck M, Chavan A, Hagl C, Friedrich H, Galanski M, Haverich A. The frozen elephant trunk technique: a new treatment for thoracic aortic aneurysms. *J Thorac Cardiovasc Surg*. 2003;125:1550-3.
- Czerny M, Schmidli J, Adler S, van den Berg JC, Bertoglio L, Carrel T, et al; EACTS/ESVS scientific document group. Current options and recommendations for the treatment of thoracic aortic pathologies involving the aortic arch: an expert consensus document of the European Association for Cardio-Thoracic surgery (EACTS) and the European Society for Vascular Surgery (ESVS). *Eur J Cardiothorac Surg*. 2019;55:133-62.
- Lansman SL, Goldberg JB, Kai M, Malekan R, Spielvogel D. Extended arch procedures for acute type A aortic dissection: a downstream problem? *Semin Thorac Cardiovasc Surg*. 2019;31:17-20.
- Lansman SL. Commentary: is more always better? *J Thorac Cardiovasc Surg*. 2019;158:1282.
- Westaby S, Saito S, Katsumata T. Acute type A dissection: conservative methods provide consistently low mortality. *Ann Thorac Surg*. 2002;73:707-13.
- Jassar AS, Sundt TM III. How should we manage type A aortic dissection? *Gen Thorac Cardiovasc Surg*. 2019;67:137-45.
- Sundt TM III. The can-should problem. *J Thorac Cardiovasc Surg*. 2011;142:e91.
- Nienaber CA, Divchev D, Palisch H, Clough RE, Richartz B. Early and late management of type B aortic dissection. *Heart*. 2014;100:1491-7.
- Clough RE, Nienaber CA. Evidence for and risks of endovascular treatment of asymptomatic acute type B aortic dissection. *J Cardiovasc Surg (Torino)*. 2017;58:270-7.
- Durham CA, Cambria RP, Wang LJ, Ergul EA, Aranson NJ, Patel VI, et al. The natural history of medically managed acute type B aortic dissection. *J Vasc Surg*. 2015;61:1192-8.
- Nienaber CA, Kische S, Rousseau H, Eggebrecht H, Rehders TC, Kundt G, et al. INSTEAD-XL trial. Endovascular repair of type B aortic dissection: long-term results of the randomized investigation of stent grafts in aortic dissection trial. *Circ Cardiovasc Interv*. 2013;6:407-16.
- Hossack M, Patel S, Gambardella I, Neequaye S, Antoniou GA, Torella F. Endovascular vs. medical management for uncomplicated acute and sub-acute type B aortic dissection: a meta-analysis. *Eur J Vasc Endovasc Surg*. 2020;59:794-807.
- Lombardi JV, Hughes GC, Appoo JJ, Bavaria JE, Beck AW, Cambria RP, et al. Society for Vascular Surgery (SVS) and Society of Thoracic Surgeons (STS) reporting standards for type B aortic dissections. *J Vasc Surg*. 2020;71:723-47.
- Poon SS, Tian DH, Yan T, Harrington D, Nawaytou O, Kuduvali M, et al; International Aortic Arch Surgery Study Group. Frozen elephant trunk does not increase incidence of paraplegia in patients with acute type A aortic dissection. *J Thorac Cardiovasc Surg*. 2020;159:1189-96.
- Leone A, Beckmann E, Martens A, Di Marco L, Pantaleo A, Reggiani LB, et al. Total aortic arch replacement with frozen elephant trunk technique: results from two European institutes. *J Thorac Cardiovasc Surg*. 2020;159:1201-11.
- Takagi H, Umamoto T, ALICE Group. A meta-analysis of total arch replacement with frozen elephant trunk in acute type A aortic dissection. *Vasc Endovascular Surg*. 2016;50:33-46.
- Tian DH, Ha H, Joshi Y, Yan TD. Long-term outcomes of the frozen elephant trunk procedure: a systematic review. *Ann Cardiothorac Surg*. 2020;9:144-51.
- Bozso SJ, Nagendran J, Chu MWA, Kiai B, El-Hamamsy I, Ouzounian M, et al. Midterm outcomes of the dissected aorta repair through stent implantation trial. *Ann Thorac Surg*. 2021;111:463-70.
- Luthra S, Tsang GM. Improving outcomes of open stent grafts for Type A acute aortic dissection repair. *Ann Thorac Surg*. March 9, 2021 [Epub ahead of print].
- Li D, Ye L, He Y, Cao X, Liu J, Zhong W, et al. False lumen status in patients with acute aortic dissection: a systematic review and meta-analysis. *J Am Heart Assoc*. 2016;5:e003172.
- Roselli EE, Idrees JJ, Bakaeen FG, Tong MZ, Soltész EG, Mick S, et al. Evolution of simplified frozen elephant trunk repair for acute DeBakey type I dissection: midterm outcomes. *Ann Thorac Surg*. 2018;105:749-55.

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