

The future of stenting in patients with type A aortic dissection: a systematic review

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Amer Harky¹ , Jeremy Chan² and
Beverly MacCarthy-Ofosu¹

Abstract

Acute type A aortic dissection (ATAAD) carries high morbidity and mortality rates and is a clinical emergency. The reported mortality rate is 50% to 65% within the first 48 hours without surgical intervention. Open surgery therefore remains the gold standard management for ATAAD. However, in patients who are deemed unfit for surgery and where possible, endovascular repair offers a useful alternative to medical treatment alone or high-risk open surgical repair. Several case reports, case series, and retrospective studies have reported good outcomes following endovascular treatment. The endovascular option also has comparable early and late outcomes, favourable aortic remodelling, and satisfactory overall survival despite having a higher-risk patient cohort. However, stenting in patients with ATAAD undoubtedly still has several limitations and technical challenges.

Keywords

Type A aortic dissection, stenting, open repair, endovascular repair, risk stratification, survival

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Introduction

The aortic wall is composed of three layers: the tunica intima, media, and adventitia. The intima is the innermost layer, and the adventitia is the outermost layer. An aortic dissection is caused by a tear in the intimal layer, which creates a false lumen between the

¹Department of Cardiothoracic Surgery, Liverpool Heart and Chest, Liverpool, UK

²Department of Cardiothoracic Surgery, Morriston Hospital, Wales, UK

Corresponding author:

Amer Harky, MBChB, MRCS, MSc, Department of Cardiothoracic Surgery, Liverpool Heart and Chest Hospital, Liverpool, L14 3PE, UK.

Email: aaharky@gmail.com



intimal and medial layers. This allows blood to flow between the two layers. In the UK, the reported incidence of aortic dissection is approximately 4 of 100,000 people.¹ This fatal clinical condition can lead to aortic rupture and other life-threatening cardiac complications.² Patients with connective tissue disorders and risk factors such as hypertension are at increased risk of developing an aortic dissection.³

Aortic dissection is defined as acute, sub-acute, or chronic if the tear occurs <14 days, 2 to 6 weeks, or >6 weeks from the onset of chest or upper abdominal pain, respectively.⁴

The Stanford classification is widely used to classify aortic dissections, mainly based on the most proximal involvement. The Stanford classification divides aortic dissections into type A and B; type A involves the ascending aorta and/or the aortic arch, while type B dissection occurs when the flap is beyond the left subclavian artery. The tear can occur in either anatomical site.

Acute type A aortic dissection (ATAAD) carries high morbidity and mortality rates of 50% to 65% within the first 48 hours of presentation when surgical intervention is not attempted.⁵ Surgery also reduces the 30-day mortality rate from 90% to <20% in certain units.⁵ In some patient groups, however, there are reports of higher rates of postoperative complications, particularly the requirement for prolonged ventilation, multiple-organ failure, and the need for renal replacement therapy.⁶

The current first-line management of ATAAD as recommended by both the 2014 European Society of Cardiology guidelines⁷ and the 2010 American Heart Association⁸ is emergency surgery to replace the dissected aorta. However, the aortic valve may require repair or replacement depending on the extent of dissection and involvement of the aortic valve. In contrast to ATAAD, management of chronic TAAD remains controversial because of

limited surgical guidelines and a lack of reported relevant data.⁹

Within this high-risk cohort, approximately 20% of patients are deemed unfit for open surgery according to the International Registry of Acute Aortic Dissection (IRAD).¹⁰ Dumfarth et al.⁶ suggested that emergency open surgery in octogenarians is associated with poor outcomes with no differences in long-term survival between medically and surgically managed patients. Moreover, Piccardo et al.¹¹ concluded that octogenarians with complicated TAAD should be managed medically because of their reportedly poor prognosis.

The first case of TAAD that was managed endovascularly was reported by Dorros et al.¹² in the year 2000; thereafter, several case reports and case series further reported successful outcomes in a selected group of patients.

Literature search

An electronic database search was conducted through PubMed, Ovid, SCOPUS, Embase, and Google Scholar to identify articles that discuss the use of endovascular stenting in the setting of TAAD. No limit was placed on the time of publication, language, or type of study. The relevant studies are tabulated and summarised in each relevant section of this manuscript.

ATAAD: stenting versus open repair

Many large studies have discussed the outcomes of open surgical repair as the gold standard management of ATAAD, while most studies involving an endovascular approach are either case reports or retrospective studies with small numbers of patients.¹³ Although the patient from the first reported case in 2000 has since died,¹² the endovascular approach has opened the

door for further innovation within the field of cardiovascular surgery.

Table 1 summarises key studies involving endovascular repair of TAAD. Thirty-nine patients underwent endovascular repair for ATAAD and 89 for either subacute or chronic TAAD. All patients who underwent endovascular repair were deemed either unfit or high-risk for open repair, and endovascular stenting was thus considered an alternative safe approach that could provide a better outcome than pure medical management.¹⁴

The largest retrospective study to date was performed by Lu et al.¹⁵ This study involved 56 patients and showed promising results with a 30-day survival rate of 92.9% and overall survival rate at follow-up of 80.9% (mean follow-up, 39.92 ± 34.42 months). Most of the deaths that occurred during that period were unrelated to the aortic disease. A similarly favourable outcome was seen in a study by Li et al.,¹⁶ in which all 15 patients in the study were alive at follow-up (median, 72 months; range, 61–81 months).

However, endovascular stenting is not without its disadvantages; several complications have also been reported. In a case report by Palma et al.,¹⁷ the patient developed acute aortic insufficiency secondary to stent interference with the aortic valve apparatus and prosthesis migration, resulting in death. Another complication was a retained delivery system mandating open conversion in the study by Roselli et al.¹⁸ In both of these studies, however, the outcomes were more favourable than those of medical management.

Extended ATAAD

Use of the endovascular approach for treatment of extended ATAAD into the aortic arch has been explored in several case studies.^{19,20} Smith et al.¹⁹ proposed a classification system for management of arch repair

in extended ATAAD. Three of the four classifications involved endovascular stenting in such cases. This included total arch replacement and descending thoracic aortic stent grafting with placement of a frozen stent graft under circulatory arrest, or hemi-arch replacement and descending thoracic aortic stent grafting with placement of the stent graft under circulatory arrest or total arch replacement with placement of the stent graft after coming off cardiopulmonary bypass and with the use of fluoroscopy to identify landing zones.

Several studies have shown that the pooled estimated hospital mortality rate was 8.6% [95% confidence interval (CI), 7.0–10.2], 6.3% (95% CI, 4.5–8.3), and 5.5% (95% CI, 3.3–8.3).²⁰ These mortality rates are lower than that associated with total arch replacement \pm the standard elephant trunk technique without descending thoracic aortic stent grafting (11.9%; 95% CI, 7.0–17.8).²⁰ The estimated stroke rate was reportedly lower in hybrid groups,²⁰ suggesting that endovascular treatment can be used safely alongside open surgery.

Risk stratification

It is increasingly common for clinicians to encounter patients who are deemed to be at high risk for conventional open surgery. According to the IRAD, approximately 20% of patients who presented with ATAAD were deemed unfit or refused surgery.¹⁰ Several studies have suggested that medical management of TAAD is associated with poor outcomes, especially in older patients or patients with complicated aortic dissection.^{10,21} Therefore, utilisation of endovascular stenting remains a safe practice between medical and surgical interventions. Several studies have shown that in selected patients, stent graft placement can be an effective and safe procedure with satisfactory outcomes.¹⁸

Table 1. Endovascular repair of type A aortic dissection.

Authors	Year	Study type	Cohort size	Disease type	Device used	Outcome
Dorros et al. ¹²	2000	Case report	1	Chronic TAAD	Custom-made stent	30-day mortality
Zimpfer et al. ³⁵	2006	Case report	1	Acute TAAD		Patient alive at 1-month follow-up
Guo et al. ³⁶	2007	Case report	1	Chronic TAAD		
Senay et al. ³⁷	2007	Case report	1	Acute TAAD + LAD stenosis	Mustang coronary stent + Medtronic endovascular stent graft	Alive at hospital discharge (day 5) and at follow-up (timeframe not stated)
Palma et al. ¹⁷	2008	Case report	1	Chronic TAAD (entry tear midway between sinotubular junction and brachiocephalic trunk)	Custom-made stent graft (Braille Biomedica)	In-hospital death caused by acute cardiac insufficiency secondary to migration of prosthesis
Metcalfe et al. ³⁸	2012	Case report	1	Acute TAAD (mid-descending)	Zenith Ascending Dissection Stent	Successful recovery (timeframe not mentioned)
Pontes et al. ⁴²	2013	Case report	1	Acute TAAD	Custom-made stent	Alive at discharge and at follow-up (timeframe not stated)
Lu et al. ³³	2013	Retrospective study	15	Acute TAAD (n = 5) Chronic TAAD (n = 10)	Zenith TX2 Pro-Form Endografts (Cook) in all patients	In hospital arrhythmia in 2 of 15 patients In-hospital mortality rate of 0% Follow-up complication in 1 of 15 patients: new dissection secondary to an entry tear needing further intervention Follow-up mortality rate of 0% (median follow-up, 26 months; range, 16–35 months)
Ronchey et al. ³⁴	2013	Retrospective study	4	Chronic TAAD	Cook TX2, OS Cook	In-hospital mortality rate of 0% Thrombosis of false lumen in ascending aorta (n = 3) and descending aorta (n = 2) Partial thrombosis in 2 of 4 patients Follow-up mortality rate of 0% (follow-up range, 4–39 months)
Atianzar et al. ⁴⁴	2014	Case report	1	Acute TAAD	Thoracic Endograft (Medtronic)	Alive at discharge (36 hours)

(continued)

Table 1. Continued.

Authors	Year	Study type	Cohort size	Disease type	Device used	Outcome
Bernardes et al. ⁴⁵	2014	Prospective study	3	Acute TAAD (n = 2) Chronic TAAD (n = 1)	Zenith Cook, TAG Gore, Medtronic Valiant	In-hospital mortality rate of 0% Follow-up mortality rate of 0% (mean follow-up, 26.3 months; range, 3.5–55.5 months) Repeat dissection needing open repair after an average of 2 months from initial repair in 2 of 3 patients Acute TAAD: early death, n = 3; late death, n = 3 Chronic TAAD: alive, n = 1 In-hospital mortality of 0% Stroke with no residual deficit in 1 of 2 patients
Roselli et al. ¹⁸	2015	Retrospective study	11	Acute TAAD (n = 9) Chronic TAAD (n = 2)	Data not available	Proximal endoleak in 2 of 2 patients Follow-up mortality in 1 of 2 patients (patient died of <i>Pseudomonas</i> pneumonia at 6 months)
Vallabhajosyula et al. ⁴⁶	2015	Retrospective study	2	Acute TAAD	Cook Zenith TX2 distal extension	In-hospital mortality rate of 0% Follow-up complications in 8 of 15 patients, reintervention required in 4 of 15 patients
Li et al. ¹⁶	2016	Retrospective study	15	Acute TAAD (n = 1) Subacute TAAD (n = 7) Chronic TAAD (n = 7)	Cook Zenith TX2 Pro-Form extension stent grafts	Follow-up mortality rate of 0% (median follow-up, 72 months; range, 61–81 months) In-hospital mortality in 1 of 15 patients Sternotomy required in 1 of 15 patients Stroke in 1 of 15 patients
Tsilimparis et al. ⁴⁷	2016	Retrospective study	5	Acute TAAD (n = 2; 1 patient developed acute TAAD during transfemoral aortic valve replacement) Chronic TAAD (n = 3)	Zenith Ascend TAA Endovascular Graft	

(continued)

Table 1. Continued.

Authors	Year	Study type	Cohort size	Disease type	Device used	Outcome
Nienaber et al. ⁴⁸	2017	Retrospective study	12	Acute TAAD (n = 6) Subacute/chronic TAAD (n = 6)	Zenith TX2 (Cook), Gore C-Tag (Gore Ltd), Relay NBS (Bolton)	Stroke in 1 of 12 patients In-hospital mortality in 1 of 12 patients Follow-up mortality in 4 of 10 patients
Lu et al. ¹⁵	2018	Retrospective study	56	Acute TAAD (n = 7) Subacute TAAD (n = 30) Chronic TAAD (n = 19)	Zenith TX2 stent (Cook), Hercules stent (Microport), Castor Stents (Microport)	30-day survival rate of 92.9% Follow-up survival rate of 80.9% (39.92 ± 34.42 months)

TAAD: type A aortic dissection, AVR: aortic valve replacement, LAD: left anterior descending artery.

In contrast, management of chronic TAAD remains controversial because surgical guidelines are limited and no long-term data have yet been published. In asymptomatic patients, the 2010 American Heart Association and American College of Cardiology foundation guideline recommends surgery only in patients with an ascending aortic diameter of ≥ 5.5 cm.⁸ Surgical management can be challenging because of several issues, such as friability of the aortic wall, difficulty in choosing the appropriate cannulation and clamp site, and complexity in managing the aortic branches because they can arise from either the true or false aortic lumen.²²

Challenges in stenting of TAAD

Chronic TAAD is often associated with aortic valve pathology, mostly aortic regurgitation. Rylski et al.²³ reported that 52% of their cohort of 66 patients who underwent elective surgery for chronic TAAD required aortic valve replacement. The main pathology behind the aortic insufficiency was dilation of the annulus, deterioration of the aortic valve geometry, and asymmetric stretching of the aortic valve secondary to chronic aortic valve insufficiency.²³ No reported case to date has described a patient who underwent stenting for chronic TAAD followed by transcatheter aortic valve implantation to manage the aortic valve pathology; this is mainly due to the regurgitant pathology, not the stenosis.²⁴ Nevertheless, patients are most likely to undergo surgery if aortic valve replacement is required.

Standardisation of the current management pathway is required in such high-risk cases; this is to provide optimum outcomes and care. The operative techniques for endovascular management vary throughout the literature.²⁵ Moreover, no standard management strategy has been established for circulatory arrest, including

temperature and cerebral perfusion management, the use of fluoroscopy, and the method of stent graft deployment.²⁶

The availability of ready-to-use stent grafting is also a central issue because of the urgency of such cases. In most cases of ascending aortic stenting, the stent graft must be customised because of individual anatomical variations. A systematic review by Muetterties et al.²⁰ revealed a significant variation in the stent graft choices among different endovascular approaches. Thirteen different aortic stent grafts were used in 118 patients, with the majority being thoracic aortic stent grafts (71.2%). This shows that anatomical variation, particularly the length of the ascending aorta, plays a major role in the suitability and availability of the graft.²⁷ Although patients with a stable chronic TAAD may be able to wait for a custom-made graft prior to intervention, this may be challenging for patients with ATAAD, which is a more urgent or even emergency condition.^{28,29}

Finally, the number of successful cases remains small, and endovascular repair is limited only to patients who are deemed unfit for surgery. Open surgery remains the gold standard for ATAAD. Furthermore, most studies to date have been single-centre case reports, case series, or retrospective studies. No prospective studies that can increase our understanding of the magnitude of the benefit obtained by endovascular stenting have yet been performed. Before a definitive

recommendation of endovascular stenting for TAAD can be made, further long-term studies are required. Table 2 summarises the key advantages and challenges in using stent grafts for TAAD.

Will the future involve stenting, or will open repair remain the gold standard approach?

Open surgical repair is currently the gold standard management option for ATAAD.³⁰ Sobocinski et al.³¹ retrospectively reviewed the imaging studies of 102 patients with Stanford TAAD who underwent open surgical repair. The authors concluded that more than half of the patients had the potential to undergo successful endovascular repair because of anatomical suitability. A further study showed that a thrombosed false lumen as seen by transoesophageal echocardiography in patients with TAAD was an indicator of survival,³² implying that achieving closure of the dissection tear and subsequent false lumen thrombosis will improve long-term survival.

Lu et al.³³ divided the ascending aorta into three sections according to the location of the entry tear. They concluded that if the tear is located in the distal third of the ascending aorta, a branched endograft, hybrid, or fenestrated procedure is necessary to maintain perfusion to the brachial cephalic vessels. A tear located in the middle third of the aorta is an ideal case for tube-stent repair, whereas an entry

Table 2. Advantages and challenges in using stent grafts.

Key advantages	Challenges
Minimal invasiveness	Availability of graft in the emergency setting
Comparable survival	No specific stent for ascending aorta
An alternative option to medical treatment in high-risk patients	Not available for patients with aortic valve pathology
	Anatomical variation
	No standardized management

tear in the proximal third of the ascending aorta does not offer a sustainable landing zone for the endograft in most cases; thus, open repair must be performed.

Endovascular repair clearly has its advantages: it eliminates the need for a median sternotomy, cardiopulmonary bypass, and, in most cases, hypothermic circulatory arrest. However, despite the increasing numbers of aortic dissection cases, these patients are treated at tertiary specialised centres.^{34–41} Whether training in endovascular techniques will be available remains uncertain considering the technical challenges involving the aortic valve, coronary arteries, and brachiocephalic vessels and depends on whether the current category of patients undergoing endovascular repair will all be deemed unfit for open surgical repair.

Endovascular repair is an appealing management option in patients with contraindications for open surgical management. However, endovascular repair also has many limitations associated with the complex anatomic features of the ascending aorta and aortic arch.²³ The chosen technique or approach is dependent on the pathological pattern of the dissection and currently cannot be performed if the aortic valve and coronary arteries are involved.³³

The use of endovascular repair for such a complex disease is still in its infancy.^{42,43} The future in this area is exciting because both endovascular repair and stenting have revolutionised the management of type B aortic dissection and aortic valve disease in patients of advanced age by the evolution of transcatheter-based aortic valve implantation. Despite the current evidence of successful use of endovascular repair for ATAAD, surgical repair will remain the gold standard approach for both acute and chronic TAAD until the long-term outcomes of endovascular repair can be proven durable and comparable with those of open repair and until a randomised controlled

study of endovascular and open surgical repair in the two subgroups can be performed.

Conclusion

Endovascular repair of TAAD is evolving and can be very useful in surgically unfit patients with ATAAD. However, because of anatomical extension of the tear and lack of immediate stent graft types due to the urgency of the disease, open surgical intervention remains the gold standard management. Further studies are required in this field to expand the utilisation of stenting in patients with ATAAD.

Declaration of conflicting interest

The author(s) declare that there is no conflict of interest.

Ethics statement

No ethics committee approval was required because this study did not include any patient information.

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ORCID iD

Amer Harky  <https://orcid.org/0000-0001-5507-5841>

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